Flint Hills Resources Alaska, LLC

FIRST SEMIANNUAL 2016 ONSITE GROUNDWATER MONITORING REPORT

North Pole Terminal
North Pole, Alaska
DEC File Number: 100.38.090

July 29, 2016

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ACRONYMS AND ABBREVIATIONS

AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
Arcadis	Arcadis U.S., Inc.
APOC	Alternative Point of Compliance
Barr	Barr Engineering Company
BTEX	benzene, toluene, ethylbenzene, and xylenes
bwt	below the water table
COC	constituent of concern
CSM	conceptual site model
DNR	Alaska Department of Natural Resources
DRO	diesel-range organics
FHRA	Flint Hills Resources Alaska, LLC
FHRA correspondence	FHRA correspondence to ADEC dated May 6, 2016
ft^2/day	square foot per day
GAC East	original treatment system
GAC West	expanded groundwater recovery and treatment system
gpm	gallons per minute
GRO	gasoline-range organics
GRTS	groundwater remediation and treatment system
lb/day	pound per day
LNAPL	light non-aqueous phase liquid
LTM Plan	Long-Term Monitoring Plan – 2015 Update
MAROS	Monitoring and Remediation Optimization System
NGP	North Gravel Pit
OCP	Final Onsite Cleanup Plan
OMM Plan	Operations, Maintenance, and Monitoring Plan – 2015 Update
Onsite RSAP	Revised Onsite Sampling and Analysis Plan
Onsite SCR – 2013	Onsite Site Characterization Report – 2013 Addendum
QA	quality assurance

QC	quality control
report	First Semiannual 2016 Onsite Groundwater Monitoring Report
reporting period	first and second quarters of 2016
SGP	South Gravel Pit
site	Flint Hills Resources Alaska, LLC North Pole Terminal, located on H and H Lane in North Pole, Alaska
SOP	standard operating procedure
SWI	Shannon & Wilson, Inc.
μg/L	micrograms per liter

1 INTRODUCTION

On behalf of Flint Hills Resources Alaska, LLC (FHRA), Arcadis U.S., Inc. (Arcadis) prepared this First Semiannual 2016 Onsite Groundwater Monitoring Report (report) for the FHRA North Pole Terminal, located on H and H Lane in North Pole, Alaska (site). This report summarizes onsite field activities completed during the first and second quarters of 2016 (reporting period) as described in Section 3 and in Table 1-1. A separate First Semiannual 2016 Offsite 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(c)(1), this report was prepared and submitted by a Qualified Environmental Professional. Samples were collected and analyzed in accordance with 18 AAC 75.355(a). The sampling and analyses for this reporting period were completed in accordance with the following documents, which were prepared by a Qualified Environmental Professional and approved by the Alaska Department of Environmental Conservation (ADEC):

- Final Onsite Cleanup Plan (OCP; Arcadis 2014)
- Long-Term Monitoring Plan – 2015 Update (LTM Plan; Arcadis 2015)
- Operations, Maintenance, and Monitoring Plan – 2015 Update (OMM Plan; Barr 2015)
- Revised Onsite Sampling and Analysis Plan (Onsite RSAP; Arcadis 2016)
- FHRA correspondence to ADEC dated May 6, 2016 (FHRA correspondence; FHRA 2016)

First quarter 2016 groundwater monitoring was conducted in accordance with the LTM Plan (Arcadis 2015) and OMM Plan (Barr 2015). Second quarter 2016 groundwater monitoring was conducted in accordance with changes requested by ADEC and noted in FHRA correspondence dated May 6, 2016 (FHRA 2016).

The site, offsite area, and the site's physical setting are described in the conceptual site model (CSM), which was presented as Appendix A of the Onsite Site Characterization Report – 2013 Addendum (Onsite SCR – 2013; Arcadis 2013). The site is shown on Figure 1-1. Current site features are shown on Figure 1-2 and an onsite site plan is presented on Figure 1-3.

