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Flint Hills Resources Alaska, LLC

2013 On-Site Site Characterization Work Plan

North Pole Refinery
North Pole, Alaska

February 1, 2013

ARCADIS

Gina France
Project Engineer

FOR

Andrew Ohrt
Senior Engineer

FOR

Rebecca Andresen
Associate Vice President

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North Pole Refinery
North Pole, Alaska

Prepared for:
Flint Hills Resources Alaska, LLC

Prepared by:
ARCADIS U.S., Inc.
2300 Eastlake Avenue East
Suite 200
Seattle
Washington 98102
Tel 206 325 5254
Fax 206 325 8218

Our Ref.:
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ARCADIS

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AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
ARCADIS	ARCADIS U.S., Inc.
ASTM	American Society for Testing and Materials
Barr	Barr Engineering Company
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and total xylenes
city	North Pole, Alaska
CSM	conceptual site model
DPR	dual-phase recovery
EU	Extraction Unit
FHRA	Flint Hills Resources Alaska, LLC
GAC	granular activated carbon
GVEA	Golden Valley Electric Association
IRAP	Interim Removal Action Plan
IRAP Addendum	Interim Removal Action Plan Addendum
ITRC	Interstate Technology & Regulatory Council
LNAPL	light nonaqueous phase liquid
NPR	North Pole Refinery
Onsite FS	Draft Final Onsite Feasibility Study
power plant	electrical generating facility
Revised Draft Final HHRA	Revised Draft Final Human Health Risk Assessment
RSAP	Revised Sampling and Analysis Plan
site	FHRA North Pole Refinery, an active petroleum refinery located on H and H Lane in North Pole, Alaska
TPT	Technical Project Team

USEPA	United States Environmental Protection Agency
work plan	2013 Site Characterization Work Plan
WWTP	wastewater treatment plant
µg/L	micrograms per liter

1. Introduction

ARCADIS U.S., Inc. (ARCADIS) prepared this 2013 Site Characterization Work Plan (work plan) on behalf of Flint Hills Resources Alaska, LLC (FHRA), for the FHRA North Pole Refinery (NPR), an active petroleum refinery located on H and H Lane in North Pole, Alaska (site). The site location and site features are shown on Figures 1 and 2.

This work plan addresses the recommendations presented in the Site Characterization Report – Through 2011 (SCR – 2011; Barr Engineering Company [Barr] 2012) and the Alaska Department of Environmental Conservation's (ADEC's) requests for additional site assessment, as expressed at Technical Project Team (TPT) meetings and in general communications between the ADEC and FHRA.

It is acknowledged that in 18 Alaska Administrative Code (AAC) 75.990(115), the ADEC defines the term "site" as an "area that is impacted, including areas impacted by the migration of hazardous substances from a source area, regardless of property ownership." For this work plan, the term "onsite" is the area that is located within the property boundary of the FHRA NPR, and the term "offsite" is the area located outside the property boundary in the downgradient north-northwest direction, based on the approximate extent of the dissolved-phase sulfolane plume detected at concentrations above the laboratory limit of detection (approximately 3 micrograms per liter [µg/L]).

Site conditions were previously evaluated in the Site Characterization and First Quarter 2011 Groundwater Monitoring Report (Barr 2011), the Site Characterization Work Plan Addendum (ARCADIS 2011a), the Site Characterization Report – Through 2011 (SCR-2011; Barr 2012) and the Site Characterization Report – 2012 Addendum (SCR-2012; ARCADIS 2013a). The Revised Draft Final Human Health Risk Assessment (Revised Draft Final HHRA; ARCADIS 2012a) evaluates whether concentrations of site-related constituents in groundwater pose a risk to onsite and offsite receptors.

ARCADIS and Shannon and Wilson, Inc. will complete the scope of work presented in this work plan, including soil vapor investigation, well installation and abandonment, additional groundwater monitoring, baildown testing, and soil boring advancement. Field activities will be completed by qualified persons as defined by 18 AAC 75.990.

1.1 Site Priorities

In a letter to FHRA dated August 18, 2011 (ADEC 2011), the ADEC listed priorities for the site per 18 AAC 75. FHRA has focused its work to address the ADEC's priorities and significant work has been completed toward achieving them. The additional characterization activities proposed below continue to address the site priorities through proposed enhancements to the monitoring network and collection of additional data to support development of an aggressive cleanup plan.

1.2 Purpose

This work plan outlines proposed field activities and includes the scope, technical background and rationale for each proposed activity. Progress of the proposed field activities will be documented in Site Characterization Subgroup Meetings. The proposed field activities include:

- Conduct an investigation to evaluate the potential for soil vapor accumulation in and beneath existing buildings onsite.
- Implement light non-aqueous phase liquid (LNAPL) baildown testing during seasonal groundwater hydrogeologic minimum.
- Installation of one replacement LNAPL recovery well and additional LNAPL observation wells for LNAPL baildown testing and additional potential recovery operations.
- Additional LNAPL composition analysis of petroleum constituents to improve the spatial understanding of the benzene, toluene, ethylbenzene, and xylene (BTEX) fraction of the LNAPL.
- Installation of groundwater monitoring wells at the property boundary downgradient of the interim remedial measures to monitor groundwater quality.
- Installation of upgradient groundwater wells for further delineation.
- Installation of additional monitoring wells and well nests for further characterization and delineation.
- Complete vertical characterization of BTEX concentrations in groundwater in select locations onsite.
- Abandon tracer testing monitoring wells.
- Perform soil characterization activities onsite to delineate soil impacts near the former southwest wash area based on 2012 soil investigation findings, as reported in the SCR – 2012 (ARCADIS 2013a).
- Conduct high density vertical soil sampling within the Southwest Area (Former Extraction Unit [EU] Wash Area) to evaluate the distribution of sulfolane impacts in the soil column in a known sulfolane source area.

Additional data collected during the proposed activities will further refine the conceptual site model (CSM), the scoping of onsite remedial alternatives, the groundwater model presented in the Groundwater Model Report (Geomega 2013 [In Press]) and the ongoing capture evaluation of the current groundwater extraction system. The additional data will enhance the project team's understanding of the fate and transport of sulfolane, BTEX and LNAPL at the site. The data will be used to develop the final Onsite Cleanup Plan. Appendix A of this work plan presents the updated onsite CSM. Field activities will be completed by qualified persons as defined by 18 AAC 75.990.

1.3 ADEC Requests

On January 18, 2013, ADEC issued a letter to FHRA detailing on-site data gaps identified by the ADEC team. A summary of the requested activities, FHRA's response to the identified data gaps and any proposed efforts to address them are summarized below:

1. Sampling of onsite granular activated carbon (GAC). Evaluate formation of intermediates in GAC filters. An evaluation of potential sulfolane intermediate products was presented in the Interim Remedial Action Plan Addendum (IRAP Addendum; ARCADIS, 2013). FHRA will continue to work with the degradation subgroup to assess the potential for formation of degradation intermediates. Sampling of the GAC filters is not included in this work plan. Future sampling of the GAC, if necessary, will be proposed at a future date.

2. Additional soil borings at depth for LNAPL delineation. ARCADIS has reviewed available soil boring logs, petroleum soil sampling data, LNAPL accumulation in current wells, LNAPL accumulation in historic wells, and LIF data. These data provide a complete picture of horizontal and vertical LNAPL delineation at the site. A compilation of the LNAPL delineation data are presented on Plate 1 (Appendix B). ARCADIS will prepare a summary of vertical delineation data and present it in the 2013 Site Characterization Report.

While FHRA believes that LNAPL delineation is complete, additional LNAPL assessment is proposed in Section 5 of this work plan to collect additional information on the LNAPL transmissivity within the LNAPL plume.

3.1 Soil gas assessment. FHRA is actively collecting information on building construction details, including the presence or absence of vapor barriers, and ventilation system configurations. FHRA will review that information in the near future with respect to the suitability of the engineering controls for protecting human health at the facility. FHRA will then provide a proposed path forward as an Addendum to this Work Plan that will include, if appropriate, a proposal for soil gas assessment.

3.2 LNAPL composition analysis. FHRA has conducted extensive LNAPL composition sampling to date. LNAPL composition data were collected as part of two studies from 19 total wells as reported in the Site Characterization Report – Through 2011 (Barr 2012). The locations of wells where LNAPL compositional data have been collected to date are presented on Figure 6.

As part of this Work Plan, FHRA will collect additional LNAPL samples for compositional analysis of petroleum constituents to improve the spatial understanding of the BTEX fraction of the LNAPL. These data will be valuable for consideration of the benefit of deployment of remedial technologies that can target removal of the BTEX fraction from LNAPL.

Regarding conducting compositional analysis for sulfolane, additional testing of LNAPL for sulfolane is not proposed at this time. FHRA believes that this is not necessary for the following reasons. First,, it is acknowledged that sulfolane is present in LNAPL, likely related to sulfolane partitioning from impacted groundwater into the LNAPL, and that the sulfolane present in the LNAPL may be a relevant source of sulfolane to groundwater in the future due to partitioning of sulfolane from LNAPL to groundwater. However, as described in Appendix A of the Site Characterization Report – 2012 Addendum, LNAPL was an insignificant source of the sulfolane that was released to the environment as compared to the other identified sources of sulfolane. In addition, existing data on sulfolane in LNAPL indicate that the LNAPL is currently a sink of or in equilibrium with sulfolane in groundwater rather than a source to groundwater. Also, there are no remedial technologies for selectively targeting sulfolane in LNAPL. Therefore the data will not inform remedial decision-making.

