Summer 6-14-2022

Draft Final BPSOU Subdrain Pump Station Remedial Design (RD) Work Plan

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June 14, 2022

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RE: Draft Final BPSOU Subdrain Pump Station Remedial Design (RD) Work Plan

Agency Representatives:

I am writing to you on behalf of Atlantic Richfield Company to submit the *Draft Final BPSOU Subdrain Pump Station Remedial Design (RD) Work Plan*. The report and appendices may be downloaded at the following link:

https://pioneertechnicalservices.sharepoint.com/:f:/s/submitted/El-HqJFKpfVDvScmLTnpVVkBS6qnsl-2EqPJu3dBf21lHw.

If you have any questions or comments, please call me at (406) 723-1834.

Sincerely,

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An affiliate of **Atlantic Richfield Company**

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SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

Draft Final

BPSOU Subdrain Pump Station Remedial Design (RD) Work Plan

Atlantic Richfield Company

June 2022

SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

Draft Final

BPSOU Subdrain Pump Station Remedial Design (RD) Work Plan

Prepared for:

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Prepared by:

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June 2022

APPROVAL PAGE

Silver Bow Creek/Butte Area NPL Site
BPSOU Subdrain Pump Station Remedial Design Work Plan

Approved: ______________________________ Date: ________
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Approved: ______________________________ Date: ________
Daryl Reed, Project Officer, Montana DEQ

Approved: ______________________________ Date: ________
Josh Bryson, Liability Manager
Atlantic Richfield Company

Approved: ______________________________ Date: ________
David Gratson, Quality Assurance Manager
Environmental Standards, Inc.

Plan is effective on date of approval.

DISTRIBUTION LIST

Silver Bow Creek/Butte Area NPL Site
BPSOU Subdrain Pump Station Remedial Design Work Plan

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DOCUMENT MODIFICATION SUMMARY

Modification No.	Author	Version	Description	Date
Rev 0	Andy Dare	Draft Final	Issued for Agency Review	June 2022

ACRONYMS

Term	Definition
ARAR	Applicable or Relevant and Appropriate Requirements
Atlantic Richfield	Atlantic Richfield Company
BPSOU	Butte Priority Soils Operable Unit
BRW	Butte Reduction Works
BSB	Butte-Silver Bow
BTC	Blacktail Creek
BTL	Butte Treatment Lagoons
CCR	Construction Completion Report
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DEQ	Montana Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
HDPE	High-density polyethylene
HSSE	Health, Safety, Security, and Environment
LAO	Lower Area One
NPL	National Priorities List
OM&M	Operation, Maintenance, and Monitoring
PDI	Pre-design Investigation
Pioneer	Pioneer Technical Services, Inc.
QA	Quality Assurance
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA	Remedial Action
RACCR	Remedial Action Construction Completion Report
RAWP	Remedial action work plan
RD	Remedial Design
RDWP	Remedial Design Work Plan
SBC	Silver Bow Creek
SD	Settling Defendants
SOW	Scope of Work
SSHASP	Site-Specific Health and Safety Plan
UAU	Upper Alluvial Unit

1.0 INTRODUCTION

This Site-specific Butte Priority Soils Operable Unit (BPSOU) Subdrain Pump Station (referred to herein as Site) Remedial Design (RD) Work Plan (RDWP) provides the framework for developing design documents for the proposed reconstruction of the Site to provide redundant capacity for post-remedy influent flow and eliminate unnecessary confined space. The location of the Site and relevant remedy infrastructure in BPSOU can be seen on Figure 1.

This RDWP has been developed consistent with applicable U.S. Environmental Protection Agency (EPA) guidance and decision documents, including the following:

- *Consent Decree* (CD) *for the BPSOU. Partial RD/Remedial Action* (RA) *and Operation and Maintenance* (O&M) (referred to herein as BPSOU CD) (EPA, 2020).
- *RD/RA Handbook*, EPA 540/R- 95/059 (EPA, 1995).

This RDWP includes the following items:

1. Descriptions of the areas requiring clarification and/or anticipated problems (e.g., data gaps) (Section 2.0).
2. Description of the proposed Pre-Design Investigation (PDI) (Section 2.0).
3. A PDI Work Plan (Section 2.1 and Attachment 1).
4. Descriptions of the applicable permitting requirements and other regulatory requirements (Section 2.4).
5. Plans for implementing all the RD activities identified in the remedial elements scope of work (SOW) that will be required to develop the RD (Section 3.0).
6. A description of the overall management strategy for performing the RD, including a proposal for phasing of design and construction, if applicable (Section 3.0).
7. A description of the proposed general approach to contracting, construction, operation, maintenance, and monitoring of the RA (Section 3.0).
8. A description of the responsibility and authority of all the organizations and key personnel involved with the development of the RD (Section 4.0).

1.1 Supporting Documents

This RDWP provides the overview of the RD work and is supported by the following documents:

- Site PDI Work Plan. *The PDI Work Plan evaluates existing data and addresses data gaps that are necessary for completing the RD (Attachment 1).*
- Quality Assurance Project Plan (QAPP) for the Site. The QAPP presents the quality assurance/quality control (QA/QC) protocols to be followed during field data collection and laboratory analytical efforts. The QAPP is included with the PDI Work Plan (Attachment 1).