2 CURRENT GROUNDWATER MONITORING PROGRAM AND METHODS

Monitoring conducted during the first and second quarters of 2016 was based on the following networks included in the LTM Plan (Arcadis 2015), FHRA correspondence (FHRA 2016), and OMM Plan (Barr 2015):

- Groundwater elevation
- Light non-aqueous phase liquid (LNAPL) thickness and migration monitoring.
- Groundwater sampling and analysis of sulfolane
- Groundwater sampling and analysis of other constituents of concern (COCs; benzene, toluene, ethylbenzene, and xylenes [BTEX]; gasoline-range organics [GRO], and diesel range organics [DRO]).

Additionally, baildown and LNAPL transmissivity testing was conducted based on the criteria described in the LTM Plan.

Table 1-1 summarizes the field activities completed during the reporting period. Monitoring methods and well construction details are summarized in the RSAP (Arcadis 2016). The following deviations from the LTM Plan (Arcadis 2015) and FHRA correspondence (FHRA 2016) were noted during the reporting period:

- Samples for sulfolane analysis were not collected from wells O-14, MW-178B-50, MW-336-15, MW-336-20, MW-336-35, MW-336-55, MW-337-20, MW-345-55, MW-345-75, and MW-361-15 during the reporting period because the wells were frozen.
- Wells MW-304-CMT-10 and S-39 were dry during the reporting period and were not sampled for sulfolane
- Due to an error, samples for sulfolane analysis were not collected from well O-27-65 during the second quarter 2016. Samples will continue to be collected during the third and fourth quarters of 2016.
- Samples for BTEX, GRO, and DRO analyses were not collected from wells MW-336-15, MW-336-20, and MW-337-20 during the reporting period because the wells were frozen.
- LNAPL was encountered in wells O-19, O-2, S-43, S-44, S-50, S-51, MW-334-15, MW-176A-15, MW-186A-15, MW-115-15, MW-135-20, and MW-136-20 during planned monitoring events within the reporting period; therefore, samples were not collected from these wells for BTEX, GRO, and DRO analyses.

3 GROUNDWATER MONITORING RESULTS

Groundwater impacts have been characterized and continue to be monitored through the analysis of water-level gauging data and groundwater samples collected from onsite monitoring wells. This section presents the results of water-level gauging and groundwater analyses of onsite well samples. Data are summarized in Tables 3-1 through 3-9.

Historical groundwater elevation and LNAPL thickness measurements, and BTEX, GRO, DRO, sulfolane, and geochemical analytical results are included as Appendix A. Analytical laboratory reports are included as Appendix B. A data quality evaluation including ADEC quality assurance (QA)/quality control (QC) checklists is included as Appendix C. Field data sheets are included as Appendix D.

3.1 Groundwater Elevation

Depth to water measurements were collected from monitoring wells on March 22, 2016 during first quarter 2016. Potentiometric maps are included 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 (Figures 3-1 through 3-4). 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. Groundwater elevations and horizontal hydraulic gradients were within the range of historical groundwater data.

Groundwater well field parameters and groundwater elevations are summarized in Tables 3-1 and 3-2, respectively. Groundwater elevation measurements collected as part of the hydraulic capture performance monitoring are presented in Section 5.1. Groundwater elevations near the groundwater remediation and treatment system (GRTS) are discussed in Section 5.1.

In addition to manual water-level measurements, automated measurements were collected with transducers from selected onsite wells and well nests. Data from well nests were used to calculate horizontal hydraulic gradients and differences in groundwater elevations between wells screened at various depths within the suprapermafrost aquifer. Groundwater elevation hydrographs were prepared in accordance with the standard operating procedure (SOP; SWI 2013) using the most recent survey data. Error ranges, calculated in accordance with the method outlined in the SOP (SWI 2013), are shown on the well nest hydrographs presented in Appendix E. A detailed evaluation of transducer data and hydraulic gradients through 2013 is provided in Appendix 6-B of the Onsite SCR – 2013 (Arcadis 2013). Hydraulic gradients are further discussed in Section 6.0.

Measurements were recorded from gauging points located at the North Gravel Pit (NGP) and South Gravel Pit (SGP) on March 22, 2016. Data are summarized in Table 3-2 and on Figures 3-1. Historical gauging data are summarized in Appendix A.