3.3 LNAPL mass estimate. FHRA has previously expressed the impracticability of calculating LNAPL mass estimates. Estimates of this type are generally only accurate within one to two orders of magnitude, and would not be useful for planning, implementing or measuring the performance of a remedy.

4.1 Bench scale test for the dead-end pore space theory referred to in the groundwater model. It is FHRA's understanding that ADEC wants to develop a conceptual model to explain the persistence of sulfolane in historical sulfolane release areas. FHRA shares this desire as an improved understanding of sulfolane persistence will allow FHRA to improve the reliability of any future sulfolane source area remedies to address.

FHRA believes that there are three reservoirs for sulfolane mass that currently discharge sulfolane or in the future may discharge sulfolane to groundwater.

- **Sulfolane in unsaturated soil and the capillary fringe**. Soil sampling has shown that sulfolane is present in unsaturated soils in former sulfolane release areas. Research has been conducted by a number of groups to explore the persistence of ethanol impacts to groundwater following a neat or denatured ethanol release. Like sulfolane, ethanol is miscible in groundwater and would not be expected to be a persistent source of groundwater contamination after a release to the environment. However, ethanol impacts to groundwater persist for months to years after release, suggesting that there must be a storage mechanism for ethanol.

  Researchers studying ethanol persistence have found that high concentrations of ethanol are present in soil moisture above the water table and within the capillary fringe

(McDowell and Powers 2003; Freitas and Barker 2011). These observations have been linked to the miscibility of ethanol and to the density of ethanol, which is lower than groundwater. While the latter mechanism would not be relevant to the sulfolane-laden wastewater that was released, which would be expected to be slightly more dense than groundwater, the solubility of sulfolane likely would have resulted in transfer of sulfolane into soil pore water. Additionally, a high concentration of sulfolane may be present in the capillary fringe as has been observed in the ethanol studies.

The persistence of sulfolane in unsaturated soils is also likely related to minimal infiltration in the impacted areas due to soil compaction in road and equipment areas, site grading to minimize accumulation of water at grade and soil capping (Lagoon B and Sump 02/04-2). Groundwater fluctuation brings sulfolane in contact with the impacted soils resulting in transfer of sulfolane from soil to groundwater.

- **Sulfolane in immobile saturated zone pore space.** Sulfolane may be stored in saturated soils of low permeability below the water table at the site, such as soil layers that have a silt matrix, resulting in dual-porosity transport behavior. Most soils consist of a mixture of both slowly and rapidly conducting pore sequences, and groundwater velocities in the smallest pores may be extremely slow and even negligible. This results in slow or incomplete mixing of solutes and results in tailing.

  Field tests conducted at the site have demonstrated a nearly four-order-of-magnitude range in hydraulic conductivity that is correlated with changes in grain size distribution and is consistent with the horizontally layered structure of site soils. For example, it is not uncommon at the site to find layers and lenses of gravel, sand, and silt that were deposited in a fluvial environment. Where low-permeability soil layers such as silt are surrounded by relatively high-permeability layers such as sand and gravel, sulfolane may enter the low permeability layers and be stored there in immobile groundwater and result in tailing and dual-porosity behavior.

  This “dual-porosity conceptual model” was first investigated and described by researchers such as Martinus van Genuchten and Jacob Bear in the 1960s and 1970s (e.g., van Genuchten and Wierenga 1976; Bear 1972). Since then, numerous bench-scale and field-scale tests have been performed by groundwater scientists to test and validate the dual-porosity conceptual model, which has resulted in a large body of scientific work to the extent that the dual-porosity conceptual model is considered “the state of the science”.

- **Sulfolane in LNAPL**. As discussed above LNAPL sulfolane data collected to date indicate that LNAPL is likely a sink of or in equilibrium with sulfolane in groundwater.

The immobile pore-space concept has been conducted by others to demonstrate the physical viability of the concept. FHRA will prepare a white paper and bibliography of relevant technical literature if desired. Site-specific bench-scale testing will not provide benefit because disturbance of the soil structure through soil collection and placement in a testing vessel would yield results that are not representative of field conditions. Field testing using tracers was completed in 2012 and determined that the mobile porosity in the vicinity of the field test was five percent, which demonstrates that the immobile pore space concept is relevant at the site. Based on the availability of existing literature and the field testing conducted previously, bench scale testing will not be pursued.

However, FHRA does see value in assessing the distribution of sulfolane impacts in the soil column in a known sulfolane source area. These data will refine our understanding of the vertical distribution of sulfolane within impacted soil and our conceptual model for sulfolane in soil as an ongoing contribution to sulfolane impacts in groundwater. FHRA proposes high density vertical soil sampling within the Southwest Area (Former EU Wash Area) to assess the vertical distribution of sulfolane in soil in a known sulfolane source area. Soil moisture data will also be collected in order to correlate the soil data to the presence of the capillary fringe. The proposed data collection location and methodology are summarized in Section 6.0.

4.2 Equilibrium solubility testing of sulfolane in LNAPL. Equilibrium solubility testing of sulfolane in LNAPL has been discussed previously in the context of achieving a lower sulfolane detection limit in LNAPL compared to historical testing. As discussed above, additional LNAPL sulfolane testing is not being proposed at this time.

4.3 Additional soil and groundwater assessment (vertical and horizontal) in areas of highest sulfolane concentrations (MW-138, MW-176, O-1, MW-110, SB-143, plus deep delineation in vicinity of former bolted tanks and other locations where hydropunch showed deep sulfolane and/or benzene). Additional soil and groundwater investigations proposed at the site are summarized in Sections 7 and 6, respectively. Recommendations for further evaluation of deep BTEX concentrations are presented in Section 5.5. Additional characterization near well nest MW-176 is proposed in the LNAPL Section (Section 4).

4.4 Bench scale test to evaluate if sulfolane becomes a solid or gel in colder temperatures. FHRA has interviewed operations personnel to determine sulfolane gelling or solidification occurs within the process equipment or could have occurred related to historic sulfolane discharges to the environment. The feedback from operations personnel is discussed in brief below.

Sulfolane is received at the facility as a concentrated water solution, which remains a liquid at relevant temperatures. As part of the sulfolane recovery process in the Extraction Unit, steam is used to strip the aromatics and most water from the sulfolane, resulting in a highly concentrated or “neat” sulfolane. While it is not free of all water, it is concentrated enough that it forms a gel at ambient temperatures above freezing in some locations in the Extraction Unit. However, it does not form identifiable crystals that separate from the solution, even as it gels or hardens, depending on the temperature. This sulfolane is reused within the extraction unit.

The sump in the Extraction Unit is emptied by a pump based on the fluid level, and there is residual water in the base of the sump even at the low level pump shut off. If gelled sulfolane were to enter the sump, it would dissolve immediately in the water standing in the base of the sump, so there is no reasonable mechanism for gelled sulfolane to be released to the environment. While historical released from the sump have been in relatively high concentrations, they would have still been in aqueous phase.

We do not believe bench testing of sulfolane forming a gel or solid is needed as the nature of the concentrated form of sulfolane is adequately understood. We also believe it is highly unlikely that sulfolane could act in the soils in a way to leave behind a residual solid, crystal, or gel. Historic sulfolane releases have been from aqueous wastewater sources.

5. *Plan for the interim remedy performance monitoring.* A plan for interim remedy performance monitoring, including the installation of additional performance monitoring wells, was included in the IRAP Addendum, submitted on January 18, 2013 (ARCADIS 2013b).

2. Site Setting

2.1 Property Description

The site is located on 240 acres inside the city limits of North Pole, Alaska (the city). The city is located approximately 13 miles southeast of Fairbanks, Alaska, within Fairbanks North Star Borough (Figure 1). NPR is an active petroleum refinery that receives crude oil feedstock from the Trans-Alaska Pipeline. The site was developed in the mid-1970s and operations began in 1977.

Three crude oil processing units are located in the southern portion of the site, making up the process area. Only one of the processing units is currently operating. Tank farms are located in the central portion of the site. Truck-loading racks are located immediately north of the tank farms and a railcar-loading rack is located west of the tank farms. Previously, a truck-loading rack was located between the railcar-loading rack and the tank farms, near the intersection of Distribution Street and West Diesel. Wastewater treatment lagoons, storage areas, and two flooded gravel pits (the North and South Gravel pits) are located in the western portion of the site. Rail lines and access roads are located in the northernmost portion of the site. Along the southern site boundary, partially surrounded by the NPR, is an electrical generating facility (power plant) operated by Golden Valley Electric Association (GVEA). FHRA representatives indicated that the power plant burns heavy aromatic gas oil (diesel 4) or other fuels produced at the site. The property south of the site and the GVEA power plant is occupied by the Petro Star, Inc. Refinery. Site features are presented on Figure 2.

North of the site are residential properties and the city's wastewater treatment plant (WWTP). The North Pole High School is located immediately north and west of the WWTP and residential properties. An undeveloped parcel, owned by the Alaska Department of Natural Resources, lies between the site and the WWTP. The Tanana River is located to the west, flowing in a northwesterly direction toward Fairbanks. East of the site is property that is residential or undeveloped, the Old Richardson Highway, and the Alaska Railroad right-of-way. Current site features are presented on Figure 2. Onsite and offsite site plans are presented on Figures 3 and 4, respectively.

