2022 Groundwater Monitoring Program
Work Plan
Beaver Creek Unit Pad 4 North
Kenai, Alaska

Prepared For:

Hilcorp Alaska, LLC

August 2022

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SIGNATURE PAGE

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This document has been prepared by Brice Engineering, LLC. The material and data in this Work Plan were prepared under the supervision and direction of the undersigned.

Kimi Lloyd, PE, PMP
Project Manager

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
µg/kg	micrograms per kilogram
µg/L	microgram per liter
µS/cm	microsiemens per centimeter
%	percent
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
BCU4	Beaver Creek Unit Pad 4
BES	Brice Environmental Services Corporation
Brice	Brice Engineering, LLC
BTEX	benzene, toluene, ethylbenzene, and total xylenes
btoc	below top-of-casing
cy	cubic yards
DOT	U.S. Department of Transportation
DRO	diesel range organics
EPA	U.S. Environmental Protection Agency
GAC	granular-activated carbon
GRO	gasoline range organics
HCl	hydrochloric acid
Hilcorp	Hilcorp Alaska, LLC
ID	identification
Marathon	Marathon Oil Company
mg/L	milligrams per liter
mL	milliliters
mL/min	milliliters per minute
MS	matrix spike
MSD	matrix spike duplicate
mV	millivolts
MSD	matrix spike duplicate
NTU	nephelometric turbidity units
PAH	polycyclic aromatic hydrocarbon
POLs	petroleum, oil, and lubricants
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RRO	residual range organics
SDS	safety data sheet

ACRONYMS AND ABBREVIATIONS (CONTINUED)

SLR	SLR International Corporation
SOP	standard operating procedure
TLC	Teflon-lined cap
TLS	Teflon-lined septa
TSCA	Toxic Substances Control Act
VOA	volatile organic analysis
VOC	volatile organic compound

1.0 INTRODUCTION

This Work Plan describes the 2022 groundwater monitoring activities to be performed at Hilcorp Alaska, LLC (Hilcorp) Beaver Creek Unit Pad 4 (BCU4 North) operation unit in the Kenai Peninsula (Figure 1). Brice Engineering, LLC (Brice) personnel will mobilize to the Kenai Peninsula to conduct annual groundwater monitoring activities at BCU4 North site. Figure 2 shows the BCU4 North operation unit where groundwater monitoring activities will take place. Figures are provided at the end of this document.

1.1 Key Personnel

Table 1-1 lists the key personnel involved in project activities along with their roles and contact information. Brice field personnel will coordinate with Hilcorp BCU4 health, safety and environmental representatives to complete site orientation and comply with Wildlife Interaction Avoidance Plan requirements. Field personnel also will coordinate with the Hilcorp BCU4 Foreman and Lead Operator, communicating work areas and schedule to avoid conflicts with simultaneous operations. The Brice Project Manager will communicate field progress and discuss project needs for Work Plan deviations with the Hilcorp Project Manager and the Alaska Department of Environmental Conservation (ADEC) Regulatory Specialist, as appropriate.

Table 1-1 Key Personnel

NAME	ORGANIZATION	TITLE	PHONE NUMBER	EMAIL
Amy Peloza	Hilcorp	Project Manager	907.777.8348 (O) 907.317.0521 (C)	apeloza@hilcorp.com
Jacob Nordwall	Hilcorp	BCU Health and Safety Officer	907.777.8418 (O) 907.748.0753 (C)	jacob.nordwall@hilcorp.com
Chad Johnson	Hilcorp	BCU Foremen	907.283.1382 907.283.1325	cjohnson@hilcorp.com
Mike Chivers/ Mike Morgan	Hilcorp	BCU Lead Operator	907.283.1316 907.283.1317	mchivers@hilcorp.com mmorgan@hilcorp.com
Kimi Lloyd	Brice	Project Manager	907.275.2906 (O) 907.317.7999 (C)	klloyd@briceeng.com
Mikayla Daigle	Brice	Geological Engineer	715.966.1354 (C)	mdaigle@briceeng.com
Victoria Pennick	Brice	Chemist	907.205.9892 (C)	vpennick@briceenvironmental.com
Peter Campbell	ADEC	BCU Regulatory Specialist	907.262.3412	peter.campbell@alaska.gov

Notes:
For definitions, refer to the Acronyms and Abbreviations section.

1.2 Site Summary

Table 1-2 summarizes the contaminated sites included in the 2022 groundwater sampling event.

Table 1-2 Beaver Creek Unit Pad 4 North Site Summary

SITE NAME	WELLS	ADEC FILE NUMBER	ADEC HAZARD ID NUMBER	2022 SITE SUMMARY		
				Wells to be Sampled[1]	Wells to be Gauged	Wells to be Redeveloped
BCU4 North	5	2320.38.081	26624	5	5	1

Notes:
For definitions, refer to the Acronyms and Abbreviations section.
[1] Primary samples only; quantity does not include QA/QC samples.

1.3 Regulatory Criteria

The groundwater analytical results will be evaluated against the ADEC levels (ADEC 2021) in Chapter 75, Section 345 Table C under Title 18 of the Alaska Administrative Code (AAC) (18 AAC 75.345). The programmatic sampling suite was evaluated for BCU4 North to remove volatile organic compound (VOC) and polycyclic aromatic hydrocarbon (PAH) analytes from the sampling suite when monitoring well concentrations were either non-detect or less than 20 percent (%) of current ADEC cleanup levels in two consecutive sampling events. The current ADEC Table C groundwater cleanup levels, specific to the BCU4 North 2022 sampling suite, are shown in Table 1-3.

Table 1-3 Groundwater Cleanup Levels

CONTAMINANT OF CONCERN	ANALYTE	CLEANUP LEVEL[1] (µg/L)
POLs	GRO	2,200
	DRO	1,500
	RRO	1,100
Petroleum-Related VOCs	1,2,4-Trimethylbenzene	56
	Benzene	4.6
	Ethylbenzene	15
	Naphthalene	1.7
	Toluene	1,100
	Total Xylenes	190

Notes:
For definitions, refer to the Acronyms and Abbreviations section.
[1] Groundwater cleanup levels as listed in 18 AAC 75.345, Table C (ADEC 2021).

1.4 Schedule Summary

Table 1-4 shows the preliminary project schedule, including planned start and end dates.

Table 1-4 Project Schedule

ACTIVITY	DELIVERABLE SUBMITTAL DATE/DEADLINE
Final Work Plan	7/22/2022
Fieldwork	Fall 2022
Reporting	10/06/2022 to 12/15/2022

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2.0 HEALTH AND SAFETY

Brice personnel follow their and Hilcorp company safety procedures, including use of PPE appropriate to project locations and activities. Table 2-1 lists emergency resources in the project area.

Table 2-1 Emergency Contact Information

RESOURCE	NAME/ASSOCIATION	CONTACT PHONE NUMBER
Emergency	Emergency Line	911
Hospital	Central Peninsula Hospital 260 Caviar Street Kenai, Alaska 99611	907.714.4536
Fire	Kenai Fire Department 105 South Willow Street Kenai, Alaska 99611	907.283.7666
Police	Kenai Police Department 107 South Willow Street Kenai, Alaska 99611	907.283.7879

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), and
- Fire resistant clothing and hearing protection (to be worn as required).

2.2 Site Safety and Health

Key project personnel coordinate project site work and schedules with the Hilcorp Lead Operator. On arrival at the site, workers will check-in at the site office and participate in a site orientation and safety briefing. Work permits are submitted as required by the Lead Operator. Hazards associated with groundwater sampling in the project area include remoteness of work locations, physical hazards, biological hazards, and chemical hazards.

2.2.1 Remoteness of Work Locations

Personnel work in pairs and maintain communication with the Hilcorp Lead Operator (checking in with the field office at the beginning and end of each workday) and the Brice Project Manager (regarding daily reports and obtaining cell phone contact numbers as necessary) for safety compliance.

2.2.2 Physical Hazards

Physical hazards may be created by inclement weather or noise, or cause slips, trips, and falls; body strain; heat and cold stress; or cuts. Weather-related hazards and the potential for heat and cold stress are mitigated by review of weather forecasts, frequent assessment of changing weather, and use of appropriate and layered clothing. Proper body mechanics, such as proper lifting techniques, are employed to mitigate the potential for body strain. PPE is used/worn to mitigate other physical hazards, including noise, cuts, slips, trips, and falls.

2.2.3 Biological Hazards

Biological hazards may cause insect bites and stings, reactions to contact with certain plants, and may include encounters with wildlife. Field workers review and comply with the Hilcorp Wildlife Interaction Avoidance Plan and complete Hilcorp's online Wildlife Interaction and Avoidance Training. They also use insect repellent, netting, and protective clothing as necessary to mitigate exposure to insects and hazardous plants. First-aid supplies are available for applications to treat bites, stings, and plant reactions as required. Workers work in pairs and frequently assess their surroundings for wildlife. Air horns and bear spray are available and employed as needed to deter interactions with wildlife. Workers take care to avoid wildlife interactions, e.g., releasing pulses on an air horn before entering areas of dense foliage; properly managing food waste and other wildlife attractants.

2.2.4 Chemical Hazards

Workers may be exposed to petroleum-related contaminants, such as diesel-range organics (DRO); gasoline-range organics (GRO); residual-range organics (RRO); benzene, toluene, ethylbenzene, and total xylenes (BTEX); and VOCs. 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 are included in the associated safety data sheets (SDSs), which is filed with this Work Plan in the project file box and kept with the Field Lead in the project vehicle. The SDS for each site contaminant is reviewed by every worker before beginning work. If additional contaminants are suspected at a site, those SDSs are evaluated as necessary.

3.0 PROJECT TASKS

Groundwater monitoring activities are conducted by ADEC-qualified environmental professionals and include the following:

- Monitoring well inspections and maintenance,
- Making visual assessments,
- Monitoring well gauging procedures,
- Collecting groundwater samples,
- Sample handling and completing chain-of-custody protocols,
- Decontaminating sampling equipment,
- Performing waste management, and
- Completing field documentation.

3.1 Monitoring Well Inspections, Maintenance, and Network Assessment

Monitoring wells are inspected, including the outer monument, inner polyvinyl chloride (PVC) riser, locks, and bolts. The condition of the wells is documented in the field notes, including present condition that may require maintenance (e.g., significant frost-heaving, locks that are broken or difficult to open, missing caps). In addition, maintenance may be performed, which is to be recorded in the field logbook. Where frost-heaving of the well hinders securing the protective cap, the riser may be cut to shorten the well. Brice personnel will determine the northing, easting, ground surface elevation, and top-of-casing elevation for monitoring wells with casings that have been shortened. On completion of the well maintenance activities, a list of modified wells will be provided to the surveyor, to re-establish top-of-casing elevations as necessary.

Furthermore, the vegetation at BCU4 North and in the surrounding area will be assessed visually for signs of possible offsite migration of contaminants, including healthy vegetation observations; signs of scarring, impact, or distressed vegetation; surface water bodies or wetlands on or near the project area; and sheen observations in rainwater puddled in roads, surface water, and wetland areas. The visual assessment of BCU4 North and the surrounding areas will be documented in the field notes, and photographs will be taken of noted observations.

Based on elevated concentrations of RRO observed in monitoring well AP-38 in 2021, additional investigation will be conducted to assess for potential secondary sources. This additional investigation will include a site assessment and personnel interviews to identify and document historical and ongoing activities which may have contributed to the 2021 RRO detection, and to identify suitable locations (clear of underground and operational conflicts) for future soil boring and potential groundwater monitoring wells to supplement the current network as appropriate. These observations and findings will be documented in the field notes and photograph log.

3.2 Monitoring Well Gauging Procedures

Groundwater levels will be measured in monitoring wells, to a precision of 0.01 feet relative to the mark on the well casing, or (in the absence of a mark) to the north side of the well casing using an electronic water level meter. Depth-to-groundwater below top-of-casing, total well depth, and height of well riser above ground surface (stick-up) will be measured and recorded. Wells at BCU4 North will be gauged in a manner to minimize the time separating the gauge data between each well, to allow more precise and representative data for informing the interpreted groundwater contours. Measurements will be conducted in accordance with Brice SOP BE-SOP-21, *Groundwater and LNAPL Measurements* (Appendix A).

Gauge data from viable wells will be represented in the groundwater contour modeling and groundwater flow direction interpretations.

3.3 Analytical Sampling

The procedures that will be used to collect and identify analytical samples, including quality assurance (QA)/quality control (QC) samples, are presented here.

3.3.1 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) guidance (EPA 2017) and ADEC's *Field Sampling Guidance* (ADEC 2019), and in accordance with BE-SOP-09, *Groundwater Sample Collection* (Appendix A). Monitoring wells will be purged and sampled using a submersible pump or bladder pump and disposable or dedicated tubing (depending on the well). If the well is unable to be sampled via submersible or bladder pump (e.g., obstruction, smaller diameter, or schedule PVC), the well may be sampled using a peristaltic pump, provided that volatile samples are collected in advance of the pump paddles or with an alternative sampling device, such as a HydraSleeve. Monitoring wells exhibiting poor recharge will be redeveloped before sampling.

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

- Drawdown during purging will be stabilized before sampling (less than 0.3 feet if possible).
- Low-flow rates typically will be between 50 and 500 milliliters (mL) per minute (mL/min) (0.01 to 0.13 gallons per minute), but higher rates will be consistent with the low-flow guidelines, provided that the drawdown requirement is met.
- Water quality parameters will be recorded as shown in Table 3-1.