1.2 Site Description

The Silver Bow Creek (SBC)/Butte Area National Priorities List (NPL) area is located in the upper Clark Fork River watershed and includes portions of Butte and Walkerville, Montana. The United States EPA designated the original SBC area as a Superfund site in September 1983 under the authority of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In 1987 EPA expanded the SBC area to include the Butte Area. The NPL consists of seven active operable units including the BPSOU.

The Butte Treatment Lagoons (BTL) system, located in Lower Area One (LAO) of the BPSOU, was originally constructed as described in the *LAO Phase I Construction Report* (Anderson, 2002) and modified in 2001 to 2002 as described in the *Draft LAO Construction Completion Report (CCR) for the Field Scale Treatability Study Modifications* (Atlantic Richfield Company, 2002), and then upgraded again under the *LAO 2004 Colorado Tailings Lagoon Modifications* (Atlantic Richfield Company, 2004). Recent improvements to the LAO and BTL system were completed according to the *Draft Final Design Report/Work Plan for the Metro Storm Drain (MSD) and Butte Reduction Works (BRW) Upgrades* (Atlantic Richfield Company, 2008), the *Final 2010 BRW East End Grading Work Plan* (Atlantic Richfield Company, 2010a), the *Draft Final 2010 MSD Discharge Line Remote Monitoring Station Work Plan* (Atlantic Richfield Company, 2010b), the *Final BTL and West Camp Pump Station (WCP-1) Upgrades Design Report/Work Plan* (Atlantic Richfield Company, 2011), and the *Final MSD Pump Station Upgrade Work Plan* (Atlantic Richfield Company, 2014). The channel (originally referred to as the MSD) is now referred to as SBC above the confluence with Blacktail Creek (BTC) and the subdrain (originally referred to as the MSD Subdrain) is now referred to as the BPSOU subdrain (subdrain). The purpose of the subdrain and BTL is the protection of adjacent surface water (BTC and SBC) through capture and treatment of groundwater impacted with contaminants of concern.

The SBC above the confluence with BTC consists of 2 independently operating components: the creek channel and the subdrain system. The primary objective of the subdrain system is to intercept groundwater from the surrounding alluvial aquifer and separate it from wet weather surface water flow in the surface channel, which is lined with a geosynthetic clay liner. Intercepted groundwater flow collected in the subdrain is pumped by 2 centrifugal pumps from the Site (located at 1000 George Street, across from the Butte Chamber of Commerce) through 2, 8-inch diameter high-density polyethylene (HDPE) discharge lines to the BTL (Figure 1). Although designed to operate at a maximum capacity of 680 gallons per minute, the actual flow rate transferred to BTL depends upon the seasonal conditions and is varied to maintain an operating elevation setpoint below the maximum operational water elevation within the concrete wet vault. A detailed discussion of the subdrain and base flow delivery system is available in the *Draft Horseshoe Bend Effluent Pipeline/MSD CCR* (Atlantic Richfield Company, 2006).

1.2.1 Climate

The Butte area climate is characterized by short, cool, dry summers and long, cold winters. The annual precipitation in Butte generally varies from 8 to 20 inches per year, with an average of 13 inches. The greatest amount of precipitation, approximately one-third, occurs during the months of May and June (obtained from the National Oceanic and Atmospheric Administration website at https://www.ncdc.noaa.gov/cdo-web/search for 1990 to 2019, excluding 2014 for which there was insufficient data) (NOAA 2020).

1.2.2 Topography

The Site is located in the east-central portion of the BPSOU at approximately 5,459 feet above mean sea level. The general slope of the terrain is relatively flat and sloping north from George Street towards SBC above the confluence with BTC for the majority of the Site. The north boundary of the Site is the creek channel, and the south boundary is George Street.

1.2.3 Geology

The Butte area lies within the Summit Valley of southwest Montana and is characterized by Quaternary alluvium surrounded by the Butte Quartz Monzonite of the Cretaceous Boulder Batholith (MBMG, 2004). The Site is underlain by native alluvium (gravel, sand, silt, and clay) deposited through centuries of morphologic stream action. The alluvium and older alluvium deposits are of decomposed granite, quartz, feldspar, and biotite with rounded pebbles of aplite and quartz. The alluvium includes terrace and glacial deposits of the Pleistocene age. The older alluvium consists of light orange to tan coarse clay, sand, silt, and gravel, with interbedded light brown clay layers and infrequent occurrence of cobbles and boulders (MBMG, 2009).