2.2 Physical Setting

The site and the surrounding North Pole area are located on a relatively flat-lying alluvial plain that is situated between the Tanana River and Chena Slough (locally known as Badger Slough). The site is located on the Tanana River Floodplain. Up to 2 feet of organic soils are typically found in the undeveloped portions of the site. A discontinuous silt and silty sand layer that varies in thickness from 0 to 10 feet typically occurs beneath the organic soils. Alluvial sand and gravel associated with the Tanana River are present below the organic soil and silty layers. Depth to bedrock has been estimated at 400 to 600 feet below ground surface (bgs).

The city is located within an area of Alaska characterized by discontinuous permafrost (Ferrians 1965). Permafrost tends to act as a confining unit, impeding and redirecting the flow direction of groundwater (Glass et al. 1996). Based on regional information (Williams 1970, Miller et al. 1999), permafrost is assumed to be absent beneath the Tanana River.

The aquifer beneath the alluvial plain between the Tanana River and Chena Slough generally consists of highly transmissive sands and gravels under water table conditions (Cederstrom 1963, Glass et al. 1996). The Tanana River has a drainage area of approximately 20,000 square miles upstream of Fairbanks (Glass et al. 1996). Near the site, this aquifer is reportedly greater than 600 feet thick (at least 616 feet thick near Moose Creek Dam) (Glass et al. 1996). Beyond the zones of influence of the site groundwater recovery system, groundwater flow directions are controlled by discharge from the Tanana River to the aquifer and from the aquifer to the Chena River, as described by Glass et al. (1996). Variations in river stage through time are believed to be the primary cause of variations in flow direction through the aquifer between the rivers (Lilly et al. 1996, Nakanishi and Lilly 1998). Based on data from U.S. Geological Survey water table wells, the flow direction varies up to 19 degrees from a north-northwesterly direction to a few degrees east of north. The flow direction trends to the north-northwest in spring and more northerly in the summer and fall (Glass et al. 1996).

2.3 Current Groundwater Impacts

On-site groundwater monitoring data collected during the most recent annual and quarterly reporting periods (second and third quarter 2012, respectively) are generally consistent with data collected during previous reporting periods. Maximum concentrations of benzene (27,300 micrograms per liter [µg/L]), toluene (23,100 µg/L), ethylbenzene (1,450 µg/L) and total xylenes (16,100 µg/L) were detected in groundwater collected from monitoring well MW-138 during the second quarter 2012; these impacts are limited to the developed portion of the site. Sulfolane concentrations continue to be detected in both on-site groundwater observation and monitoring wells at concentrations up to 4,940 µg/L (O-1) and in offsite groundwater monitoring wells at concentrations up to 286 µg/L (MW-161B). The plume geometry inferred from third quarter 2012 monitoring well data is generally consistent with previous monitoring events (ARCADIS 2012b). Second and third quarter 2012 data are presented in quarterly groundwater monitoring reports (ARCADIS 2012b and 2012c, respectively)

2.4 Current Light Nonaqueous Phase Liquid Impacts

Depth to LNAPL measurements are regularly collected from a network of monitoring, observation, and recovery wells screened across the water table onsite. During the third quarter 2012, LNAPL accumulation was measured in 21 wells during July 2012, in 22 wells during August 2012, and in 28 wells during September 2012. A visible sheen or trace (not measureable in the field) was recorded in seven wells during July 2012, in eight wells during August 2012, and in two wells during September 2012. During the reporting period (on

September 19, 2012), a maximum LNAPL thickness of 2.89 feet was measured at monitoring well MW-176A (Figure 2). LNAPL thicknesses are consistent with historical LNAPL measurements.

2.5 Current Soil Impacts

Soil samples were collected at the site as described in the SCR – 2011 (Barr 2012).Based on recommendations outlined in the SCR – 2011 (Barr 2012), FHRA conducted further soil characterization of soil impacts at the site from May to August 2012. Areas for focused investigation included:

- Area around boring SB-143, the Southwest Area (Former EU Wash Area)
- Area near the exchanger wash skid
- Area around boring O-6, west of the railcar-loading rack in the historical storage yard
- Area around boring O-27, west of the current truck-loading rack area
- Area north of the asphalt-truck loading rack and O-25
- Lagoon B
- Area northwest of Lagoon B

As part of this supplemental investigation, FHRA collected and submitted 146 soil samples for laboratory analysis. Delineation of sulfolane and BTEX was achieved at some locations. However, laboratory analysis of the soil samples showed potential source-area level concentrations of sulfolane in the Southwest Area (Former EU Wash Area). Samples in this area were collected from the surface (0-2 feet bgs) and immediately above the air-groundwater interface (approximately 5-9 feet bgs). Additional borings were added during the investigation, but delineation of the elevated concentrations was not completed. Results of the soil investigations are discussed in the SCR – 2012 (ARCADIS 2013a).

2.6 Current Remedial Operations

FHRA is currently in the final stages of implementing the interim corrective actions described in the Interim Remedial Action Plan (IRAP; Barr 2010) to optimize the existing groundwater pump and treat remediation system to address LNAPL and impacted groundwater onsite. Operation of the remediation system currently involves groundwater recovery from five recovery wells (R-21, R-35R, R-39, R-40, and R-42). Recovered groundwater is treated through a prefilter for solids removal, a coalescer for LNAPL removal, and four air strippers for removal of volatile organic compounds before accumulating in the Gallery Pond. The groundwater from the Gallery Pond is then pumped through sand filters for solids removal and a four-vessel GAC system for sulfolane removal. Installation and startup of the sand filters and GAC treatment system was completed during the second quarter 2011 and active operation was initiated on June 9, 2011.

A fifth recovery well (R-42) was installed as part of the IRAP (Barr 2010) implementation and pumping from well R-42 was initiated on July 26, 2011. Also, in accordance with the IRAP (Barr 2010), nested monitoring wells MW-186 A/B/C were installed and a capture zone test was conducted in late August and early September 2011. Performance monitoring was conducted to evaluate the horizontal and vertical capture of the groundwater pump and treat remediation system. Results of the performance monitoring are discussed in the SCR – 2011 (Barr 2012).

FHRA is in the process of completing installation of four additional recovery wells (R-43, R-44, R-45, and R-46). These new wells will replace R-39 and R-40, and augment capture in the R-21 area. Recovery wells existing prior to 2012 are shown on Figure 3. A technical memorandum describing the proposed recovery wells was submitted to ADEC on September 14, 2012, and approval of the plan was received from the ADEC on October 3, 2012 (ADEC, pers. comm. 2012b). The proposed wells are designed with dual-phase capability to allow for a greater increase in both groundwater and LNAPL recovery. The proposed design includes deeper wells with larger diameter casings and longer screened intervals compared to the existing recovery wells. Each proposed well will have a submersible groundwater recovery pump and a floating LNAPL skimmer pump.

Pneumatic LNAPL recovery systems are continuously operated at MW-138, R-20R, R-21, R-35R and R-40. Additional pneumatic LNAPL recovery systems are operated seasonally at R-32, R-33 and S-50. The LNAPL recovery system currently utilized at S-50 was previously installed at O-2, but was moved due to low LNAPL recovery. FHRA also uses a hand-held product recovery pump at other locations (e.g., R-39) if LNAPL is present and recovery is possible. Recent LNAPL recovery data are included in the third quarter groundwater monitoring report (ARCADIS 2012c). An expanded LNAPL recovery network was proposed in the IRAP Addendum (ARCADIS 2013b).

Recovered LNAPL is recycled within the refinery process unit. In addition, LNAPL recovered from the groundwater stream by the groundwater recovery pumps is collected for recycling in a coalescer installed ahead of the air stripper. FHRA installed replacement recovery wells for R-21, R-39, and R-40 during the fourth quarter 2012. Development and operation of these new wells will be completed in second quarter 2013 to increase the system’s ability to capture groundwater and LNAPL (Barr 2012).

3. Current Conceptual Site Model

An updated ADEC onsite CSM was most recently updated in connection with the Revised Draft Final HHRA (ARCADIS 2012a) and was presented in the Draft Final Onsite Feasibility Study (Onsite FS; ARCADIS 2012d) and is included in Appendix A of this work plan. The CSMs will be refined as needed to account for additional data collected in the future.

4. LNAPL Investigation

LNAPL investigation activities proposed in this work plan include revisions to the baildown testing schedule, installation of additional or replacement LNAPL recovery wells, and an additional LNAPL composition evaluation. Baildown testing supports characterization of LNAPL transmissivity at the site. The LNAPL transmissivity results are used to quantify relative LNAPL recoverability to focus LNAPL recovery efforts in areas that have higher recovery potential and to establish practical limits of recovery. Additional LNAPL composition data will be used to assess the spatial distribution of BTEX in LNAPL.

4.1 LNAPL Baildown Testing Technical Background

The recoverability of LNAPL at an environmental site is influenced by many factors including LNAPL saturation in the impacted soil, soil permeability, and physical properties of the LNAPL. The saturation and permeability directly influence the relative permeability of LNAPL. Due to the interactions of groundwater, air, and LNAPL within petroleum-impacted soil, the relative permeability of LNAPL is less than the overall soil permeability. Moreover, the physical properties of the LNAPL influence the rate that LNAPL can flow within the formation. An empirical method to assess LNAPL recoverability at the field scale is to test LNAPL transmissivity, which integrates all of the relevant factors influencing LNAPL recoverability. LNAPL transmissivity is commonly characterized using short-term duration LNAPL stress testing, also called LNAPL baildown testing.

An LNAPL baildown test is initiated by quickly removing LNAPL accumulated in a well, making it analogous to a groundwater rising-head slug test. The rate of LNAPL flow into the well is a function of soil and LNAPL properties discussed above and the magnitude of the initial hydraulic gradient toward the well developed during LNAPL removal. The baildown test response is influenced by the prevalent fluid levels at the time of testing. Therefore, to obtain optimal results, baildown testing should be performed during seasonal hydrogeologic lows.