Water quality parameters are considered stable when three successive readings, collected 3 to 5 minutes apart, are within the criteria shown in Table 3-1.

Table 3-1 Stability Criteria for Low-Flow Purging

PARAMETER	UNITS	RECORDING PRECISION	STABILITY CRITERIA	TYPICAL VALUE RANGE FOR STABILITY CRITERIA
Temperature	°C	0.01	±3% (minimum of ±0.2°C)	0.1 to 15
pH	--	0.01	±0.1	5 to 8
Conductivity	µS/cm	1	±3%	80 to 1,000
Turbidity	NTU	0.1	±10% or < 10 NTU	0.3 to >900

Table 3-1 Stability Criteria for Low-Flow Purging

PARAMETER	UNITS	RECORDING PRECISION	STABILITY CRITERIA	TYPICAL VALUE RANGE FOR STABILITY CRITERIA
Oxidation-Reduction Potential	mV	1	±10 mV	-120 to 350
Dissolved Oxygen	mg/L	0.1	±10%	0 to 12

Notes:
For definitions, refer to the Acronyms and Abbreviations section.
Stability criteria from ADEC's *Field Sampling Guidance* (ADEC 2019).
Only three parameters are required to stabilize; four when using temperature.

Groundwater samples will be submitted to an ADEC-approved laboratory for analytical testing. Analytes for each groundwater sample are specified in Section 4.0, and the analytical results will be compared to ADEC Table C groundwater cleanup levels (Table 3-2).

If a well is purged dry, it will be allowed to recharge for 24 hours or to 80% of its pre-purge volume. Without further purging, the well will be sampled (ADEC 2019).

3.3.2 Analytical Methods and Quality Assurance/Quality Control

Table 3-2 summarizes the analytical parameters, methods, containers, and preservation for groundwater and surface water sample collection.

Table 3-2 Summary of Groundwater Analyses

PARAMETER	METHOD	CONTAINER DESCRIPTION	PRESERVATION/ HOLDING TIME
DRO/RRO	AK102/103	Two 250-mL amber glass jars, TLC	HCl to pH<2, 0 to 6°C 14 days to extraction, 40 days to analysis
GRO	AK101	Three 40-mL VOA vials, TLS	HCl to pH<2, 0 to 6°C 14 days
Petroleum-related VOCs, including BTEX	EPA SW8260C	Three 40-mL VOA vials, TLS	

Notes:
For definitions, refer to the Acronyms and Abbreviations section.

Field QA/QC samples will be collected and submitted at the following frequencies:

- Field duplicate samples will be collected and submitted at a frequency of one per day and one for every 10 or fewer field samples (whichever is more frequent), for each matrix and each target analyte (10%). At a minimum, one field duplicate will be collected at BCU4 North and per day of sampling at that site.
- Matrix spike (MS)/matrix spike duplicate (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 at BCU4 North.
- A trip blank will be submitted with each cooler containing samples for volatile analyses (GRO by AK101, and petroleum-related VOCs by SW8260C).
- A field blank will be collected at AP-38 to assess for external analytical contributors to the analytical detections in this monitoring well.

Appropriate wells for duplicate and MS/MSD sample collection will be based on historical results and determined in the field, based on such observations as well recharge and field indications of contamination.

3.3.3 Sample Identification

The sample identification nomenclature will be as follows:

- The first set of characters will identify the site:
  - BCP4N represents BCU Pad 4 North.
- The second set of characters will identify the well:
  - For example, AP4 identifies monitoring well AP-4.
- The third set of characters will identify the month and year that the sample was collected:
  - For example, 0622 indicates June 2022.

For example, a sample collected in June 2022 from monitoring well AP-4 at the BCU4 North site will be labeled “BCP4N-AP4-0622.” Duplicate samples will be identified by a “Z” appended to the well designation; for example, a duplicate sample of the previous example will be labeled “BCU4N-AP4Z-0622.”

3.4 Sample Handling and Chain-of-Custody Protocols

Following sample collection, jars will be sealed, labeled, and placed immediately 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 form will be prepared in accordance with BE-SOP-02, *Sample Chain-of-Custody* (Appendix A) and 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 A).

3.5 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 that is generated during decontamination activities of sampling equipment will be collected in U.S. Department of Transportation-approved 5-gallon buckets with screw-top lids, combined with purge water, and treated onsite through a granular-activated carbon (GAC) filter. Wastewater will be poured into this GAC filtration unit and allowed to drain in a secondary container. The water will be inspected visually for sheen before being discharged to a vegetated area of the site, at least 100 feet from drinking water sources and surface water bodies. If sheen is observed on the treated water, the water will be poured through the GAC and treated up to three times. Decontamination procedures are detailed in BE-SOP-14, *Equipment Decontamination* (Appendix A).

3.6 Waste Management

Investigation-derived waste will be generated during groundwater sampling activities, including purge water, decontamination water, and general refuse (e.g., nitrile gloves and other expended PPE, paper towels, and disposable tubing). Table 3-3 shows the anticipated waste streams, estimated quantities, and method of disposal for each waste stream.

Table 3-3 Anticipated Waste Streams

WASTE STREAM	WASTE CLASSIFICATION	ESTIMATED QUANTITY	CONTIANER	PROPER SHIPPING NAME	DISPOSAL	NOTES
Liquid investigation-derived waste– no odor/sheen (purge water, decontaminated water)	Non-TSCA/RCRA regulated	30 gallons	DOT-approved 5-gallon buckets with screw-top lids	Non-hazardous liquid	GAC	Discharge GAC-treated water free of sheen to a vegetated, upland area of the project site at least 100 feet from drinking water sources and surface water.
Solid Waste	Non-TSCA/RCRA regulated	1 bag	Heavy-duty 42-gallon trash bag	Non-hazardous waste, solid (general refuse)	Local landfill	General refuse includes nitrile gloves and other expended PPE, paper towels, and disposable tubing. Document volume and transfer to local landfill or transfer station.
Spent GAC	Non-TSCA/ RCRA-regulated	5 gallons	DOT-approved 5-gallon bucket with screw-top lid	Non-hazardous waste, solid (GAC)	Hilcorp	Hilcorp will facilitate disposal when filter material is no longer usable.

Notes:
For definitions, refer to the Acronyms and Abbreviations section.

3.7 Field Documentation

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

3.8 Reporting

After completion of field activities and receipt of all analytical laboratory data, a report will be submitted that 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 chain-of-custody forms, a sample summary, and the cooler receipt forms,
- A photographic log, and
- Conclusions and recommendations, including assessment of potential secondary sources around monitoring well AP-38 and future investigation and well network modifications as appropriate for 2023 budget, schedule, and logistical considerations.

An initial report detailing activities at BCU4 North will be prepared and provided to Hilcorp for comments. Comments will be incorporated into the final report for submittal to ADEC and inclusion in the administrative record.

4.0 SITE-SPECIFIC INFORMATION

The BCU4 North project area is part of the North Kenai assets in the northern portion of the BCU4 oil and gas field, approximately 50 air miles southwest of Anchorage and approximately 12 miles northeast of Kenai, Alaska (Figure 1). BCU4 North is near the Oil Truck Loading Facility (Figure 3). This oil and gas unit is managed by the Bureau of Land Management and is on land leased from the U.S. Fish and Wildlife Service within the Kenai National Wildlife Refuge.

BCU4 was constructed by Marathon Oil Company (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 it 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 2014). Hilcorp took over BCU4 operations from Marathon in 2013. Environmental investigations and monitoring activities have been conducted at BCU4 North since 2016 (BES 2017).

Information about site geology and hydrogeology as well as site-specific details about previous investigations and groundwater monitoring, well maintenance summary, and planned 2022 groundwater monitoring activities at BCU4 North are presented below. The figures at the end of this document show the site and well locations.

4.1 Site History and Previous Investigations

In July 2016, crews that were operating at the BCU4 facility identified a crude oil leak coming from the ground near the Oil Truck Loading Facility dock and began removing impacted material. Approximately 60 cubic yards (cy) of material were removed during this initial response, exposing four oil lines, oriented north to south, and three additional lines running in the transverse direction. A 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 (Brice 2021).

Follow-on remedial activities were conducted in 2016 and included decommissioning and removal of oil lines, removal and disposal of an additional approximate 650 cy of impacted material, installation of four additional monitoring wells around the area of release (AP-35, AP-36, AP-38, and AP-39), and soil and groundwater sampling and analysis. Excavation confirmation soil samples were analyzed for GRO, DRO, RRO, and BTEX; two samples with the highest field screening results also were analyzed for PAHs. The excavation confirmation soil sample results indicated that contaminants (including GRO, DRO, RRO, BTEX, and several PAHs) remained in the excavation floor and east and west sidewalls, at concentrations above the ADEC Method Two soil cleanup levels in effect at that time. Additional material could not be removed because of site constraints; therefore, the excavation was lined with indicator fabric and backfilled with clean material. The analytical results for groundwater samples that were collected from the surrounding monitoring wells indicated concentrations of GRO, DRO, RRO, and BTEX were either non-detect or were less than ADEC Table C groundwater cleanup levels. The 2016 report recommended that the monitoring wells surrounding the area of release be incorporated into the monitoring program to assess for potential migration of contaminants (BES 2017).

In 2017, monitoring wells AP-4, AP-35, AP-36, and AP-38 were sampled for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAHs. Monitoring well AP-39 was purged dry and had insufficient recharge for sampling. All the results for sampled monitoring wells were either non-detect or were detected at concentrations less than ADEC Table C groundwater cleanup levels, consistent with the 2016 monitoring results (BES 2018).

In 2018, ADEC requested annual sampling of GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAHs until 2022 for monitoring wells AP-4, AP-35, AP-36, AP-38, and AP-39. The analyte list was based on soil exceedances identified from the 2016 contaminated soil excavation (ADEC 2018). After completing 5 years of annual monitoring, the need for continued monitoring was to be evaluated based on analytical results. Monitoring wells AP-4, AP-35, AP-36, and AP-38 were sampled for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAHs. Monitoring well AP-39 was purged dry during redevelopment activities and did not recover enough volume after 24 hours to be sampled. All results for sampled monitoring wells were either non-detect or were detected at concentrations less than ADEC Table C groundwater cleanup levels, consistent with historical results (BES 2019a).

In 2019, monitoring wells AP-4, AP-35, AP-36, AP-38, and AP-39 were sampled for GRO, DRO, RRO, petroleum-related VOCs (including BTEX), and PAHs. Analytical results from monitoring well AP-39 indicated that DRO, benzene, ethylbenzene, and total xylenes were detected at concentrations above the ADEC Table C groundwater cleanup levels. All other results were either non-detect or were detected at concentrations less than ADEC Table C groundwater cleanup levels. Monitoring well AP-39 was sampled using a peristaltic pump because it purged dry in 2017, because of slow recharge with little volume; however, 2019 was the first time this monitoring well was sampled without being purged dry. During monitoring well inspection and maintenance activities, the wells were observed to be in generally good condition and required little maintenance (BES 2019b).

The monitoring wells were not sampled in 2020 because of the COVID-19 pandemic.

In 2021, monitoring wells AP-4, AP-35, AP-36, AP-38, and AP-39 were sampled for GRO, DRO, RRO, BTEX, naphthalene, and 1,2,4-trimethylbenzene. Monitoring well AP-39 purged dry and was sampled using a peristaltic pump because of slow recharge with little groundwater volume. Volatile samples were collected in advance of the pump paddles, e.g., disconnect and decant. The analytical results from monitoring well AP-39 showed GRO and benzene at concentrations of 3,360 micrograms per liter (µg/L) and 231 µg/L, respectively, above the current ADEC Table C groundwater cleanup levels. All other results were either non-detect or were detected at concentrations less than ADEC Table C groundwater cleanup levels, including ethylbenzene and total xylenes, which exceeded the cleanup levels in 2019. Furthermore, the results for GRO and petroleum-related VOC compounds appeared to be slightly less than the 2019 results, and the DRO and RRO detections appeared to be slightly elevated. The analytical results from monitoring well AP-38 showed RRO to be at a concentration equal to the current ADEC Table C groundwater cleanup level. Although the RRO result in monitoring well AP-38 did not exceed the ADEC Table C groundwater cleanup level, it was elevated in comparison to previous years. During monitoring well inspection and maintenance activities, locks were replaced on monitoring wells AP-36 and AP-38, and monitoring well AP-36 was redeveloped because of observed biological infiltration. All other wells were observed to be in generally good condition and required no maintenance. The visual assessment of BCU4 North and the surrounding areas revealed no evidence (e.g., scarring, sheen, distressed vegetation) of surface or offsite contaminant migration (Brice 2021).

4.2 Geology and Hydrogeology

BCU4 is on glaciolacustrine deposits from the Holocene and Upper Pleistocene. Complex stratigraphy underlies BCU4, with relatively thick silt aquitards above thinly bedded, water-bearing sand intervals. Clayey silt and clayey sand intervals occur at approximately 20 feet below ground surface and deeper (SLR 2014).

Historical groundwater elevations at BCU4 North (measured between 2017 and 2021) range from 128.89 to 137.97 feet (relative to the North American Vertical Datum of 1988), and the groundwater flow direction remains consistent between west-southwest (observed in 2017), southwest (observed in 2018), and south-southwest (observed in 2019 and 2021) (BES 2018, 2019a, 2019b; Brice 2021).

4.3 2022 Monitoring Well Inspection and Maintenance

BCU4 North monitoring wells will be inspected, and the condition of the monitoring wells will be documented in the field logbook, including condition that may require maintenance. Table 4-1 summarizes well maintenance for BCU4 North.