1.2.4 Groundwater

The groundwater beneath the Site flows through an alluvial aquifer that is bounded at depth by bedrock. The alluvial aquifer is comprised of groundwater flowing through intermixed layers of clay, silt, sand, and gravel-sized alluvial material. Groundwater travels through the aquifer via the small, interconnected pore spaces between the alluvial material grains. Recent investigations of the alluvial groundwater system identified 3 general depths of conductive alluvium within the SBC above the confluence with BTC drainage basin: the Upper Alluvial Unit (UAU), the Middle Alluvial Unit, and Lower Alluvial Unit. Well logs in the area of the Site (e.g., BPS07-21C, BPS07-22C) reflect this general aquifer structure. The UAU is the alluvial unit of most relevance to this RDWP because it is nearest to the surface, ranging in depth from a few feet to approximately 35 feet below ground surface in the Site area. Groundwater in the UAU generally flows to the west and northwest through the Site and is predominantly captured within the subdrain.

1.2.5 Surface Water

The Site is bounded to the south by BTC and to the north by SBC above the confluence with BTC. The SBC above the confluence with BTC is an engineered channel with a primary purpose as a storm water conveyance channel that receives storm water runoff from the East Buffalo Gulch, Warren Avenue, Anaconda Road, Butte Civic Center, and Texas Avenue areas, in addition to other sub-drainage inputs to the north and east of the channel.

1.3 Background

As described in Section 1.2, the Site is located at 1000 George Street within the BPSOU, Butte, Montana. The project is part of the final remedy for BPSOU that includes excavation and disposal of historic mine waste from the BTC and SBC riparian corridors; construction of storm water detention and retention basins; relocation and reconstruction of SBC; capping of waste left in place; optimization and expansion of the Groundwater Remedy; and construction of End Land Use additions and amenities. Known collectively as the SBC Conservation Area (SBCCA), work will also include completion of limited components of Ongoing Remedial Elements and select Further Remedial Elements as described within Attachment B.1 and Attachment C to Appendix D of the BPSOU CD. End Land Use additions will be constructed according to Addendum 1 to Attachment C of Appendix D of the BPSOU CD as generally depicted within the SBCCA Master Plan.

Construction for the original Site and pipeline began in October 2003 and was completed in September 2005. From April 2005 through mid-2008, the original wet vault had been configured as a lift station to pump water from the terminus of the subdrain to the BTL; however, it was determined that the existing pump system was undersized for the flow requirements and operating environment. The system was modified and upgraded in 2008. Upgrades included a revised pumping system located in a separate concrete dry vault, remote monitoring capabilities, increased accessibility, and system design elements to allow continuous operation in certain adverse conditions. In 2010, further upgrades were performed to optimize the pumps and associated discharge piping. Related Site upgrades were also included to address specific requests provided by the Agencies and Butte-Silver Bow (BSB) including security and parking (Atlantic Richfield Company, 2019). The second 8-inch diameter HDPE discharge line to BTL was installed in 2015 together with a pig launcher and discharge manifold located in a new below-grade concrete vault.

The Ongoing Remedial Elements Statement of Work requires the Atlantic Richfield Company (Atlantic Richfield) to evaluate the performance, capacity, and opportunities for optimization of the existing groundwater collection and treatment system. Among other work on the remedy system, this will include reconstruction of the Site to provide redundant capacity for post-remedy influent flow and eliminate unnecessary confined space.

2.0 DESIGN SUPPORT ACTIVITIES

This section describes the pre-design activities including filling data gaps, evaluating treatability, outlining permitting requirements, outlining access plans (per EPA Guidance Items 1 through 6 [Section 1.0]).

2.1 Pre-Design Investigation

The Site has been characterized to some degree by the previous construction activity including 2007 and 2013 geotechnical characterization; however, more detail is needed to support the proposed RD. The investigation will include the following activities to refine the extent and characterization of the existing subgrade materials. Details of the PDI are included in the PDI

Work Plan in Attachment 1, and specific details of the soil data from the prior geotechnical investigations are included. This section provides an overview of the key points in the PDI.

The PDI Work Plan identifies the general activities that will be completed to refine the geotechnical characterization of subgrade materials within the Site. Fieldwork is anticipated to begin in July 2022. The focus of the PDI is to complete a geotechnical investigation. Test pits will be excavated at the proposed parking area location and a Geoprobe will be used to drill boreholes, perform Standard Penetration Tests, and obtain soil samples for field testing and laboratory analyses in areas where the new building and wet well are likely to be located. During the investigation, a geotechnical engineer from Pioneer Technical Services, Inc. (Pioneer) will log soil lithology, visually classify the soil in the field, and collect soil samples for laboratory testing.

2.2 Data Gaps

For the pre-investigation work, the design team reviewed existing data and documents with the objective of identifying the data needed to support the RD. The review found that additional data collection was needed to fill the following data gaps:

- The existing topographical survey data for the project area are Light Detection and Ranging. To ensure design accuracy and avoid potential datum conflicts, the design team proposes that a topographical survey be conducted at the Site. It is anticipated that a Real Time Kinematic total station method will be used with an expected 0.5-foot contour break.
- Inventory the locations and properties of utilities and infrastructure that might be on or adjacent to the Site that will need to be avoided, removed, or replaced during construction.
- Determine geotechnical parameters related to the removal and replacement of existing infrastructure, subgrade stability for construction of new infrastructure, and design of finished grade.

