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Flint Hills Resources Alaska, LLC

First Semiannual 2015 Offsite Groundwater Monitoring Report

North Pole Terminal

North Pole, Alaska
DEC File Number: 100.38.090

July 31, 2015

ARCADIS

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ARCADIS

Table of Contents

Table of Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AHL	Arctic Home Living
ARCADIS	ARCADIS U.S., Inc.
Barr	Barr Engineering Company
bgs	below ground surface
bwt	below the water table
CCV	continuing calibration verification
city	North Pole, Alaska
CSM	Conceptual Site Model
DOT	Department of Transportation
DQO	data quality objective
Environmental Standards	Environmental Standards, Inc.
FHRA	Flint Hills Resources Alaska, LLC
ft/ft	foot per foot
ICAL	initial calibration
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
MAROS	Monitoring and Remediation Optimization System
monitoring plan	Deep Private Well Groundwater Monitoring Plan
MS	matrix spike
MSD	matrix spike duplicate
NPB	North Property Boundary
NPT	North Pole Terminal
Offsite RSAP	Offsite Revised Sampling and Analysis Plan

Offsite SCR – 2013	Offsite Site Characterization Report – 2013 Addendum
Offsite SCWP	Revised 2013 Offsite Site Characterization Work Plan
Pace	Pace Analytical Services, Inc.
POE	point of entry
POE SAP	Point-of-Entry Sampling and Analysis Plan
QA	quality assurance
QC	quality control
report	Draft First Semiannual 2015 Offsite Groundwater Monitoring Report
reporting period	first and second quarters 2015
RPD	relative percent difference
SGS	SGS Laboratories
site	Flint Hills Resources Alaska, LLC North Pole Terminal, a petroleum terminal located on H and H Lane in North Pole, Alaska
SOP	standard operating procedure
sulfolane-d8	sulfolane internal standard
SWI	Shannon & Wilson, Inc.
USGS	U.S. Geological Survey
WO	work order
µg/L	micrograms per liter
°C	degrees Celsius

1. Introduction

On behalf of Flint Hills Resources Alaska, LLC (FHRA), ARCADIS U.S., Inc. (ARCADIS) prepared this First Semiannual 2015 Offsite Groundwater Monitoring Report (report) for groundwater located downgradient of the FHRA North Pole Terminal (NPT), located on H and H Lane in North Pole, Alaska (site). This report summarizes offsite field activities completed in areas beyond the FHRA site boundary during the first and second quarters of 2015 (reporting period) as described in Section 3. A separate First Semiannual 2015 Onsite Groundwater Monitoring Report is being submitted concurrently with this report.

The data, analyses, and conclusions presented in this report are the product of a collaborative effort among FHRA's consulting team members. The team includes qualified professionals in a variety of technical disciplines from three environmental consulting firms: ARCADIS, Shannon & Wilson, Inc. (SWI), and Barr Engineering Company (Barr). FHRA engaged these consulting firms to perform various tasks for the project. Pursuant to 18 Alaska Administrative Code (AAC) 75.335, this report was prepared and submitted by a Qualified Person. The sampling plan for this report was prepared by a Qualified Person and was approved by the Alaska Department of Environmental Conservation (ADEC). Samples were collected and analyzed in accordance with 18 AAC 75.355(c). The work 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 Qualified Persons.

2. Site Setting

The NPT is located inside the city limits of North Pole, Alaska (the city). The city is located approximately 13 miles southeast of Fairbanks, Alaska, within the Fairbanks North Star Borough (Figure 2-1). Groundwater containing sulfolane has migrated off the Terminal site. An offsite site plan is presented on Figure 2-2.

The site (both offsite and onsite areas) and the site's physical setting are described in the Conceptual Site Model (CSM; Appendix A to the Offsite Site Characterization Report – 2013 Addendum [Offsite SCR – 2013; ARCADIS 2013a]). The CSM summarizes how chemicals were historically released to the environment at the NPT, how those chemicals move through the environment and affect living organisms, and ongoing efforts to protect people from exposure to those chemicals. The CSM is based on extensive environmental assessment activities that were conducted onsite and offsite during the past 26 years; the majority of field activities occurred since 2009. The environmental assessment included a thorough review of historical chemical use at the NPT, collection and analysis of water and soil samples from the surface and subsurface, groundwater monitoring data through time, hydrologic studies of groundwater gradients and movement, geophysical studies of permafrost in the area, and computer-based simulations of groundwater flow and transport of sulfolane in groundwater.

3. Current Groundwater Monitoring Program and Methods

The current offsite groundwater monitoring program was originally proposed in the Site Characterization and First Quarter 2011 Groundwater Monitoring Report (Barr 2011) and was subsequently revised in several iterations of site characterization reports. Table 3-1 summarizes the offsite field activities completed during the reporting period. Table 3-2 summarizes the offsite well construction details. The offsite groundwater elevation and sulfolane monitoring networks used for the reporting period are included in Tables 1 and 2 of the Offsite Revised Sampling and Analysis Plan (Offsite RSAP; Appendix A to the Fourth Quarter 2014 Offsite Groundwater Monitoring Report [ARCADIS 2015]). Offsite well locations are shown on Figure 2-2.

Groundwater monitoring data are used to monitor offsite dissolved-phase sulfolane concentrations and groundwater nature and movement. Sulfolane is the only offsite contaminant of concern. Groundwater monitoring through the second quarter 2015 was completed according to the procedures summarized in the Offsite RSAP (ARCADIS 2015).

3.1 Groundwater Elevation Monitoring

The first and second quarter 2015 groundwater elevation monitoring events were conducted on March 18 and June 11, 2015, respectively, at an extensive network of offsite wells. Monthly groundwater measurements were taken from the vertical gradient network on January 28, February 17 and 20, March 18 and 27, April 14, May 18, and June 5 and 11, 2015. In addition to manual water-level measurements, automated measurements were collected from a network of wells using pressure transducers to observe hydrogeological conditions between wells screened at various depths within the suprapermafrost aquifer. Groundwater elevation measurements were downloaded from the deployed offsite transducers on March 27 and 31 and April 3, 2015 during first quarter 2015, and on May 28 and 29 and June 5 and 16, 2015 during second quarter 2015.

