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ARCADIS Project No.:
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Subject:
Tracer Testing Results at the North Pole Refinery, North Pole, Alaska

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On behalf of Flint Hills Resources Alaska, LLC (FHRA), ARCADIS U.S., Inc. performed a large-scale tracer injection test on March 26, 2012 at the North Pole Refinery in North Pole, Alaska (the site). The tracer test was performed following completion of two potable water injection tests summarized in the Draft Final Onsite Feasibility Study (Draft Final Onsite FS; ARCADIS 2012).

The large-scale tracer test was proposed in the Scope of Work for Additional Site Characterization Activities (ARCADIS 2011) with the following objectives:

- Estimate mobile and immobile porosity in the area of the injection.
- Evaluate effective in-situ reagent delivery strength.
- Evaluate the injection volume-to-coverage relationship.
- Estimate a mass transport coefficient.
- Estimate groundwater velocity and flow direction.

Analysis of the parameters listed above can provide the required information for design of a water injection-based in situ remedial alternative. The injection solution used for the injection test consisted of potable water amended with low concentrations of two conservative tracers: deuterium oxide and sodium chloride (i.e., table salt).

As shown in **Figure 1**, the monitoring well network consisted of:

- Injection well: IW-1
- Dose-response monitoring well: INJ-MW-4
- Downgradient tracer monitoring wells: MW-139, INJ-MW-1, INJ-MW-2, INJ-MW-3

Injection and monitoring well details are summarized below:

Well ID	Screen Interval (feet bgs)	Distance from IW-1 (feet)
IW-1	20-40	0
INJ-MW-4	20-40	9.3
MW-139	5-25	26
INJ-MW-1	10-40	56
INJ-MW-2	10-40	88
INJ-MW-3	10-40	117
MW-154B	90.2-94.8	11.6

bgs = below ground surface

Methods

Prior to injection, an Underground Injection Control authorization was obtained from the United State Environmental Protection Agency Region 10. Two non-reactive tracers (sodium chloride [table salt} and deuterium oxide [deuterated water]) were added to the injection solution. Table salt was added to the injection solution to increase the specific conductivity of the groundwater from approximately 350 microSiemens per centimeter (µS/cm) to approximately 900 µS/cm to allow for in-field detection of tracer breakthrough at the dose-response monitoring well. Approximately 780 milliliters (mL) of 99% deuterium oxide tracer was added to each 870-gallon batch volume for a concentration of 0.02% (volume/volume %). Deuterium oxide can be applied at higher ratios of background to applied concentrations than is possible using table salt. Thus, deuterium oxide can be used to measure tracer breakthrough at downgradient tracer monitoring wells where conductivity changes may not be a reliable indicator due to dilution to below detection limits over the transport distance.

The tracer injection test was performed at injection well IW-1 (**Figure 1**). Data-logging pressure transducers were installed in injection well IW-1, dose-response monitoring well INJ-MW-4, and monitoring well MW-139. Pressure transducers were set to record water pressure in units of water head above the pressure transducer, temperature, and specific conductivity at 1-minute intervals. In order to maintain a constant injection flow rate, the injection solution was gravity fed into the injection well using an alternating method from the two injection tanks. Two batches of injection solution were prepared. Immediately after the first tank was emptied, the ball valves on the injection manifold were switched to allow for injection from the second tank. After this tank switch was made, a new injection solution batch was mixed in the recently emptied tank. This process was repeated throughout injection. The tracer solution was injected at a flow rate of approximately 40 gallons per minute (gpm) for approximately 4 hours resulting in a final injected volume of approximately 9,600 gallons. The injection flow rate used was identified as the optimal flow rate during injectability testing summarized in the Draft Final Onsite FS (ARCADIS 2012).

Manual depth to groundwater, temperature, and conductivity readings were completed at dose-response monitoring well INJ-MW-4 and monitoring well MW-139 to verify the accuracy of the pressure transducer readings. Manual specific conductivity readings were taken at three depths (between 10 and 35 feet bgs) across the monitoring well screen intervals to assess the vertical distribution of breakthrough of the injected solution (**Tables 1 and 2**). Manual readings of depth to groundwater, temperature, and specific conductivity were also collected at the beginning and completion of tracer injection activities at downgradient monitoring wells INJ-MW-1, INJ-MW-2, and INJ-MW-3; and side-gradient, deep monitoring well MW-154B (**Tables 3 through 6**). **Attachment 1** includes all field notes recorded during the test.

Mobile porosity, a key parameter in remediation hydraulics, can be quantified during the injection portion of a tracer study. Mobile porosity represents the portion of total porosity that contributes to advective groundwater flow and transport. To calculate mobile porosity during the test, the tracer breakthrough curve for INJ-MW-4 was plotted and the volume injected to reach 50 percent of the maximum concentration observed was determined. This volume was then used to calculate the mobile porosity using **Equation 1** (Payne et al. 2008, Nelson and Divine 2005).

$$n_m = \frac{V_{inj50}}{(r_{inj})^2 \pi h} \qquad \textit{Equation 1}$$

Where:

n_m	mobile porosity
V_{inj50}	Volume injected (ft^3) at the time the observed concentration reaches 50 percent of the maximum observed concentration
h	screened interval
r_{inj}	radius of influence (feet)

The total porosity is composed of the sum of the mobile and immobile porosity. Thus, immobile porosity can be calculated by subtracting mobile porosity from total porosity, determined during laboratory testing (Payne et al. 2008). Immobile porosity is defined as that portion of the total porosity that does not contribute to advective flow, but acts as a reservoir or contributes to much slower moving groundwater when compared to the mobile pore space (Payne et al. 2008).

Volume-to-coverage relationships were also estimated based on the tracer breakthrough curve observed at INJ-MW-4 during the injection. The volume-to-coverage relationship provides an indication of how much reagent must be injected to achieve a certain concentration at a given distance from the injection well. This provides data to determine required injection volumes for full-scale design and the concentration of reagent required to achieve target in situ concentrations at a given distance. Based on the breakthrough curve alone, injection volume, injection well spacing, and injected reagent strengths can be evaluated.

Washout data are collected at the injection well and dose-response well during the post-injection monitoring phase to monitor for tracer concentration decreases as upgradient groundwater flows through the injected area. The washout curves can be helpful in indicating groundwater velocities at the site. The washout data can also provide information about longevity of an injected solution and assist in determining injection frequency.

Baseline Monitoring and Sampling

Baseline monitoring and sampling were completed on March 20, 2012 prior to tracer injection activities. Depth to water and field measurements of pH, specific conductivity, dissolved oxygen concentration, temperature, and oxidation/reduction potential (ORP) were recorded. Measurements were collected at wells IW-1, INJ-MW-4, MW-139, and INJ-MW-1 through INJ-MW-3 (**Figure 1**) using a calibrated Yellow Springs Instruments (YSI) model 556 multi-meter and oil/water interface probe:

Groundwater samples were collected on March 20 and March 26, 2012, at wells MW-139, IW-1, and INJ-MW-4, and at the potable water source used for injection. The groundwater and potable water samples were submitted for analysis of deuterium oxide to Isotope Tracer Technologies (IT2) of Waterloo, Ontario, Canada and analyzed using Picarro Isotopic Water Analyzer equipped with a Cavity Ring-Down Spectroscopy (CRDS).

Deuterium oxide tracer concentrations in background groundwater prior to injection ranged from -163.7 to -170.9 per mil, with an average of -167.2 per mil (‰) at the site. The per mil notation is a concentration unit most commonly used to express quantities of isotopes in water samples relative to a standard, and can be expressed as:

$$per\ mil_{\text{sample}}\ (‰) = \left(\frac{Rsample}{Rstd} - 1\right) \times 1000$$

Where:
R_{sample} = ratio of the heavy to light isotopes in the sample
R_{std} = ratio of the heavy to light isotopes in the standard.

Thus, per mil units indicated the relative abundance of an isotope compared to a known standard. For example, in the source water used to mix the injection solution, the deuterium tracer concentration was -170.9 per mil. This value is negative because the water is naturally depleted in deuterium compared to the Vienna Standard Mean Ocean Water (VSMOW) standard. VSMOW is the international standard for comparing the isotopic composition of water. The mixed injection solution had an average deuterium oxide concentration of 1,398 per mil, indicating it was enriched in deuterium compared to the standard.

Dose-Response Monitoring During Injection

During the injection phase, tracer monitoring was performed at injection well IW-1, dose-response well INJ-MW4, and monitoring well MW-139. During the injection phase, six samples were collected from INJ-MW-4 at intervals of approximately 12, 18, 30, 36, 54, and 66 percent of the total injection volume and sent for laboratory analysis of deuterium oxide. Dataloggers installed in wells IW-1, INJ-MW-4, and MW-139 recorded pressure, temperature, and specific conductivity throughout the injection.