2.3 Treatability Study

A treatability study is not applicable to this RD. Additional data from a laboratory or field test are not needed to evaluate and support the proposed upgrade of previously implemented technology. As previously described, Atlantic Richfield currently operates the existing Site that conveys intercepted groundwater to BTL for treatment.

A geotechnical characterization of existing subgrade materials will be completed to accurately determine the engineering characteristics and suitability of Site soil for proposed construction activities.

2.4 Permitting/Regulatory Requirements

In accordance with CERCLA Section 121[e][1], Applicable or Relevant and Appropriate Requirements (ARARs) associated with administrative requirements, such as permitting, are not applicable to CERCLA on-Site activities. In general, the CERCLA permitting exemption will be extended to all remedial activities conducted in the BPSOU. The RD for the Site will incorporate the substantive environmental permitting and regulatory requirements; in particular, the action-specific ARARs identified in the Record of Decision (EPA, 2006) and the relevant requirements in the BSB *Municipal Storm Water Engineering Standards* (BSB, 2020). The exact requirements will be detailed in the forthcoming design documents.

2.5 Access Plan

Atlantic Richfield owns the Site property. If Atlantic Richfield needs access to adjacent private property to complete the RA-related activities, Atlantic Richfield will request that all private property owners grant access to their properties for all RA-related activities. Atlantic Richfield and/or its representatives will maintain copies of completed agreements received from property owners. Completed agreements will be photocopied and scanned with the electronic version stored on a network server.

2.6 Schedule

The proposed schedule for deliverables outlined in this RDWP is specified in Attachment 2.With Agency approval, the PDI field efforts are scheduled to begin in July 2022. Effective, open communications will be critical to achieving timely completion of the project. As such, periodic meetings between EPA and Atlantic Richfield will be scheduled to discuss the status of ongoing efforts, upcoming events, and deliverables and to resolve any issues that may arise. Because of the uncertainty associated with the schedule for several tasks that are out of Atlantic Richfield’s control (e.g., seasonal constraints, EPA review periods, the need to fill data gaps, etc.), the schedule lists important deliverables and design activities relative to key milestones and other conditions.

A preliminary (30%) RD document is in development by Pioneer and will be submitted for review in summer 2022. Meetings and discussions of the 30% design will be completed as needed until agreement is reached on the conceptual design. Once agreement is reached on the preliminary 30% design, intermediate (60%) and pre-final (95%) design documents will be completed and subsequently submitted for Agency review and approval. This iterative approach fosters collaboration between all parties involved. The proposed schedule has a goal of beginning the remediation work in summer 2024 and finishing in 2025. A final RA CCR (RACCR) will be submitted to the Agencies within 60 days of the final inspection.

3.0 REMEDIAL DESIGN OVERVIEW

The design will be detailed in the preliminary (30%), intermediate (60%) and pre-final (95%) documents. These design documents will be supported by the results of the PDI to fill data gaps. The design documents will include the design drawings and technical specifications. Because the RD construction design documents will be developed with input from EPA, Montana Department of Environmental Quality (DEQ), and BSB though an iterative process, only a high-level overview is provided in this RDWP. The RD will include at a minimum, the following elements:

1. Site Controls (plot plans, existing topography and survey control, construction fencing, temporary traffic control, construction staging and field office areas, construction storm water management, etc.).
2. Site Excavation (horizontal and vertical extents, salvage and stockpile, laybacks, shoring and sheet pile placement, dewatering, etc.).
3. Site Backfill and Grading (Site backfill and reconstruction, general fill and subbase placement, and rough grading).
4. Engineered Covers (placement, grading, and amendment).
5. Hydraulic Features (including concrete wet well and bypass structures, pumps, valves, piping, and appurtenances, etc.).
6. Architectural (building structure including mechanical, plumbing, and electrical).
7. Instrumentation and Controls (including piping and instrumentation, logic, controls, panels, etc.).
8. Civil Infrastructure (water, sanitary sewer, storm sewer, Site electrical and lighting, curb and gutter, parking lot and access road improvements, etc.).
9. Institutional Controls (signage, fencing, and agreements).

3.1 Management Strategy

The general management strategy is for Atlantic Richfield to manage the Site design using one design engineer and one contractor for the RD and implementation of the RA. All design documents will be submitted to and reviewed and approved by EPA and Montana DEQ. Atlantic Richfield will implement the Site RD and RA as outlined in the Section 2.6. Details on the organizational structure, roles, and responsibilities are provided in Section 4.0. Data management procedures are provided in the QAPP (Attachment 1).

4.0 PROJECT ORGANIZATION

This section provides descriptions of the responsibility and authority of key organizations and personnel involved with developing the RD (EPA Guidance Item 4 [Section 1.0]).

4.1 Key Organizations

The key organizations and their roles and responsibilities are listed below.

