2017 Kenai Groundwater Monitoring Program Work Plan

North and South Kenai Assets
Kenai, Alaska
AFE: 1751314

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ACRONYMS

°C	degrees Celsius
µS/cm	microSiemens per centimeter
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AK	Alaska Method
AOGCC	Alaska Oil and Gas Conservation Commission
BC	Beaver Creek
BCP4	Beaver Creek Pad 4
bgs	below ground surface
Brice	Brice Environmental Services Corporation
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTOC	below top-of-casing
CLU	Cannery Loop Unit
cy	cubic yards
DO	dissolved oxygen
DOT	Department of Transportation
DRO	diesel-range organics
EPA	U.S. Environmental Protection Agency
ft	feet
GAC	granular activated carbon
GRO	gasoline-range organics
HCl	hydrochloric acid
Hilcorp	Hilcorp Alaska, LLC
HVE	high vacuum extraction
KGF	Kenai Gas Field
LNAPL	light non-aqueous phase liquid
Marathon	Marathon Oil Company
mg/L	milligrams per liter
MS/MSD	matrix spike/matrix spike duplicate
mV	millivolts
NAVD88	North American Vertical Datum of 1988
NGC	natural gas condensate
NTU	nephelometric turbidity units
Oasis	Oasis Environmental Inc.
ORP	oxidation reduction potential
PAH	polycyclic aromatic hydrocarbons
POL	petroleum, oil, and lubricant
PPE	personal protective equipment
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
RRO	residual-range organics
SDS	safety data sheet
SLR	SLR International Corporation
SOP	standard operating procedures

ACRONYMS (continued)

SRF	Swanson River Field
TAH	total aromatic hydrocarbons
TAqH	total aqueous hydrocarbons
TLC	Teflon-lined cap
TLS	Teflon-lined septa
TS	Tank Setting
Unocal	Union Oil Company of California
USFWS	U.S. Fish and Wildlife Service
VOA	volatile organic analysis
VOC	volatile organic compounds

1.0 INTRODUCTION

Brice Environmental Services Corporation (Brice) personnel will mobilize to the Kenai Peninsula to conduct annual and semi-annual groundwater monitoring activities at the Hilcorp Alaska, LLC (Hilcorp) contaminated sites (North and South Kenai Assets) in the Kenai area. Figure 1 (Appendix A) presents the four sites where groundwater monitoring activities will take place: Beaver Creek (BC) Unit, Swanson River Field (SRF), Cannery Loop Unit 3 (CLU3), and the Kenai Gas Field (KGF) Unit.

1.1 Purpose and Organization of Report

This Work Plan describes the 2017 groundwater monitoring activities to be performed at the Hilcorp contaminated sites. This information has been organized into the following sections:

- Section 1.0 introduces the document purpose and organization, contact information for key personnel, site summary information, regulatory criteria, and schedule summary.
- Section 2.0 summarizes the health and safety considerations, including personal protective equipment (PPE) and evacuation routes.
- Section 3.0 describes project tasks, including field activities such as monitoring well inspection and maintenance; monitoring well installation and development; monitoring well gauging and analytical sampling; sample handling and chain-of-custody, waste management, and reporting.
- Section 4.0 provides site-specific details for the North Kenai Sites, including site conditions and analytical requirements.
- Section 5.0 provides site-specific details for the South Kenai Sites, including site conditions and analytical requirements.
- Section 6.0 lists the references used throughout the document.
- Appendix A contains Figures illustrating the site features, monitoring well locations, and groundwater flow directions.
- Appendix B provides the applicable Brice standard operating procedures (SOPs), including the field documentation forms.

1.2 Key Personnel

Table 1 lists the key personnel involved in these project activities along with their association to the project and their contact information.

Table 1: Key Personnel

Name	Organization	Title	Phone Number	Email
Kelley Nixon	Hilcorp	Project Manager	907.777.8335 (O) 907.350.3524 (C)	knixon@hilcorp.com
Greg Rutkowski	Hilcorp	Environmental Contractor	907.350.6742 (C)	grutkowski@hilcorp.com
John Coston	Hilcorp	SRF and BC Health and Safety	907.776.6726 (O) 907.227.3189 (C)	jcoston@hilcorp.com
Matt Hogge	Hilcorp	Kenai Gas Field (KGF) and CLU Health and Safety	907.777.8418 (O) 907.227.9829 (C)	mhogge@hilcorp.com
Bruce Hershberger / Joey Hensley	Hilcorp	SRF and BC Foremen	907.283.2541	bhershberger@hilcorp.com jhensley@hilcorp.com
Kevin Cassidy / Dale Ashe	Hilcorp	SRF Lead Operators	907.283.2543	kcassidy@hilcorp.com dashe@hilcorp.com
Warren Camp / Sean (Mac) Maguire	Hilcorp	BC Lead Operators	907.283.1317	wcamp@hilcorp.com / smaguire@hilcorp.com
Chris Walgenbach / Pete Iverson	Hilcorp	KGF & CLU Foremen	907.283.1382 / 907.283.1325	cwalgenbach@hilcorp.com / jpiverson@hilcorp.com

Table 1: Key Personnel (continued)

Name	Organization	Title	Phone Number	Email
Mike Chivers / Nick Fortney	Hilcorp	KGF & CLU Lead Operators	907.283.1345 / 907.283.1305	mchivers@hilcorp.com nfortney@hilcorp.com
Jennifer Anderson	Brice	Program Manager	907.275.2895 (O) 907.351.9158 (C)	janderson@briceenvironmental.com
Nicole Ward	Brice	Environmental Scientist	907.275.2913 (O) 907.230.7222 (C)	nward@briceenvironmental.com
Penny Bullock	Brice	Environmental Scientist	907.275.2866 (O) 907.229.6056 (C)	pbullock@briceenvironmental.com
Alison Sacks	Brice	Environmental Engineer	907.277.7290 (O)	asacks@briceenvironmental.com
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Peter Campbell	ADEC	Regulatory Specialist	907.262.3412	peter.campbell@alaska.gov
Paul Horwath	ADEC	Regulatory Specialist	907.262-3422	paul.horwath@alaska.gov

Notes:
For definitions, see the Acronyms section.

1.3 Summary of Sites

Table 2 summarizes the contaminated sites included in the 2017 groundwater sampling effort.

Table 2: Site Summary

Site Name	Wells[1]	ADEC File No.	ADEC Haz. ID No.	2017 Scope							
				Wells to be Sampled[2]	Wells to be Gauged	Wells to be Replaced	Wells to be Decommissioned	New Wells to be Installed	Wells to be Surveyed	Surface Water Points to be Sampled	LNAPL Socks to be Installed/Replaced
NORTH KENAI											
BCP4 (South)	17	2320.38.007	1005	4	17	--	--	--	1	--	--
BCP4 (North)	5	2320.38.081	26624	5	5	--	--	--	4	--	--
SRF Tank Setting 1-4	8	2334.38.018	441	6	8	1	1	--	2	--	2
SRF Electric Shop	9	2334.38.014	447	9	9	--	--	--	--	--	3
SRF Tank Setting 1-9	12	2334.38.019	448	6	12	--	--	--	--	--	2
SRF Tank Setting 1-27	7	2334.38.020	442	4	7	--	--	--	--	--	--
SRF Tank Setting 1-33	12	2334.38.021	443	5	13	2	2	1	3	--	1
SRF Tank Setting 2-15	5	2334.38.022	444	1	5	--	--	--	--	--	--
SRF Tank Setting 3-4	12	2334.38.023	445	6	12	--	--	--	--	--	2
SRF Tank Setting 3-9	14	2334.38.024	446	7	14	1	1	--	1	--	4
SOUTH KENAI											
CLU 3	14 [3]	2320.38.012	2063	7	14	--	1	--	14	--	--
KGF 14-6	31 [10]	2320.38.029	2434	13	31	--	1	--	31	8	3
KGF 34-31	16 [4]	2320.38.031	3331	10	16	--	4	--	16	--	--
KGF 41-7	20 [15]	2320.38.032	3191	17	20	1	4	--	20	7	--
KGF 41-18	14 [7]	2320.38.033	3189	7	14	--	7	--	14	5	--

Notes:
For definitions, see the Acronyms section.
[1] Lists the number of viable wells in solid text; abandoned or obsolete wells are indicated in brackets and gray text.
[2] Primary only; quantity does not include QA/QC samples.

1.4 Regulatory Criteria

Groundwater and surface water analytical results will be evaluated against the Alaska Department of Environmental Conservation (ADEC) groundwater cleanup levels presented in Title 18 of the Alaska Administrative Code (AAC), Chapter 75, Section 345 (18 AAC 75.345), Table C (ADEC 2017a) and the ADEC surface water quality criteria from 18 AAC 70.020 (ADEC 2017b). Current cleanup levels are presented below in Table 3.

Table 3: Groundwater and Surface Water Cleanup Levels

	Analyte	Cleanup Level[1] [mg/L]
POLs	DRO	1.5
	GRO	2.2
	RRO	1.1
BTEX	Benzene	0.0046
	Toluene	1.1
	Ethylbenzene	0.015
	Total xylenes	0.19
PAHs	1-Methylnaphthalene	0.011
	2-Methylnaphthalene	0.036
	Acenaphthene	0.53
	Acenaphthylene	0.26
	Anthracene	0.043
	Benz[a]anthracene	0.00012
	Benzo[a]pyrene	0.000034

	Analyte	Cleanup Level[1] [mg/L]
PAHs	Benzo[b]fluoranthene	0.00034
	Benzo[g,h,i]perylene	0.00026
	Benzo[k]fluoranthene	0.00080
	Chrysene	0.0020
	Dibenz[a,h]anthracene	0.000034
	Fluoranthene	0.26
	Fluorene	0.29
	Indeno[1,2,3-cd]pyrene	0.00019
	Naphthalene	0.0017
	Phenanthrene	0.17
	Pyrene	0.12
Other	Ethylene glycol	40
	TAH	0.010
	TAqH	0.015

Notes:

For definitions, see the Acronyms section.

[1] Groundwater cleanup levels as listed in 18 AAC 75.345, Table C (ADEC 2017a). Surface water quality criteria from 18 AAC 70.020 (ADEC 2017b).

1.5 Schedule Summary

Table 4 presents the preliminary project schedule, including planned start and end dates.

Table 4: Project Schedule

Activity	Deliverable Submittal Date / Deadline
Work Plan submission to ADEC	8/18/2017
Final Work Plan	9/25/2017
Field work	9/25/2017 to 10/23/2017
Reporting	11/6/2017 to 12/31/2017

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2.0 HEALTH AND SAFETY

Brice personnel will follow company safety procedures including use of PPE appropriate to project locations and activities. Table 5 lists emergency resources in the project area.

Table 5: Emergency Contact Information

Resource	Name/Association	Contact
Emergency	Emergency Line	911
Hospital	Central Peninsula Hospital 260 Caviar Street Kenai, Alaska 99611	907.714.4536
Fire	Kenai Fire Department 105 S Willow Street Kenai, Alaska 99611	907.283.7666
Police	Kenai Police Department 107 S Willow Street Kenai, Alaska 99611	907.283.7879

Notes:
For definitions, see the Acronyms section.

2.1 Personal Protective Equipment

Field personnel will wear modified level D PPE, consisting of the following:

- Hard hat
- Safety glasses
- Steel-toed boots
- High-visibility vest
- Gloves (leather or nitrile as appropriate)
- Fire resistant clothing and hearing protection will be worn as required.

2.2 Site Safety and Health

Personnel will coordinate site work and schedules with the Lead Operator at each site. Upon arrival at the site, personnel will check in with the site office and will participate in a site orientation and safety briefing. Hazards associated with groundwater and surface water sampling in the project area include remoteness of project locations, physical hazards, biological hazards, and chemical hazards.

2.2.1 Remoteness

Personnel will work in pairs and will maintain communication with site operators (checking in with the field office at the beginning and end of each work day) and the project team (daily reports and cell phone contact as necessary) to ensure personnel safety.

2.2.2 Physical Hazards

Physical hazards include, but are not limited to inclement weather; slips, trips, and falls; body strain; heat and cold stress; noise; and cuts. Weather hazards and potential for heat and cold stress will be mitigated by review of weather forecasts, frequent assessment for changing weather, and appropriate and layered clothing. Proper body mechanics will be employed to mitigate potential for body strain. PPE will be employed to mitigate other physical hazards, including noise, cuts, and slips, trips, and falls.

2.2.3 Biological Hazards

Biological hazards may include insect bites and stings, reactions to plants, and encounters with wildlife. Repellent, netting, and protective clothing will be employed as needed to mitigate exposure to insects and hazardous plants. First aid materials will be available and applied to treat bites, stings, and plant reactions as required. Personnel will work in pairs and will frequently assess their surroundings for wildlife. Air horns and bear spray will be available and employed as needed to deter interactions with wildlife. Personnel will take care to avoid wildlife interactions, such as releasing pulses on an air horn before entering areas of dense foliage.

2.2.4 Chemical Hazards

Personnel may be exposed to petroleum, oil, and lubricant (POL)-related contaminants such as diesel-range organics (DRO); gasoline-range organics (GRO); residual-range organics (RRO); benzene, toluene, ethylbenzene, and xylenes (BTEX); and polycyclic aromatic hydrocarbons (PAH). Detailed information regarding product identification, hazardous components, physical and chemical characteristics, fire and explosion hazard data, reactivity data, health hazards, precautions for safe handling and use, and control measures can be found in the associated safety data sheets (SDS). The SDS for each contaminant will be reviewed by every site worker prior to commencing work. If additional contaminants are suspected at a site, those SDSs will be evaluated as necessary.

3.0 PROJECT TASKS

Groundwater monitoring activities will be conducted by ADEC-qualified environmental professionals and will consist of the following:

- Monitoring well inspections and maintenance;
- Monitoring well installation and development;
- Monitoring well gauging;
- Analytical sampling, including the collection of groundwater and surface water samples;
- Sample handling and chain-of-custody;
- Decontamination of sampling equipment;
- Waste management; and
- Field documentation.

3.1 Monitoring Well Inspection and Maintenance

Monitoring wells will be inspected, including the outer casing, inner casing, locks, and bolts. The condition of the wells will be documented in the field logbook, including any present condition that may require maintenance (e.g., significant frost-heaving, locks that are broken or difficult to open, missing caps, etc.). In addition, maintenance will be performed as needed and recorded in the field logbook. Wells with casings where frost-heaving hindered closing of the protective cap may be cut down. Brice personnel will determine the northing, easting, ground surface elevation, and top-of-casing elevation (as necessary) for all monitoring wells with casings that have been cut. Monitoring wells will be surveyed within a horizontal accuracy of 1.0 feet and a vertical accuracy of 0.01 foot.

3.2 Monitoring Well Installation and Development

A direct push drilling unit will be used for well installation activities. The wells will be installed through the stem of the outer drill casing and will consist of 2-inch diameter, Schedule 40 polyvinyl chloride (PVC) riser. The wells will include a screened interval pre-packed with sand that will cover the groundwater interface and extend into the aquifer and vadose zone. Depending on the groundwater depth, the screen length will be 5 or 10 feet of 0.010-inch screen. The pre-packed screened section will be surrounded with sand or other filter material and capped with a bentonite grout seal. Each well will have an aboveground style completion, unless site conditions and activity dictate that a flush-mount completion is necessary.

Monitoring wells will be developed no earlier than 24 hours after well installation, and sampled no sooner than 24 hours after development. The wells will be developed by cyclically surging with a surge block (the entire submerged length of the screen will be surged for approximately 10 minutes in each cycle) and pumping with a submersible pump, a peristaltic pump, or a bailer. Sediment will be removed from the bottom of the well and well screen by surging and removing water the full length of the well screen. Initially, heavy silt loading may require the use of a bailer. A minimum of three well casing volumes (calculated from the borehole diameter and the length of screen below the water table, corrected for 30 percent porosity of the filter pack) of water and twice the volume of water added during drilling and construction will be removed. Monitoring wells will be considered developed after at least three well volumes are purged, stabilization of field parameters (listed below) has occurred, or when purged dry.

Well installation and development will be conducted in accordance with ADEC's *Monitoring Well Guidance* (ADEC 2013) and BE-SOP-22 *Monitoring Well Installation and Development* (Appendix B).

3.3 Monitoring Well Gauging Procedures

Groundwater levels will be measured in all monitoring wells to a precision of 0.01 feet (ft) relative to the north side of the well casing using an electronic water level meter or oil-water interface probe. Depth to groundwater and depth to product (if present) will be measured. All wells at a site will be gauged within 24 hours. Measurements will be conducted in accordance with BE-SOP-21 *Groundwater and LNAPL Measurements* (Appendix B).

3.4 Analytical Sampling

The following subsections describe the procedures that will be used to collect and identify analytical samples, including quality assurance/quality control (QA/QC) samples.

3.4.1 Groundwater Sampling Procedures

Groundwater samples will be collected from wells in accordance with low-flow sampling procedures based on U.S. Environmental Protection Agency (EPA) and ADEC guidelines (EPA 2010, ADEC 2017c) and SOP BE-SOP-09 *Groundwater Sample Collection* (Appendix B). Monitoring wells will be purged and sampled using a peristaltic pump, submersible pump, or bladder pump and disposable or dedicated tubing (depending on the well).

Water quality parameters will be continuously monitored using a portable water quality meter, such as a YSI, and turbidimeter (BE-SOP-20). Purging will be complete when at least three (four when using temperature) water quality parameters have stabilized or when three well volumes have been removed from the well. Criteria for low-flow sampling are as follows:

- Drawdown during purging will be less than 0.3 ft, if possible.
- Low-flow rates are typically between 50 to 500 milliliters per minute (0.01 to 0.13 gallons per minute), but higher rates are consistent with low-flow guidelines as long as the drawdown requirement is met.
- Water quality parameters will be recorded as tabulated in Table 6.

Water quality parameters will be considered stable when three successive readings, collected 3-5 minutes apart, are within the criteria included in Table 6.

Table 6: Stability Criteria for Low-Flow Purging

Parameter	Units	Recording Precision	Stability Criterion	Typical Value Range for Stability Criterion
pH	—	0.01	±0.1	5 to 8
Temperature	°C	0.01	±3% (minimum of ±0.2°C)	0.1 to 15
Conductivity	µS/cm	1	±3%	80 to 1,000
Turbidity	NTU	0.1	± 10% or ± 1 NTU (whichever is greater)	0.3 to > 900
ORP	mV	1	±10 mV	-120 to 350
DO	mg/L	0.1	±10% or 0.2 mg/L (whichever is greater)	0 to 12

Notes:
For definitions, see the Acronyms section.
Stability criteria from ADEC *Field Sampling Guidance* (ADEC 2017c).
Only three parameters are required to stabilize, four when using temperature.

If a well is purged dry, it will be allowed to recharge for 24 hours. Without further purging, the well will be sampled. For low yield wells that are purged dry, the well will be sampled when the well has recharged to approximately 80% of its pre-purge volume per the ADEC *Field Sampling Guidance* (ADEC 2017c).

If light non-aqueous phase liquid (LNAPL) is observed in a well, the thickness of the LNAPL will be documented, but the well will not be sampled. As applicable, LNAPL will be removed to the extent practicable and LNAPL-absorbent socks will be installed or replaced.

Groundwater samples will be submitted to an ADEC-approved laboratory for analytical testing. Table 7 summarizes the analytical parameters, methods, containers, and preservation. Analytes for each groundwater sample are specified in the site-specific sections (Section 4.0), and the analytical results will be compared to the ADEC Table C cleanup levels (refer to Table 3).

Table 7: Summary of Analyses

Parameter	Method	Container Description	Preservation / Holding Time
Groundwater			
DRO/RRO	AK102/AK103	(2) 250 mL amber glass jar, TLC	HCl preservative, 0 to 6°C 14 days to extraction, 40 days to analysis
GRO	AK101	(3) 40 mL VOA vials, TLS	HCl preservative, 0 to 6°C 14 days
BTEX	EPA SW8260C	(3) 40 mL VOA vials, TLS	HCl preservative, 0 to 6°C 14 days
Ethylene glycol	EPA SW8015C	(3) 40 mL VOA vials, TLS	0 to 6°C, 14 days
Surface Water			
TAH/TAqH[1]	EPA 624	(3) 40 mL VOA vials, TLS	HCl preservative, 0 to 6°C 14 days
	EPA 625	(2) 250 mL amber glass jar, TLC	0 to 6°C 7 days to extraction, 40 days to analysis

Notes:
For definitions, see the Acronyms section.
[1] TAH is calculated from the sum of the BTEX compounds; TAqH is calculated from the sum of TAH plus PAH compounds. PAHs include acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene.

3.4.2 Surface Water Sampling Procedures

Surface water samples will be collected from KGF 14-6, KGF 41-7, and KGF 41-18. Surface water sample locations are identified on the site-specific figures in Appendix A (Figures 20, 22, and 23). Color, odor, and presence of sheen (or lack thereof) will be noted at each surface water sampling location in the field logbook. A clean container will be used to transfer surface water into laboratory-supplied pre-preserved sample jars (as applicable depending on analysis). Surface water samples will be collected in accordance with BE-SOP-10 *Surface Water Sampling* (Appendix B).

3.4.3 Quality Assurance/Quality Control

Field duplicate samples will be collected at a frequency of one per day and one for every 10 or fewer field samples (whichever is more frequent), for each matrix and for each target analyte (10%). At a minimum, one field duplicate will be collected per site and per day of sampling at that site. Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one MS/MSD set for every 20 or fewer field samples (5%). At a minimum, one MS/MSD sample will be collected per site. These QA/QC sampling frequencies will be applied to each site individually; field duplicate and MS/MSD samples will not be shared between the sites described in Sections 4.0 and 5.0.

A trip blank will be submitted with each cooler containing samples for volatile analyses (GRO by AK101, or BTEX by SW8260C). Quantities of QA/QC samples will be determined for each site independently. Samples will be segregated by site and submitted to the laboratory under separate chain-of-custody forms.

3.4.4 Sample Identification

The sample identification nomenclature for this project is defined below:

- The first set of characters identify the site
  - BCP4S represents Beaver Creek Pad 4 (South)
  - BCP4N represents BCP4 (North)
  - SRF14 represents Swanson River Field Tank Setting 1-4
  - SRFES represents SRF Electric Shop
  - SRF19 represents SRF Tank Setting 1-9
  - SRF127 represents SRF Tank Setting 1-27
  - SRF133 represents SRF Tank Setting 1-33
  - SRF215 represents SRF Tank Setting 2-15
  - SRF34 represents SRF Tank Setting 3-4
  - SRF39 represents SRF Tank Setting 3-9
  - CLU3 represents Cannery Loop Unit 3
  - KGF146 represents Kenai Gas Field 14-6
  - KGF3431 represents KGF 34-31
  - KGF417 represents KGF 41-7
  - KGF4118 represents KGF 41-18
- The second set of characters identifies the well
  - e.g. MW4 identifies well MW-4
  - e.g. SW01 identifies the first surface water sample collected at that site
- The third set of characters identifies the month and year that the sample was collected
  - e.g. 0717 indicates July 2017

For example, a sample collected in October 2017 from well TS1-27L at the SRF Tank Setting 1-27 site would be labeled “SRF127-TS127L-1017.” Duplicate samples will be identified by a “Z” appended to the well designation; for example, a duplicate sample of the previous example would be labeled “SRF127-TS127LZ-1017.”

3.5 Sample Handling and Chain-of-Custody

Following sample collection, jars will be sealed, labeled, and immediately placed in a cooler with gel ice to maintain a temperature between 0 and 6 degrees Celsius (°C). A temperature blank and a trip blank will be kept with the samples. A chain-of-custody will be prepared in accordance with BE-SOP-02 *Sample Chain-of-Custody* and will accompany the samples from the time of collection until the samples are delivered to the ADEC-certified laboratory for analysis. Samples will be packaged and shipped to the analytical laboratory in accordance with BE-SOP-03 *Labeling, Packaging, and Shipping Samples* (Appendix B).

3.6 Decontamination

Reusable, non-dedicated sampling equipment requiring decontamination, including the electronic water level meter, pump, turbidimeter, and YSI, will be decontaminated between uses at each monitoring well. Disposable tubing will be used for purging and sampling in wells where dedicated tubing is not provided.

Decontamination will consist of washing the equipment with a mixture of potable water and Alconox, followed by a deionized or distilled water rinse. The water generated during decontamination activities will be collected in a tub or 55-gallon drum (for decontamination water generated from drilling equipment), or 5-gallon buckets with screw-top lids (for water generated from decontamination of sampling equipment). Decontamination water will be filtered using a granular activated carbon (GAC) filter and discharged at the point of generation. Decontamination procedures are detailed in BE-SOP-14 *Equipment Decontamination* (Appendix B).

3.7 Waste Management

Investigative-derived waste will be generated during groundwater sampling activities including purge water, decontamination water, and general refuse (to include expended PPE, such as nitrile gloves, paper towels, and disposable tubing).

Water will be collected in Department of Transportation (DOT)-approved 5-gallon buckets with screw-top lids, or in 55-gallon drums, and passed through a portable GAC unit at the point of generation. The water will be visually inspected for sheen, and discharged to a vegetated area at each site through the GAC filter. The GAC filter will be placed in a 5-gallon bucket, and the wastewater without sheen will be poured over the GAC filter. The GAC filter will be removed from the 5-gallon bucket, and the filtered water will be discharged to a vegetated area of the site at least 100 ft from surface water bodies. At the end of the field event, the spent GAC material will be placed in a DOT-approved, 55-gallon drum with the well installation soil cuttings for offsite disposal. Spent LNAPL-absorbent socks will also be containerized and disposed of offsite. Purge water with sheen will be disposed of by Hilcorp.

General refuse will be disposed of as solid waste in Kenai.

3.8 Field Documentation

Fieldwork will be documented in field logbooks and groundwater sampling forms in accordance with BE-SOP-01 *Logbook Documentation and Field Notes*. Daily reports will also be provided to summarize daily activities and overall project progress. Field documentation will be appended to the final report.

3.9 Reporting

After the completion of field activities and receipt of all analytical laboratory data, a report will be submitted in draft and final versions. The content of this report will include the following:

- A summary of project goals and objectives;
- A detailed description of completed field activities;
- Analytical data tables;
- An interpretation of the analytical data, and a summary of the data quality and usability;
- ADEC Laboratory Data Review Checklists;
- Site figures;
- Supporting field documentation;
- Copies of the chains-of-custody, a sample summary, and cooler receipt forms;
- A photographic log; and
- Conclusions and recommendations.

An individual draft report will be prepared for each site and will be provided to Hilcorp for comments. Comments will be incorporated into a final report version for submittal to ADEC and inclusion in the administrative record.

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4.0 SITE-SPECIFIC INFORMATION – NORTH KENAI SITES

The following subsections detail the North Kenai Sites, sampling requirements, and analyses. Appendix A includes the figures presenting the sites and well locations.

4.1 Beaver Creek Pad 4 (South)

BCP4 is located approximately 50 air miles southwest of Anchorage, Alaska, and approximately 12 miles northeast of Kenai, Alaska, as shown on Figure 2. BCP4 is located at latitude 60°39'31.8" north, longitude 151°2'14.21" west, on land leased from the U. S. Fish and Wildlife Service (USFWS) within the Kenai National Wildlife Refuge. Hilcorp took over the lease and operations of the facility from Marathon Oil Company (Marathon) in 2013.

BCP4 was constructed by Marathon in 1966 to facilitate natural gas and crude oil production in the area. A production well with two reserve pits was drilled in 1972 and produced crude oil. Drilling muds were buried in the western reserve pit. Additional infrastructure, ranging from production facilities to offices, was constructed on the pad. In 2000, ADEC granted closure of the western reserve pit (SLR International Corporation [SLR] 2014d). Environmental investigations and monitoring activities have been conducted at BCP4 (South) (Figure 9) since 1990.

4.1.1 Geology and Hydrogeology

The Beaver Creek facility is located on glaciolacustrine deposits from the Holocene and Upper Pleistocene. Complex stratigraphy underlies the Beaver Creek facility, with relatively thick silt aquitards above thinly-bedded sand aquifers. Clayey silt and clayey sand intervals occur at approximately 20 ft below ground surface (bgs) and deeper (SLR 2014d).

Groundwater elevations measured at the site since 2009 range from 121 to 133 ft above mean sea level. Groundwater flow has historically been to the west-east, with mounding in the vicinity of monitoring well AP-10 (which was replaced with well AP-10R in 2016 and is presented on Figure 9) (SLR 2014d).

4.1.2 Previous Investigation and Monitoring Activities

The following subsections describe the previous investigations and monitoring efforts conducted at the Beaver Creek Pad 4 area associated with the 1990 diesel spill near the Generator Building.

In 1990, a diesel spill was encountered near the Generator Building south of the Office/Shop Building (Figure 9). Between September 1990 and September 1991, approximately 984 cubic yards (cy) of diesel-impacted soil was removed near the Generator Building and thermally treated. The extent of the excavation was reportedly limited by proximity to the Generator Building and the presence of the main access road. Two soil borings and groundwater monitoring wells were installed at this time to assess contamination of soil and groundwater (SLR 2014e).

Monitoring assets were expanded in June of 1992 with the addition of 18 soil borings and 13 monitoring wells. With the goal of determining the extent of groundwater contamination, subsurface hydrogeology, and potential for in-situ bioremediation, soil and groundwater samples were collected and analyzed for petroleum constituents, nutrients, and microbial analytes. At this time, LNAPL was observed in one of the monitoring wells (SLR 2014e).

Later in 1992, additional investigations were performed to determine the boundary of the initial diesel release and the extent of contamination at the facility. Three monitoring wells were installed, soil and groundwater samples were collected, and a geophysical survey was conducted to evaluate subsurface soil lithology. Soil sampling indicated petroleum contamination was present at concentrations exceeding ADEC Method Two migration to groundwater soil cleanup criteria for the under 40-inch precipitation zone (SLR 2014e).

Routine groundwater monitoring began in 1995 and passive free-product-recovery skimmers were installed in monitoring wells AP-9 and AP-15. AP-9 was abandoned in 1999 and in 2000 monitoring well AP-29 was installed near the original AP-9 location. AP-29 was drilled at an angle of approximately 28 degrees from vertical to reach under the Generator Building (Oasis Environmental Inc. [Oasis] 2001). Annual gauging and sampling has been conducted since 1995, except in 1998 when only quarterly gauging of static water levels and LNAPL thickness were completed. Parameters analyzed routinely included GRO, DRO, RRO, and BTEX. DRO and/or benzene have been detected exceeding ADEC groundwater cleanup levels in five monitoring wells (AP-3, AP-10, AP-14, AP-25, and AP-26). LNAPL has consistently been encountered in two monitoring wells (AP-15 and AP-29). Groundwater flow and contaminant concentrations indicate two aboveground storage tanks are the likely sources of contamination. Although no longer on site, one was located next to the existing Generator Building and one was near a previous generator building located near AP-15 (Oasis 2008).

In 2007, a site assessment was performed with the focus of further defining groundwater contamination from the previously described tank releases and to evaluate ethylene glycol contamination discovered in 2000 near the Compressor and Manifold Buildings (Figure 9). As part of this assessment, four new soil borings were drilled, three of which were completed as monitoring wells AP-32 through 34, to delineate vertical and horizontal extents of the ethylene glycol and diesel hydrocarbon plumes.

A drum of waste sediment and water was collected from the floor sump in the Office/Shop Building (Figure 9) in November 2007. Analytical results indicated the presence of crude, lube oils, and chlorinated solvents. The closest monitoring well to the area (AP-25) was checked for observed constituents by sampling for volatile organic compounds (VOC) and Resource Conservation and Recovery Act (RCRA) metals to identify possible impacts from the septic drain field. Analytical results from AP-25 indicated no contamination present from the drain field above the ADEC groundwater cleanup levels. Drain sump sediments were removed and disposed of by Emerald Alaska. The sump within the shop was then isolated. In 2008, the septic system was removed and replaced with a holding tank (SLR 2014e).

Quarterly groundwater sampling between October 2007 and September 2008 indicated that the DRO plume near the Office/Shop area is stable aside from some glycol compounds appearing in one well, AP-10, within the diesel plume area, and one well north of this plume area, AP-25, located within the septic drain field (Figure 9). Review of DRO analytical gas chromatograms for samples from AP-10 indicated contribution to DRO concentrations by glycol compounds of an unknown source. Fecal coliform was not detected in wells AP-10 and AP-25; therefore, possible impact from the septic system leachate was deemed inconclusive (SLR 2014e).

During the 2008 assessment, glycol and diesel fuel were detected at the Compressor and Manifold Buildings, but the impacts were not fully delineated. Additional delineation of glycol impacts at this location was deemed unnecessary by ADEC due to the low concentration and intermittent nature of the exceedances. Groundwater sample results for all other parameters did not exceed associated ADEC groundwater cleanup levels during the 2008 assessment (SLR 2014e).

Soil gas testing was conducted in July 2008 by Oasis to evaluate potential biodegradation remedial activities and ongoing natural attenuation. Impacted monitoring wells (AP-15, AP-25, AP-26, and AP-29) showed a characteristic oxygen deficiency and carbon dioxide surplus compared to a background well, suggesting aerobic biodegradation of organic constituents. It was also reported that biodegradation could be causing anaerobic conditions, and that the addition of oxygen to contaminated zones could stimulate natural attenuation of present contaminants (SLR 2014e).

Routine groundwater monitoring was conducted at BCP4 in February and October 2010. The dissolved-phase and LNAPL plume near the Generator Building and south of the Office/Shop Building was found to be stable when compared with previous data. During 2010, none of the samples collected from wells surrounding the Generator Building plume area contained DRO at a concentration greater than the ADEC groundwater cleanup level. No samples collected in the Generator Building plume area contained evidence of glycol (SLR 2014e).

Monitoring of wells near the Compressor and Manifold Buildings revealed detectable glycol only once, at AP-3 in February 2010. Review of gas chromatograms indicated glycol at the site is mixed approximately 50% with diesel fuel. Only DRO was detected above ADEC cleanup levels in one monitoring well, AP-3, during February 2010 (SLR 2014e).

Petropore™ passive skimmers were deployed in monitoring wells AP-15 and AP-29 because of previously-reported LNAPL. Removal of these skimmers was recommended due to a reported lack of recovery (SLR 2014e).

Groundwater monitoring activities were completed by Oasis between 19 October and 4 November 2011. All DRO sample results were less than the ADEC groundwater cleanup criteria in the Generator Building plume area near AP-26. The two passive skimmers in wells AP-15 and AP-29 were removed and free-product was still noted in these wells. Samples were collected from three monitoring wells in the Compressor and Manifold Building area. No impact was indicated at well AP-32, and DRO was only detected at concentrations less than ADEC groundwater cleanup levels in samples from AP-3 and AP-33 (SLR 2014e).

A Groundwater Monitoring Program Optimization was conducted in 2015 in an effort to improve data quality of ongoing monitoring efforts, remove potential redundancy in the well networks, and ensure that continued monitoring is protective of human health and the environment in accordance with 18 AAC 75. The Optimization consisted of a review of historical analytical results, groundwater flow directions, and presence of LNAPL in order to determine if any wells could be removed from the sampling program or if sampling frequencies or analytes could be adjusted.

Based on the well-by-well assessment of the BCP4 groundwater monitoring program during the optimization effort, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

During the 2015 annual groundwater monitoring activities, water levels were measured at 17 wells located at the BCP4, and groundwater flow was determined to be generally toward the northeast. Groundwater quality parameters and analytical samples were collected from ten wells. Samples were analyzed for DRO. Additionally, two wells, AP-3 and AP-33, were sampled for BTEX and ethylene glycol (Brice 2016a).

The 2015 groundwater monitoring results indicate that all DRO, BTEX, and ethylene glycol concentrations, excluding DRO in AP-10, were non-detect or are less than ADEC cleanup levels. Measurable LNAPL was observed in AP-15 and AP-29, measured to be 0.10 and 0.14 feet thick, respectively. A total of approximately 0.5 gallon of product was removed from AP-15 and AP-29 and disposed of with purge water at the Beaver Creek facility (Brice 2016a).

4.1.3 2017 Groundwater Monitoring Activities

BCP4 (South) groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Sample two wells for DRO: AP-10R and AP-25. (Well AP-10 was replaced in September 2016 with flush-mount well AP-10R.)
- Eight wells are sampled for DRO at a frequency of every four years and will be sampled next in 2019: AP-3, AP-4, AP-14, AP-28, AP-30, AP-31, AP-33, and AP-34. Groundwater levels will be gauged in these wells in 2017. AP-3 and AP-33 were previously analyzed for ethylene glycol. As documented in the 2015 Groundwater Monitoring Report, ethylene glycol was not detected in any samples and is no longer considered a contaminant of concern.
- Remove LNAPL from AP-15 and AP-29. If LNAPL is not present, sample well(s) for BTEX.

- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Resurvey top-of-casing elevations if significant changes in monitoring well elevations are observed, such as frost-heaving.

Table 8 identifies the BCP4 (South) wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 9. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 8: BCP4 (South) Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES		QUALITY CONTROL	
				DRO	BTEX	Duplicate	MS/MSD
AP-3	25.03	Gauge Only	X_2	X_4			
AP-4[a]	28.57	Gauge Only	X_2	X_4			
AP-10R[b]	--	✓	X_2	X_2		✓	
AP-14[c]	23.05	Gauge Only	X_2	X_4			
AP-15[d]	21.90	✓	X_2		X_2		
AP-23	22.26	Gauge Only	X_2	Removed from sampling program			
AP-24	26.99	Gauge Only	X_2	Removed from sampling program			
AP-25	29.10	✓	X_2	X_2			✓
AP-26	25.97	Gauge Only	X_2	Removed from sampling program			
AP-27[e]	27.87	Gauge Only	X_2	Removed from sampling program			
AP-28	32.54	Gauge Only	X_2	X_4			
AP-29[f]	22.69	✓	X_2		X_2		
AP-30	23.85	Gauge Only	X_2	X_4			
AP-31	21.66	Gauge Only	X_2	X_4			
AP-32	23.61	Gauge Only	X_2	Removed from sampling program			
AP-33	23.91	Gauge Only	X_2	X_4			
AP-34	21.97	Gauge Only	X_2	X_4			

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring
X_4 Monitoring every 4 years

[a] Well AP-4 will also be sampled in 2017 as part of Beaver Creek Pad 4 (North).
[b] Missing protective casing. Well was replaced with AP-10R in September 2016.
[c] Missing protective casing.
[d] Missing protective casing. 0.1 ft LNAPL observed in 2015 sampling event.
[e] Casing is broken and frost-jacked.
[f] Installed at a 28-degree angle. 0.14 ft LNAPL observed in 2015 sampling event.

4.2 Beaver Creek Pad 4 (North)

BCP4 (North) is located approximately 50 air miles southwest of Anchorage, Alaska, and approximately 12 miles northeast of Kenai, Alaska, as shown on Figure 2. BCP4 is located at latitude 60°39’31.8” north, longitude 151°2’14.21” west, on land leased from USFWS within the Kenai National Wildlife Refuge (Figure 10). Hilcorp took over the lease and operations of the facility from Marathon in 2013. BCP4 (North) is located in the area of the Oil Truck Loading Facility northeast of BCP4 (South).

4.2.1 Geology and Hydrogeology

The Beaver Creek facility is located on glaciolacustrine deposits from the Holocene and Upper Pleistocene. Complex stratigraphy underlies the Beaver Creek facility, with relatively thick silt aquitards above thinly-bedded sand aquifers. Clayey silt and clayey sand intervals occur at approximately 20 ft bgs and deeper (SLR 2014d).

Groundwater elevations measured at the site since 2009 range from 121 to 133 ft above mean sea level. Groundwater flow has historically been to the west-east, with mounding in the vicinity of monitoring well AP-10 (SLR 2014d).

4.2.2 Previous Investigation and Monitoring Activities

At approximately 4:00am on Thursday, 21 July 2016, crews operating at the Pad 4 facility identified a crude oil leak coming from the ground near the oil loading dock and began removing impacted material. Approximately 60 CY of material was removed during this initial response, exposing four oil lines oriented north/south and three additional lines running in the transverse direction. Subsequent investigation identified a leak in one of the four oil lines. The leak was repaired, and integrity testing was performed on the oil lines, all of which passed successfully.

Follow on remedial activities conducted in 2016 included decommissioning and removal of oil lines, removal and disposal of an additional ~650 CY of impacted material, installation of four additional wells around the area of release, and soil and groundwater sampling and analysis. Excavation soil sampling showed contaminants remaining in the excavation floor and east and west sidewalls at concentrations exceeding ADEC Method Two cleanup levels. Additional material could not be removed due site constraints; therefore, the excavation was lined with indicator fabric and filled with clean material. Analysis of groundwater samples collected from the surrounding wells showed that contaminant concentrations were either non-detect or were below ADEC Table C cleanup levels. The 2016 report recommended that the wells surrounding the area of release be incorporated into the monitoring program to assess for potential migration of contaminants (Brice 2017).