Table 4-1 BCU4 North Well Maintenance Summary

WELL ID	2021 OBSERVATIONS					WELL DIAMETER[2]	NOTES
	CONDITION	HEAVING NOTED	STICKUP HEIGHT[1] (feet)	DEPTH TO WATER (feet btoc)	TOTAL DEPTH (feet btoc)		
AP-4	Good	No	3.55	27.68	33.10	2 inches	Soft hit at bottom
AP-35	Good	No	Flush Mount	16.80	24.38	2 inches	Hard hit at bottom
AP-36	Good	No	2.70	17.48	26.35	2 inches	Hard hit at bottom
AP-38	Good	No	3.00	13.30	21.84	2 inches	Hard hit at bottom
AP-39	Good	No	2.80	16.90	22.87	2 inches	Purged dry in 2017 with insufficient recharge to sample; sampled in 2019 despite continuous drawdown; some bentonite on probe in 2021; purged dry, but able to be sampled

Notes:
For definitions, refer to the Acronyms and Abbreviations section.
[1] Stickup height were measured to gravel or ground surface.
[2] All monitoring wells were constructed with Schedule 40 PVC casing.

4.4 2022 Groundwater Monitoring Activities

BCU4 North groundwater sampling is conducted annually to determine whether contaminants are migrating through the soils to the groundwater. Viable wells are gauged during each sampling event. The planned field activities for the 2022 groundwater monitoring at BCU4 North are summarized as follows:

- The vegetation at and surrounding BCU4 North will be assessed visually for potential offsite migration of contaminants. The visual assessment will focus on signs of stressed vegetation and/or impacts on wetlands and surface water.
- Groundwater levels in monitoring wells at BCU4 North will be gauged in a manner to minimize the time separating the gauge data between each well, to determine groundwater elevation and flow direction.
- Monitoring wells AP-4, AP-35, AP-36, AP-38, and AP-39 will be sampled for GRO, DRO, RRO, BTEX, naphthalene, and 1,2,4-trimethylbenzene.

Table 4-2 shows the BCU4 North monitoring wells and sample analyses. The monitoring well locations are shown in Figure 3.

Table 4-2 BCU4 North Summary of Monitoring Wells and 2022 Analyses

WELL ID	GAUGE	ANALYSES / METHOD			
		AK101	AK102	AK103	SW8260C
		GRO	DRO	RRO	VOCS[1]
AP-4	X	X	X	X	X
AP-35	X	X	X	X	X
AP-36	X	X	X	X	X
AP-38	X	X	X	X	X
AP-39	X	X	X	X	X

Notes:

For definitions, refer to the Acronyms and Abbreviations section.

[1] Petroleum-related VOCs BCU4 North List: BTEX, naphthalene, and 1,2,4-trimethylbenzene only.

5.0 REFERENCES

Alaska Department of Environmental Conservation (ADEC). 2019. Field Sampling Guidance. Division of Spill Prevention and Response. Contaminated Sites Program. August.

ADEC. 2021. Alaska Administrative Code (18 AAC 75), Oil and Other Hazardous Substances Pollution Control. November.

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BES. 2017. 2016 Beaver Creek Pad 4 Release Response. Beaver Creek Pad 4, Kenai, Alaska. March.

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U.S. Environmental Protection Agency (EPA). 2017. Low-Stress (Low-Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells. EQASOP-GW4. September.

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FIGURES

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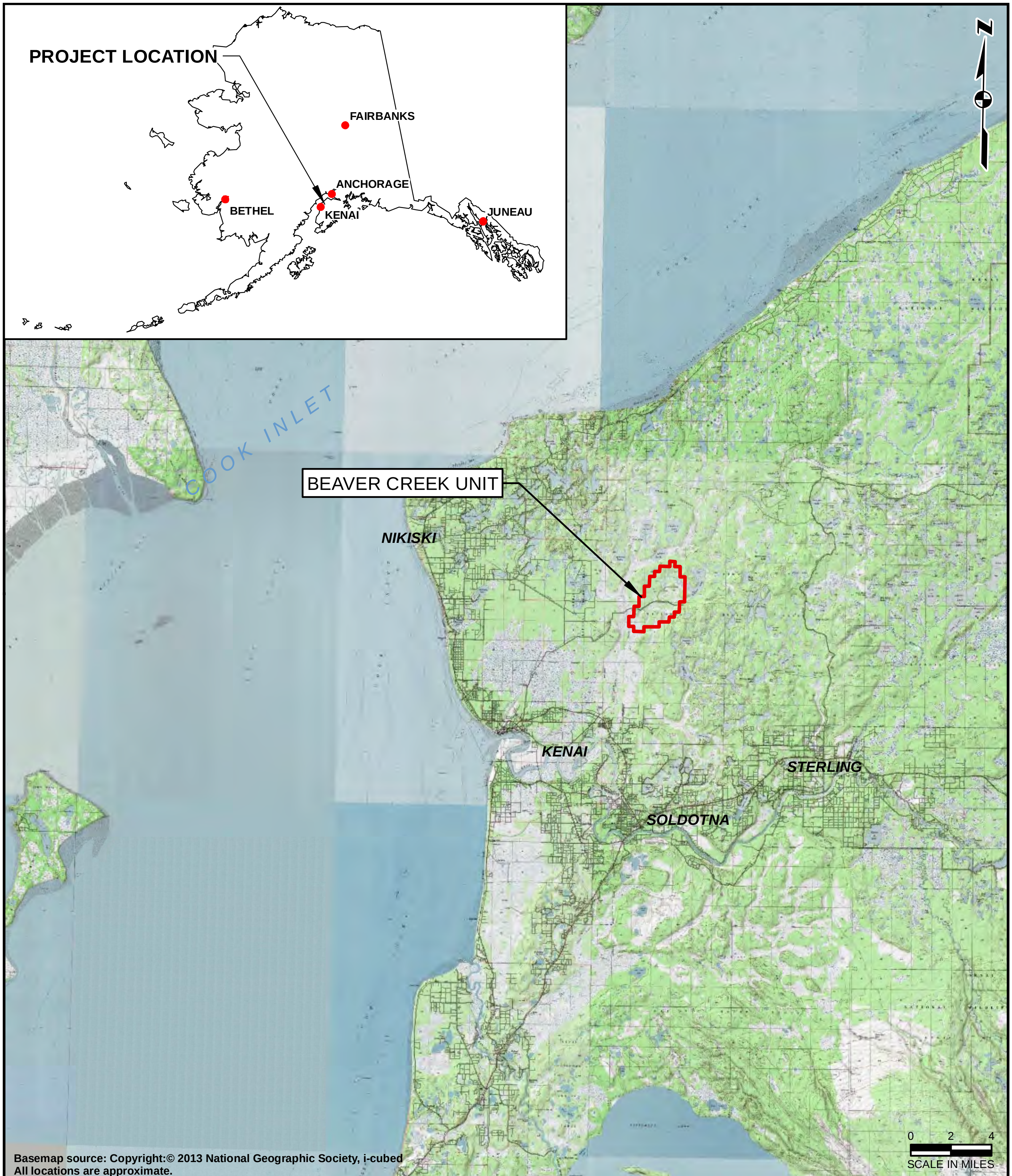

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Anchorage, AK 99503

2022 GROUNDWATER MONITORING PROGRAM REPORT
BEAVER CREEK UNIT PAD 4

KENAI PENINSULA, ALASKA

STATE AND SITE VICINITY

DATE: 5/31/2022

PROJECT No.: 760401

P.M./DRAWN: K.L/J.C.

FIGURE: 1

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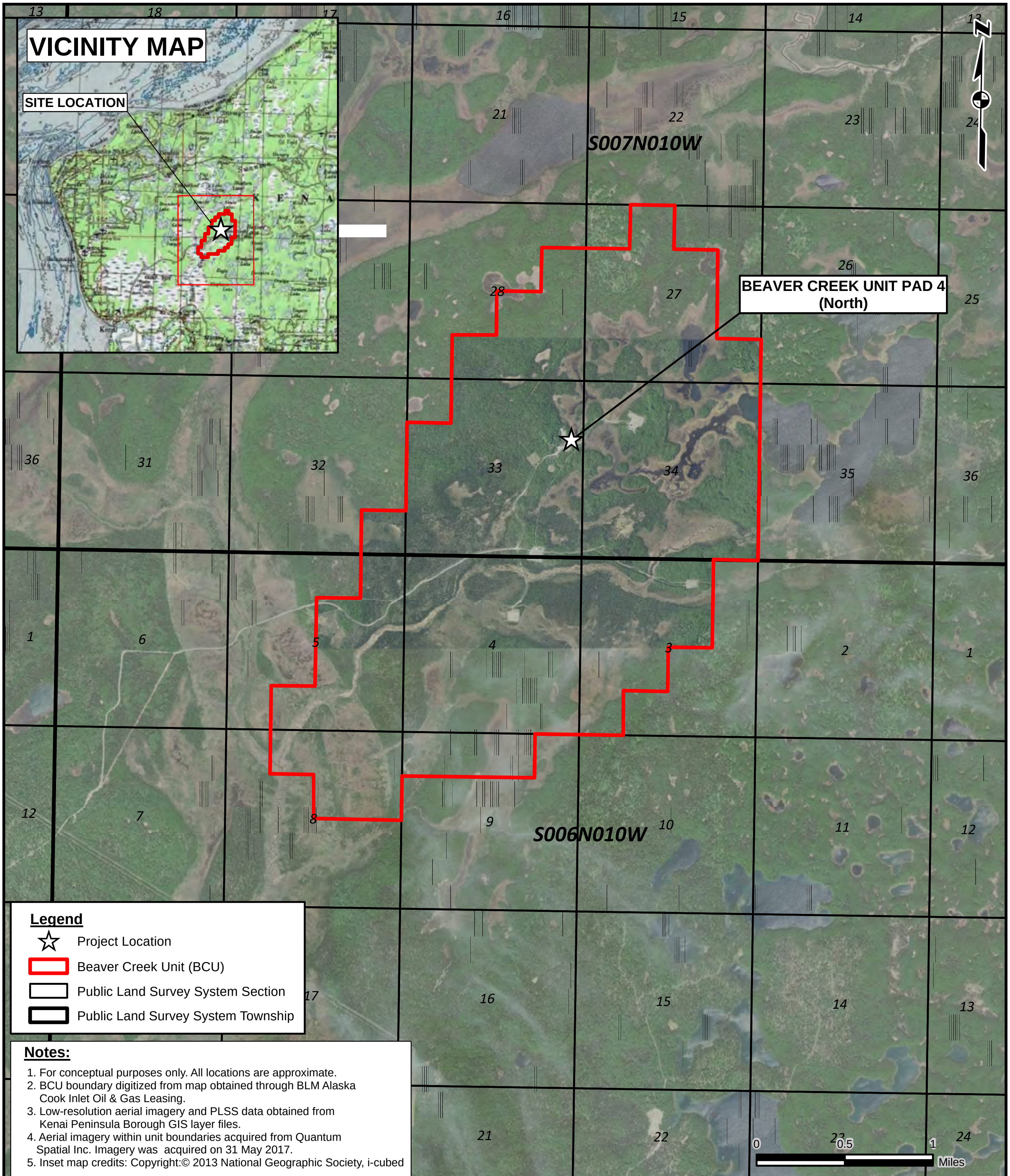

Legend

- ☆ Project Location
- Beaver Creek Unit (BCU)
- Public Land Survey System Section
- Public Land Survey System Township

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. Low-resolution aerial imagery and PLSS data obtained from Kenai Peninsula Borough GIS layer files.
4. Aerial imagery within unit boundaries acquired from Quantum Spatial Inc. Imagery was acquired on 31 May 2017.
5. Inset map credits: Copyright:© 2013 National Geographic Society, i-cubed

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2022 GROUNDWATER MONITORING PROGRAM REPORT
BEAVER CREEK UNIT PAD 4

KENAI PENINSULA, ALASKA

BEAVER CREEK UNIT SITE MAP

DATE: 5/31/2022

PROJECT No.: 760401

P.M./DRAWN: K.L./J.C.

FIGURE: 2

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1 INCH

2022 GROUNDWATER MONITORING PROGRAM REPORT - BEAVER CREEK UNIT PAD 4
KENAI PENINSULA, ALASKA

BEAVER CREEK UNIT PAD 4 NORTH MONITORING WELL LOCATIONS AND GROUNDWATER FLOW DIRECTION

Legend

132 — Groundwater Contour with Elevation (feet)

XX.XX

Approximate Grondwater Flow Direction

Monitoring Well Location

Gauge and Sample

Gauge and Sample; Previous Exceedance; Maintenance Required

Approximate Area of 2016 Excavation

Notes

1. For conceptual purposes only. Site feature locations are approximate.
2. Imagery acquired from Quantum Spatial Inc. Imagery was taken on 31 May 2017.
3. All presented groundwater results are based on findings from 2021 activities and ADEC Table C groundwater cleanup levels (ADEC 2021).
4. Groundwater elevations are expressed in feet (NAVD88). Map in NAD83 (2011) Alaska State Plane Zone 4.
5. Groundwater contours were generated with Surfer 16 software using kriging and groundwater gauging data collected from each well.
6. All viable monitoring wells were surveyed in 2021.