4.1.1 Environmental Protection Agency

In the SBC/Butte Area NPL area, EPA is the lead agency for RD/RA efforts by Settling Defendants (SDs) (Atlantic Richfield and BSB). Communications with Atlantic Richfield, Montana DEQ, and BSB will be led by EPA, then EPA will review and authorize this RDWP and the associated preliminary (30%), intermediate (60%), pre-final (95%), and final (100%) RDs and RA work plans (RAWP). During construction EPA may participate in pre-construction Site walks, and pre-final and final inspections. EPA will attend the weekly progress meetings and review daily construction reports provided by Atlantic Richfield via email and will communicate any concerns or questions to Atlantic Richfield. EPA will also provide QA oversight to ensure the RD is being implemented as designed and approved. EPA will also review and approve the final project RACCR.

4.1.2 Montana Department of Environmental Quality

The Montana DEQ is the state Agency for review of RD/RA efforts by SDs in the SBC/Butte Area NPL area. The Montana DEQ will review and provide comments to EPA on the associated preliminary (30%), intermediate (60%), pre-final (95%), and final (100%) RDs and RAWPs. During construction, the Montana DEQ may participate in technical meetings, pre-construction Site walks, and pre-final and final inspections. The Montana DEQ will attend the weekly progress meetings and review daily construction reports provided by Atlantic Richfield via email and will communicate any concerns or questions to EPA.

4.1.3 Atlantic Richfield Company

Atlantic Richfield manages, funds, and performs the project RD and RA construction. Atlantic Richfield will administer the contract and monitor the overall progress of RD and RA activities conducted under the project and will be the primary authority regarding interpretation of the project requirements.

4.1.4 Butte-Silver Bow

The BSB City-County is the local agency for coordination and review of RD and RA efforts conducted in the SBC/Butte Area NPL area. A BSB representative will review and provide comments to EPA on the associated preliminary (30%), intermediate (60%), pre-final (95%), and final (100%) RDs and RAWPs. Once the project is complete, long-term Operation, Maintenance, and Monitoring (OM&M) activities will be turned over to BSB.

4.1.5 Pioneer Technical Services, Inc.

Pioneer is the Atlantic Richfield engineer for investigation and preliminary design activities at the Site. Pioneer will be responsible for administering subcontracts for the necessary remaining professional services including, but not limited to, architectural design, instrumentation and control design, electrical design, and landscape architecture. Pioneer developed this RDWP and associated PDI Work Plan in Attachment 1. Pioneer will also develop the associated preliminary (30%), intermediate (60%), pre-final (95%), and final (100%) RDs, the RAWP, and bid documents.

4.1.6 Construction Contractor

The selected contractor will be responsible for executing the project in strict compliance with the RD, RAWP, and technical specifications. The contractor will have primary responsibility for project safety, construction activities, subcontractor management, daily project documentation, and reporting, and the construction QC measures associated with implementing the RA. Atlantic Richfield will select the contractor and inform EPA of its choice prior to starting the project. Pioneer will serve as QA contractor on behalf of Atlantic Richfield to oversee construction activities.

The contractor will be responsible for attending weekly progress meetings, providing required status reports and two-week look-ahead schedules, and discussing any construction issues that occur or may occur.

4.1.7 Contract Laboratory

The Contract Laboratory will ensure that the laboratory QA personnel are familiar with the QAPP (Attachment 1) and are available to perform the work as specified. Contract Laboratory personnel will be responsible for reviewing final analytical reports produced by the laboratory, scheduling laboratory analyses, and supervising in-house chain of custody procedures.

4.2 Key Personnel

Key personnel and their roles and responsibilities for the site are listed below. During construction activities, EPA, Montana DEQ, Atlantic Richfield, and the contractor(s) will be coordinating or attending (as necessary) technical meetings, pre-construction Site walks, weekly progress meetings, and pre-final and final inspections.

4.2.1 EPA Project Manager

Mr. Nikia Greene is EPA remedial project manager for this work. Mr. Greene is based in EPA Region 8 office in Helena, Montana. He will be the primary contact for EPA and ensure that RDs and RAs comply with the Agency RD/RA SOW. Mr. Greene will be responsible for review and approval of this RDWP and the preliminary (30%), intermediate (60%), pre-final (95%), and final (100%) RDs and RAWP. During construction Mr. Greene will be responsible for providing construction oversight on behalf of EPA.

4.2.2 DEQ Project Manager

Mr. Daryl Reed is the Montana DEQ project officer for this work. Mr. Reed is based in the Montana DEQ Remediation Division office located in Helena, Montana. He will be the primary contact for Montana DEQ and ensure that RDs and RAs comply with the Agency RD/RA SOW. Mr. Reed will be responsible for review and approval of this RDWP and the preliminary (30%), intermediate (60%), pre-final (95%), and final (100%) RDs and RAWP on behalf of the Montana DEQ.

4.2.3 Atlantic Richfield Project Manager

The Atlantic Richfield liability manager is Mr. Josh Bryson. Mr. Bryson is responsible for overall programmatic planning for technical and administrative components of RD and RA work completed by Atlantic Richfield. Mr. Bryson will be the primary technical point of contact for EPA, Montana DEQ, BSB, and the project engineer and contractor.