4.2.3 2017 Groundwater Monitoring Activities

BCP4 (North) groundwater wells are monitored on an annual schedule. All viable wells are gauged during each sampling event. The scope of work for 2017 field activities is summarized below:

- Sample five wells for GRO, DRO, RRO, and BTEX: AP-4, AP-35, AP-36, AP-38, and AP-39.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Survey new monitoring wells AP-35, AP-36, AP-38, and AP-39 to establish well coordinates and top-of-casing elevations.

Table 9 identifies the BCP4 (North) wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 10. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 9: BCP4 (North) Summary of Monitoring Wells and Analyses

WELL ID	2017 SCOPE	GAUGE	ANALYSES				QUALITY CONTROL	
			DRO	RRO	GRO	BTEX	Duplicate	MS/MSD
AP-4	✓	X_1	X_1	X_1	X_1	X_1		✓
AP-35	✓	X_1	X_1	X_1	X_1	X_1		
AP-36	✓	X_1	X_1	X_1	X_1	X_1	✓	
AP-38	✓	X_1	X_1	X_1	X_1	X_1		
AP-39	✓	X_1	X_1	X_1	X_1	X_1		

Notes:
For definitions, see the Acronyms section.
X_1 Annual monitoring

4.3 Swanson River Field Electric Shop and Tank Settings

SRF is located at Milepost 17.5 outside of Sterling, Alaska, on a 12-square-mile parcel of land leased from the USFWS within the boundaries of the Kenai National Wildlife Refuge (Figure 4). SRF is also a Bureau of Land-managed oil and gas unit. Hilcorp took over the lease and operations of the facility from Union Oil Company of California (Unocal) in 2012.

Monitoring well installation at the SRF Tank Settings began in 1989, following investigations of contaminated soil at each site. By 1990, 53 monitoring wells were installed across the seven Tank Settings, focusing on hydrocarbon-based contaminants. In 2002, an additional 23 monitoring wells were installed based on groundwater monitoring results. Monitoring wells were generally installed around each tank setting and within flare pits to monitor potential releases. Monitoring wells are 2-inch diameter PVC casings with aboveground protective monuments and have 10-ft screened intervals ranging in depth from approximately 16 to 49 ft bgs (SLR 2015c).

4.3.1 Swanson River Field Tank Setting 1-4

The following subsections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2017 groundwater monitoring activities at SRF Tank Setting (TS) 1-4.

4.3.1.1 Geology and Hydrogeology

Geology beneath SRF is comprised of sandy silt deposits commonly forming an aquitard beneath ponds, wetlands, and shallow aquifers. The depth to the water table varies from 5 to 28 ft bgs. Groundwater flow direction at TS 1-4 (Figure 11) has historically been to the north.

4.3.1.2 Previous Investigation and Monitoring Activities

The groundwater monitoring wells at TS 1-4 have been sampled for BTEX on an approximately annual basis from 2000 to present, although 2011-2013 sampling data is not available. BTEX was selected as the mobile segment of contaminants that can be monitored in groundwater. Five monitoring wells were installed by 1990, and three additional monitoring wells were installed in 2002.

Benzene concentrations have exceeded the groundwater cleanup level consistently in samples from monitoring wells TS1-4F, TS1-4G, TS1-4J, and FS1-4E. LNAPL has been observed in TS1-4F, TS1-4G, and TS1-4J during previous sampling events. TS1-4J is currently the only monitoring well with LNAPL.

During previous sampling events, all BTEX analytes in samples from monitoring wells TS1-4CC and TS1-4DD have been non-detect or detected at concentrations below the cleanup levels.

On September 26, 2015, a release of approximately 1,600 gallons of a 50/50 mixture of ethylene glycol and water occurred at TS 1-4. The source was a corroded pipeline under the oil line heater located near TS1-4G.

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the TS 1-4 groundwater monitoring program, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

Groundwater depths were measured in eight monitoring wells located at TS 1-4, and groundwater flow direction was determined to be generally north-northeast. Groundwater quality parameters and analytical samples were collected from five of the eight monitoring wells at TS 1-4. Samples were analyzed for BTEX. Additionally, TS1-4EE was sampled for ethylene glycol (Brice 2016b).

In 2015, measurable LNAPL was observed in TS1-4J at 0.03 feet thick. The 2015 groundwater monitoring results indicated that benzene concentrations exceeded the ADEC cleanup level in samples from two monitoring wells (TS1-4F and FS1-4E). All remaining analytes in samples from these two monitoring wells, and BTEX analytes in samples collected from the other three monitoring wells, were non-detect or were detected at concentrations below ADEC cleanup levels. Ethylene glycol in TS1-4EE was detected at a concentration below the ADEC cleanup level. No surface water was observed at or adjacent to the site, and the contaminated groundwater is adequately bound downgradient with uncontaminated monitoring wells (Brice 2016b).

4.3.1.3 2017 Groundwater Monitoring Activities

SRF Tank Setting 1-4 groundwater wells are monitored on a biennial schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Monitor and remove LNAPL in TS1-4J and replace LNAPL-absorbent sock. If LNAPL is not observed, sample well for BTEX.
- Replace the LNAPL-absorbent sock in TS1-4F.
- Decommission and replace TS1-4G. This monitoring well has an obstruction and was unable to be sampled in 2014; however, it has historically contained benzene exceeding the cleanup level and is located near a potential source area. Survey to establish coordinates and top-of-casing elevations for the replacement well.
- Cut the PVC well casing on FS1-4E in order to properly close and lock the steel casing. Re-measure total well depth and survey the top-of-casing elevation in accordance with ADEC guidance.
- Sample five monitoring wells for BTEX: TS1-4EE, TS1-4F, FS1-4E, FS1-4H, and TS1-4GR (replacement well for TS1-4G).
- Sample two monitoring wells for ethylene glycol: TS1-4EE and TS1-4GR (replacement well for TS1-4G).
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Table 10 identifies the SRF Tank Setting 1-4 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 11. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 10: SRF Tank Setting 1-4 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES		QUALITY CONTROL	
				BTEX	Ethylene Glycol	Duplicate	MS/MSD
TS1-4CC	5.68	Gauge Only	X_2	Removed from sampling program			
TS1-4DD[a]	3.77	Gauge Only	X_2	Removed from sampling program			
TS1-4EE	4.24	✓	X_2	X_2	X_2		✓
TS1-4F[b]	10.05	✓	X_2	X_2			
TS1-4G[c]	14.52	Replace	--	To be decommissioned			
TS1-4GR[d]	--	✓	X_2	X_2	X_2	✓	
TS1-4J[e]	7.58	✓	X_2	X_2			
FS1-4H[f]	13.04	✓	X_2	X_2			
FS1-4E[g]	6.37	✓	X_2	X_2			

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring
[a] Steel casing and concrete heaved.
[b] Replace LNAPL-absorbent sock.
[c] Obstruction at 15.43 ft; sock could not be removed. Recommended for replacement.
[d] Planned replacement well to be installed and sampled in 2017.
[e] 0.03 ft of LNAPL observed in 2015 sampling event. Replace LNAPL-absorbent sock.
[f] Steel casing and concrete heaved. Missing well cap.
[g] PVC heaved above steel casing.

4.3.2 Swanson River Field Electric Shop

The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2017 groundwater monitoring activities at the SRF Electric Shop.

4.3.2.1 Geology and Hydrogeology

Geology beneath SRF is comprised of sandy silt deposits commonly forming an aquitard beneath ponds, wetlands, and shallow aquifers. The depth to the water table varies from 8 to 54 ft bgs. Groundwater flow direction around the Electric Shop (Figure 12) and former tanks has generally been to the north-northwest and northeast.

4.3.2.2 Previous Investigation and Monitoring Activities

Hydrocarbon contamination was first identified in the vicinity of the Electric Shop in 1989 and 1990, when five soil borings and one monitoring well were installed. Two soil borings found hydrocarbon-contaminated soil, and LNAPL was observed in the monitoring well in several subsequent monitoring events. In 1999, additional monitoring wells were installed around the Electric Shop and the since-removed Tanks 300 and 301. Groundwater monitoring in 2000 and 2001 indicated groundwater flow direction at the Electric Shop was to the southwest. However, just 100 to 200 ft to the south, at former Tanks 300 and 301, groundwater flow direction was determined to be to the northeast. Monitoring wells around the former Tank Setting Building, 300 ft east of former Tanks 300 and 301, indicated groundwater flow direction was toward the north (Geosphere, Inc. 2002).

Groundwater monitoring at the Electric Shop and in the vicinity has been conducted periodically since 2001. In 2014, groundwater monitoring activities indicated the hydraulic gradient in the area of the former pig launcher remains reversed from historically observed patterns; groundwater flow direction was determined to be to the north-northwest. Groundwater flow direction at former Tanks 300 and 301 remained to the northeast. An attempt was made to recover LNAPL from two wells, ESMW-A and KSW-2, using LNAPL-absorbent socks. The water level in ESMW-A had dropped below the level of the LNAPL-absorbent sock, and as a result no LNAPL was recovered. A small amount of LNAPL was recovered from KSW-2. Three monitoring wells, KSW-6, KSW-7, and KSW-8, were sampled for GRO, DRO, and BTEX. Benzene and GRO concentrations exceeded the ADEC cleanup level in one well, KSW-8 (Kent & Sullivan, Inc. 2015).

During the 2015 field activities, groundwater depth and/or LNAPL thickness was measured in four monitoring wells located at the Electric Shop: KSW-2, KSW-3, KSW-5, and ESMW-A. Groundwater flow was determined to be toward the northeast. Three of these monitoring wells contained measurable LNAPL. KSW-2, KSW-5, and ESMW-A contained LNAPL measuring 2.6 feet, 0.05 feet, and 0.6 feet thick, respectively; therefore, these wells were not sampled for BTEX, GRO, and DRO. The groundwater level in monitoring well KSW-3 was gauged; no LNAPL was observed. Existing LNAPL-absorbent socks in the three wells containing LNAPL were replaced (Brice 2016c).

4.3.2.3 2017 Groundwater Monitoring Activities

SRF Electric Shop groundwater wells are monitored on a biennial schedule. All viable wells are gauged during each sampling event. Recommendations were developed in the 2015 Groundwater Monitoring Report based on the subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Replace the LNAPL-absorbent socks in three wells: ESMW-A, KSW-2, and KSW-5. If LNAPL is not observed in the well, sample for GRO, BTEX, and DRO.
- Sample five wells for BTEX: KSW-1, KSW-3, KSW-4, KSW-6, and KSW-7.
- Sample well KSW-8 for GRO and BTEX.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Resurvey top-of-casing elevations if significant changes in monitoring well elevations are observed, such as frost-heaving.

Table 11 identifies the SRF Electric Shop wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 12. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 11: SRF Electric Shop Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES			QUALITY CONTROL	
				DRO	GRO	BTEX	Duplicate	MS/MSD
ESMW-A[a]	9.40	✓	X_2	X_2	X_2	X_2		
KSW-1	--	✓	X_2			X_2		
KSW-2[a]	48.10	✓	X_2	X_2	X_2	X_2		
KSW-3	11.65	✓	X_2			X_2		
KSW-4	--	✓	X_2			X_2		
KSW-5[a]	54.50	✓	X_2	X_2	X_2	X_2		
KSW-6	--	✓	X_2			X_2		
KSW-7	--	✓	X_2			X_2		
KSW-8	--	✓	X_2		X_2	X_2	✓	✓

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring [a] Replace LNAPL-absorbent sock.

4.3.3 Swanson River Field Tank Setting 1-9

The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2017 groundwater monitoring activities at SRF TS 1-9.

4.3.3.1 Geology and Hydrogeology

Geology beneath SRF is comprised of sandy silt deposits commonly forming an aquitard beneath ponds, wetlands, and shallow aquifers. The elevation of the water table is approximately 114 ft relative to the North American Vertical Datum of 1988 (NAVD88). Groundwater flow direction at TS 1-9 has historically been to the west-northwest (SLR 2015c), but in 2015 groundwater was determined to flow southwest (Figure 13).

4.3.3.2 Previous Investigation and Monitoring Activities

The groundwater monitoring wells at TS 1-9 have been sampled for BTEX on an approximately annual basis from 2000 to present, although 2011-2013 sampling data is not available. Ten monitoring wells were installed by 1990, and two additional monitoring wells, TS1-9HH and TS1-9II, were installed in 2002.

Benzene concentrations have exceeded the groundwater cleanup level consistently in samples from monitoring wells TS1-9A, TS1-9B, TS1-9D, FS1-9F, and FS1-9N.

In 2005, the furthest downgradient monitoring well, TS1-9U, contained concentrations of benzene, ethylbenzene, and xylenes exceeding the ADEC groundwater cleanup levels. However, BTEX concentrations in this monitoring well have been non-detect or below the cleanup levels during all other sampling events.

Xylenes were detected above the cleanup levels in TS1-9D in 2003, and in samples from TS1-9C during five of seven sampling events between 2000 and 2007. Toluene has only been detected above the cleanup level once, during the 2000 sampling event in TS1-9A.

LNAPL was observed in TS1-9B, TS1-9C, TS1-9D, and FS1-9F during previous sampling events. FS1-9F is currently the only monitoring well with LNAPL.

During previous sampling events, all BTEX analytes in samples from monitoring wells TS1-9HH, TS1-9II, FS1-9D, FS1-9I, and FS1-9M have been non-detect or detected at concentrations below the cleanup levels.

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the TS 1-9 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

In 2015, groundwater depths were measured in 12 monitoring wells at TS 1-9, and groundwater flow direction was determined to be generally toward the southwest. A new monitoring well was previously recommended for installation downgradient of TS1-9B; however, TS1-9U is downgradient of this well; therefore it was not recommended that a new well be installed (Brice 2016d).

Groundwater quality parameters and analytical samples were collected from 11 wells at TS 1-9. Benzene exceeded the ADEC cleanup level in samples from four monitoring wells. All remaining analytes in samples from these four monitoring wells, as well as BTEX concentrations in samples from the other seven monitoring wells, were not detected or were detected at concentrations below the ADEC cleanup levels. Measurable LNAPL was observed in FS1-9F, measured to be 1.99 feet thick (Brice 2016d).

4.3.3.3 2017 Groundwater Monitoring Activities

SRF Tank Setting 1-9 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Sample four wells for BTEX: TS1-9A, TS1-9C, TS1-9D, and FS1-9N.
- Five wells are sampled for BTEX every four years and will be sampled next in 2019: TS1-9U, TS1-9HH, FS1-9D, FS1-9I, and FS1-9M. Gauge groundwater levels in these wells in 2017.
- Replace LNAPL-absorbent socks in two wells: TS1-9B and FS1-9F. If LNAPL is not observed, sample wells for BTEX.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Resurvey top-of-casing elevations if significant changes in monitoring well elevations are observed, such as frost-heaving.

Table 12 identifies the SRF Tank Setting 1-9 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 13. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 12: SRF Tank Setting 1-9 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				BTEX	Duplicate	MS/MSD
TS1-9A[a]	22.88	✓	X_2	X_2		✓
TS1-9B[b,c]	21.99	✓	X_2	X_2	✓	
TS1-9C	22.75	✓	X_2	X_2		
TS1-9D	22.13	✓	X_2	X_2		
TS1-9HH	21.20	Gauge Only	X_2	X_4		
TS1-9II	21.68	Gauge Only	X_2	Removed from sampling program		
TS1-9U	24.15	Gauge Only	X_2	X_4		
FS1-9D	14.15	Gauge Only	X_2	X_4		
FS1-9F[c,d]	14.70	✓	X_2	X_2		
FS1-9I	13.64	Gauge Only	X_2	X_4		
FS1-9M	20.69	Gauge Only	X_2	X_4		
FS1-9N	17.23	✓	X_2	X_2		

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring
X_4 Monitoring every 4 years
[a] Slightly heaved, cracked concrete.
[b] No LNAPL observed in 2015.
[c] Replace LNAPL-absorbent sock.
[d] 1.99 ft of LNAPL observed in 2015 sampling event.

4.3.4 Swanson River Field Tank Setting 1-27

The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2017 groundwater monitoring activities at SRF TS 1-27.

4.3.4.1 Geology and Hydrogeology

Geology beneath SRF is comprised of sandy silt deposits commonly forming an aquitard beneath ponds, wetlands, and shallow aquifers. The elevation of the water table is approximately 245 ft relative to the NAVD88. Groundwater flow direction at TS 1-27 has historically been west-southwest (Figure 14).

4.3.4.2 Previous Investigation and Monitoring Activities

The groundwater monitoring wells at SRF TS 1-27 have been sampled for BTEX on an approximately annual basis from 2000 to present, although 2011-2013 sampling data is not available. Four monitoring wells, TS1-27G, TS1-27J, TS1-27K, and FS1-27C, were installed by 1990 and the remaining three wells, TS1-27L, TS1-27M, and TS1-27N, were installed in 2002.

Benzene and ethylbenzene were the only analytes detected that exceeded the ADEC cleanup levels at TS 1-27 since 2000. Benzene concentrations in samples from TS1-27K have consistently exceeded the ADEC groundwater cleanup level since sampling began. Several ethylbenzene exceedances have also occurred in TS1-27K, the most recent being in 2014. Benzene concentrations exceeded the ADEC cleanup level in samples from TS1-27G until 2007, and again in 2015. Benzene concentrations exceeded the ADEC cleanup level in samples from TS1-27J until 2006. Samples from TS1-27M had concentrations of benzene that exceeded the cleanup level in 2002 and 2003. Samples from TS1-27L have had concentrations of benzene that exceeded the cleanup level several times since sampling began, most recently in 2014. Analytes in samples from TS1-27N and FS1-27C have consistently been non-detect. LNAPL has not been measured in any of the monitoring wells at TS 1-27 (SLR 2015c).

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the TS 1-27 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

Groundwater depths were measured in seven monitoring wells at TS 1-27, and groundwater flow direction was determined to be generally toward the west-southwest. Groundwater quality parameters and analytical samples were collected from five wells at TS 1-27. Samples were analyzed for BTEX (Brice 2016e).

The 2015 groundwater monitoring results indicate that benzene concentrations exceeded the ADEC cleanup level in samples from two monitoring wells. Results for all remaining analytes in samples from those two monitoring wells, and BTEX results in samples from the other three wells, were non-detect or below ADEC cleanup levels (Brice 2016e).

4.3.4.3 2017 Groundwater Monitoring Activities

SRF Tank Setting 1-27 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Sample four monitoring wells for BTEX: TS1-27G, TS1-27K, TS1-27L, and TS1-27M.
- One well is sampled for BTEX every four years and will be sampled next in 2019: FS1-27C. Gauge the groundwater level in this well in 2017.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.

- Resurvey top-of-casing elevations if significant changes in monitoring well elevations are observed, such as frost-heaving.

Table 13 identifies the SRF Tank Setting 1-27 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 14. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 13: SRF Tank Setting 1-27 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				BTEX	Duplicate	MS/MSD
TS1-27G	15.18	✓	X_2	X_2		✓
TS1-27J	13.68	Gauge Only	X_2	Removed from sampling program		
TS1-27K	16.05	✓	X_2	X_2	✓	
TS1-27L	15.27	✓	X_2	X_2		
TS1-27M	21.80	✓	X_2	X_2		
TS1-27N	16.85	Gauge Only	X_2	Removed from sampling program		
FS1-27C	8.15	Gauge Only	X_2	X_4		

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring
X_4 Monitoring every 4 years

4.3.5 Swanson River Field Tank Setting 1-33

The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2017 groundwater monitoring activities at SRF TS 1-33.

4.3.5.1 Geology and Hydrogeology

Geology beneath SRF is comprised of sandy silt deposits commonly forming an aquitard beneath ponds, wetlands, and shallow aquifers. The elevation of the water table is approximately 145 ft relative to the NAVD88. Groundwater flow direction at TS 1-33 (Figure 15) has historically been east-southeast (SLR 2015c).

4.3.5.2 Previous Investigation and Monitoring Activities

The groundwater monitoring wells at the TS 1-33 have been sampled for BTEX on an approximately annual basis from 2000 to present, although 2011-2013 data is not available. Eight monitoring wells were installed by 1990, and four additional monitoring wells, TS1-33JJ, TS1-33KK, TS1-33O2, and FS1-33T, were installed in 2002.

Benzene and ethylbenzene have been the only analytes detected exceeding ADEC groundwater cleanup levels at TS 1-33 since 2000. Benzene concentrations have consistently exceeded the ADEC cleanup level in samples collected from four monitoring wells since 2000: TS1-33Q, TS1-33O2, FS1-33F, and FS1-33H. TS1-33U has also had consistent benzene exceedances, although this well has not been sampled since 2009 due to an obstruction. Ethylbenzene exceeded the ADEC cleanup level in one monitoring well, TS1-33Q, from 2000 to 2009.

Benzene concentrations have exceeded the ADEC cleanup level occasionally in samples from five monitoring wells at TS 1-33; twice in samples collected from TS1-33KK (in 2002 and 2003), six times in samples collected from FS1-33O (as recently as 2014), four times in samples collected from FS1-33R (as recently as 2010), and five times in samples collected from FS1-33S (as recently as 2010). BTEX concentrations in samples collected from TS1-33JJ, TS1-33P, and FS1-33T have been non-detect or below the ADEC cleanup levels since 2000. Measurable LNAPL has been observed four times in TS1-33U (2000, 2001, 2003, and 2005) and five times in FS1-33H (2000-2003, 2014).

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the TS 1-33 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

Groundwater depths were measured in ten monitoring wells at TS 1-33, and groundwater flow direction was determined to be southeast. Groundwater quality parameters and analytical samples were collected from six wells at TS 1-33. Samples were analyzed for BTEX (Brice 2016f).

The 2015 groundwater monitoring results indicate that benzene exceeded the ADEC cleanup level in samples from four monitoring wells (TS1-33O2, TS1-33Q, FS1-33F, and FS1-33H). Results for all remaining analytes in those four monitoring wells, and BTEX results for samples from the other two wells, were non-detect or were below ADEC cleanup levels. Measurable LNAPL was observed in well TS1-33U (Brice 2016f).

No surface water was observed at the site, and the contaminated groundwater is adequately bound downgradient with one uncontaminated monitoring well, FS1-33S (Brice 2016f).

4.3.5.3 2017 Groundwater Monitoring Activities

SRF Tank Setting 1-33 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Decommission and replace wells FS1-33R and TS1-33U. FS1-33R is damaged and cannot be sampled, but has historically been contaminated and monitoring should continue. TS1-33U cannot be sampled due to an obstruction; however, LNAPL was observed above the obstruction.
- Sample seven wells for BTEX: TS1-33Q, TS1-33UR (replacement well for TS1-33U), TS1-33O2, TS1-33N (to be installed upgradient of TS1-33O2), FS1-33F, FS1-33R2 (replacement well for FS1-33R), and FS1-33S.
- One well is sampled for BTEX every four years and will be sampled next in 2019: TS1-33JJ. Gauge the groundwater level in this well in 2017.
- Remove LNAPL from FS1-33H and replace LNAPL-absorbent sock. If LNAPL is not present, sample well for BTEX.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Install a well upgradient (north) of contaminated well TS1-33O2 to confirm the gradient is toward the southeast and benzene is not impacting groundwater to the north.
- Survey newly installed wells to establish well coordinates and top-of-casing elevations. If significant changes in monitoring well elevations are observed, such as frost-heaving, resurvey for top-of-casing elevations.

Table 14 identifies the SRF Tank Setting 1-33 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 15. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 14: SRF Tank Setting 1-33 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				BTEX	Duplicate	MS/MSD
TS1-33JJ	15.38	Gauge Only	X_2	X_4		✓
TS1-33KK[a]	11.00	Gauge Only	X_2	Removed from sampling program		
TS1-33P	8.98	Gauge Only	X_2	Removed from sampling program		
TS1-33Q[b]	15.25	✓	X_2	X_2	✓	
TS1-33U[c]	--	Replace	--	Decommission		
TS1-33UR[h]	--	✓	X_2	X_2		
TS1-33O2[d]	13.65	✓	X_2	X_2		
TS1-33N[h]	--	✓	X_2	X_2		

Table 14: SRF Tank Setting 1-33 Summary of Monitoring Wells and Analyses (continued)

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				BTEX	Duplicate	MS/MSD
FS1-33F[e]	27.61	✓	X_2	X_2		
FS1-33H[f]	23.98	✓	X_2	X_2		
FS1-33O	28.36	Gauge Only	X_2	Removed from sampling program		
FS1-33R[g]	--	Replace	--	Decommission		
FS1-33R2[h]	--	✓	X_2	X_2		
FS1-33S	24.08	✓	X_2	X_2		
FS1-33T	18.09	Gauge Only	X_2	Removed from sampling program		

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring
X_4 Monitoring every 4 years

[a] Orange chunks and mildew odor observed in 2015 sampling event.
[b] Heaved.
[c] Obstruction at 8.2 ft below top-of-casing (BTOC); 0.2 ft LNAPL observed in 2015 sampling event.
[d] Steel casing was bent/crushed and cover was missing, but PVC intact in 2015 sampling event.
[e] Standing water within the steel casing and surrounding the well observed in 2015 sampling event.
[f] Missing plug in 2015 sampling event.
[g] Steel casing was filled with charred material.
[h] Planned replacement well to be installed and sampled in 2017.

4.3.6 Swanson River Field Tank Setting 2-15

The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2017 groundwater monitoring activities at SRF TS 2-15.

4.3.6.1 Geology and Hydrogeology

Geology beneath SRF is comprised of sandy silt deposits commonly forming an aquitard beneath ponds, wetlands, and shallow aquifers. The elevation of the water table is approximately 145 ft relative to the NAVD88. Groundwater flow direction at TS 2-15 (Figure 16) has historically been to the west-northwest (SLR 2015c).

4.3.6.2 Previous Investigation and Monitoring Activities

The groundwater monitoring wells at TS 2-15 have been sampled for BTEX on an approximately annual basis from 2000 to present, although 2011-2013 data is not available. Two monitoring wells (TS2-15O and FS2-15B) were installed at TS 2-15 by 1990. Three additional wells were installed in 2002: TS2-15P, TS2-15Q, and TS2-15R.

Benzene concentrations have exceeded the ADEC groundwater cleanup level in samples from one monitoring well, TS2-15O, since 2000. Toluene concentrations over the ADEC cleanup level have been detected in samples collected from TS2-15O in 2000 and 2006. BTEX has not been detected or has been detected at low concentrations in samples collected from monitoring wells TS2-15P, TS2-15Q, TS2-15R, and FS2-15B since 2000. LNAPL has not been observed in any of the monitoring wells at TS 2-15 (SLR 2015c).

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the TS 2-15 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

Groundwater depth was measured at five monitoring wells at TS 2-15, and groundwater flow direction was determined to be west-northwest. Groundwater quality parameters and analytical samples were collected from four wells at TS 2-15. Samples were analyzed for BTEX.

The 2015 groundwater monitoring results indicate that benzene concentrations exceeded the ADEC cleanup level in one monitoring well, TS2-15O. Concentrations of benzene have exceeded the ADEC cleanup level in samples from this well in previous monitoring events. Results for all remaining analytes in TS2-15O and BTEX analytes in the other three wells sampled were non-detect or were below ADEC cleanup levels (Brice 2016g).

No surface water was observed at or adjacent to the site, and the contaminated groundwater is adequately bound downgradient with uncontaminated monitoring wells (Brice 2016g).

4.3.6.3 2017 Groundwater Monitoring Activities

SRF Tank Setting 2-15 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Sample one well for BTEX: TS2-15O.
- Three wells are sampled for BTEX every four years and will be sampled next in 2019: TS2-15P, TS2-15R, and FS2-15B. Gauge the groundwater levels in these wells in 2017.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- If significant changes in monitoring well elevations are observed, such as frost-heaving, resurvey for top-of-casing elevations.

Table 15 identifies the SRF Tank Setting 2-15 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 16. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 15: SRF Tank Setting 2-15 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				BTEX	Duplicate	MS/MSD
TS2-15O	15.14	✓	X_2	X_2	✓	✓
TS2-15P	16.11	Gauge Only	X_2	X_4		
TS2-15R	15.38	Gauge Only	X_2	X_4		
FS2-15B	18.64	Gauge Only	X_2	X_4		
TS2-15Q	17.73	Gauge Only	X_2	Removed from sampling program		

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring
X_4 Monitoring every 4 years

4.3.7 Swanson River Field Tank Setting 3-4

The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2017 groundwater monitoring activities at SRF TS 3-4.

4.3.7.1 Geology and Hydrogeology

Geology beneath SRF is comprised of sandy silt deposits commonly forming an aquitard beneath ponds, wetlands, and shallow aquifers. The elevation of the water table is approximately 146 ft relative to the NAVD88. Groundwater flow direction at TS 3-4 (Figure 17) has historically been to the east (SLR 2015c).

4.3.7.2 Previous Investigation and Monitoring Activities

The groundwater monitoring wells at the SRF Tank Settings have been sampled on an approximately annual basis from 2000 to present, although 2011-2013 data is not available. Seven monitoring wells were installed by 1990, and five additional monitoring wells were installed in 2002.

Benzene, ethylbenzene, and toluene have been detected at concentrations exceeding ADEC cleanup levels at TS 3-4 since groundwater monitoring began (SLR 2015c). Benzene concentrations have exceeded the groundwater cleanup level consistently in samples from monitoring wells TS3-4D, TS3-4P, and FS3-4D. Several benzene exceedances have been detected in samples from TS3-4CC (most recent in 2009) and samples from FS3-4F (most recent in 2015).

Toluene and ethylbenzene concentrations exceeded the cleanup levels in a sample from TS3-4P during one sampling event in 2003. Toluene concentrations exceeded the cleanup level in samples collected from FS3-4D during two sampling events in 2000 and 2002. LNAPL was observed in TS3-4D and FS3-4D during previous sampling events. FS3-4D is currently the only monitoring well with LNAPL. During previous sampling events, results for all BTEX analytes in monitoring wells TS3-4Z, TS3-4MM, TS3-4NN, TS3-4OO, TS3-4PP, FS3-4A, and FS3-4B were non-detect or below the cleanup levels.

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the TS 3-4 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

Groundwater depths were measured in 12 monitoring wells at TS 3-4, and groundwater flow direction was determined to be generally east-southeast. Groundwater quality parameters and analytical samples were collected from eight wells at TS 3-4. Samples were analyzed for BTEX (Brice 2016h).

The 2015 groundwater monitoring results indicate that benzene concentrations exceeded the ADEC cleanup level in samples from three monitoring wells (TS3-4D, TS3-4P, and FS3-4F). Benzene concentrations have historically exceeded the ADEC cleanup level in samples collected from these three wells. Results for all remaining analytes in samples from these three wells, and BTEX analytes in samples from the other five wells, were non-detect or were below ADEC cleanup levels. LNAPL was observed in TS3-4D (Brice 2016h).

No surface water was observed at or adjacent to the site, and the contaminated groundwater is adequately bound downgradient with uncontaminated monitoring wells (Brice 2016h).

4.3.7.3 2017 Groundwater Monitoring Activities

SRF Tank Setting 3-4 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Remove LNAPL and replace LNAPL-absorbent socks in two wells: TS3-4D and FS3-4D. If LNAPL is not present, sample wells for BTEX. As FS3-4D is a 1-inch well, it is recommended to use a smaller diameter LNAPL-absorbent sock, a bailer, or a pump to remove LNAPL.
- Sample four wells for BTEX: TS3-4P, TS3-4CC, FS3-4A, and FS3-4F.
- Three wells are sampled for BTEX every four years and will be sampled next in 2019: TS3-4MM, TS3-4OO, and FS3-4B. Gauge the groundwater levels in these wells in 2017.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- If significant changes in monitoring well elevations are observed, such as frost-heaving, resurvey for top-of-casing elevations.

Table 16 identifies the SRF Tank Setting 3-4 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 17. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 16: SRF Tank Setting 3-4 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				BTEX	Duplicate	MS/MSD
TS3-4D[a,b]	15.42	✓	X_2	X_2		
TS3-4P	12.67	✓	X_2	X_2	✓	
TS3-4Z	17.32	Gauge Only	X_2	Removed from sampling program		
TS3-4CC	11.19	✓	X_2	X_2		
TS3-4MM[c]	5.53	Gauge Only	X_2	X_4		
TS3-4NN	9.45	Gauge Only	X_2	Removed from sampling program		
TS3-4OO[d]	7.94	Gauge Only	X_2	X_4		
TS3-4PP	10.64	Gauge Only	X_2	Removed from sampling program		
FS3-4A	12.77	✓	X_2	X_2		✓
FS3-4B	6.27	Gauge Only	X_2	X_4		
FS3-4D[b,e]	--	✓	X_2	X_2		
FS3-4F	16.85	✓	X_2	X_2		

Notes:

For definitions, see the Acronyms section.

X_2 Biennial monitoring

X_4 Monitoring every 4 years

[a] No LNAPL observed in 2015 sampling event; sock was replaced in 2015.

[b] Replace LNAPL-absorbent sock. Use a smaller diameter LNAPL-absorbent sock for FS3-4D as it is a 1-inch well.

[c] Concrete is slightly heaved.

[d] Concrete is heaved approximately 18 inches.

[e] LNAPL present in 2015. A clear water level signal could not be obtained to measure product thickness, but it was estimated to be greater than 2 feet.

4.3.8 Swanson River Field Tank Setting 3-9

The following sections include site-specific information about site geology and hydrogeology, previous investigations and groundwater monitoring, and planned 2017 groundwater monitoring activities at SRF TS 3-9.

4.3.8.1 Geology and Hydrogeology

Geology beneath SRF is comprised of sandy silt deposits commonly forming an aquitard beneath ponds, wetlands, and shallow aquifers. The elevation of the water table is approximately 146 ft relative to the NAVD88. Groundwater flow direction at TS 3-9 has historically been to the east (Figure 18).

4.3.8.2 Previous Investigation and Monitoring Activities

The groundwater monitoring wells at TS 3-9 have been sampled for BTEX on an approximately annual basis from 2000 to present, although 2011-2013 sampling data is not available. Ten monitoring wells were installed by 1990, and four additional monitoring wells, TS3-9AA, TS3-9BB, TS3-9CC, and TS3-9DD were installed in 2002.

Benzene is the only analyte that has been detected in groundwater samples collected at TS 3-9 at concentrations exceeding the ADEC cleanup level since 2000. Benzene concentrations have consistently exceeded the ADEC cleanup level in three monitoring wells since 2000: TS3-9C, TS3-9F, and FS3-9E. Benzene concentrations have exceeded ADEC cleanup level occasionally in samples from seven monitoring wells at TS 3-9: six times in samples collected from TS3-9B and TS3-9S (as recently as 2007), nine times in samples collected from TS3-9T (most recently in 2009), five times in samples collected from TS3-9U (as recently as 2014), seven times in samples collected from TS3-9V (as recently as 2014), once in TS3-9AA (2005), two times in samples collected from TS3-9BB (2008 and 2014), and once in a sample collected from FS3-9B (2002). BTEX concentrations in TS3-9CC, TS3-9DD, and FS3-9G have not been detected or have been detected at low concentrations since 2000.

Measurable LNAPL has been observed in five monitoring wells. Prior to 2015, the most recent LNAPL observations were as follows: TS3-9A in 2014, TS3-9C in 2014, TS3-9T in 2002, TS3-9U in 2005, and FS3-9E in 2003.

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the TS 3-9 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

Groundwater depths were measured in 14 monitoring wells at TS 3-9, and groundwater flow direction was determined to be generally toward the north-northeast. Groundwater quality parameters and analytical samples were collected from ten wells at TS 3-9. Samples were analyzed for BTEX.

The 2015 groundwater monitoring results indicate that benzene concentrations exceeded the ADEC cleanup level in samples collected from five monitoring wells (TS3-9F, TS3-9T, TS3-9V, TS3-9BB, and FS3-9E). Results for all remaining analytes in samples from these five wells, and for BTEX analytes in samples from five other wells, were non-detect or were below ADEC cleanup levels. Measurable LNAPL was observed in two wells, TS3-9A and TS3-9C (Brice 2016i).

No surface water was observed at or adjacent to the site, and the contaminated groundwater is adequately bound downgradient with one uncontaminated monitoring well, TS3-9AA (Brice 2016i).

4.3.8.3 2017 Groundwater Monitoring Activities

SRF Tank Setting 3-9 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Decommission and replace TS3-9C. The well has an obstruction preventing replacement of the absorbent sock and measurement of the LNAPL thickness and groundwater level. Survey to establish coordinates and top-of-casing elevations for the replacement well.
- Monitor and remove LNAPL and replace LNAPL-absorbent socks in wells TS3-9A, TS3-9CR (replacement well for TS3-9C), TS3-9U, and FS3-9E. If LNAPL is not present, sample TS3-9A, TS3-9CR, and FS3-9E for BTEX. If LNAPL is not present, gauge groundwater level in TS3-9U; this well will be sampled every four years, with the next sampling planned for 2019.
- Sample four wells for BTEX: TS3-9F, TS3-9T, TS3-9V, and TS3-9BB.
- Four wells are sampled every four years and will be sampled next in 2019: TS3-9AA, FS3-9DD, FS3-9B, and FS3-9G. Gauge the groundwater levels in these wells in 2017.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- If significant changes in monitoring well elevations are observed, such as frost-heaving, resurvey for top-of-casing elevations.

Table 17 identifies the SRF Tank Setting 3-9 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 18. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 17: SRF Tank Setting 3-9 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				BTEX	Duplicate	MS/MSD
TS3-9A[a,b]	20.30	✓	X_2	X_2		
TS3-9C[c]	--	Replace	--	Decommission		
TS3-9CR[b]	--	✓	X_2	X_2		
TS3-9F[d]	23.25	✓	X_2	X_2		
TS3-9S	21.17	Gauge Only	X_2	Removed from sampling program		
TS3-9T	19.60	✓	X_2	X_2	✓	
TS3-9U[b]	17.30	Gauge Only	X_2	X_4		
TS3-9V	12.60	✓	X_2	X_2		✓
TS3-9AA	21.94	Gauge Only	X_2	X_4		
TS3-9BB	22.25	✓	X_2	X_2		
TS3-9CC	10.21	Gauge Only	X_2	Removed from sampling program		
TS3-9DD	8.57	Gauge Only	X_2	X_4		
FS3-9B	15.15	Gauge Only	X_2	X_4		
FS3-9E[b]	11.55	✓	X_2	X_2		
FS3-9G[e]	11.35	Gauge Only	X_2	X_4		

Notes:

For definitions, see the Acronyms section.

X_2 Biennial monitoring

X_4 Monitoring every 4 years

[a] 0.3 ft of LNAPL observed during 2015 sampling event.

[b] Planned replacement well to be installed and sampled in 2017 with LNAPL-absorbent sock.

[c] Obstruction at 20.2 ft BTOC; LNAPL observed in 2015. Recommended for replacement.

[d] Heaved.

[e] Slightly heaved.

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5.0 SITE-SPECIFIC INFORMATION – SOUTH KENAI SITES

The following subsections detail the South Kenai Sites, sampling requirements, and analyses. Appendix A includes the figures presenting the sites, well locations, and surface water sample locations (as applicable).

5.1 Cannery Loop Unit 3

CLU3 is located approximately 60 air miles southwest of Anchorage, Alaska, on the Kenai Peninsula, as shown on Figure 6. CLU3 is located at 500 Childs Avenue, off the Bridge Access Road near Kenai, Alaska (Figure 19).

A borehole at CLU3 was advanced in 1981, identifying dry gas-bearing reservoir strata within three distinct lithologic units defined as the Cannery Loop Extension (Alaska Oil and Gas Conservation Commission [AOGCC] 1987). Drilling fluids and natural gas condensate associated with reserve pits and miscellaneous spills have resulted in diesel contamination of soil and groundwater (SLR 2014d).

5.1.1 Geology and Hydrogeology

CLU3 is located on Holocene and Upper Pleistocene glaciolacustrine deposits. The gravel pad is positioned on an organic soil horizon, up to 6 ft thick, underlain by layers of sand and silt to a depth of at least 15 ft (SLR 2014d).

The depth to groundwater ranges from approximately 9.5 to 11.5 ft bgs. Groundwater flow is generally toward the west-southwest (Figure 19) (SLR 2014d).

5.1.2 Previous Investigation and Monitoring Activities

Groundwater monitoring began at CLU3 in 1996. Quarterly monitoring was conducted in 1998, then was reduced to biannual monitoring from 1999 through 2003. Between 2004 and 2010, annual monitoring for DRO was conducted. Odd year biennial monitoring began in 2011 (SLR 2014d).

Passive product recovery systems were installed in two monitoring wells in 2004; the systems recovered 1.7 gallons of LNAPL. The 2004 monitoring indicated two monitoring wells contained DRO exceeding the ADEC Table C groundwater cleanup level of 1.5 milligrams per liter (mg/L). DRO was detected in four monitoring wells at concentrations less than the ADEC cleanup level (SLR 2014d).

LNAPL was detected in PZ-1 in 2005, and a product recovery trap was installed.

Monitored natural attenuation was evaluated at the site during the 2007-2008 monitoring events. Results indicated that DRO concentrations in groundwater were generally decreasing at CLU3, and that natural attenuation through both aerobic and anaerobic degradation was active (SLR 2014d).