During injections, tracer breakthrough based on specific conductivity measurements was observed at dose-response well INJ-MW-4 (**Figure 2**) but not at monitoring well MW-139. INJ-MW-4 is located 9.3 feet northwest of IW-1, and MW-139 is located 26 feet north of IW-1, just outside the anticipated radius of influence (ROI). Monitoring well MW-139 is screened across a shallower interval than the injection well, with only the lower 5 ft of MW-139 crossing the injected interval; therefore, a lack of tracer detection at this location is not unexpected. Due to inadequate mixing in the well column prior to sampling (dilution), there was a muted response in deuterium oxide concentrations. As such, tracer breakthrough at dose-response monitoring wells during injection was based on in-situ conductivity measurements, which were not influenced by sampling methods. Sampling methods were corrected on Day 25 during the post-injection monitoring activities, and provided suitable data quality to evaluate deuterium concentrations in downgradient monitoring wells.

Using the specific conductivity response data collected at dose-response monitoring well INJ-MW-4, approximately 70 percent of the injected concentration was observed prior to the end of the injection test (**Figure 2**). Based on tracer breakthrough at this dose-response well, mobile porosity in this area of the site ranges between 3 and 5 percent. Based on the formula for a cylinder (**Equation 1**) and an estimated mobile porosity of 4 percent, the maximum estimated ROI for approximately 10,000 gallons of injection solution is 23 feet.

The immobile porosity at the site was calculated by subtracting the mobile porosity from the total porosity measured in the laboratory. The total porosity at the site has been measured at 25 percent (Barr Engineering 2011), which places the immobile porosity between 20 and 22 percent.

Based on the tracer breakthrough curve in **Figure 1**, volume-to-coverage ratios were estimated to assist in planning injection volumes, injection well spacing, and injected reagent strengths during an injection-based remedy. The data indicated that injection wells on 20 ft centers should achieve effective in-situ reagent strengths. The in-situ reagent concentration is related to the injection volumes, and the following volume to coverage ratios should be used for injection wells on 20 ft centers (10 ft ROIs):

- Injection of 4,300 gallons achieves the maximum in-situ reagent strength (70%)
- Injection of 1,650 gallons achieves half the maximum in-situ reagent strength (35%)

Manual depth to groundwater, temperature, and conductivity readings were also collected in dose-response monitoring well INJ-MW-4 and monitoring well MW-139 (**Attachment 1**). These measurements indicated that some depths showed more rapid conductivity response than others, which is evidence of heterogeneity across the screen interval.

Post Injection Monitoring

Post-injection monitoring was conducted at IW-1, INJ-MW-4, MW-139, INJ-MW-1, INJ-MW-2, and INJ-MW-3 through March, April, and May 2012. Samples were collected for deuterium oxide, and wells were surveyed for specific conductivity and temperature. **Table 7** summarizes the results of the deuterium oxide samples analyzed. **Figure 3** shows the results of the specific conductivity changes at IW-1, INJ-MW-4, and MW-139.

As expected, due to dilution, changes in specific conductivity were only observed at the injection well (IW-1) and dose-response monitoring well INJ-MW-4, not at downgradient monitoring wells (**Figure 3**). As explained earlier, due to initial sampling methods, deuterium oxide data were muted at IW-1 and INJ-MW4 due to dilution during sampling for the initial 25 days, and these results could not be used to assess washout (**Table 7**).

Washout data were analyzed based on in-situ specific conductivity measurements, which were not impacted by sampling methods. The washout data observed at both the injection well and the dose-response well were rapid with substantial tailing (**Figure 3**). This pattern indicates heterogeneous lithology across the screen interval, resulting in variable groundwater flow across the screen.

Washout data can provide information about the longevity of an injected solution in the area and can help determine injection frequency. Washout was observed at both the injection and dose-response wells (INJ-MW-4) to within 20 percent of the injected concentration and was observed within 5 days after the end of the injection, when washout monitoring ceased. The washout data indicate that, in less than 1 week, the injected concentrations within the injection ROI were likely to be lower than those typically considered effective reagent strengths. This data suggests that frequent injections would be necessary for any full-scale injection-based remedy at the site.

Washout data can also provide an indication of the possible range of groundwater velocities at the site, which can then be used to modify the frequency of post-injection monitoring (i.e., rapid washout indicates that more frequent downgradient sampling is required, slower washout indicates that sampling can be less frequent). However, washout data do not provide a quantitative measure of groundwater velocity at the site. In order to calculate groundwater velocities based on washout data from the injection and dose-response wells, a distribution of tracer upgradient of that well must be accurately assumed, and this is impossible given the monitoring network used for this injection.

Accurate estimates of groundwater velocity can only be achieved if tracer breakthrough is observed at downgradient monitoring wells. In this study, tracer breakthrough was not observed with either tracer at any of the downgradient tracer monitoring wells during this test (**Figure 3 and Table 7**). The lack of tracer breakthrough at downgradient monitoring locations prior to day 25 could be due to dilution during sampling, as discussed earlier; however, the analytical detection range and sensitivity for the applied deuterium oxide used for this study was relatively high, and it was likely that, had breakthrough occurred during this period, even a muted detection of at least 10 to 15 per mil deuterium would have been observed to support the occurrence of breakthrough. Monitoring conducted at downgradient locations after day 25 did not show the presence of deuterium at any time. Given the geology at the site, the distance to the downgradient monitoring wells from the injection well (between 56 and 117 feet), and the spacing between those wells, it is possible that slight variations in flow direction or sub-surface flow pathways could cause the tracer plume to miss the monitoring wells at measurable concentrations. This is considered the most likely explanation for a lack of observed tracer breakthrough at INJ-MW-1, INJ-MW-2, and INJ-MW-3. In addition, natural short-term hydraulic stresses such as spring breakup, rainfall event, or snow melt may have influenced tracer migration and could have led to the results that were obtained

As groundwater velocity at the site was not established with this study, a mass transport coefficient could not be determined. To determine the mass transport coefficient knowledge of the total recovered mass over a given time period must be measured at a downgradient monitoring location.

Conclusions

The results of the tracer injection test suggest the following conclusions:

1. Mobile porosity in this area of the site is estimated between 3 and 5 percent and immobile porosity is between 20 and 22 percent.
2. Volume-to-coverage ratios for injection remedy design were determined using observed data and aid in determining injection well spacing along a transect, required injection volumes, and injection solution strength. Injection wells on 20 ft centers can achieve effective in-situ reagent strengths, up to a maximum of 70 percent of the injected solution concentration, with injection of approximately 4,300 gallons.
3. Reliable groundwater flow velocities and an approximation of flow direction cannot be determined using the data collected during this study.
4. A mass transport coefficient cannot be estimated due to insufficient data.
5. Washout data from the injection and dose response wells show rapid washout (~5 days) with substantial tailing and support the site conceptual understanding that the geology is heterogeneous.

References

ARCADIS U.S., Inc. (ARCADIS). 2011. Scope of Work for Additional Site Characterization Activities. November 1, 2011.

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Payne FC, Quinnan JA, and Potter ST. 2008. Remediation Hydraulics, CRC Press, Taylor and Francis Group LLC.