4.2.4 Atlantic Richfield Quality Assurance Manager

The Atlantic Richfield QA Manager (QAM) for the project is Mr. David Gratson. Mr. Gratson will interface with the Atlantic Richfield liability manager on company policies regarding quality and has the authority and responsibility to approve QA documents specific to the project.

4.2.5 Pioneer Project Manager

Atlantic Richfield will contract directly with Pioneer who will serve as the Atlantic Richfield Representative for the investigation and pre-design phases of the project. Pioneer's project manager for Atlantic Richfield is Mr. Andy Dare, P.E. Mr. Dare will be responsible for ensuring the PDI Work Plan (Attachment 1) is implemented and will coordinate all project-specific assignments and provide overall project direction to the Pioneer team. Mr. Dare will be the primary contact for Atlantic Richfield. He was responsible for developing this RDWP and will also be responsible for the preliminary (30%), intermediate (60%), pre-final (95%), and final (100%) RDs and RAWP.

4.2.6 Field Team Leader

The Field Team Leader for the geotechnical investigation will be Mr. Caleb Gillis. Mr. Gillis will ensure that all members of the field team review and follow the project QAPP (Attachment 1) when implementing field activities. The Field Team Leader will also be responsible for maintaining the QAPP. The Field Team Leader will conduct daily safety meetings, assist in field activities, and document activities in the logbook. The Field Team Leader will be responsible for equipment coordination, problem solving, and decision making in the field for technical aspects of the project. Additionally, the Field Team Leader will provide "on-the-ground" overviews of project implementation by observing Site activities to ensure compliance with technical project requirements; Health, Safety, Security, and Environment (HSSE) requirements; and the Site-Specific Health and Safety Plan (SSHASP). Finally, the Field Team Leader will identify potential integrity management issues, as appropriate, and prepare required project documentation.

4.2.7 Quality Assurance Officer

The QA Officer (QAO), Mr. Mike Browne, P.E., from Pioneer, will be responsible for reviewing field and laboratory data and evaluating data quality during investigation and pre-design activities. He will also conduct on-Site reviews and prepare Site review reports for the QAM.

4.2.8 Project Safety and Health Manager

The Safety and Health Manager, Ms. Tara Schleeman from Pioneer, will conduct the initial safety meeting prior to starting investigation fieldwork. Ms. Schleeman will ensure that work crews comply with all health and safety requirements and revise the project SSHASP, if necessary. In addition, she will be responsible for safety and health reviews during the preliminary (30%) and intermediate (60%) RD process to identify any potential safety concerns associated with implementation and assure that HSSE requirements are met during the design process.

5.0 REMEDIAL DESIGN DELIVERABLES

This section describes the major reporting deliverables for the RD and construction.

5.1 Remedial Design Documentation

Atlantic Richfield will submit a preliminary (30%), intermediate (60%), pre-final (95%), and final (100%) RD for EPA's comment, in consultation with Montana DEQ. Each RD document will contain the components listed in the BPSOU CD. The following sections detail what each of the RD documents will contain.

Preliminary (30%) RD. The preliminary RD will include the following:

1. Design report with design criteria and basis of design included, as described in the RD/RA Handbook, EPA 540/R-95/059 (EPA, 1995). The RD report will include, but not be limited to, the following:
    a. Project description.
    b. Evaluation of how ARARs will be met.
    c. Design requirements including, but not limited to, BPSOU Statement of Work requirements (BPSOU CD), RA Objectives, and RA Levels.
    d. Design assumptions including, but not limited to, pump selection, building and wet well siting, intake and discharge piping construction, dewatering design, site grading, and immediately adjacent civil infrastructure (exterior lighting, curb and gutter, and parking lot).

    e. Design approach including, but not limited to, pump system design, building and wet well design, backfill and Site grading, cap and re-vegetation, and immediately adjacent landscape design.
    f. Description of permit requirements, if applicable, and plans to address substantial requirements of permits.
    g. Description of monitoring and control measures to protect human health and the environment, such as air monitoring and dust suppression, during the RA.
    h. Description of how the RA will be implemented in a manner that minimizes environmental impacts in accordance with *EPA's Principals for Greener Cleanups* (EPA, 2009).
2. Preliminary drawings, including but not limited to the following:
    a. Pump Station building and wet well location in plan and cross-section view.
    b. Pump system design including intake and discharge piping design.
    c. Backfill and regrading design in plan and cross-section view.
    d. Plan view of other construction elements: existing conditions map, Site utilities, ownership, Site plan, etc.
3. Any proposed revisions to the RA schedule.
4. Updates of all supporting deliverables required to accompany the RDWP.