Continued monitoring through 2010 found the presence of LNAPL in four monitoring wells. Natural attenuation parameters indicated that anaerobic conditions were present.

Passive product skimmers were removed from three wells in 2011. A total of 6.5 gallons of LNAPL were removed throughout the life of the passive skimming program. Groundwater monitoring in 2011 found four wells containing DRO concentrations exceeding the ADEC cleanup level (SLR 2014d).

Groundwater monitoring in 2013 found DRO results exceeding the ADEC cleanup level in four of ten monitoring wells sampled (SLR 2014d).

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the CLU3 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program (Brice 2016j).

Groundwater depths were measured in 14 monitoring wells at CLU3, and groundwater flow direction was determined to be generally toward the west. Groundwater quality parameters and analytical samples were collected from eight monitoring wells. DRO concentrations exceeded the ADEC cleanup level in four monitoring wells (MW-2, MW-3, PZ-1, and PZ-2). All other DRO concentrations in the monitoring wells sampled were non-detect or were detected at concentrations less than the ADEC cleanup levels (Brice 2016j).

5.1.3 2017 Groundwater Monitoring Activities

CLU3 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Sample seven wells for DRO: MW-2, MW-3, MW-5, MW-6, MW-8, PZ-1, and PZ-2. In accordance with the 2015 Optimization, monitoring wells MW-5 and MW-6 were removed from the sampling program; however, based on 2015 groundwater flow directions, the wells are located downgradient of contaminated wells and sampling could indicate if contamination is migrating off the pad. These wells are sampled every four years, with the next sampling event due in 2017.
- Three wells are sampled for DRO at a frequency of every four years and will next be sampled in 2019: MW-1, MW-4, and MW-12. Groundwater levels will be gauged in these wells in 2017.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Investigate the condition of MW-13; if located, inspect and decommission well. MW-13 was surveyed in 2012 but was not mentioned in the 2011 or 2014 Groundwater Monitoring reports, and was not included in 2015 groundwater monitoring activities. The well was likely abandoned prior to 2011 and is unlikely to provide valuable data to the sampling program.
- Resurvey all monitoring wells for top-of-casing elevations.

Table 18 identifies the CLU3 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 19. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 18: CLU3 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				DRO	Duplicate	MS/MSD
MW-1	10.48	Gauge Only	X_2	X_4		
MW-2	10.25	✓	X_2	X_2		✓
MW-3	10.72	✓	X_2	X_2		
MW-4	10.44	Gauge Only	X_2	X_4		
MW-5	6.27	✓	X_2	X_4		
MW-6	7.53	✓	X_2	X_4		
MW-7	8.41	Gauge Only	X_2	Removed from sampling program		
MW-8	10.68	✓	X_2	X_2		
MW-9	11.55	Gauge Only	X_2	Removed from sampling program		
MW-10	10.03	Gauge Only	X_2	Removed from sampling program		
MW-11	6.94	Gauge Only	X_2	Removed from sampling program		
MW-12	9.33	Gauge Only	X_2	X_4		
MW-13	--	--	--	Decommission		
MW-C	--	--	--	Abandoned		
PZ-1	9.80	✓	X_2	X_2		
PZ-2	10.02	✓	X_2	X_2	✓	
PZ-3	--	--	--	Abandoned		

Notes:
For definitions, see the Acronyms section. X_2 Biennial monitoring X_4 Monitoring every 4 years

5.2 Kenai Gas Field 14-6

KGF 14-6 is located approximately 60 miles southwest of Anchorage, Alaska, and 10 miles south of Kenai, in the KGF (Figure 6). The property lies within Salamatof Native Association, Inc. land on Kenai Peninsula Borough Tax Parcels 13103001 and 13103014.

KGF 14-6 is one of several KGF production facilities, originally developed in 1959 by Unocal. Marathon acquired the KGF facilities in 1994. Hilcorp took over the pad in 2013 and is the current operator.

KGF 14-6 was constructed in the late 1950s; it consists of a 3 to 4-ft gravel pad placed over native tundra and wetland. Peat up to 5 ft thick can be found beneath the pad over most of the area. Gas recovery and transmission infrastructure is present on the pad along with several buildings, clustered on the southern half of the pad. Monitoring wells (Figure 20) are located around the buildings and extend east into the native wetland, where surface water samples have been collected (SLR 2014a).

5.2.1 Geology and Hydrogeology

KGF 14-6 is a gravel pad built in spruce bog terrain in the Kenai lowlands. The Kenai lowlands consist of topographically flat, discontinuous wetlands with organic soil from the surface to as deep as 6 ft bgs. KGF 14-6 was constructed by placing 3 to 4 ft of gravel on top of the organic soil. Beneath the organic soil layer lies a thin layer of fine-grained alluvium, then interbedded sand and sandy gravel to at least 17 ft bgs (SLR 2014a).

The groundwater flow direction at the site has historically varied between west-northwest and west-southwest. Groundwater elevation can fluctuate up to 5 ft seasonally (SLR 2014a).

5.2.2 Previous Investigation and Monitoring Activities

A hydrocarbon sheen was observed on the western edge of KGF 14-6 in 1995 following a season of abnormally high precipitation. The incident was reported to ADEC by Marathon as a historical release; Marathon elected to initiate remedial efforts. Site assessment activities in 1996 and 1997 indicated the source of the sheen was natural gas condensate (NGC) associated with an unknown release. A historical leak at the Arctic Pipeline building was noted on the ADEC Contaminated Sites Database (SLR 2014a).

Additional investigations at KGF 14-6 have been conducted in order to delineate the impacted area and conduct remedial actions. A LNAPL plume was discovered off the pad, south and west of the former Retention Basin. Between 1996 and 2006, 41 monitoring and recovery wells have been installed at the site, with groundwater monitored at varying frequencies. In 1998, approximately 1,100 cy of impacted soil was excavated from the source area and thermally treated. High vacuum extraction (HVE) systems were installed to recover LNAPL in the source area, and operated from 1998 to 2001 and 2003 to 2007. LNAPL-absorbent socks were installed in six wells in 2004 and 2005. A Membrane Interface Probe study was performed in 2006 as an in-situ investigation to delineate LNAPL southwest of the pad (SLR 2014a).

An HVE System LNAPL Recoverability Assessment in 2010/2011 concluded that the LNAPL plume near the Meter Building was no longer migrating laterally and was naturally attenuating. It would be impossible to hydraulically remove all LNAPL, due to emulsified LNAPL in groundwater and the presence of peat. In 2010, an evaluation of groundwater-surface water hydrology was performed, to determine the relationship between groundwater and surface water in the wetland southwest of KGF 14-6. Despite shallow groundwater at the site, the evaluation found that LNAPL is not migrating to the ground surface in the wetland (SLR 2014a).

Groundwater monitoring in 2013 and 2014 found concentrations of DRO and benzene decreasing over time, indications that the LNAPL plume is immobile and naturally attenuating, and no petroleum hydrocarbon impact to adjacent surface water. It was recommended to sample groundwater and surface water biennially (SLR 2014a, 2015a).

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the KGF 14-6 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

Groundwater depths were measured in monitoring wells located at KGF 14-6, and groundwater flow direction was determined to be generally toward the west. Groundwater quality parameters and analytical samples were collected from 18 monitoring wells at KGF 14-6. Samples were analyzed for BTEX, GRO, DRO, and RRO (Brice 2016k).

The 2015 groundwater monitoring results indicated that DRO concentrations exceeded the ADEC cleanup level in ten monitoring wells, RRO concentrations exceeded the ADEC cleanup level in 11 monitoring wells, and benzene concentrations exceeded the ADEC cleanup level in four monitoring wells. Measurable LNAPL was observed in three monitoring wells: MW-23, MW-33, and MW-41. All remaining analytes in the monitoring wells sampled were not detected or were below the ADEC cleanup levels (Brice 2016k).

Surface water samples were collected at eight locations adjacent to KGF 14-6 and analyzed for BTEX and PAH. All analytical results were less than ADEC cleanup levels. Results were used to calculate total aromatic hydrocarbons (TAH) and total aqueous hydrocarbons (TAqH). All calculated TAH and TAqH values were an order of magnitude less than the surface water quality criteria listed in 18 AAC 70.020 (Brice 2016k).

5.2.3 2017 Groundwater Monitoring Activities

KGF 14-6 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Additionally, eight surface water samples are collected biennially from historical locations (Figure 20). Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Monitor and remove LNAPL and install or replace LNAPL-absorbent socks in the following three wells: MW-23, MW-33, and MW-41. If LNAPL is not present, sample wells for BTEX, GRO, DRO, and RRO.
- Sample ten wells for BTEX, GRO, DRO, and RRO: MW-7, MW-8, MW-9, MW-17, MW-20, MW-22, MW-24, MW-26, MW-29, and MW-36.
- Nine wells are sampled for BTEX, GRO, DRO, and RRO at a frequency of every four years and will be sampled next in 2019: MW-4, MW-6, MW-10R, MW-11, MW-25, MW-28, MW-35, MW-37, and MW-40. Gauge groundwater levels in these wells in 2017.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevations and flow direction.
- Sample surface water at the same eight locations for BTEX and PAH in order to calculate TAH and TAqH and ensure contamination is not migrating off-pad and/or to the surface water.
- Decommission MW-12. The well has an obstruction and is unable to be sampled. Nearby wells provide similar data.
- Resurvey the top-of-casing elevations of all monitoring wells.

Table 19 identifies the KGF 14-6 wells, sample analyses, and quality control samples. Monitoring wells and surface water sample locations are presented on Figure 20. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 19: KGF 14-6 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES					QUALITY CONTROL	
				DRO	RRO	GRO	BTEX	PAH	Duplicate	MS/MSD
MW-1[a]	--	--	--	HVE System						
MW-2[a]	--	--	--	HVE System						
MW-3[a]	--	--	--	HVE System						
MW-4	6.46	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-5	6.65	Gauge Only	X_2	Removed from sampling program						
MW-6	5.66	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-7	5.60	✓	X_2	X_2	X_2	X_2	X_2			
MW-8	4.73	✓	X_2	X_2	X_2	X_2	X_2			
MW-9	4.81	✓	X_2	X_2	X_2	X_2	X_2			
MW-10R[b]	--	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-11	4.05	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-12[c]	--	Locate	--	Decommission						
MW-13[a]	--	--	--	HVE System						
MW-14[a]	--	--	--	HVE System						
MW-15[a]	--	--	--	HVE System						
MW-16[a]	--	--	--	HVE System						
MW-17[d]	8.20	✓	X_2	X_2	X_2	X_2	X_2			
MW-18[b]	--	Locate and gauge	X_2	Removed from sampling program						
MW-19	--	--	--	Abandoned in 2011						
MW-20	6.96	✓	X_2	X_2	X_2	X_2	X_2			
MW-21[a]	--	--	--	HVE System						
MW-22[e]	6.98	✓	X_2	X_2	X_2	X_2	X_2			
MW-23[f]	6.99	✓	X_2	X_2	X_2	X_2	X_2			
MW-24	7.20	✓	X_2	X_2	X_2	X_2	X_2			
MW-25[e]	3.99	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-26	3.39	✓	X_2	X_2	X_2	X_2	X_2			✓
MW-27	6.57	Gauge Only	X_2	Removed from sampling program						
MW-28	6.58	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-29	5.88	✓	X_2	X_2	X_2	X_2	X_2		✓	
MW-30	7.00	Gauge Only	X_2	Removed from sampling program						
MW-31	5.45	Gauge Only	X_2	Removed from sampling program						
MW-32	--	--	--	Abandoned in 2005						
MW-33[g]	3.63	✓	X_2	X_2	X_2	X_2	X_2			
MW-34	3.46	Gauge Only	X_2	Removed from sampling program						
MW-35	3.91	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-36	3.82	✓	X_2	X_2	X_2	X_2	X_2		✓	
MW-37	4.15	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-38	3.83	Gauge Only	X_2	Removed from sampling program						
MW-39	4.21	Gauge Only	X_2	Removed from sampling program						
MW-40	3.83	Gauge Only	X_2	X_4	X_4	X_4	X_4			
MW-41[h]	--	✓	X_2	X_2	X_2	X_2	X_2			
Surface Water (x8)		✓					X_2	X_2	✓	✓

Notes:

For definitions, see the Acronyms section.

X_2 Biennial monitoring

X_4 Monitoring every 4 years

[a] HVE system.
[b] Not located in 2015.
[c] Obstruction in well.
[d] Heaved.
[e] Plug replaced in 2015 sampling effort.
[f] 0.13 ft of LNAPL observed in 2015 sampling effort.
[g] 0.02 ft of LNAPL observed in 2015 sampling effort.
[h] LNAPL observed in 2015 sampling effort; thickness could not be determined due to high viscosity.

5.3 Kenai Gas Field 34-31

KGF 34-31 is located approximately 60 miles southwest of Anchorage, Alaska, and 10 miles south of Kenai, in the KGF (Figure 6). The property lies within Kenai Peninsula Borough Tax Parcel numbers 05529054 and 05529014.

KGF 34-31 is one of several KGF production facilities, originally developed in 1959 by Unocal. Marathon acquired the KGF facilities in 1994. Hilcorp took over the pad in 2012 and is the current operator.

The pad at KGF 34-31 was constructed in the late 1950s; six production wells were drilled between 1959 and 1994. Supporting natural gas recovery and processing infrastructure, offices, and maintenance facilities have been constructed on the pad. Infrastructure on the pad includes several gas wells, former reserve pits, drum storage areas, wastewater buildings, a water injection building, a meter building, a generator building, a compressor building, offices, and workshops (SLR 2014c).

5.3.1 Geology and Hydrogeology

Soils beneath KGF 34-31 are interbedded, poorly sorted, medium-coarse-grained sands and gravelly sands with occasional layers of finer sands. Near the former reserve pit, lenses of silt and silty sand have been observed at 5 to 10 ft bgs. Off the pad, organic soils including vegetation, peat, and organic silt are present to approximately 6 ft bgs, and are underlain by poorly sorted, fine to coarse-grained sands and gravelly sands (SLR 2014c).

Groundwater flow at KGF 34-31 (Figure 21) has historically been reported to the west-northwest (SLR 2014c).

5.3.2 Previous Investigation and Monitoring Activities

Site investigations and groundwater monitoring have been conducted at KGF 34-31 in association with the eastern reserve pit since the 1980s. Unocal initiated cleanup of the reserve pit in 1992, resulting in 12,000 cy of soil removed and disposed of offsite. Impacted soil was left in place along the western wall due to existing active gas wells and infrastructure (SLR 2014c).

An NGC hydrocarbon sheen and odor were observed in 1999 in the well cellar at the WD-1 Water Injection Building. Also in 1999, a pipeline release was discovered beneath the Jump-Over No. 6 building. Monitoring wells were installed to investigate the nature and extent of impacts to soil and groundwater. One downgradient well location contained DRO concentrations in soil and groundwater exceeding ADEC cleanup levels in 2000. Subsequently, an additional soil and groundwater assessment was performed in September 2000, with the installation of eight monitoring wells. DRO was detected in soil and groundwater exceeding ADEC cleanup levels in three monitoring well locations. Results suggested the source of impacted soil and groundwater could be historical releases from the WD-1 well cellar, the Jump-Over No 6 building, and a dry well associated with the Wastewater Building housing Tanks 2 and 3. One monitoring well, MW-3, near the Jump-Over No. 6 Building, was abandoned because it was not providing necessary data for plume delineation (SLR 2014c).

Monitoring in 2002 found two monitoring wells containing LNAPL; however, later the same year LNAPL was only found in one of the wells. LNAPL-absorbent socks were installed; no LNAPL was recovered in 2003, 2004, or 2006. In 2005, 6 ounces of LNAPL were recovered. Several monitoring wells contained DRO concentrations exceeding the ADEC cleanup level (SLR 2014c).

Natural attenuation parameters were collected between 2000 and 2003. In 2004, in concurrence with ADEC, it was determined that aerobic and anaerobic processes were occurring and hydrocarbons were naturally attenuating. Collection of natural attenuation parameters was terminated. Annual groundwater monitoring was conducted in 2005 and 2006 (SLR 2014c).

Additional soil borings and monitoring wells were installed at KGF 34-31 in 2007, on and off the pad, in order to assess potential impacts from the former reserve pit. Areas of concern identified following the 2007 assessment were related to historical operations at KGF 34-31, including produced fluid and diesel fuel impacts to the pad surface and subsurface. DRO has been the only contaminant detected exceeding the ADEC cleanup level. During quarterly monitoring in 2007 and 2008, LNAPL was not observed and DRO remained the only contaminant exceeding ADEC cleanup levels. Annual monitoring from 2010 to 2012 reported similar observations, with DRO the only analyte exceeding ADEC cleanup levels, and LNAPL observed in one well in 2010 and 2011 (SLR 2014c). Following groundwater monitoring in 2011, ADEC recommended evaluating the soundness and value of three monitoring wells (MW-A, MW-C, and MW-E); it was suggested the wells be considered for decommissioning.

Groundwater monitoring conducted in 2013 found seven of 15 wells sampled containing DRO at concentrations greater than the ADEC cleanup level. LNAPL was not observed in any of the monitoring wells gauged (SLR 2014c). Groundwater monitoring in 2014 found similar results, with five of 12 monitoring wells sampled containing DRO concentrations exceeding the ADEC cleanup level. LNAPL was not observed in any monitoring wells (SLR 2015d).

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the KGF 34-31 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program (Brice 2016l).

Groundwater depths were measured in 16 monitoring wells located at KGF 34-31, and groundwater flow direction was determined to be generally toward the west. Groundwater quality parameters and analytical samples were collected from 11 monitoring wells at KGF 34-31. The 2015 groundwater monitoring results indicate that DRO concentrations exceeded the ADEC cleanup level in samples from four monitoring wells. DRO concentrations in the remaining monitoring wells sampled were not detected or were below ADEC cleanup levels. No LNAPL was observed in any of the monitoring wells at KGF 34-31 (Brice 2016l).

5.3.3 2017 Groundwater Monitoring Activities

KGF 34-31 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Sample ten monitoring wells for DRO: MW-1, MW-2, MW-4, MW-6, MW-7, MW-8, MW-9, MW-10, MW-11, and MW-12.
- Three monitoring wells are sampled for DRO every four years and will be sampled next in 2019: MW-5, MW-15, and MW-16. Gauge groundwater levels in these wells in 2017.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Locate and decommission monitoring wells MW-A, MW-C, MW-E, and MW-3.
- Resurvey all monitoring wells for top-of-casing elevations.

Table 20 identifies the KGF 34-31 wells, sample analyses, and quality control samples. Monitoring well locations are presented on Figure 21. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 20: KGF 34-31 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				DRO	Duplicate	MS/MSD
MW-A[a]	--	Locate	--	Decommission		
MW-C[a]	--	Locate	--	Decommission		
MW-E[a]	--	Locate	--	Decommission		
MW-1	23.41	✓	X_2	X_2		
MW-2	22.86	✓	X_2	X_2		
MW-3	--	--	--	Abandoned		

Table 20: KGF 34-31 Summary of Monitoring Wells and Analyses (continued)

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES	QUALITY CONTROL	
				DRO	Duplicate	MS/MSD
MW-4	22.78	✓	X_2	X_2	✓	
MW-5	22.94	Gauge Only	X_2	X_4		
MW-6	22.52	✓	X_2	X_2		
MW-7	22.16	✓	X_2	X_2		
MW-8	22.49	✓	X_2	X_2		
MW-9	23.31	✓	X_2	X_2		✓
MW-10	23.58	✓	X_2	X_2		
MW-11	24.05	✓	X_2	X_2		
MW-12	20.01	✓	X_2	X_2		
MW-13	15.61	Gauge Only	X_2	Removed from sampling program		
MW-14	16.27	Gauge Only	X_2	Removed from sampling program		
MW-15	25.04	Gauge Only	X_2	X_4		
MW-16	21.36	Gauge Only	X_2	X_4		
MW-17	17.29	Gauge Only	X_2	Removed from sampling program		

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring
X_4 Monitoring every 4 years
[a] Not located in 2015 sampling event.

5.4 Kenai Gas Field 41-7

KGF 41-7 is located approximately 60 miles southwest of Anchorage, Alaska, and 10 miles south of Kenai, in the KGF (Figure 6). The property lies within Salamatof Native Association, Inc. land on Kenai Peninsula Borough Tax Parcel number 13103014.

KGF 41-7 was constructed in the late 1950s by Unocal, as a 3- to 4-ft gravel pad placed over native tundra and wetland. Several buildings and gas recovery and transmission infrastructure are present on the pad, including a Reboiler, Meter, Contractor, and Compressor buildings clustered in the southern half of KGF 41-7. Marathon acquired the KGF facilities in 1994. Hilcorp took over operations of KGF 41-7 in 2013 and is the current operator (SLR 2015a).

5.4.1 Geology and Hydrogeology

KGF 41-7 is a gravel pad built in spruce bog terrain in the Kenai lowlands. The Kenai lowlands consist of topographically flat, discontinuous wetlands with organic soil from the surface to as deep as 6 ft bgs. KGF 41-18 was constructed by placing 3 to 4 ft of gravel on top of the organic soil. Beneath the organic soil layer lies a thin layer of fine-grained alluvium, then interbedded sand and sandy gravel to at least 20 ft bgs (SLR 2015a).

Previous investigations indicate groundwater flow direction (Figure 22) at the site may vary from west/northwest on the west side of the pad and east/northeast on the east side of the pad (SLR 2015a).

5.4.2 Previous Investigation and Monitoring Activities

A release from a fluid discharge line spurred the beginning of site investigations and assessments of soil and groundwater at KGF 41-7 in 1999. Five hand-driven well points were installed near the observed release; soil and groundwater samples confirmed produced water impacts were present. Contaminant concentrations exceeded the applicable ADEC cleanup levels. KGF 41-7 was expanded to the south in 2003, covering up this area with gravel. The well points were abandoned (SLR 2015b).

Following a 2005 expansion of the pad, site assessment activities including installation of six soil boring and monitoring wells near the edge of the pad. Soil and groundwater sampling in 2005 and 2006 found petrogenic contaminants exceeding ADEC cleanup levels in one soil boring and one different monitoring well (SLR 2015b).

In the winter of 2007, seven additional monitoring wells were installed in the wetlands surrounding KGF 41-7. Twelve more monitoring wells were installed on the pad during the summer in 2007. Groundwater sampling indicated that natural attenuation was occurring beneath the pad. Areas of concern on the pad at KGF 41-7 related to releases of produced fluid and diesel fuel were identified. A dissolved-phase plume was identified on the east side of the pad (SLR 2015b).

Groundwater monitoring conducted in 2008 included the decommissioning of MW-1, MW-6, MW-7, MW-8, and MW-18. LNAPL, from NGC, was observed in the western area of the pad, and was surrounded by a dissolved-phase DRO plume. DRO-impacted groundwater was also observed around MW-16, likely associated with drilling muds incorporated into the pad. Analytical results did not indicate contaminants were migrating off the pad to the north or south (SLR 2015b).

Additional site assessment activities were conducted in 2009. Eight soil borings were advanced and completed as monitoring wells along the northern edge of the pad. Soil within a fibrous peat layer was detected containing DRO and benzene concentrations greater than ADEC cleanup levels, and was not fully delineated. Groundwater analytical samples indicated groundwater was not impacted (SLR 2015b).

Groundwater monitoring in 2010 found the dissolved-phase DRO plume was not fully delineated, as most of the on-pad wells exceeded ADEC cleanup levels. Fluid level gauging indicated that LNAPL could be migrating to the west, potentially affecting the natural attenuation processes thought to be occurring at wetland-pad interface (SLR 2015b).

Site monitoring in 2011 included groundwater sampling at 13 wells and collection of six surface water samples. DRO was detected exceeding ADEC cleanup levels in samples from several on-pad monitoring wells, and it appeared the dissolved-phase plume was expanding to the west. Increased LNAPL thickness was observed in MW-24. No impact to surface water was observed (SLR 2015b).

Eight soil borings were installed and completed as monitoring wells in 2012 in order to further delineate on-pad hydrocarbon impacts to soil and groundwater. Three source areas were identified: the dissolved-phase DRO plume on the eastern edge of the pad, LNAPL in the southern area of the pad, and dissolved and separate phase hydrocarbons in the western area of the pad. DRO, RRO, and benzene were the primary contaminants of concern (SLR 2015b).

Groundwater monitoring was conducted in 2013 and 2014. Groundwater samples were analyzed for DRO, GRO, and BTEX. DRO and benzene were the only analytes detected above ADEC cleanup levels. LNAPL was detected in MW-24 during both sampling events. Surface water samples indicated no impact to the wetlands west and east of KGF 41-7 (SLR 2015b).

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the KGF 41-7 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program.

Groundwater depths were measured in thirteen of 34 monitoring wells at KGF 41-7. Twenty-one monitoring wells were not able to be gauged; one well was heaved too high to be gauged, 12 wells are assumed to be decommissioned or destroyed, and eight wells were not located. Groundwater flow direction was determined to be generally west-northwest. Groundwater quality parameters and analytical samples were collected from nine monitoring wells at KGF 41-7. Samples were analyzed DRO, and select monitoring well samples were also analyzed for RRO, GRO, and BTEX. LNAPL was observed in one monitoring well (Brice 2016m).

The 2015 groundwater monitoring results indicate that DRO concentrations exceeded the ADEC cleanup level in three monitoring wells and RRO and benzene concentrations exceeded the ADEC cleanup level in one of those wells. Remaining concentrations of all other analytes for all wells sampled were less than ADEC cleanup levels or were not detected (Brice 2016m).

Surface water samples were collected at seven locations adjacent to KGF 41-7 and analyzed for BTEX and PAH. All analytical results were less than ADEC cleanup levels. Results were used to calculate TAH and TAqH. All calculated TAH and TAqH values were an order of magnitude less than the surface water quality criteria listed in 18 AAC 70.020 (Brice 2016m).

5.4.3 2017 Groundwater Monitoring Activities

KGF 41-7 groundwater wells are monitored on a biennial schedule. All viable wells are gauged during each sampling event. Additionally, seven surface water samples are collected biennially from the historical locations (shown on Figure 22). Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Decommission and replace MW-24. The well contains LNAPL and is thought to be a conduit between two different aquifers. The replacement well should be screened across only one aquifer. If LNAPL is present in the new replacement well, remove LNAPL. If LNAPL is not present in the new well, sample well for DRO, RRO, GRO, and BTEX.
- Sample the following wells:
  - Sample eight wells for DRO: MW-15, MW-16R, MW-20, MW-25, MW-26, MW-29, MW-35, and MW-37.
  - Sample one well for DRO and RRO: MW-21R.
  - Sample three wells for DRO, GRO, and BTEX: MW-19, MW-22R, and MW-28.
  - Sample five wells for DRO, RRO, GRO, and BTEX: MW-23R, MW-24R, MW-32, MW-33, and MW-36.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Locate and decommission wells MW-4, MW-30, and MW-34. These wells are damaged and were unable to be sampled in 2014. Several nearby wells provide similar data.
- Collect surface water samples from seven locations for BTEX and PAH in order to calculate TAH and TAqH and verify contamination is not migrating off-pad and/or to surface water.
- Resurvey the top-of-casing elevations of all monitoring wells.

Table 21 identifies the KGF 41-7 wells, sample analyses, and quality control samples. Monitoring well and surface water sample locations are presented on Figure 22. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 21: KGF 41-7 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE ONLY	ANALYSES					QUALITY CONTROL	
				DRO	RRO	GRO	BTEX	PAH	Duplicate	MS/MSD
MW-1	--	--	--	Abandoned						
MW-2	--	--	--	Decommissioned						
MW-3	--	--	--	Decommissioned						
MW-4	--	Locate	--	Decommission						
MW-5	--	--	--	Decommissioned						
MW-6	--	--	--	Decommissioned						
MW-7	--	--	--	Decommissioned						
MW-8	--	--	--	Decommissioned						
MW-9	--	--	--	Abandoned						
MW-10	--	--	--	Decommissioned						

Table 21: KGF 41-7 Summary of Monitoring Wells and Analyses (continued)

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE ONLY	ANALYSES					QUALITY CONTROL	
				DRO	RRO	GRO	BTEX	PAH	Duplicate	MS/MSD
MW-11	--	--	--	Decommissioned						
MW-12	--	--	--	Decommissioned						
MW-13	--	--	--	Decommissioned						
MW-14	--	--	--	Abandoned						
MW-15	5.38	✓	X_2	X_2						
MW-16R	2.51	✓	X_2	X_2						
MW-17	4.74	Gauge Only	X_2	Removed from sampling program						
MW-18	--	--	--	Decommissioned						
MW-19	2.16	✓	X_2	X_2		X_2	X_2		✓	
MW-20	2.87	✓	X_2	X_2						
MW-21	--	--	--	Decommissioned						
MW-21R	4.17	✓	X_2	X_2	X_2					✓
MW-22	--	--	--	Decommissioned						
MW-22R[a]	--	✓	X_2	X_2		X_2	X_2			
MW-23[a]	--	--	--	Decommissioned						
MW-23R[a]	--	✓	X_2	X_2	X_2	X_2	X_2			
MW-24[b]	--	Replace	--	Decommission						
MW-24R[c]	--	✓	X_2	X_2	X_2	X_2	X_2			
MW-25	4.93	✓	X_2	X_2						
MW-26[a]	--	✓	X_2	X_2						
MW-27	4.89	Gauge Only	X_2	Removed from sampling program						
MW-28[a]	--	✓	X_2	X_2		X_2	X_2			
MW-29	4.52	✓	X_2	X_2						
MW-30[d]	--	Locate	--	Decommission						
MW-31	0.64	Gauge Only	X_2	Removed from sampling program						
MW-32	1.56	✓	X_2	X_2	X_2	X_2	X_2		✓	
MW-33[e]	--	✓	X_2	X_2	X_2	X_2	X_2			
MW-34[d]	--	Locate	--	Decommission						
MW-35[a]	--	✓	X_2	X_2						
MW-36[e]	--	✓	X_2	X_2	X_2	X_2	X_2			
MW-37	4.93	✓	X_2	X_2						
Surface Water (x7)		✓					X_2	X_2	✓	✓

Notes:
For definitions, see the Acronyms section.
X_2 Biennial monitoring
[a] Not located in 2015 sampling event.
[b] LNAPL observed in 2015 sampling event. Recommended for replacement.
[c] Planned replacement well to be installed and sampled in 2017.
[d] Not located in 2015 sampling event; "destroyed" as of 2014.
[e] Not located in 2015 sampling event; likely under water.

5.5 Kenai Gas Field 41-18

KGF 41-18 is located approximately 60 miles southwest of Anchorage, Alaska, and 10 miles south of Kenai, in the KGF (Figure 6). The property lies within Cook Inlet Region, Inc. Tax Parcel 13108022.

KGF 41-18 was constructed in 1971 by Unocal and has been used for oil and gas exploration and production ever since. Marathon assumed operation of the gas field in 1994. Hilcorp assumed operation of KGF 41-18 in 2013. The pad includes multiple gas wellheads, groundwater monitoring wells, and several current and former operations buildings including a Water Well Building, Equipment Building, Meter Building, former Wastewater Building, and Grind and Inject Building (Figure 23) (SLR 2014b).

A reserve pit, formerly located in the southwestern area of KGF 41-18, was excavated, sampled, and closed in 1998. Another inactive reserve pit in the northern area of the pad was closed in 2000. Marathon periodically expanded the pad, most significantly in 1996 and 2006 (SLR 2014b).

5.5.1 Geology and Hydrogeology

KGF 41-18 is a gravel pad built in spruce bog terrain in the Kenai lowlands. The Kenai lowlands consist of topographically flat, discontinuous wetlands with organic soil from the surface to as deep as 6 ft bgs. KGF 41-18 was constructed by placing 3 to 4 ft of gravel on top of the organic soil. Beneath the organic soil layer lies a thin layer of fine-grained alluvium, then interbedded sand and sandy gravel to at least 20 ft bgs (SLR 2014b).

The groundwater flow direction (Figure 23) at the site is generally to the northwest (SLR 2014b).

5.5.2 Previous Investigation and Monitoring Activities

Hydrocarbon staining and a liquid were observed inside a well cellar at KGF 41-18 in 1999. A shallow aquifer groundwater investigation was conducted in 2000, and included the installation of a monitoring well, collection of soil and groundwater samples, and collection of samples from within the well cellar. Analytical results indicated that DRO and benzene concentrations exceeded the ADEC soil cleanup levels in the subsurface. Analytical groundwater results demonstrated that DRO and RRO were present, but at concentrations less than ADEC cleanup levels. Liquid within the well cellar contained DRO concentrations above the ADEC groundwater cleanup level. Groundwater monitoring has been conducted on a regular basis since 2000. An additional assessment was conducted in 2001; eight soil borings and three monitoring wells were installed at KGF 41-18. Analytical results confirmed subsurface soil and groundwater were impacted by petroleum hydrocarbons near the former Wastewater Building (SLR 2014b).

Site characterization and assessment activities in 2008 included installation of nine soil borings, completed as groundwater monitoring wells, four of which were off the pad. Analytical samples were assessed for biogenic contribution to petroleum hydrocarbon results, as the site is surrounded by vegetative tundra peat. Analytical results for all four analytical soil samples from off-pad exceeded the ADEC soil cleanup level for DRO, however further analysis of gas chromatograms indicated the source of the elevated DRO concentrations was biogenic, not petrogenic. On-pad soil samples indicated DRO-impacted soil at MW-11 (SLR 2014b).

Groundwater monitoring was conducted twice in 2008; groundwater from all but two of the on-pad wells exceeded the ADEC DRO cleanup level. DRO was detected in groundwater off-pad, but at concentrations less than the ADEC cleanup level. Gas chromatograms from the off-pad samples indicated elevated DRO concentrations remained biogenic. Surface water samples downgradient of the pad did not exceed surface water quality criteria for petroleum contaminants (SLR 2014b).

Two soil borings were advanced in 2009 at the northern edge of the pad, and were completed as monitoring wells. DRO concentrations exceeded the ADEC soil cleanup level in one borehole, benzene concentrations exceeded soil cleanup levels in both boreholes. Groundwater samples from all monitoring wells at KGF 41-18 indicated two areas of DRO-impacted groundwater: adjacent to the former Wastewater Building, and along the north and west edges of the pad (SLR 2014b).

Annual groundwater monitoring in 2011 through 2014 found similar results to previous monitoring events, with DRO-impacted groundwater in monitoring wells near the former Wastewater Building, as well as in monitoring wells on the north and west sides of the pad. Surface water samples collected from downgradient locations off the pad did not exceed surface water quality criteria (SLR 2015c).

A Groundwater Monitoring Program Optimization was conducted in 2015. Based on the well-by-well assessment of the KGF 41-18 groundwater monitoring program, as part of the 2015 Optimization, recommendations for future monitoring at the site were made and accepted by Hilcorp and ADEC. In 2015, these recommendations were implemented as part of the groundwater monitoring program (Brice 2016n).

Groundwater depths were measured in 15 monitoring wells located at KGF 41-18, and groundwater flow direction was determined to be generally northwest. Groundwater quality parameters and analytical samples were collected from 12 monitoring wells at KGF 41-18. The 2015 groundwater monitoring results indicate that DRO exceeded the ADEC cleanup level in four monitoring wells. All remaining monitoring wells sampled contained DRO at concentrations less than ADEC cleanup levels or DRO was not detected (Brice 2016n).

Surface water samples were collected at five locations adjacent to KGF 41-18, and all analytical results were below ADEC cleanup levels. Results were used to calculate TAH and TAqH. All calculated TAH and TAqH values were an order of magnitude less than the surface water quality criteria listed in 18 AAC 70.020 (Brice 2016n).

5.5.3 2017 Groundwater Monitoring Activities

KGF 41-18 groundwater wells are monitored on a biennial and a four-year schedule. All viable wells are gauged during each sampling event. Additionally, five surface water samples are collected biennially from historical locations (shown on Figure 23). Recommendations for future groundwater monitoring efforts were developed in the 2015 Groundwater Monitoring Report based on the 2015 Groundwater Monitoring Program Optimization and subsequent sampling results. The scope of work for 2017 field activities is summarized below:

- Sample seven wells for DRO: MW-3R, MW-4, MW-9, MW-11R, MW-15, MW-16, and MW-17.
- Five wells are sampled for DRO every four years and will be sampled next in 2019: MW-2, MW-12, MW-14, MW-18, and MW-19. Gauge groundwater levels in these wells in 2017.
- Decommission wells MW-A, MW-C, MW-1, MW-5, MW-6, MW-7, and MW-13. These wells are damaged and have not been gauged or sampled since 2010 (excluding MW-13, which was sampled in 2013 and gauged in 2015). Several nearby wells provide similar data.
- Gauge groundwater levels in all monitoring wells within a 24-hour period in order to determine groundwater elevation and flow direction.
- Sample surface water at the same five locations for BTEX and PAH in order to calculate TAH and TAqH and verify that contamination is not migrating off-pad and/or to surface water.
- Resurvey the top-of-casing elevations of all monitoring wells.

Table 22 identifies the KGF 41-18 wells, sample analyses, and quality control samples. Monitoring well and surface water sample locations are presented on Figure 23. Reference Section 1.4 for ADEC Table C cleanup levels.

Table 22: KGF 41-18 Summary of Monitoring Wells and Analyses

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES			QUALITY CONTROL	
				DRO	BTEX	PAH	Duplicate	MS/MSD
MW-A[a]	--	Locate	--	Decommission				
MW-C[b]	--	Locate	--	Decommission				
MW-1[b]	--	Locate	--	Decommission				
MW-2[c]	5.11	Gauge Only	X_2	X_4				
MW-3R	4.52	✓	X_2	X_2				
MW-4	7.91	✓	X_2	X_2				
MW-5[d]	--	--		Decommission				
MW-6[d]	--	--		Decommission				
MW-7[b]	--	Locate		Decommission				
MW-8R	4.12	Gauge Only	X_2	Removed from sampling program				
MW-9	6.70	✓	X_2	X_2				
MW-10	7.11	Gauge Only	X_2	Removed from sampling program				
MW-11R	6.02	✓	X_2	X_2				
MW-12	5.99	Gauge Only	X_2	X_4				

Table 22: KGF 41-18 Summary of Monitoring Wells and Analyses (continued)

WELL ID	2015 DEPTH TO GW	2017 SCOPE	GAUGE	ANALYSES			QUALITY CONTROL	
				DRO	BTEX	PAH	Duplicate	MS/MSD
MW-13[e]	0.42			Decommission				
MW-14	6.87	Gauge Only	X_2	X_4				
MW-15	7.30	✓	X_2	X_2				✓
MW-16[f]	6.75	✓	X_2	X_2				
MW-17	4.73	✓	X_2	X_2			✓	
MW-18	7.26	Gauge Only	X_2	X_4				
MW-19	5.59	Gauge Only	X_2	X_4				
Surface Water (x5)		✓			X_2	X_2		

Notes:

For definitions, see the Acronyms section.

X_2 Biennial monitoring

X_4 Monitoring every 4 years

[a] Not located in 2015 sampling event; potentially buried under stockpile.

[b] Not located in 2015 sampling event.

[c] Minor heaving; missing cap.

[d] Heaved approximately 5 ft.

[e] Heaved and casing full of water.

[f] No casing.