3.2 Groundwater Sampling Priorities

Well networks are evaluated and each well was assigned a priority (one through four). Sampling is conducted in order of priority to assure that the most valuable data are collected during each sampling event. Table 2 of the Offsite RSAP (ARCADIS 2015) summarizes the priority levels assigned to each well in the offsite sulfolane monitoring network.

The following two deviations from the RSAP (ARCADIS 2014) were noted during the reporting period:

- During the reporting period, wells MW-349-15 and MW-349-45 were inadvertently sampled for the deep private well network geochemical parameters.

- The monitoring well MW-171 well nest was destroyed during Alaska DOT road construction sometime following the first quarter sampling event and hence, MW-171-A and MW-171B were not gauged during the second quarter 2015 monitoring event.

3.3 Private Well Sampling

Characterization activities began offsite in 2009. A door-to-door survey was previously conducted downgradient from the site to identify private water-supply wells in Search Areas 1 through 11 (Barr 2014a). Private well locations with well identifiers are shown on the figure included as Appendix A. Additional background information about private well sampling is documented in the Alternative Water Solutions Program – Management Plan (Barr 2014a) and Alternative Water Solutions Program – 2013 Annual Report (Barr 2014b).

During the first quarter 2015 sampling event, FHRA collected initial groundwater samples from two private wells (PW-2217 and PW-2218). PW-2217 is located 2 miles east of the site. PW-2218 is located northwest of monitoring wells MW-328-15/151. Both locations are outside the search areas and samples were collected at the homeowner's request as "call-in" samples.

During the second quarter 2015, FHRA collected initial groundwater samples from two private wells (PW-0688 and PW-1761). PW-0688 is located outside of the search area and was sampled at the homeowner's request as a "call-in" sample. PW-1761 is located within the sulfolane search area. The property where PW-1761 is located was previously vacant and FHRA was unable to collect a sample until the second quarter 2015.

The wells sampled for the first time during the reporting period are identified on Figure 3-1 with pink halos for first quarter results and purple halos for second quarter results.

FHRA sampled 26 previously-sampled private wells during the second quarter 2015. 25 of the 26 sampled wells are included in the 2015 buffer zone and resampling program described in the Alternative Water Solutions Program – 2014 Annual Report (Barr 2015), where wells within or near the detectable sulfolane plume boundary without previous sulfolane detections are sampled. The 26th private well (PW-0001) was resampled per the owner's request.

To date (between November 11, 2009 and June 9, 2015), FHRA has sampled and received results for 668 wells within the search areas (Barr 2014a), with many locations sampled several times as part of the annual resampling events or point of entry (POE) treatment system maintenance. In addition, 188 private well samples were collected from outside the

search areas at locations near the existing search areas or in situations where FHRA was contacted by a landowner, resident, or real estate agent with requests for testing.

3.4 Point of Entry Sampling

During the reporting period, FHRA continued to collect POE system maintenance sulfolane samples. Figure 3-1 presents raw water influent sampling results from private wells. Well symbols differentiate the wells with and without a POE treatment system. POE treatment system monitoring results and a discussion of effectiveness for 2015 will be included in the Alternative Water Solutions Program 2015 Annual Report.

3.5 Deep Private Well Monitoring

FHRA currently has to access to private wells on 15 properties for quarterly groundwater monitoring. FHRA no longer has access to deep private wells PW-0259, PW-0332, and PW-1630.

Fifteen of the deep private wells have intake intervals reported at depths below permafrost (based on installation logs), with total depths between approximately 89 feet below ground surface (bgs) (PW-0463) and 305 feet bgs (PW-1109). Two of the wells reportedly have shallow intake intervals at approximately 24 feet bgs (PW-0297) and 30 feet bgs (PW-1458) and are located on the same properties as two of the deep wells.

During the first quarter 2015 SWI sampled 13 deep private wells between February 12 and March 23, 2015. Two private wells (PW-0943 and PW-1109) were not sampled because the new owners were unable to be reached. Two shallow garden wells (PW-0297 and PW-1458) that have been previously sampled in conjunction with the deep private wells were frozen and samples could not be collected.

During the second quarter 2015, samples were collected from 15 deep private wells between May 5 and 19, 2015. PW-0297 and PW-1458 remained frozen and were not sampled during the second quarter 2015.

4. Groundwater Monitoring Results

Offsite groundwater impacts have been characterized, and continue to be monitored through the analysis of water-level gauging data and groundwater samples collected from offsite monitoring, U.S. Geological Survey (USGS), and private wells. This section presents results of water-level gauging and sulfolane analysis of offsite monitoring well and private well samples collected during the reporting period. Groundwater monitoring well field parameters, groundwater elevations, and vertical gradient network groundwater elevations are presented in Tables 4-1, 4-2, and 4-3. Tables 4-4 through 4-8 present results of monitoring well sulfolane analysis, private well initial sampling, private well resampling, deep private well field parameters, and deep private well sulfolane results. Historical groundwater elevation, sulfolane, geochemical parameters, private wells, and culvert measurements are included as Appendix B. Analytical laboratory reports and ADEC quality assurance (QA)/quality control (QC) checklists for data collected from monitoring wells and private wells (including POE systems and the deep private well network) are included as Appendices C and D, respectively. Field data sheets are included as Appendix E.

4.1 Groundwater Elevation

Depth to water measurements and groundwater elevation data for the reporting period are summarized in Table 4-2. Vertical gradient network groundwater elevations are provided in Table 4-3. Vertical head differences between nested wells are evaluated in Appendix F.