Tables

Figures

Attachments

Table 1
Manual Readings Collected at INJ-MW-4
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		30 ft btoc (midpoint of screened interval)		25 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
3/26/2012	11:22	14.47	4.4	0.379	4.3	0.379	4.3	0.378	Baseline
3/26/2012	14:12	14.12	4.5	0.568	4.4	0.561	4.5	0.485	+30 minutes
3/26/2012	14:30	14.14	4.6	0.734	4.6	0.803	4.6	0.568	+45 minutes
3/26/2012	14:45	14.14	4.7	0.762	4.7	0.859	4.6	0.606	+1 hour
3/26/2012	15:00	14.13	4.8	0.856	4.9	0.917	4.9	0.932	+1 hour & 15 minutes
3/26/2012	15:15	14.13	5.1	0.821	5.4	0.994	5.4	0.964	+1 hour & 30 minutes
3/26/2012	15:30	14.11	5.2	0.916	5.3	0.985	5.4	0.932	+1 hour & 45 minutes
3/26/2012	16:00	14.15	5.4	0.891	5.7	0.984	5.6	1.006	-
3/26/2012	16:30	14.13	5.7	0.932	5.9	0.964	5.7	0.988	-
3/26/2012	17:00	14.13	6.0	0.997	6.0	1.012	5.8	0.950	-
3/26/2012	17:30	14.12	5.7	0.998	5.7	0.998	5.7	1.022	-
3/26/2012	18:15	14.47	5.5	0.982	5.5	0.989	5.5	0.963	-
3/27/2012	11:00	14.48	5.3	0.901	5.3	0.895	5.2	0.886	DO @ Cntr = 1.73 mg/L
3/28/2012	10:48	14.48	5.1	0.792	5.1	0.789	5.0	0.749	DO @ Cntr = 2.20 mg/L
3/29/3/30	10:55	14.48	5.1	0.657	5.1	0.695	4.9	0.600	DO @ Cntr = 1.18 mg/L
3/30/2012	11:27	NR	5.0	0.594	4.9	0.558	4.8	0.507	DO @ Cntr = 2.15 mg/L
3/31/2012	16:14	14.52	4.8	0.517	4.8	0.496	4.7	0.453	DO @ Cntr = 1.86 mg/L
3/31/2012	-	-	-	-	4.6	0.499	-	-	YSI Reading (Additional)
4/1/2012	14:17	14.51	4.7	0.483	4.7	0.475	4.6	0.431	DO @ Cntr = 4.14 mg/L
4/1/2012	-	-	4.5	0.460	4.3	0.447	3.3	0.387	YSI Reading (Additional)
4/2/2012	10:00	14.49	4.6	0.453	4.6	0.441	4.4	0.401	DO @ Cntr = 4.75 mg/L
4/2/2012	-	-	4.4	0.430	4.3	0.429	3.9	0.392	YSI Reading (Additional)
4/3/2012	11:50	14.48	4.6	0.431	4.5	0.416	4.4	0.393	DO @ Cntr = 0.12 mg/L
4/4/2012	11:00	14.48	4.5	0.413	4.4	0.407	4.2	0.392	DO @ Cntr = 0.21 mg/L
4/5/2012	11:30	14.46	4.4	0.401	4.3	0.392	4.2	0.382	DO @ Cntr = 0.17 mg/L
4/6/2012	11:00	14.46	4.4	0.392	4.2	0.392	4.1	0.379	DO @ Cntr = 0.12 mg/L
4/7/2012	13:03	14.43	4.3	0.388	4.2	0.382	4.0	0.371	DO @ Cntr = 0.11 mg/L
4/7/2012	13:03	-	-	-	4.3	0.399	-	-	YSI Reading (Additional)
4/9/2012	13:35	14.40	4.2	0.376	4.1	0.369	3.9	0.385	DO @ Cntr = 0.10 mg/L
4/9/2012	13:35	-	-	-	4.0	0.386	-	-	YSI Reading (Additional)
4/10/2012	12:00	14.35	4.2	0.378	4.0	0.371	3.9	0.367	DO @ Cntr = 0.11 mg/L
4/10/2012	12:00	-	-	-	3.9	0.434	-	-	YSI Reading (Additional)
4/13/2012	13:15	14.30	4.0	0.372	3.9	0.369	3.8	0.368	DO @ Cntr = 0.16 mg/L
4/13/2012	13:15	-	-	-	3.9	0.378	-	-	YSI Reading (Additional)
4/16/2012	10:52	14.08	3.9	0.373	3.8	0.363	3.8	0.366	Ice at 4'
4/17/2012	11:08	13.98	3.9	0.375	3.8	0.369	3.8	0.367	Ice at 5'
4/17/2012	11:39	13.91	3.37	0.399	3.27	0.423	2.96	0.457	Data logger
					3.40	0.437			YSI
4/20/2012	10:56	13.62	3.29	0.399	3.21	0.426	2.69	0.444	Data logger
					3.80				YSI
4/23/2012	9:48	13.49	3.23	0.411	3.12	0.437	2.76	0.490	Data logger
					3.70	0.463			YSI
4/24/2012	10:54	12.48	3.24	0.410	3.11	0.440	2.69	0.470	Data logger
					3.80	0.482			YSI
4/27/2012	10:19	13.59	3.19	0.412	3.04	0.456	2.47	0.496	Data logger
					4.00	0.504			YSI

Table 1
Manual Readings Collected at INJ-MW-4
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		30 ft btoc (midpoint of screened interval)		25 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
4/28/2012	9:02	13.65	3.13	0.417	3.01	0.454	2.62	0.508	Data logger
					3.30	0.504			YSI
4/30/2012	9:52	13.75	3.20	0.411	2.99	0.452	2.57	0.508	Data logger
					3.30	0.410			YSI
5/1/2012	11:37	13.77	3.14	0.413	2.99	0.448	2.41	0.487	Data logger
					3.30	0.439			YSI
5/2/2012	10:11	13.83	3.05	0.420	2.89	0.469	2.61	0.513	Data logger
					3.30	0.432			YSI
5/3/2012	10:47	13.79	2.99	0.434	2.89	0.465	2.44	0.505	Data logger
					3.00	0.473			YSI
5/4/2012	10:20	13.82	3.10	0.415	2.91	0.447	2.32	0.505	Data logger
					3.40	0.428			YSI
5/7/2012	10:36	14.01	3.03	0.418	2.85	0.463	2.27	0.499	Data logger
					3.50	0.487			YSI
5/8/2012	11:21	14.04	2.98	0.418	2.84	0.465	2.46	0.502	Data logger
					3.60	0.432			YSI
5/9/2012	12:11	14.08	3.01	0.419	2.85	0.457	2.43	0.510	Data logger
					3.50	0.424			YSI
5/11/2012	10:16	14.16	2.98	0.425	2.76	0.470	2.38	0.523	Data logger
					3.20	0.458			YSI
5/18/2012	12:24	14.32	2.86	0.417	2.70	0.459	2.42	0.500	Data logger
					3.00	0.461			YSI

Notes:

-	Not collected.
DO	Dissolved oxygen.
ft btoc	Feet below top of casing.
mg/L	Milligrams per liter.
mS/cm	Milli Siemens per centimeter.

Table 2
Manual Readings Collected at MW-139
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	20 ft btoc (bottom of screened interval)		15 ft btoc (midpoint of screened interval)		10 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
3/26/2012	11:31	13.73	2.8	0.475	2.5	0.474	2.3	0.475	Baseline
3/26/2012	14:19	13.61	2.7	0.476	2.5	0.476	2.4	0.473	+30 minutes
3/26/2012	15:05	13.61	2.6	0.476	2.5	0.477	2.6	0.472	+45 minutes
3/26/2012	15:45	13.62	3.0	0.534	2.9	0.546	3.0	0.543	+1 hour
3/26/2012	16:00	13.61	2.8	0.548	2.7	0.542	2.7	0.540	+1 hour & 15 minutes
3/26/2012	16:30	13.61	2.8	0.547	2.7	0.543	2.7	0.539	+1 hour & 30 minutes
3/26/2012	16:45	13.61	3.0	0.544	3.0	0.545	2.8	0.536	+1 hour & 45 minutes
3/26/2012	17:30	13.61	2.8	0.548	2.7	0.542	2.7	0.543	-
3/26/2012	18:00	13.71	2.8	0.546	2.7	0.541	2.9	0.535	-
3/27/2012	10:40	13.75	3.0	0.545	2.8	0.538	2.9	0.528	DO @ Cntr = 1.96 mg/L
3/28/2012	11:15	13.74	3.1	0.545	2.8	0.538	3.0	0.529	DO @ Cntr = 2.24 mg/L
3/29/2012	11:15	13.74	3.1	0.538	2.8	0.426	2.7	0.517	DO @ Cntr = 1.34 mg/L
3/30/2012	10:40	13.74	3.5	0.535	3.2	0.533	2.8	0.528	DO @ Cntr = 2.46 mg/L
3/30/2012	10:52	-	-	-	-	-	2.2	0.517	YSI Reading (Additional)
3/31/2012	16:31	13.77	2.9	0.542	2.7	0.538	2.5	0.513	DO @ Cntr = 1.87 mg/L
3/31/2012	-	-	-	-	-	-	2.1	0.503	YSI Reading (Additional)
4/1/2012	15:00	13.78	2.6	0.515	2.8	0.538	-	-	DO @ Cntr = 3.66 mg/L
4/1/2012	-	-	2.5	0.510	2.0	0.505	-	-	YSI Reading (Additional)
4/2/2012	10:35	13.76	3.0	0.542	2.7	0.536	-	-	DO @ Cntr = 2.55 mg/L
4/2/2012	-	-	2.3	0.511	1.9	0.505	-	-	YSI Reading (Additional)
4/3/2012	13:26	13.73	3.2	0.539	2.7	0.536	2.5	0.525	No DO taken due to ice
4/4/2012	11:58	18:14	2.9	0.539	2.6	0.538	2.2	0.534	No DO taken due to ice
4/5/2012	-	13.7	3.1	0.534	2.6	0.528	2.3	0.484	No DO taken due to ice
4/6/2012	10:48	13.7	3.2	0.534	2.6	0.534	2.2	0.500	No DO taken due to ice
4/7/2012	12:46	13.69	3.2	0.536	2.6	0.537	2.2	0.529	No DO taken due to ice
4/9/2012	12:20	13.66	3.1	0.537	2.6	-	2.1	0.521	No DO taken due to ice
4/10/2012	-	13.62	3.0	0.537	2.5	-	2.4	0.525	No DO taken due to ice
4/13/2012	13:28	13:40	-	-	-	-	2.3	0.008	No DO taken due to ice
4/16/2012	10:59	13.35	-	-	-	-	3.0	0.005	No DO taken due to ice
4/17/2012	11:18	6:00	-	-	-	-	2.8	0.007	No DO taken due to ice

Table 2
Manual Readings Collected at MW-139
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	20 ft btoc (bottom of screened interval)		15 ft btoc (midpoint of screened interval)		10 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
4/20/2012	11:32	12.98	N/A	N/A	N/A	N/A	2.10	0.008	No DO taken; YSI would not fit down well due to ice. Depth to water (~13.0 ft) is below top of screened interval (10ft). Sampled with bailer.
4/23/2012	11:14	12.84	N/A	N/A	2.40	0.459	2.10	0.008	DO taken at 14' from TOC due to ice. Depth to water (~12.8 ft) is below top of screened interval (10ft).
4/24/2012	10:02	12.81	N/A	N/A	2.90	0.460	2.40	0.009	DO taken at 14' from TOC due to ice. Depth to water (~12.8 ft) is below top of screened interval (10ft).
4/27/2012	10:18	12.93	N/A	N/A	2.20	0.463	1.90	0.007	DO taken at 14' from TOC due to ice. Depth to water (~12.9 ft) is below top of screened interval (10ft). Sampled with bailer.
4/28/2012	9:18	13.00	N/A	N/A	3.20	0.462	2.60	0.007	DO taken at 14' from TOC due to ice. Depth to water (~13.0 ft) is below top of screened interval (10ft).
4/30/2012	10:02	13.10	N/A	N/A	2.20	0.406	1.90	0.007	DO taken at 14' from TOC due to ice. Depth to water (~13.1 ft) is below top of screened interval (10ft).