3.2 Light Nonaqueous Phase Liquid Monitoring Results

LNAPL migration observations and thickness measurements were collected from a network of monitoring, observation, and recovery wells screened across the water table according to the LTM Plan (Arcadis 2015) and FHRA correspondence (FHRA 2016). Additionally, LNAPL was gauged throughout the reporting period during monitoring events outside of the LNAPL migration and thickness networks. A comprehensive LNAPL gauging table is presented in Appendix F.

3.2.1 Light Nonaqueous Phase Liquid Extent

Per the LTM Plan (Arcadis 2015) and FHRA correspondence (FHRA 2016), LNAPL migration observations were made from wells along the perimeter of the LNAPL plume. LNAPL was not observed in any of the LNAPL migration monitoring wells during the reporting period. Results are summarized in Table 3-3.

3.2.2 Light Nonaqueous Phase Liquid Thickness

Per the LTM Plan (Arcadis 2015) and FHRA correspondence (FHRA 2016), LNAPL thickness measurements were made from wells within the LNAPL thickness monitoring well network. These results are included in Table 3-4, and maximum thickness data measured during the reporting period are presented on Figures 3-5 and 3-6. Additionally, LNAPL was gauged during the following monitoring events throughout the quarter: groundwater elevation monitoring, groundwater sampling and field parameter collection, vertical gradient monitoring, hydraulic capture monitoring, and FHRA operator gauging. A comprehensive table including gauging data from each monitoring event conducted at the site during the reporting period is included in Appendix F.

LNAPL thickness measurements are similar to historical results. LNAPL recovery results are discussed in Section 4.3.

3.2.3 Transmissivity Testing

LNAPL baildown tests are conducted during periods when groundwater levels are at or near seasonal lows (water table minima), which have been historically observed in March and late October (Arcadis 2015). LNAPL thickness was measured at greater than 0.5 foot in 22 wells during the reporting period and baildown tests were completed at eight wells (MW-334-15, MW-366-15, O-13, O-31, O-33, R-18, R-20R, and R-32R) during this reporting period. Transmissivity testing results for the reporting period are included in Table 3-5 and Appendix G. A full discussion of 2016 transmissivity testing results will be included in the Second Semiannual 2016 Onsite report.

3.2.4 Groundwater Extraction-Enhanced Light Nonaqueous Phase Liquid Recovery

FHRA calculated the LNAPL transmissivity for recovery wells R-21 and R-40 using remediation system data collected during the reporting period. LNAPL and groundwater drawdowns are required input values for the LNAPL transmissivity calculation. Two simplifying assumptions were made to facilitate the LNAPL transmissivity calculations:

- LNAPL drawdown used in the calculations was based on the observed thickness of LNAPL in the well during gauging and system data collection.
- Groundwater drawdown can be reasonably calculated for R-21 and R-40 by pairing the recovery well with a monitoring well outside the zone of capture.

LNAPL transmissivity results from the groundwater extraction-enhanced LNAPL recovery at R-21 and R-40 are included in Tables 3-6a and 3-6b, respectively. Semiannual and overall results are summarized in Table 3-6c. Time series plots for groundwater extraction-enhanced LNAPL recovery at R-21 and R-40 are included on Figures 3-7a and 3-7b, respectively. Appendices H-1 and H-2 include data analysis output for groundwater extraction-enhanced LNAPL recovery at R-21 and R-40, respectively.

LNAPL transmissivities at R-21 for the reporting period ranged from 0.014 to 2.5 square foot per day (ft^2/day), with a cumulative overall transmissivity of 0.3 ft^2/day since 2010. During the reporting period, LNAPL transmissivities at R-21 were above the upper limit of 0.8 ft^2/day. Data from only one recovery event were used to calculate LNAPL transmissivity at R-40 during the reporting period. LNAPL transmissivity during the reporting period was 0.1 ft^2/day, with a cumulative overall transmissivity of 0.1 ft^2/day since 2010. These transmissivities are less than the upper limit of 0.8 ft^2/day and have historically been less than the limit.