Depth to water measurements were collected from monitoring wells on March 18 and June 11, 2015 for the first and second quarter 2015 groundwater elevation monitoring events, respectively. Potentiometric maps for the first quarter and second quarter 2015 monitoring events are included on Figures 4-1 through 4-4 and Figures 4-5 through 4-8, respectively, for each monitoring zone: water table, 10 to 55 feet below the water table (bwt), 55 to 90 feet bwt, and 90 to 160 feet bwt. The average magnitudes of the offsite horizontal hydraulic gradients for groundwater during the first quarter 2015 monitoring event were calculated as follows: water table – 0.001 foot per foot (ft/ft), 10 to 55 feet bwt – 0.0009 ft/ft, 55 to 90 feet bwt – 0.001 ft/ft, and 90 to 160 feet bwt – 0.001 ft/ft. The average magnitudes of the offsite horizontal hydraulic gradients for groundwater during the second quarter 2015 monitoring event were calculated as 0.001 ft/ft for each of the four zones. During the reporting period, the general direction of the horizontal hydraulic gradient was interpreted to be to the north-northwest, which is consistent with historical groundwater data. Vertical hydraulic gradients were also within the range of historical groundwater data as depicted in Table 4-3 and Appendix F.

In addition to manual water-level measurements, automated measurements were collected using pressure transducers deployed in 40 offsite wells, including 15 well nests. Groundwater elevation hydrographs were prepared in accordance with the SOP for

groundwater elevation monitoring (SWI 2013) using the most recent survey data. Error ranges, calculated in accordance with the method outlined in the SOP for groundwater elevation monitoring (SWI 2013), are shown on the well nest hydrographs presented in Appendix G.

Ten pressure transducer data logs identified in the table below were incomplete for the reporting period.

Monitoring Well	Reason for Omitted Data	Comments
MW-151B-25	Data logger was frozen and not accessible.	Second quarter 2015 data will be imported when monitoring well thaws.
MW-151C-60	Data logger was frozen and not accessible.	Second quarter 2015 data will be imported when monitoring well thaws.
MW-161A-15	Data logger was frozen and not accessible.	Second quarter 2015 data will be imported when monitoring well thaws.
MW-164C-60	Data logger was frozen and not accessible.	Second quarter 2015 data will be imported when monitoring well thaws.
MW-171A-15	Well nest was destroyed during road construction. Data logger was not recovered.	FHRA team is evaluating adding wells located on right-of-ways to the 811 utility locating system.
MW-172A-15	Data logger was frozen and not accessible.	Second quarter 2015 data will be imported when monitoring well thaws.
MW-190A-15	Data logger was frozen and not accessible.	Second quarter 2015 data will be imported when monitoring well thaws.
MW-320-20	Data logger was frozen and not accessible.	First and second quarter 2015 data will be imported when monitoring well thaws.
MW-320-130	Data logger was frozen and not accessible.	Second quarter 2015 data will be imported when monitoring well thaws.
MW-328-151	Data logger was frozen and not accessible.	Second quarter 2015 data will be imported when monitoring well thaws

The pressure transducers installed in the following wells were removed prior to first quarter 2015 per ADEC's request: MW-166A-15, MW-167A-15, MW-168A-15, MW-182A-15, MW-183A-15, MW-187-15, MW-189-15, MW-191A-15, and MW-194-15.

A detailed evaluation of transducer data and hydraulic gradients is provided in Appendix 5-A to the Offsite SCR – 2013 (ARCADIS 2013a). An updated evaluation is presented as Appendix F.

Culvert measurements were recorded only in January (on January 12, 2015) during the first quarter 2015 because the culverts were frozen in February and March. Measurements were recorded monthly during the second quarter 2015 on April 6, May 4, and June 2, 2015. Measurements collected since the beginning of 2015 are included in historical tables provided in Appendix B.

4.2 Sulfolane Distribution in Offsite Groundwater

As depicted in Figure 2-2, offsite monitoring wells are utilized to characterize the nature and extent of sulfolane impacts and permafrost depths offsite (ARCADIS 2013b). In addition, FHRA compiled data from an extensive review of available private well logs, collected information regarding construction of private wells from property owners, and discussed private well depths and the depths to both the top and bottom of permafrost with well drillers. A total of 70 private wells were identified to be installed beneath permafrost, within and near the detectable sulfolane plume, at depths ranging from 60 to 353 feet bgs. The 70 private wells include deep private wells as described in Section 3.5.

During the first and second quarter 2015 groundwater monitoring events, samples were collected and submitted for sulfolane analysis from 124 and 90 monitoring wells, respectively, from the offsite monitoring well network. The offsite monitoring well data are presented in Table 4-4. Results from private wells sampled for the first time during the reporting period are presented in Table 4-5 (initial sampling). Results for the resampled private wells are presented in Table 4-6. Offsite sulfolane distribution for the first and second quarters of 2015 are included on Figures 4-9 through 4-12 and Figures 4-13 through 4-16, respectively. The approximate extent of sulfolane distribution on Figures 4-9, 4-10, 4-13 and 4-14 considers results from monitoring wells sampled during the quarterly monitoring periods and private wells sampled within the last 12 months. The approximate extent of sulfolane distribution on Figures 4-11 and 4-15 consider results from subpermafrost private wells sampled within the last 12 months as there are no monitoring wells screened within the subpermafrost aquifer. Historical sulfolane analytical results are included in Appendix B.

4.2.1 Private Well Sampling Results

During the first quarter 2015, two call-in samples were collected from private wells outside the plume area sampled for the first time (PW-2217 and PW-2218). Both initial private well samples did not contain detectable concentrations of sulfolane. During the second quarter 2015, an additional two samples were collected from private wells for the first time (PW-0688 was a call-in location from outside the plume area and PW-1761 was from a property being newly occupied within the plume area). The sample from PW-1761 contained detectable concentrations of sulfolane at 18.1 µg/L. This location is within the sulfolane search area and interim bottled water is being provided to the residence (PW-1761).

Initial sample results are presented in Table 4-5. Initial samples collected during the reporting period are highlighted on Figures 3-1, 4-9, and 4-13. Private well locations are also shown on the figure presented as Appendix A.