4.2 LNAPL Baildown Testing Schedule Revision

Baildown testing is currently performed semiannually during the second and fourth quarters. The LNAPL baildown testing schedule will be revised to target local hydrogeologic cycle minima instead of a calendar based schedule. Targeting the groundwater “low” will provide LNAPL baildown testing results that are more representative of the maxima of the transmissivity range.

The transducer network includes monitoring wells MW-113, MW-186A, MW-186B, MW-186C, MW-186E, O-12 and S-43 which are within or adjacent to the LNAPL body. The available transducer data from these wells were evaluated to determine the timing of the approximate seasonal hydrogeologic lows. The hydrographs for the wells listed above are included as Appendix C, and generally indicate a period of low seasonal groundwater elevations from approximately November to March. However, due to regional weather patterns, November through February is not a reliable period for conducting field work. Therefore, while data collection in March may be impeded by suboptimal weather conditions, LNAPL baildown testing is proposed for annual implementation in March. Testing during this will provide an assumed maximum LNAPL transmissivity. To evaluate transmissivity during periods of higher groundwater an additional test will be completed later in the year, no later than October.

LNAPL baildown testing will be conducted according to procedures outlined in the Revised Sampling and Analysis Plan (RSAP), which was most recently submitted with the Work Plan for Evaluation of Perfluorinated Compounds–Phase II (ARCADIS 2012e). Hydrographs are included in Appendix C.

4.3 Additional LNAPL Observation Well Installation for Transmissivity Testing

Active remediation is ongoing to recover LNAPL at the site. From 1986 through the end of 2012, approximately 394,000 gallons of LNAPL were recovered at the site. Annual recovery volumes have generally decreased as remediation has progressed and the volume of recoverable LNAPL has decreased. However, based on LNAPL baildown testing conducted in 2012, LNAPL transmissivities measured at the site indicate high LNAPL recoverability (ARCADIS 2012c; ARCADIS 2013c [In Press]). LNAPL baildown testing and transmissivity monitoring will take place at the wells specified below to support development of the Final Onsite FS and the Onsite Cleanup Plan.

LNAPL recovery is the physical removal of LNAPL from a well and reduces LNAPL saturation until it reaches residual saturation. At residual saturation, LNAPL will not flow and hydraulic recovery is no longer possible (Interstate Technology & Regulatory Council [ITRC] 2009). The effectiveness of LNAPL recovery is dependent on the flow of LNAPL into the recovery well at which recovery operations are conducted.

To further assess LNAPL transmissivity and potentially improve LNAPL recovery at the site, one replacement LNAPL recovery well and eight new LNAPL observation wells are proposed:

- R-32R – This well is proposed to replace existing well R-32. Well R-32 is currently installed as a shallow culvert and LNAPL recovery is limited due to groundwater elevation fluctuations below the bottom of the well. It is expected that a new, properly constructed LNAPL recovery well at this location will improve LNAPL recovery.

- O-31 through O-34 and O-36 through O-38 – These wells will provide additional LNAPL observation well density for baildown testing and potential future recovery operations within or near areas with known LNAPL impacts.

- O-35 – This well is proposed near the MW-176 well nest. Manual recovery is ongoing on well MW-176A which is a 2-inch PVC well. Properly constructed wells in this area will optimize transmissivity measurements and potential future recovery operations at this location.

Recovery and observation wells will be constructed as four-inch stainless steel risers with stainless steel wire-wrapped screens and installed according to procedure outlines in the RSAP. Proposed LNAPL recovery and observation wells are summarized in Table 1 and shown on Figure 5.

4.4 Additional LNAPL Composition Evaluation

As previously mentioned, LNAPL composition data were collected as part of two studies from 19 total wells as reported in the Site Characterization Report – Through 2011 (Barr 2012). FHRA will collect additional LNAPL samples for compositional analysis of petroleum constituents from the following wells to improve the spatial understanding of the BTEX fraction of the LNAPL:

- New LNAPL recovery and observation wells (R-32R and O-31 through O-38) proposed in Section 4.3, if LNAPL is present.

- Wells for additional LNAPL composition analysis: MW-186A, MW-334-15, O-19, and O-27.

- Select wells that have been previously evaluated for LNAPL composition: MW-138, R-33, and S-51.

Figure 6 presents the wells proposed for additional LNAPL composition analyses and locations where historical LNAPL composition data were collected.

5. Phase 8 Groundwater Monitoring Well Installation

Phase 7 monitoring well installation was completed in August 2012 (ARCADIS 2013a) to provide additional site characterization at the site. Phase 8 wells are proposed to further enhance the understanding of the vertical and lateral extent of the sulfolane and BTEX plumes and monitor contaminant removal by the remediation system.

5.1 Previously Proposed Phase 8 Monitoring Wells

Phase 8 monitoring wells at the north property boundary were proposed in the IRAP Addendum (ARCADIS 2013b). These previously proposed Phase 8 monitoring wells are summarized in Table 2 and presented on Figure 7.

5.2 Upgradient Groundwater Delineation

While upgradient monitoring wells (MW-105, MW-105A, MW-192A, MW-192B and MW-196 provide adequate upgradient monitoring data for the site, these wells are greater than 500 feet upgradient of the sulfolane source areas. To better define conditions upgradient of the process areas, FHRA proposes to install five new monitoring wells upgradient of Crude Units 1 and 2 and the sulfolane extraction unit. Proposed wells will be screened across the water table and are summarized in Table 2 and presented on Figure 7.

5.3 Proposed Additional Monitoring Wells for Further Characterization

Horizontal and vertical delineation of the sulfolane plume has progressed; however, to further enhance the understanding of the nature and extent of sulfolane impacts, FHRA proposes to install 11 additional onsite monitoring wells. Proposed wells described below are summarized in Table 2 and presented on Figure 7.

An additional deeper monitoring well (8-L) near the MW-154 well cluster will be installed to evaluate sulfolane concentrations deeper than the screened interval of MW-154B to support air sparge barrier design testing proposed in the IRAP Addendum (ARCADIS 2013b). During installation of well MW-154B, permafrost was observed at approximately 102 ft bgs, which may limit the installation depth of the additional well.

An additional deeper monitoring well (8-M) will be installed near MW-110 to further characterize sulfolane concentrations at 10 to 55 feet below the water table.

A new monitoring well (MW-174-15) is proposed to replace decommissioned well MW-111. The replacement well will be located near the MW-174 well cluster north of Lagoon C. Well MW-174-15 will be screened across the water table to support delineate of sulfolane concentrations identified during the Hydropunch investigation (ARCADIS 2013a).

A well cluster (8-N) will be installed to evaluate sulfolane concentrations in the area northwest of observation well O-1. This cluster will consist of a water table well, and a well installed approximately 50-ft below the water table.

Five new monitoring wells will be installed in the vicinity of well MW-138 for further characterization of the sulfolane plume downgradient of the extraction unit sump source area. One well (MW-337-20) will be installed just northeast of well MW-138 and screened a few feet below seasonal LNAPL fluctuations to monitor sulfolane concentrations without the presence of LNAPL during sampling. Four nested wells (MW-336-15, MW-336-20, MW-336-35, and MW-336-55) will be installed farther east-northeast of well MW-138 to further characterize sulfolane concentrations across the water table and 10 to 55 feet below the water table identified during the Hydropunch investigation (ARCADIS 2013a).

Three wells were proposed in the 2012 Site Characterization Work Plan (ARCADIS 2012f) for well nest 7-J: one screened across the water table and two screened at depth. Of these, two wells (MW-334-15 and MW-334-65) were installed. Installation of the third proposed well was temporarily postponed based on monitoring results from the other two wells. During the third quarter 2012, groundwater collected from well MW-334-65 exhibited an estimated sulfolane concentration of 6.21J µg/L. Therefore, the third well (MW-334-85) is proposed for installation and will be screened at a depth between 55 and 90 feet below the water table.

Soil samples will be collected during installation of these proposed wells, and will be submitted for laboratory analysis in accordance with the RSAP. Select soil samples will be submitted for laboratory analysis to determine concentrations of BTEX by US EPA Method 8021B, gasoline range organics by AK101, diesel range organics by AK102, polynuclear aromatic hydrocarbons by 8270C, and sulfolane by USEPA modified Method 8270D.

The additional proposed wells will also be sampled in conjunction with quarterly groundwater monitoring events according to procedures outline in the RSAP. Collected groundwater samples will be analyzed for sulfolane by modified USEPA Method 1625 with isotope dilution.

5.4 Additional Observation Wells for Groundwater Capture

FHRA updated the progress on the Recovery Well Replacement Project, an upgraded groundwater extraction system and LNAPL dual-phase recovery (DPR) program, in the IRAP Addendum (ARCADIS 2013b). The objectives of groundwater extraction and DPR operations are to provide capture of the shallow dissolved-phase sulfolane and BTEX plumes at the site and to recover LNAPL within the zone of treatment (Barr 2012).

Performance monitoring will be conducted to evaluate the effectiveness of the groundwater extraction system through assessment of hydraulic capture of downgradient contaminant concentrations in groundwater. To further evaluate trends and improve monitoring of contaminant capture of sulfolane and BTEX concentrations, additional wells screened in the 10 to 55 feet below water table groundwater zone are proposed for installation adjacent to observation wells O-5, O-12, O-24 and O-26 located downgradient of the groundwater extraction system. Proposed wells are summarized in Table 2 and presented on Figure 7.