3.3 Onsite Monitoring Well Sampling

Onsite wells included in the other COCs monitoring network in the LTM Plan (Arcadis 2015) and FHRA correspondence (FHRA 2016) were sampled for BTEX, GRO, and DRO during the reporting period. Results are summarized in Table 3-7. Figure 3-8 presents analytical results for benzene, including the inferred extent of the dissolved-phase benzene distribution within the suprapermafrost aquifer at the site.

Analyses for sulfolane were completed on groundwater samples collected from the wells identified in the LTM Plan (Arcadis 2015) and FHRA correspondence (FHRA 2016), including wells that are on a monthly performance monitoring schedule for the GRTS, as described in the OCP (Arcadis 2014). Sulfolane analytical results are summarized in Table 3-8 and on Figures 3-9 through 3-15, which show the inferred extent (based on current and past data) of the dissolved-phase sulfolane distribution at the water table, 10 to 55 feet bwt and 55 to 90 feet bwt, within the suprapermafrost aquifer at the site. In accordance with the updated sampling schedule (Arcadis 2016), no data were collected during second quarter 2016 at the 90 to 160 feet bwt interval.

Groundwater samples were collected from the alternative point of compliance (APOC) wells to evaluate the vertical distribution of sulfolane concentrations. Sample results collected from the APOC, which includes well clusters MW-301 through MW-306, MW-101-25A, MW101-60, MW-141-20, and MW-143-20, are summarized in Table 3-8 and on Figures 3-9 through 3-15. Sulfolane concentrations for the APOC wells are also summarized in Table 3-9 and on Figures 3-16 and 3-17. Sulfolane concentrations continue to decline along the APOC, with the shallow data at the MW-304 well nest showing the highest residual concentrations. The MW-304 well nest is located near the historical longitudinal axis of the plume and, according to tracer studies, is likely influenced by dual-porosity characteristics (Arcadis 2013).

3.4 Statistical Analysis of Benzene and Sulfolane Data

A statistical and graphical evaluation of benzene and sulfolane concentration trends using a Mann-Kendall trend analysis is conducted semiannually during the first and third quarters at monitoring and observation wells to evaluate plume migration and stability and remedial action effectiveness, and to identify relationships between concentrations, groundwater elevations, and flow directions. The use of the Monitoring and Remediation Optimization System (MAROS) for Mann-Kendall trend analysis was applied to groundwater monitoring data collected since 2006 from monitoring and observation wells. Wells having a historical presence of LNAPL were excluded from evaluation of the benzene statistical trend. Section 5.2 describes an additional evaluation of the sulfolane and benzene concentration trends for data collected from the performance monitoring network associated with the GRTS since 2011.

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

Parameter Trend	First Quarter	
	Benzene	Sulfolane
Number of wells	141	293
All results nondetect[1]	88	111
Insufficient data points[1]	7	10
Probably decreasing	3	11
Decreasing	8	95
Probably increasing	0	4
Increasing	3	4
Stable	7	31
No trend	25	27

Note:
[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.”

The results of the trend analyses are discussed below.

3.4.1 Benzene Statistical Evaluation

The Mann-Kendall trend analysis resulted in an increasing benzene concentration trend at wells R-46, R-47, and O-24. Based on the benzene time series plots included as Attachment 1 in Appendix I, concentrations appear to be decreasing at well R-46 since October 2014, and increasing at well O-24. Concentrations at R-47 are generally low level detections or non-detectable. Well R-46 is within the detectable benzene plume at the site and is currently being actively pumped by the recovery system, which is likely influencing dissolved benzene concentrations at this location. Well O-24 is within the detectable benzene plume at the site, near the downgradient extent. Some seasonal variation is evident in this well, and a decrease in concentrations was noted in first quarter 2016.

3.4.2 Sulfolane Statistical Evaluation

Using statistical approaches to evaluate groundwater monitoring data collected since 2006, increasing or probably increasing sulfolane concentration trends were indicated at only eight onsite monitoring wells.