There were no private wells resampled as part of the buffer zone and resampling project or call-in sampling during the first quarter 2015. During the second quarter 2015, 26 previously sampled private wells were resampled. These results are shown in Table 4-6 and presented on Figures 4-13, 4-14, and 4-15, based on their classification as either suprapermafrost or subpermafrost wells. Two of the samples (PW-0283 and PW-1051) contained estimated sulfolane concentrations below the limit of quantitation at 6.28 J and 4.81 J µg/L, respectively. Construction and well intake information for PW-0283 is uncertain; however, concentration data shows that the well is likely a suprapermafrost well. Due to the absence of conclusive information regarding the well intake, this well is displayed on both suprapermafrost (Figures 4-10 and 4-14) and subpermafrost figures (Figures 4-11 and 4-15). The other 24 samples collected during the second quarter 2015 did not contain detectable concentrations of sulfolane. The most recent data for each private well data point are shown on Figure 3-1 with color gradation to indicate the concentration.

During the reporting period, 174 raw water (taken upstream of the treatment system) samples were collected from locations with a POE treatment system and were evaluated to identify plume trends. Raw water data for locations with a POE treatment system are also included on Figure 3-1. Historical private well data, including current and historical POE treatment system data for raw water samples, are presented in Appendix B. Laboratory reports and associated ADEC QA/QC checklists reviewed during the reporting period are presented in Appendices C and D, respectively. Data were evaluated for potential sulfolane concentration trends through first quarter 2015; results are discussed in Section 4.3 and included in Appendix H.

4.2.2 Deep Private Well Monitoring Results

As stated in Section 3.5, groundwater samples were collected from 13 and 15 private wells during the first and second quarters of 2015, respectively. Sulfolane was not detected in the samples collected from two private wells (PW-0972 and PW-1343) during the reporting period. Sulfolane concentrations detected in the remaining private wells ranged from 10.3J µg/L (PW-0296) to 695 µg/L (PW-1230) during the first quarter 2015 and 9.54 J µg/L (PW-0296) to 724 µg/L (PW-1230) during the second quarter 2015.

Deep private well field parameter results are included in Table 4-7 and analytical results are included in Table 4-8. Sulfolane concentrations for the deep private well network for the first and second quarters of 2015 are presented on Figures 4-12 and 4-16, respectively. Historical data are included in Appendix B. Sulfolane statistical trends for deep private monitoring well network are discussed in Section 4.3. Laboratory reports and ADEC QA/QC checklists are included in Appendices C and D, respectively.

4.2.3 Subpermafrost and Suprapermafrost Aquifers

Permafrost is present under much of the offsite area as a relatively continuous mass that extends beyond the northern and western extents of the site boundary, as presented in the Offsite SCR – 2013 (ARCADIS 2013a). Permafrost is believed to be absent under the Tanana River and appears to be truncated on portions of the eastern edge of the sulfolane plume by a thawed zone beneath Badger Slough. Estimated depth to permafrost and the permafrost extent are shown on Figures 4-9 and 4-13.

Wells that define the extent of dissolved sulfolane in the suprapermafrost aquifer include offsite monitoring wells and private wells with reliable construction information, indicating that the well intake is within the suprapermafrost zone and near the detectable sulfolane plume.

There are no offsite monitoring wells installed beneath permafrost. Private wells that are located within or near the detectable sulfolane plume and have intakes within the subpermafrost aquifer were used to define the extent of dissolved sulfolane in subpermafrost aquifer. Private wells were designated as suprapermafrost or subpermafrost based on the criteria identified below:

- Private wells with geologic logs confirming the presence of frozen soil to depths greater than 60 feet bgs and well construction information indicating that the well is completed below the permafrost.

- Private wells without geologic logs, but with information from the ADEC Septic Registry or owner knowledge confirming a total depth of greater than 60 feet bgs and that the well is reasonably near other private wells with similar total depths that are categorized as subpermafrost wells per the above condition.

- Some deeper wells that are too shallow to be part of the subpermafrost aquifer system at their location are designated to the suprapermafrost aquifer.

- Additional lines of evidence (e.g., geologic, hydrologic, aerial photo, and/or land use features) and sampling results were considered when designating wells to either the suprapermafrost or subpermafrost aquifer.

Using the criteria identified above, 325 wells were identified as being screened within the suprapermafrost aquifer and have been sampled. Seventy private wells were identified as being installed beneath permafrost and therefore represent the subpermafrost aquifer system (generally with depths greater than 60 feet) and have been sampled. An additional 14 subpermafrost wells were identified, but are not included in the current sampling

program per the parameters defined in the Alternative Water Solutions Program – Management Plan (Barr 2014a).

Figures 4-9 and 4-13 show the cumulative sulfolane analytical results from offsite monitoring and private wells in both the suprapermafrost and subpermafrost aquifers for first and second quarters of 2015, respectively. This 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. If the well was not sampled in first or second quarter 2015, then the most recent result within 12 months is indicated on the map, and was used to estimate the extent of sulfolane. Sections 4.2.3.1 and 4.2.3.2 summarize the analytical data collected during the reporting period from offsite groundwater monitoring and private wells that are designated to the suprapermafrost or subpermafrost aquifer, respectively. Section 5 discusses the sulfolane detections in offsite monitoring and private wells that were flagged as estimated.

4.2.3.1 Offsite Sulfolane Distribution in the Suprapermafrost Aquifer

Offsite monitoring wells were sampled throughout the reporting period. Samples from two monitoring wells (MW-349-15 and MW-349-45), located on the same property as PW-1230, were sampled on the same schedule as the deep private wells during the reporting period to minimize disruption to the property owners.

A total of 124 offsite monitoring wells were sampled and analyzed for sulfolane during the first quarter 2015 monitoring event. Sulfolane was not detected in 55 samples. In the remaining 692 samples, sulfolane was detected at concentrations ranging from 3.59J µg/L (MW-187-15) to 225 µg/L (MW-332-150). Based on the site characterization studies, the following monitoring wells appear to be installed in an area just beyond the edge of a large permafrost body: MW-332-15 (<5.25 µg/L), MW-332-41 (<5.00J* µg/L), MW-332-75 (<5.00 µg/L), MW-332-110 (20.4J* µg/L), MW-332-150 (225 µg/L), MW-346-15 (8.60J µg/L), MW-346-65 (24.7 µg/L), and MW-346-150 (<5.20 µg/L). Sulfolane concentrations in these wells may indicate a “mixing zone” between the subpermafrost and suprapermafrost aquifers, as shown on Figure 4-9. These results are presented in Table 4-4.