Proposed wells will be installed according to procedures outlined in the RSAP. Groundwater samples will be analyzed for BTEX by USEPA Method 8021 and sulfolane by modified USEPA Method 1625 with isotope dilution.

5.5 Proposed BTEX Characterization and Delineation

As described in the SCR – 2011, FHRA proposed a "one-time" sampling of a subset of monitoring wells screened in the 10-55' BWT zone and the 55-90' BWT zone for BTEX (Barr 2012). Additionally, the SCR – 2011 recommended a discrete interval groundwater sampling investigation to obtain additional BTEX data, which was implemented and reported as the Hydropunch investigation in the SCR – 2012 (ARCADIS 2013a). Results from the Hydropunch investigation indicated that additional data within the vicinity of borings HP-14, HP-16, HP-45, HP-46 and downgradient of the BTEX monitoring wells will further refine site characterization in the 10 to 55 feet below water table and 55 to 90 feet below water table groundwater zones. To support BTEX delineation, FHRA proposed to collect "one-time" groundwater samples from four wells near HP-14 and HP-16 (MW-175, MW-186B/C, and MW-334-65), eight wells near HP-45 and HP-46 (MW-176B/C, MW-178B/C, MW-179B/C, and MW-180BC) and three wells downgradient from the BTEX monitoring wells (MW-101 and MW-154A/B). Wells proposed for additional BTEX characterization are summarized in Table 3 and presented on Figure 8.

Groundwater will be sampled according to procedures outline in the RSAP and groundwater samples will be analyzed for BTEX by USEPA Method 8021.

5.6 Wells Proposed for Abandonment

Wells INJ-MW-1 through INJ-MW-4 were installed to support a large-scale tracer test conducted in March 2012. The wells were constructed with 20-foot screens specifically to monitor injected water associated with the tracer test. Because the well screens span two separate groundwater zones (water table and 10 to 55 feet below water table), the wells are not suitable to monitor the sulfolane plume; therefore FHRA proposes to abandon wells INJ-MW-1 through INJ-MW-4 according to procedures outlined in the RSAP.

6. Soil Characterization

An extensive onsite soil investigation was conducted in 2011 to evaluate soil impacts at the site. Results from this investigation and specific recommendations for further soil characterization activities are summarized in the SCR – 2011 (Barr 2012). Further soil characterization activities were conducted in the Southwest Area (Former EU Wash Area) to delineate sulfolane concentrations identified in soil boring SB-143 during the 2011 soil investigation. Samples were collected from the surface (0-2 feet bgs) and immediately above the air-groundwater interface (approximately 5-9 feet bgs) at locations SB-188 through SB-197 and SB-235 through SB-251 (Figure 9). The maximum sulfolane concentration detected at each boring is depicted on Figure 9.

To delineate the southern lateral extent of sulfolane impacts near the Southwest Area (Former EU Wash Area), two additional soil borings will be advanced to the southeast of boring SB-249, to a depth of approximately 10 feet bgs and sampled for sulfolane by USEPA modified Method 8270D with isotope dilution. Boring advancement, soil sampling, soil classification, soil screening and field quality control measures will be completed in accordance with the procedures described in the RSAP. Similar to soil investigation activities completed in 2012, finer-grained soil layers will be targeted for analytical sampling. Boring logs will be prepared for each boring and submitted to the ADEC.

Additionally, FHRA proposes high density vertical soil sampling within the vicinity of boring SB-238 in the Southwest Area (Former EU Wash Area) to assess the vertical distribution of sulfolane in soil. The proposed soil boring will be advanced to approximately 10 feet bgs by continuous coring methods. A soil sample will be collected at every foot within the vadose zone and every three inches within the capillary fringe zone and analyzed for sulfolane by USEPA modified Method 8270D with isotope dilution. To determine where the top of the capillary fringe zone is encountered, soil moisture data will be collected and evaluated in the field with a soil moisture meter. Additionally, one sample from within the soil column will be collected and analyzed for bulk density. The proposed location for high density vertical soil sampling is depicted on Figure 9. The Southwest Area (Former EU Wash Area) contains elevated sulfolane concentrations in soil, and is therefore considered a target area where remedial activities may be conducted in the future. Data from the additional soil borings will assist FHRA in determining appropriate remedial activities for this area.

7. Investigation-Derived Waste

Waste materials generated during site investigation activities will be removed from the site and disposed of in a timely manner, in accordance with the RSAP.

8. Schedule

Data collected during the proposed additional site investigation activities will be added to the extensive historical site data set. The CSM and groundwater model will be refined if appropriate, based on the findings of these assessments. The data will support the preparation of the Final Onsite FS and Onsite Cleanup Plan.

Activities proposed in this work plan are anticipated to be completed during the 2013 field season. Updates on data collection will be presented to the ADEC during TPT meetings, Site Characterization Subgroup Meetings, and in quarterly groundwater monitoring reports.

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Tables

Table 1
Proposed LNAPL Recovery and Observation Wells

North Pole Refinery
North Pole, Alaska

Well	Rationale	Notes
R-32R	Replace 24-inch culvert to improve LNAPL recovery	
O-31	Potential area of high LNAPL recovery based on LNAPL baildown test data near well O-13	1
O-32	Evaluate LNAPL transmissivity in the proposed area.	
O-33	Evaluate LNAPL transmissivity in the proposed area.	
O-34	Evaluate LNAPL transmissivity in the proposed area.	
O-35	Proposed to improve LNAPL recovery at the MW-176 well nest.	
O-36	Evaluate LNAPL transmissivity in the proposed area.	
O-37	Evaluate LNAPL transmissivity in the proposed area.	
O-38	Evaluate LNAPL transmissivity in the proposed area.	

Notes:

[1] Baildown testing data collected in October 2012 and will be reported in the forthcoming Fourth Quarter 2012 Groundwater Monitoring Report (ARCADIS In Press).

LNAPL light non-aqueous phase liquids

Table 2
Proposed Wells for Additional Characterization and Delineation

North Pole Refinery
North Pole, Alaska

Well	Depth Zone (relative to water table) (feet bwt)	Rationale
Previously Proposed Phase 8 Monitoring Wells		
8-A	15 (WT), 25, 35, 50, 80, PF	Downgradient Well; monitor the north property boundary
8-B	15 (WT), 20, 40, 60, PF	Downgradient Well; monitor the north property boundary
8-C	15 (WT), 35, 50, 80, PF	Downgradient Well; monitor the north property boundary
8-D	15 (WT), 35, 50, 80, PF	Downgradient Well; monitor the north property boundary
8-E	15 (WT), 25, 35, 50, 65, 80, PF	Downgradient Well; monitor the north property boundary
8-F	15 (WT), 35, 50, 80, PF	Downgradient Well; monitor the north property boundary
Upgradient Groundwater Delineation		
8-G	WT	Upgradient Well; monitor near the process area
8-H	WT	Upgradient Well; monitor near the process area
8-I	WT	Upgradient Well; monitor near the process area
8-J	WT	Upgradient Well; monitor near the process area
8-K	WT	Upgradient Well; monitor near the process area
Proposed Additional Monitoring Wells for Further Characterization		
8-L	90-160	Support air sparge barrier design testing
8-M	10-55	Vertical delineation well for MW-110
8-N	WT and 10-55	Further characterization northwest of O-1
MW-174-15	WT	Replacement well for MW-111
MW-336-15	WT	Northeast of MW-138 to further characterize sulfolane plume
MW-336-20	10-55	Northeast of MW-138 to further characterize sulfolane plume
MW-336-35	10-55	Northeast of MW-138 to further characterize sulfolane plume
MW-336-55	10-55	Northeast of MW-138 to further characterize sulfolane plume
MW-337-20	10-55	Northeast of MW-138 to monitor sulfolane below LNAPL
MW-334-85	55-90	Vertical delineation well for MW-334-65
Additional Observation Wells for Groundwater Capture		
O-5	10-55	Additional nested well to monitor groundwater capture
O-12	10-55	Additional nested well to monitor groundwater capture
O-24	10-55	Additional nested well to monitor groundwater capture
O-26	10-55	Additional nested well to monitor groundwater capture

Notes:

BWT	Below water table
PF	Permafrost
WT	Water table

Table 3
Proposed Locations for BTEX Characterization and Delineation

North Pole Refinery
North Pole, Alaska

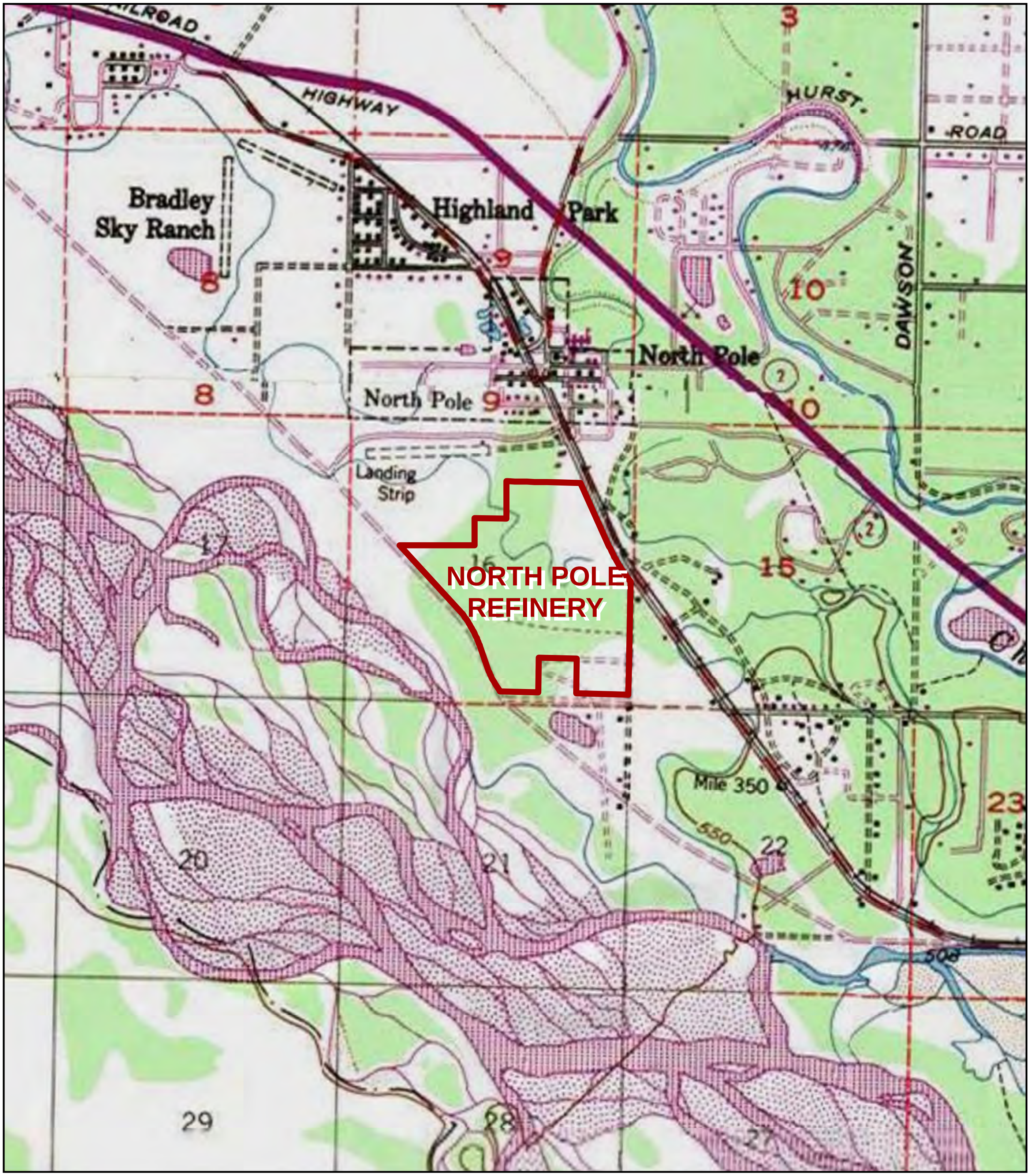
Well	Depth Zone (relative to water table) (feet bwt)	Well Screen Depth to Top (feet BGS)	Depth to Bottom (feet BGS)	Length (feet)
Monitoring wells in area of Hydropunch samples HP-45 and HP-46				
MW-176B	10-55	45.6	50.1	4.5
MW-176C	55-90	85.4	89.9	4.5
MW-178B	10-55	46.0	50.7	4.7
MW-178C	55-90	85.2	89.9	4.8
MW-179B	10-55	45.8	50.3	4.5
MW-179C	55-90	85.4	89.9	4.5
MW-180B	10-55	45.7	50.2	4.5
MW-180C	55-90	85.3	89.9	4.5
Monitoring wells in area of Hydropunch samples HP-14 and HP-16				
MW-175	55-90	85.8	90.3	4.5
MW-186B	10-55	50.7	60.4	9.7
MW-186C	55-90	90.7	100.3	9.6
MW-334-65	10-55	60.6	65.2	4.7
Downgradient Monitoring Wells				
MW-101	10-55	56.0	61.0	5.0
MW-154A	10-55	71.0	75.0	4.0
MW-154B	55-90	90.2	94.8	4.6

Notes:

BGS Below ground surface
BWT Below water table
BTEX Benzene/Toluene/Ethylbenzene/Xylenes (total)

ARCADIS

Figures



LEGEND:

FHRA PROPERTY BOUNDARY

0 0.5 Miles

GRAPHIC SCALE

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

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

SITE LOCATION

ARCADIS

FIGURE
1

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Project (Project #) B0081981.0006.00001
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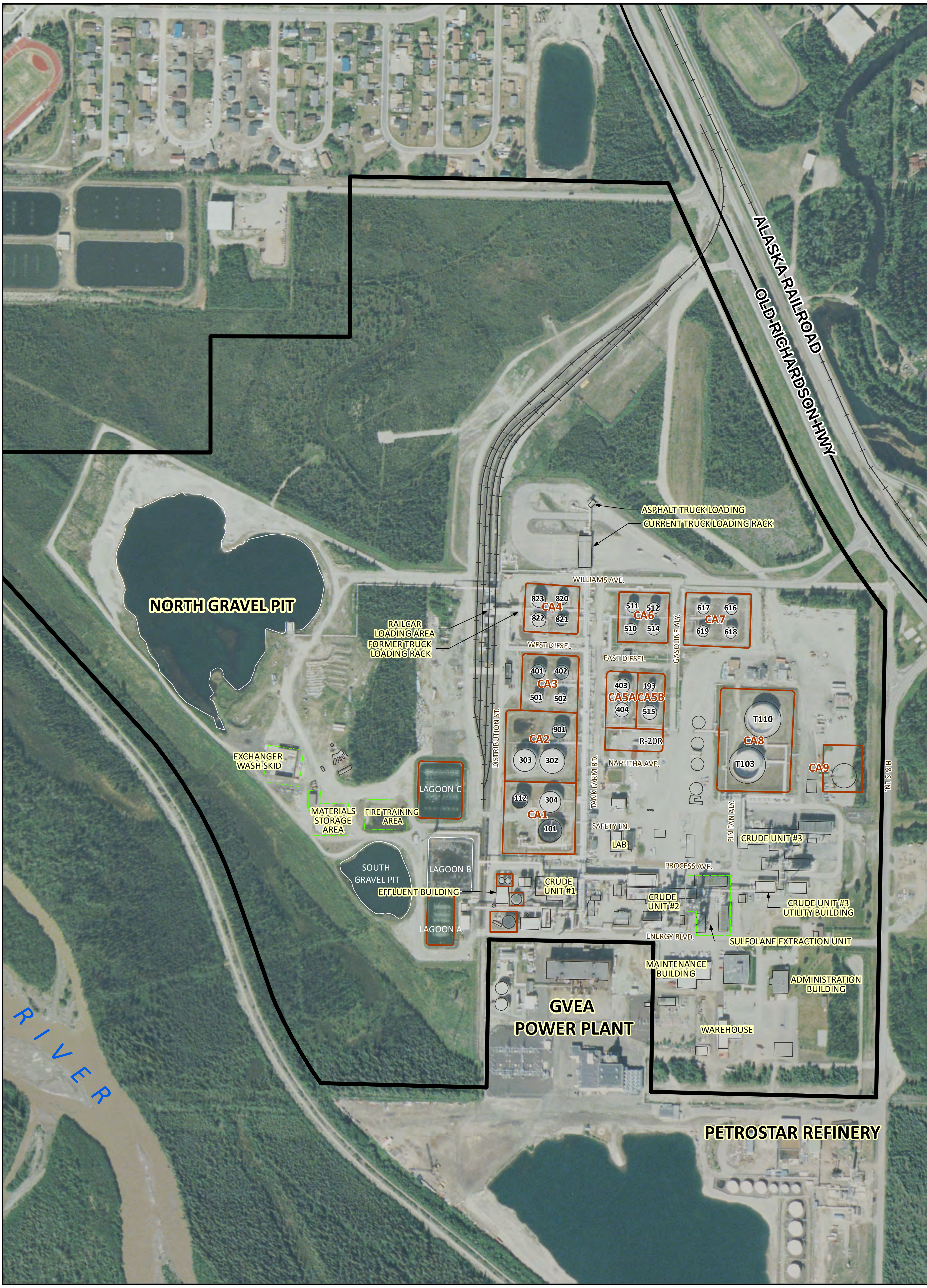

Legend
- Bermed Containment Areas (CA)
- Approximate Area
- FHRA Property Boundary