A visual observation of the concentration trend plots (Attachment 1 of Appendix I) show that concentrations at most locations with increasing Mann-Kendall trends are either stable or decreasing since October 2014, and some, such as MW-304-96 and MW-321-65, are influenced by how non-detect results are handled in the calculations. The exceptions include O-27-65, MW-345-75, and MW-348-65. Concentrations have remained below 15 micrograms per liter (µg/L) at O-27-65, below 20 µg/L at MW-345-75, and below 40 µg/L at MW-348-65 since sampling began at these locations.

3.5 Nonroutine Activities

Non-routine activities were not conducted during the reporting period.

4 GROUNDWATER REMEDIATION AND TREATMENT SYSTEM RESULTS AND EVALUATION

This section discusses operating results for the existing GRTS for the reporting period. Ongoing remediation efforts at the site include groundwater recovery and treatment and LNAPL recovery and recycling, as described in Sections 4.2 and 4.3, respectively. The GRTS layout is shown on Figure 4-1 and process flow diagrams for the systems are shown on Figures 4-2a and 4-2b.

4.1 Associated Permits

Treated groundwater from the original treatment system (GAC East) is discharged at the SGP in accordance with wastewater disposal permit 2005-DB0012 issued by ADEC, temporary water use permit A2011-48 issued by the Alaska Department of Natural Resources (DNR), and temporary water use permit LAS24907 issued by the DNR.

Treated groundwater from the expanded groundwater recovery and treatment system (GAC West), including recovery well R-42, is discharged at the NGP in accordance with an Interim Approval to Operate issued by ADEC, temporary water use permit A2011-48 for R-42 issued by the DNR, and temporary water use authorization A2014-13 issued by DNR. Temporary water use permit A2011-28 expired on May 1, 2016. A new temporary water use authorization A2016-41 was issued by the DNR on April 29, 2016, effectively replacing A2011-48 and A2014-13.

In correspondence dated June 20, 2016, ADEC Division of Water approved a modification to GAC West operation. The modification allowed suspension of hypochlorite addition, elimination of influent monitoring of iron, manganese, and total organic carbon, and reduction of sulfolane monitoring to quarterly. These modifications have been made. In correspondence dated June 21, 2016, ADEC Division of Spill Prevention and Response, Contaminated Sites Program, conditionally approved shut-down of the GAC West system. ADEC and FHRA are in the process of resolving questions about the GAC West shut-down; the system continues to be operated in the interim.

4.2 Groundwater Recovery and Treatment

The average groundwater recovery rate for the GRTS was 526 gallons per minute (gpm) during the reporting period. This rate was calculated from the combined GAC East and GAC West flow rates and is consistent with target recovery rates for the GRTS. The average flow rates (when pumping) and total and percent runtimes for the reporting period are shown in the table below, along with the target flow rate for each well.

Location	First and Second Quarter 2016 Average Flow Rate	Target Flow Range*	First and Second Quarter 2016 Runtime	Percent Runtime
R-21	50.7 gpm	40 to 50 gpm	4,142 hours	94.8

Location	First and Second Quarter 2016 Average Flow Rate	Target Flow Range*	First and Second Quarter 2016 Runtime	Percent Runtime
R-35R	51.1 gpm	50 to 65 gpm	4,082 hours	93.5
R-40	15.3 gpm	See R-45 below	4,126 hours	94.5
R-42	85.0 gpm	60 to 85 gpm	4,350 hours	99.6
R-43	61.0 gpm	60 to 85 gpm	4,111 hours	94.1
R-44	61.4 gpm	60 to 70 gpm	4,157 hours	95.2
R-45	35.0 gpm (with R-40, 50.3 gpm)	50 to 65 gpm (combined with R-40)	4,121 hours	94.3
R-46	30.6 gpm	30 to 40 gpm	4,147 hours	94.9
R-47	65.0 gpm	55 to 80 gpm	4,359 hours	99.8
R-48	95.0 gpm	80 to 120 gpm	4,359 hours	99.8

Note:
* Target flow ranges as presented in the OMM Plan (Barr 2015).

Each of the recovery wells maintained a high runtime during the reporting period. Downtime for each recovery well is further discussed in Section 4.6.