A total of 90 offsite monitoring wells were sampled and analyzed for sulfolane during the second quarter 2015 monitoring event. Sulfolane was not detected in 39 samples. In the remaining 51 samples, sulfolane was detected at concentrations ranging from 3.36J µg/L (MW-187C-120) to 230 µg/L (MW-332-150). Sulfolane concentrations in the inferred mixing zone monitoring wells are as follows: MW-332-15 (<5.25 µg/L), MW-332-41 (<5.15 µg/L), MW-332-75 (<5.30 µg/L), MW-332-110 (18.0 µg/L), MW-332-150 (230 µg/L), MW-346-15 (11.6 µg/L), MW-346-65 (27.9 µg/L), and MW-346-150 (<5.00 µg/L). These results are shown on Figure 4-13 and in Table 4-4.

Thirty-six private wells screened in the suprapermafrost aquifer were sampled in the first quarter 2015. All 36 samples were locations with POE systems. Sulfolane detections discussed in this section for locations with POE systems are for the raw water samples. None of the private wells were resampled as part of the buffer zone and resampling project during the first quarter 2015. Sulfolane detections ranged from 3.00J µg/L (PW-622) to 152 µg/L (PW-1374). Thirty-five suprapermafrost wells were sampled in the second quarter 2015. This included 14 suprapermafrost wells sampled as part of the buffer zone and resampling project and 21 locations with POE systems. Sulfolane detections ranged from 5.20 J µg/L (PW-622) to 78 µg/L (PW- 647).

4.2.3.2 Offsite Sulfolane Distribution in the Subpermafrost Aquifer

Twenty-three subpermafrost locations were sampled during the first quarter 2015 sampling event. Subpermafrost wells sampled during the first quarter included 12 locations with POE systems and 11 deep private wells. Sulfolane concentrations ranged from 4.50 J µg/L (PW-391) to 695 µg/L (PW-1230). Sulfolane was not detected in the samples collected from PW-972 and PW-1343 during the reporting period.

Twenty-two subpermafrost locations were sampled during the second quarter 2015 sampling event. Subpermafrost wells sampled during the second quarter included six locations with POE systems, 13 deep private wells, and three resampled private wells. Sulfolane concentrations ranged from 6.28 J µg/L (PW-283) to 724 µg/L (PW-1230) during the reporting period. Sulfolane at PW-389, PW-972, PW-1053, and PW-1343 was below the detection limit during the second quarter 2015 sampling event.

Figures 4-11 and 4-15 present sulfolane data for the previous 12 months, based on the samples collected from private wells installed beneath the permafrost in the deep aquifer system.

4.3 Statistical Analysis of Offsite Sulfolane Data

The Mann-Kendall Trend Analysis is a nonparametric statistical method used to determine trends for concentrations of a given constituent at a given monitoring well. The protocol described in the Monitoring and Remediation Optimization System (MAROS) is used to complete the Mann-Kendall Trend analysis for sulfolane in select groundwater monitoring wells using data collected through first quarter 2015. Mann-Kendall Trend analysis will be completed for the next reporting period using data collected through the third quarter 2015 sampling event.

MAROS is a decision support tool developed by the Air Force Center for Engineering and the Environment in order to use statistical methods based on site-specific data. The use of

MAROS for Mann-Kendall analysis was applied to offsite groundwater monitoring data collected since 2009 from monitoring wells and private wells.

Statistical and graphical evaluations of sulfolane concentration trends at monitoring wells and private wells are used to evaluate plume migration and attenuation, and to identify relationships between dissolved-phase concentrations, groundwater elevations, and flow directions.

The analysis trends are expressed as probably increasing, increasing, probably decreasing, decreasing, stable, or no trend. Results of the Mann-Kendall analysis for the reporting period are presented in Tables 1 through 2 and Figures 1A through 2D of Appendix H and summarized in the table below.

Parameter/Trend	First Quarter 2015		
	Monitoring Wells	Suprapermafrost Private Wells	Subpermafrost Private Wells
No. of Wells	158	325	70
All Results Nondetect[1]	72	192	33
Insufficient Data Points[1]	1	61	6
Probably Decreasing	1	2	1
Decreasing	43	9	1
Probably Increasing	1	3	2
Increasing	15	29	19
Stable	16	10	3
No Trend	9	19	5

Private wells with unknown depth information are not included in this table. Refer to Appendix H, Table 2 for trends associated with private wells with unknown depths.
[1]Wells with insufficient data points for the statistical analysis (less than four points), but with all results below detection limits, are listed under "All Results Nondetect."

Sulfolane trends in monitoring wells and private wells continue to exhibit trends consistent with the Offsite SCR – 2013 and CSM. Notable is the continued decrease in concentrations from monitoring locations downgradient of the NPT.

4.4 Geochemical Parameters

Geochemical parameter monitoring will be performed annually during the third quarter in accordance with the Offsite RSAP (ARCADIS 2015). Geochemical monitoring results for deep private wells for the reporting period are included in Table 4-8. Historical geochemical parameter monitoring results are included in Appendix B.

5. Analytical Quality Assurance and Quality Control

QA/QC procedures assist in producing data of acceptable quality and reliability. Analytical results for laboratory QC samples were reviewed and a QA assessment was completed on the data generated for this reporting period. The QA review procedures provided documentation of the accuracy and precision of the analytical data and confirmed that the analyses were sufficiently sensitive to detect analytes at levels below suggested action levels or regulatory standards, where such standards exist. SWI conducted QA/QC reviews of the data for this reporting period. The laboratory reports for each of the samples for this report, including case narratives describing laboratory QA results and completed ADEC QA/QC checklists, are included in Appendices C and D, respectively. Data quality flags applied to the analytical results are summarized in Table 5-1.