Notes:
Image Date June 9, 2007

0 400 800
SCALE IN FEET

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

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

CURRENT SITE FEATURES

ARCADIS

FIGURE
2

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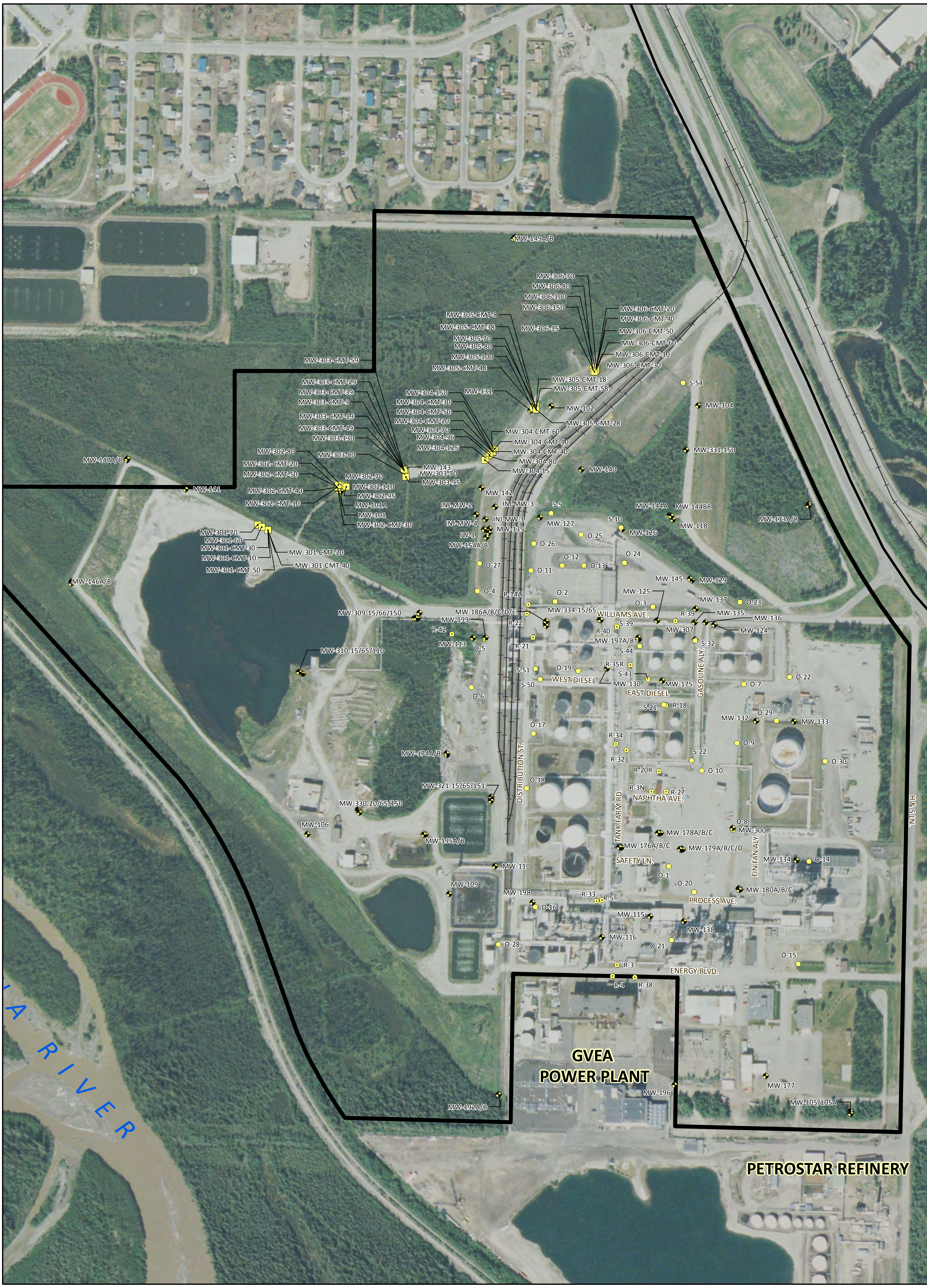

Legend
- Monitoring Well
- Recovery Well
- Observation Well
- Vertical Profile Transect Well
- FHRA Property Boundary

Note:
Image Date June 9, 2007

0 400 800
SCALE IN FEET

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

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

SITE PLAN - ONSITE

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FIGURE
3

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Legend:

- Monitoring Well
- Recovery Well
- Observation Well
- Vertical Profile Transect Well
- FHRA Property Boundary
- RAIL LINE
- Highway
- Major Road
- Local Road

0 3,300 6,600 Feet

GRAPHIC SCALE

Notes:
Image Date June 9, 2007

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

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

SITE PLAN - OFFSITE

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FIGURE
4

Legend

- MONITORING WELL
- VERTICAL PROFILE WELL
- OBSERVATION WELL
- RECOVERY WELL
- ACTIVE RECOVERY WELLS
- PROPOSED LNAPL OBSERVATION OR RECOVERY WELL
- ACTIVE/PROPOSED GROUNDWATER RECOVERY WELLS
- MANUAL PRODUCT RECOVERY
- INSTALLED PRODUCT RECOVERY SYSTEM
- FHRA PROPERTY BOUNDARY
- DIKED CONTAINMENT AREAS
- REFINERY UNITS
- 0.47 LNAPL THICKNESS RANGE (FEET)

Notes:
*LNAPL recovery systems installed in wells R-32 and R-33 are under evaluation.
Manual product recovery is completed with a vacuum truck or portable product pump.
LNAPL = Light non-aqueous phase liquid
Image Date June 9, 2007

0 200 400
SCALE IN FEET

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

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

PROPOSED LNAPL RECOVERY AND OBSERVATION WELLS

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FIGURE
5

CITY: SF DIV/GROUP: ENV/IM DB: BGRIFFITH LD: PIC: PM: TM: TR:
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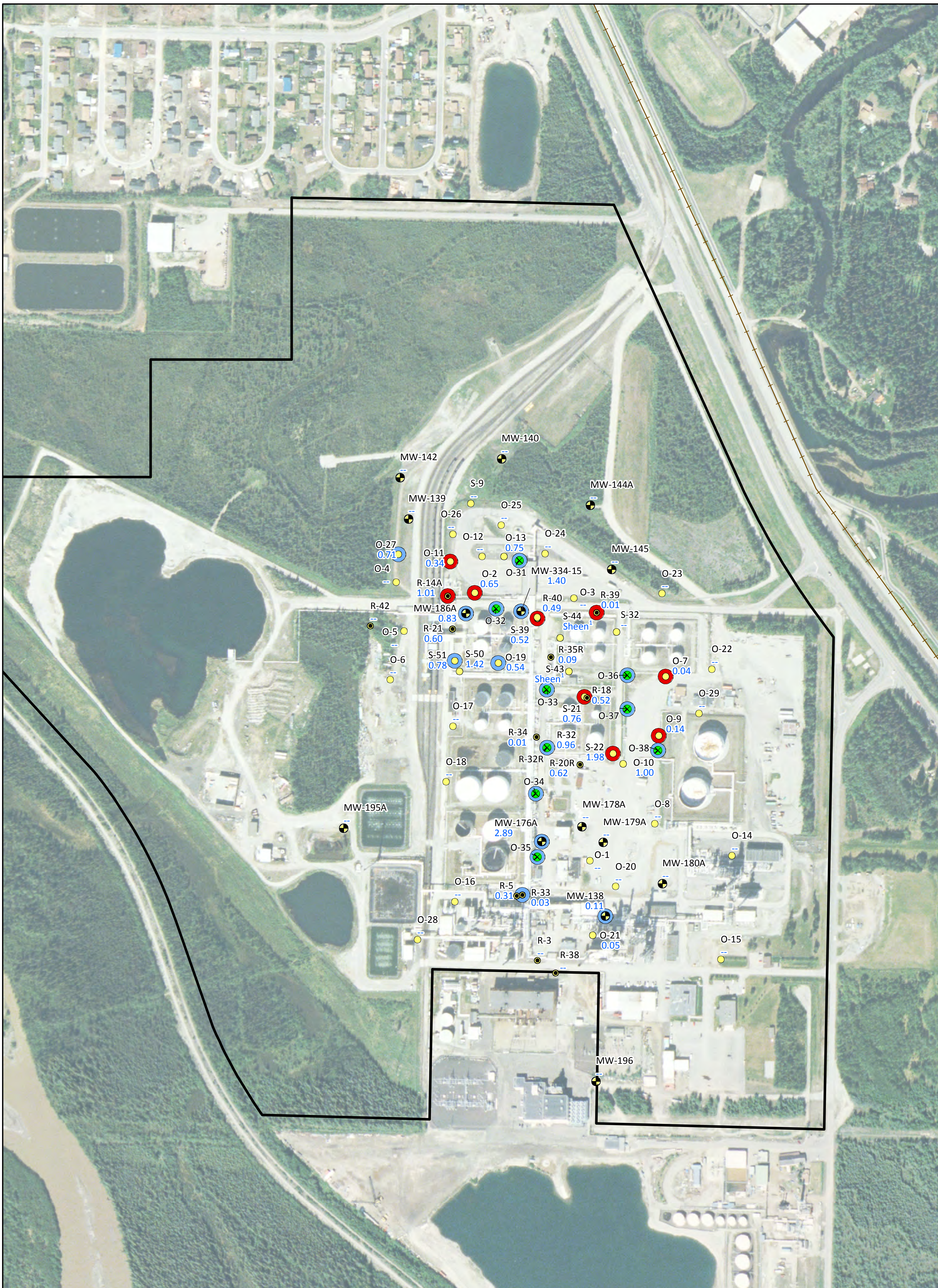

Legend

- Monitoring Well
- Observation Well
- Recovery Well
- Proposed LNAPL Observation or Recovery Well
- Proposed Additional LNAPL Composition Analysis
- Historical LNAPL Composition Data

FHRA Property Boundary

1.39	LNAPL Thickness (feet)
--	LNAPL was not detected
Sheen[1]	LNAPL not detected with air/product/water interface probe: LNAPL was visually observed

Notes:
LNAPL results posted on figure are in feet.
Data measured during third quarter 2012
Image date June 9, 2007