6.0 REFERENCES

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APPENDIX A:
FIGURES

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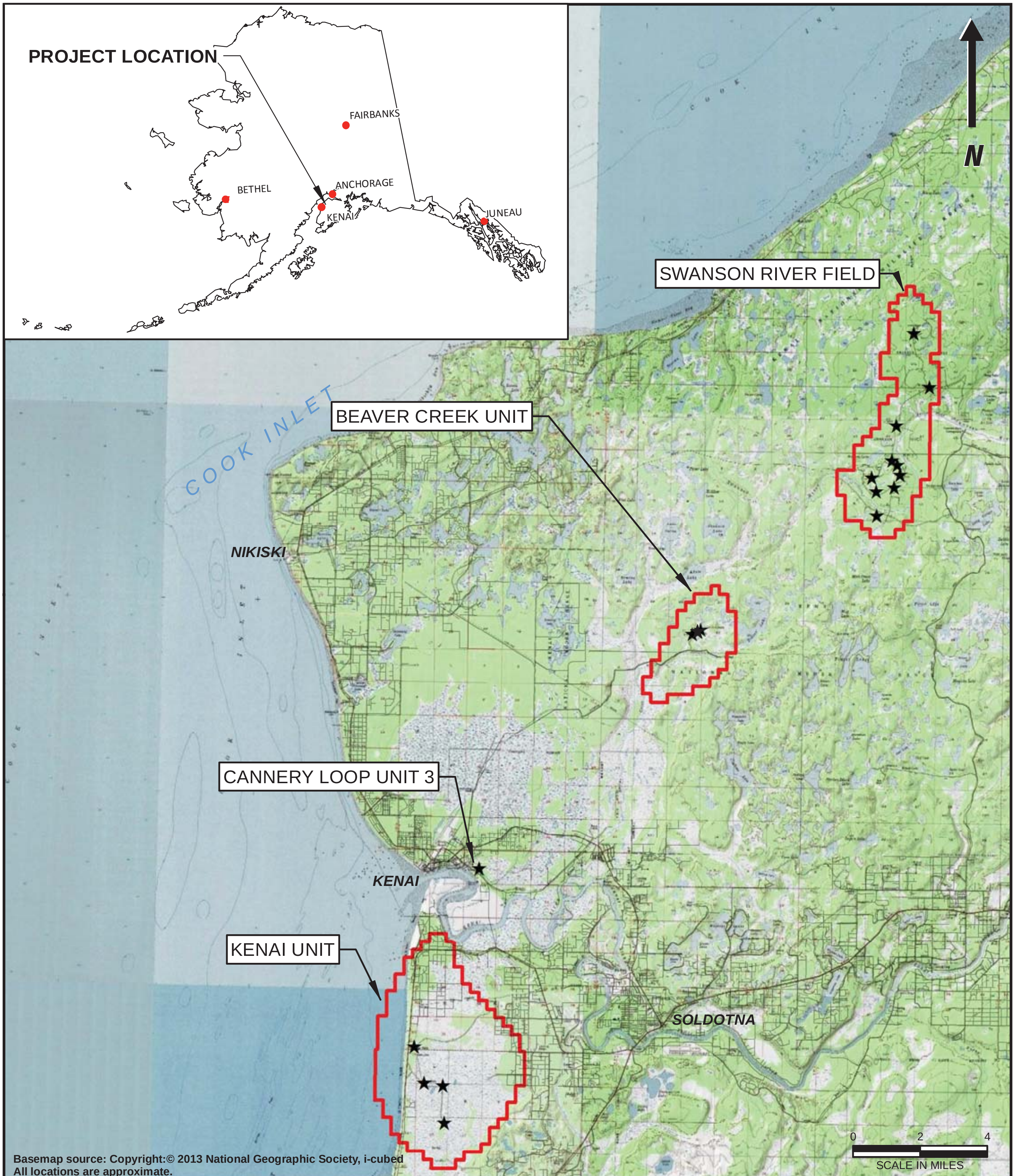

Brice ANC 8(a)
Environmental Services Corporation
3800 Centerpoint Dr. Ste.400
Anchorage, AK 99503

2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

STATE AND SITE VICINITY

DATE:	4/19/2017
PROJECT No.:	HG0001
DRAWN:	D.H.
FIGURE:	1

Document Path: Q:\BES Anchorage\GEOSPATIAL_PROJECTS\BES\HILCORP\2015_Groundwater_Monitoring_HGO001\GIS\MXD\Beaver_Creek_Production_Facility_Pad_4\2017_Beaver_Creek_GWM_WorkPlan_F1.mxd

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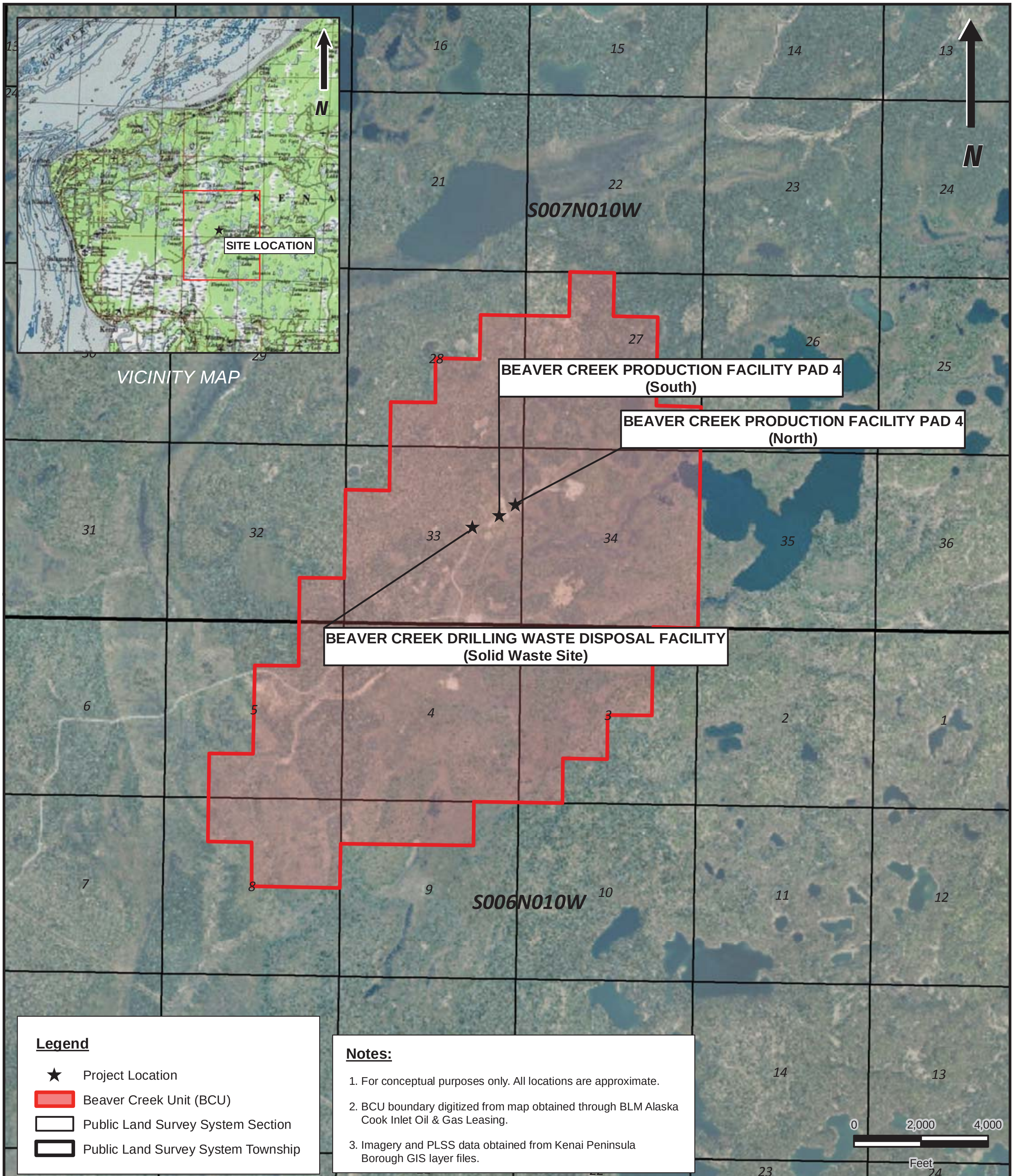

Brice ANC 8(a)
Environmental Services Corporation
3800 Centerpoint Dr. Ste. 400
Anchorage, AK 99503

2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

BEAVER CREEK UNIT SITE MAP

DATE: 4/11/2017

PROJECT No.: HG0001

DRAWN: D.H.

FIGURE: 2

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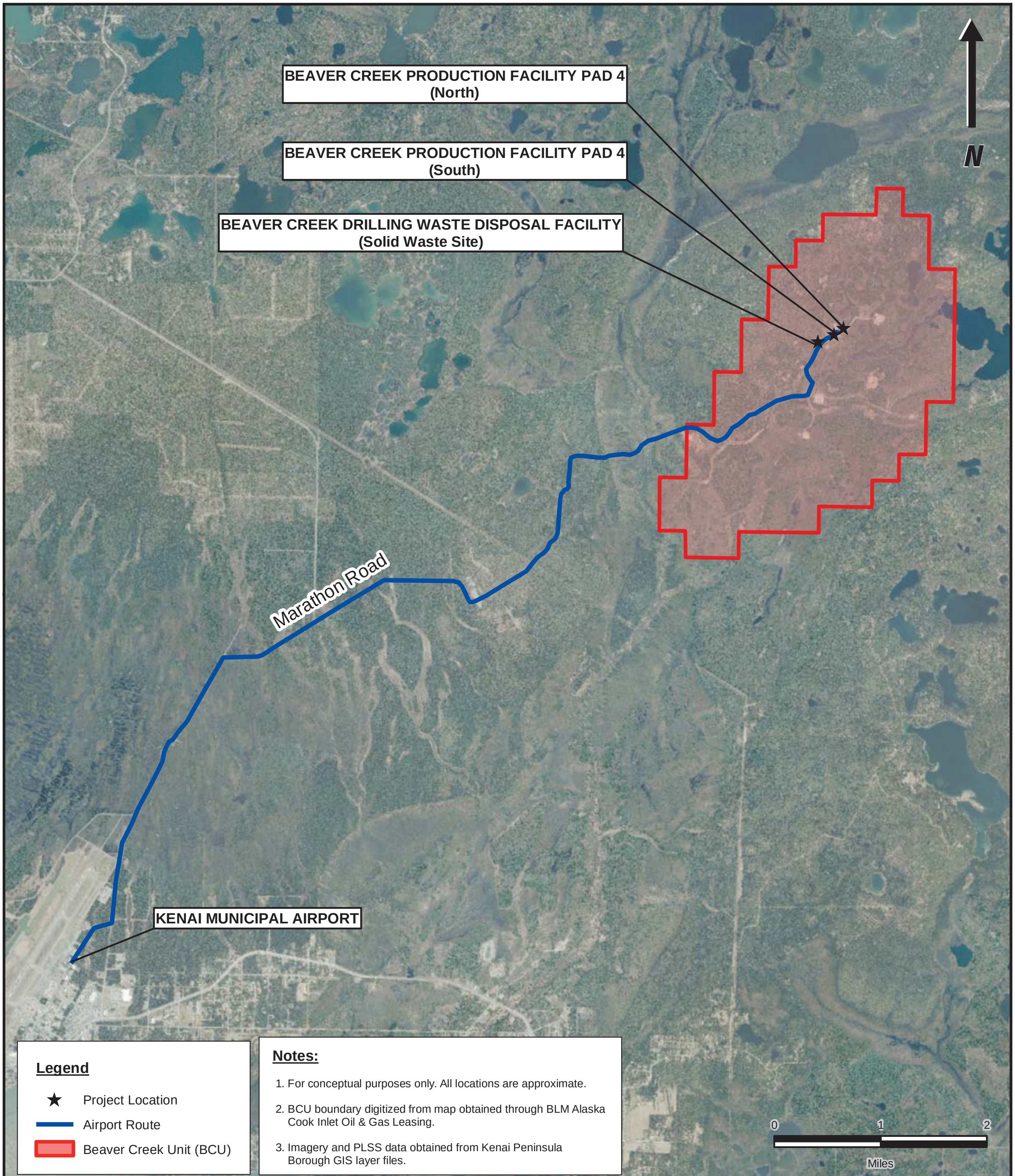

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Anchorage, AK 99503

2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

BEAVER CREEK UNIT DIRECTIONS

DATE: 4/19/2017
PROJECT No.: HG0001
DRAWN: I.A.E.

FIGURE: 3

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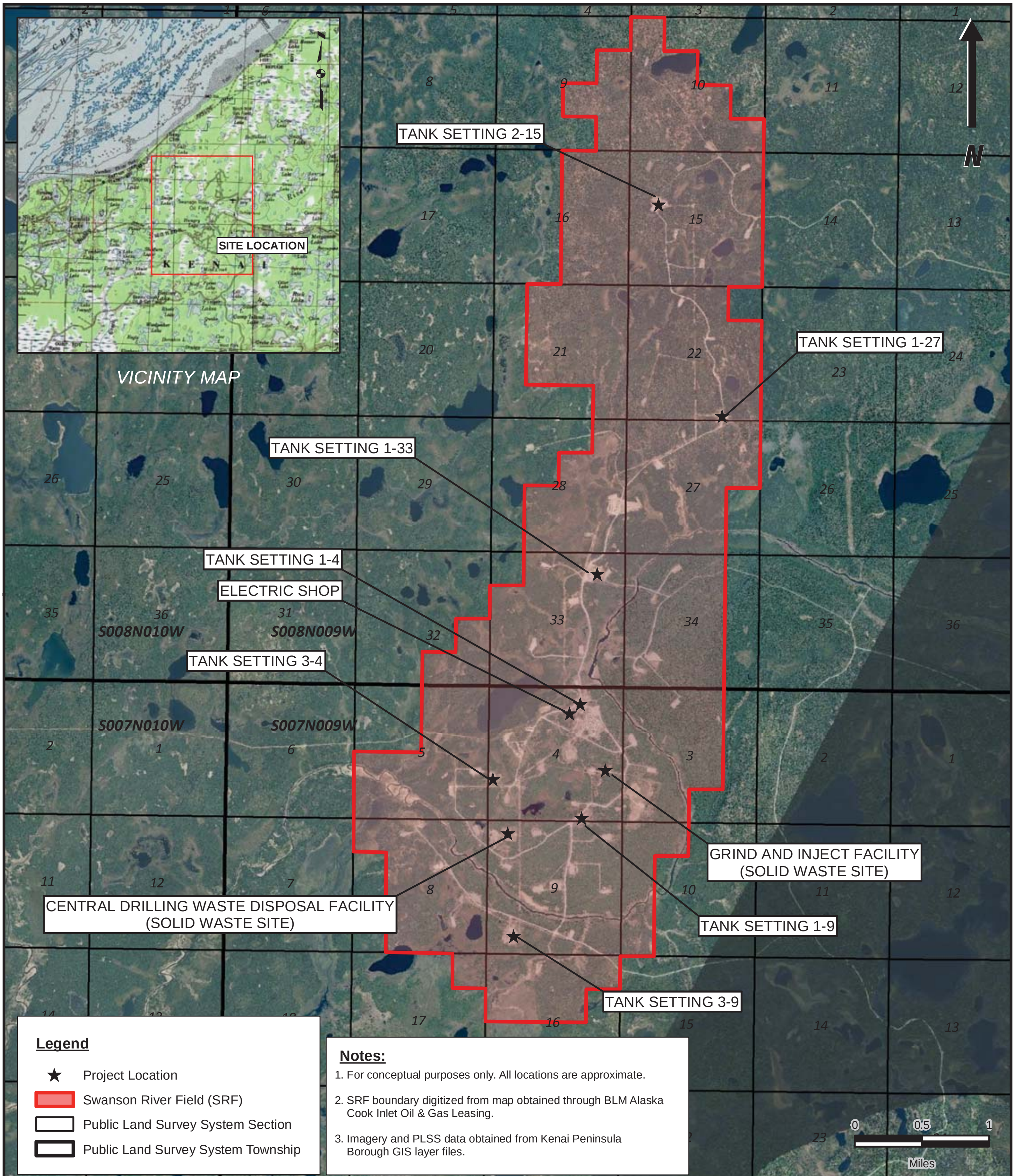

Legend

- ★ Project Location
- Swanson River Field (SRF)
- Public Land Survey System Section
- Public Land Survey System Township

Notes:

1. For conceptual purposes only. All locations are approximate.
2. SRF boundary digitized from map obtained through BLM Alaska Cook Inlet Oil & Gas Leasing.
3. Imagery and PLSS data obtained from Kenai Peninsula Borough GIS layer files.

Brice ANC 8(a) Environmental Services Corporation 3800 Centerpoint Dr. Ste. 400 Anchorage, AK 99503	2017 GROUNDWATER MONITORING WORK PLAN KENAI, ALASKA **SWANSON RIVER FIELD SITE MAP**	DATE: 5/2/2017 PROJECT No.: HG0001 DRAWN: D.H.	FIGURE: 4

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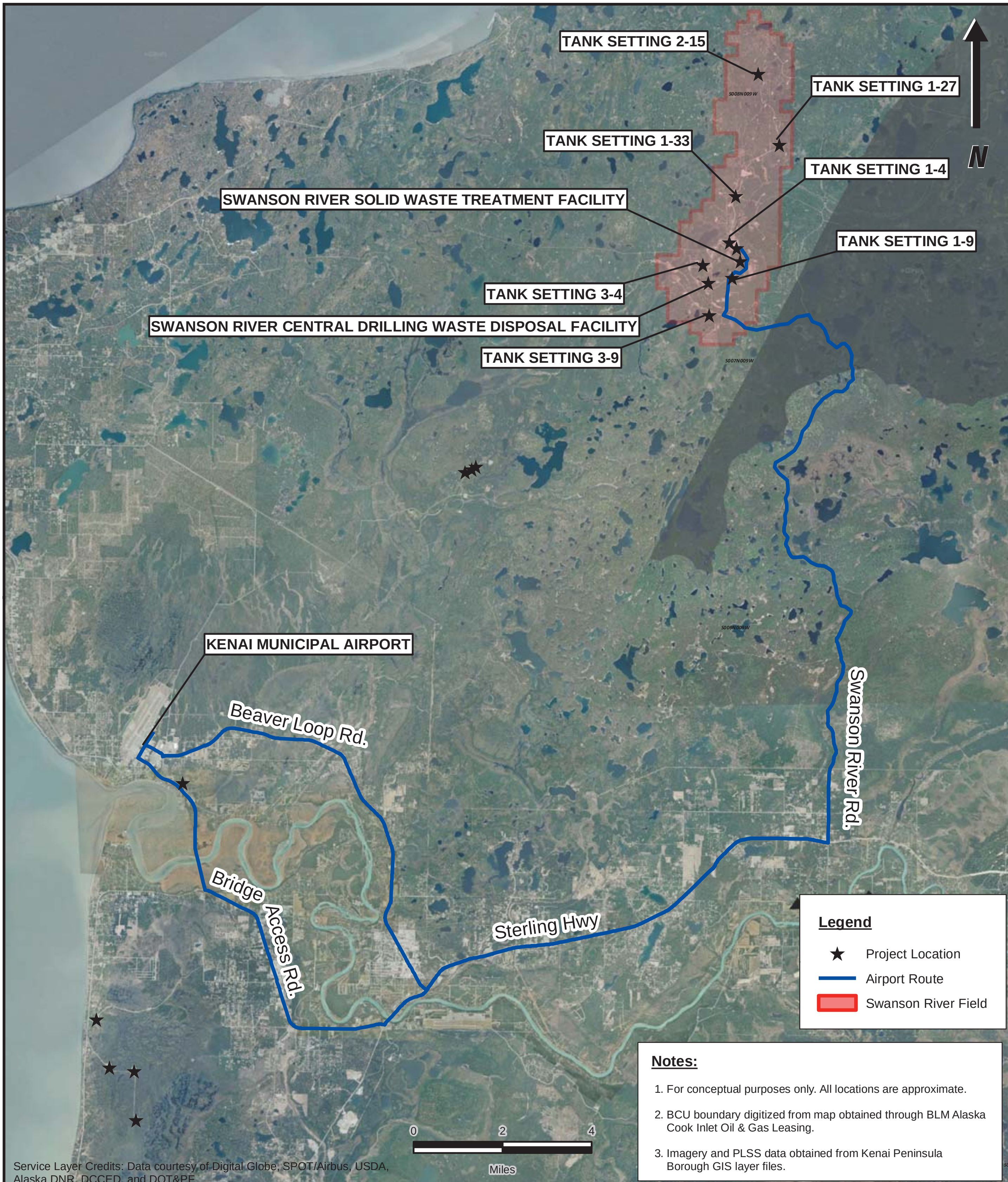

Brice ANC 8(a)
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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

SWANSON RIVER FIELD DIRECTIONS

DATE: 5/3/2017

PROJECT No.: HG0001

DRAWN: I.A.E.

FIGURE: 5

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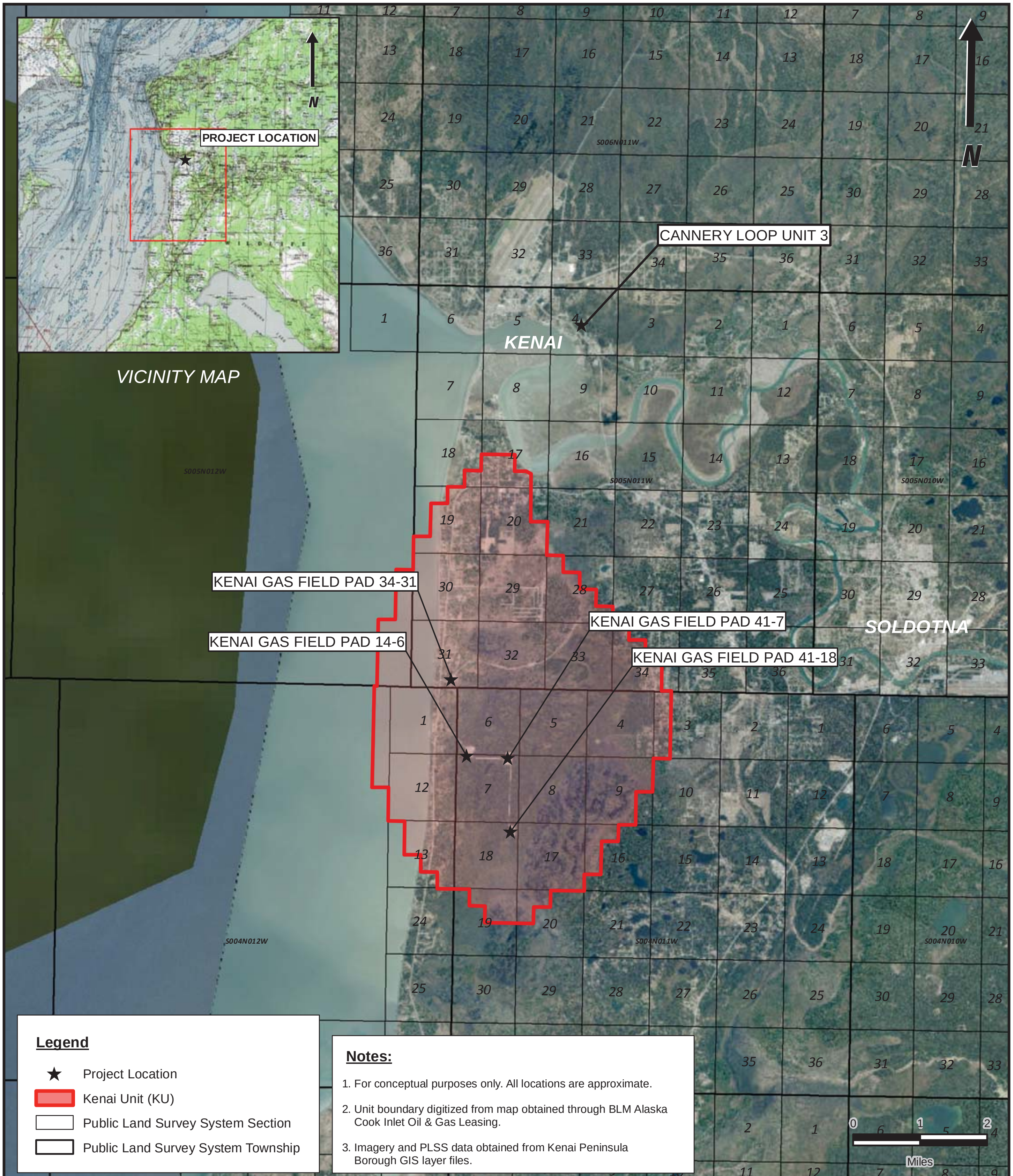

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

CANNERY LOOP UNIT 3 AND KENAI UNIT SITE MAP

DATE: 5/1/2017
PROJECT No.: HG0001
DRAWN: D.H.

FIGURE: 6

Q:\BES Anchorage\GEOSPATIAL_PROJECTS\BESHILCORP\2015_Groundwater_Monitoring_HG0001\GIS\MXD\Data_Driven\2017_Beaver_Creek_GWM_WorkPlan_F6.mxd

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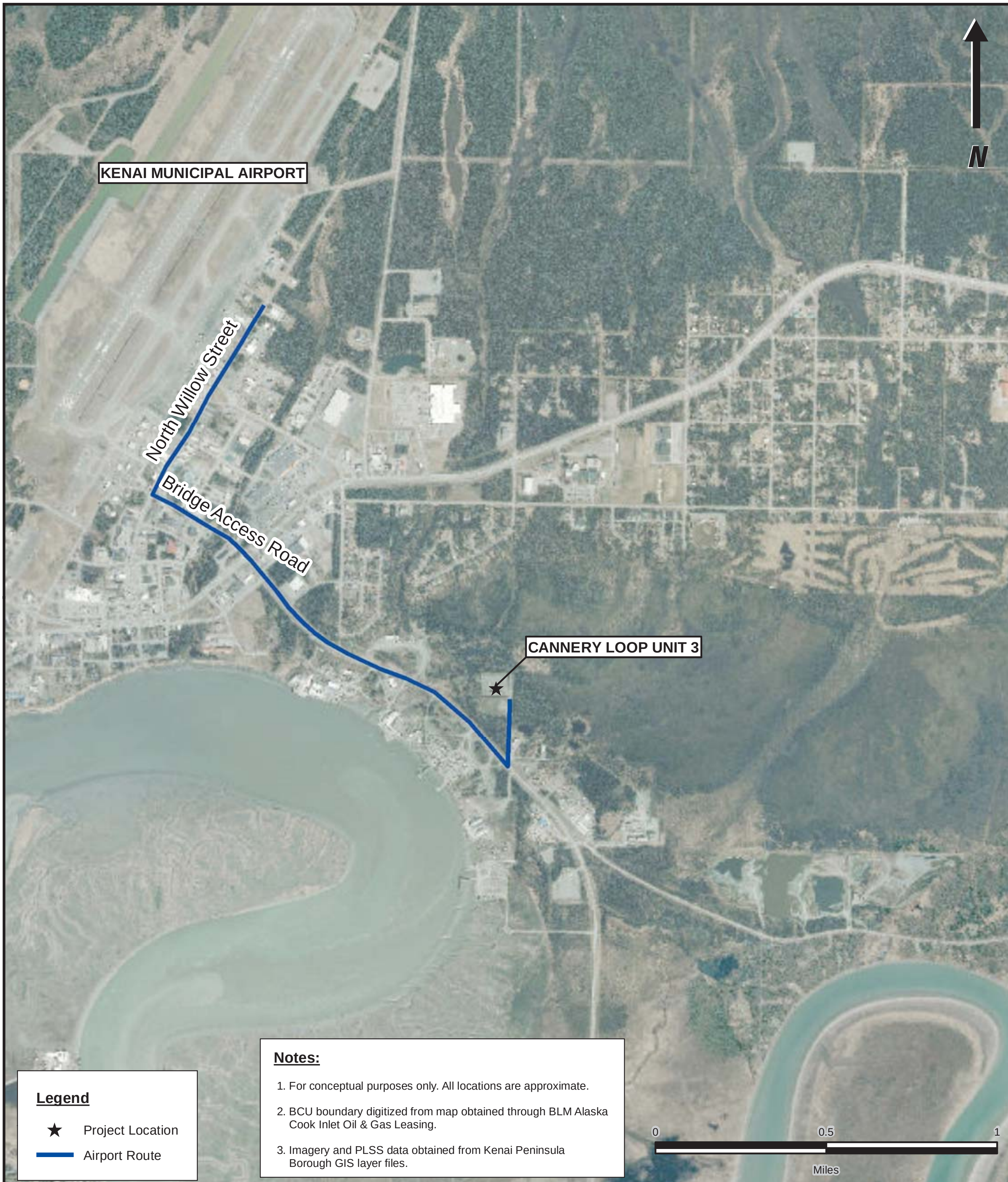

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

CANNERY LOOP UNIT 3 DIRECTIONS

DATE:	FIGURE:
4/19/2017	7
PROJECT No.: HG0001	
DRAWN: I.A.E.	

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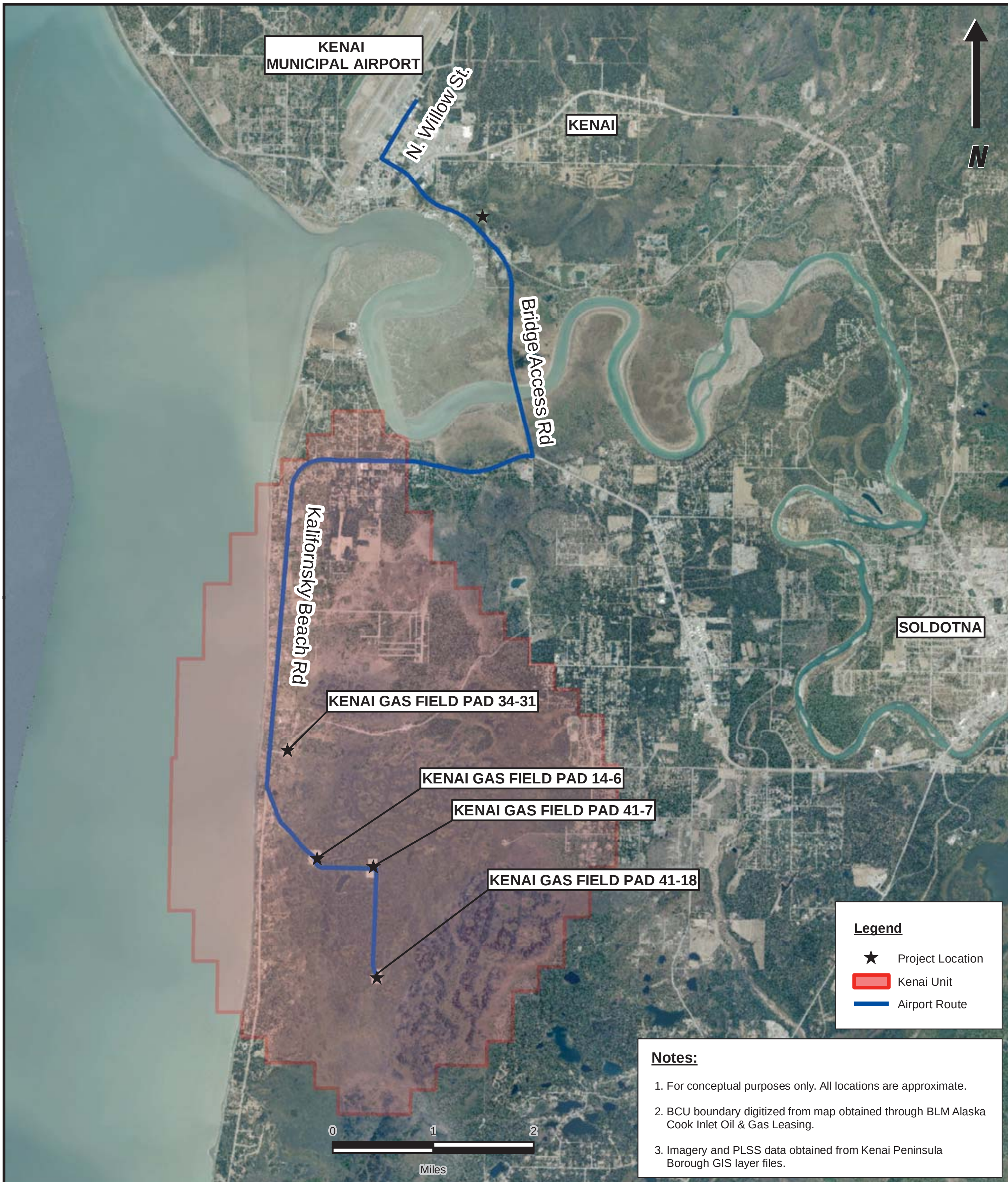

Notes:

1. For conceptual purposes only. All locations are approximate.
2. BCU boundary digitized from map obtained through BLM Alaska Cook Inlet Oil & Gas Leasing.
3. Imagery and PLSS data obtained from Kenai Peninsula Borough GIS layer files.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

KENAI UNIT DIRECTIONS

DATE: 4/12/2017
PROJECT No.: HG0001
DRAWN: I.A.E.

FIGURE: 8

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

BCP4 (SOUTH) GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE: 5/3/2017

PROJECT No.: HG0001

DRAWN: D.H.

FIGURE: 9

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Notes:
1. For conceptual purposes only. Site feature locations are approximate.
2. Groundwater contours are derived from 2015 groundwater data.
3. Imagery dated 04.17.11, and acquired through Google Earth under professional license.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

BCP4 (NORTH) GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE: 5/3/2017
P.M.: BE1302
DRAWN: D.H.

FIGURE: 10

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Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in NAVD88 datum and are based on a 2015 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13. **FS1-4E** was not used in the groundwater flow direction calculation due to its anomalous groundwater elevation measurement. **TS1-4G** was not used in the groundwater flow direction calculation due to an obstruction in the well and potentially inaccurate groundwater level measurement; no survey data was available for this well.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

SRF TANK SETTING 1-4 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE: 5/3/2017

PROJECT No.: HG0001

DRAWN: D.H.

FIGURE: 11

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Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in NAVD88 datum and are based on a 2015 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13. Groundwater elevation in select monitoring wells at the Electric Shop and Tank Setting 1-4 (ESMW-A, KSW-3, TS1-4CC, TS1-4DD, TS1-4EE, TS1-4F, and FS1-4H) were used to generate contours, however not all of the wells used are shown on this figure.
5. Potentiometric surface elevations are corrected for LNAPL thickness assuming a specific gravity of 0.8 g/cm^3.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

SRF ELECTRIC SHOP GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE:	5/3/2017
PROJECT No.:	HG0001
DRAWN:	D.H.
FIGURE:	12

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Legend

[XX.XX] Groundwater Elevation (feet)

Monitoring Well LNAPL present in 2015

Monitoring Well to be decommissioned

Monitoring Well - sample and gauge

Monitoring Well in sampling program - gauge only

Monitoring Well - gauge only

100.00 Groundwater Contour with Elevation

Groundwater Flow

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in NAVD88 datum and are based on a 2015 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13. **TS1-9A**,**TS1-9B**, and **TS1-9C** were not used in the groundwater flow direction calculation due to potential anomalous groundwater elevation measurements in these wells.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

SRF TANK SETTING 1-9 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE: 5/3/2017

PROJECT No.: HG0001

DRAWN: D.H.

FIGURE: 13

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Legend

[XX.XX] Groundwater Elevation (feet)
Monitoring Well LNAPL present in 2015
Monitoring Well in sampling program - gauge only
Monitoring Well - sample and gauge
Monitoring Well - gauge only
100.00 Groundwater Contour with Elevation
Groundwater Flow

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in NAVD88 datum and are based on a 2015 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13. **TS 1-27J** was not used in the groundwater flow direction calculation due to potential anomalous groundwater elevation measurement in the well.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

SRF TANK SETTING 1-27 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE: 5/3/2017
PROJECT No.: HG0001
DRAWN: D.H.

FIGURE: 14

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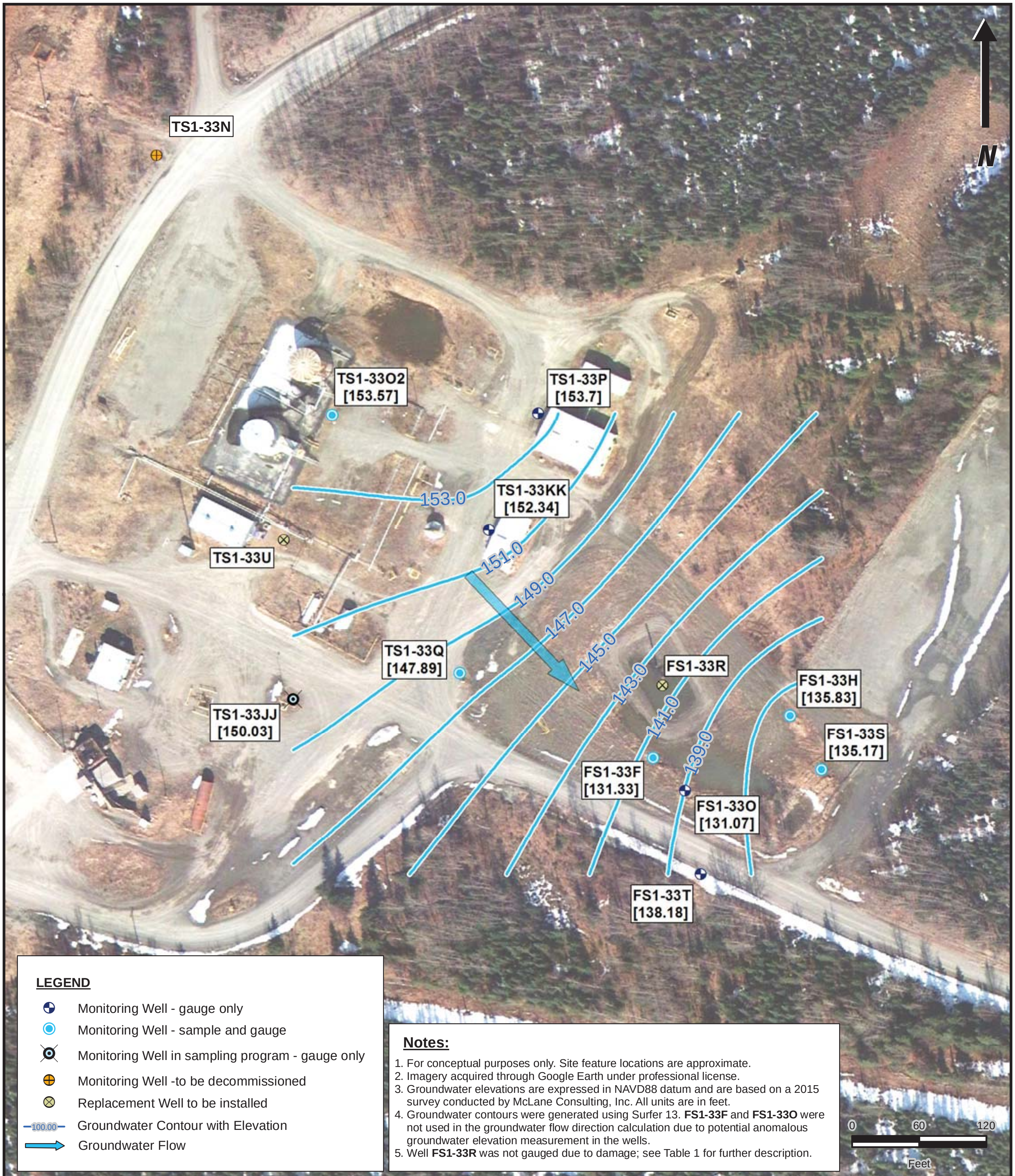

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in NAVD88 datum and are based on a 2015 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13. **FS1-33F** and **FS1-33O** were not used in the groundwater flow direction calculation due to potential anomalous groundwater elevation measurement in the wells.
5. Well **FS1-33R** was not gauged due to damage; see Table 1 for further description.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

SRF TANK SETTING 1-33 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE: 5/3/2017

PROJECT No.: HG0001

DRAWN: D.H.

FIGURE: 15

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Legend

[XX.XX] Groundwater Elevation (feet)

Monitoring Well - sample and gauge

Monitoring Well in sampling program - gauge only

Monitoring Well - gauge only

100.00 Groundwater Contour with Elevation

Groundwater Flow

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in NAVD88 datum and are based on a 2015 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

SRF TANK SETTING 2-15 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE: 5/2/2017

PROJECT No.: HG0001

DRAWN: D.H.

FIGURE: 16

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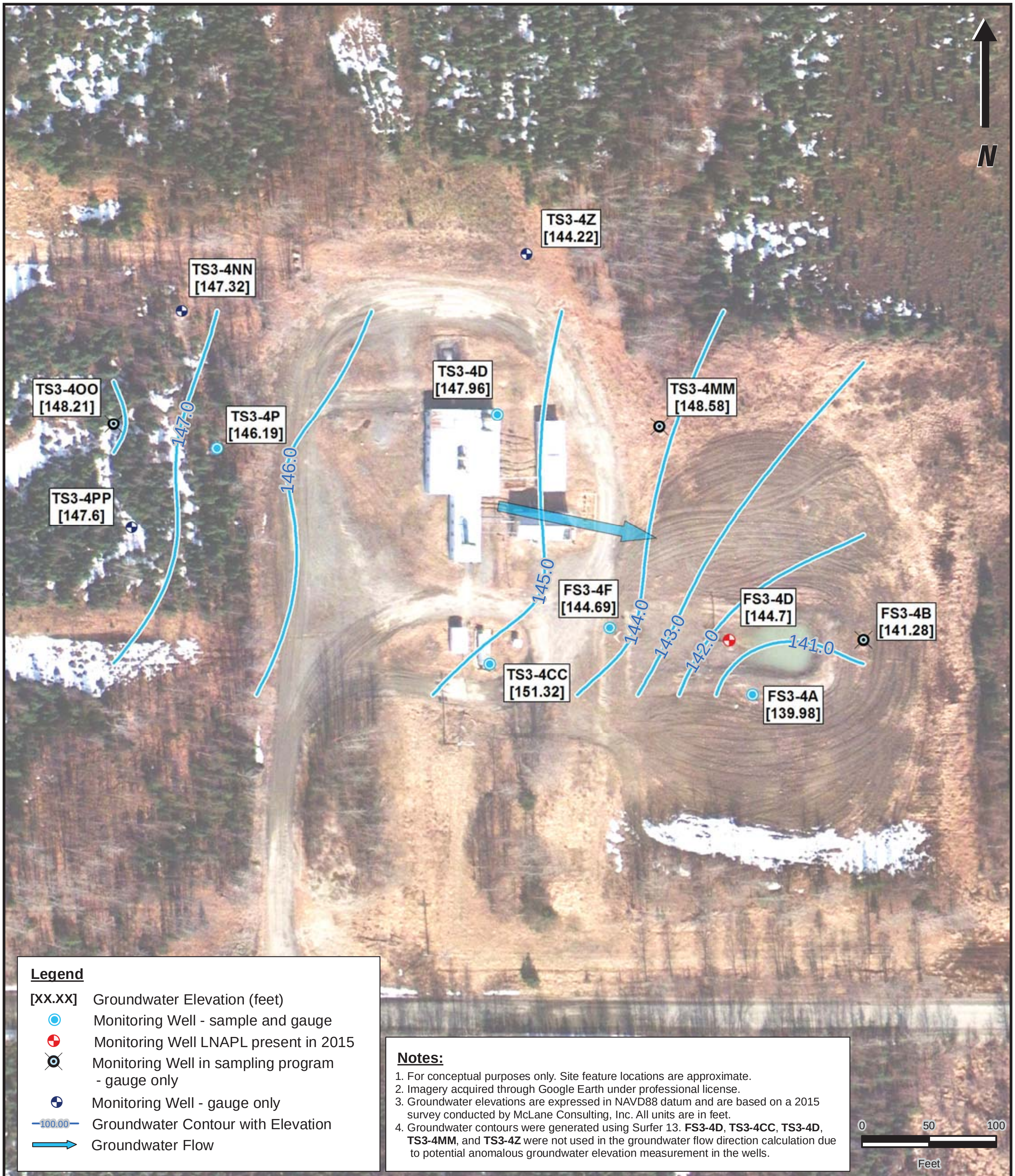

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2017 GROUNDWATER MONITORING
SWANSON RIVER FIELD, ALASKA

SRF TANK SETTING 3-4 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE:	FIGURE:
5/3/2017	**17**
PROJECT No.: HG0001	
DRAWN: D.H.	