4.2.1 Cumulative Groundwater Recovery

Table 4-1 summarizes the volume and rate of groundwater recovered monthly from 2009 through the end of the reporting period.

4.2.2 Groundwater Treatment Performance Evaluation – GAC East

In accordance with the OCP (Arcadis 2014) and the wastewater disposal permit for GAC East, FHRA conducted monthly monitoring of the GAC East effluent during the reporting period. FHRA also conducted multiple additional monitoring events to evaluate performance of the treatment system. Results for the monthly and additional monitoring events are summarized in Tables 4-2a through 4-2e.

The sulfolane concentration measured in the GAC East final effluent was below 15 µg/L and the detection limits during each monitoring event for the reporting period (Table 4-2a).

BTEX and semivolatile organic compound concentrations measured at the GAC East final effluent were below the discharge limits for the system during each monitoring event (Tables 4-2b and 4-2c). VOCs, total organic carbon, total suspended solids, iron, and manganese monitoring were performed to evaluate system operation; results are included in Tables 4-2d and 4-2e. Analytical laboratory reports are provided in Appendix B.

No GAC media changeouts were completed during the reporting period.

4.2.3 Groundwater Treatment Performance Evaluation – GAC West

During the reporting period, GAC West was sampled at an increased frequency (in addition to the required monthly sampling) to evaluate system performance. Results for monitoring completed at GAC West are included in Tables 4-3a, 4-3b, and 4-3c.

As shown in Table 4-3a, the GAC West treatment system removed sulfolane and the final effluent was below 15 µg/L and the detection limit during each monitoring event in the reporting period. Quarterly BTEX monitoring was also conducted and the results are shown in Table 4-3b. Results for the GAC West recovery wells (R-42, R-47, and R-48) indicated only low-level detections of benzene and xylenes, below cleanup levels in ADEC Table C (18 AAC 75.345). Iron and manganese monitoring were performed to evaluate system operation and the results are included in Table 4-3c.

No GAC media changeouts were performed during the reporting period.

4.3 Light Nonaqueous Phase Liquid Recovery Rates and Recycling

During the reporting period, FHRA performed LNAPL recovery via a skimmer system when adequate LNAPL was consistently present and/ or conducted manual recovery using a vacuum truck or portable LNAPL pump at the wells shown on Figure 4-1. LNAPL recovered from the skimmer systems and from manual recovery activities is stored onsite until it is recycled.

LNAPL recovery for the reporting period is summarized in Table 4-4; historical LNAPL recovery at the site since 1986 is summarized in Table 4-5. During the reporting period, 1,245 gallons of LNAPL were recovered. From 1986 to present, approximately 398,264 gallons of LNAPL have been recovered. LNAPL gauging data collected as part of the operations and maintenance of the LNAPL recovery efforts are included in Appendix F.

4.4 Benzene, Toluene, Ethylbenzene, and Xylenes Mass Capture

FHRA monitored the BTEX concentrations in recovered groundwater on a quarterly basis to calculate mass removal rates (Table 4-6).

Based on the monitoring results, BTEX mass removal averaged 0.39 pound per day (lb/day) and totalled approximately 115 pounds during the reporting period.

The BTEX concentrations were near or below detection limits in GAC West recovery well samples (Table 4-3b); therefore, GAC West is not included in the mass removal calculations shown in Table 4-6.

4.5 Sulfolane Mass Capture

FHRA monitored the sulfolane concentration in recovered groundwater at each active recovery well; mass recovery rates for each well are summarized in Tables 4-7a and 4-7b for GAC East and GAC West, respectively. During the reporting period, the highest average mass recovery rate was measured at well R-21 (0.16 lb/day; Table 4-7a). Well R-46 had no measurable recovery of sulfolane and is considered to be outside the sulfolane plume (Table 4-7a).

Table 4-8 summarizes the combined sulfolane mass removal rates for GAC East and GAC West. The rates were calculated from sulfolane concentrations measured monthly in the GRTS influent or individual recovery wells. Approximately 138,000,000 gallons of recovered groundwater were remediated during the reporting period. Sulfolane mass removal averaged 0.32 lb/day and, based on the system runtime, totalled approximately 59 pounds during the reporting period.