0 400 800
SCALE IN FEET

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

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

PROPOSED WELLS FOR ADDITIONAL LNAPL COMPOSITION ANALYSIS

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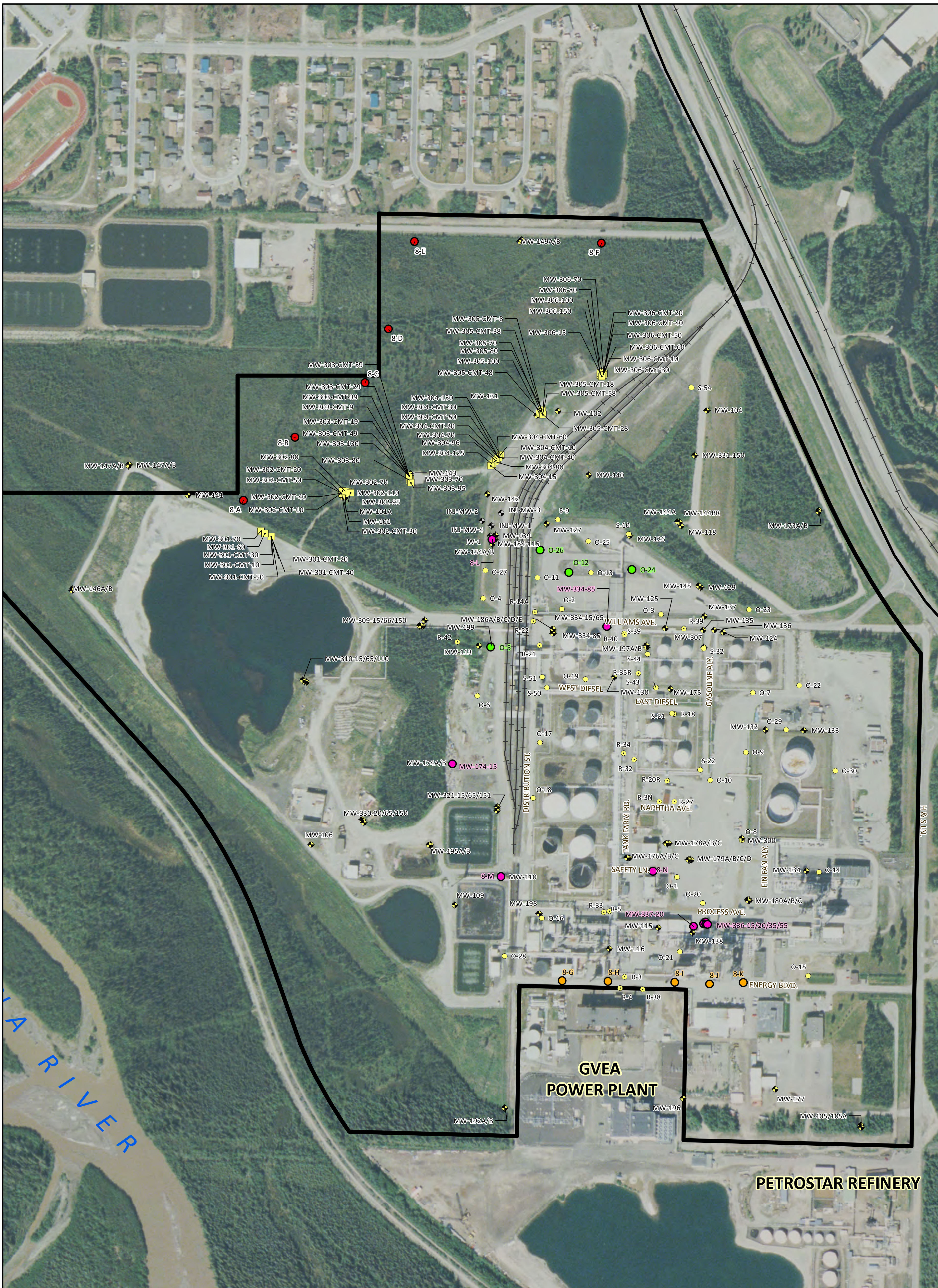
FIGURE
6

CITY: SF DIV/GROUP: ENV/IM DB: BGRIFFITH LD: PIC: PM: TM: TR:
PROJECT: (PROJECT #)
PATH: V:\FHR_AK\NorthPoleRefinery\SiteCharacterization2013\Fig 6 PropWells_AddCharDelineation.mxd 1/30/2013 11:02:33 AM



Legend
- Monitoring Well
- Recovery Well
- Observation Well
- Vertical Profile Transect Well
- Wells Proposed for Abandonment
- Proposed Downgradient Wells
- Proposed Upgradient Wells
- Proposed Additional Capture Evaluation Wells
- Proposed Characterization Wells
- FHRA Property Boundary

Note:
Image Date June 9, 2007

0 400 800
SCALE IN FEET

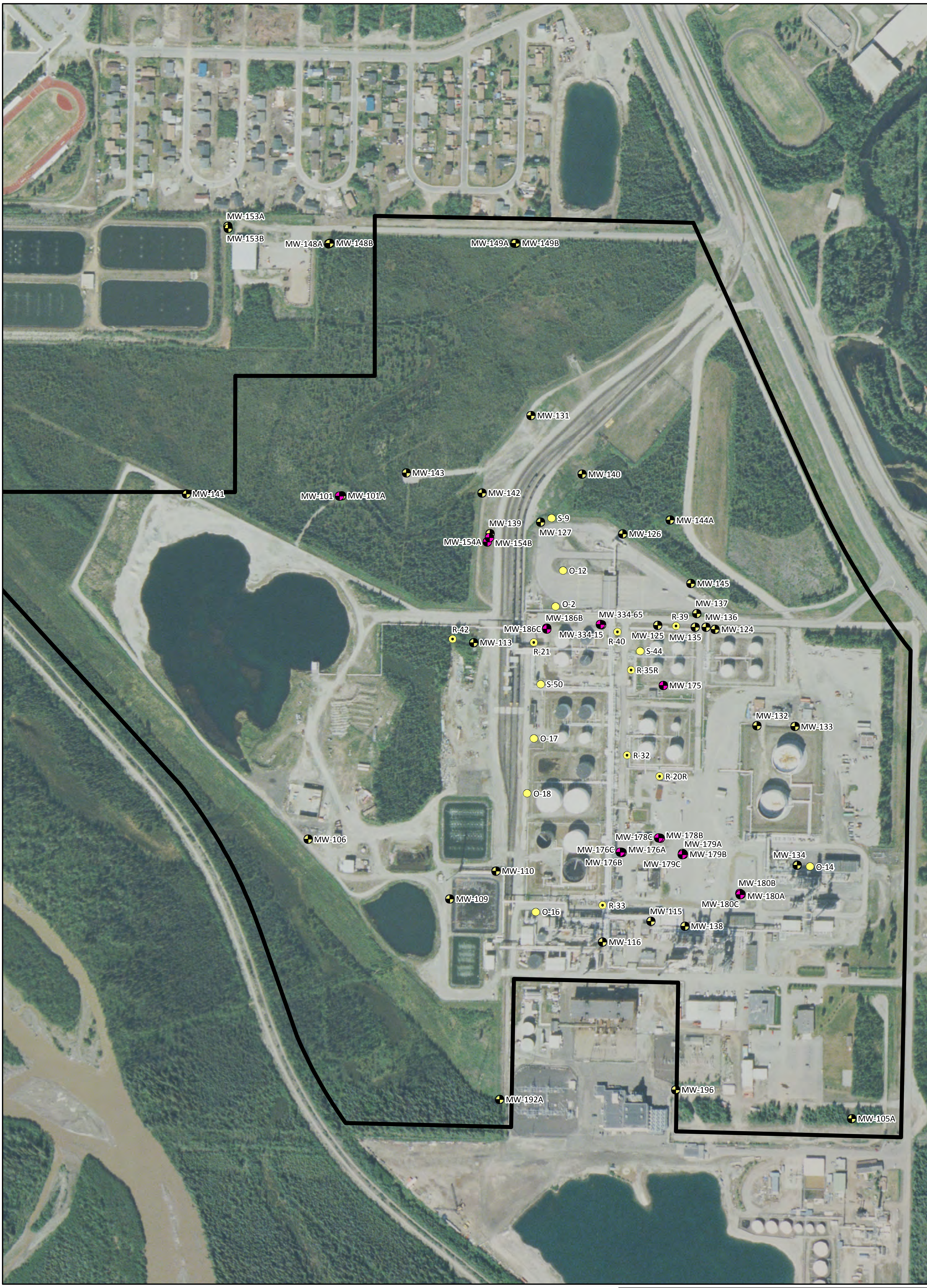
FLINT HILLS RESOURCES ALASKA, LLC
NORTH POLE REFINERY, NORTH POLE, ALASKA

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

PROPOSED WELLS FOR ADDITIONAL CHARACTERIZATION AND DELINEATION

ARCADIS

FIGURE
7



LEGEND:

- MONITORING WELL
- OBSERVATION WELL
- RECOVERY WELL
- PROPOSED SAMPLING LOCATION

FHRA Property Boundary

Image Date June 9, 2007

0 400 800 Feet

GRAPHIC SCALE

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

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

PROPOSED LOCATIONS FOR BTEX CHARACTERIZATION AND DELINEATION

ARCADIS

FIGURE 8

Notes:
All results are measured in milligrams per kilogram (mg/kg)

Result posted is the highest sulfolane concentration detected at that boring location

J - Result is considered estimated

Legend:

Soil Boring Sulfolane Results

- Non Detect
- 0.0043 - 0.043 mg/kg
- 0.043 - 0.43 mg/kg
- 0.43 - 4.3 mg/kg
- 4.3 - 43 mg/kg
- >43 mg/kg
- Proposed Soil Boring for Vertical Characterization
- Proposed Soil Boring for Lateral Delineation

0 30 60
SCALE IN FEET

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

2013 ON-SITE SITE CHARACTERIZATION WORK PLAN

PROPOSED SOIL BORING LOCATIONS
THE SOUTHWEST AREA (FORMER EU WASH AREA)

ARCADIS

FIGURE
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