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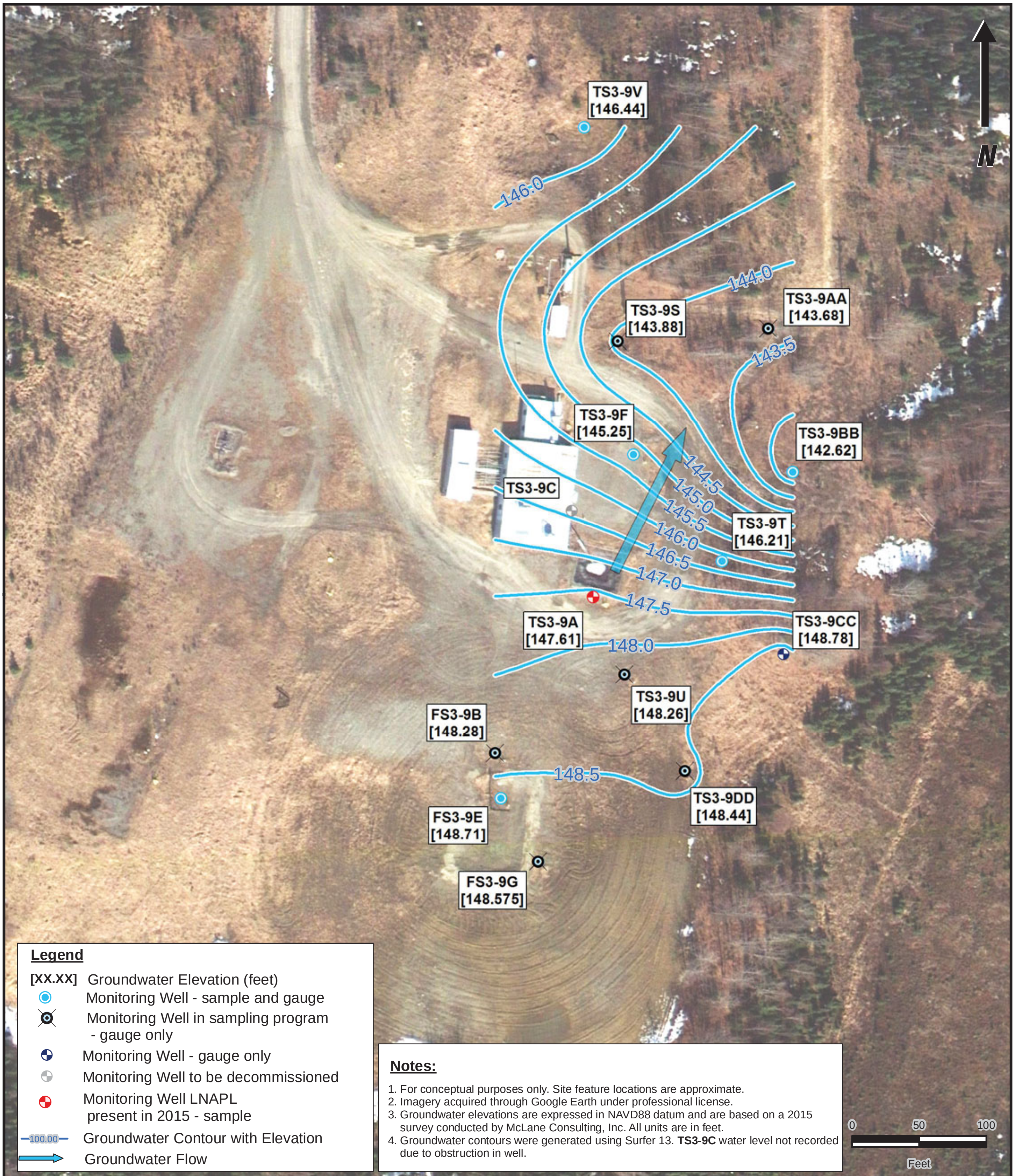

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in NAVD88 datum and are based on a 2015 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13. **TS3-9C** water level not recorded due to obstruction in well.

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2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

SRF TANK SETTING 3-9 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

DATE: 5/3/2017
PROJECT No.: HG0001
DRAWN: D.H.

FIGURE: 18

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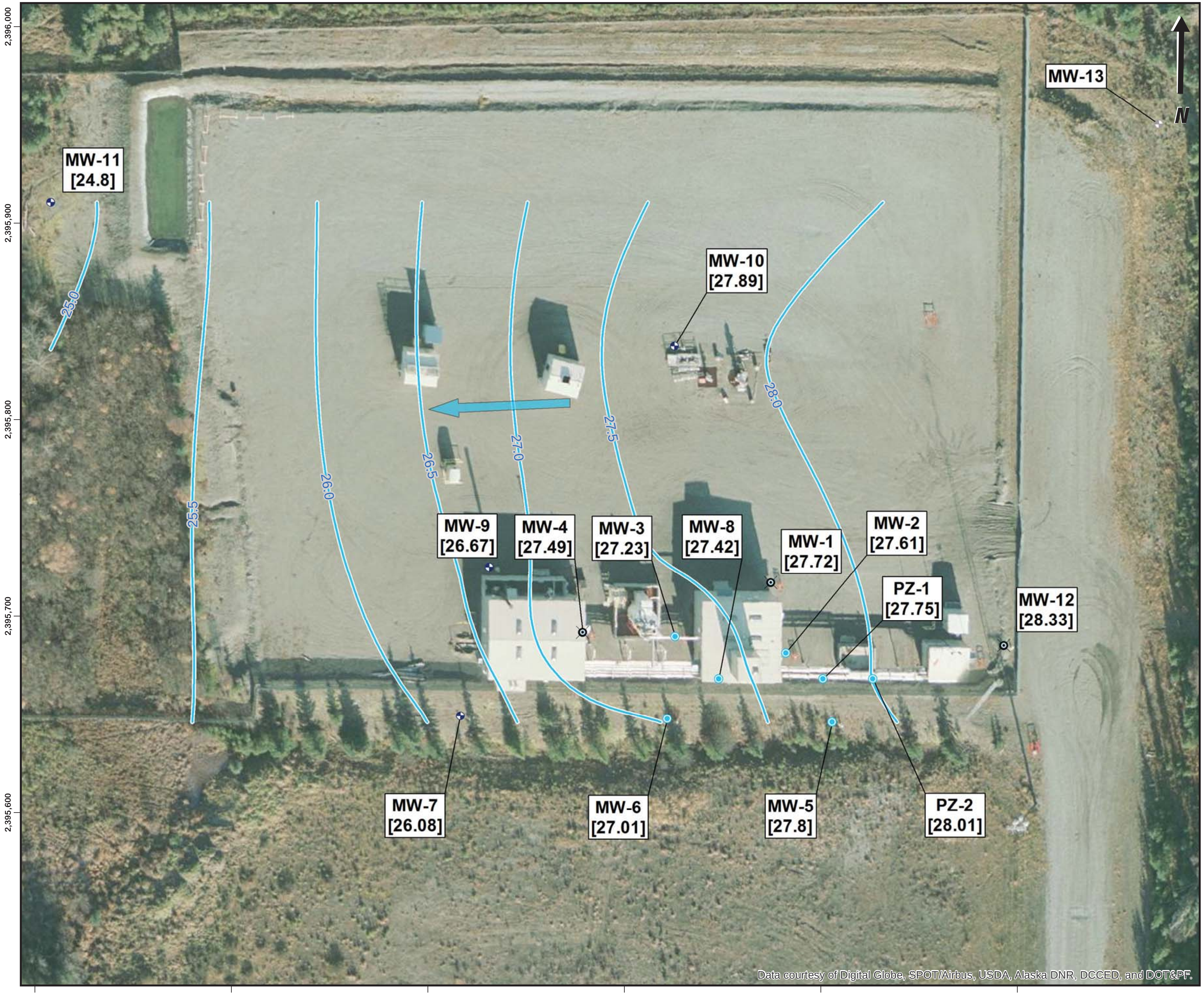

2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

CANNERY LOOP UNIT 3 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

[XX.XX]	Groundwater Elevation (feet)
	Monitoring Well LNAPL present in 2015
	Monitoring Well to be decommissioned
	Monitoring Well - sample and gauge
	Monitoring Well in sampling program - gauge only
	Monitoring Well - gauge only
100.0	Groundwater Contour with Elevation
	Groundwater Flow

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Geographic Network of Alaska (GINA).
3. Groundwater elevations are expressed in local mean sea level (tidal gauge ID unknown) datum and are based on a 2012 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13. MW-13 was not recorded.

ALASKA STATE PLANE COORDINATE SYSTEM ZONE 4

U.S. SURVEY FEET
HORIZONTAL DATUM: NAD83 (2011)
VERTICAL DATUM: LMSL

50 25 0 50 100

Scale in Feet

Fairbanks Office
301 Cushman Street, Street 100
Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

Anchorage Office
3800 Centerpoint Drive, Suite 400
Anchorage, AK 99503
907.275.2896 (Office and Fax)

Brice ANC 8(a) Environmental Services Corporation

PROJECT No.: HG0001	DATE: 5/3/2017	FIGURE: 19
P.M.: K.L.	DRAWN: D.H.	

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2017 GROUNDWATER MONITORING WORK PLAN

KENAI, ALASKA

KGF 14-6 GROUNDWATER MONITORING WELL AND SURFACE WATER SAMPLE LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

[XX.XX]	Groundwater Elevation (feet)
	Monitoring Well LNAPL present in 2015
	Monitoring Well to be decommissioned
	Monitoring Well - sample and gauge
	Monitoring Well in sampling program - gauge only
	Monitoring Well - gauge only
	Water Samples 2015
	Recovery Well
100.0	Groundwater Contour with Elevation
	Groundwater Flow

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in local mean sea level (tidal gauge ID unknown) datum and are based on a 2012 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13.MW-6, M,W-17, MW-20, MW-24, MW-26, MW-29, MW-36, and MW-37 were not included in the groundwater surface calculation; frost heave appears to have occured since last survey.
5. MW-10R, and MW-18 not located in 2015.

ALASKA STATE PLANE COORDINATE SYSTEM ZONE 4

U.S. SURVEY FEET
HORIZONTAL DATUM: NAD83 (2011)
VERTICAL DATUM: LOCAL MEAN SEVEL (LMSL)

40 20 0 40 80

Scale in Feet

Fairbanks Office
301 Cushman Street, Street 100
Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

Anchorage Office
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Anchorage, AK 99503
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PROJECT No.: HG0001	DATE: 5/3/2017	FIGURE: 20
P.M.: K.L.	DRAWN: D.H.	

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2017 GROUNDWATER MONITORING WORK PLAN

KENAI, ALASKA

KGF 34-31 GROUNDWATER MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

[XX.XX]	Groundwater Elevation (feet)
	Monitoring Well to be decommissioned
	Monitoring Well - sample and gauge
	Monitoring Well in sampling program - gauge only
	Monitoring Well - gauge only
	Monitoring Well Destroyed/ Abandoned /Decommissioned
100.0	Groundwater Contour with Elevation
	Groundwater Flow
	Existing Structure

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in local mean sea level (tidal gauge ID unknown) datum and are based on a 2012 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Groundwater contours were generated using Surfer 13. MW-3 (Not located), MW-A, MW-C and MW-E Not recorded not located.

ALASKA STATE PLANE COORDINATE SYSTEM ZONE 4

U.S. SURVEY FEET
HORIZONTAL DATUM: NAD83 (2011)
VERTICAL DATUM: LOCAL MEAN SEA LEVEL (LMSL)

100 50 0 100 200

Scale in Feet

Fairbanks Office
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907.452.5018 (fax)

Anchorage Office
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Anchorage, AK 99503
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PROJECT No.: HG0001	DATE: 5/3/2017	FIGURE: 21
P.M.: K.L.	DRAWN: D.H.	

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2,362,000
2,361,750
2,361,500
2,361,250
1,414,500
1,414,750
1,415,000
1,415,250
1,415,500

1 INCH

2017 GROUNDWATER MONITORING WORK PLAN
KENAI, ALASKA

KGF 41-7 GROUNDWATER MONITORING WELL AND SURFACE WATER SAMPLE LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

[XX.XX] Groundwater Elevation (feet)
Monitoring Well LNAPL present in 2015
Monitoring Well to be decommissioned
Monitoring Well destroyed
Monitoring Well - sample and gauge
Monitoring Well in sampling program - gauge only
Monitoring Well - gauge only
Water Samples 2015
Recovery Well
100.0 Groundwater Contour with Elevation
Groundwater Flow

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in local mean sea level (tidal gauge ID unknown) datum and are based on a 2012 survey conducted by McLane Consulting, Inc. All units are in feet.
4. Monitoring wells MW-22R, MW-23, MW-23R, MW-26, MW-28, MW-30, MW-33, MW-34, MW-35, and MW-36 not located during 2015 monitoring activities.
5. Groundwater contours were generated using Surfer 13. Water levels at monitoring wells MW-15, MW-19, MW-20, MW-24, MW-31, and MW-32 were omitted due to anomalous groundwater elevations.

ALASKA STATE PLANE COORDINATE SYSTEM ZONE 4

U.S. SURVEY FEET
HORIZONTAL DATUM: NAD83 (2011)
VERTICAL DATUM: LOCAL MEAN SEA LEVEL (LMSL)

100 50 0 100 200
Scale in Feet

Fairbanks Office
301 Cushman Street, Street 100
Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

Anchorage Office
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Anchorage, AK 99503
907.275.2896 (Office and Fax)

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PROJECT No.: HG0001	DATE: 5/3/2017	FIGURE: 22
P.M.: K.L.	DRAWN: D.H.	

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2017 GROUNDWATER MONITORING WORK PLAN

KENAI, ALASKA

KGF 41-18 GROUNDWATER MONITORING WELL AND SURFACE WATER SAMPLE LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

[XX.XX]	Groundwater Elevation (feet)
⊕	Monitoring Well Destroyed/ Abandoned / Decommissioned
	Monitoring Well LNAPL present in 2015
	Monitoring Well to be decommissioned
	Monitoring Well - sample and gauge
	Monitoring Well in sampling program - gauge only
	Monitoring Well - gauge only
100.0	Groundwater Contour with Elevation
	Groundwater Flow
▲	Water Sample
	Existing Structure

Notes:

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired through Google Earth under professional license.
3. Groundwater elevations are expressed in local mean sea level (tidal gauge ID unknown) datum and are based on a 2012 survey conducted by McLane Consulting, Inc. All units are in feet. Elevations for monitoring wells MW-3R, MW-8R, MW-11R, MW-16, MW-17, MW-18, and MW-19 are from Weston (2013). The reported basis of vertical control is NAVD88. However, those water level elevations appear consistent with LMSL, and so no offset from NAVD88 to LMSL has been applied.
4. Groundwater contours were generated using Surfer 13. MW-2 was not included in the groundwater calculation.
5. Monitoring wells MW-A, MW-C, MW-1, and MW-7 were not located in 2015.

ALASKA STATE PLANE COORDINATE SYSTEM ZONE 4

U.S. SURVEY FEET
HORIZONTAL DATUM: NAD83 (2011)
VERTICAL DATUM: LOCAL MEAN SEA LEVEL (LMSL)

100 50 0 100 200

Scale in Feet

Fairbanks Office
301 Cushman Street, Street 100
Fairbanks, AK 99701
907.456.1955 (office)
907.452.5018 (fax)

Anchorage Office
3800 Centerpoint Drive, Suite 400
Anchorage, AK 99503
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Environmental Services Corporation

PROJECT No.: HG0001	DATE: 5/3/2017	FIGURE: 23
P.M.: K.L.	DRAWN: D.H.	

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APPENDIX B:
STANDARD OPERATING PROCEDURES

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STANDARD OPERATING PROCEDURE BE-SOP-01

Logbook Documentation and Field Notes

1.0 SCOPE AND PURPOSE

This Standard Operating Procedure (SOP) describes the criteria for the content and format of field logbooks. This SOP should be used to direct field personnel in the requirements for recording information in logbooks and to ensure that field activities are properly documented.

Adequate documentation is necessary to describe the work performed. Attention to detail is vital as field logbooks have been shown to be useful in the reporting process as well as in administrative and judicial proceedings. As a result, it is important that documentation be factual, complete, accurate, consistent, and clear.

2.0 PERSONNEL RESPONSIBILITIES

All site personnel who make logbook entries are responsible for maintaining the required documentation. The Field Team Lead will inform personnel as to who will be responsible for field notebook and form entries, care, and maintenance.

3.0 FIELD NOTEBOOK PROCEDURE

Field logbooks are bound, sequentially paginated, weatherproof notebooks used to record daily field activities. All notes will be entered in permanent ink.

3.1 FRONT COVER

The front cover of each logbook must include the following information:

- Project Name and Site ID
- Project Month(s) and Year
- Name(s) of field logbook author(s)

3.2 PROJECT CONTACT INFORMATION

Include project contact information on the inside front cover or first page of the logbook. Contact information includes names and phone numbers of subcontractors, project assistants, field team members, and emergency numbers from the site-specific Health and Safety Plans.

3.3 DAILY ENTRIES

Logbook entries should abide by the following guidelines:

- Pages should never be removed from the logbook.
- All information must be printed legibly and in permanent ink.
- Entries should be written using objective and factual language and should be made in chronological order.
- Entries will be made on subsequent lines such that no blank lines exist on any page.
- If any space remains on the bottom of the last page of field entries at the conclusion of the day's entries, a diagonal line will be drawn and signed to obscure any additional entries on that page.
- If corrections are necessary, a single line may be drawn through the original entry. The corrected information may then be added and should be initialized and dated.

Each logbook page should include the following:

- Job name or number, date, and personnel at the top of each page.
- Date and signature at the bottom of each page, with a line through any remaining blank lines.

The daily standard logbook entries will include the following:

- Project name/ Site ID / Client
- Date and time of each activity (including work start/stop times); time will be based on the 24-hour clock (i.e., 2100 instead of 9 pm)
- Location of activity
- Weather conditions and changing weather that may impact site conditions
- Pertinent observations and comments
- Level of Personal Protective Equipment
- Full names of onsite personnel and affiliations (including all visitors)
- Daily objectives
- Field measurements and calibrations
- Deviations from the project-specific Work Plan
- Log of photographs
- Location of work areas (sketches or photographs when appropriate, with north arrow and approximate scale or "not-to-scale" noted)
- Survey and/or location of any sampling points, including swing-tie measurements
- For each sample record: date, time, sampler(s), sample ID, media, sample depth taken below ground surface (bgs), container(s), preservatives, QC (dup/MS/MSD), analysis, MeOH lot number, tare weight
- Sample shipments (when, what, destination)
- Waste tracking (when, how much, destination)
- References to relevant data sheets and documentation preserved outside of the logbook such as groundwater sampling data sheets, soil boring logs, etc. Do not duplicate information from the referenced sheets in the logbook.
- Decontamination times and methods
- Daily summary of activities (i.e. number of samples collected)

3.4 FIELD DATA SHEETS

All other supportive unbound data documentation that is a part of the field records should be maintained as part of the field forms. These records should be recorded in weatherproof ink and on weatherproof paper as necessary. Once back into the office, the unbound records will be scanned to create an electronic record to ensure document preservation.

3.5 ELECTRONIC DATA SHEETS

Electronic data documents include photographs, GPS and survey data, etc. All electronic data that are part of the field records will be downloaded to a designated location and maintained for project use. Take care when downloading, storing, and managing data. Naming conventions (according to the project-specific Work Plan) should be used to indicate the project, date, and other relevant information to ensure accurate use.

3.6 DOCUMENT CONTROL

At the conclusion of a task or project, all field documentation should be submitted to the Project Admin for record retention. All original documents should be kept in the project file.

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STANDARD OPERATING PROCEDURE BE-SOP-02

Sample Chain-of-Custody

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines that will be met during sample handling, with respect to custody, and the proper techniques for documenting the custody on the Chain of Custody (COC) Form. This SOP will be used to direct field personnel in the techniques and requirements for maintaining the sample COC.

Proper handling, COC, and documentation are necessary to provide an accurate written record to track the possession, handling, and location of samples from the moment of collection through reporting.

2.0 MATERIALS

Materials needed for COC documentation includes the following:

- Sample jars that have been filled and labeled in accordance with the project-specific Work Plan
- Quality control (QC) sample bottles
- Coolers with return address written on inside lid
- COC forms
- Two custody seals for the outside of each cooler
- Gallon-sized re-sealable plastic bag
- Clear tape
- Field logbook and/or appropriate field form
- Weatherproof pen

3.0 SAMPLE HANDLING PROCEDURE

The following sections describe sample COC documentation, field custody procedures, COC record, sample packaging, custody seals, transfer of custody, and laboratory custody procedures.

3.1 SAMPLE COC DOCUMENTATION

Sample identification documents will be carefully prepared so that sample identification and COC are maintained. Sample identification documents include the field logbook, sample labels, custody seals, and COC records.

A sample is in custody if it meets one of the following conditions:

- In an authorized person's physical possession,

- in an authorized person's view after being in possession,
- was in an authorized person's possession then secured (locked up), or
- kept in a secured area that is restricted to authorized personnel.

3.2 FIELD CUSTODY PROCEDURES

The following procedures will be used by field personnel:

- The sample collector will be personally responsible for the care and custody of samples collected until they are properly transferred to another company representative or relinquished to the laboratory.
- The sample collector will record sample data (time of collection, sample number, analytical requirements, and matrix) in the field logbook and/or appropriate field form.
- Sample labels shall be completed for each sample, using weatherproof ink.

3.3 CHAIN-OF-CUSTODY RECORD

The COC record will be fully completed prior to the shipment of samples. Information to be included on a COC form includes the following:

- COC Number
- Cooler ID
- Project number
- Contractor name
- Sampler name or initials
- Sample identification
- Location ID
- Sample date and time (in 24-hour format)
- Laboratory analysis methods required for each sample jar
- Volume submitted
- Preservatives added to each sample jar
- Sample matrix (soil, water, or other)
- Quantity of containers per sample
- Turn-around-time
- Instructions or notes regarding the samples in the "Notes" section of the custody record

3.4 SAMPLE PACKAGING

Samples will be labeled and packaged according to the *Labeling, Packaging, and Shipping Samples* SOP (BE-SOP-03). The COC record will accompany all sample shipments. Two COC records should be prepared for each shipment. One COC record will be placed in a re-sealable plastic bag, the bag sealed shut to prevent water intrusion from the moisture in the cooler, and the bag taped to the inside lid of the cooler. The duplicate copy of the COC record will be retained by the sampler and distributed as necessary to the sample coordinators. Airway bills will also be retained with the COC record as documentation of transport.

3.5 CUSTODY SEALS

Custody seals are preprinted, adhesive-backed seals with security slots designed to break if the seals are disturbed. Seals will be signed and dated at the time of use. Sample shipping containers will be sealed in as many places as necessary to ensure that the container cannot be opened without tearing the custody seals. Typically one custody seal will be placed along the front opening, and one along the side or back opening of a cooler. Clear tape will be placed over the seals to ensure that seals are not accidentally broken during shipment.

If a sampler hand-transports the samples to the laboratory without sample shipment, custody seals are not required.

3.6 TRANSFER OF CUSTODY

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler will sign, date, and note the time as “relinquished by” on the COC record. The receiver will also sign, date, and note the time as “received by” on the COC record. However, when samples are transported by a common commercial carrier such as Alaska Airlines or Federal Express, the carrier will not sign the COC record.

3.7 LABORATORY CUSTODY PROCEDURES

A designated sample custodian will accept custody of the shipped samples and verify that the sample identification number matches the COC record. Pertinent information about shipment, pickup, and courier will be entered in the “Remarks” section. The custodian then will enter sample identification number data into a bound logbook that is arranged by a project code and station number.

ATTACHMENTS

Attachment 1 Chain of Custody Form

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Chain-of-Custody Report

Collection Organization: | **Chain-of-Custody:** | **Cooler ID:** | **NPDL Number:**

Project Number: | **Laboratory:** | **Bill To:** | **Report To:**

COC Sample ID	Loc ID	Collection Date	Collection Time	Sampler	Quantity	Container Type	Volume	Preservative	Matrix	Analyses Requested Group	QC	TAT	Notes:

Special Instructions:

Relinquish By: | Relinquish By:

Signature/Printed Name | Date/Time | Signature/Printed Name | Date/Time

Received By: | Received By:

Signature/Printed Name | Date/Time | Signature/Printed Name | Date/Time

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STANDARD OPERATING PROCEDURE BE-SOP-03

Labeling, Packaging, and Shipping Samples

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) will be used to direct field personnel in the techniques and requirements of labeling samples for identification, packaging samples for safe transport, and shipping samples from the field to laboratory for analysis.

Proper labeling, packaging, transport, and shipping are necessary to maintain an accurate record to track the samples, as well as safe methods of packing and transporting samples.

2.0 MATERIALS

The term "environmental sample" refers to any sample that has less than reportable quantities of any hazardous constituents according to Department of Transportation (DOT) 49 CFR - Section 172. Equipment required for labeling, packaging, and shipping environmental samples include:

- Weatherproof labels for sample containers
- Coolers
- Contractor-grade plastic bags
- Sorbent pads
- Plastic zip-top bags, quart and gallon
- Clear tape
- Strapping tape
- Bubble wrap and/or foam inserts
- Wet ice or gel ice packs
- Cooler labels: "keep cool/refrigerate/do not freeze," "this end up," "fragile," address, dangerous goods, excepted quantities, Saturday delivery (as necessary), etc.

3.0 PROCEDURES

This section describes the procedures for labeling, packaging, and shipping of samples that have been collected.

3.1 LABELING

Samples will be labeled using nomenclature defined in the project-specific Work Plan. All sample labels will be weatherproof and contain the following information:

- Project number
- Sampler name or initials
- Sample identification
- Sample date and time (in 24-hour format)
- Laboratory analysis methods required for sample jar
- Volume submitted
- Preservatives added to sample jar
- Sample matrix (soil, water, or other)
- Turn-around-time

Adhesive sample labels will be placed directly on the sample containers. If the labels do not adequately adhere due to moisture, secure the label by placing clear packaging tape over the label. Sample containers that are weighed by the laboratory prior to use **should not** have any additional labels placed on the container as it affects the weight. For those containers, use the label that is already provided on the jar. Only one label should be placed on each sample container.

3.2 PACKAGING

When packing sample containers for shipment, the steps below must be followed. Depending on how the samples are being kept to temperature, follow either section 3.2.1 or 3.2.2.

1. Choose a cooler with structural integrity that will withstand shipment. Secure and tape the drain plug with duct tape.
2. Be sure that the caps on all containers are tight and will not leak. Make sure not to over-tighten and/or break the cap.
3. Ensure that the sample labels are intact, fully completed with the correct information, and that identification exactly matches the chain-of-custody record.
4. Use sufficient ice in packaging to ensure that samples are received by the laboratory at the proper temperature of 4°C ± 2°C.
5. Wrap and package containers sufficiently to prevent cross contamination, and ensure that containers remain intact during shipment.

3.2.1 Wet Ice

When packing samples with wet ice, the following steps must be taken:

1. Place a sorbent pad in the cooler.
2. Line the cooler with a large contractor grade plastic bag. This will act to contain the wet ice and prevent fluids from reaching the cooler vessel.
3. Place a layer of bubble wrap along the bottom of the cooler, inside the garbage bag.
4. Wrap each sample container in bubble wrap or place it in a foam insert.
5. Place all sample containers in separate re-sealable plastic bags. Remove excess air and seal the bags. Three volatile organic analysis vials may be placed in one re-sealable bag.
6. Placed the wrapped and bagged sample containers into the cooler with caps up.
7. Fill excess space between sample containers with additional bubble wrap.

8. Place wet ice around all sample containers. If desired, wet ice can be placed into re-sealable plastic bags and then placed around all sample containers.
9. Securely fasten the large plastic bag.
10. Fill remaining headspace with additional packing material.

3.2.2 Gel Ice

When packing samples with gel ice packs, the following steps must be taken:

1. Place a layer of frozen gel ice packs, along the bottom of the cooler. Cover the ice packs with a layer of bubble wrap and then place a sorbent pad over the bubble wrap.
2. Place sample containers in bubble wrap, bubble bags, in their original boxes, or in re-sealable bags with sorbent pads, depending on the type of container.
3. Place the containers into the cooler with caps up.
4. Fill excess space between sample containers with additional bubble wrap or gel ice,
5. Place another layer of bubble wrap along the top of the cooler, and as possible, place a layer of gel ice packs along the top of the cooler.
6. Fill remaining headspace with additional packing material.

Note that partially melted or soft gel ice packs should not be used to pack coolers for transport. A minimum of 8 frozen gel ice packs should be used to maintain sample temperature during transit for 24 hours.

After either wet ice or gel ice have been placed in cooler, the following steps must be taken:

1. Ensure that a temperature blank is included in each cooler. The temperature blank should be placed at the same level and next to the samples, preferably in the center of the cooler.
2. Place the completed Chain-of-Custody record for the laboratory into a plastic zip-top bag, tape the bag to the inner side of the cooler's lid, and then close the cooler.
3. Conduct a "shake test" by gently shaking the cooler and listen to hear whether the containers are shifting in the cooler. If so, add additional packing material until there are no sounds of shifting when shaken.
4. Wrap strapping tape around each end of the cooler two times to secure the lid. Place completed custody seals to the front and side of the cooler so that the cooler cannot be opened without breaking the seals. Place clear tape over custody seals.
5. Attach an address label containing the name and address of the shipper to the top of the cooler. Attach other stickers such as "Refrigerate" or "Keep Cool," "Do Not Freeze," and "Fragile." For samples with liquid (including preserved soil samples), place "up arrow" stickers on opposite sides of the cooler pointing in the same direction as the containers containing liquids.

3.3 SAMPLE SHIPPING

Environmental samples are shipped as non-hazardous materials unless the samples meet the established DOT criteria for a "hazardous material" or the International Air Transport Association (IATA)/International Civil Aviation Organization (ICAO) for air definition of "dangerous goods." If the samples meet criteria for hazardous materials or dangerous goods, then DOT and IATA/ICAO regulations must be followed, which includes having qualified personnel send shipments.

Attach a shipping address label to the top or front of the cooler, with sender information. Samples that are being shipped as "Dangerous Goods in Excepted Quantities" must have the appropriate labelling and be declared as dangerous goods to the shipping carrier. However, no dangerous goods "candy-striped" form must be filled out and no Notification to Caption (NOTOC) is required (IATA 2016).

3.3.1 Soil Sample Shipments

Soil samples preserved with methanol, and any excess methanol vials, must be shipped as "Dangerous Goods in Excepted Quantities" per the IATA regulations. The volume for excepted quantities of methanol is 30 mL per container and 300 mL per cooler. The class number is 3, flammable liquid, UN 1230.

3.3.2 Water Sample Shipments

Water samples preserved with hydrochloric acid or other insignificant amounts of preservative are not shipped as dangerous goods. However, excess pre-preserved sample containers with preservative must be shipped as "Dangerous Goods in Excepted Quantities" per IATA regulations. The volume for excepted quantities of hydrochloric acid or nitric acid is 30 mL per container and 300 mL per cooler respectively. The class number is 8, corrosive.

Upon shipping samples, notify the laboratory contact that samples have been shipped and provide the airway bill number.

4.0 REFERENCES

IATA. (2016). *Dangerous Goods Regulations (DGR) Limited/Excepted Quantities Labels.*

STANDARD OPERATING PROCEDURE BE-SOP-04

Quality Control Samples

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to direct field personnel in the requirements necessary for collecting field quality control (QC) samples from certain matrixes. Field QC samples are collected to ensure the reliability and validity of field and laboratory data.

2.0 PROCEDURE

The following sections describe different QC sample types that will be required in project-specific Work Plans.

2.1 FIELD DUPLICATE

A field duplicate is collected to evaluate whether sample matrix inhomogeneity, contaminant distribution, or sample collection methods affect analytical precision. The field sampler will ensure the primary and duplicate samples are effectively identical. The duplicate sample is collected from the same location, at the same time, with the same techniques, and the same matrix.

Frequency of field duplicates, at a minimum, are 1 blind field duplicate per day and 1 blind field duplicate per 10 samples for each analytical method and matrix for offsite laboratory analysis of all field samples

The Alaska Department of Environmental Conservation requires field duplicates be submitted as blind samples with a unique sample number and collection time to the approved laboratory for analysis.

2.2 MATRIX SPIKE AND MATRIX SPIKE DUPLICATE (MS/MSD)

An MS/MSD sample is collected to evaluate the precision and accuracy of laboratory procedures in the project sample matrix. The MS/MSD compound will be added at the laboratory. This sample is collected at the same time as the primary sample using the same procedure, equipment, and type of container. The MS/MSD sample should be labeled the same as the primary sample with the same sample identification and time, and denoted on the Chain of Custody (CoC) to ensure that the project MS/MSD pair is used in the laboratory report. The frequency of MS/MSD samples collected at a minimum, is 1 per 20 or fewer samples, or one for each analytical batch, whichever is more frequent. The required frequency of the MS/MSD sample collected is specified in the Quality Assurance Protection Plan (QAPP) and/or project-specific Work Plan, and the evaluation process is specified in the QAPP.

2.3 TEMPERATURE BLANK

A temperature blank will be included in each sample cooler. A temperature blank is measured by the laboratory to verify and document that the cooler temperature is received between 0-6 degrees Celsius (ºC). Temperature blanks consist of plastic bottles filled with water, which the laboratory typically prepares. Once shipments are received by the laboratory, the temperature will be recorded on the CoC to document preservation requirements were met.

2.4 TRIP BLANKS

Trip blanks will accompany samples to be analyzed for volatile analysis including GRO, BTEX, and VOCs. Trip blanks are prepared by the laboratory and are used to establish that the sample has not been contaminated by external sources during the transport of sample bottles to and from the field. Trip blanks are samples of reagent-grade water, and properly preserved in a controlled environment prior to field mobilization by the laboratory. Trip blanks will be kept with the sample containers throughout the sampling process and returned to the laboratory with the other samples. One trip blank will accompany each cooler containing VOC and/or GRO samples, or as specified in the QAPP or project-specific Work Plan, and the evaluation process is specified in the QAPP. All trip blanks will be labeled and included on the CoC. Trip blank sample times will generally be recorded as 0800 on the CoC.

2.5 EQUIPMENT BLANKS

Equipment blanks will be used to evaluate the effectiveness of a decontamination procedure. The equipment rinsate blank is collected by pouring deionized water onto or into the sampling equipment after the equipment has been decontaminated, and then collecting the rinsate water for analysis of the identical suite of analyses performed for the associated soil sample(s). The required frequency of equipment rinsate blanks collected is specified in the QAPP and/or project-specific Work Plan, and the evaluation process is specified in the QAPP. Decontamination procedures are to be performed according to the *Equipment Decontamination* SOP (BE-SOP-14).

Based on the use of disposable sampling equipment, equipment blanks will not be collected during the SS035 Drum and Sediment Removal and Disposal activities.

STANDARD OPERATING PROCEDURE BE-SOP-05

Drilling and Core Logging

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes a standard process for the classification and logging of soil core recovered using a drill rig or other mechanized equipment. This SOP also describes procedures for utility clearance, drilling methods, borehole advancement, core collection and logging, and borehole conversion or abandonment. These standards may vary as dictated by actual site conditions and equipment characteristics. Field notes will document adherence to these procedures and all details of variances to the standards presented in this SOP, and the project-specific Work Plan.

2.0 MATERIALS

Field materials will include, but are not limited to the following:

- Metal clipboard box case (container for well logs)
- Description aids (Munsell color & Unified Soil Classification charts)
- Hand tools (trowels, spoons, rock hammer, etc.)
- Soil Boring/Monitoring Well Field Data Collection Forms
- Tape measure
- Permanent ink pen
- Camera

3.0 PROCEDURES

The drilling subcontractor will manage the technical and operational aspect of drilling and recovery of soil cores under the direction of the onsite Brice Environmental Geologist. The drilling subcontractor will advance borings according to the depths provided in the project-specific Work Plan and under the direction of the Brice Geologist.

Soil core lithology will be determined and documented in general accordance with standards established by the Unified Soil Classification System (USCS), as described in *American Society for Testing and Materials* (ASTM) Method D2488 (Attachment 1). In general, the process involves visual observation of the soils and documentation in field notes or field data sheets (Attachment 2). It is important to note that since samples are generally collected for environmental sampling and contaminant characterization purposes, strict adherence to the USCS may not be required, unless specified by the project-specific Work Plan.

3.1 UTILITY CLEARANCE

Prior to beginning drilling activities, a utility clearance of the area within the proposed soil boring location(s) will be completed. Proposed boring locations will be marked with marking paint, survey lath, or pin flags. Utility locate procedures will be performed in accordance with the Alaska Statute Section 42.30 and will include calling the Alaska Digline locate request number at 811. The procedure for utility locates are outlined in further detail in the *Underground Utility Locates* SOP (BE-SOP-25) and in the project-specific Site Safety and Health Plan (SSHP).

3.2 DRILLING METHODS

Direct-Push Drilling: Direct-push drilling consists of advancing a macrocore or dual tube drill string in 4-foot or 5-foot long increments to the desired depth. Direct-push methods involve drilling equipment that hydraulically pushes or drives small-diameter, hollow steel rods into the subsurface without rotating the drill rods.

Hollow Stem Auger Drilling: The hollow-stem auger allows for continuous soil recovery and monitoring well installation. Comparison studies between direct push and hollow-stem auger drilled wells in a wide range of formations show little difference in performance.

Sonic Drilling: Sonic drilling is a technique that strongly reduces friction on the drill string and drill bit due to liquefaction, inertia effects and a temporary reduction of porosity of the soil. The combination aids in penetrating a large range of soil types.

Refusal (in all drilling methods) can be met in certain soil types such as gravel, or where large cobbles are present. If refusal is encountered, a secondary borehole location may be advanced, depending on site lithology, current conditions, or the recommendation of the on-site Brice Geologist.

3.3 BOREHOLE ADVANCEMENT

Teflon®-, fish oil-, or vegetable-based lubricants may be used to prevent seizing on downhole tooling. No other lubricants are approved for use without prior consent from Alaska Department of Environmental Conservation (ADEC 2013). Below the water table, potable water may be used as necessary to control heaving. No other drilling fluid may be used without prior consent from ADEC. The volume of added fluid will be noted in the field logbook. Drill tooling will be decontaminated according to the guidelines in the *Equipment Decontamination* SOP (BE-SOP-14).

3.4 CORE COLLECTION AND LOGGING

After samples are collected, soil cores will be logged in accordance with Standard Terminology for Soil Descriptions (Attachment 1) that was developed in general accordance with the Universal Soil Classification System (ASTM 2009). Waste soil and core liners will be handled and disposed of as described in the waste management section of the project-specific Work Plan.

3.5 BOREHOLE CONVERSION OR ABANDONMENT

Boreholes will either be converted to a monitoring well, extraction well, or abandoned following boring completion.

3.5.1 Borehole Conversion to a Monitoring Well or Extraction Well

The well will be converted as described in the *Monitoring Well Installation and Development* SOP (BE-SOP-22).

3.5.2 Borehole Abandonment

A borehole that is not converted to a well will be abandoned in accordance with the monitoring well decommissioning section of ADEC's *Monitoring Well Guidance* (ADEC 2013) and the *Monitoring Well Decommissioning* SOP (BE-SOP-23).