Level IV data packages and a third-party review are requested if an analytical interference is noted in the groundwater samples from a new well or interference is identified in an existing well where no interference was previously identified. In addition, when laboratory sample mislabeling or systematic analytical failures are noted, Level IV reports may be requested. A Level IV may also be requested if analytical results are not consistent with historical or expected results. Level IV reports can also be requested for an in-depth review of laboratory performance. Laboratory level IV reports are included as Appendix C. Environmental Standards, Inc. (Environmental Standards) conducts Level IV data validation for the site. The Level IV data validation reports prepared by Environmental Standards are included in Appendix I.

5.1 Water Sample Data Quality

This section summarizes the results of the QA/QC review of data for this reporting period (monitoring well and private well sample results received from January 1 through June 9, 2015). Samples were submitted to SGS Laboratories (SGS) or Pace for analysis of sulfolane in monitoring and private wells. ADEC QA/QC checklists are included in Appendix D.

The SGS work orders (WOs) reviewed during the reporting period for results associated with the groundwater monitoring wells are listed in the tables below.

First Quarter 2015 Groundwater Monitoring WO List					
1157513	1157522	1157527	1157541	1157542	1157591
1157592	1157598	1157602	1157603	1157634	1157644

Second Quarter 2015 Groundwater Monitoring WO List						
1157736	1157741	1157747	1157753	1157766	1157771	1157772
1157775	1157777	1157783	1157805	1157813	1157913	

The SGS WOs reviewed during the reporting period for results associated with initial and resampled private wells samples are listed in the tables below.

First Quarter 2015 Initial Private Well Sample WO List	
1157619	1157647

Second Quarter 2015 Initial and Resampled Private Well Sample WO List				
1157832	1157869	1157917	1157918	1157919
1157920	1157921	1157954	1157955	1157959
1157960	1157961	1157962	1157973	1157995
1157996	1157997	1157998	1158008	1158012
1158013	1158026	1158027	1158028	1158029

The SGS WOs reviewed during the reporting period for results associated with deep private well monitoring network samples are listed in the tables below.

First Quarter 2015 Deep Private Well Sample WO List						
1157589	1157590	1157594	1157595	1157597	1157607	115762
1157640	1157648	1157663	1157664	1157666	1157670	115770

Second Quarter 2015 Deep Private Well Sample WO List							
1157876	1157877	1157879	1157899	1157900	1157909	1157910	1157911
1157912	1157927	1157928	1157929	1157963	1157964	1157972	1157974

The Pace WOs reviewed during the reporting period for sulfolane results associated with POE system samples, excluding raw water samples, are listed in the tables below.

First Quarter 2015 POE Sample Pace WO List							
10290130	10290132	10290580	10290581	10290583	10290585	10290586	10290976
10290983	10291307	10291308	10291309	10291311	10291313	10291314	10291965
10291967	10291968	10291969	10291971	10291972	10292427	10292428	10292429
10292697	10292701	10292847	10292850	10293223	10293224	10293225	10293227

First Quarter 2015 POE Sample Pace WO List							
10293228	10293318	10293455	10293456	10293457	10293567	10293569	10293805
10293807	10293809	10293922	10293923	10293925	10294064	10294065	10294069
10294604	10294605	10294606	10294607	10294907	10294908	10294910	10295302
10295303	10295304	10295305	10295307	10295309	10295457	10295459	10295530
10295698	10295699	10295700	10295858	10295859	10296105	10296106	10296456
10296458	10296461	10296462	10296596	10296598	10297091	10297092	10297093
10297094	10297097	10297209	10297210	10297211	10297213	10297689	10297708
10297709	10297710	10297843	10297844	10297847	10298211	10298213	10298214
10298353	10298356	10298644	10298916	10298917	10298918	10299117	10299119
10299120	10299425	10299707	10299709	10299862	10299863	10299974	10300386
10300546	10300548						

Second Quarter 2015 POE Sample Pace WO List							
10299975	10299976	10300683	10300684	10301090	10301329	10301330	10301810
10301811	10302008	10302009	10302010	10302011	10302177	10302178	10302219
10302708	10302709	10302710	10302711	10302713	10302847	10302850	10302851
10303302	10303563	10303565	10303698	10303699	10303700	10304324	10304327
10304329	10304482	10304994	10304995	10304997	10305205	10305206	10305209
10305344	10305347	10305348	10305873	10305874	10305875	10306111	10306117
10306118	10306266	10306267	10306864	10306865	10307271	10307272	10307274
10307275	10307277	10307858	10307859				

Results of the QA/QC review are discussed below. Only those instances where data quality was affected (i.e., data qualifiers were necessary) are summarized; additional details regarding QA/QC for each WO are provided in the ADEC QA/QC checklists (Appendix D).

5.2 Sample Handling

Monitoring and private well samples collected by SWI were generally hand delivered to the SGS (Fairbanks, Alaska) receiving office and then shipped overnight via Lynden Transport or Alaska Airlines Goldstreak to SGS in Anchorage, Alaska to perform the requested analyses, using the methods specified in the chain of custody records. POE samples collected by AHL were shipped to Pace in Minneapolis, Minnesota via FedEx

overnight service to perform the requested analyses, using the methods specified in the chain of custody records.

Sample receipt forms for each WO for both SGS Alaska locations, or for Pace, were reviewed and checked to verify that samples were received in good condition and within the acceptable temperature range. The ADEC QA/QC checklists (Appendix D) contain details regarding this review. ADEC considers samples received at temperatures between 0 and 6 degrees Celsius (°C) acceptable in the absence of ice, as specified by US Environmental Protection Agency Method SW-846. Therefore, for this report, temperatures between 0 and 6 °C are considered acceptable.

Samples were received within the acceptable temperature range upon arrival at each location during the reporting period, with some minor discrepancies that did not affect data quality or usability (see ADEC QA/QC checklists in Appendix D for details), and were received properly preserved and in good condition, with the following exceptions:

- *First quarter 2015 SGS WOs 1157513 and 1157591*. Sample containers for samples MW-332-41, MW-332-110, MW-150A-10, MW-150B-25, MW-150C-60, MW-158A-15, MW-158B-60, MW-159C-70, MW-184-45, MW-250B-25, MW-316-15, and MW-316-56 were received at the SGS Fairbanks office with ice present inside the samples. The analytical results are considered estimated and are flagged ‘UJ’ for nondetects and ‘J’ for detected results.