50 25 0 50 FEET

ALASKA STATE PLANE ZONE 4, US SURVEY FEET
HORIZONAL DATUM: NAD83 (2011) | VERTICAL DATUM: NAVD88

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Anchorage Office
3700 Centerpoint Drive, Ste. 8223
Anchorage, AK 99503
907.275.2896 (office and fax)

PROJECT No.:	DATE:	FIGURE:
760401	5/27/2022	3
P.M.: KL	DRAWN: JC	

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APPENDIX A
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 content and format of field logbooks. It was generated in accordance with the Alaska Department of Environmental Conservation (ADEC) *Field Sampling Guidance* (ADEC 2022) and United States Army Corps of Engineers, Alaska District requirements. This SOP will be used to direct personnel in field documentation and record keeping requirements 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 are used 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 Lead designates 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 must be entered in permanent ink.

3.1 Front Cover

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

- Owner of the book (Example: Brice Engineering, LLC)
- Book number
- Job name and Contract number
- Start date
- End date

3.2 Project Contact Information

Include project contact information on the inside front cover or first page of the logbook. Contact information may include names and phone numbers of subcontractors, project assistants, field team members, and emergency numbers from the Accident Prevention Plan and/or Site-Specific Health and Safety Plan.

3.3 Daily Entries

Logbook entries must abide by the following guidelines:

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

The minimum daily standard logbook entries include the following:

- Date and time
- Work start and stop times
- Full names, titles and roles of personnel on site, including visitors
- Safety meetings/tailgates
- Level of PPE
- Name(s) of person(s) collecting samples or performing work
- Location of work areas (excavations and landfill areas) and sampling points (sketches with north arrows when appropriate)
- Sample identification numbers and descriptions
- Sample shipping information (date, time, destination, location)
- Type of field instrumentation (model and serial numbers)
- All calibrations performed
- Other work performed
- Any deviations from the work plan

Correct erroneous field record or logbook entries with a single line through the error. Do not erase incorrect information. Date and initial revised entries.

3.4 Field Data sheets

All other supportive unbound data documentation that is a part of the field records are maintained as part of the field forms. These entries are recorded in weatherproof ink on weatherproof paper.

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 are downloaded to a designated location. Take care when downloading, storing, and managing data. Naming conventions (according to the project-specific work plan) are used to indicate the project, date, and other relevant information.

3.6 Document Control

At the conclusion of a task or project, all field documentation, including logbooks, field forms, photographs, etc., is scanned and placed in a designated location (typically the "Field" folder) and maintained for project use.

REFERENCES

ADEC.2022. *Field Sampling Guidance*. January

STANDARD OPERATING PROCEDURE

BE-SOP-02

Sample Chain-of-Custody

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the guidelines for sample handling and custody and has been generated in accordance with the Alaska Department of Environmental Conservation (ADEC) *Field Sampling Guidance* (January 2022). This SOP will be used to direct field personnel in sample chain-of-custody (COC) management. The purpose of the COC is to demonstrate accountability and document sample integrity from the time of sample collection until sample analysis by the laboratory.

2.0 COC ELEMENTS

The elements of a COC include the following:

- Sample labels
- Laboratory receipt forms
- Field custody forms (COC form)
- Custody seals
- Inter-laboratory transfer documentation, if applicable

3.0 SAMPLE HANDLING PROCEDURE

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

3.1 Sample COC Documentation

Sample identification documents are 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.
- In an authorized person's possession and then secured (locked up).
- Kept in a secured area that is restricted to authorized personnel.

3.2 Field Custody Procedures

The following procedures are used by field personnel:

- The sample collector is 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 records sample data (time of collection, sample number, analytical requirements, and matrix) in the field logbook and/or on the appropriate field form.
- Sample labels are completed for each sample, using weatherproof ink.

3.3 Chain-of-Custody Record

The COC record is fully completed prior to sample shipment. When possible, an electronic COC record should be used. Required information on the COC includes the following:

- Client (contractor name)
- Reporting Information (Chemist name and contact information)
- Project Name
- Invoice information
- PO Number
- COC number
- Cooler ID
- Page number
- NPDL number
- Field Sample ID
- Location ID
- Collection date
- Collection time (in 24-hour format)
- Sampler initials
- Quantity (number of containers)
- Container types (VOA, amber, 40 mL, etc.)
- Container volumes
- Preservative
- Sample matrix (soil, water, other)
- Requested laboratory analysis methods required for each jar
- Quality control (trip blanks and MS/MSD)
- Turn-around-time (TAT)
- Notes
- Special instructions

3.4 Sample Packaging

Samples are labeled and packaged according to the *Labeling, Packaging, and Shipping Samples* SOP (BE-SOP-03). The COC record accompanies all sample shipments. Two COC records are prepared for each shipment. One COC record is placed in a re-sealable plastic bag with the bag sealed shut to prevent water intrusion from moisture in the cooler, and the bag is taped inside the cooler lid. The duplicate or electronic copy of the COC record is retained by the sampler and provided to the Project Chemist and other sample coordinators. Airway bills are retained with the COC record and provided to the Project Chemist, so sample pickup can be coordinated with the laboratory. Airway bills must be scanned and placed in a designated location, typically the "Field" folder, and maintained for project use.

3.5 Custody Seals

Custody seals are preprinted, adhesive-backed seals with security slots designed to break if the seals are disturbed. Seals are signed and dated at the time of use. Sample shipping containers (coolers) are sealed in as many places as necessary to ensure that the container cannot be opened without tearing the custody seals. Typically, one custody seal is placed along the front corner of the cooler, and a second is placed along the opposite back corner of the cooler. Clear tape is placed over the seals to ensure that seals are not accidentally broken during shipment. If the custody seal was broken at some point during transport, the reason for breaking the seal, condition of the container contents, the cooler temperature, and anything added to or removed from the container must be documented on the COC form. The container must then be sealed with a new custody seal.

If a sample handler transports the samples to the laboratory without sample shipment, custody seals are not required but are recommended.

3.6 Transfer of Custody

When transferring the possession of samples from the field sampler to a transporter or to the laboratory, the sampler must sign, date, and note the time as "relinquished by" on the COC record. The receiver also signs, dates, and notes 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 does not sign the COC record; rather, the COC record is signed by the sampler as "relinquished by" prior to closing the sample coolers for shipment and relinquishing them to the commercial carrier.

3.7 Laboratory Custody Procedures

A designated sample custodian accepts custody of the shipped samples and verifies that the sample identification number matches the COC record. The laboratory completes a cooler receipt form when samples are received. The cooler receipt form documents any discrepancies identified between the sample labels and COC, cooler temperature(s), sample preservation, and sample integrity. Cooler receipt information, including a signed COC, custody seals, and a completed cooler receipt form, are provided to the Project Chemist within 24 hours of cooler receipt.

4.0 REFERENCES

ADEC. 2022 (January). *Field Sampling Guidance*.

ATTACHMENTS

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 for labeling, packaging, and shipping samples from the field to the laboratory for analysis.

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 includes:

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

3.0 PROCEDURES

This section describes the procedures for labeling, packaging, and shipping collected samples.

3.1 Labeling

Samples must be labeled using nomenclature defined in the project-specific work plan. All sample labels must be weatherproof and contain the following information:

- Project or project number
- Sampler name or initials
- Sample identification
- Sample date and time (in 24-hour format)
- Laboratory analysis methods required for sample jar
- Preservatives added to sample jar

Adhesive sample labels are 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 or tape 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.

1. Choose a cooler with structural integrity to withstand shipment. Secure and tape the drain plug with duct tape.
2. Be sure that container lids 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 the sample identification exactly matches the chain-of-custody record.
4. 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. Wrap and package containers sufficiently to prevent cross contamination and ensure that containers remain intact during shipment (bubble wrap and plastic zip-top bags).
5. 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.
6. Line the cooler with a contractor-grade plastic bag.
7. Place the containers inside the contractor-grade plastic bag with caps up.
8. 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.
9. If the cooler contains volatile samples, ensure that a trip blank is included.
10. Fill excess space between sample containers with additional bubble wrap or gel ice.
11. Tape the top of the contractor-grade plastic bag shut once all sample containers, trip blanks, and the temp blank are inside.
12. Place another layer of bubble wrap along the top of the cooler, and if possible, place a layer of gel ice packs along the top of the cooler. **Use sufficient ice in packaging to ensure that samples are received by the laboratory at the proper temperature of 0 to 6°C. 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.**
13. Fill remaining headspace with additional packing material.
14. 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.
15. Conduct a "shake test" by gently shaking the cooler to determine if the containers are shifting in the cooler. If so, add additional packing material until there are no sounds of shifting when shaken.
16. Wrap strapping tape around each end of the cooler two times to secure the lid. Place completed custody seals on the front and back of the cooler so that the cooler cannot be opened without breaking the seals. Place clear tape over custody seals.
17. Attach an address label containing the name and address of the shipper to the top of the cooler. Attach other markings 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) 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.

Samples shipped as "Dangerous Goods in Excepted Quantities" must have the appropriate labelling and be declared as dangerous goods to the shipping carrier; however, a dangerous goods "candy-striped" form and Notification to Caption (NOTOC) are not required (IATA 2020).

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 500 mL per cooler. The hazard class number is 3, flammable liquid, UN 1230. Sample jars with methanol in excess of 30 mL and coolers with methanol in excess of 500 mL require shipment as "Dangerous Goods" and require the completion of a "candy-striped" form.

3.3.2 Water Sample Shipments

Water samples preserved with hydrochloric acid or other insignificant amounts of preservative are not shipped as dangerous goods once filled; however, pre-preserved sample containers with preservative and no water added 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 500 mL per cooler, respectively. The hazard class number is 8, corrosive. Sample jars with hydrochloric acid or nitric acid in excess of 30 mL and coolers with hydrochloric acid or nitric acid in excess of 500 mL require shipment as "Dangerous Goods" and require the completion of a "candy-striped" form.

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

4.0 REFERENCES

IATA. 2020. *Dangerous Goods Regulations (DGR) Limited/Excepted Quantities Labels*. 61st Edition. January.

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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 SAMPLING PROCEDURE

The following sections describe different QC sample types that may be required in project-specific work plans.

2.1 Field duplicate

A field duplicate is collected to evaluate whether sample matrix heterogeneity, contaminant distribution, or sample collection methods affect analytical precision. The field sampler ensures that primary and duplicate samples are effectively identical by collecting the samples from the same location, at the same time, with the same techniques, and from the same matrix. Non-volatile samples should be homogenized in a metal bowl or sealable zip-top bag prior to sample collection. Volatile samples should not be homogenized to minimize loss of volatile constituents; however, an effort should be made to collect samples from the same matrix and part of the sample interval.

At a minimum, one blind field duplicate should be collected per day and per 10 samples for each analytical method and matrix for offsite laboratory analysis. In some cases, such as when only one monitoring well per day can be sampled because of low yielding groundwater, it is not feasible to achieve the one field duplicate per day requirement. If anticipated prior to conducting project work, these site-specific deviations should be included in the site-specific work plan. If multiple sample coolers are shipped together, an effort should be made during sample packaging to include a duplicate in each cooler.

Field duplicates are submitted as blind samples with a unique sample number and collection time to the approved laboratory for analysis (Alaska Department of Environmental Conservation [ADEC] 2022). A duplicate sample collection time of one hour before the primary sample time is recommended to ensure there are no holding time issues.

2.2 Matrix Spike and Matrix Spike Duplicate (MS/MSD)

MS/MSD samples are collected to evaluate the precision and accuracy of laboratory procedures in the project sample matrix. The MS/MSD compound is 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 a matching sample identification and time denoted on the chain-of-custody (CoC) form to ensure that the project MS/MSD pair is used in the laboratory report. The MS/MSD should be noted in the QC column of the CoC. At a minimum, the frequency of MS/MSD samples collected is one for each analytical batch. Note that the analytical laboratory often batches samples in the same cooler together for shipments containing multiple coolers, so an effort should be made during sample packaging to include an MS/MSD in each cooler. The MS/MSD evaluation process is specified in the QAPP.

2.3 Temperature Blank

A temperature blank must 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 and 6 degrees Celsius (°C). Temperature blanks consist of plastic bottles filled with water, typically prepared by the laboratory. Once shipments are received by the laboratory, the temperature is recorded on the CoC to document that preservation requirements were met.

2.4 Trip Blanks

Trip blanks must accompany volatile samples, 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 sample bottle transport to and from the field. Trip blanks are samples of reagent-grade water, properly preserved in a controlled environment by the laboratory prior to field mobilization. Trip blanks are kept with the sample containers throughout the sampling process and returned to the laboratory with the analytical samples. One trip blank must accompany each cooler containing volatile samples. All trip blanks must be labeled and included on the CoC. Trip blank sample times will be recorded as 0800 on the CoC. The trip blank evaluation process is specified in the QAPP.

2.5 Equipment Blanks

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

3.0 REFERENCES

ADEC. 2022. *Field Sampling Guidance*. January.

STANDARD OPERATING PROCEDURE

BE-SOP-09

Groundwater Sample Collection

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) provides methodology for planning groundwater sampling events and collection of groundwater samples.