4.0 DOCUMENTATION

In addition to documentation requirements specified in the *Logbook Documentation and Field Notes* SOP (BE-SOP-01), a core log will be completed for each soil boring location. All fields on the core log will be used or an "NA" will be inserted to indicate a field that is not applicable.

5.0 REFERENCES

ADEC. 2016 (April). *Field Sampling Guidance*.

ADEC. 2013 (September). *Monitoring Well Guidance*.

ASTM. 2009 (July). *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure.* D2488. West Conshocken, Pennsylvania.

ATTACHMENTS

Attachment 1 Standard Terminology for Soil Descriptions

Attachment 2 Core Log

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Standard Terminology for Soil Descriptions

SOIL DESCRIPTION FORMAT

USCS SOIL NAME: angularity (coarse sand or greater), soil description (order of abundance), cobbles and boulders, *Munsell color (optional)*, color, density, moisture, *odor strength and type (optional)*, *structure (optional)*, *other comments (optional)*, USCS symbol, *geologic environment (optional).*

EXAMPLES

WELL-GRADED GRAVELLY SAND: angular coarse sand, some gravel, trace silt/clay, 3-5 inch cobbles, 5Y 3/1 gray, very dense, moist, no odor, lensed, with trace fine organics and fine roots, SW, (GLACIAL TILL).

POORLY GRADED GRAVEL: angular fine gravel, some silt/clay, trace sand, 12-18 inch boulders, gray, dense, dry, weak petroleum odor, homogenous, GP.

SILT WITH SAND: silt, with fine to coarse sand, trace gravel, 5Y 3/1, gray, medium dense, wet, ML.

SILT/CLAY: silt, trace sand and gravel, tan, moderate organic odor, hard, wet, laminated, fine organics and roots, ML-CL, (LACUSTRINE).

NOTES:

- Descriptions are in general accordance with ASTM D2488, moisture content and particle abundance descriptors have been modified from the ASTM specification.
- Descriptions may include but are not limited to the information described in this procedure.
- Abundances of gravel, sand, and silt are estimated visually; sieve analysis is not performed typically.
- Blows should be counted when possible (e.g., pounding a split spoon on an auger or mud-rotary drill rig), but direct-push drill rigs typically lack a 140-pound hammer.

PARTICLE ABUNDANCE

Descriptor	Criteria
Some	> 30%
With	15-30%
Little	5-15%
Trace	<5%

Notes: Boulders and cobbles should be listed as present with the range of size in inches.

GRAIN SIZES

Component	Particle Size
Boulders	>12 inches (30cm)
Cobbles	12 to 3 inches (30 to 7.6 cm)
Gravel	3 inch to #4 sieve (75 to 4.75 mm)
Sand	#4 to #200 sieve (4.75 to 0.075 mm)
Silt/Clay	<#200 sieve(<0.075mm)

MOISTURE CONTENT

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Damp	Slight amount of water
Moist	No visible water, sand will hold together
Wet	Visible free water with effort, glistens
Saturated	Pore space filled (below water table)

SAND AND GRAVEL SIZE

Description	Sand Range	Gravel Range
Fine	0.07 to 0.43 mm	0.5 to 1.9 cm
Medium (Sand Only)	0.43 to 2 mm	N/A
Coarse	2 to 5 mm	1.9 to 7.6 cm

Notes: Boulders and cobbles should be listed as present with the range of size in inches.

RELATIVE DENSITY

Fine-Grained Soil		Coarse-Grained Soil	
Density	**N-Value**	**Density**	**N-Value**
Very Soft	0 to 1	Very Loose	0 to 3
Soft	2 to 4	Loose	4 to 9
Medium Stiff	5 to 8	Medium Dense	10 to 29
Stiff	9 to 15		
Very Stiff	16 to 30	Dense	30 to 49
Hard	>30	Very Dense	>50

Notes: N-Value (Standard Penetration or Blow Count) is considered the number of blows to advance a 2-inch O.D. split-spoon sampler the last 12 inches of the total 18-inch penetration with a 140-pound hammer falling 30 inches (ASTM D1586). Any variation should be noted. If no blow counts are measured, density should be estimated.

SIMPLIFIED USCS CLASSIFICATION SYSTEMS

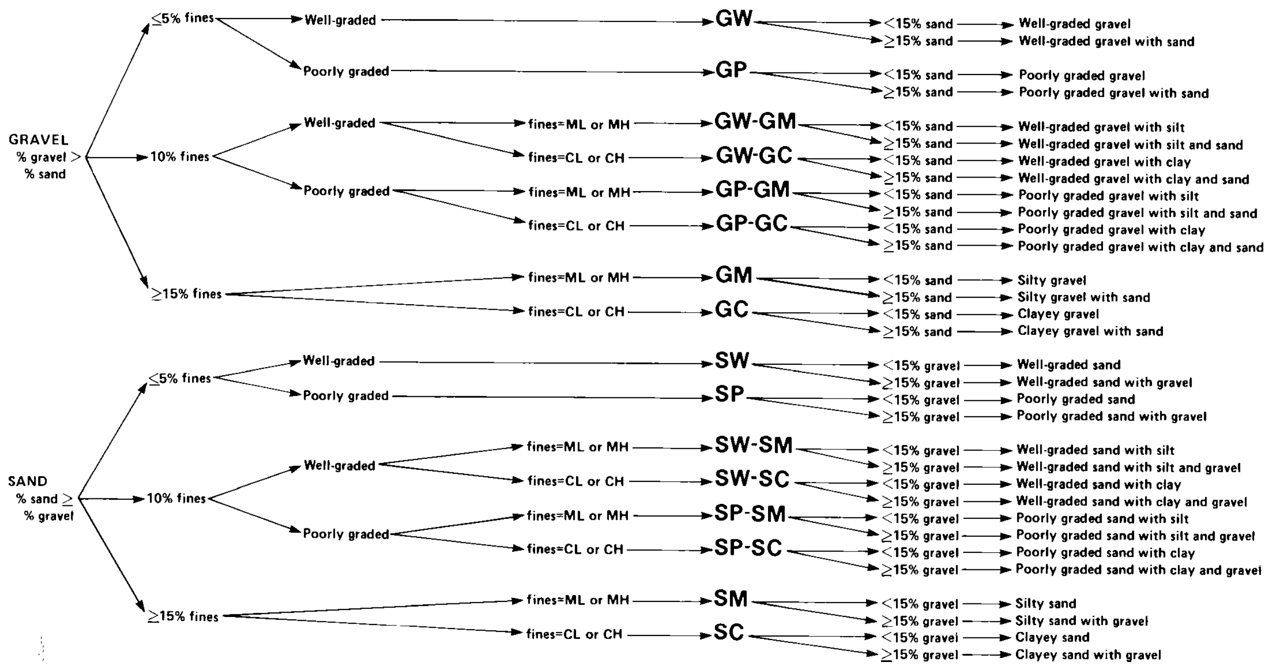
COARSE-GRAINED SOILS <50% passes #200 sieve	GRAVEL <50% coarse fraction passes #4 sieve	GRAVEL <5% pass the #200 sieve	GW	Well-graded gravel, gravel-sand mixture, little or no fines
			GP	Poorly-graded gravel, gravel-sand mixtures, little or no fines
		GRAVEL 5-15%pass the #200 sieve	GW-GM	Well-graded gravel with fines
			GP-GM	Poorly-graded gravel with fines
		GRAVEL >15% pass the #200 sieve	GM	Silty gravel, poorly-graded gravel-sand-silt mixture
			GC	Clayey gravels, poorly-graded gravel-sand-clay mixture
	SANDS >50% coarse fraction passes #4 sieve	SAND <5% pass the #200 sieve	SW	Well-graded sand, gravelly sand, little or no fines
			SP	Poorly-graded sands, gravelly sands, little or no fines
		SAND 5-15% pass the #200 sieve	SW-SM	Well-graded sand with fines
			SP-SM	Poorly-graded sand with fines
		SAND >15% pass the #200 sieve	SM	Silty sand, poorly-graded sand-gravel-silt mixture
			SC	Clayey sand, poorly-graded sand-gravel-clay mixture
FINE-GRAINED SOILS >50% passes #200 sieve	SILT/CLAY Liquid Limit <50%		ML	Inorganic silt & very fine sand, silty or clayey fine sands, clayey silt with slight plasticity
			CL	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay, silty clay, lean clay
			OL	Organic silt & clay of low plasticity
	SILT/CLAY Liquid Limit >50%		MH	Inorganic silt, micaceous or diatomaceous fine sand or silt
			CH	Inorganic clay of high plasticity, fat clay
			OH	Organic silt & clay of medium to high plasticity
HIGHLY ORGANIC SOILS			PT	Peat, humus, swamp soils with high organic content

Notes: If coarse-grained soil contains >10% fines use a dual symbol, e.g. GP-GM. Full USCS chart on page 2.

UNIFIED SOIL CLASSIFICATION SYSTEM
(from ASTM D2488)

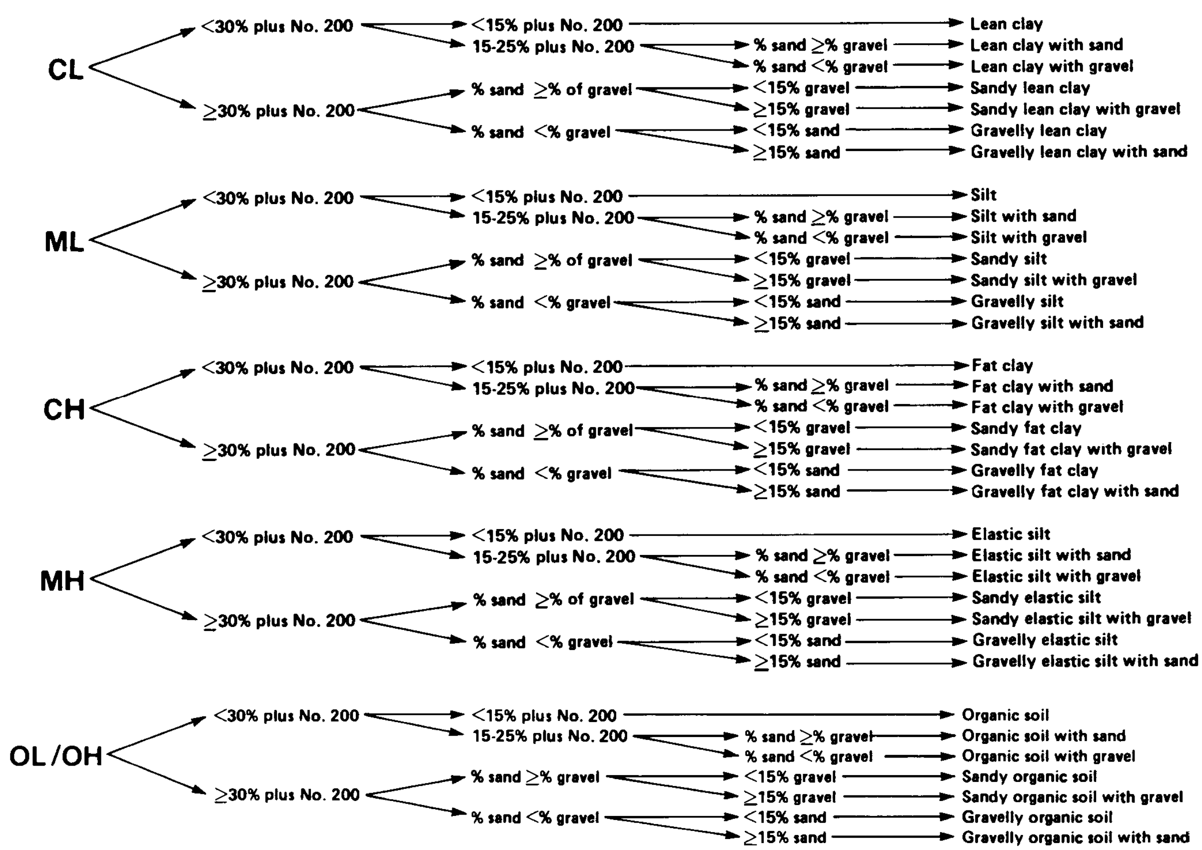
COARSE-GRAINED SOILS

Group Symbol — Group Name



FINE-GRAINED SOILS

Group Symbol — Group Name



CORE LOG

Well ID:

Driler: ________________________ **Date:** ____________ **Page** ___ **of** ___

Equipment: ____

Geologist: ________________________ **Plunge:** ____________________

Easting: __________ **Northing:** __________ **System/Units:** ______ **Elev/Units/Datum:** ________

Recovery (in)	Core Time	Moisture	Product	Depth (ft)	USCS	PID (ppm)	Sample Int.	Description (lithology, color, USCS, sample ID)

CORE LOG

Well ID:

Page ___ of ___

Recovery (in)	Core Time	Moisture	Product	Depth (ft)	USCS	PID (ppm)	Sample Int.	Description (lithology, color, USCS, sample ID)

STANDARD OPERATING PROCEDURE BE-SOP-06

Soil Sampling

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) will be used for collecting soil samples from both surface and sub-surface soils including stockpiles and excavations. The techniques described in this SOP are consistent with the Alaska Department of Environmental Conservation (ADEC) *Field Sampling Guidance* (ADEC 2016).

The sampling methodology must be outlined in the project-specific Work Plan and be approved by ADEC prior to the initiation of the sampling activity. Refer to *Sediment Sampling* SOP (BE-SOP-07) for related procedures.

2.0 EQUIPMENT AND MATERIALS

The following equipment is typically used for soil sampling, but is not limited to the following:

- Photoionization Detector for field screening (BE-SOP-15)
- Spade or trowel
- Shovel, pick ax, pick mattock, or other excavating tools
- Hand auger with extension rods, as necessary
- Survey stakes, flags, or whiskers to mark sample locations
- Tape measure
- Sample gloves-plastic or latex, disposable, powderless
- Personal Protective Equipment (PPE)
- Stainless steel homogenization bucket or bowl
- Stainless steel lab spoons or the equivalent
- Zip-top plastic bags
- Scale
- Laboratory-supplied sample containers, preservatives, labels, custody seals, and temperature blanks
- Ice (gel ice or wet ice)
- Decontamination supplies/equipment
- Trash bags
- Field logbook
- Permanent pens and markers

Refer to Attachment 1, *Soil/Sediment Sampling Checklist* for a more detailed equipment list.

3.0 METHOD SUMMARY

Soil samples may be collected using a variety of methods and equipment, depending on the depth of the soil profile, the type of sample required (disturbed vs. undisturbed), contaminants present, and soil classification. Under State of Alaska regulation 18 AAC 75.390(127) surface soil is defined as soil that extends no more than two feet below the ground surface (bgs). Subsurface soil is defined under State of Alaska regulation 18 AAC 75.390(123) as soil that is more than two feet bgs.

Soil is collected using a spoon, shovel, trowel, or auger. Always don a new pair of gloves prior to collecting a sample. Following collection, soil is transferred from the sampling device to a sample container of appropriate size for the analyses requested. If composite sampling techniques are employed, multiple grabs are placed into a container constructed of inert material, homogenized, and transferred to a sample container. Prior to sampling, confirm the availability of sample equipment and containers.

The homogenization procedure should not be used if sample analysis includes volatile organic compounds (VOCs) or gasoline range organics (GRO); in this case sample VOCs and GROs first. Soil or multiple grabs of soil, should be transferred directly from the sample collection device to the sample container in a manner that minimizes disturbance of the sample. The sample should weigh approximately 25 grams. A scale will be used to weigh the sample before adding 25 milliliters of methanol solvent provided by the laboratory. The methanol solvent should cover the sample in its entirety. Additional methanol can be added to cover the sample if necessary but the exact quantity will be noted and provided to the laboratory prior to analysis.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Potential issues associated with soil sampling are cross-contamination and inadequate sample homogenization. To prevent cross-contamination, sampling equipment will be disposable and used only once, or reusable sampling equipment will be decontaminated according to the guidelines in BE-SOP-14 prior to each use. To ensure representative samples and to minimize the variance of duplicates, samples for all parameters, other than VOCs and GRO will be homogenized to the extent practicable prior to transferring the soil to the sample jar.

5.0 SAMPLE COLLECTION PROCEDURES

Prior to sample collection, determine the appropriate locations based on the project-specific goals and project-specific Work Plan specifications.

5.1 Manual Retrieval

Soil samples may be collected from surface or subsurface soils using hand tools, shovels, hand-auger, or by heavy-equipment in an excavation. For manual sampling, follow these general steps.

1. Ensure that the sampling area is safe for entry. If the sample is to be collected from within an excavation, ensure that the excavation meets all criteria for safe entry.

2. Use hand tools to access the depth required for sampling. If using a shovel or hand auger, place the soil cuttings on plastic sheeting or as specified in the project-specific Work Plan. If possible, lay the cuttings in stratigraphic order.
3. When collecting the sample collect soil from **freshly** uncovered soil.

5.2 Discrete Sampling

Discrete sampling is when a single portion of soil is collected from a specific location at a given point in time. Typically, discrete sampling is the preferred method of sampling unless otherwise dictated for the specific project. The locations where discrete samples are to be collected will be explained in the project-specific Work Plan.

5.3 Composite Sampling

Composite sampling is when two or more grab sub-samples (aliquots) are taken from a specific soil and site at a specific point in time. The aliquots are collected and homogenized, and then a single average sample is collected from the mixture.

Composite sampling may only be conducted if previously-approved in a project-specific Work Plan. Composite samples will have equal measurement of soil (as measured by mass) collected as discrete samples from all sub-locations. Aliquots of volatile samples will be collected directly into laboratory-supplied jars and preserved immediately. Aliquots of non-volatile samples will be homogenized before placing into laboratory-supplied jars.

6.0 SAMPLE COLLECTION

After retrieval of soil, follow the general steps for all soil samples:

1. Remove bits of vegetation and large gravel from the sample as these items are not analyzed and reduce the available sample volume for analysis.
1. Take care to prevent cross-contamination and misidentification of samples.
2. Properly label the sample according to the project-specific Work Plan.
3. Record the sample location and depth, the sample date and time, and any other applicable information in the field notebook and on any applicable sampling forms prior to moving on to another sampling location.
4. Decontaminate any non-dedicated, reusable sampling equipment according to the Equipment Decontamination SOP (BE-SOP-14), prior to moving on to the next sampling location.
5. Samples that are degraded by aeration (volatiles) will be collected first and with the least disturbance as possible, and immediately preserved. Collect a volatile grab sample using a sampling spoon or gloved-hand, or as necessary, use a TerraCore® or EnCore® sampler to collect a pre-determined volume. Place volatile samples directly into a laboratory-supplied jar pre-tared jar, weigh the sample on a scale immediately following collection, and add the preservative.
6. Samples that are not degraded by aeration will be collected after soil is homogenized. Collect a non-volatile grab sample using a sample spoon or gloved hand, and place the soil into a re-sealable plastic bag or bowl/pan/tray to homogenize the soil. To homogenize the soil seal the plastic bag and mix and/ or stir the soil with a spoon or spatula. Place the homogenized soil directly into a laboratory-supplied jar.

7. Make notes on the boring log regarding the soil characterization and geologic features, including any staining or olfactory observations (see BE-SOP-05 for soil logging). Note that samples will generally be collected prior to characterization of soil to preserve the integrity of the volatile samples.
8. Wipe down the jar threads to remove any soil, close the jar with the lid, and wipe the outside of the jar using paper towels or other clean, dry wipes.
9. Label the sample container with the appropriate information, typically using a label with waterproof adhesive, or if not, securing the label with clear tape.

ATTACHMENTS

Attachment 1 Soil/Sediment Sampling Checklist

7.0 REFERENCES

ADEC. 2016 (April). *Field Sampling Guidance.*

Soil/Sediment Sampling Checklist

Prior to Sampling	Initial
Safety Tailgate meeting	
Obtain Permits	
Obtain Sample Containers from Lab	

Soil Sampling	Initial
Ekman or Ponar dredge device	
Spade/Trowel	
Shovel, pick ax, pick mattock	
Hand auger with extension rods	
Survey stakes, flags, or whiskers	
Tape measure	
Samplekits	
gel Ice	
Sample sheets	
DI & Alconox	
Paper towels	
Shovel	
Full socket set (14mm)	
Tool to open well lids	
zip lock bags	
laboratory supplied containers,	
preservatives, labels, custody seals,	
temperature blanks	
Plastic Sheeting	
Coolers	
Trash bags	
Decontamination equipment	
Sample kits	
Gel Ice	
Sample sheets	
DI & Alconox	
Paper towels	
Stainless steel homogenization bucket	
Stainless steel lab spoon or equivalent	
Scale	

PPE/Misc.	Initial
Nitrile gloves	
Shades	
Tailgate form	
Knee pads	
Safety gear (hard hat, gloves, vest, etc.)	
Water	
Laminated site map	
Garbage bags	
PEP/HSE Plan	
Camera	
Whiteboard and marker	

After Sampling	Initial
Address Waste	
Close out permits	
CoC and Samples in cooler	
Download Cameras	
Charge harmony	
QC, chill, and secure samples	
Complete field notes	
Debrief (tailgate form)	

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Last Updated: 9/23/2015

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Soil/Sediment Sampling Checklist

Prior to Sampling	Initial
Safety Tailgate meeting	
Obtain Permits	
Obtain Sample Containers from Lab	

Soil Sampling	Initial
Ekman or Ponar dredge device	
Spade/Trowel	
Shovel, pick ax, pick mattock	
Hand auger with extension rods	
Survey stakes, flags, or whiskers	
Tape measure	
Samplekits	
gel Ice	
Sample sheets	
DI & Alconox	
Paper towels	
Shovel	
Full socket set (14mm)	
Tool to open well lids	
zip lock bags	
laboratory supplied containers,	
preservatives, labels, custody seals,	
temperature blanks	
Plastic Sheeting	
Coolers	
Trash bags	
Decontamination equipment	
Sample kits	
Gel Ice	
Sample sheets	
DI & Alconox	
Paper towels	
Stainless steel homogenization bucket	
Stainless steel lab spoon or equivalent	
Scale	

PPE/Misc.	Initial
Nitrile gloves	
Shades	
Tailgate form	
Knee pads	
Safety gear (hard hat, gloves, vest, etc.)	
Water	
Laminated site map	
Garbage bags	
PEP/HSE Plan	
Camera	
Whiteboard and marker	

After Sampling	Initial
Address Waste	
Close out permits	
CoC and Samples in cooler	
Download Cameras	
Charge harmony	
QC, chill, and secure samples	
Complete field notes	
Debrief (tailgate form)	

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STANDARD OPERATING PROCEDURE BE-SOP-09

Groundwater Sample Collection

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) provides field operation and protocols applicable to the collection of representative water samples from groundwater monitoring wells and temporary well points. This SOP is consistent with the Alaska Department of Environmental Conservation (ADEC) *Field Sampling Guidance* (ADEC 2016) and with the U.S. Environmental Protection Agency (EPA) *Low-flow (Minimal Drawdown) Ground-Water Sampling Procedure* (EPA 1996). For specific sampling locations and analytes, refer to the project-specific Work Plan.

2.0 EQUIPMENT AND SUPPLIES

Groundwater sampling equipment will include but is not limited to the following:

- Appropriate level of Personal Protective Equipment (PPE)
- Camera
- Logbook, weatherproof pen, sharpie, etc.
- RAE Systems MiniRAE photoionization detector (PID) (or similar)
- *Groundwater Sampling Data Sheet* (Attachment 1)
- Sample labels
- Sampling containers and packing materials
- Tape measure
- Oil/water interface probe
- Submersible (stainless steel centrifugal Proactive Monsoon pump with low-flow controller, or equivalent) or peristaltic pump
- Disposable Teflon bailers and twine
- 5-gallon bucket
- Graduated cylinder or beaker
- Yellow Springs Instruments (YSI) water-quality meter (or similar)
- Potable water and/or deionized water
- Tubing (Teflon and/or silicone)
- Liquinox, Alconox, or equivalent

3.0 PROCEDURES

The following sections describe methods of recording field observations, field instrument calibration, air monitoring, free product and water level measurements, and purging, groundwater sampling using a submersible or peristaltic pump.

3.1 RECORDING FIELD OBSERVATIONS

Attachment 1 is intended to capture all of the information routinely collected during the sampling process for established monitoring wells. The field logbook is intended to record all equipment calibration checks, the wells sampled, sampling start and end times, or any other pertinent information not captured on the Groundwater Sampling Data Form. All data collected from temporary well points will be recorded in the field logbook.

3.2 FIELD INSTRUMENT CALIBRATION

Field instruments will be calibrated in accordance with the manufacturer's recommended procedures and frequency for each instrument. Operation and maintenance manuals will be available in the field for reference. Calibrations will be evaluated at the beginning of each day prior to use. If any reading is outside ± 5% from the expected calibration standard, the equipment will be re-calibrated. If after calibration, the instrument remains outside the expected calibration standard, the instrument will be removed from project use and replaced as soon as practicable.

3.3 AIR MONITORING

Air monitoring will be conducted to analyze for the presence of volatile organic compounds (VOCs) using a PID (MiniRAE 2000 or similar). PID readings will be monitored until stable and then recorded in the field logbook. Procedures in the project-specific SSHP will be followed if organic vapors are detected above concentrations listed in the air monitoring section of the Site Safety and Health Plan (SSHP). PID readings will be collected in situations as follows:

- Prior to removing the well plug, open the well monument (either above ground or flush mount type) and remove any standing water.
- To monitor the ambient conditions in the breathing zone when opening the well or removing the well plug.
- To monitor the headspace immediately after removing the well plug
- To monitor the breathing zone after the well plug has been removed

3.4 FREE PRODUCT AND WATER LEVEL MEASUREMENT

The depth to free product (if present) and the depth to groundwater will be measured with an oil/water interface probe. Interface probes provide distinct responses when immersed in nonconductive product or conductive water. The type and order of measurement activities include determining the reference elevation, taking product and water level measurements, removing free product, and measuring the total depth of casing as described below:

- Reference Elevation:
  - Pre-existing reference elevation (mark or notch on the casing)
  - No pre-existing reference elevation (typically for new wells)
    - Place a mark on the outside of the top north side of the well casing with indelible ink
- Product and Water Level Measurements (measured to the nearest 0.01 foot):
  - Measure the depth to free product (if present)
  - Measure the thickness of free product (if present)
  - Measure the depth to groundwater
- Free Product Removal (if present and more than 0.1 feet thick):
  - Remove free product with a bailer or peristaltic pump
  - Determine the volume of product removed
  - Dispose in accordance with the project-specific Work Plan
- Total Well Depth (after well construction is complete or after sampling in established wells):
  - Measure the depth to the bottom of the well casing
  - Compare to constructed well depth to determine the thickness of silt

3.5 PURGING

Purging is the process by which stagnant water is removed from the location prior to sampling and replaced with groundwater from the adjacent formation. This allows for a representative sample to be collected from the actual aquifer condition.

Purging will be conducted in accordance with EPA and ADEC low-flow guidelines (EPA 1996, ADEC 2016). Monitoring wells will be purged, at minimum, the equivalent of three times the well volume, or until the specific conductance, temperature, and pH parameters stabilize. The volume of water purged from each well will be calculated based on the length of the water column and well casing diameter. The formula to calculate the water volume to be purged is as follows:

Purge volume = 3 well casing volumes = (total depth of casing (ft) – depth to groundwater) * gallons per linear foot * 3. Refer to the Attachment 1 for the various gallons per linear foot based on the casing diameter of the well.

$$V = *0.041D^2(d_2-d_1)$$

V= Volume in gallons

D = Inside diameter of well casing in inches

d_2 = Total depth of well in feet

d_1 = Depth to water surface in feet

*0.041 is based on a 1-inch diameter well.

Criteria for low-flow sampling are described below:

- Drawdown during purging will be less than 0.3 feet, if possible.

- Flow rates typically range from 0.1 to 1.0 liters per minute (0.03 to 0.3 gallons per minute), but higher rates are consistent with low-flow guidelines as long as the drawdown requirement is met.
- Water quality parameters will be measured and recorded as tabulated in Table 1.

If a well is purged dry, it will be allowed to recharge for 24 hours. Without further purging, the well will be sampled. Water quality parameter stabilization is reached when three consecutive changes between successive readings at approximately 3-5 minute intervals are within the criteria in Table 1. Turbidity readings consistently below 10 nephelometric turbidity units (NTU) are considered to represent stabilization.

Table 1 Stability Criteria for Low-Flow Purging

Parameter[1]	Units	Recording Precision	Stability Criterion	Typical Value Range for Stability Criterion
pH	-	0.01	±0.1	5 to 8
Temperature	°C	0.01	±0.2	0.1 to 15
Conductivity	µS/cm	1	±0.3	80 to 1,000
Turbidity	NTU	0.1	± 10% or ± 1 NTU	0.3 to > 900
Oxidation Reduction Potential (ORP)	mV	1	± 10	-120 to 350
Dissolved Oxygen (DO)	Mg/L	0.1	± 10 or 0.2 mg/L (whichever is greater)	0 to 12

Note: Stability criteria from ADEC *Field Sampling Guidance* (ADEC 2016).
[1] Only three parameters are required to stabilize, four when using temperature.

3.6 GROUNDWATER SAMPLE COLLECTION USING A SUBMERSIBLE OR PERISTALTIC PUMP

Low-flow sampling will use a submersible or peristaltic pump. For collection of VOCs, a peristaltic pump should not be used unless approval from ADEC is obtained prior to sample collection. VOC samples will be collected using a peristaltic pump in accordance with low flow procedures and in conjunction with a Hydrasleeve groundwater sampler. Wells that contain free product are not typically sampled. Samples will be collected using the following steps:

- Line the ground with plastic sheeting to provide a clean work environment
- Lower the pump (submersible) or tubing (peristaltic) to the target depth below the static water level. Record the depth of the pump on the Groundwater Field Data Form. For wells screened across the groundwater interface, a pump intake of 1.0 to 2.0 feet below the static water level is typically used. For wells with submerged screens, set the pump intake at the middle of the screened interval.
- Begin purging water into a container (i.e. 5-gallon bucket). Adjust the flow rate so that drawdown does not exceed 0.3 feet. The flow rate can be slowly increased or decreased as needed.
- After the turbidity of the water decreases, connect the flow-through cell to begin measuring stabilization parameters. Continue to purge until stabilization criteria are met (Table 1) or three

well casing volumes are removed. Remove the supply line from the flow-through cell and place such that the purge water is captured in a container.

- Don new nitrile gloves prior to handling sample bottles.
- Collect samples in the appropriate containers (with preservatives if required by the analytical methods):
  - If ADEC approves the use of a peristaltic pump for the collection of VOC samples, the following procedure will be followed: 40 mL vials for VOCs/GRO must be filled slowly to prevent splashing and entrainment of air bubbles. Reduce the pumping rate, if necessary, to control the flow rate. Care should be taken to avoid touching the mouth of the discharge line, the top of the sample bottle, the inside of the cap, or the Teflon septum. A septum that falls out of the cap onto the ground cannot be used. The vial will be filled completely so that a convex meniscus forms. The cap will then be secured and the bottle inverted, tapped firmly, and checked for the presence of air bubbles. Analytical results will be compromised if air is trapped in the sample container.
    - If a Hydrasleeve groundwater sampler is used in conjunction with a peristaltic pump for VOC/GRO sample collection, the *Hydrasleeve Standard Operating Procedure: Sampling Ground Water with a HydraSleeve* (Attachment 2) will be followed.
- Remove the submersible pump or the tubing.
- Measure the total depth of the well as described in Section 3.4
- Record measurements on Attachment 1.

Waste will be handled in accordance with the project-specific Work Plan.

4.0 POTENTIAL INTERFERENCES

Two potential interferences associated with groundwater sampling are cross-contamination and a lack of sample representation due to improper well purging or stabilization. To prevent cross-contamination between wells, dedicated tubing will be placed in each well and all non-disposable equipment that may directly or indirectly come in contact with samples, will be decontaminated prior to use at a different location. The *Equipment Decontamination* SOP (BE-SOP-14) outlines the decontamination procedure. To ensure that representative conditions within the aquifer are captured during sample collection, the purge rate will be maintained at a rate that produces minimal drawdown until three well casings have been collected or until water quality parameters have stabilized as described in Section 3.5.

5.0 SAMPLE HANDLING, PRESERVATION, AND STORAGE

The following procedure will be followed for sampling handling, preservation, and storage:

1. Transfer the sample into a labeled container
2. Preserve the sample or use pre-preserved sample bottles (if required by analytical method)
3. Cap the container and place into a cooler to maintain 4 ± 2°C (if required by analytical method)
4. Record all pertinent data in the site logbook and/or on the field data sheet
5. Complete the chain of custody form
6. Attach the custody seals to the cooler prior to shipment

Refer to the *Labeling, Packaging, and Shipping* SOP (BE-SOP-03) for procedures on labeling, packaging, and shipping samples.

6.0 DATA AND RECORD MANAGEMENT

The chain of custody form is signed over to the laboratory. A copy is kept with the sampling records. Refer to *Sample Chain of Custody* SOP (BE-SOP-02) for procedures on sample chain-of-custody.

7.0 QUALITY CONTROL AND QUALITY ASSURANCE

All field Quality Control (QC) sample requirements in the project-specific Work Plan must be followed. These may involve trip blanks, equipment blanks, field duplicates, and the collection of additional sample volumes for the laboratory's quality control (matrix spike and matrix spike duplicates). The frequency of QC samples will be outlined in the project-specific Work Plan. Refer to the *Quality Control* SOP (BE-SOP-04) for procedures on quality control samples.

8.0 DECONTAMINATION

Refer to the *Equipment Decontamination* SOP (BE-SOP-14) for procedures on decontamination.

9.0 REFERENCES

ADEC. 2016 (April). Draft Field Sampling Guidance.

EPA. 1996 (April). Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. EPA/540/S-95/504. R.W. Puls and M.J. Barcelona (authors).

ATTACHMENTS

Attachment 1 Groundwater Sampling Data Sheet

Attachment 2 Hydrasleeve Groundwater Sampler Manufacturer Instructions

Groundwater Sampling Data Sheet

Site Name	Event	Well ID	Project Number
Weather Conditions	PID Readings of Total VOCs (ppm) Ambient _______ Breathing Zone _______ In Well _______	Date	Sampler Initials

Well Information

Well Integrity	TOC Stickup (ft ags)	Well Casing Material	Casing Diameter(in) / Gallons per linear foot(gal/ft)
Good Fair Poor		PVC SS	1 / 0.041 2 / 0.163 4 / 0.653 6 / 1.469
Depth to Product (ft)	Depth to GW (ft btoc)	Total Depth of Casing (ft btoc) (final)	Product Thickness (ft) and Volume Recovered (mL)

Max purge volume (3 well casing volumes) = [previous† total depth of casing (ft) – (depth to water[GW table well] or top of filter pack[submerged well] (ft)] ∗ gallons per linear foot of casing ∗ 3

SHOW WORK Max Purge Volume = (________† ft – ________ft) ∗ ________ gal/ft ∗ 6 = ________ gal ∗ 3.785 L/gal = ________ L

Well Purging Information

Start Time	Finish Time	Depth of Tubing (ft btoc)		Equipment Used for Purging
				Bailer Peristaltic Pump Submersible Pump
Color	Odor	Sheen	Purged Dry	Meter Used During Purging
Clear Cloudy Brown Other:	None Moderate Faint Strong	Yes No	Yes No	YSI Multi Meter Hach Turbidimeter

Purging reached: Stability Max Vol. | Purge water was: Treated Stored Other Note:

Time (HH:mm)	Volume (Gallons or Liters)		Acceptable Range to Demonstrate Stability						
			± 0.2 °C	± 3%	± 10% or 0.2 mg/L (whichever is greater)	± 0.1	± 10 mV	± 10% or ±1 NTU	Drawdown < 0.3 ft
	Change	Total	Temperature (°C)	Conductivity (µS/cm)	DO (mg/L)	pH (std units)	ORP (mV)	Turbidity (NTU)	Water Level (feet btoc)

Sample Collection Information

Start Time	Finish Time / Date	Depth of Tubing (ft btoc)	Equipment Used for Sampling
			Peristaltic Pump Submersible Pump
SAMPLE ID:		QC: Dup MS/MSD	Ferrous Iron (Fe^{2+}) (mg/L) =

Container/Preservative	Analysis Requested	Notes

Suggested Notation:

"——" = not measured "✓"= stable "+" = rising "-" = falling "*" = all parameters stable

Groundwater Sampling Data Sheet

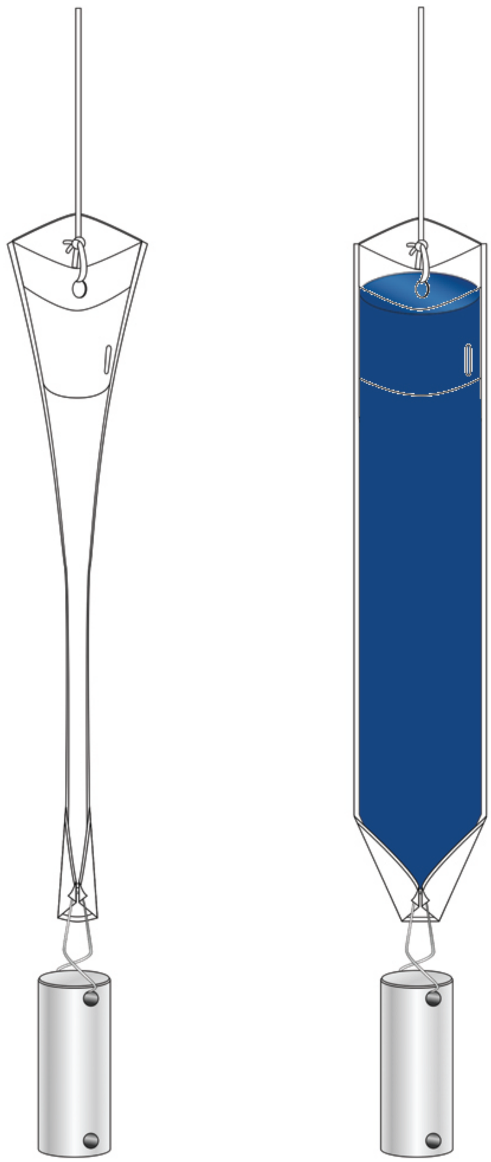
Site Name	Event	Well ID	Project Number
		Date	Sampler Initials

Time (HH:mm)	Volume (Gallons or Liters)		Acceptable Range to Demonstrate Stability						
			± 0.2 °C	± 3%	± 10% or 0.2 mg/L (whichever is greater)	± 0.1	± 10 mV	± 10% or ±1 NTU	Drawdown < 0.3 ft
	Change	Total	Temperature (°C)	Conductivity (µS/cm)	DO (mg/L)	pH (std units)	ORP (mV)	Turbidity (NTU)	Water Level (feet btoc)

HYDRASleeve™

Simple by Design US Patent No. 6,481,300; No. 6,837,120 others pending

Standard Operating Procedure: Sampling Ground Water with a HydraSleeve



This Guide should be used in addition to field manuals appropriate to sampling device (i.e., HydraSleeve or Super Sleeve).

Find the appropriate field manual on the HydraSleeve website at http://www.hydrasleeve.com.

For more information about the HydraSleeve, or if you have questions, contact:
GeoInsight, 2007 Glass Road, Las Cruces, NM 88005, 1-800-996-2225, info@hydrasleeve.com.

Table of Contents

Introduction

The HydraSleeve is classified as a no-purge (passive) grab sampling device, meaning that it is used to collect ground-water samples directly from the screened interval of a well without having to purge the well prior to sample collection. When it is used as described in this Standard Operating Procedure (SOP), the HydraSleeve causes no drawdown in the well (until the sample is withdrawn from the water column) and only minimal disturbance of the water column, because it has a very thin cross section and it displaces very little water (<100 ml) during deployment in the well. The HydraSleeve collects a sample from within the screen only, and it excludes water from any other part of the water column in the well through the use of a self-sealing check valve at the top of the sampler. It is a single-use (disposable) sampler that is not intended for reuse, so there are no decontamination requirements for the sampler itself.

The use of no-purge sampling as a means of collecting representative ground-water samples depends on the natural movement of ground water (under ambient hydraulic head) from the formation adjacent to the well screen through the screen. Robin and Gillham (1987) demonstrated the existence of a dynamic equilibrium between the water in a formation and the water in a well screen installed in that formation, which results in formation-quality water being available in the well screen for sampling at all times. No-purge sampling devices like the HydraSleeve collect this formation-quality water as the sample, under undisturbed (non-pumping) natural flow conditions. Samples collected in this manner generally provide more conservative (i.e., higher concentration) values than samples collected using well-volume purging, and values equivalent to samples collected using low-flow purging and sampling (Parsons, 2005).

Applications of the HydraSleeve

The HydraSleeve can be used to collect representative samples of ground water for all analytes (volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], common metals, trace metals, major cations and anions, dissolved gases, total dissolved solids, radionuclides, pesticides, PCBs, explosive compounds, and all other analytical parameters). Designs are available to collect samples from wells from 1" inside diameter and larger. The HydraSleeve can collect samples from wells of any yield, but it is especially well-suited to collecting samples from low-yield wells, where other sampling methods can't be used reliably because their use results in dewatering of the well screen and alteration of sample chemistry (McAlary and Barker, 1987).