4.6 Summary of Routine and Nonroutine Repairs, Changes, and Maintenance

The GRTS maintained a high runtime percentage as demonstrated at the individual recovery wells (Section 4.2.1). A non-routine downtime event occurred at the GAC East wells in April 2016 for installation of a piping modification between the GAC vessels and for inspection and repair of the Gallery Pond liner. Recovery well R-35R also experienced pump motor failure, resulting in additional downtime. Four recovery wells (R-35R, R-45, R-46, and R-47) had downtime for interim well rehabilitation but maintained a high overall runtime percentage for the reporting period. The interim well rehabilitation includes utilizing the hydropuls tool to dislodge scale and biological growth. The pumps are not removed from the wells for the interim rehabilitation. The results of the efforts have indicated improvement in preventing excessive drawdown in the recovery wells. Step-drawdown tests are not being performed during the interim rehabilitation work.

Additional downtime for smaller maintenance events and changes at the individual recovery wells or treatment systems during the reporting period are summarized in Table 4-9.

As further described in Section 5, results of the hydraulic capture events and continued overall declines in concentration in the sulfolane and BTEX plumes north of the GRTS capture zone indicate the effectiveness of the GRTS during the first and second quarters of 2016 and preceding quarters. Thus, operation of the GRTS is meeting its performance goals and limited downtime events in the reporting period fell within design expectations.

5 GROUNDWATER REMEDIATION AND TREATMENT SYSTEM PERFORMANCE MONITORING

This section discusses performance monitoring results for the GRTS, as defined in the OCP (Arcadis 2014), including two quarterly hydraulic capture events conducted during the first and second quarters of 2016.

5.1 Groundwater Capture Evaluation

Performance monitoring for the GRTS includes hydraulic capture monitoring (quarterly) and water quality assessment (quarterly to annually). Performance monitoring is conducted to confirm the continued effectiveness of the GRTS. Hydraulic capture of the sulfolane and BTEX plumes was evaluated during the reporting period using groundwater elevation and groundwater quality data. Measured depth to water, calculated hydraulic heads, and capture zone estimates are presented in Appendix J.

The capture evaluation results indicate that operation of the GRTS at rates achieved throughout the first and second quarters of 2016 supports meeting the combined groundwater extraction and treatment system performance standard of 15 µg/L at the alternative point of compliance (Arcadis 2014). Appendix J provides additional detail regarding the capture zone evaluation.

5.2 Concentration Trend Evaluation

FHRA performs an evaluation of the concentration graphs for sulfolane (quarterly or semiannual sampling frequency) and benzene (semiannual or annual sampling frequency) to examine any recent trends that may be influenced by remediation measures and to evaluate the performance of the GRTS.

5.2.1 Sulfolane

Table 5-1 summarizes FHRA's interpretation of sulfolane concentration trends since 2010 at individual GRTS performance monitoring wells to identify the effects of enhanced groundwater remediation; wells are generally presented in the table from west to east. The performance monitoring wells identified in Table 5-1 are categorized based on location relative to the treatment zone; each area is summarized below:

- *Upgradient*. Sulfolane concentration trends for wells located upgradient from the GRTS treatment zone are generally decreasing or stable. Two recent fluctuations were noted in wells O-6 and O-19-55. It is likely that the upgradient locations are minimally influenced by operation of the GRTS; these trends are believed to primarily be the result of a decreasing stored sulfolane mass in upgradient source areas.
- *Within the treatment zone*. Sulfolane concentration trends for monitoring wells located within the treatment zone are decreasing or stable, with the following exceptions:

  - Since 2011, sulfolane concentrations in wells O-5 and MW-113-15 have fluctuated between 100 and 260 µg/L and 40 and 350 µg/L, respectively. The variations may be the result of GAC West recovery wells operation, which alters the flow paths in the area prior to capture.
  - Sulfolane concentrations in wells MW-345-55 and MW-345-75 increased from 2013 through third quarter 2015, which may be the result of increased pumping at R-43. The two most recent monitoring events indicate decreasing sulfolane concentrations.
- *Downgradient*. Sulfolane concentration trends for monitoring wells located downgradient from the treatment zone are decreasing or stable.