Intermediate (60%) RD. The intermediate RD is a continuation and expansion of the preliminary (30%) RD and will include the following:

1. Revised RD Report that will include revisions from EPA / State / Stakeholder comments to the preliminary (30%) RD and updates to components where additional data have been collected as part of the Site investigations.
2. Intermediate drawings, including, but not limited to the following:
    a. Updated and revised drawings from the preliminary (30%) RD based on EPA / State / Stakeholder comments and updates to components where additional data have been collected as part of the Site investigations.
    b. Additional Site-wide plans including, but not limited to, building architectural, traffic control, temporary fencing, staging and stockpile management, demolition, erosion control, utility plan and profiles, hardscape, instrumentation and control, site lighting, planting, and irrigation.
    c. Technical specifications as available.
    d. Draft or schematic details, where applicable. Structure detailing to be submitted with the pre-final (95%) RD.
3. Any proposed revisions to the RA schedule.

Pre-Final (95%) RD. The pre-final RD must be a continuation and expansion of the previous design submittal and address EPA's comments regarding the intermediate (60%) RD. The pre-final RD will serve as the approved final (100%) RD, if EPA approves it without comments. The pre-final RD must include a continuation of deliverables identified above for the intermediate (60%) RD in addition to the following:

1. A complete set of construction drawings and specifications that are (1) certified by a registered professional engineer; (2) suitable for procurement; and (3) follow the current Construction Specifications Institute's Master Format.
2. Additional Site-wide plans including, but not limited to, instrumentation and controls, performance monitoring, and electrical.
3. Additional detail including, but not limited to, architectural, structural, mechanical, electrical, Site lighting, planting, and irrigation.
4. Any proposed revisions to the RA schedule.

Final (100%) RD. Atlantic Richfield will submit the final (100%) RD for EPA approval, in consultation with Montana DEQ. The final RD must address EPA and Montana DEQ comments on the pre-final RD and must include final versions of all pre-final RD deliverables finalized for construction.

RAWP. Atlantic Richfield currently anticipates submittal of a RAWP specific to the Site. The following elements will be included in the RAWP:

1. Project Background.
2. Summary of Data Collected.
3. Team Organization.
4. Pre-Construction Activities.
5. Design Summary.
6. Construction Meeting Description and Procedures.
7. Design and Field Change Procedures.
8. Post Construction Activities Procedures.
9. Construction QA.
10. Construction Monitoring and Associated QAPPs.
11. Construction Records and Reporting.
12. Health and Safety Requirements.
13. Construction Plans.
14. Specifications.
15. OM&M Plan Revisions.

Atlantic Richfield will submit the draft RAWP near the intermediate (60%) design.

5.2 Construction Documentation and Records

5.2.1 Daily Contractor Quality Control Reports

The contractor will prepare daily contractor QC reports. The reports will list a description of the trades working on the project, the number of personnel working, weather conditions encountered, and any delays encountered. The reports will cover both conforming and deficient features and will include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. The daily reports will include copies of test reports. The contractor must also take photographs documenting the day's major work activities and incorporate them into the reports. The Construction QC Manager must sign and date the reports.

The contractor will provide the reports to the independent QA contractor daily within 24 hours after the date covered by the report, with one exception: reports need not be submitted for days on which no work is performed.

5.2.2 Daily Construction Activity Report

An independent QA contractor will complete a daily construction activity report and submit it daily to Atlantic Richfield. The report will summarize the activities at the Site based on daily field notes. The report will address weather, contractor/subcontractor personnel that are at the Site, equipment used, construction activities performed, samples collected, field test results, and any issues encountered.

5.2.3 Material Receipt Inspections

All materials, equipment, and/or supplies that arrive at the Site will be inspected by the independent QA contractor to ensure that the products are as ordered or as specified; any deviations will be relayed to the contractor and Atlantic Richfield immediately. Receiving checklists for critical materials will be completed and recorded in a suitable location on the Site. These checklists will be included with other inspection documentation as part of the final CCR.

5.2.4 Inspections and Testing Records

All observations, field test results, and laboratory test results performed on the Site or off the Site will be recorded in a suitable manner. Recorded observations may take the form of notes, charts, sketches, photographs, or any combination of these. At a minimum, the inspection documentation will include the following information:

- Description or title of the inspection activity with the date activity was inspected.
- Location of the inspection activity or location from which the sample was obtained.
- Type of inspection activity and procedure used.
- Recorded observation or test data.
- Results of the inspection activity (e.g., pass/fail).

- Comparison with specification requirements.
- Personnel involved in the inspection besides the individual preparing the data sheet.
- Signature of the QAO accompanied by the date.

5.2.5 Photo Documentation

Pioneer will take and obtain digital photographs that document existing Site conditions, progress activities, and completion conditions.

5.2.6 Record Field Data

The contractor will keep at the Site two complete sets of as-built field data, one for the contractor's use and one for Atlantic Richfield construction oversight personnel. The as-built field data will consist of full size, blackline prints of the Construction Drawings marked by the contractor to show all deviations in actual construction from the original Construction Drawings. These working-as-built drawings will be updated weekly.

5.2.7 Record Drawings

Pioneer will document the final Site construction through as-built record drawings. The record drawings will be incorporated into the final RACCR (Section 5.4).

5.3 Record Maintenance

The contractor will store and manage all project records and back up documents during construction activities. The contractor will maintain all current records and always make those documents available for inspection by the QA contractor, Pioneer. The contractor will submit all the deliverables to Pioneer. Pioneer will include these materials in the final RACCR (Section 5.4).