Table 2
Manual Readings Collected at MW-139
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	20 ft btoc (bottom of screened interval)		15 ft btoc (midpoint of screened interval)		10 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
5/1/2012	11:41	13.13	N/A	N/A	2.20	0.435	1.90	0.009	DO taken at 14' from TOC due to ice. Depth to water (~13.1 ft) is below top of screened interval (10ft).
5/2/2012	9:51	13.16	N/A	N/A	2.10	0.432	2.10	0.008	DO taken at 14' from TOC due to ice. Depth to water (~13.2 ft) is below top of screened interval (10ft).
5/3/2012	10:29	13.19	N/A	N/A	2.30	0.428	3.90	0.003	DO taken at 14' from TOC due to ice. Depth to water (~13.2 ft) is below top of screened interval (10ft).
5/4/2012	10:20	13.22	N/A	N/A	1.80	0.485	1.70	0.007	DO taken at 14' from TOC due to ice. Depth to water (~13.2 ft) is below top of screened interval (10ft).
5/7/2012	10:28	13.35	N/A	N/A	3.50	0.469	3.40	0.009	DO taken at 14' from TOC due to ice. Depth to water (~13.4 ft) is below top of screened interval (10ft).
5/8/2012	10:58	13.38	N/A	N/A	2.60	0.422	2.50	0.010	DO taken at 14' from TOC due to ice. Depth to water (~13.4 ft) is below top of screened interval (10ft).
5/9/2012	12:14	13.42	N/A	N/A	2.30	0.425	2.20	0.009	DO taken at 14' from TOC due to ice. Depth to water (~13.4 ft) is below top of screened interval (10ft).

Table 2
Manual Readings Collected at MW-139
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	20 ft btoc (bottom of screened interval)		15 ft btoc (midpoint of screened interval)		10 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
5/11/2012	9:49	13.50	N/A	N/A	2.30	0.450	2.30	0.010	DO taken at 14.5' from TOC due to ice. Depth to water (~13.5 ft) is below top of screened interval (10ft).
5/18/2012	12:04	13.67	N/A	N/A	N/A	N/A	N/A	N/A	YSI would not advance any further than approx. 7 ft due to ice.

Notes:

-	Not collected.
DO	Dissolved oxygen.
ft btoc	Feet below top of casing.
mg/L	Milligrams per liter.
mS/cm	Milli Siemens per centimeter.

Table 3
Manual Readings Collected at INJ-MW-1
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		25 ft btoc (midpoint of screened interval)		15 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
3/26/2012	11:43	14.41	3.5	0.372	3.4	0.379	3.0	0.462	Baseline
-	18:31	14.4	3.4	0.386	3.1	0.435	2.7	0.461	-
3/27/2012	11:30	14.42	3.5	0.409	3.2	0.446	2.5	0.486	DO @ Cntr = 1.44mg/L
3/28/2012	11:42	14.41	3.4	0.407	3.4	0.453	3.1	0.494	DO @ Cntr = 3.43mg/L
3/29/2012	11:38	14.43	3.4	0.407	3.4	0.398	3.0	0.492	DO @ Cntr = 1.80mg/L
3/30/2012	11:50	14.43	3.4	0.398	3.4	0.397	3.1	0.480	DO @ Cntr = 1.03mg/L
3/31/2012	16:54	14.43	3.4	0.400	3.4	0.399	3.0	0.494	DO @ Cntr = 2.30mg/L
4/1/2012	15:20	14.42	3.4	0.399	3.4	0.391	2.9	0.495	DO @ Cntr = 2.73mg/L
4/2/2012	11:00	14.41	3.3	0.398	3.1	0.430	2.3	0.453	DO @ Cntr = 1.35mg/L
4/3/2012	13:30	14.11	3.5	0.421	3.4	0.456	2.7	0.516	DO @ Cntr = 0.30mg/L
4/3/2012	13:30	-	-	-	-	0.470	-	-	YSI Reading (Additional)
4/4/2012	13:07	14.44	3.5	0.425	3.3	0.482	2.6	0.530	DO @ Cntr = 0.10mg/L
4/4/2012	13:07	-	-	-	-	-	-	-	YSI Reading (Additional)
4/5/2012	14:20	14.39	3.5	0.419	3.3	0.467	3.3	0.467	DO @ Cntr = 0.18mg/L
4/5/2012	14:20	-	-	-	-	-	-	-	YSI Reading (Additional)
4/6/2012	11:37	14.39	3.5	0.418	3.3	0.466	2.9	0.525	DO @ Cntr = 0.12mg/L
4/6/2012	11:37	-	-	-	-	-	-	-	YSI Reading (Additional)
4/7/2012	12:17	14.36	3.5	0.408	3.3	0.457	3.0	0.524	DO @ Cntr = 0.15mg/L
4/7/2012	12:17	-	-	-	3.4	0.527	-	-	YSI Reading (Additional)
4/9/2012	11:55	14.33	3.4	0.417	3.2	0.467	2.8	0.531	DO @ Cntr = 0.12mg/L
4/9/2012	11:55	-	-	-	3.3	0.481	-	-	YSI Reading (Additional)
4/10/2012	14:05	6:57	3.2	0.466	3.2	0.466	2.7	0.512	DO @ Cntr = 0.12mg/L
4/10/2012	14:05	-	-	-	3.4	0.527	-	-	YSI Reading (Additional)
4/13/2012	12:40	14.23	3.4	0.413	3.2	0.453	2.9	0.506	DO @ Cntr = 0.12mg/L
4/13/2012	12:40	-	-	-	3.3	0.456	-	-	YSI Reading (Additional)
4/16/2012	10:18	14.2	3.3	0.407	3.2	0.444	3.0	0.487	DO @ Cntr = 0.14mg/L
4/16/2012	10:18	-	-	-	3.3	0.464	-	-	YSI Reading (Additional)
4/17/2012	11:39	21:50	3.4	0.339	3.3	0.423	3.0	0.457	DO @ Cntr = 0.12mg/L
4/17/2012	11:39	-	-	-	3.4	0.437	-	-	YSI Reading (Additional)
4/20/2012	10:56	13.62	3.29	0.399	3.21	0.426	2.69	0.444	
			-	-	3.80	-	-	-	Sampled using low flow pump.
4/23/2012	9:48	13.49	3.23	0.411	3.12	0.437	2.76	0.490	
			-	-	3.70	0.463	-	-	Sampled using low flow pump.

Table 3
Manual Readings Collected at INJ-MW-1
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		25 ft btoc (midpoint of screened interval)		15 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
4/24/2012	10:54	12.48	3.24	0.410	3.11	0.440	2.69	0.470	
			-	-	3.80	0.482	-	-	Sampled using low flow pump.
4/27/2012	10:19	13.59	3.19	0.412	3.04	0.456	2.47	0.496	
			-	-	4.00	0.504	-	-	Sampled using low flow pump.
4/28/2012	9:02	13.65	3.13	0.417	3.01	0.454	2.62	0.508	
			-	-	3.30	0.504	-	-	
4/30/2012	9:52	13.75	3.20	0.411	2.99	0.452	2.57	0.508	
			-	-	3.30	0.410	-	-	Sampled using low flow pump.
5/1/2012	11:37	13.77	3.14	0.413	2.99	0.448	2.41	0.487	
			-	-	3.30	0.439	-	-	Sampled using low flow pump.
5/2/2012	10:11	13.83	3.05	0.420	2.89	0.469	2.61	0.513	
			-	-	3.30	0.432	-	-	Sampled using low flow pump.
5/3/2012	10:47	13.79	2.99	0.434	2.89	0.465	2.44	0.505	
			-	-	3.00	0.473	-	-	
5/4/2012	10:20	13.82	3.10	0.415	2.91	0.447	2.32	0.505	
			-	-	3.40	0.428	-	-	Sampled using low flow pump.
5/7/2012	10:36	14.01	3.03	0.418	2.85	0.463	2.27	0.499	
			-	-	3.50	0.487	-	-	Sampled using low flow pump.
5/8/2012	11:21	14.04	2.98	0.418	2.84	0.465	2.46	0.502	
			-	-	3.60	0.432	-	-	Sampled using low flow pump.
5/9/2012	12:11	14.08	3.01	0.419	2.85	0.457	2.43	0.510	
			-	-	3.50	0.424	-	-	Sampled using low flow pump.
5/11/2012	10:16	14.16	2.98	0.425	2.76	0.470	2.38	0.523	
			-	-	3.20	0.458	-	-	
5/18/2012	12:24	14.32	2.86	0.417	2.70	0.459	2.42	0.500	Logger Removed
			-	-	3.00	0.461	-	-	

Table 3
Manual Readings Collected at INJ-MW-1
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		25 ft btoc (midpoint of screened interval)		15 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	

Notes:

-	Not collected.
DO	Dissolved oxygen.
ft btoc	Feet below top of casing.
mg/L	Milligrams per liter.
mS/cm	Milli Siemens per centimeter.