The HydraSleeve can collect samples from wells of any depth, and it can be used for single-event sampling or long-term ground-water monitoring programs. Because of its thin cross section and flexible construction, it can be used in narrow, constricted or damaged wells where rigid sampling devices may not fit. Using multiple HydraSleeves deployed in series along a single suspension line or tether, it is also possible to conduct in-well vertical profiling in wells in which contaminant concentrations are thought to be stratified.

As with all groundwater sampling devices, HydraSleeves should not be used to collect ground-water samples from wells in which separate (non-aqueous) phase hydrocarbons (i.e., gasoline, diesel fuel or jet fuel) are present because of the possibility of incorporating some of the separate-phase hydrocarbon into the sample.

Description of the HydraSleeve

The HydraSleeve (Figure 1) consists of the following basic components:

- A suspension line or tether (A.), attached to the spring clip or directly to the top of the sleeve to deploy the device into and recover the device from the well. Tethers with depth indicators marked in 1-foot intervals are available from the manufacturer.
- A long, flexible, 4-mil thick lay-flat polyethylene sample sleeve (C.) sealed at the bottom (this is the sample chamber), which comes in different sizes, as discussed below with a self-sealing reed-type flexible polyethylene check valve built into the top of the sleeve (B.) to prevent water from entering or exiting the sampler except during sample acquisition.
- A reusable stainless-steel weight with clip (D.), which is attached to the bottom of the sleeve to carry it down the well to its intended depth in the water column. Bottom weights available from the manufacturer are 0.75" OD and are available in three sizes: 5 oz. (2.5" long); 8 oz. (4" long); and 16 oz. (8" long). In lieu of a bottom weight, an optional top weight may be attached to the top of the HydraSleeve to carry it to depth and to compress it at the bottom of the well (not shown in Figure 1);
- A discharge tube that is used to puncture the HydraSleeve after it is recovered from the well so the sample can be decanted into sample bottles (not shown).
- Just above the self-sealing check valve at the top of the sleeve are two holes which provide attachment points for the spring clip and/or suspension line or tether. At the bottom of the sample sleeve are two holes which provide attachment points for the weight clip and weight.

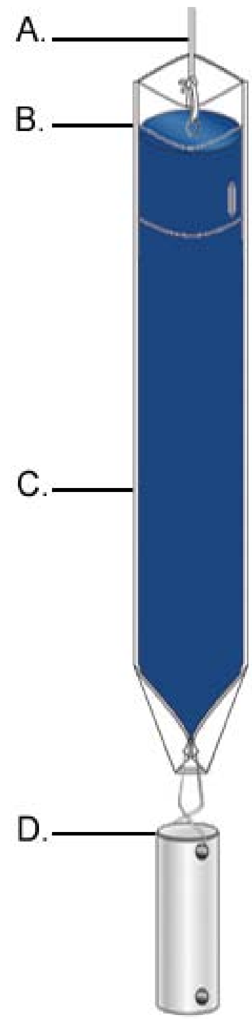


Figure 1. HydraSleeve components.

> **Note:** The sample sleeve and the discharge tube are designed for one-time use and are disposable. The spring clip, weight and weight clip may be reused after thorough cleaning. Suspension cord is generally disposed after one use although, if it is dedicated to the well, it may be reused at the discretion of the sampling personnel.

Selecting the HydraSleeve Size to Meet Site-Specific Sampling Objectives

It is important to understand that each HydraSleeve is able to collect a finite volume of sample because, after the HydraSleeve is deployed, you only get one chance to collect an undisturbed sample. Thus, the volume of sample required to meet your site-specific sampling and analytical requirements will dictate the size of HydraSleeve you need to meet these requirements.

The volume of sample collected by the HydraSleeve varies with the diameter and length of the HydraSleeve. Dimensions and volumes of available HydraSleeve models are detailed in Table 1.

Table 1. Dimensions and volumes of HydraSleeve models.

Diameter	Volume	Length	Lay-Flat Width	Filled Dia.
2-Inch HydraSleeves				
Standard 625-ml HydraSleeve	625 ml	< 30”	2.5”	1.4”
Standard 1-Liter HydraSleeve	1 Liter	38”	3”	1.9”
1-Liter HydraSleeve SS	1 Liter	36”	3”	1.9”
2-Liter HydraSleeve SS	2 Liters	60”	3”	1.9”
4-Inch HydraSleeves				
Standard 1.6-Liter HydraSleeve	1.6 Liters	30”	3.8”	2.3”
Custom 2-Liter HydraSleeve	2 Liters	36”	4”	2.7”

HydraSleeves can be custom-fabricated by the manufacturer in varying diameters and lengths to meet specific volume requirements. HydraSleeves can also be deployed in series (i.e., multiple HydraSleeves attached to one tether) to collect additional sample to meet specific volume requirements, as described below.

If you have questions regarding the availability of sufficient volume of sample to satisfy laboratory requirements for analysis, it is recommended that you contact the laboratory to discuss the minimum volumes needed for each suite of analytes. Laboratories often require only 10% to 25% of the volume they specify to complete analysis for specific suites of analytes, so they can often work with much smaller sample volumes that can easily be supplied by a HydraSleeve.

HydraSleeve Deployment

Information Required Before Deploying a HydraSleeve

Before installing a HydraSleeve in any well, you will need to know the following:

- The inside diameter of the well
- The length of the well screen
- The water level in the well
- The position of the well screen in the well
- The total depth of the well

The inside diameter of the well is used to determine the appropriate HydraSleeve diameter for use in the well. The other information is used to determine the proper placement of the HydraSleeve in the well to collect a representative sample from the screen (see HydraSleeve Placement, below), and to determine the appropriate length of tether to attach to the HydraSleeve to deploy it at the appropriate position in the well.

Most of this information (with the exception of the water level) should be available from the well log; if not, it will have to be collected by some other means. The inside diameter of the well can be measured at the top of the well casing, and the total depth of the well can be measured by sounding the bottom of the well with a weighted tape. The position and length of the well screen may have to be determined using a down-hole camera if a well log is not available. The water level in the well can be measured using any commonly available water-level gauge.

HydraSleeve Placement

The HydraSleeve is designed to collect a sample directly from the well screen, and it fills by pulling it up through the screen a distance equivalent to 1 to 1.5 times its length. This upward motion causes the top check valve to open, which allows the device to fill. To optimize sample recovery, it is recommended that the HydraSleeve be placed in the well so that the bottom weight rests on the bottom of the well and the top of the HydraSleeve is as close to the bottom of the well screen as possible. This should allow the sampler to fill before the top of the device reaches the top of the screen as it is pulled up through the water column, and ensure that only water from the screen is collected as the sample. In short-screen wells, or wells with a short water column, it may be necessary to use a top-weight on the HydraSleeve to compress it in the bottom of the well so that, when it is recovered, it has room to fill before it reaches the top of the screen.

Example

2" ID PVC well, 50' total depth, 10' screen at the bottom of the well, with water level above the screen (the entire screen contains water).

Correct Placement (figure 2): Using a standard HydraSleeve for a 2" well (2.6" flat width/1.5" filled OD x 30" long, 650 ml volume), deploy the sampler so the weight (an 8 oz., 4"-long weight with a 2"-long clip) rests at the bottom of the well. The top of the sleeve is thus set at about 36" above the bottom of the well. When the sampler is recovered, it will be pulled upward approximately 30" to 45" before it is filled; therefore, it is full (and the top check valve closes) at approximately 66" (5 ½ feet) to 81" (6 ¾ feet) above the bottom of the well, which is well before the sampler reaches the top of the screen. In this example, only water from the screen is collected as a sample.

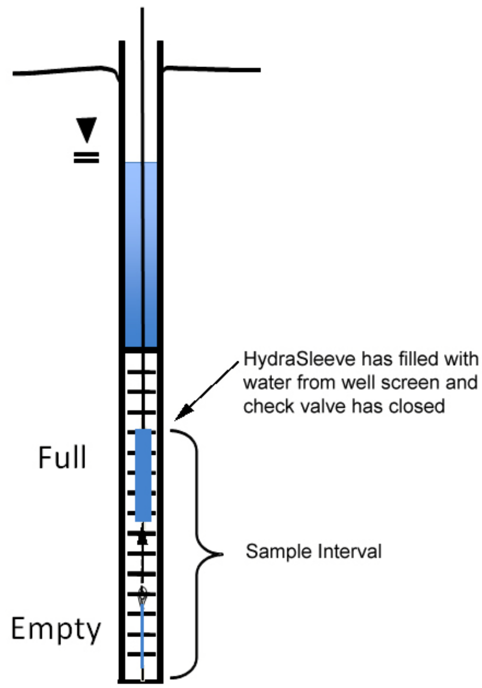


Figure 2. Correct placement of HydraSleeve.

Incorrect Placement (figure 3): If the well screen in this example was only 5' long, and the HydraSleeve was placed as above, it would not fill before the top of the device reached the top of the well screen, so the sample would include water from above the screen, which may not have the same chemistry.

The solution? Deploy the HydraSleeve with a top weight, so that it is collapsed to within 6" to 9" of the bottom of the well. When the HydraSleeve is recovered, it will fill within 39" (3 ¼ feet) to 54" (4 ½ feet) above the bottom of the well, or just before the sampler reaches the top of the screen, so it collects only water from the screen as the sample.

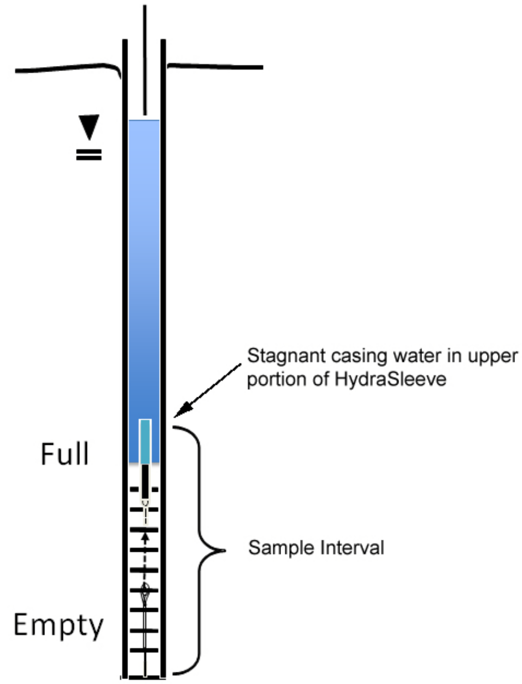


Figure 3. Incorrect placement of HydraSleeve.

This example illustrates one of many types of HydraSleeve placements. More complex placements are discussed in a later section.

Procedures for Sampling with the HydraSleeve

Collecting a ground-water sample with a HydraSleeve is a simple one-person operation.

Note: Before deploying the HydraSleeve in the well, collect the depth-to-water measurement that you will use to determine the preferred position of the HydraSleeve in the well. This measurement may also be used with measurements from other wells to create a ground-water contour map. If necessary, also measure the depth to the bottom of the well to verify actual well depth to confirm your decision on placement of the HydraSleeve in the water column.

Measure the correct amount of tether needed to suspend the HydraSleeve in the well so that the weight will rest on the bottom of the well (or at your preferred position in the well). Make sure to account for the need to leave a few feet of tether at the top of the well to allow recovery of the sleeve

Note: Always wear sterile gloves when handling and discharging the HydraSleeve.

I. Assembling the HydraSleeve

1. Remove the HydraSleeve from its packaging, unfold it, and hold it by its top.
2. Crimp the top of the HydraSleeve by folding the hard polyethylene reinforcing strips at the holes.
3. Attach the spring clip to the holes to ensure that the top will remain open until the sampler is retrieved.
4. Attach the tether to the spring clip by tying a knot in the tether.

Note: Alternatively, attach the tether to one (NOT both) of the holes at the top of the Hydrasleeve by tying a knot in the tether.

5. Fold the flaps with the two holes at the bottom of the HydraSleeve together and slide the weight clip through the holes.
6. Attach a weight to the bottom of the weight clip to ensure that the HydraSleeve will descend to the bottom of the well.

II. Deploying the HydraSleeve

1. Using the tether, carefully lower the HydraSleeve to the bottom of the well, or to your preferred depth in the water column

   During installation, hydrostatic pressure in the water column will keep the self-sealing check valve at the top of the HydraSleeve closed, and ensure that it retains its flat, empty profile for an indefinite period prior to recovery.

Note: Make sure that it is not pulled upward at any time during its descent. If the HydraSleeve is pulled upward at a rate greater than 0.5'/second at any time prior to recovery, the top check valve will open and water will enter the HydraSleeve prematurely.

2. Secure the tether at the top of the well by placing the well cap on the top of the well casing and over the tether.

Note: Alternatively, you can tie the tether to a hook on the bottom of the well cap (you will need to leave a few inches of slack in the line to avoid pulling the sampler up as the cap is removed at the next sampling event).

III. Equilibrating the Well

The equilibration time is the time it takes for conditions in the water column (primarily flow dynamics and contaminant distribution) to restabilize after vertical mixing occurs (caused by installation of a sampling device in the well).

- Situation: The HydraSleeve is deployed for the first time or for only one time in a well

  The HydraSleeve is very thin in cross section and displaces very little water (<100 ml) during deployment so, unlike most other sampling devices, it does not disturb the water column to the point at which long equilibration times are necessary to ensure recovery of a representative sample.

  In most cases, the HydraSleeve can be recovered immediately (with no equilibration time) or within a few hours. In regulatory jurisdictions that impose specific requirements for equilibration times prior to recovery of no-purge sampling devices, these requirements should be followed.

- Situation: The HydraSleeve is being deployed for recovery during a future sampling event

  In periodic (i.e., quarterly or semi-annual) sampling programs, the sampler for the current sampling event can be recovered and a new sampler (for the next sampling event) deployed immediately thereafter, so the new sampler remains in the well until the next sampling event.

Thus, a long equilibration time is ensured and, at the next sampling event, the sampler can be recovered immediately. This means that separate mobilizations, to deploy and then to recover the sampler, are not required. HydraSleeves can be left in a well for an indefinite period of time without concern.

IV. HydraSleeve Recovery and Sample Collection

1. Hold on to the tether while removing the well cap.

2. Secure the tether at the top of the well while maintaining tension on the tether (but without pulling the tether upwards)

3. Measure the water level in the well.

4. In one smooth motion, pull the tether up between 30" to 45" (36" to 54" for the longer HydraSleeve) at a rate of about 1' per second (or faster).

   The motion will open the top check valve and allow the HydraSleeve to fill (it should fill in about 1 to 1.5 times the length of the HydraSleeve). This is analogous to coring the water column in the well from the bottom up.

   When the HydraSleeve is full, the top check valve will close. You should begin to feel the weight of the HydraSleeve on the tether and it will begin to displace water. The closed check valve prevents loss of sample and entry of water from zones above the well screen as the HydraSleeve is recovered.

5. Continue pulling the tether upward until the HydraSleeve is at the top of the well.

6. Decant and discard the small volume of water trapped in the Hydrasleeve above the check valve by turning the sleeve over.

V. Sample Collection

Note: Sample collection should be done immediately after the HydraSleeve has been brought to the surface to preserve sample integrity.

1. Remove the discharge tube from its sleeve.

2. Hold the HydraSleeve at the check valve.

3. Puncture the HydraSleeve just below the check valve with the pointed end of the discharge tube

4. Discharge water from the HydraSleeve into your sample containers.

Control the discharge from the HydraSleeve by either raising the bottom of the sleeve, by squeezing it like a tube of toothpaste, or both.

5. Continue filling sample containers until all are full.

Measurement of Field Indicator Parameters

Field indicator parameter measurement is generally done during well purging and sampling to confirm when parameters are stable and sampling can begin. Because no-purge sampling does not require purging, field indicator parameter measurement is not necessary for the purpose of confirming when purging is complete.

If field indicator parameter measurement is required to meet a specific non-purging regulatory requirement, it can be done by taking measurements from water within a HydraSleeve that is not used for collecting a sample to submit for laboratory analysis (i.e., a second HydraSleeve installed in conjunction with the primary sample collection HydraSleeve [see Multiple Sampler Deployment below]).

Alternate Deployment Strategies

Deployment in Wells with Limited Water Columns

For wells in which only a limited water column exists to be sampled, the HydraSleeve can be deployed with an optional top weight instead of a bottom weight, which collapses the HydraSleeve to a very short (approximately 6” to 9”) length, and allows the HydraSleeve to fill in a water column only 36” to 45” in height.

Multiple Sampler Deployment

Multiple sampler deployment in a single well screen can accomplish two purposes:

- It can collect additional sample volume to satisfy site or laboratory-specific sample volume requirements.
- It can accommodate the need for collecting field indicator parameter measurements.
- It can be used to collect samples from multiple intervals in the screen to allow identification of possible contaminant stratification.

It is possible to use up to 3 standard 30” HydraSleeves deployed in series along a single tether to collect samples from a 10’ long well screen without collecting water from the interval above the screen.

The samplers must be attached to the tether at both the top and bottom of the sleeve. Attach the tether at the top with a stainless-steel clip (available from the manufacturer). Attach the tether at the bottom using a cable tie. The samplers must be attached as follows (figure 4):

- The first (attached to the tether as described above, with the weight at the bottom) at the bottom of the screen
- The second attached immediately above the first
- The third (attached the same as the second) immediately above the second

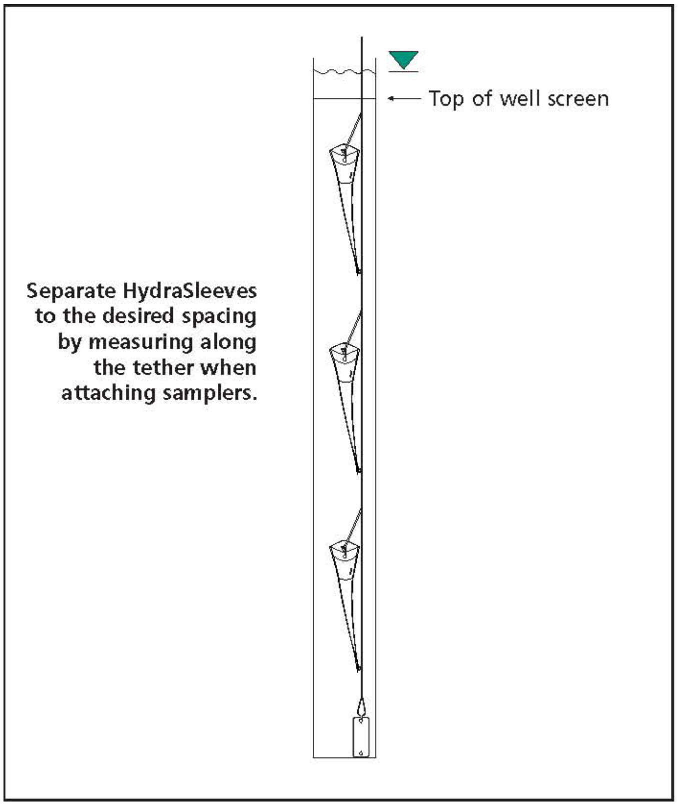


Figure 4. Multiple HydraSleeve deployment.

Alternately, the first sampler can be attached to the tether as described above, a second attached to the bottom of the first using a short length of tether (in place of the weight), and the third attached to the bottom of the second in the same manner, with the weight attached to the bottom of the third sampler (figure 5).

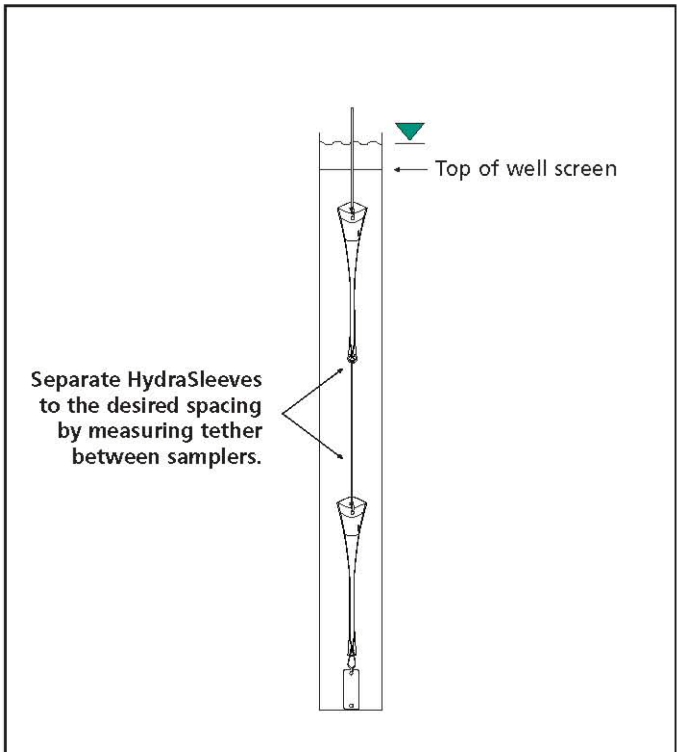


Figure 5. Alternative method for deploying multiple HydraSleeves.

In either case, when attaching multiple HydraSleeves in series, more weight may be required to hold the samplers in place in the well than would be required with a single sampler. Recovery of multiple samplers and collection of samples is done in the same manner as for single sampler deployments.

Post-Sampling Activities

The recovered HydraSleeve and the sample discharge tubing should be disposed as per the solid waste management plan for the site. To prepare for the next sampling event, a new HydraSleeve can be deployed in the well (as described previously) and left in the well until the next sampling event, at which time it can be recovered.

The weight and weight clip can be reused on this sampler after they have been thoroughly cleaned as per the site equipment decontamination plan. The tether may be dedicated to the well and reused or discarded at the discretion of sampling personnel.

References

McAlary, T. A. and J. F. Barker, 1987, Volatilization Losses of Organics During Ground-Water Sampling From Low-Permeability Materials, Ground-Water Monitoring Review, Vol. 7, No. 4, pp. 63-68

Parsons, 2005, Results Report for the Demonstration of No-Purge Ground-Water Sampling Devices at Former McClellan Air Force Base, California; Contract F44650-99-D-0005, Delivery Order DKO1, U.S. Army Corps of Engineers (Omaha District), U.S. Air Force Center for Environmental Excellence, and U.S. Air Force Real Property Agency

Robin, M. J. L. and R. W. Gillham, 1987, Field Evaluation of Well Purging Procedures, Ground-Water Monitoring Review, Vol. 7, No. 4, pp. 85-93

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STANDARD OPERATING PROCEDURE BE-SOP-10

Surface Water Sampling

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines and procedures of collecting surface water samples. The SOP for the collection and analysis of sediment samples is found separately in the *Sediment Sampling* SOP (BE-SOP-07). The methodologies discussed in this procedures are applicable for liquid samples, both aqueous and non-aqueous, from streams, rivers, lakes ponds, lagoons, and surface impoundments. These procedures are applicable for samples collected at the surface.

Collection and handling of surface water samples will be executed or directly supervised by a qualified environmental professional, as defined in 18 AAC 75.333(b).

2.0 MATERIALS AND EQUIPMENT

Collection of surface water includes, but is not limited to:

- Logbook
- Waterproof pen
- Field datasheets (e.g., sample description sheets, etc.)
- Tape measure
- Survey stakes, flags (white), or buoy and anchors
- Dip sampler
- Sampling jars
- Kemmerer bottle
- Preservatives
- Safety equipment
- Decontamination fluids and equipment
- Bottle labels
- Coolers and ice

Refer to Attachment 1, *Water Sampling Checklist* for a more detailed equipment list.

2.1 REAGENTS

Reagents are used for the preservation of surface water samples including hydrochloric acid (HCL), nitric acid (HNO3), sodium hydroxide (NaOH), sodium sulfite, and ascorbic acid. HCL, HNO3, and NaOH are used to preserve surface water samples collected in the field for volatile organic compound (VOC), metals, and cyanide analyses respectively. It is not expected that surface water samples will contain free (residual) chlorine unless they are treated effluent samples or are collected near the outfall of a treated water effluent. If chlorine is suspected, the water will be tested for free chlorine using chlorine test strips according to manufacturer directions. If samples are collected for VOC, semi-volatile organic compound (SVOC), or cyanide analyses, samples that test positive for residual chlorine will require treatment with a reducing agent before sample preservation. Ascorbic acid is used as a reducing agent for samples collected for VOC and cyanide analyses, and sodium sulfite is used as a reducing agent for samples collected for SVOC analysis. Samples collected for oil analysis may sometimes be preserved with HCL or sulfuric acid to prevent degradation by microbial action.

Reagents used for decontamination of sampling equipment is found in the *Equipment Decontamination* SOP (BE-SOP-14). Non-aqueous samples are typically not preserved due to the uncertain nature of the matrix, which may evolve harmful gases upon addition of acid or base to the sample.

3.0 PROCEDURE

3.1 SAMPLING PREPARATION

Prior to conducting sampling activities, a sampling preparation meeting will be held by the team to discuss the proposed sampling strategy for the project-specific Work Plan. Site history, contaminant concerns, sampling methodology, individual responsibilities, sample shipment or delivery, health and safety issues, and lines of communication anticipated during the sampling event will be discussed.

3.2 SURFACE WATER COLLECTION

Surface water samples will be collected using hand tools. Typically, surface samples are collected from just below the water surface. Sampling locations greater than 1 foot below water surface is considered outside the scope of the procedure.

Samples will be collected at a frequency specified in the project-specific Work Plan. Samples will be collected as follows:

- Don new PPE (gloves, etc.) before starting sample collection.
- Verify that all needed equipment is readily available and that the sample containers are new and have been properly prepared.
- Label container and sample-specific data sheet, if applicable.
- Using decontaminated or disposable sampling equipment, collect water from the sampling location by slightly submerging the sample container just below the water surface at a slight angle. If preservatives are in the sampling container, use a sampling container with no preservatives to collect the surface water and fill any pre-preserved sampling containers.
- Allow the container to fill with minimal agitation of the water. Be sure to avoid overfilling of the sample container by leaving a slight amount of headspace in the sample jar.
- Place the cap on the sample jar and tighten.
- Wipe the outside surface of the sample jar using a paper towel
- Place samples upright in a pre-chilled cooler immediately after sample collection.
- Record in the field logbook the sample identification, the sample collection location (sketch), the depth from which the sample was collected, and if a duplicate sample was collected, any discoloration or odor, and other pertinent details.

- Decontaminate any reusable sampling equipment or discard used disposable sampling equipment between samples. The *Equipment Decontamination* SOP (BE-SOP-14) will be followed for decontamination procedures.

3.3 HANDLING AND PRESERVATION

Samples will be collected using the appropriate unused sample containers (with preservative, if required by the analytical method) provided by the analytical laboratory. Sample containers will be labeled with the sample identification number, date and time of collection, sampler initials, and analysis requested. Samples will maintained at 4 degrees Celsius (°C) ± 2 °C while in storage (if required by the analytical method). Samples will then be packaged and transported to the subcontracted laboratory for analysis.

3.4 QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control samples will be collected in accordance with the *Quality Control Samples* SOP (BE-SOP-04) and the project-specific Work Plan.

ATTACHMENTS

Attachment 1 Water Sampling Checklist

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Water Sampling Checklist

Prior to Sampling	Initial
Safety Tailgate meeting	
Calibrate YSI	
Obtain permits	

Monitoring Well Sampling	Initial
Water level meter	
YSI	
Pump	
Tubing (both soft and hard)	
Tubing cutting tool	
5 gallon buckets for purge water	
Samplekits	
gel Ice	
Sample sheets	
DI & Alconox	
Paper towels	
Shovel	
Full socket set (14mm)	
Tool to open well lids	

Surface Water Sampling	Initial
Water level meter	
YSI	
Pump	
Tubing (both soft and hard)	
Tubing cutting tool	
Sample kits	
gel Ice	
Sample sheets	
DI & Alconox	
Paper towels	
5 gall on buckets fo purge water	

PPE/Misc.	Initial
Nitrile gloves	
Shades	
Tailgate form	
Knee pads	
L1RA	
Safety gear (hard hat, gloves, vest, etc.)	
Water	
Laminated site map	
Garbage bags	
PEP/HSE Plan	
Camera	
Whiteboard and marker	

After Sampling	Initial
Drop waste off at waste coordinators	
Close out permits	
Bump Check YSIs	
Download Cameras	
Charge peri pumps	
Charge harmony	
QC, chill, and secure samples	
Complete field notes	
Debrief (tailgate form)	

Brice Environmental Services Corportation
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STANDARD OPERATING PROCEDURE BE-SOP-14

Equipment Decontamination

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to describe the procedures for decontamination of reusable equipment.

2.0 MATERIALS

Materials used for decontamination, include but are not limited to the following:

- Modified Level D Personal Protective Equipment (PPE)
- Brushes, typically stiff bristle
- 5-gallon buckets
- Liquinox, Alconox, or equivalent
- Spray or rinse bottles, or pump sprayer
- Paper towels
- Potable water and/or deionized water
- Distilled or deionized water
- Other hand tools for gross contamination (shovels, brooms, etc.)
- Garbage bags
- Plastic sheeting
- Approved waste containers

3.0 PROCEDURE

Decontamination of reusable sampling equipment will be conducted between sample locations and at the end of each work day. Drilling and excavation equipment will be decontaminated prior to beginning site activities, at the termination of site activities, and, if used for sampling, prior to each sampling event. Materials removed during decontamination will be collected and managed with similar waste streams and the project-specific Work Plan.

3.1 DECONTAMINATION AREA

Identify a localized decontamination area for drill rigs and other sampling equipment. Select the decontamination area so that decontamination fluids and soil wastes can be managed in a controlled area with minimal risk to the surrounding environment. The decontamination area should be large enough to allow temporary storage of cleaned equipment and materials before use, as well as to stage drums of decontamination investigation-derived waste (IDW). In the case of large decontamination areas (for example, for hollow-stem auger decontamination), line each area with a heavy-gauge plastic sheeting and include a collection system designed to capture potential decontamination IDW.

Decontamination areas should be laid out in such a manner as to prevent overspray while performing equipment and personnel decontamination.

Smaller decontamination tasks, such as surface water and sediment equipment decontamination, may take place at the sampling locations. In this case, all required decontamination supplies and equipment must be mobilized to the site and smaller decontamination areas for personnel and portable equipment will be provided as necessary. These locations will include basins or tubs to capture decontamination IDW, which will be transferred to larger containers as necessary.

3.2 PERSONNEL AND PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personnel decontamination involves removal of gross contamination first. Contaminated solids such as mud should be scraped and wiped from boots, and gloves should be removed by rolling off the hands, starting at the cuff, in such a way that the gloves are turned inside out during removal. If necessary, a clean pair of gloves should be worn to complete the boot cleaning process. Boots can be cleaned while being worn or following removal. Any remaining contamination should be removed using soapy water, brushes or other similar means such as a pressure washer, if available. Once all debris is removed, rinse with clean water. If boots are not laden with gross solid materials, a brush can simply be used to knock off or remove any residual solid materials. If the boots have contacted liquid-phase contaminants, it is important that the contaminants be removed using soapy water and a brush followed by a clean water rinse. If the contaminants have adsorbed into the boots, the boots must be disposed of and a replacement pair obtained before conducting any further field activities.

Following removal and cleaning of reusable PPE, field personnel should wash their hands or any exposed body parts which may have been in contact with the associated contaminated substances.

3.3 SAMPLING EQUIPMENT DECONTAMINATION

All reusable sampling equipment will be cleaned prior to use. The following procedure will be used by field personnel:

1. Remove as much gross contamination as possible off equipment at the sampling site.
2. If heavy petroleum residuals are encountered during sampling, an appropriate solvent such as methanol should be used to remove any petroleum residues from sampling equipment.
3. Wash water-resistant equipment thoroughly and vigorously with potable water containing laboratory-grade detergent such as Liquinox, Alconox, or equivalent. Use a bristle brush or similar utensil to remove any remaining residual contamination.
4. Rinse equipment thoroughly with potable water (1st rinse).
5. Rinse equipment thoroughly with distilled or deionized water (2nd rinse).
6. For sensitive field instruments, rinse equipment with distilled, deionized, or reagent grade water (3rd rinse).
7. Air dry at a location where dust or other fugitive contaminants may not contact the sample equipment. Alternatively, wet equipment may be dried with a clean, disposable paper towel to assist the drying process. All equipment should be dry before reuse.

Clean, dry sampling equipment will be stored within a protective medium (plastic bag, etc.) or staged in a clean area for future use.

Cleaning and decontamination of the equipment will be accomplished in stages and in such a way that the contamination does not discharge into the environment. Cleaning and decontamination wastes must be properly contained and disposed of in accordance with applicable state and federal regulations.

Disposable sampling equipment should be used whenever possible (e.g. drum thieves, bailers, spoons, etc.) to minimize the need to decontaminate these items.

3.4 HEAVY EQUIPMENT DECONTAMINATION

Gross decontamination of equipment will be performed prior to transporting or walking equipment within different areas of or between contaminated areas or exclusion zones. Gross decontamination will focus on minimizing the spread of contaminated media as a result of equipment movement or transport. This decontamination process will use dry methods (brooms, wipes, shovels, etc.) within the exclusion zone in order to remove large, easily dislodged deposits of soil and other contaminated media prior to exiting the exclusion zone. The Site Manager may increase the level of gross decontamination based upon the effectiveness of the use of dry decontamination.

Final decontamination will occur when equipment is no longer needed on site within a decontamination pad in order to allow for the collection of decontamination materials, sludge, and water. When equipment is to be removed permanently, it will be decontaminated using brushes and/or a pressure washer with a detergent wash followed by a fresh water rinse. All areas of the equipment which were potentially contaminated will be decontaminated as described in Section 3.3.

3.5 DRY DECONTAMINATION

Where dry decontamination is required, the following steps will be followed at the sampling site by field personnel:

1. Remove as much debris or contamination as possible using a dry brush or paper towel.
2. Spray equipment with a detergent/water mix.
3. Wipe down with a clean, dry paper towel.
4. Spray equipment with potable water.
5. Wipe down with a clean, dry paper towel.
6. Spray equipment with deionized or distilled water.
7. Wipe down with a clean, dry paper towel.

Dispose of all paper towels with other IDW and disposable sampling supplies.

4.0 INTERFERENCES

Improper decontamination may cause cross-contamination across the sites, analytical samples, or field screening instruments. To prevent cross-contamination of analytical samples, sampling equipment will be disposed of after one use, or decontaminated after, or prior to each use. Additionally, laboratory-certified clean glassware will only be used for storing analytical samples.

5.0 QUALITY CONTROL

Quality Control (QC) samples may be collected in order to verify the decontamination process is effective. QC samples include the equipment rinsate blank and the equipment wipe sample which are described in detail in the *Quality Control* SOP (BE-SOP-04).

STANDARD OPERATING PROCEDURE BE-SOP-20

Water Quality Measurements

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the methods for calibrating, maintaining, and operating the YSI 556 Multi-Parameter Water Quality Meter. The YSI 556 simultaneously measures numerous water quality parameters including temperature, conductivity, salinity, dissolved oxygen (DO), pH, and oxidation Reduction Potential (ORP). This SOP also describes the guidelines of operation for the Hach Portable Turbidity Meter.

2.0 EQUIPMENT

Water quality meters and instruments vary. Below is a list of the typical instruments used in the field:

- YSI 650 MDS Multi-Parameter Datalogger
- YSI 6-Series Sonde Field Cable
- Flow-Thru Cell
- Hach 2100P Portable Turbidity Meter
- Discharge hoses and fittings to attach sample tubing to the flow-thru cell
- Distilled water
- Calibration solution for YSI (pH 4, 7, and 10, ORP, and conductance)

3.0 PROCEDURES

It is important to note however that different models of instruments exist and therefore the appropriate operation and procedure manual should be referenced prior to use.

3.1 CALIBRATION FOR YSI 556

Calibration using Calibration Solution of all instruments for all field parameters needs to be conducted on a daily basis. Document field calibration readings in the field logbook. If a field instrument will not calibrate, perform troubleshooting as described in the manufactures manual. If the issue cannot be resolved, use a backup instrument. If that is not an option, contact the PM on whether data collection will continue or any other corrective actions should be taken. Flag any data recorded from a meter with suspected calibration problems on the field forms. Calibrate YSI for pH, conductivity, ORP, and DO.

3.1.1 pH Calibration

Always calibrate pH with a 3-point calibration method. The 3-point calibration method accounts for the full pH range and assures maximum accuracy when the pH of the media to be monitored cannot be anticipated.

3.2 YSI MULTI-PARAMETER WATER QUALITY METER

3.2.1 Groundwater parameters

Follow the general procedure for collecting water quality parameters using a flow-thru cell:

- Secure the multi-meter probe to the flow-thru cell. Connect a short discharge tube to the effluent connector at the top of the flow-thru cell and run the other end of the discharge tube into a purge water container.
- Place the tube from the pump directly into the 5-gallon purge water bucket and start to purge approximately half a minute or until the purge water begins to visually clear up. The intent is to limit any initially high turbidity water from filling and settling in the flow-thru cell.
- Once visually clear, turn off pump briefly and secure the tube from the pump to the influent connector at the bottom of the flow-thru cell. Turn on the pump again and allow the flow-thru cell to completely fill with water.
- Begin low flow purging of the well at a flow rate of approximately 1 liter (0.25 gallons) every 3-5 minutes.
- Routinely measure and record DO, ORP, conductivity, pH, turbidity, temperature, and the depth to groundwater every 3-5 minutes until stabilized. A minimum of three recordings will be monitored and recorded.
- Continue to monitor until stabilized or until three well case volumes have been purged. Use the following stabilization parameters:
    - ± 3% for temperature (minimum of ± 0.2 °C),
    - ± 0.1 for pH,
    - ± 3% for conductivity,
    - ± 10 mv for redox potential,
    - ± 10% for dissolved oxygen (DO), and
    - ± 10% for turbidity.

Note: Low flow purging and sampling are particularly useful for wells that purge dry or take one hour or longer to recover. If a well is low yield and purged dry, do not collect a sample until it has recharged to approximately 80% of its pre-purge volume, when practical.

- When parameters have stabilized, record final measurements and collect samples as per the project-specific Work Plan.

3.2.2 Surface Water Parameters

When collecting surface water samples a flow-thru cell is not required. Instead connect the probe sensor guard to the connector nut to protect the sensors. Place the probe in the water being careful not to disturb the bottom. Let sit for about 5 – 10 minutes and then take parameters.

3.3 HACH 2100P PORTABLE TURBIDITY METER

The Hach Model 2100P Portable Turbidimeter measures turbidity from 0.01 to 1000 NTU in automatic range mode with automatic decimal point placement. Use the following generic procedure for turbidity measurements:

- Collect a representative sample in a clean container. Fill a sample cell to the line (about 15 mL), taking care to handle the sample cell by the top. Cap the cell.
- Wipe the cell with a soft cloth to remove water spots and fingerprints.
- Apply a thin film of silicone oil. Wipe with a soft cloth to obtain an even film over the entire surface.
- Turn the instrument on and place on a flat sturdy surface.
- Insert the sample cell in the instrument call compartment so the diamond or orientation mark aligns with the raised orientation mark in from of the cell compartment.
- Press READ and the result will show in units of NTU.

Refer to the user's manual provided with rental equipment for calibration and maintenance documentation.

4.0 REFERENCES

Hach Company. 2008 (April). *Hach Portable Turbidity Meter Model 2100P Instrument and Procedure Manual*

YSI Environmental. 2009 (August). *YSI 556 Multi Probe System Operations Manual*

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STANDARD OPERATING PROCEDURE BE-SOP-21

Groundwater and LNAPL Measurements

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) will be used as guidance on the method and equipment used to determine water levels, depth to floating product, or total depth in a groundwater monitoring well. Groundwater measurements can be used for several purposes during field activities, including but not limited to, measuring changes in time, determining the magnitude of horizontal and vertical hydraulic gradients in an aquifer system.

A water level meter will typically be used to measure depth to groundwater (DTW), depth to product (DTP), and total depth (TD) in wells. If Light Non-Aqueous Phase Liquid (LNAPL) is present in the well, an oil-water interface probe will be used.

2.0 EQUIPMENT

Groundwater and LNAPL measurement equipment will include:

- Water Level meter with audible alarm and a cable marked in 0.01 foot increments
- Oil-water interface meter (only if LNAPL layer is suspected)
- Decontamination equipment

2.1 DEPTH TO WATER/DEPTH TO LNAPL MEASUREMENT

If the well is sealed with an airtight cap, allow time for pressure to equilibrate after the cap is removed before measuring water levels. Take measurements until consecutive readings are within 0.01 foot.

Before taking measurements, ensure a reference point is established. For easy reference, mark the point with a permanent surveyor’s reference mark, such as a small notch cut into the casing or a permanent ink mark at the top of the casing. If no reference mark is present, mark the north side of the monitoring well casing.