In addition to the trends presented in Table 5-1, a low concentration zone has developed immediately north (downgradient) of the recovery wells (Figures 3-13, 3-14, and 3-15). Overall downward trends in concentration and mass flux at the APOC are consistent with the source controls and operation of the GRTS.

5.2.2 Benzene

Performance monitoring for benzene occurred during first quarter 2016, with the exceptions noted in Section 2. Table 5-2 summarizes FHRA's interpretation of benzene concentration trends since 2010 at individual performance monitoring wells to identify the effects of enhanced groundwater remediation, which are generally presented from west to east. The performance monitoring wells identified in Table 5-2 are categorized based on location relative to the treatment zone; each area is summarized below:

- *Upgradient*. Of the seven monitoring wells located upgradient of the GRTS, three wells are consistently nondetect. Concentrations had been increasing in well MW-130-25, but the two most recent monitoring events may indicate stabilization. Three wells were not sampled due to the presence of LNAPL.
- *Within the treatment zone*. Eight of the 13 treatment zone monitoring wells have decreasing or stable concentrations. Three of the 13 monitoring wells were not sampled due to the presence of LNAPL, and concentrations are fluctuating at low concentrations in one well. Concentrations in well MW-344-55 increased during first quarter 2016.
- *Downgradient*. Ten of the 12 downgradient wells have stable or decreasing concentrations. Fluctuating concentrations of benzene were noted in one well and concentrations in one well had increased until the latest sampling event.

5.3 Transect Trend Evaluation

To further evaluate the effectiveness of the GRTS, sulfolane concentration trends were evaluated along three longitudinal transects parallel to the groundwater flow path (Figure 5-1). Transects A and B (Figures 5-2 and 5-3) comprise shallow wells (water table and 10 to 55 feet bwt); Transect C (Figure 5-4) comprises deeper wells (55 to 90 feet bwt).

The data presented on Figures 5-2 and 5-3 demonstrate that shallow sulfolane concentrations downgradient from the treatment zone are lower than concentrations upgradient from the treatment zone. In addition, these figures show that decreasing downgradient sulfolane concentrations correlate with increased pumping from the GRTS starting in 2010. This indicates that ongoing groundwater extraction is successfully recovering sulfolane-impacted groundwater and is eliminating the migration of sulfolane-impacted groundwater past the GRTS. Additionally, concentrations measured in deeper wells are decreasing or stable (Figure 5-4).

6 CONCLUSIONS

Groundwater monitoring and sampling events were conducted during this reporting period in accordance with the LTM Plan (Arcadis 2015) and OMM Plan (Barr 2015), FHRA correspondence to ADEC (FHRA 2016), and the Onsite RSAP (Arcadis 2016). During this reporting period, the GRTS system was operated and monitored in accordance with the OCP (Arcadis 2014) and the OMM Plan (Barr 2015). This section summarizes conclusions based on results of the onsite field activities conducted during the reporting period:

- Groundwater monitoring data collected during the reporting period are consistent with data collected during recent quarters.
- The statistical analyses included in Appendix I show that sulfolane concentrations in 106 wells and benzene concentrations in 11 wells across the plume are decreasing or probably decreasing, while sulfolane concentrations in eight wells and benzene concentrations in three wells across the plume are increasing or probably increasing.
- Sulfolane concentrations and trends continue to decrease in the onsite areas near the downgradient site boundary.
- BTEX concentrations are consistent with historical detections and the core of the BTEX plume appears to be stable. BTEX concentrations continue to be limited to the developed area onsite.
- During the reporting period, the GRTS continued to capture and remediate sulfolane- and BTEX-impacted groundwater.
- Concentrations of sulfolane and BTEX in the downgradient portion of the plume adjacent to the capture zone continue to show an overall decline, thus indicating the effectiveness of the GRTS.

7 REFERENCES

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