Table 4
Manual Readings Collected at INJ-MW-2
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		25 ft btoc (midpoint of screened interval)		15 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
3/26/2012	11:45	13.02	3.9	0.347	3.6	0.363	2.5	0.363	Baseline
3/26/2012	18:46	13.03	3.9	0.351	3.4	0.382	2.4	0.357	-
3/27/2012	11:40	13.02	3.9	0.382	3.6	0.393	2.6	0.328	DO @ Cntr = 1.67mg/L
3/28/2012	11:52	13.03	3.9	0.376	3.6	0.374	2.6	0.392	DO @ Cntr = 1.89mg/L
3/29/2012	11:45	13.03	4.0	0.370	3.7	0.384	3.7	0.409	DO @ Cntr = 2.65mg/L
3/30/2012	11:55	13.03	3.9	0.367	3.6	0.382	2.5	0.375	DO @ Cntr = 1.01mg/L
3/31/2012	17:00	13.04	3.9	0.370	3.6	0.380	2.6	0.380	DO @ Cntr = 1.46mg/L
4/1/2012	15:40	13.44	3.8	0.374	3.6	0.379	2.6	0.385	DO @ Cntr = 1.76mg/L
4/2/2012	11:10	13.03	3.9	0.670	3.6	0.382	2.5	0.383	DO @ Cntr = 1.17mg/L
4/3/2012	14:00	13.02	4.1	0.452	3.9	0.463	2.8	0.467	DO @ Cntr = 0.13mg/L
4/3/2012	14:51	-	-	-	-	0.470	-	-	YSI Reading (Additional)
4/4/2012	13:11	13.06	4.0	0.405	3.8	0.416	2.8	0.406	DO @ Cntr = 0.21mg/L
4/5/2012	-	13	4.1	0.399	4.0	0.412	2.9	0.398	DO @ Cntr = 0.46mg/L
4/6/2012	-	13	4.1	0.394	3.9	0.401	2.9	0.398	DO @ Cntr = 0.46mg/L
4/7/2012	11:50	12.99	4.1	0.408	4.0	-	3.1	0.415	DO @ Cntr = 0.46mg/L
4/9/2012	11:03	12.93	4.1	0.402	3.9	0.407	2.9	0.415	DO @ Cntr = 0.09mg/L
4/10/2012	13:15	12.9	4.3	0.448	3.8	0.455	2.8	0.455	DO @ Cntr = 0.16mg/L
4/11/2012	10:40	12.95	3.9	0.391	3.8	0.402	3.6	0.429	DO @ Cntr = 0.36mg/L
4/11/2012	10:40	-	-	-	3.8	0.410	-	-	YSI Reading (Additional)
4/13/2012	13:00	12.84	4.0	0.384	3.9	0.395	3.8	0.041	DO @ Cntr = 0.14mg/L
4/13/2012	13:00	-	-	-	3.6	0.417	-	-	YSI Reading (Additional)
4/16/2012	10:02	12.63	4.1	0.374	3.9	0.380	3.8	0.383	DO @ Cntr = 0.48mg/L
4/16/2012	10:02	-	-	-	4.3	0.395	-	-	YSI Reading (Additional)
4/17/2012	10:09	12.52	4.2	0.370	4.0	0.370	3.9	0.369	DO @ Cntr = 0.14mg/L
4/17/2012	10:09	-	-	-	4.0	0.381	-	-	YSI Reading (Additional)
			4.15	0.371	4.01	0.369	3.77	0.368	
4/20/2012	11:11	12.27	-	-	4.60	-	-		Sampled using low flow pump.
			4.01	0.378	3.76	0.384	3.58	0.390	
4/23/2012	10:00	12.11	-	-	4.40	0.438	-	-	Sampled using low flow pump.
			3.99	0.379	3.76	0.388	3.73	0.394	
4/24/2012	11:36	12.10	-	-	5.00	0.439	-	-	Sampled using low flow pump.

Table 4
Manual Readings Collected at INJ-MW-2
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		25 ft btoc (midpoint of screened interval)		15 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
			3.85	0.393	3.61	0.408	3.62	0.425	
4/27/2012	11:05	12.21	-	-	4.30	0.453	-	-	Sampled using low flow pump.
			3.91	0.394	3.61	0.409	3.39	0.430	
4/28/2012	9:41	12.28	-	-	4.00	0.445	-	-	Sampled using low flow pump.
			3.89	0.393	3.59	0.410	3.38	0.432	
4/30/2012	11:28	12.39	-	-	4.00	0.393	-	-	Sampled using low flow pump.
			3.81	0.392	3.59	0.408	3.39	0.427	
5/1/2012	12:13	12.41	-	-	3.90	0.418	-	-	Sampled using low flow pump.
			3.69	0.399	3.53	0.412	3.36	0.442	
5/2/2012	10:41	12.45	-	-	3.80	0.411	-	-	Sampled using low flow pump.
			3.73	0.396	3.53	0.415	3.26	0.446	
5/3/2012	11:44	12.48	-	-	4.00	0.403	-	-	Sampled using low flow pump.
			3.85	0.392	3.53	0.413	3.26	0.440	
5/4/2012	10:47	12.50	-	-	4.10	0.405	-	-	Sampled using low flow pump.
			3.76	0.397	3.48	0.416	3.22	0.450	
5/7/2012	11:11	12.63	-	-	3.80	0.460	-	-	
			3.77	0.398	3.49	0.418	3.24	0.447	
5/8/2012	11:45	12.67	-	-	3.90	0.408	-	-	
			3.69	0.399	3.47	0.417	3.27	0.445	
5/9/2012	12:58	12.71	-	-	3.70	0.402	-	-	
			3.69	0.400	3.40	0.420	3.28	0.449	
5/11/2012	10:32	12.79	-	-	4.00	0.401	-	-	
			3.61	0.394	3.38	0.416	3.25	0.438	Logger Removed
5/18/2012	12:37	12.86	-	-	3.80	0.421	-	-	

Notes:

-	Not collected.	mg/L	Milligrams per liter.
DO	Dissolved oxygen.	mS/cm	Milli Siemens per centimeter.
ft btoc	Feet below top of casing.		

Table 5
Manual Readings Collected at INJ-MW-2
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		25 ft btoc (midpoint of screened interval)		15 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
3/26/2012	11:47	14.05	3.5	0.378	3.0	0.376	2.1	0.380	Baseline
3/26/2012	18:52	14.04	3.6	0.377	3.0	0.375	2.6	0.374	-
3/27/2012	11:40	14.04	3.8	0.414	3.2	0.414	1.9	0.387	DO @ Cntr = 1.38mg/L
3/28/2012	12:00	14.04	3.5	0.410	3.0	0.408	2.1	0.385	DO @ Cntr = 1.30mg/L
3/29/2012	11:53	140.5	3.5	0.410	3.0	0.408	2.1	0.389	DO @ Cntr = 2.08mg/L
3/30/2012	12:00	14.05	3.5	0.403	3.0	0.401	2.1	0.377	DO @ Cntr = 1.14mg/L
3/31/2012	17:10	14.06	3.5	0.405	3.0	0.403	2.1	0.378	DO @ Cntr = 1.11mg/L
4/1/2012	15:50	14.07	3.6	0.404	3.0	0.402	2.1	0.376	DO @ Cntr = 3.90mg/L
4/2/2012	11:20	14.06	3.4	0.403	3.0	0.402	2.1	0.375	DO @ Cntr = 2.05mg/L
4/3/2012	15:00	14.04	3.8	0.490	3.3	0.487	2.4	0.461	DO @ Cntr = 0.14mg/L
4/4/2012	13:25	14.08	3.7	0.436	3.3	0.433	2.3	0.409	DO @ Cntr = 0.16mg/L
4/5/2012	-	14.02	3.7	0.430	3.3	0.428	2.4	0.405	DO @ Cntr = 0.16mg/L
4/6/2012	-	14.02	3.8	0.426	3.3	0.425	2.4	0.406	DO @ Cntr = 0.08mg/L
4/7/2012	12:10	14.00	3.7	0.438	3.4	0.435	2.4	0.412	DO @ Cntr = 0.17mg/L
4/9/2012	-	13.95	3.8	0.433	3.3	0.431	2.4	0.407	DO @ Cntr = 0.10mg/L
4/10/2012	14:25	13.91	3.8	0.485	3.3	0.482	2.3	0.459	DO @ Cntr = 0.13mg/L
4/11/2012	11:15	13.96	3.5	0.424	3.3	0.422	2.3	0.400	DO @ Cntr = 0.20mg/L
4/13/2012	12:37	13.86	3.7	0.426	3.6	0.425	2.3	0.399	DO @ Cntr = 0.38mg/L
4/16/2012	10:28	13.67	3.9	0.433	3.5	0.430	2.3	0.409	DO @ Cntr = 0.21mg/L
4/17/2012	10:06	13.55	4.1	0.429	3.5	0.426	2.3	0.414	DO @ Cntr = 0.53mg/L
4/20/2012	11:40	13.27	4.00	0.437	3.60	0.438	2.50	0.435	Sampled using low flow pump.
4/23/2012	12:11	13.13	3.80	0.463	3.30	0.463	2.30	0.447	
4/24/2012	10:46	13.11	3.90	0.475	3.50	0.473	2.30	0.447	Sampled using low flow pump.
4/27/2012	12:04	13.23	3.90	0.466	3.70	0.463	2.30	0.436	Sampled using low flow pump.
4/28/2012	10:00	13.30	3.60	0.471	3.40	0.469	2.10	0.434	
4/30/2012	10:27	13.39	3.50	0.421	3.40	0.419	2.20	0.384	
5/1/2012	12:28	13.42	3.60	0.447	3.20	0.444	2.10	0.408	
5/2/2012	10:28	13.46	3.40	0.434	3.20	0.429	2.00	0.394	
5/3/2012	12:32	13.49	3.40	0.439	3.00	0.438	2.40	0.396	
5/4/2012	12:24	13.52	3.70	0.443	3.50	0.435	2.20	0.409	Sampled using low flow pump.
5/7/2012	11:04	13.65	3.50	0.464	3.90	0.462	2.10	0.423	
5/8/2012	11:36	13.68	3.40	0.420	3.40	0.414	2.10	0.382	