- *First quarter 2015 SGS WO 1157607*. The cooler containing samples were received at a temperature of 8 °C by ALS Environmental Laboratory for methane analysis. The methane result for sample PW-0464 is considered estimated, biased low, and is flagged ‘JL.’

- *Second quarter 2015 SGS WOs 1157963 and 1157964*. The cooler containing samples were received at a temperature of 8 °C by ALS Environmental Laboratory for methane analysis. The methane results for samples PW-1099, PW-1099DUP, and PW-1109 are considered estimated, biased low, and flagged ‘JL.’

- *First quarter 2015 Pace WO 10299425*. The cooler containing samples were received at a temperature of at 7.4 °C for sulfolane analysis. The analytical result from PW-1108 is considered to be estimated due to the sample handling anomaly and is flagged ‘J’ for the detected result.

Chain of custody records for each WO were also reviewed to confirm that information was complete, custody was not breached, and samples were analyzed within the acceptable holding time. COC records were complete and accurate, with the exception of minor discrepancies associated with sample names or sample times that do not affect the data

quality or usability (see ADEC QA/QC checklists in Appendix D for details). Samples were analyzed within holding times, with the following exceptions:

- *First quarter 2015 SGS WOs 1157598 and 1157603*. Samples from wells MW-181A-15 and MW-270B-75 were analyzed outside the hold time for sulfolane. Sulfolane was not detected in the samples. The sample results are considered estimated and are flagged 'UJ'.

- *Second quarter 2015 Pace WO 10302219*. The sample from PW-0608 was analyzed outside the recommended hold time for sulfolane. The sample result is considered estimated and flagged 'J' for the detected result.

In addition, some samples required re-extractions past their hold times to confirm results that were inconsistent with historical results. Because the original results are used for reporting purposes and were extracted within the prescribed hold time, qualification of the re-extracted result was not necessary.

No other sample handling anomalies were identified during the reporting period that would adversely affect data quality.

5.3 Analytical Sensitivity and Blanks

Reported limits of detection for regulated analytes, where applicable, were below ADEC interim action levels during the reporting period.

Laboratory method blanks were analyzed in association with samples collected for this reporting period to check for laboratory contamination affecting analytical results. Equipment blanks were collected to assess the possibility of cross-contamination from sampling equipment. There were no blank detections affecting data quality for the reporting period, with the following exceptions:

- *First quarter 2015 SGS WOs 1157640, 1157648, and 1157876*. Total organic carbon (TOC) was detected in the method blanks for these WOs. TOC was detected in samples PW-1230, PW-1230 DUP, MW-349-45, and PW-1155 at concentrations greater than five times, but less than 10 times, the concentration in the method blank. The samples are considered estimated, biased high, and are flagged 'JH.'

- *Second quarter 2015 SGS WOs 1157877, 1157879, 1157899, 1157900, 1157909, 1157910, 1157911, 1157912, 1157927, 1157928, 1157929, 1157963, and 1157974*. TOC was detected in the method blanks for these WOs. The associated samples that had TOC concentrations greater than five times, but less than 10 times, the method blank detection are considered estimated, biased high, and are flagged 'JH.' The

associated samples that had TOC concentrations less than five times the method blank detection are considered nondetect and are flagged 'UB' at the greater of the limit of quantitation and the reported concentration.

5.4 Accuracy

Laboratory analytical accuracy may be assessed by evaluating the analyte recoveries from continuing calibration verification (CCV), laboratory control sample (LCS), and laboratory control sample duplicate (LCSD) analyses. LCS/LCSD samples assess the accuracy of analytical procedures by checking the laboratory's ability to recover analytes added to clean aqueous matrices. In some cases, the laboratory spiked samples from the reporting period as matrix spike (MS) and matrix spike duplicate (MSD) to assess their ability to recover analytes from a matrix similar to that of samples from the reporting period. Accuracy was also assessed for organic analyses by evaluating the recovery of analyte surrogates added to the reporting period samples. For sulfolane results, the recovery of the sulfolane internal standard (sulfolane-d8) was evaluated.

No CCV or initial calibration (ICAL) verification failures affecting data quality were noted in the case narratives for samples obtained during the reporting period. Recovery information was reviewed for all LCS/LCSDs and MS/MSDs for the reporting period. LCS, LCSD, MS, and MSD recoveries were within laboratory control limits for each preparatory batch, with the following exceptions:

- *First quarter 2015 SGS WO 1157640*. Ammonia-N was recovered above laboratory control limits in the MSD associated with sample PW-1230 DUP. The ammonia-N result for this sample is considered estimated, biased high, and is flagged 'JH.' Both the primary and duplicate samples are impacted by a field duplicate relative percent difference (RPD) failure. Refer to the ADEC QA/QC checklist in Appendix D for additional details for this WO.

- *Second quarter 2015 SGS WO 1157900*. Ammonia-N was recovered above laboratory control limits in the MSD associated with the sample PW-0466. The ammonia-N result for this sample is considered estimated, biased high, and is flagged 'JH.'

Recovery of analyte surrogates and sulfolane-d8 were within laboratory control limits, with the following exceptions:

- *First quarter 2015 Pace WOs 10290132 and 10291307*. Sulfolane-d8 was recovered outside laboratory control limits for samples PW-1407 and PW-1395. The sulfolane results are considered estimated and are flagged 'UJ' for nondetects and 'J' for detected results.

Laboratory CCV, LCS/LCSD, MS/MSD, and surrogate-recovery information indicate the analytical results were accurate, with the exceptions noted above.

5.5 Precision

Field duplicate samples were collected at a frequency of approximately 10 percent of the overall number of samples collected during the reporting period to evaluate the precision of analytical measurements as well as the reproducibility of the sampling technique. The RPD, which is the difference between the sample and its field duplicate divided by the arithmetic mean of the two, was calculated to evaluate the precision of the data.