This SOP was developed in accordance with the following guidance documents:

- *Field Sampling Guidance* (Alaska Department of Environmental Conservation [ADEC] 2022)
- *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers* (U.S. Environmental Protection Agency [EPA] 2002)
- *Low Stress (Low Flow)-Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells* (EPA 2017).
- *Standard Practice for Low-Flow-Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations* (American Society for Testing and Materials [ASTM] 2018)
- *Underground Storage Tanks Procedures Manual: Guidance for Treatment of Petroleum-Contaminated Soil and Groundwater and Standard Sampling Procedure* (ADEC 2017)

This SOP focuses on the most commonly used monitoring well sampling tasks and should be used in conjunction with other applicable SOPs, including the following:

- BE-SOP-01: *Logbook Documentation and Field Notes*
- BE-SOP-02: *Sample Chain of Custody*
- BE-SOP-03: *Labeling, Packaging, and Shipping Samples*
- BE-SOP-04: *Quality Control Samples*
- BE-SOP-05: *Drilling and Core Logging*
- BE-SOP-14: *Equipment Decontamination*
- BE-SOP-20: *Water Quality Measurements*
- BE-SOP-22: *Monitoring Well Installation, Development, and Decommissioning*
- BE-SOP-66: *Breathing Zone Air Monitoring*

Groundwater sampling consists of collecting a water sample that is representative of the aquifer. Representative samples can be analyzed for groundwater contamination and/or naturally occurring analytes. Three common methods for well sampling include:

1. Low-Flow Method
2. Well-Volume Method
3. Low-Permeability Formation Method

Monitoring well sampling can be initiated as soon as the groundwater has re-equilibrated, is free of visible sediment, water quality parameters have stabilized, or 24 hours have passed following development (ADEC 2022).

Disturbance of the well, water column, and samples must be minimized, and only discrete grab samples may be collected. If multiple wells are to be sampled, the wells should be sampled from the least contaminated well progressing to higher levels of contamination. Groundwater samples need to be collected and analyzed for all appropriate contaminants of concern based on Appendix E of the *Field Sampling Guidance* and the project-specific work plan. Samples must be collected in the order of volatility (ADEC 2022):

1. Volatile organic compounds (VOCs) and gasoline range organics (GRO)
2. Semi-volatile organic compounds (SVOCs); including diesel range organics/residual range organics (DRO/RRO), polynuclear aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and herbicides
3. Total organic carbon (TOC), and
4. Inorganic compounds (total metals, dissolved metals, nitrate/nitrite, and sulfide)

2.0 EQUIPMENT AND SUPPLIES

Groundwater sampling can be performed using several devices including submersible pumps, bladder pumps, peristaltic pumps, and bailers. Groundwater sampling devices must support the intended data use and site decisions, and selected groundwater purging and sampling equipment must minimize increases in sample temperature, water column agitation, and sample agitation (ADEC 2022).

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

- Appropriate level of personal protective equipment
- Well keys
- Camera
- Logbook, weatherproof pen, sharpie, etc.
- *Groundwater Sampling Form* (Attachment 1)
- Sample labels
- Sampling containers and packing materials
- Oil/water interface probe or water level indicator
- Submersible (e.g., Proactive Monsoon pump with low-flow controller, or equivalent), bladder (e.g., QED Sample Pro), or peristaltic pump (e.g., MasterFlex Easy-Flow)
- Disposable Teflon bailers and twine
- Graduated cylinder or beaker
- YSI water-quality meter or similar multimeter
- Hach turbidimeter
- Potable water and/or deionized water
- Tubing (Teflon, high-density polyethylene [HDPE] and/or silicone)
- Liquinox, Alconox, or equivalent
- RAE Systems MiniRAE photoionization detector (PID) (or similar), if necessary
- Colorimetric gas detector tubes, if necessary

3.0 PROCEDURES

3.1 RECORDING FIELD OBSERVATIONS

The *Groundwater Sampling Form* (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 Form*.

3.2 FIELD EQUIPMENT DECONTAMINATION

Clean and/or decontaminate all equipment and materials used during groundwater sampling before use, as discussed in *Equipment Decontamination* (BE-SOP-14). Groundwater sampling equipment that typically requires decontamination includes all measurement devices before and between measurements at each well, groundwater sampling pumps between sampling at each well, water quality meters and probes and the inside of flow-through cells (ADEC 2022). Used decontamination solution will be managed as investigation-derived waste, according to the project-specific work plan.

3.3 FIELD INSTRUMENT CALIBRATION

Field instruments will be calibrated in accordance with the manufacturer's recommended procedures and frequency for each instrument. Refer to *Water Quality Measurements* SOP (BE-SOP-20) and *Field Screening with PID* SOP (BE-SOP-15) for related procedures.

3.4 AIR MONITORING

Air monitoring will be conducted to screen for the presence of VOCs using a PID, or colorimetric gas detector tubes, if necessary. PID readings will be monitored until stable and then recorded in the field logbook. Procedures in the project-specific Site Safety and Health Plan (SSHP) and *Breathing Zone Air Monitoring* SOP (BE-SOP-66) will be followed if organic vapors are detected above concentrations listed in the air monitoring section of the SSHP.

Prior to removing the well plug, remove any standing water in the well annulus. Collect PID readings in situations as follows:

- 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.

3.5 FREE PRODUCT AND WATER LEVEL MEASUREMENT

Measure the depth to groundwater (DTW), depth to product (DTP) if present, and total depth (TD) with an oil/water interface probe (or water level meter if no product) to the nearest 0.01-foot. Interface probes provide distinct responses when immersed in nonconductive product or conductive water. If non-aqueous phase liquid (NAPL) is encountered in a well, unless otherwise specified in the project-specific work plan, do not collect laboratory samples (ADEC 2022). If samples are to be collected, remove the product with a bailer and make a note on the chain of custody that free product is present.

DTW, DTP, and TD are measured relative to an established reference mark from the top of the casing (TOC). The reference mark should be permanent, such as a small notch cut into the TOC or a permanent ink mark at the TOC. If a reference mark is not present, place a mark on the outside of the top north side of the well casing with indelible ink.

TD of a monitoring well should be compared to the well construction log to determine the thickness of silt present on the bottom, if present.

3.6 PURGING

Purging is the process by which stagnant water is removed from the well casing 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 2017, ADEC 2022). Monitoring wells will be purged, at a minimum, the equivalent of three times the well volume, or until a minimum of three (four, if using temperature) water quality parameters stabilize, or for low yield wells, the entire well casing is evacuated.

The formula to calculate one well casing volume is as follows:

*(TD of Casing – DTW) * Gallons per Foot of Casing*

Refer to Attachment 1 for the various gallons per foot of casing based on the diameter of the well.

All measurements, except turbidity, must be obtained using a flow-through cell. Water quality parameter stabilization is reached when three consecutive changes between successive readings at approximately 3 – 5 minute intervals are within:

- ± 3% for temperature,
- ± 0.1 for pH,
- ± 3% for conductivity,
- ± 10 millivolts for oxidation reduction potential,
- ± 10% for dissolved oxygen,
- ± 10% or ≤ 10 NTU for turbidity.

3.7 GROUNDWATER SAMPLING

3.7.1 Low-Flow Method

The low-flow sampling method uses groundwater quality parameters as indicators to determine when formation water is being discharged. Sampling at low-flow rates provides more accurate and reproducible samples of the formation water by minimizing hydraulic stress compared to high flow/high volume purging, while also reducing purge water volume. Low-flow sampling is not suitable for very low-yield wells, sampling in wells known to contain NAPL, and may require longer purge times (ASTM 2018).

Low-flow sampling is typically conducted using bladder pumps (positive displacement pumps), submersible pumps or peristaltic pumps. The use of Teflon-lined polyethylene tubing is preferred for the sample collection of organic compounds. For the analysis of per- or polyfluorinated alkyl substances hydrocarbons (PFAS) HDPE tubing is to be used; however, the use of HDPE equipment should be minimized to the extent practical (ADEC 2022).

Sampling of wells in order of increasing chemical concentrations (known or anticipated) is preferred. If wells contain free product, alternate wells that are representative of the affected groundwater should be sampled instead. Samples will be collected using the following steps:

- Measure and record the initial water level before installing the pump.
- Lower the pump or peristaltic pump tubing to the target depth below the static water level.
    - Record the depth of the pump on the Groundwater Field Data Form.
    - Consult the project-specific work plan for pump placement. Typically:
        - 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 (ADEC 2017).
        - For wells with submerged screens, set the pump intake at the middle of the screened interval (ASTM 2018).
- Begin purging water into a graduated bucket. Adjust the flow rate, for low-flow sampling, the goal is minimum drawdown (<0.3 feet) during purging, but this is not always possible with slow recharge aquifers (EPA 2002, ADEC 2022).
    - Flow rates typically range from 50 to 500 milliliters per minute (mL/min) (0.01 to 0.13 gallons per minute[gal/min]), but higher rates are consistent with low-flow guidelines as long as the drawdown requirement is met (ADEC 2022).
    - Flow adjustments are best made in the first 15 minutes of pumping in order to minimize purging time.
- After observable turbidity decreases, connect the flow-through cell to begin measuring and recording stabilization parameters and DTW on Attachment 1.
- Continue to purge and record measurements until stabilization criteria are met (Section 3.6) or a minimum of three or maximum of six well casing volumes are removed (EPA 2002).
- When collecting samples, disconnect the tubing from the flow-through cell and collect samples directly from the pump's tubing.
- Begin filling laboratory-supplied analytical sample containers in order of volatility as described in Section 1.0.
- Record sample information on the sample bottle labels and Attachment 1.

3.7.2 Well-Volume Method

This method is the default method used during low-flow sampling if groundwater stabilization parameters cannot be achieved. The well-volume method is based on purging three to six well volumes before sampling (EPA 2002). One well casing volume of water may be calculated using the formula in Section 3.6.

Well-volume method sampling should be conducted as above in the Low-Flow Method, but:

- The purge rate should not be great enough to produce excessive turbulence in the well.

  - Flow rates typically range from 500 mL/min to 3.8 L/min (0.13 to 1 gal/min) in a 2-inch well (EPA 2002).
- Routinely measure and record groundwater parameters and DTW at approximately every 0.5 – 1 well volume interval on Attachment 1 (EPA 2002).
- Once groundwater parameters have stabilized and a minimum of three well casing volumes have been removed, record the final measurements.
- If parameters have not stabilized within six well volumes, stop purging and record the final measurements.
- Reduce the flow rate of the pump to about 0.13 gal/min and collect samples as above (EPA 2002).

3.7.3 Low-Permeability Formation Method

If a well is screened in low hydraulic conductivity aquifers (silt and clay) there may be no way to avoid pumping or bailing a well dry. Low-flow purging and sampling are useful for wells that purge dry or take one hour or longer to recover (ADEC 2022).

If a low yield well is purged dry, and it is not possible to obtain groundwater stability parameters:

- Purge the well dry and allow the well to recover until at least one of the following is met:
  - If full recovery exceeds one hour, collect samples as soon as the well has recharged to 80 percent of the DTW (ADEC 2022).
  - A minimum of 2 hours has passed since purging (EPA 2002).
  - There is sufficient water volume present to obtain a sample.
- Collect samples in order of volatility, as described in Section 1.0.
  - Bailers or a peristaltic pump may be used; however, analytical results may be biased low for VOCs if using a peristaltic pump or biased high for metals if using a bailer due to increased turbidity (EPA 2002).

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. Cross-contamination can be a significant problem when attempting to characterize low concentrations of organic compounds or when soils are highly contaminated (ADEC 2017). To prevent cross-contamination between wells, dedicated tubing can 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 removed or until water quality parameters have stabilized, as described in Section 3.6.

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.

REFERENCES

ADEC. 2017. *Underground Storage Tanks Procedures Manual: Guidance for Treatment of Petroleum-Contaminated Soil and Groundwater and Standard Sampling Procedure.* March.

ADEC. 2022. *Field Sampling Guidance*. January.

ASTM. 2018. D6671 - *Standard Practice for Low-Flow-Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations*. September.

U.S. EPA. 2002. *Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers*. Office of Solid Waste and Emergency Response. EPA 542-S-02-001. May.

U.S. EPA. 2017. *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells*. EPA 540-S-95-504. September.

ATTACHMENTS

Groundwater Sampling Data Form

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GROUNDWATER SAMPLING DATA FORM

Well ID:______________________

Project Name:
Project Number:
Sampling Team:
Date:
Start Time:
End Time:

Sample ID: Time: primary dup other:
Sample ID: Time: primary dup other:
Sample ID: Time: primary dup other:

Depth to Top of Product (BTOC):
Depth to Oil/Water Interface (BTOC):

Casing Diameter:	*1 in.*	*2 in.*	*4 in.*
gal/ft of casing:	*0.041*	*0.163*	*0.653*

Pump Intake Depth:
Stable DTW (BTOC):

Total Depth (BTOC):
Depth to Water (BTOC)
Water Column (ft)
Casing Volume (gal)
Screen Interval
Measured Stick-up

Method of Purging (circle one):

Pump: SUB BLDR PERIST OTHER:
Pump Type: Flow Rate (gpm):
Pump Time:

Bailer: TEFLON SS OTHER:
Required Pulls: Bailer Vol. (gal): 0.25 / 0.33
Vol. Purged (gal):

WELL STABILIZATION DATA

Time	Total Volume Purged (gallons)	Water Level (ft BTOC)	Draw Down	Temp. (°F or °C)	pH	Conductivity (µS/cm)	ORP (mV)	D.O. (mg/L)	Turbidity (NTU)
				± 3%	± 0.1	± 3%	± 10mV	± 10%	± 10% or <10 NTU

Notes: Drawdown should be less than 0.3 feet from the original DTW. Minimal drawdown achieved and measured by: 1) pumping at a low rate (approx. 1 liter/3 minutes or 0.26 gallons/3 minutes or 50-500 mL/min) **and** 2) continually measuring water levels in the well.
Sample after 1) removing min. of 3 casing volumes **or** 2) min. of 3 parameters stabilize (4, if using temp.), **or** 3) for low yield wells, entire well casing is evacuated (ADEC, 2013).