Table 5
Manual Readings Collected at INJ-MW-2
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	35 ft btoc (bottom of screened interval)		25 ft btoc (midpoint of screened interval)		15 ft btoc (top of screened interval)		Comments
			Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	
5/9/2012	12:52	13.72	3.40	0.412	3.50	0.409	2.10	0.407	
5/11/2012	10:44	13.80	3.40	0.434	3.40	0.426	2.10	0.394	Sampled using low flow pump.
5/18/2012	12:52	13.97	3.70	0.454	3.30	0.443	2.10	0.411	Sampled using low flow pump.

Notes:

-	Not collected.
DO	Dissolved oxygen.
ft btoc	Feet below top of casing.
mg/L	Milligrams per liter.
mS/cm	Milli Siemens per centimeter.

Table 6
Manual Readings Collected at INJ-MW-2
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Date	Time	Depth to Water (ft btoc)	Temperature (degrees Celcius)	Specific Conductivity (mS/cm)	Dissolved Oxygen (mg/L)	Comments
3/26/2012	11:50	14.28	3.0	0.304	-	Baseline
3/26/2012	13:24	14.28	-	0.309	-	Baseline
3/27/2012	11:26	14.28	3.1	0.336	1.700	-
3/28/2012	12:05	14.30	3.0	0.333	1.700	-
3/29/2012	11:30	14.29	3.1	0.333	1.500	-
3/30/2012	11:15	14.29	3.0	0.350	1.390	-
3/31/2012	15:56	14.31	3.6	0.329	3.480	-
4/1/2012	14:45	14.32	3.5	0.330	3.340	-
4/2/2012	11:20	14.29	3.4	0.328	1.090	-
4/3/2012	-	14.28	3.6	0.402	0.110	-
4/4/2012	11:44	14.30	3.7	0.355	0.230	-
4/5/2012	-	14.25	3.8	0.352	0.260	-
4/6/2012	-	14.26	3.6	0.350	0.110	-
4/7/2012	-	14.24	-	-	-	-
4/9/2012	-	14.21	3.6	0.355	0.120	-
4/10/2012	14:14	14.17	3.7	0.398	0.210	-
4/13/2012	13:35	14.11	3.6	0.350	0.140	-
4/16/2012	11:14	13.90	3.6	0.361	0.170	-
4/17/2012	10:47	13.79	3.6	0.359	0.220	-
4/20/2012	10:37	13.50	3.50	0.380	0.24	
4/23/2012	9:46	13.39	3.30	0.400	0.21	Sampled using low flow pump.
4/24/2012	9:54	13.36	3.50	0.396	0.43	
4/27/2012	9:33	13.49	3.30	0.385	0.46	
4/282012	8:54	13.57	3.50	0.383	0.51	
4/30/2012	9:44	13.66	3.40	0.337	0.52	
5/1/2012	11:23	13.67	3.10	0.358	0.49	
5/2/2012	9:33	13.73	3.20	0.346	0.50	
5/3/2012	10:12	13.74	3.50	0.349	0.44	
5/4/2012	10:50	13.77	3.20	0.358	0.17	
5/7/2012	10:02	13.90	3.40	0.370	0.56	
5/8/2012	10:41	13.94	3.40	0.332	0.53	
5/9/2012	11:53	13.98	3.40	0.346	0.37	
5/11/2012	9:30	14.06	3.40	0.341	0.45	
5/18/2012	11:49	14.22	2.70	0.363	0.52	

Table 6
Manual Readings Collected at INJ-MW-2
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Notes:

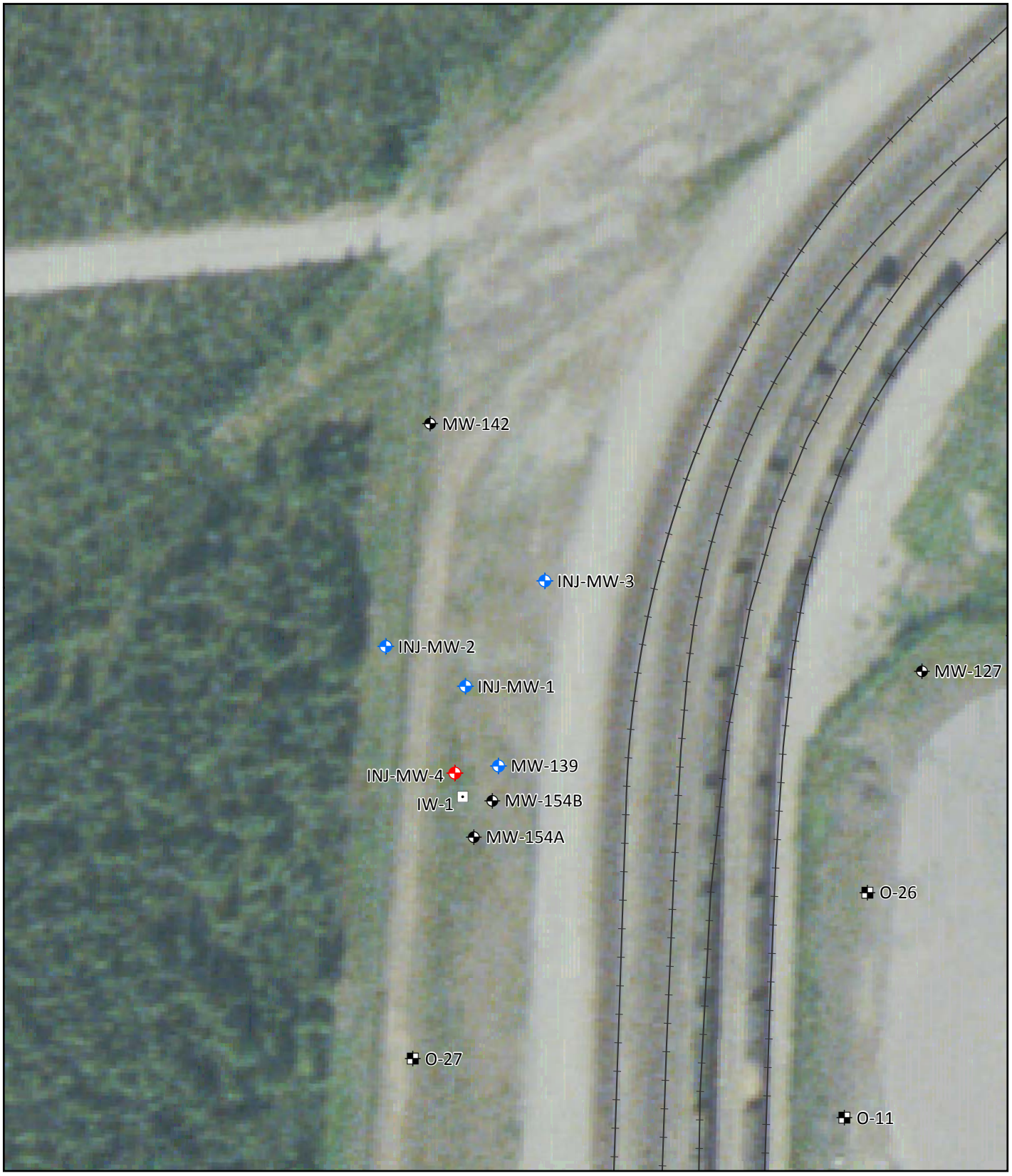
-	Not collected.
DO	Dissolved oxygen.
ft btoc	Feet below top of casing.
mg/L	Milligrams per liter.
mS/cm	Milli Siemens per centimeter.