During the first quarter 2015, the following duplicate samples were collected:

- Thirteen duplicates for monitoring well samples analyzed for sulfolane (124 primary samples total).
- Three duplicates for deep private well samples analyzed for sulfolane (15 primary samples total).
- No duplicates for initial and resampled private well samples analyzed for sulfolane by SGS (two primary samples total).
- Forty-eight duplicate samples for POE samples analyzed for sulfolane by Pace (114 total raw water primary samples).

During the second quarter 2015, the following duplicate samples were collected:

- Twelve duplicates for monitoring well samples analyzed for sulfolane (90 primary samples total).
- Two duplicates for deep private well samples analyzed for sulfolane (17 primary samples total).
- Four duplicates for initial and resampled private well samples analyzed for sulfolane by SGS (16 primary samples total).
- Twenty-six duplicate samples for POE samples analyzed for sulfolane by Pace (60 total raw water primary samples).

The overall goal for the frequency of sample duplicates of approximately 10 percent was met. Results of RPD calculations for each of these duplicate samples were within the data quality objective (DQO) of 30 percent, where calculable, with the following exceptions:

- *First quarter 2015 SGS WOs 1157595 and 1157640*. The results for field duplicate pairs PW-0466/PW-0466 DUP and PW-1230/PW-1230 DUP for ammonia-N yielded RPDs outside the acceptable criteria. Results for the duplicate pairs are considered estimated and flagged 'J' for both samples. As noted in Section 5.4, PW-1230 DUP was also affected by an MSD recovery failure. Refer to the ADEC QA/QC checklist (Appendix D) for additional details for this WO.

- *Second quarter 2015 SGS WO 1157929*. The results for field duplicate pair PW-0463 /PW-0463 DUP for ammonia-N yielded an RPD outside acceptable criteria. The results for the duplicate pair are considered estimated and flagged 'J' for both samples.

Laboratory analytical precision can also be evaluated by laboratory RPD calculations using the LCS/LCSD and MS/MSD, or laboratory duplicate sample results. Results of RPD calculations for each of these duplicate samples were within the DQO of 30 percent, where calculable.

Based on a review of the data, the analytical results obtained during the reporting period are considered precise, with the exceptions noted above.

5.6 Hydrocarbon Interference and Level IV Review

In addition to the standard QA review described in the sections above, Environmental Standards also reviews select private well WOs. There were no hydrocarbon-interference issues that prevented the laboratory from identifying sulfolane during the reporting period.

Level IV laboratory reports associated with the reporting period are included in Appendix C. The level IV data validation reports prepared by Environmental Standards are included in Appendix I. Completed ADEC QA/QC checklists are included as Appendix D.

Environmental Standards conducted a Level IV review for a suspected sample switch from the fourth quarter 2014. An "A" sample from PW-1116 and a "C1" sample from PW-0158 were suspected to have been switched. The Environmental Standards review confirmed the sample switch and the corrected results are not considered to be affected by the sample handling anomaly. Because the Environmental Standards report was not finalized before submittal of the Fourth Quarter 2014 Offsite Groundwater Monitoring Report (ARCADIS 2015), the corresponding Level IV data validation report is included in Appendix I of this report.

Additionally, an investigation was concluded regarding an inadvertent switch of quantitation ion for some POE samples analyzed by Pace between December 30, 2013 and March 23, 2014. Pace has reprocessed the data for comparison to the results reported in the historical analytical data tables. The evaluation by Environmental Standards determined that the reprocessed results would not have altered the interpretation of the data. A memorandum summarizing the error and the corrective actions is included in Appendix I.

5.7 Data Quality Summary

Based on the methods outlined in the Offsite RSAP (ARCADIS 2015), the samples collected during the reporting period are considered to be representative of site conditions at the locations and times they were obtained. Based on the QA review, no samples were rejected as unusable due to QC failures. In general, the quality of the analytical data for this reporting period does not appear to have been compromised by analytical irregularities and results affected by QC anomalies are qualified with the appropriate data flags.

6. Conclusions

Quarterly groundwater monitoring events were conducted in the first and second quarter of 2015. The events were conducted in general accordance with the Offsite RSAP (ARCADIS 2015). The average magnitude of the horizontal hydraulic gradient in offsite groundwater was calculated at approximately 0.001 ft/ft during the reporting period. This result is consistent with historical data.

Groundwater monitoring data collected during the reporting period are consistent with data collected during recent quarters. Sulfolane trends in monitoring wells and private wells continue to exhibit trends consistent with the Offsite SCR – 2013and CSM. Notable is the continued decrease in concentrations from monitoring locations down gradient of the NPT. These decreases are continued indication that FHRA's onsite remediation activities continue to successfully support mitigation of the historical sulfolane releases that were caused by others prior to FHRA's ownership of the Site.

Quarterly groundwater monitoring will continue. The results from the third and fourth quarter monitoring events will be submitted in a semiannual report in January 2016.

7. References

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ARCADIS U.S., Inc. 2013a. Offsite Site Characterization Report – 2013 Addendum. December 20.

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Barr Engineering Company. 2011. Site Characterization and First Quarter 2011 Groundwater Monitoring Report. May.

Barr Engineering Company. 2014a. Alternative Water Solutions Program – Management Plan. October.

Barr Engineering Company. 2014b. Alternative Water Solutions Program – 2013 Annual Report. February 28.

Barr Engineering Company. 2015. Alternative Water Solutions Program – 2014 Annual Report. February 25.

Shannon and Wilson, Inc. 2013. Standard Operating Procedure for Groundwater-Elevation Monitoring.

ARCADIS

Tables

ARCADIS

Figures

ARCADIS

Appendices
(on enclosed CD)

ARCADIS

Appendix A

Private Well Location Map

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Appendix B

Historical Data Tables for Groundwater Elevation, Sulfolane, Geochemical Parameters, Private Wells, and Culvert Parameters

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Appendix C

Analytical Laboratory Reports

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Appendix D

ADEC QA/QC Checklists

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Appendix E

Field Data Sheets

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Appendix F

Offsite Vertical Head Differences and Hydraulic Gradients

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Appendix G

Hydrographs

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Appendix H

Mann-Kendall Trend Analysis Summary

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Appendix I

Level IV Data Validation Reports