Sensory Observations

Color: Clear, Amber, Tan, Brown, Gray, Milky White, Other

Odor: None, Low, Medium, High, Very Strong, H2S, Fuel-Like, Chemical ?, Unknown

Turbidity: None, Low, Medium, High, Very Turbid, Heavy Silts

Comments:

WELL STABILIZATION DATA

Time	Total Volume Purged (gallons)	Water Level (ft BTOC)	Draw Down	Temp. (°F or °C)	pH	Conductivity (µS/cm)	ORP (mV)	D.O. (mg/L)	Turbidity (NTU)
				± 3%	± 0.1	± 3%	± 10mV	± 10%	± 10% or <10 NTU

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 may include:

- Level D Personal Protective Equipment (PPE) – nitrile or rubber gloves, safety glasses, safety toed boots, hard hat and safety vest (if decontaminating drilling or heavy equipment)
- Hand tools for bulk contamination removal (shovels, brooms, etc.)
- Liquinox or Alconox
- Spray or rinse bottles, or pump sprayer
- Pressure washer/steam cleaner
- Potable water
- Distilled or deionized water
- Bristle brushes
- Plastic tubs
- Plastic sheeting
- Department of Transportation (DOT)-approved, 5-gallon buckets with screw top lids
- DOT-approved, 55-gallon open-top drums
- Contractor-grade plastic bags
- Paper towels

3.0 PROCEDURE

Reusable sampling equipment must be decontaminated between samples and at the end of each workday. Drilling and excavation equipment should be decontaminated prior to beginning site activities, before collecting each sample when non-dedicated sampling equipment is used, and after completing site activities. Decontamination procedures are detailed in the following subsections.

3.1 DECONTAMINATION AREA

Identify a localized decontamination area for larger drilling and excavation equipment. Select an area with easy access and level ground to minimize slip, trip, and fall hazards. The decontamination area should be large enough to temporarily store clean equipment and materials. When decontaminating larger drilling tooling, such as hollow-stem augers, line each area with a heavy-gauge plastic sheeting and include a collection system designed to capture potential decontamination wastes (water and residual soil). Containerize decontamination water and residual soil in approved containers, such as DOT-approved 55-gallon drums, before treating/disposing the water and residual soil as specified in the approved project-specific Work Plan. Decontamination areas should be set up to minimize overspray and risk to the surrounding environment.

Smaller equipment (spoons, trowels, groundwater sampling pumps, etc.) may be decontaminated near the sampling locations. In this case, all required decontamination supplies must be mobilized to the sampling location. A 5-gallon bucket with a screw top lid or a plastic tub should be used to capture decontamination water, which should be transferred to larger containers, as necessary.

3.2 SAMPLING EQUIPMENT DECONTAMINATION

Improper decontamination can cause cross-contamination. To prevent cross-contamination, sampling equipment must be either disposed of after one use or decontaminated after each use. Disposable or dedicated sampling equipment should be used whenever possible. When non-dedicated, reusable equipment is used, it should be decontaminated in stages in a way that minimizes contaminant discharge to the environment. The following procedures should be used:

1) Remove as much bulk contamination as possible from equipment at the point of origin.
2) Wash equipment thoroughly with potable water containing a laboratory-grade detergent, such as Liquinox or Alconox. Use a bristle brush to remove any remaining residual contamination.
3) Rinse equipment thoroughly with potable water.
4) Rinse equipment thoroughly with distilled or deionized water. Note that some instruments can be damaged by deionized water, such as YSI 556 and Aqua TROLL 500 probes.
5) Air dry equipment in clean area free of dust or other fugitive contaminants. Alternatively, wet equipment may be dried with a clean, disposable paper towel to assist the drying process. All equipment should be dry before reuse.
6) Store clean and dry sampling equipment within a protective medium (plastic bag, carrying case, etc.).

3.3 HEAVY EQUIPMENT DECONTAMINATION

Equipment decontamination must be performed prior to transporting or walking equipment between contaminated areas. Decontamination will focus on minimizing the spread of contaminated media resulting from equipment movement or transport. This decontamination process will use dry methods (brooms, brushes, shovels, etc.) within the exclusion zone to remove large, easily dislodged deposits of soil and other contaminated media from equipment (tracks, buckets, etc.) prior to exiting the exclusion zone. The Field Lead may alter decontamination procedures based on dry decontamination effectiveness.

Final decontamination should be conducted when equipment is no longer needed onsite. A decontamination area should be established to collect decontamination materials, sludge, and water. Bulk contamination should be removed using shovels and brushes, and the equipment should be further cleaned using a pressure washer with a detergent wash, followed by a potable water rinse, if needed.

3.4 PERSONNEL AND PERSONAL PROTECTIVE EQUIPMENT DECONTAMINATION

During environmental investigations and removal actions, boots and gloves are commonly the most contaminated types of PPE. Contaminated solids such as mud should be scraped and wiped from boots. Personnel decontamination involves removal of bulk contamination first. Any remaining contamination should be removed using soapy water and brushes. Once all debris is removed, rinse the boots with clean water. If boots are not laden with solid materials, a brush can 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 replaced. Gloves should be removed rolling the glove off from the top down to avoid contact with contaminated soil.

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.

4.0 INVESTIGATION-DERIVED WASTE MANAGEMENT

Typical investigation-derived wastes (IDW) consist of soil cuttings, decontamination water, and solid wastes. Wastes will be managed based on media type following the procedures specified in the Alaska Department of Environmental Conservation -approved project-specific Work Plan and in accordance with the federal, state, and local regulations. Typical methods of managing IDW are described in the *Waste Management* SOP (BE-SOP-79).

5.0 QUALITY CONTROL

Quality Control (QC) samples may be collected to verify that the decontamination process is effective. QC samples include equipment rinsate blanks and equipment wipe samples, which are described in the *Quality Control Samples* SOP (BE-SOP-04).

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STANDARD OPERATING PROCEDURE

BE-SOP-20

Water Quality Measurements

1.0 INTRODUCTION

The purpose of the Standard Operating Procedure (SOP) is to describe the methods of calibrating, maintaining and operating water quality meters and probes used for groundwater sampling. The YSI 556 Multi-Probe System (MPS) and Aqua TROLL 500 are common multimeters used which will simultaneously measure temperature, conductivity, pH, dissolved oxygen (DO), and oxidation reduction potential (ORP). This SOP also describes the guidelines for calibration and operation of the Hach Portable Turbidity Meter. The manufacturer's operator's manual should be referred to for specific calibration, operation procedures and troubleshooting.

This SOP was developed in accordance with the following guidance documents:

- *Field Sampling Guidance* (Alaska Department of Environmental Conservation [ADEC], 2022)
- *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations* (American Society for Testing and Materials [ASTM], 2018)

This SOP focuses on the mostly commonly used collection methods of field water quality parameters and should be used in conjunction with other applicable SOPs, including the following:

- BE-SOP-01: *Logbook Documentation and Field Notes*
- BE-SOP-09: *Groundwater Sampling*
- BE-SOP-10: *Surface Water Sampling*
- BE-SOP-14: *Equipment Decontamination*
- BE-SOP-21: *Groundwater and LNAPL Measurements*

2.0 EQUIPMENT AND SUPPLIES

Calibration and water quality measurement equipment will include, but is not limited to the following:

- Multimeter, which may include:
    - YSI 556 MPS (or similar)
    - YSI 5563 Probe Module
    - Aqua TROLL 600 Multiparameter Sonde, Wireless TROLL Com communication device, and Aqua TROLL tablet with VuSitu App
- Flow-through cell
- Discharge hoses and fittings to attach sample tubing to the flow-through cell
- Calibration standards (pH 4, 7, and 10, ORP, and conductance)
- Aqua TROLL Quick-Cal Multiple Sensor Solution, if using Aqua TROLL
- Rugged DO (RDO) calibration sponge or 100% saturation bubbler, if using Aqua TROLL
- Deionized water (DI)
- Spray bottle

- Graduated cylinder or beaker, if needed
- 5-gallon buckets
- Portable turbidity meter (e.g., Hach 2100P or Hach 2100Q) and turbidity standards (<0.1, 20, 100, and 800 NTU)
- Appropriate level of personal protective equipment
- Logbook, weatherproof pen, sharpie, etc.
- Multi-parameter and turbidimeter calibration logs (Attachment 1 and 2)

3.0 PROCEDURES

Calibrate or perform a calibration check on equipment daily. Calibration readings should be documented in the field logbook and/or calibration logs (Attachment 1 and 2). If a field instrument will not calibrate, perform troubleshooting as described in the manufacturer's manual. If the issue cannot be resolved, use a backup instrument. If that is not an option, contact the Project Manager on whether data collection will continue or if any other corrective actions should be taken. Flag any data recorded from a meter with suspected calibration problems on the field forms. If anomalous field readings are given during sample collection, stop and recalibrate the instrument.

3.1 Calibration of YSI 556 MPS

The transport/calibration cup that comes with the probe module serves as the calibration chamber and minimizes the volume of calibration reagents required. The key to successful calibration is to ensure that the sensors are completely submersed when calibration values are entered. For maximum accuracy, use a small amount of calibration solution to pre-rinse the probe module (YSI, 2009). Consult the YSI operation's manual for further information.

3.1.1 pH

Always calibrate pH using the 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. To calibrate pH:

- Select the 3-point option to calibrate the pH sensor using three calibration solutions.
- When calibrating pH, always calibrate with buffer 7 first.
- Place 30 milliliters (mL) of pH buffer into a clean, dry, or pre-rinsed transport/calibration cup, and securely tighten the cup on the threaded end of the probe module.
- Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.
- Enter the calibration value of the buffer at the current temperature.
- Press **Enter**. The pH Calibration screen is displayed.
- Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
- When the readings show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.
- Repeat these steps using a second pH buffer, and then repeat again using a third pH buffer.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.

3.1.2 Conductivity

For maximum accuracy, the conductivity standard should be within the same conductivity range as the samples you are preparing to measure.

- For fresh water use a 1 mS/cm conductivity standard.
- For brackish water use a 10 mS/cm conductivity standard.
- For seawater use a 50 mS/cm conductivity standard.

Always calibrate conductivity for specific conductance. Calibrating for specific conductance will automatically calibrate for conductivity and salinity. To calibrate specific conductance:

- Place 55 mL of conductivity standard into a clean, dry, or pre-rinsed transport/calibration cup, and securely tighten the cup on the threaded end of the probe module.
- Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.
- Enter the calibration value of the standard you are using in mS/cm at 25°C and press **Enter**.
- Allow at least one minute for temperature equilibration before proceeding. The current values of all enabled sensors will appear on the screen and will change with time as they stabilize.
- When the readings show no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.

3.1.3 ORP

To calibrate for ORP:

- Place 30 mL of a known ORP solution into a clean, dry, or pre-rinsed transport/calibration cup, and securely tighten the cup on the threaded end of the probe module.
- Gently rotate and/or move the probe module up and down to remove any bubbles from the conductivity cell.
- Enter the correct value of the calibration solution at the current temperature. Refer to the solution values on the calibration standard bottle.
- Press **Enter**. The ORP calibration screen will be displayed.
- Allow at least one minute for temperature equilibration before proceeding. Verify that the temperature reading matches the value you used.
- Observe the reading under ORP. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.

3.1.4 DO

Always calibrate for % DO. Calibrating for % DO will automatically calibrate for mg/L. The instrument must be on for at least 10 – 15 minutes to polarize the DO sensor before calibrating. To calibrate dissolved oxygen:

- Place 1/8 inch (3 mm) of water in the bottom of the transport/calibration cup.
- Place the probe module into the transport/calibration cup.

- Make sure the DO and temperature sensors are **not** immersed in the water.
- Engage only 1 or 2 threads of the transport/calibration cup to ensure the DO sensor is vented to the atmosphere.
- Use the keypad to enter the current local barometric pressure in mmHg.
  - If the unit has the optional barometer, no manual entry is required.
- Press **Enter**. The DO % saturation calibration screen will be displayed.
- Allow approximately 10 minutes for the air in the transport/calibration cup to become water saturated and for the temperature to equilibrate before proceeding.
- Observe the reading under DO %. When the reading shows no significant change for approximately 30 seconds, press **Enter**. The screen will indicate that the calibration has been accepted and prompt you to press **Enter** again to continue.
- After returning to the Calibrate screen, rinse the probe module and sensors with tap or purified water and dry.

3.2 Aqua TROLL 500 Multiparameter Sonde

The restrictor attached in storage/calibration mode serves as the calibration chamber and minimizes the volume of calibration reagents required. For best calibration, it is recommended to rinse twice with the calibration solution to ensure all contaminants have been removed (In Situ, 2019). Aqua TROLL may be calibrated using single sensor calibration standards for pH, conductivity, and ORP. However, the Aqua TROLL sonde may also be calibrated using a multi-sensor calibration standard, Quick-Cal Solution, for these three parameters.