Table 7
Manual Readings Collected at INJ-MW-2
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Well ID	Date/Time of Sample Collection	Deuterium Result (per mil)
IW-1	3/20/2012 17:50	-168.3
	3/28/2012 11:17	70.1
	4/2/2012 10:30	-158.4
INJ-MW-4	3/26/2012 14:15	-170.9
	3/26/2012 14:30	-170.3
	3/26/2012 15:00	-166.1
	3/26/2012 15:15	-163.1
	3/26/2012 16:00	-148.3
	3/26/2012 16:30	-112.7
	3/26/2012 18:15	-88.2
	3/27/2012 11:15	-51.4
	3/29/2012 11:00	144.8
	3/31/2012	-21.4
	4/2/2012 10:05	-94.6
MW-139	3/20/2012 16:35	-164.6
	3/26/2012 18:00	-164.5
	4/1/2012 15:05	-164.0
	4/2/2012 10:50	-164.0
INJ-MW-1	4/9/2012 11:55	-163.7
	4/13/2012 12:48	-164.4
	4/17/2012 11:39	-165.3
	4/20/2012 12:14	-167.9
	4/23/2012 11:45	-167.9
	4/24/2012 11:48	-167.4
	4/27/2012 11:17	-166.4
	4/30/2012 12:10	-167.7
	5/1/2012 13:08	-167.1
	5/2/2012 11:17	-166.9
	5/4/2012 11:46	-167.5
	5/7/2012 12:01	-166.4
INJ-MW-2	3/20/2012 15:30	-167.9
	4/17/2012 10:39	-162.8
	4/20/2012 12:47	-152.7
	4/24/2012 12:20	-157.1
	4/30/2012 12:49	-150.1
	5/2/2012 11:55	-157.8
	5/4/2012 12:12	-153

Table 7
Manual Readings Collected at INJ-MW-2
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

Well ID	Date/Time of Sample Collection	Deuterium Result (per mil)
INJ-MW-3	3/20/2012 14:40	-168.1
	4/11/2012 11:21	-168.2
	4/20/2012 13:19	-168.5
	4/24/2012 12:53	-168.6
	5/4/2012 12:45	-167.8
MW-303-CMT-29	6/7/2012 12:20	-169.1
MW-303-CMT-30	6/7/2012 14:15	-169.3



- TRACER MONITORING WELL
- DOSE-RESPONSE MONITORING WELL
- MONITORING WELL
- INJECTION WELL
- OBSERVATION WELL
- RECOVERY WELL

0 70 140

SCALE IN FEET

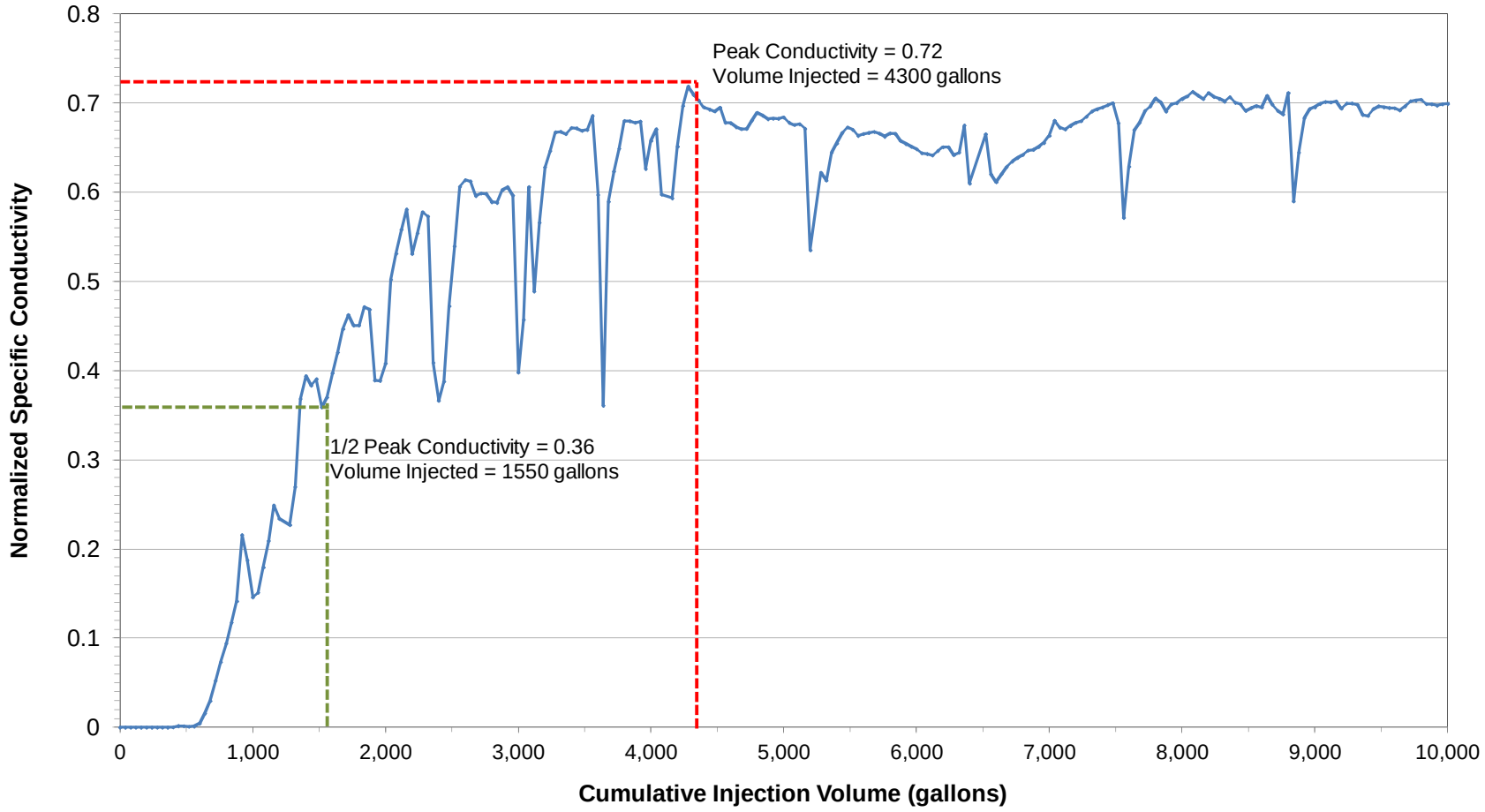
FLINT HILLS RESOURCES, ALASKA LLC.
NORTH POLE REFINERY, NORTH POLE, ALASKA

INJECTION TESTING LOCATION

ARCADIS

FIGURE
1

CITY: SAN FRANCISCO DIV/GROUP: ENV/IM DB: KERNST LD: PIC: PM: TM: TR:
PROJECT: (PROJECT #)
PATH: Q:\FlintHillsResources\NorthPoleRefinery\GW_Monitoring\General\MXD\Potential_InjectionWells_v2.mxd 6/28/2012 1:07:22 PM