Measure DTW and DTP as follows:

- With the water level indicator switched on, slowly lower the water level meter or oil-water indicator probe down the monitoring well until the probe contacts the groundwater or LNAPL surface, as indicated by the audible alarm. Do not let the probe tip and tape free-fall down the well. Always hold onto the meter's reel handle.
- Raise the probe out of the water or LNAPL until the audible alarm stops. Continue raising and lowering the probe until a precise level is determined within 0.01 foot.

- If LNAPL is present in the well, measure and record the depth from the TOC reference point to the top surface of the LNAPL layer (that is, DTP). The oil-water indicator probe alarm will sound a continuous tone when LNAPL is detected.
- Continue to lower the probe until the meter indicates the presence of groundwater. The alarm will typically emit a beep when water is detected. Measure the first static groundwater level and record the measurement (DTW) from the reference point to the top of the static groundwater level.
- Record the measurements in the field logbook or field form.

2.2 TOTAL DEPTH MEASUREMENT

Use the following procedures to measure the TD of a groundwater monitoring well:

- Slowly lower the water level meter until the cable goes slack. Do not let the probe tip and tape free-fall down the well. Always hold onto the meter's reel handle.
- Gently raise and lower the water level meter probe to tap the bottom of the well.
- Record the reading on the cable at the established reference point to the nearest 0.01 foot.

If there is an offset between the bottom of the probe and the water level sensor, adjust the measurement accordingly. Record the TD measurement in the field logbook or groundwater field form.

STANDARD OPERATING PROCEDURE BE-SOP-22

Monitoring Well Installation and Development

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) is to be used as reference to describe the process for constructing, installing, and developing groundwater monitoring wells provided by a drilling subcontractor via drill-rig operation. This SOP provides a standard set of procedures applicable under typical site conditions and may vary based on actual site conditions and/or equipment characteristics. This SOP is consistent with *Monitoring Well Guidance* issued by the Alaska Department of Environmental Conservation (ADEC 2013). Specific monitoring well design and installation procedures depend on project objectives and subsurface conditions, and should be discussed in the project-specific Work Plan (WP).

Monitoring wells can be installed as long-term monitoring wells, which can be repeatedly sampled over several years, or as temporary well points, which allow for a one-time groundwater sampling event. Following development, purging, and sampling - a temporary well point is usually removed and backfilled in accordance with ADEC regulations.

2.0 EQUIPMENT AND MATERIALS

The drilling subcontractor will supply all materials and equipment necessary to perform drilling activities in accordance with the Drilling and Core Logging SOP (BE-SOP-05) and will install monitoring wells in locations based on field observations, the Statement of Work (SOW), and in the project-specific WP.

Temporary well points are most commonly 1- to 2-inch diameter screened PVC or stainless steel pipe, which can be pre-packed with filter material, or used without a filter pack. Temporary well points can be installed using a direct push drill rig or by hand, if in unconsolidated material with a shallow water table.

Monitoring wells are usually installed with pre-packed screens, using a direct push drill rig or a hollow stem auger.

Equipment and materials needed for monitoring well installation include, but are not limited to, the following:

- Geoprobe® 66 series drill rig or equivalent
- Well casing and screen
- Filter pack materials
- Bentonite/cement grout
- Surface seal materials (concrete)
- Potable water and/or deionized water

- Weighted tape measure

Monitoring well development equipment includes, but is not limited to the following:

- Water level meter or Oil/Water interface probe
- Surge block (with foot valve)
- Submersible pump
- Sprinkler pump (useful for removing large volumes of silt and fine sand laden water)
- Inertial pump and tubing (optional-consider for deep wells greater than 30 feet)
- Disposable polyethylene or Teflon bailers
- 5-gallon buckets
- Graduated cylinder or beaker
- YSI water-quality meter
- Hach portable turbidity meter
- Potable water and/or deionized water
- Disposable polyethylene tubing

3.0 DOCUMENTATION

Fill out the attached *Well Installation and Well Development Forms* following installation and when developing the monitoring well. All fields on the installation form must be completed for long term monitoring wells as well as temporary well points. All fields on applicable field forms will be used or an "NA" will be inserted to indicate a field that is not applicable. The field form sections are outlined below:

- Well designation;
- Date of well installation;
- Date of development;
- Static water level before and after development;
- Quantity of drilling fluid lost during drilling;
- Well volume;
- Depth from top of well casing to bottom of well;
- Screen length;
- Depth from top of well casing to top of sediment inside well, before and after development, if present;
- Physical characteristics of removed water, including changes during development in clarity, color, particulates, and odor;
- Type and size/capacity of pump and/or bailer used;
- Height of well casing above/below ground surface;
- Typical pumping rate;
- Estimate of recharge rate; and
- Quantity of water removed and time of removal.
- The *Drilling and Core Logging* SOP (BE-SOP-05) will be followed in compliance with the ASTM D2488 Unified Soil Classification standards. The *Core Log* SOP (BE-SOP-05 Attachment) field form

must be completed during installation and before leaving the site to ensure all details are captured and are complete and accurate.

- Monitoring wells will be surveyed within a horizontal accuracy of 1.0 feet and a vertical accuracy of 0.01 foot. The top of the well casing will be surveyed as well as ground surface for use as a reference point to determine water-level elevation, sampling depths, and groundwater flow direction. All survey information will be documented in the field log book.

4.0 WELL INSTALLATION PROCEDURES

This section describes drilling, borehole, casing, well screen, bentonite seal, and monitoring well completion requirements.

Prior to monitoring well installation, ADEC recommends developing a conceptual model of the site geology and hydrology. This allows for a better understanding of the distribution of aquifers and aquitards at or near the site, hydrologic boundaries, the water surface table, and other hydrogeographic properties. This is a working model to be updated as new data is obtained.

4.1 DRILLING REQUIREMENTS

Several drilling methods are available for creating a borehole for well installation. Primary methods include hollow stem, direct push, air rotary, mud rotary, and cable tool The drilling method is chosen based on physical subsurface properties.
All drilling activities will be supervised by a qualified environmental professional. The drill rig will be decontaminated appropriately before it enters and leaves the site in accordance with the *Equipment Decontamination* SOP (BE-SOP-14). All leaks will be repaired prior to coming to the site or as soon as they are discovered at the site. The drill rig will not leak any fluids that may enter the borehole or contaminate equipment placed in the hole. The use of rags or absorbent materials to soak up leaking fluids is unacceptable. Brice, or the drilling subcontractor, will have spill response equipment on site at all times to ensure constant preparedness in the case fluids begin to drip from the rig so they do not impact the site.
Drilling mud, synthetic drilling fluids, petroleum or metal based pipe joint compounds, and other potential contaminants will not be used unless necessary. Only high yield sodium bentonite clay free of organic polymer additives will be used if drilling mud is needed to stabilize the hole.

Decontamination water must be potable and obtained from a known water source.

An “as built” drawing will be constructed for each monitoring well. Each well point will be surveyed.

4.2 BOREHOLE REQUIREMENTS

Borehole diameters should be at least three inches larger than the nominal outside diameter of the casing and well screen. If using a hollow stem auger, the inside diameter of the auger should be at least four inches larger than the nominal outside diameter of the casing and well screen, unless otherwise specified in the approved project-specific Work Plan.

The completed monitoring well must be straight and plumb to allow passage of pumps or sampling devices.

4.3 CASING REQUIREMENTS

The following lists requirements for the casings of monitoring wells:

- All casing will be new, unused, and pre-cleaned (if necessary).
- Glue or solvent will not be used to join casing; casings will be joined only with water-tight flush-joint threads or thermal welds that will not interfere with the planned use of the well.
- Pop rivets or screws should not be used on casings or other monitoring well components.
- All monitoring wells will conform to the American Society for Testing Materials (ASTM) F-480-06b. The inside diameter should be at least 1.9 inches, with the exception of well points for piezomenters and transducers. Polyvinyl chloride (PVC) is a durable monitoring well with good chemical resistance (EPA 1991).
- All metal casing will be seamless stainless steel casing, and the casing "mill" papers will be included in the appendix of the technical report.
- The casing will be straight and plumb within the tolerance stated for the borehole.
- A notch in the top of the casing will be cut to be used as a measuring point for water levels and survey activities. Boring location will be noted based on the identification number.

4.4 WELL SCREEN REQUIREMENTS

The following are the requirements that must be met for well screens:

- All requirements that apply to casing will also apply to well screen, except for strength requirements.
- Monitoring wells will not be screened across more than one water-bearing unit. Screens will be factory slotted or wrapped.
- Screen slots will be sized to prevent 90 percent of the filter pack from entering the well, and for wells where no filter pack is used, the screen slot size will be selected to retain 60 to 70 percent of the formation materials opposite the screen.
- The bottom of the screen is to be capped, and the cap will be joined to the screen by threads.

In most hydrogeologic settings, screen lengths should not exceed 10 feet. The use of shorter well screens may allow for contaminant detection by reducing excessive dilution.

4.5 FILTER PACK REQUIREMENTS

Surrounding the monitoring well intake with materials that are coarser, of uniform grain size, and have a higher permeability than natural formation material allows the groundwater to flow freely into the well from adjacent formation material while minimizing or eliminating the entrance of fine gained materials. Determine the appropriate filter pack (natural or artificial) application for a given well. An artificial filter pack typically meets these conditions. Deciding between natural and artificial filter pack depends on the grain size distribution of the natural formation materials in the monitored zone. Grain size is determined by conducting a sieve analysis of a soil sample for the intended screened interval. The filter pack should extend above the well screen to a length of 20 % of the well screen length, but no less than 2 feet (ASTM D5092 2005). The thickness of the filter pack should be at least 2 inches between the borehole and the well screen, and no greater than 8 inches (EPA 1991).

4.6 SEAL REQUIREMENTS

An annular seal should be installed to restrict vertical movement of water or contaminants by sealing the well casing to the adjacent soil formation. The annular seal consists of grout and bentonite chips from the filter pack to approximately 2 feet below the ground surface.

The bentonite seal requirements for wells installed deeper than 12 feet below ground surface, are as follows:

- The bentonite seal will consist of at least two feet of bentonite between the filter pack and the casing grout.
- The bentonite will be hydrated before placement.
- Only 100 % sodium bentonite will be used.

The bentonite seal will be terminated at least 18 inches from the ground surface. The remainder of the annulus will be backfilled using silica sand to minimize bentonite intrusion into the well monument and to promote drainage of water from inside the monument. If the monitoring well is advanced in frozen ground, the annular space between the casing and any permafrost should be sealed to minimize effects on the subsurface thermal regime and to prevent water within the well from freezing.

A bentonite seal is not required for wells installed on gravel pads with shallow active layer water 2 to 8 feet below ground surface.

4.7 SOIL BORING AND LOGGING

Soil borings will be logged at each site where monitoring wells will be installed. Refer to BE-SOP-05 for the drilling and core logging procedure.

4.8 MONITORING WELL SURFACE COMPLETION REQUIREMENTS

Surface completion is not necessary for temporary well points.

If flush-mounted completions, cut the casing approximately six inches below the ground surface and provide a water-tight casing cap to prevent surface water from entering the well. A freely draining surface monument with a locking cover should be placed over the casing. The surface monument should be placed in well-sorted sand to allow water drainage. If the well is located on a gravel pad, the top of the monument must be completed at least three inches below pad grade to protect it from snow removal equipment. The top of the casing will be at least one foot above the bottom of the box. The identity of the well should be permanently marked on the monument lid and the casing cap.

For above-ground monitoring well completions, extend the well casing two or three feet above ground surface. Provide a casing cap for each well, and shield the extended casing with a steel sleeve that is placed over the casing and cap and seated in a 3-foot by 3-foot by 4-inch concrete surface pad. To allow for escape of gas, a small diameter (e.g., 1/4-inch) vent hole must be placed in the well casing, or a ventilated well cap will be used. The diameter of the sleeve should be at least six inches greater than the diameter of the casing. Install a lockable cap or lid on the guard pipe. The identity of the well should be permanently marked on the casing cap and the protective sleeve.

Well locations must be designed to ensure groundwater samples and water level measurements characterize discrete stratigraphic intervals. This is achieved by positioning the screened interval relative to the water table elevation.

Well locations and designs must prevent surface contaminants from entering the groundwater as well as leakage of groundwater or contaminants between the stratigraphic intervals in the well bore or along the well annulus. Complete wells above grade to decrease potential of surface contaminants entering the well.

Install monitoring wells where there is no chance of seasonal inundation by floodwaters, unless the wells have special watertight construction.

Long-term monitoring well development:

- A drilled, long term monitoring well is typically composed of well casing, well screen, and filter pack.
- Place the filter pack into the annulus to a minimum of two feet above the top of the screen and one foot beneath the well endcap.
- Reduce the required filter pack height to allow for annular space sealant.
- Apply grout or bentonite chips to seal the annular space.

5.0 WELL DEVELOPMENT PROCEDURES

Monitoring wells should not be developed for at least 24 hours after installation.

Wells can be developed using a submersible pump, peristaltic pump, and or bailer. Bailers are more commonly used in wells where there is a small volume of water.

Monitoring wells can be developed by first purging the well dry, if possible, then allowing the monitoring well to refill with formation water. If the recovery rate by the formation water is too slow, up to one well casing volume of potable water can be added to the well. The well should be surged vigorously for approximately 10 minutes using either a surge block or bailer. Add more water as necessary. Purge the well dry again to complete the development process (ADEC 2013).

A minimum of three borehole volumes (calculated from the borehole diameter and the length of screen below the water table, corrected for 30 percent porosity of the filter pack) of water and twice the volume of water added during drilling and construction will be removed.

In the event of submerged wells, the borehole volume is calculated over the interval of the filter pack (length of screen plus 2 feet of added sand above the screen).

After initial surging and pumping, groundwater parameters will be monitored for stability criteria (described below).

Groundwater parameter stability is reached when three changes between successive readings at approximately 5-minute intervals at a low-flow pumping rate (drawdown less than 0.3 feet) are less than the criteria provided in Table 1.

Table 1
Stability Criteria for Low-Flow Purging

Parameter[1]	Units	Recording Precision	Stability Criterion
pH	—	0.01	±0.1
Temperature	°C	0.01	±0.2
Conductivity	µS/cm	1	±3%
Turbidity	NTU	0.1	± 10% or ± 1 NTU (whichever is greater)
Oxidation Reduction Potential (ORP)	mV	1	±10
Dissolved Oxygen (DO)	mg/L	0.1	±10% or 0.3 mg/L (whichever is greater)

Notes:
°C = degrees Celsius
µS/cm = microSiemens per centimeter NTU
= nephelometric turbidity units mV =
millivolts mg/L=milligrams per liter
Stability criteria from ADEC *Field Sampling Guidance* (ADEC 2016).
[1] Only three parameters are required to stabilize, four when using temperature.

Low-yielding wells are exceptions to the above criteria. Such wells should be purged dry, then either be allowed to recover or be filled with potable water to the static water level for surging. Add water as needed to maintain the water level during surging. Satisfactory recovery is defined as 80 percent of the well volume. After the initial recovery period, such wells will be surged and pumped dry again to complete the development process.

Alternative development procedures may be used if they will not affect the ability of the well to provide representative samples. Wells installed with an annular seal must not be developed until 24 hours after well installation to allow annular seal materials to set or cure. ADEC recognizes that remote site work may make this impractical. Contact your ADEC project manager for site-specific approval if development is to be conducted prior to the 24-hour waiting period. Sample the monitoring well in accordance with the ADEC *Draft Field Sampling Guidance* (ADEC 2016).

Well purge water can be discharged to the ground surface within 25 feet of the monitoring or recovery well casing, unless there is contamination present, or otherwise specified by the ADEC project manager. If there is evidence of contamination present the purge water will be remediated based off of the project-specific Work Plan.

A well is considered fully developed when the following criteria are met:

- The well water is clear to the unaided eye (based on observations of water clarity through a clear glass jar); and/or

- If stability cannot be achieved, the well is considered developed when the total volume of water removed from the well equals five times the standing water volume in the well plus the volume of drilling fluid lost or potable water added (if fluids were added).

6.0 WELL DECOMMISSIONING

The purpose of decommissioning monitoring wells and temporary well points is to protect the aquifer. Monitoring wells and temporary well points should be decommissioned as soon as ADEC has determined they are no longer needed. Decommissioning procedures are as follows:

1. Knock the bottom of the screen out with a steel drill rod/ pipe, which allows the well to be used as a tremie pipe.
2. Remove the well casing and screen until the screened interval is above the groundwater interface. This allows the material surrounding the well to collapse into the borehole. Keep a 1:1 ratio when pulling out the screen. A 10’ screen, pull the well out 10’.
3. After the casing is withdrawn above the groundwater interface, add sealing grout or bentonite chips to the well to within approximately 2 feet below ground surface. Sealing grout should begin to be placed within the confining stratum, if the well is located in a confined aquifer.
4. Record decommissioning procedures and report to ADEC.

If the well casing and screen are unable to be removed at the time of decommission, the screen should be filled with sand and the casing should be completely sealed in-place up to the casing cutoff point located near the ground surface.

If the monitoring well is damaged, broken, filled or plugged with soil or other extraneous material preventing successful decommissioning efforts by the methods described previously, decommissioning can be achieved by re-drilling the monitoring well. The PVC casing and well screen may be destroyed by re-drilling the original borehole to the total depth of the well. When the auger is at the bottom of the well, sealing grout or bentonite chips should be added continuously as the auger is carefully removed.

7.0 REFERENCES

ADEC. 2013 (September). Monitoring Well Guidance.

ADEC. 2016 (April). Field Sampling Guidance.

ASTM. 2009 (July). *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure.* D2488. West Conshocken, Pennsylvania.

U.S. EPA .1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells, Office of Research and Development.

U.S. EPA, Region 4. 2008 (February). Design and Installation of Monitoring Wells, Science and Ecosystem Support Division.

ATTACHMENTS

Attachment 1 Record of Well Construction

Attachment 2 Well Development Data Sheet

Record of Well Construction

Project		Project Number	Client	Boring No.
Address, City, State			Drilling Contractor	

Logged by	Date	Started	Drilling Method and Equipment Used	
Drill Crew		Completed		
	Groundwater Depth		Elevation	Total Depth

Depth (feet)	Diagram	Field Installation Information
1		________ Surface Monument (material ________________)
2		________ Surface Seal
3		________ Bentonite Seal
4		________ Casing (material ________________)
5		________ Screen (material ________________)
6		________ Screen Filter (material ________________)
7		________ Surface Elevation
8		________ Casing Elevation
9		________ Casing Stickup
10		________ Depth of Well
11		________ Depth of Boring
12		________ Depth to Groundwater from ________ on (date) ________
		Development Method ________________
		Development Time and Purge Volume ________________

Record of Well Construction

Field Notes from Drilling

Date	End Time	Start Time
Note-Taker Name		Boring Number
Surface Conditions		

Well Development Data Sheet

Site Name	Event	Well ID	Project Number
Weather Conditions	**PID Readings of Total VOCs (ppm)** Ambient _______ Breathing Zone _______ In Well _______	**Date**	**Developer Initials**

Well Information

Well Material / Size (in)	Drilling Water Added (gal)	As-Built TD of Casing (ft)	Borehole Diameter(in) / Gallons per linear foot (gal/ft)
PVC / 2 SS / 2 ___/___			4.5 / 0.362 6 / 0.555 8 / 0.898 10 / 1.34 (filter pack porosity = 0.3)
Depth to Product (ft TOC)	**Depth to GW (ft TOC)**	**Initial TD of Casing (ft)**	**Product Thickness (ft) and Volume Recovered (mL)**

Borehole Vol. (BV) water table well = (TD of casing – depth to water) ∗ gal/ft; submerged well = (TD of casing – Depth Top Filter Pack *gal/ft

Min Purge Vol. = 2 * Added Water + 3 * BV Max Purge Vol. = 2 * Added Water + 10 * BV

BV = (________ ft – ________ ft) ∗ ________ gal/ft = ________ gal (* 3.785 L/gal = ________ L)

Min Purge Vol. = 2 * ________ gal + 3 * ________ gal = ________ gal (* 3.785 L/gal = ________ L)

Max Purge Vol. = 2 * ________ gal + 10 * ________ gal = ________ gal (* 3.785 L/gal = ________ L)

Well Purging Information

Start Time	Finish Time	Final TD of Casing (ft)		Equipment Used for Purging	
				sprinkler pump w/ surge block submersible pump peristaltic pump	
Color	**Odor**	**Sheen**	**Purged Dry**	**Stabilization Meters**	**Pump Intake Depth (ft btoc)**
Clear Cloudy Brown Other:	None Moderate Faint Strong	Yes No	Yes No	YSI Multi Meter Hach Turbidimeter	(during stabilization)

Purging reached: Stability Max Vol. | Purge water was: Treated Stored Other Note:

Time (HH:mm)	Volume (Gallons or Liters)		Acceptable Range to Demonstrate Stability						Water Level (feet btoc)
			± 1.0 °C	± 3%	± 10% or 0.3 mg/L (whichever is greater)	± 0.1	± 10 mV	± 10% or ±1 NTU	
	Change	Total	Temperature (°C)	Conductivity (µS/cm)	DO (mg/L)	pH (std units)	ORP (mV)	Turbidity (NTU)	

Suggested Notation

"——" = not measured "✓"= stable "+" = rising "-" = falling "*" = all parameters stable

____ Additional observations on back

Well Development Data Sheet

Site Name	Event	Well ID	Project Number
		Date	Developer Initials

Time (HH:mm)	Volume (Gallons or Liters)		Acceptable Range to Demonstrate Stability						Water Level (feet btoc)
			± 1.0 °C	± 3%	± 10% or 0.2 mg/L (whichever is greater)	± 0.2	± 10 mV	± 10% or ±1 NTU	
	Change	Total	Temperature (°C)	Conductivity (µS/cm)	DO (mg/L)	pH (std units)	ORP (mV)	Turbidity (NTU)	

STANDARD OPERATING PROCEDURE

BE-SOP-29

GeoXH GPS Location Survey

1.0 INTRODUCTION

The purpose of this Standard Operating Procedure (SOP) is to direct field personnel in the proper use of a Trimble GeoXH global positioning system (GPS) unit for the collection of locations. This SOP applies to all personnel engaged in surveying locations with a handheld Trimble GeoXH GPS. This unit is mapping-grade capable of sub-meter accuracy and should be used only when contract requirement allow for this resolution. If higher resolution/accuracy of surveyed locations is required, a survey-grade GPS should be used.

The Trimble GeoXH handheld GPS is a high precision, dual frequency, differential GPS with accuracy capabilities to the decimeter. A GeoXH 3000 and a GeoXH 6000, both running Windows Mobile with Trimble Terrasync software, may be utilized. The GeoXH 6000 has Floodlight technology, which performs better in areas with multipath errors and should be used in conditions with heavy canopy or around tall buildings.

GPS uses 24 satellites and their associated ground stations to form a world-wide radio-navigation system. The GPS receiver (the handheld GeoXH) determines the relative positions of items using the geometry of triangles (trilateration) created from the position of the receiver and the satellites it detects, and time, synchronized to universal time. A minimum of 4 satellites are needed to determine position; typically more are required for accuracy. Trimble GeoXH systems can received up to 12 satellite positions simultaneously.

Errors can be introduced into the GPS system from a variety of sources including atmospheric conditions and physical objects causing obstructions and reflected signals. Care must be taken to ensure the best conditions for collecting location data. A tool on the Trimble GeoXH helps to plan the best time to collect locations by graphing satellite positions for the next 12 hours.

2.0 EQUIPMENT

The following equipment is necessary, but not limited to:

- Trimble GeoXH handheld unit
- External Tornado antenna and connection cable
- Range pole with level bubble and connection brackets
- Stylus
- Metal measuring tape (in feet and meters)
- Computer with internet connection and Pathfinder Office Software

Note that this SOP is intended to be used in conjunction with *Logbook Documentation and Field Notes* (BE-SOP-01).

3.0 INSTRUMENT

Prior to collecting location data, determine where the data is going to be collected, and where the nearest GPS base stations are located for differential correction of the data. The nearer the differential correction station, the greater the potential accuracy of the data. Typical base stations include continuously-operating reference stations (CORS) and UNAVCO stations. These are shown on maps at the National Geodetic Survey (NGS) website and UNAVCO website, respectively. Additional base stations are maintained by various organizations throughout Alaska such as the Department of Transportation (DOT) and universities, and can be found on those websites.

3.1 SETTING UP THE UNIT

1. Turn on the unit by pressing the green button at the bottom.
2. On the main screen, click on “GNSS Application Launcher.” This will boot the GPS program. This program can also be launched by clicking on the Start icon ( ) and selecting “Terrasync.”
3. Within the Terrasync software program, there are two stacked menus in the upper left-hand corner. They will be referred to in this SOP as the upper menu and the lower menu.
4. Click the down arrow on the upper menu and choose “Data.” This allows to either create a new file to store data (click “Create” and enter the file name and height of the antenna), or to open an existing file (click “Existing File” on the lower menu, choose the appropriate file, and click “Open”).
5. Check the number of satellites the unit is receiving signals from by clicking the down arrow in the upper menu and choosing “Status.” In the lower menu choose “Skyplot.” There should be at least 5 satellites for the unit to get lock. The satellites shown in black are the ones the unit is using to calculate position.
6. Check the settings for data collection by clicking the down arrow in the upper menu and choosing “Setup.” Click the down arrow in the lower menu and choose “Options.” These settings should typically be the following, although there may be exceptions based on site conditions. Refer to the work plan for details on survey setup.
   - Logging Settings:
     - Accuracy Value for Display/Logging should be Horizontal, Post-processed.
     - Post-Processing Base Distance is determined from the nearest base station (See Section 5.2)
     - Use Accuracy-based Logging – Yes, and apply to all features
   - Real Time Settings:
     - Choice 1 – Integrated SBAS
     - Choice 2 – Use Uncorrected GNSS
   - GPS Settings:
     - Make sure that the GPS is connected
   - Coordinate System:
     - Use Latitude/Longitude WGS 84, Height above ellipsoid

- Units:
    - Use US survey feet
- External Sensors – Typically none will be used

7. Set up the range pole, brackets, and external Tornado antenna (if necessary). The internal antenna is suitable for many conditions; the Tornado antenna can improve yield under canopy and improves accuracy for post-processing. Setup the antenna (both internal and external) by clicking the down arrow in the upper menu and choosing "Setup." Click the down arrow in the lower menu and choose "Logging Settings."
    - Antenna Settings:
        - Measure Height To: Bottom of Antenna Mount for the external antenna or Bottom of Bracket for the internal.
        - Antenna Height: Use the measurement (to the thousandth of a meter) from the ground to the bottom of the antenna as show in the images below.

 

        - C Type: If using the external, choose "Tornado." If using the internal, choose "Internal."
        - Confirm: Choose how often to ask the antenna height (user preference).
        - Type: If using the external, choose "Tornado." If using the internal, choose "Internal."

8. Check the GPS status. Along the top of the screen is a notification bar.
    - A battery icon shows the remaining power left in the battery. The left half shows the charge level of the receiver battery. The right side shows the status of the computer battery. If fully green, the battery is fully charged. Yellow indicates low power and red indicates critically low.
    - A little satellite icon show with a number next to it shows the number of satellites that the unit is connected to for determining position. When there are not enough satellites to calculate position, the number flashes. If the GPS is not connected, two unconnected plugs will animate.
    - When successfully locked to satellites for position, a double-headed arrow with a number above indicates the estimated accuracy. Typically this is showing horizontal accuracy in real-time (uncorrected).
    - When collecting the location of a feature, a count appears indicating the number of seconds of occupation at that location. A bullseye with the count indicates a line or point feature rather than a point feature.

3.2 COLLECTING LOCATIONS

1. There are three types of locations, called features that can be collected with the GeoXH – points, lines, and areas.
2. To collect a point, place the GeoXH antenna on the location to collect and ensure that it will be stationary for the entire length of the occupation (approximately 1-2 minutes).

3. Click the down arrow in the upper menu and choose "Data." Click the down arrow in the lower menu and choose "Collect."
4. Click on the type of feature to collect. This will begin collecting data to log the point. Occupy the location for at least 60 seconds. If the estimated accuracy icon indicates poor accuracy, occupy the location for longer. As the point is being collected, use the keyboard to type a name of the point. Refer to the work plan for naming conventions.
5. When the time has been reached to collect the point, click "Done."
6. Review collected locations by using the Map feature. Click the down arrow of the upper menu and choose "Map." This will display a map of the features that have been collected.
7. When all features have been collected, close the file by choosing "Close."

Many additional features are available with the GeoXH including offsets, background files, setting waypoints and navigating, using data dictionaries, taking photographs, and more. To use these features, refer to the GeoXH User's Manual.

3.3 DOWNLOAD DATA

Connect the GeoXH device to a computer to download the data, follow these steps:

1. Make sure the device and the computer are switched on.
2. Make sure that the computer has the Windows Mobile Device Center (WMDC) for Windows Vista, 7 or 8, or ActiveSync for Windows XP or 2000 to be able to recognize the device when it is connected.
3. Connect the USB data cable to the device port and to the USB computer port.
4. WMDC or ActiveSync should automatically recognize the device and start a manager dialog box.
5. To transfer files manually, click on "File Management" and copy and paste files from the device to the computer. If the computer has Trimble Pathfinder Office software installed, click on the Data Transfer utility to download the location data via the software.
6. Save the files in the project folder and ensure that the Project Manager and GIS Manager know where the files are located.

3.4 POST FIELD

Once all data is downloaded to a computer, the data should be differentially corrected for maximum accuracy. Use Trimble Pathfinder Office software to differentially correct data automatically. Typically for projects in Alaska we are unable to differentially correct data real time in the field due to limited connectivity and this must be done after data collection. Base files are typically available 24 hours after the data is collected.

3.5 TROUBLESHOOTING AND MAINTENANCE

Additional details on the GeoXH device can be find in the User's Manual, which is kept in the hard case with the GPS unit at all times. The following table shows some typical problems that occur with the GeoXH.

TABLE 1: GEOXH TROUBLESHOOTING

Problem	Possible Cause	Possible Solution
The handheld will not turn on.	The battery is dead.	Recharge or swap the battery.
The handheld is not charging.	The internal temperature has risen above the allowed maximum for charging (104°F).	Remove the unit from any external heat sources and the unit will automatically start charging again when the internal temperature has dropped.
Concentration is dropping very slowly back to zero after taking a reading.	There is an obstruction in the filter or probe.	Replace the filter and any tubing connected to the instrument probe.
The backlight does not come on when you tap the screen or press a button.	The backlight is not set to turn on in the Backlight control.	Tap > Settings > System > Backlight to view the Backlight control and make sure that the brightness is not set to dark, and the turn on backlight box is checked.
The handheld is not receiving GNSS positions.	The integrated GNSS receiver is not activated.	Use the Connect or Activate GNSS/GPS command in the field software to open the GNSS COM port and activate the integrated GNSS receiver.
	Incorrect configuration of serial COM port.	When supplying GNSS data to an external device using the COM1 USB to serial converter cable, set the baud rate to the high-speed TSIP setting: 38400, 8, 1, Odd.
	The GNSS COM port is already in use. Only one application at a time can have the port open.	Do the following • Exit the software that is using the GNSS COM port and then retry in your application. • Check that a GNSS application is not running in the background. Tap / Task Manager and then select and close (click End Task) any GNSS applications you are not using. • Make sure that connections are not left in use by the GNSS Connector software; close the application when you are not using the connections.
	The GNSS field software is using the wrong GNSS COM port.	Connect to COM2 if the GNSS field software uses NMEA messages, or COM3 for TSIP messages. For information on which protocol to use, check the documentation for the application.
	Not enough satellites are visible.	Move to a location where the receiver has a clear view of the sky and ensure the antenna is not obstructed. Alternatively, adjust the GNSS settings to increase productivity.
	The DOP (Dilution of Precision) value for the current position is above the maximum DOP setting.	Wait until the DOP value falls below the maximum DOP specified. Alternatively, adjust the GNSS settings to increase productivity.
	Wait for real-time is selected in the GNSS field software and the integrated receiver is waiting to receive real-time corrections.	If you are collecting data for post processing, clear the wait for real-time selection.
	External antenna connected but not receiving data.	The handheld can take up to two seconds to detect that an external antenna has been connected or disconnected.

4.0 REFERENCES

Trimble, 2012. GeoExplorer® 3000 Series User Guide, Version 1.00, Revision B, May.

Trimble, 2011. GeoExplorer® 6000 Series User Guide, Version 1.00, Revision A, February.

STANDARD OPERATING PROCEDURE BE-SOP-51

Material Handling/ Manual Lifting

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines that should be met when material handling/manual lifting at and around a job site.

2.0 GENERAL POLICY

Back injuries are one of the most common and most preventable injuries on the job site. After determining the object is within lifting capabilities, warm up by stretching before doing any lifting or strenuous work. Use proper lifting procedures - bend at the knees rather than the waist, and use your leg muscles, not your back. Keep a wide base of support by standing with legs hip distance apart, and never twist while lifting. Take proper breaks during repetitive tasks, and get help when moving heavy or awkward objects. Use lifting devices when possible. If necessary, have a competent worker or supervisor demonstrate the proper method of bending and lifting.

Identifying when materials require lifting equipment, such as slings and chokers, is key. Conduct an evaluation of the proper equipment to use to assist in lifting if manual lifting techniques are not safe.

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STANDARD OPERATING PROCEDURE BE-SOP-52

Driver Safety Program

1.0 INTRODUCTION

This standard operating procedure (SOP) is for all individuals who will operate motorized vehicles.

2.0 DRIVER SAFETY AND POLICIES

Statistics show that many accidents involve those in company vehicles. It is the hope of the Brice Companies to avoid the injuries, possible loss of life, and costs related to accidents. The purpose of this plan is to demonstrate Brice's commitment to eliminate accidents involving company vehicles.

2.1 COMPANY AUTO USAGE POLICIES

- Company vehicles are for company business only, and are to be driven by active employees only (unless permission is given by a supervisor) who are appropriately licensed, certified, and/or trained for the vehicle of which they are to operate.
- Vehicles are to be maintained in good operating condition. Drivers will conduct a complete safety walk-around prior to entering the vehicle and inspect the vehicle on a daily basis prior to use.
- Occupants will wear seatbelts when vehicles are in motion.
- Vehicles may not be operated while using cell phones. This includes sending or receiving calls, texting, emailing or any other application on the phone. (This includes personal vehicles on company business).
- Vehicles are strictly prohibited from use while under the influence of alcohol.
- Vehicles may not be operated while eating or drinking, reading, or the use of other devices that distract from driving.
- Vehicles must be driven within the laws and regulations for operating motorized vehicles (i.e. valid license, posted speed limits, etc.) and within the manufacturer's operating guidelines.
- Vehicles may not be used to transport alcohol.
- Vehicles must be clean of all garbage, paper, boxes, etc. when no longer in use.
- Smoking is prohibited in company vehicles.
- Vehicle loads must be secured and within the manufacturer's specs and the legal size/weight limits.
- If involved in an accident while on company business, it must be reported to the Safety Officer as soon as possible. All required forms must be completed in a timely manner.

2.2 NEAR MISS POLICY

Near misses are to be reported to one's immediate supervisor and forwarded to the Safety Officer. An investigation will be conducted as soon as possible.

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STANDARD OPERATING PROCEDURE BE-SOP-59

Site Traffic

1.0 INTRODUCTION

This standard operating procedure (SOP) is for all individuals who will work in and around roadways while conducting job related activities and may need to set up work zones as protection from vehicular traffic. It is also for response and recovery workers operating or working near heavy equipment who will need to establish and follow traffic safety procedures to avoid injury and equipment damage.

While OSHA requires that operators be familiar with the pieces of machinery they operate, there is also a need to implement controls to ensure these activities are performed safely. Controls are needed where multiple pieces of heavy equipment, vehicles, and response and recovery workers are in close proximity.

2.0 PERSONAL PROTECTIVE EQUIPMENT (PPE)

The following PPE is recommended for all operations:

- Hard hat
- Eye protection with side shields
- Gloves appropriate for job hazards expected (e.g., heavy-duty leather work gloves for handling debris with sharp edges and/or chemical protective gloves appropriate for potential chemical contact)
- ANSI-approved protective footwear
- High visibility safety vest

Additional PPE may be warranted depending on site conditions. This evaluation is to be made prior to commencement of work activities.

3.0 PROTECTING WORKERS FROM VEHICULAR TRAFFIC

When working around traffic, the following should be used to warn oncoming traffic that there are people working in the area:

- Flaggers;
- Traffic cones;
- Flood Lights;
- “Reduce Speed” signs and/or message boards to warn approaching vehicles of work area.

Ensure that the work zone is well lit, but control glare to avoid temporarily blinding passing motorists.

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STANDARD OPERATING PROCEDURE BE-SOP-64

Working with Hand Tools

1.0 INTRODUCTION

This standard operating procedure (SOP) is for all individuals who will work with hand tools.

2.0 GUIDELINES

Hand tools must be kept in proper working order. All tools must be inspected before each use and all employees must be trained to use tools with proper safety.

3.0 TOOL USE

Hand tools will be kept in good condition (undamaged handles and proper working edges) that are not cracked or mushroomed with the potential to chip or create flying objects.

When using hand tools, the tools will:

- Be used within their designated capacity,
- Not be carried or left in a position that could cause injury to employees,
- Be put in storage when work is finished,
- Disconnected from their sources and pressures in lines released prior to any repair work.

4.0 PERSONAL PROTECTIVE EQUIPMENT

It is critical to use proper personal protective equipment (PPE) when using hand tools. When using hand tools, proper PPE will be implemented:

- Glove selection based on hand tool: leather work gloves versus cut resistant; and
- Safety glasses with side shields

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STANDARD OPERATING PROCEDURE BE-SOP-66

Breathing Zone Air Monitoring

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines for protection against occupational exposure where potential hazards exist for dust, fumes, mist, radionuclides, toxic gas, vapors, or oxygen deficiency. A Respiratory Protection Program will be implemented in accordance with Occupational Safety and Health Administration (OSHA) Standard 29 CFR 1910.134 and USACE's Safety and Health Requirements Manual (USACE 2014).

Breathing zone screening measurements will be periodically collected during activities which warrant air monitoring with a photoionization detector (PID) or colorimetric gas detector tubes to verify that workers are not exposed to contaminants above the levels specified in the project-specific Work Plan. Although not anticipated, if the levels exceed established thresholds, work at the location will be stopped and the respiratory protection program will be updated as necessary.

Downwind locations may also be monitored, as described in the Work Plan.

2.0 MATERIALS AND EQUIPMENT

Air Monitoring Equipment includes but is not limited to:

- PID equipped with a 9.8-, 10.6-, or 11.7-electron volt lamp
- Colorimetric gas detector tubes
- Personal Protective Equipment (PPE)

3.0 PROCEDURE

Under supervision of the site safety and health officer (SSHO), air monitoring will be conducted where contaminant-bearing vapors or dust, lead dust, POLs, or other air-borne contaminants of concern may be present. The project-specific Work Plan will provide air monitoring requirements and action levels for the sites. The type and extent of monitoring will depend upon site-specific conditions and the contaminants encountered at the sites. If a change in conditions is observed at either site, additional air monitoring may be required.

3.1 AIR MONITORING WITH A PID

PIDs should be calibrated daily and tested regularly, as described in Field Screening with a PID SOP (BE-SOP-15).

Prior to PID use, background levels must be established by monitoring outside the exclusion zone or controlled area and upwind of the site.

Once background levels are established, begin taking readings. The PID reads in units of parts per million (ppm), and the readings should be sustained for at least one minute to determine exposure. Record readings on a regular basis. If readings exceed thresholds established in the Work Plan, work will be stopped and the SSHO or superintendent will be notified to determine the appropriate course of action.

3.1.1 Benzene

The PID method is not sensitive enough to detect harmful levels of benzene. If the PID detects organic vapors (readings greater than 1 ppm above background) in the breathing zone at a site where benzene is a known contaminant of concern, the breathing zone shall be tested with a direct reading instrument for benzene. If benzene is detected, personnel will wear passive dosimeters and will modify procedures in accordance with the project-specific Work Plan. The AHAs will also address the required PPE for potential exposure for specific activities. Conditions that exceed project action levels will require an upgrade of PPE until monitoring demonstrates otherwise. The SSHO, with the assistance of trained field personnel, will identify these conditions.

3.2 AIR MONITORING WITH COLORIMETERIC GAS DETECITON TUBES

Instructions for using colorimetric gas detection tubes vary by manufacturer. Always review and follow the manufacturer directions, which are usually printed on the box.

Instructions usually include the following:

- Break both sides of the tube being careful not to puncture or cut skin
- Place the tube in the appropriate pump in the correct orientation. Only use pumps that are in good condition and regularly maintained.
- Draw a fixed volume of gas into the tube. Follow directions to ensure the appropriate volume is being drawn into the tube.
- Wait the appropriate amount of time and then immediately measure the color change. Colors may fade with time.
- Make any humidly or temperature corrections if necessary.
- Record results.

If readings exceed thresholds established in the Work Plan work will be stopped and the SSHO or superintendent will be notified to determine the appropriate course of action.

4.0 REFERENCES

U.S. Army Corps of Engineers (USACE). 2014 (November). Safety and Health Requirements Manual. EM385-1-1.