3.2.1 Solution-Based Calibration

Refer to the Aqua TROLL operator's manual if using single sensor calibration standards. The following procedures will be used for performing a multi-sensor calibration using Quick-Cal Solution:

- Ready the instrument for calibration
  - Remove the rubber bumper and blue top cap from the restrictor.
  - Remove the restrictor and reattach in calibration mode to form the calibration cell.
  - Invert the instrument, so the sensors are facing up.
  - Rinse the sensors with DI or tap water. Ensure the sensor face and inside of calibration cell are clean and free of debris.
- Ready the tablet for calibration
  - From the main menu, select **Connected Instrument.**
  - Select **Calibrations**.
  - Select **Quick-Cal (multi-sensor)**.
    - All available sensors are selected by default. If one or more sensors are not installed properly, an error message will pop up.
  - Select **Next**.
- Solution Rinse Procedure
  - Pour 10 – 20 mL (½-inch above the sensor face) of the calibration standard onto the sensors to perform the first rinse.
  - Ensure the solution comes in contact with the sensors by moving the solution around in the calibration cell. Reinstall the blue top cap and shake gently, if necessary.
  - Discard the calibration standard.
  - Repeat solution rinse procedure. Aqua TROLL recommends two rinses to ensure the best calibration of the instrument.
- Sensor Calibration Procedure

  - Fill the calibration cell with 40 – 50 mL (to the bottom of the threads inside the restrictor) with fresh calibration solution.
    - Check the sensor for bubbles and gently tap to remove any bubbles.
  - Select **Next**.
  - After the calibration is stable, select **Accept**.
  - The calibration values applied to the sensor will appear on-screen. Select **Done** to return to the calibration menu.

3.2.2 DO 100% Saturation Calibration

The RDO sensor is typically calibrated using a 1-point calibration method. The water saturated air method is most commonly used, while the saturation bubbler method requires an additional calibration chamber. Other calibration methods are available in the owner's manual. The factory calibration of the RDO sensor should produce readings within 3% accuracy (In Situ, 2019). If greater accuracy is required, In-Situ recommends performing a 1-point 100% water-saturated air calibration using the following procedure:

- From the main menu, select **Connected Instrument**.
- Select **Calibrations**.
- Select **RDO Saturation**.
- For a 1-point calibration, select **100% Saturation**.
- Set up the instrument for one of the following methods:

<u>Option 1 – Water Saturated Air</u>

- Remove the restrictor and thoroughly dry the RDO sensing foil and temperature sensor.
- Saturate a small sponge with water (does not need to be dripping).
- Place the sponge in the bottom of the restrictor and attach the end cap, turning one full rotation.
  - Do not fully seal the bottom of the restrictor.
- Wait 5 – 10 minutes for 100% water saturation of the air within the calibration chamber before starting the calibration.
- After the calibration chamber has stabilized, select **Next**.
- After calibration is stable, select **Next**.
- The calibration values will be applied to the sensor and appear on-screen. Select **Done** to return to the Calibration Menu.

<u>Option 2 – Bubbler</u>

- Fill at 100% saturation bubbler half full of tap water.
- Turn on the bubbler.
- Wait 5 – 10 minutes for the bubbler to reach 100% saturation.
- Install the restrictor in deployment mode, remove blue end cap and place the sonde in the bubbler.
- After the calibration chamber or bubbler have stabilized, select **Next**.
- After calibration is stable, select **Next**.
- The calibration values will be applied to the sensor and appear on-screen. Select **Done** to return to the Calibration Menu.

3.3 Hach Portable Turbidimeter

The Hach Model 2100P or 2100Q Portable Turbidimeter measures turbidity from 0.01 to 1000 NTU in automatic range mode with automatic decimal point placement. For more information, consult the Hach user manual. Use the following 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.

3.3.1 Calibration of Hach 2100Q Portable Turbidimeter

For best consistency and accuracy, calibrate using the StablCal Calibration Set and always insert the cell so the orientation mark on the cell is correctly aligned with the mark on the front of the cell compartment (Hach, 2017).

- Push the **Calibration** key to enter the Calibration mode.
    - Gently invert each standard before insertion.
- Insert the 20 NTU StablCal Standard and close the lid.
- Push **Read**. The display shows Stabilizing and then shows the result.
- Repeat with the 100 NTU and 800 NTU StablCal Standard.
- Push **Done** to review the calibration details.
- Push **Store** to save the results.

3.4 Collection of Water Quality Measurements

Water quality parameters (DO, ORP, pH, and conductivity) are chemical properties measured to determine when discharged groundwater is considered representative of the formation water and sampling can begin (ASTM, 2018). Water quality parameters are measured using a multi-parameter instrument coupled with an in-line flow- through cell. The typical volume of the flow-through cell is 500 mL.

3.4.1 Groundwater Parameters

Follow this general procedure for collecting water quality parameters using a flow-through cell:

- Secure the instrument to the flow-through cell. Connect a short discharge tube to the effluent connector at the top of the flow-through cell and run the other end of this discharge tube into a 5-gallon purge water bucket.
- Place the tube from the pump directly into the 5-gallon purge water bucket and purge for approximately half a minute or until the purge water begins to visually clear up. The intent is to limit any initially highly turbid water from accumulating in the flow-through cell.
- Once visually clear, secure the tube from the pump to the influent connector at the bottom of the flow-through cell.
- Continue low flow purging at a flow rate of approximately 1 liter (0.26 gallons) every 3-5 minutes, or 50 – 500 mL/min (ADEC, 2022).
- Routinely measure and record required parameters and the depth to groundwater every 3-5 minutes. A minimum of three recordings will be monitored and recorded.
- Continue to monitor until parameters stabilize or until three well casing volumes have been purged. Use the following stabilization parameters (ADEC, 2022):
    - ± 3% for temperature (minimum of ± 0.2 °C),

  - ± 0.1 for pH,
  - ± 3% for conductivity,
  - ± 10 mv for redox potential,
  - ± 10% for DO, and
  - ± 10% for turbidity.
- When parameters have stabilized, record final measurements, and collect samples per the project-specific work plan.

Note: Low-flow purging and sample collection are particularly useful for wells that purge dry or take one hour or longer to recover. If a well is purged dry or recovery exceeds one hour, collect a sample as soon as the well has recharged to approximately 80% of its pre-purge volume, when practical (ADEC, 2022).

3.4.2 Surface Water Parameters

Water quality measurements should be taken when collecting surface water samples, when specified in the project specific workplan. Additional parameters (stream discharge rate, salinity, etc.) may be necessary when collecting surface water samples (ADEC, 2022). Section 8.0 of the ADEC *Field Sampling Guidance* (2022) contains additional information for surface water sampling and parameter collection.

4.0 DATA AND RECORD MANAGEMENT

The *Multi-Parameter Calibration Log* (Attachment 1) and the *Turbidimeter Bump Check Log* (Attachment 2) are intended for use in the field during groundwater sampling and monitoring well development activities. Complete these datasheets according to this SOP and the *Logbook Documentation and Field Notes* (BE-SOP-01).

REFERENCES

ADEC. 2022. *Field Sampling Guidance*. January.

ASTM. 2018. *Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations.* D6771. West Conshohocken, Pennsylvania. September.

Hach Company. 2017. *Hach 2100Q and 2100Qis User Manual.* December.

In-Situ. 2020. *Aqua TROLL 500 Multiparameter Sonde Operator's Manual.* November

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

ATTACHMENTS

Multi-Parameter Calibration Log
Turbidimeter Bump Check Log

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Multi-Parameter Calibration Log

Project Name/Location:____

Project Number:____

Equipment Make and Model(s):____________________ & ____________________

Serial Number(s): ____________________ & ____________________

Serial Num.	Date	Temp.	pH (3 pt.)		Cond. (us/cm)		ORP (mV)		DO (100%)		Initials
			Standard	Reading	Standard	Reading	Standard	Reading	Atm. Press. (mmHg)	Reading (%)	

Serial Num.	Date	Temp.	pH (3 pt.)		Cond. (us/cm)		ORP (mV)		DO (100%)		Initials
			Standard	Reading	Standard	Reading	Standard	Reading	Atm. Press. (mmHg)	Reading (%)	

Turbidity Meter Calibration Verification Check

Project Name/Location: ____

Project Number: ____

Equipment Make and Model(s): ______________________ & ______________________

Date	Time	Serial #:			Serial #:			Initials
		______NTU	______NTU	______NTU	______NTU	______NTU	______NTU	

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STANDARD OPERATING PROCEDURE

BE-SOP-21

Groundwater and LNAPL Measurements

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the procedures and equipment that should be 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, and 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 the 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 on the *Well Purge and Sampling 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 on the *Well Purge and Sampling Form*.

STANDARD OPERATING PROCEDURE

BE-SOP-22

Monitoring Well Installation, Development, and Decommissioning

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.

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 driller 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 Work Plan.

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.

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
- Surface seal materials (concrete)
- Potable water and/or deionized water
- Weighted tape measure

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

- Water level meter or Oil/Water interface probe
- Surge block (with foot valve)
- Peristaltic pump

- 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 or Aqua-TROLL
- 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 (if applicable);
- 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 (ASTM 2009). 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. A monitoring well construction form will be completed for each monitoring well. Each well point will be surveyed.

4.2 Borehole Requirements

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.. Polyvinyl chloride (PVC) is a durable monitoring well material with good chemical resistance (EPA 1991). Diameters will be identified in the wp.
- 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 or marked to be used as a measuring point for water levels and survey activities. Boring location will be noted based on the identification number.

- The addition of bentonite surrounding the PVC casing will be visually verified during well installation activities to ensure that bridging is not occurring during withdrawal of the drill string/equipment.

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-grained 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. 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 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 silica sand used to fill the borehole to the ground surface.
- The bentonite will be hydrated after placement.
- Only 100 % sodium bentonite will be used.

The bentonite seal will be terminated 2 feet 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.

Seal requirements for wells with submerged screens or screened in deep confined aquifers will be described in the site-specific work plan.

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 surface monument. 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 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).

For a well with sufficient water supply, there is no minimum volume of purge water identified in guidance for well development, but a minimum of three casing volumes is recommended; A clear, steady flow of water is the development target.

Removing twice the volume of water added during drilling and construction is often a workplan requirement.

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 recommended to be 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 2022).
[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 *Field Sampling Guidance* (ADEC 2022). Additionally, temporary wells are often not developed; this will be described in the project specific work plan.

The well purge water will be collected into buckets or drums and treated on site or shipped off for disposal as identified in 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. This SOP is consistent with the decommissioning section of the *Monitoring Well Guidance* issued by the Alaska Department of Environmental Conservation (ADEC 2013). Specific monitoring well decommissioning procedures depend on project objectives and subsurface conditions and must be discussed and presented in the project-specific Work Plan. ADEC approval of the Work Plan is required prior to decommissioning the wells.

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 (i.e., if you have a 10-foot screen, pull the well out 10 feet).
3. After the casing is withdrawn above the groundwater interface, add some bentonite chips to the well. Withdraw the casing further and continue adding bentonite chips. Continue this iterative process (pull the casing, fill the borehole, pull the casing, fill the borehole) to within 2 feet of the ground surface.
4. If the well is shallow, add water to hydrate the bentonite chips. Add additional bentonite chips as necessary to seal the well to within 2 feet of the ground surface.
5. If the well is located in a confined aquifer, bentonite chips should begin to be placed within the confining stratum.
6. Fill the remaining 2 feet of the borehole with sand or gravel and restore the site as necessary.

7. Record decommissioning procedures and report to ADEC.

If the well casing and screen are unable to be removed at the time of decommissioning, and it is known that the well construction included a competent annular seal of bentonite chips surrounding the well casing, the screen should be filled with sand and the casing should be completely sealed in-place with bentonite chips 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 digging to two feet below the ground surface, cutting off the well at that depth, the backfilling with sand and bentonite.

REFERENCES

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ADEC. 2022. *Field Sampling Guidance.* January.

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

U.S. Environmental Protection Agency (EPA). 1991. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.* Office of Research and Development.

EPA, Region 4. 2008. *Design and Installation of Monitoring Wells, Science and Ecosystem Support Division.* February.