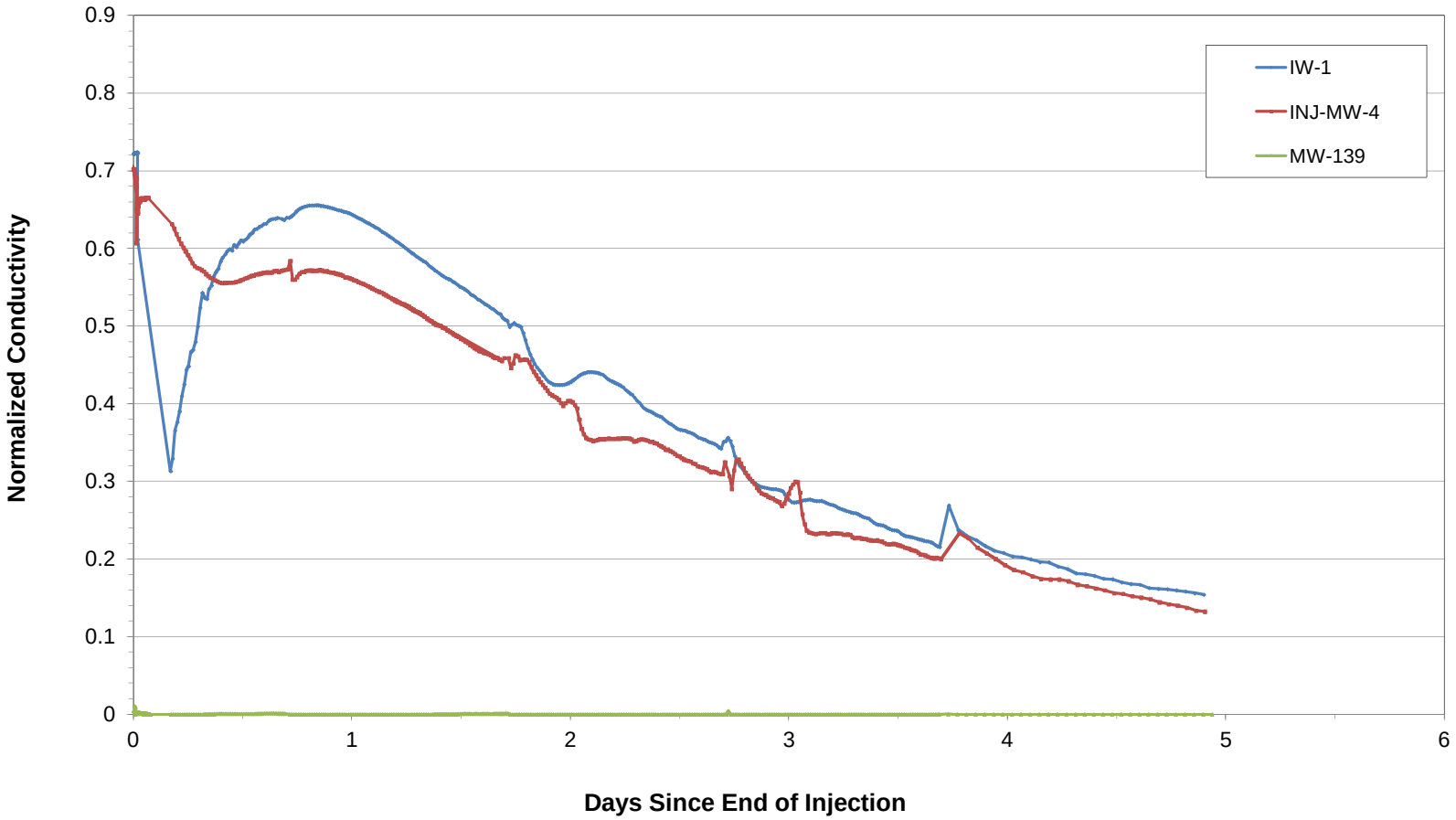
NOTES:

FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

TRACER RESPONSE AT INJ-MW-4 DURING INJECTION PHASE

ARCADIS
Infrastructure · Water · Environment · Buildings

FIGURE
2



NOTES:

FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

SPECIFIC CONDUCTIVITY RESPONSE POST-INJECTION

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Infrastructure · Water · Environment · Buildings

FIGURE
3

Mixing Tank

INJECTION MONITORING LOG
North Pole, Alaska

Date / Time	Sampled for Deuterium?	Mixing Tank		~~Comments~~
		Temp.	units	Cond ms/cm
3/26/12	~~RED VALV~~			initial / initial - started inj. w/ blue
3/26 1325	~~Y~~	4.99	C	.881 RED / 10% vol sample collected
1337	N	4.90	C	0.869 BLUE
1420	N	5.67	C	0.925 BLUE.
1440	N	5.78	C	0.925 RED
1500	N	5.73	C	0.927 BLUE
1520	N	5.71	C	0.899 RED
1540	N	5.84	C	0.899 BLUE
1600	Y	5.87	C	0.842 RED 50% VOL SAMPLE COLLECTED.
1620	N	5.38	C	0.727 BLUE
1640	N	5.29	C	0.950 RED
1700	N	5.29	C	0.893 BLUE
1720	N	5.27	C	0.917 RED
1735	Y	4.95	C	0.888 BLUE 90% VOL SAMPLE COLLECTED

ARCADIS

Flint Hills Refinery - North Pole, Alaska
Step and Constant Rate Monitoring Log

Page 1 of 1

Date: 3/26/12
Weather: Sunny; calm, ~15°F
Injection Well: IW-1

Test Area: Flint Hills Refinery
Personel: Mary Warren, Christopher Kochiss

Water (gal) deuterium + salt
Type of Test ~~trailer~~ injection test

25% = 25,916
50% = 28416
75% = 30916
100% = 33416
90% = 32446

Manual Injection Well Readings:

Manual
DTW (ft) prior to injection 15.31
Totalizer reading prior to injection 23416

Manual Monitoring Well Readings:

Time	Total Vol. Injected (gal)	Wellhead Pressure (psi)	Totalizer reading	Flow Rate (gpm)	DTW (ft)
1248	0	0	23416	0	15.31
1345	Pump	On	–	–	–
1354		–	23720	39	–
1402		–	24008	38.5	–
1411		–	24359	40.5	–
1427		–	24990	40	–
1440		–	25500	38.5	–
1448		–	25810	41.5	–
1503		–	26615	40	–
1525		–	27206	41.5	–
1537		–	27750	40.5	–
1549		–	28230	40.5	–
1606		–	28910	42	–
1619		–	29280	41	–
1627		–	29513	41	–
1700		–	31083	41.5	–
1721		–	31940	42	–
1748		–	32715	NR	–
1757	PUMP	OFF	33373	0	–

flush potable water through holes with pumps

1900 33550

3/27 1006 removed wellhead assembly and reclaimed tdx
Manual dh_2O = 14.44
tdx dh_2O = 20.90
set depth = 35.34 (@35.34')

Time	DTW	Cond	Temp	DO	
3/28/12 1110	14.45	0.797	5.24	3.37	✓ sampled
3/29/12	14.49	0.649	5.13	1.91	
3/30/12	14.48	0.576	4.93	1.14	✓ sampled
3/31/12 1601	14.46	0.481	4.73		✓
		20.524	4.51	2.72	

tdx

Time	Well	Total Vol. Injected (gal)	DTW (ft)	Totalizer reading	Other
3/26 1150	MW-154B	0	14.28		Baseline
3/26 1324	MW-154B		14.28		Pump on
3/27 1126	MW-154B		14.28		DO: 1.78 mg/L
3/28 1205	MW-154B		14.30		DO: 1.70 mg/L
3/29 1130	MW-154B		14.29		DO: 1.50 mg/L
3/30 1115	MW-154B		14.29		DO: 1.39 mg/L
3/31 1356	MW-154B		14.31		DO: 3.48 mg/L

ms/cm Cond	°C Temp
0.304	2.95
0.309	5.27
0.330	4.49
~~0.333~~	3.89
0.333	2.96
0.330	3.84
0.326	3.00
0.329	3.64

1345 B
1406 B→R
1426 R→B
1445 B-R
1503 R-B
1523 B→R
0 R→B
19 R→B

1345 pump on (31 gpm)
1349 pump ↑ (34 gpm)
1351 pump ↑ (37.5 gpm)
1353 pump ↑ (38.5 gpm)
1354 pump ↑ (39 gpm)
1356 pump ↑ (39 gpm)
1357 pump ↑ (34 gpm)
1406 (43 gpm)
1407 pump ↓ (42.5 gpm)
1409 pump ↓ (40.5 gpm)

~~MW-139~~ INJ-MW-4

INJECTION MONITORING LOG

North Pole, Alaska

35' 30 25'

Date / Time	Sampled for Deuterium?	DTW (ft btoc)	~~20' btoc~~ (bottom of screened interval)				~~18' btoc~~ (midpoint of screened interval)				~~10' btoc~~ (top of screened interval)				Comments
			Temp.	units	Cond.	units	Temp.	units	Cond.	units	Temp.	units	Cond.	units	
3/26/12 1122	n	14.47					~~4.31~~	~~C~~	~~.379~~						
1122	N	14.47	4.38	C	.379	ms/cm	4.31	C	.379	ms/cm	4.31	C	.378	ms/cm	Baseline
1412	~~n~~ y	14.12	4.48		.568		4.43		.561		4.46		.485		+30 min
1430	y	14.14	4.56		.734		4.63		.803		4.58		.568		+45 min
1445	y	14.14	4.66		.762		4.68		.859		4.61		.606		+1 hr
1500	y	14.13	4.83		.856		4.99		.917		4.89		.932		+1-15 mn
1515	y	14.13	5.07		.821		5.42		.994		5.39		.964		+ 1hr 30 mn
1530	y	14.11	5.15		.916		5.32		.985		5.35		.932		~~+ 1hr 45 mn~~
1600	y	14.15	5.40		.891		5.66		.984		5.58		1.006		+
1630	y	14.13	5.66		.932		5.86		.964		5.69		.988		
1700 ~~169~~	n	14.13	6.02		.997		6.02		1.012		5.81		.950		
1730	n	14.12	~~5.66~~		~~.998~~		5.66		.998		5.68		1.022		
1815	y	14.47	5.48		.982		5.47		.989		5.49		.963		
3/~~29~~/12 1100	y	14.48	5.26		0.901		5.29		0.895		5.22		0.886		DO @ center 1.73 mg/L
3/30/12 1048	y	14.49	5.11		0.792		5.08		0.799		5.02		0.749		DO @ center 2.20 mg/L
3/29/12 1055	y	14.48	5.05		0.657		5.05		0.695		4.99		0.600		DO @ center 1.18 mg/L
3/30/12 1127	y		4.95		0.594		4.90		0.558		4.84		0.507		DO @ center 2.15 mg/L