ATTACHMENTS

Record of Well Construction
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

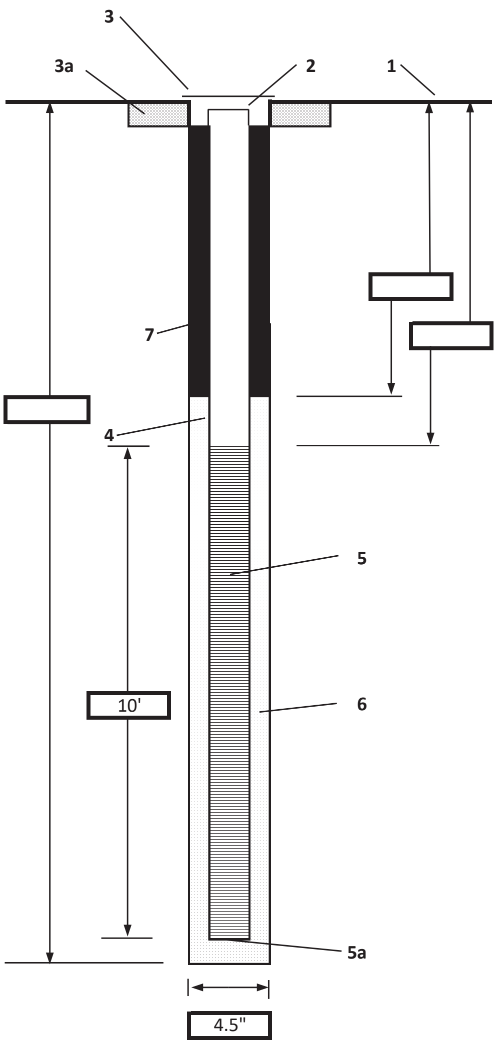
Field Notes from Drilling

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

PROJECT NUMBER	SHEET 1 OF 1 WELL ID

FLUSH MOUNT WELL COMPLETION DIAGRAM

PROJECT/CLIENT: LOCATION :
DRILLING CONTRACTOR:
DRILLING METHOD AND EQUIPMENT USED:
WATER LEVEL: START : END : LOGGED BY:



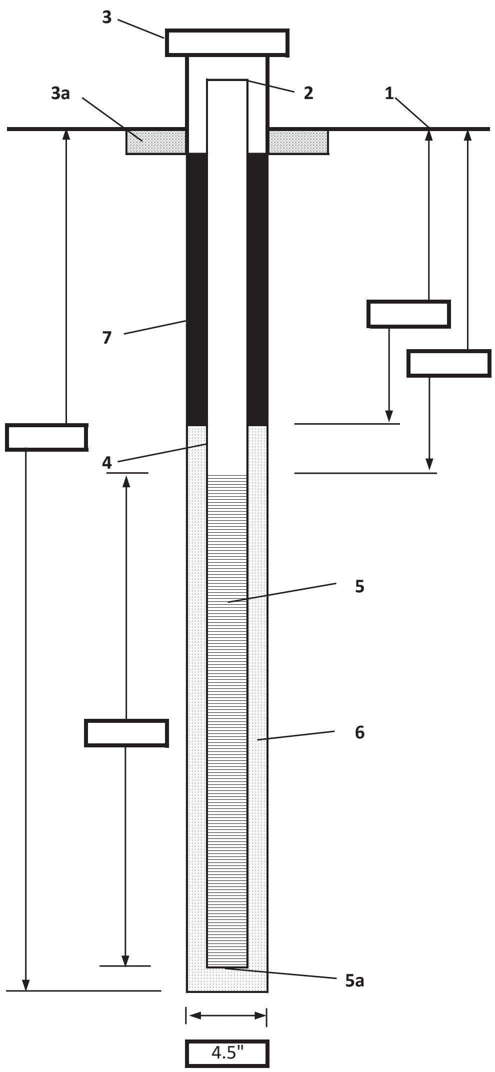
1- Ground elevation at well	TBD
2- Top of casing elevation	TBD
3- Wellhead protection cover type	8" x 12" steel monument
a) concrete pad dimensions	20" diameter
4- Dia./type of well casing	2" Schedule 40 PVC
5- Type/slot/size of screen	2" Schedule 40 PVC 0.010" screen
a) End cap	2" D x 4" L threaded end cone
6- Type of screen filter	Premier Colorado Silica Sand 12/20
7- Type of seal	Baroid Casing Seal
Development method	See Development Sheet
Development time	See Development Sheet
Estimated purge volume	See Development Sheet

Comments

PROJECT NUMBER	SHEET 1 OF 1 WELL ID

RISER WELL COMPLETION DIAGRAM

PROJECT/CLIENT:		**LOCATION :**	
DRILLING CONTRACTOR:			
DRILLING METHOD AND EQUIPMENT USED:			
WATER LEVEL:	**START :**	**END :**	**LOGGED BY:**



1- Ground elevation at well	TBD
2- Top of casing elevation	TBD
3- Wellhead protection cover type	8" x 48" steel riser
a) concrete pad dimensions	20" diameter
4- Dia./type of well casing	2" Schedule 40 PVC
5- Type/slot/size of screen	2" Schedule 40 PVC 0.010" screen
a) End cap	2" D x 4" L threaded end cone
6- Type of screen filter	Premier Colorado Silica Sand 12/20
7- Type of seal	Baroid Casing Seal
Development method	See Development Sheet
Development time	See Development Sheet
Estimated purge volume	See Development Sheet

Comments

WELL DEVELOPMENT FORM

PROJECT NO: **SITE ID:** **WELL ID:** **SHEET of**

PROJECT NAME	WELL CONSTRUCTION DATA		BOREHOLE VOLUME FACTORS [BVF]			
CLIENT	TIME/DATE WELL COMPLETED		CASING MATERIAL	CASING I.D. (in)	BOREHOLE DIAMETER (in)	CV / BVF (gal/lin ft)
	AS-BUILT TOTAL DEPTH OF WELL (ft BTOC)		1" Sch40 PVC	1.049	4.5	0.041 / 0.279
EVENT	CASING MATERIAL AND DIMENSIONS		2" Sch40 PVC	2.067	4.5	0.163 / 0.370
DEVELOPER(S)	SCREEN LENGTH (ft) /SCREEN TYPE		2" Sch40 PVC	2.067	6	0.163 / 0.370
WEATHER/ TEMPERATURE	DEPTH TO TOP FILTER PACK (ft BTOC)/FILTER PACK TYPE		2" Sch40 PVC	2.067	8	0.163 / 0.370
DATE	DEPTH TO WATER AT TIME OF DRILLING (ft BTOC)		2" Sch40 PVC	2.067	10	0.163 / 0.370
START TIME	HEIGHT OF WATER COLUMN AT TIME OF DRILLING (ft)		4" Sch40 PVC	4.026	8	0.653 / 0.370
END TIME	BOREHOLE DIAMETER (in)		4" Sch40 PVC	4.026	10	0.653 / 0.370
TOTAL PURGE VOLUME	VOLUME OF WATER ADDED DURING DRILLING (gal)		All BVF calculations assume a filter pack porosity of 0.3.			

PRE-PURGE DEVELOPMENT DATA

PURGING EQUIPMENT:
(PUMP TYPE AND MATERIAL, OTHER APPARATUS)

IF PRODUCT IS PRESENT	
DEPTH TO PRODUCT (ft FROM TOC):	THICKNESS OF PRODUCT (ft):
PRODUCT DESCRIPTION:	

EQUIPMENT DECON PROCEDURE: ______________________ PURGE WATER DISPOSAL METHOD: ______________________

EQUIPMENT SERIAL NUMBERS: TURBIDIMETER OTHER

PRE-PURGE WATER COLUMN OBSERVATIONS AND RECOVERY CALCULATIONS

DEPTH TO WATER (ft BTOC)	
TOTAL DEPTH (ft BTOC)	
HEIGHT OF WATER COLUMN (ft)	
80% HEIGHT OF WATER COLUMN (ft)	
80% HEIGHT OF WATER COLUMN (ft BTOC)	
DROWNED SCREEN?	

PURGE VOLUME CALCULATIONS

For screen across the water table: Borehole + Casing Volume (BV) = [Casing Total Depth - Depth to Water] * BVF	For a drowned screen: Borehole + Casing Volume (BV) = [Casing Total Depth - Depth to Top Filter Pack]* BVF	For borehole volume factors (BVF), see uppermost section on the right side of this form, above.
BOREHOLE VOLUME (BV, gal) Calculated using the appropriate formula above.		
Casing Volume (CV, gal)		
3X Casing Volume (CV, gal) Recommended minimum purge vol.		

PURGE DATA

ACTIVITY [SURGE, PURGE, RECOVERY]	TIME	WATER LEVEL (ft BTOC)	DRAW DOWN (ft)	TOTAL DEPTH (ft BTOC)	PURGED VOLUME (gallons or liters) THIS CYCLE	PURGED VOLUME (gallons or liters) CUMULATIVE	TURBIDITY (Qualitative or NTU)	NOTES [Flow data: pump intake depth, approximate flowrate, purged dry] [Water quality: color, odor, sheen, sediment in purge water or at TD]

WELL DEVELOPMENT FORM

PROJECT NO: **SITE ID:** **WELL ID:** **SHEET of**

ADDITIONAL PURGE DATA

ACTIVITY [SURGE, PURGE, RECOVERY]	TIME	WATER LEVEL (ft BTOC)	DRAW DOWN (ft)	TOTAL DEPTH (ft BTOC)	PURGED VOLUME (gallons or liters)		TURBIDITY (Qualitative or NTU)	NOTES [Flow data: pump intake depth, approximate flowrate, purged dry] [Water quality: color, odor, sheen, sediment in purge water or at TD]
					THIS CYCLE	CUMULATIVE	IDEAL <50 NTU	

STABILIZATION DATA

START TIME: **END TIME:** **TOTAL VOLUME PURGE (GAL):** **STABILITY ACHIEVED: Y / N**

STABILIZATION EQUIPMENT:

(PUMP TYPE AND MATERIAL, OTHER APPARATUS)

PURGE WATER DISPOSAL METHOD:

EQUIPMENT DECON PROCEDURE

PUMP INTAKE DEPTH: (ft BTOC or ft BTOW)

MAX FLOWRATE: (mL/min or gal/min)

STABILIZE DRAWDOWN AT THIS FLOWRATE?

DEDICATED TUBING LEFT?

EQUIPMENT SERIAL NUMBERS: **YSI** **TURBIDIMETER** **OTHER**

CONVERSIONS: 1000 mL/min = 0.264 gal/min 1 gal/min = 1893 mL/min 1 gal = 3.785 L 1 L = 0.264 gal

FIELD WATER QUALITY PARAMETERS

TIME	WATER LEVEL (ft BTOC)	DRAW DOWN (ft)	CUMULATIVE PURGED VOLUME (gallons or Liters)	TEMPERATURE (°C or °F)	pH	CONDUCTIVITY (µS/cm)	ORP (mV)	D.O. (mg/L)	TURBIDITY (NTU)	COLOR	ODOR
				± 3% (min ± 0.2°C/0.36°F)	± 0.1	± 3%	± 10 mV	± 10%	± 10% or <10 NTU		

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 / Geo 7X 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/Geo 7X 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 or Geo 7X. Both units are considered 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, after post-processing. The Geo 7X is also a dual frequency, differential GPS, but capable of logging precise carrier phase measurements and has 1-10 cm accuracy capabilities, after post-processing. A GeoXH or Geo 7X, both running Windows Mobile with Trimble Terrasync software, may be utilized, depending on accuracy requirements.

GPS uses 24 satellites and their associated ground stations to form a world-wide radio-navigation system. The GPS receiver (the handheld GeoXH/Geo 7X) determines the relative positions of features by using the geometry of intersecting ranges (space resection) 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 to achieve the rated accuracies.

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/Geo 7X 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/Geo 7X handheld unit
- External Tornado or Zephyr 2 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/Zephyr 2 antenna (if necessary). The internal antenna is suitable for many conditions; the Tornado/Zephyr 2 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/Zephyr 2." If using the internal, choose "Internal."
  - Confirm: Choose how often to ask the antenna height (user preference).
  - Type: If using the external, choose "Tornado/Zephyr 2." 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/Geo 7X – points, lines, and areas.
2. To collect a point, place the GeoXH/Geo 7X unit or external antenna mounted on a survey rod 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/Geo 7X including offsets, background files, setting waypoints and navigating, using data dictionaries, taking photographs, and more. To use these features, refer to the GeoXH/Geo 7X User's Manual.

3.3 Download Data

Connect the GeoXH/Geo 7X 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/Geo 7X 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/Geo 7X.

TABLE 1: GEOXH / GEO 7X 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.

Trimble. 2017. Geo 7 Series *User Guide*. Revision F. Version 1.00 May.

STANDARD OPERATING PROCEDURE

BE-SOP-51

Material Handling/ Manual Lifting

1.0 INTRODUCTION

This Standard Operating Procedure (SOP) describes the procedures that will be used 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. After determining an 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 support base 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.

It is important to identify when materials require lifting equipment, such as slings and chokers, and to determine the proper equipment to assist in lifting the object 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) applies to all individuals operating motorized vehicles for work.

2.0 DRIVER SAFETY AND POLICIES

Statistics show that many accidents involve company vehicles. The purpose of this SOP is to avoid injuries, possible loss of life, and costs related to accidents involving company vehicles.

2.1 Company Auto Usage Policies

The following policies are applicable to company vehicles:

- Company vehicles are for company business only and must be driven by active employees (unless permission is given by a supervisor) who are appropriately licensed, certified, and/or trained for the vehicle that they are operating.
- Vehicles must be maintained in good operating condition. A vehicle inspection form should be completed daily for vehicles used on project sites. Any noted deficiencies should be corrected as soon as possible.
- Drivers must conduct a complete safety walk-around prior to entering the vehicle.
- Occupants must 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 using 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

Company site personnel and subcontractors are required to immediately report all incidents or near misses to their immediate supervisor, SSHO, and/or Site Superintendent. The SSHO/Site Superintendent will evaluate the incident, determine if an emergency exists, and direct response activities as necessary. If necessary, injured workers will be accompanied to the medical facility by the SSHO or Project Manager for proper case management.

After rendering first aid or summoning emergency services and securing the accident scene, all accidents will be immediately reported as required by the SSHO or Site Superintendent to the Company Project Manager and Company Safety Manager, who will then contact applicable Client Representatives, security personnel, law enforcement or any other involved parties.

The SSHO/Superintendent will then complete and submit an Initial Notice of Incident (and Immediate Report of Accident USACE Form POD 265 for USACE projects) to the Company Safety Manager, Project Manager, and USACE or client representatives within 24-hours of any incident or near miss.

STANDARD OPERATING PROCEDURE

BE-SOP-59

Site Traffic

1.0 INTRODUCTION

This standard operating procedure (SOP) applies to all individuals working in and around roadways while conducting job related activities that may need to set up work zones as protection from vehicular traffic. It also applies to 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 required:

- 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 should be made prior to commencing 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 the 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) describes safe working practices that should be followed by all individuals working 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 power sources and the pressure 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 the *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 Site-Specific Health and Safety 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. *Safety and Health Requirements Manual*. EM385-1-1. November.