5.4 Final Reporting

5.4.1 Remedial Action Construction Completion Report

Atlantic Richfield expects to provide a RACCR to EPA within 60 days of the successful completion of the final inspection. The RACCR will contain all construction-related information and documented aspects of QA associated with the project. The RACCR will include a summary of the project activities and document all aspects of the QA program performed during the project. In addition, revisions to the BPSOU Subdrain Collection System OM&M Plan (Atlantic Richfield, 2019) will be submitted to reflect any issues that may have been encountered during construction. In the report, Pioneer's Design Engineer of Record registered in the State of Montana will state that the project has been constructed consistent with the project Construction Drawings and Technical Specifications and that the discrete RD elements are complete.

6.0 REFERENCES

Anderson, 2002. LAO Phase I Construction Report.

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EPA, 2006. Environmental Protection Agency, Region 8. Butte Priority Soils Operable Unit (BPSOU) Record of Decision (ROD). EPA, 2006.

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EPA, 1995. Remedial Design/Remedial Action Handbook, EPA 540/R-95/059. U.S. Environmental Protection Agency June 1995.

MBMG, 2009. Geologic Map and Geohazard Assessment of Silver Bow County, Montana: Montana Bureau of Mines and Geology Open-File Report 585, 88 p., 3 sheets, scale 1:50,000. Prepared by Elliott, C.G., and McDonald, C.

MBMG, 2004. Geologic Map of the Upper Clark Fork Valley, Southwestern Montana, Open File Report 506. Mapped and compiled by Richard B. Berg and Phyllis A. Hargrave for the Montana bureau of Mines and Geology, 2004.

NOAA, 2020. National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI). https://www.ncdc.noaa.gov/cdo-web/search. June 2020.

FIGURES

Figure 1. BPSOU Subdrain Pump Station Site Location Map

LEGEND:

- BPSOU SUBDRAIN
- BPSOU SUBDRAIN DISCHARGE LINE

N

	DISPLAYED AS:
COORD SYS/ZONE:	MONTANA STATE PLANE
DATUM:	NAD 83
UNITS:	FEET
SOURCE:	2020 QSI

SCALE IN FEET
0 250 500

FIGURE 1

PIONEER TECHNICAL SERVICES, INC.
www.pioneer-technical.com
(406) 782-5177

BPSOU SUBDRAIN SITE LOCATION MAP

DATE: 4/2022

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Attachment 1

BPSOU Subdrain Pump Station Pre-Design Investigation (PDI) Work Plan

SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

Draft Final

BPSOU Subdrain Pump Station Pre-Design Investigation (PDI) Work Plan

Atlantic Richfield Company

June 2022

SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

Draft Final

BPSOU Subdrain Pump Station Pre-Design Investigation (PDI) Work Plan

Prepared for:

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Prepared by:

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June 2022

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DOCUMENT MODIFICATION SUMMARY

Modification No.	Author	Version	Description	Date
Rev 0	Ross Monasmith	Draft Final	Issued for Agency Review	June 2022

ACRONYMS

Acronym	Definition
Atlantic Richfield	Atlantic Richfield Company
BPSOU	Butte Priority Soils Operable Unit
BTL	Butte Treatment Lagoons
CD	Consent Decree
EPA	U.S. Environmental Protection Agency
HSEE	Health, Safety, Security, and Environment
LAO	Lower Area One
MSD	Metro Storm Drain
OSHA	Occupational Safety and Health Administration
PDI	Pre-design Investigation
Pioneer	Pioneer Technical Services, Inc.
QAPP	Quality Assurance Project Plan
QC	quality control
RDWP	Remedial Design Work Plan
RM	Remediation Management
SSHASP	Site-Specific Health and Safety Plan

1.0 INTRODUCTION

This Pre-Design Investigation (PDI) Work Plan (PDI Work Plan) has been developed consistent with the applicable U.S. Environmental Protection Agency (EPA) guidance and decision documents, including the following:

- *Consent Decree (CD) for the Butte Priority Soils Operable Unit* (BPSOU). *Partial Remedial Design/Remedial Action and Operation and Maintenance* (EPA, 2020), referred to herein as BPSOU CD.
- *Remedial Design/Remedial Action Handbook, EPA 540/R- 95/059* (EPA, 1995).

The investigation at the BPSOU Subdrain Pump Station project Site (Site) is necessary to support the redesign of the existing pump station infrastructure to provide redundant capacity for post-remedy influent flow and eliminate confined space. This PDI Work Plan includes the following items:

- General information regarding the pump station (Section 2.0).
- Existing data summary (Section 3.0).
- A summary of the work activities (Section 4.0).
- Project Quality Control (QC) and the Quality Assurance Procedure Plan (QAPP) outlining the procedures and protocols necessary for conducting a geotechnical investigation (Section 5.0 and Appendix A).
- The proposed Geotechnical Investigation Evaluation Report format (Section 6.0).

Data gaps relevant to the design of the Site, project organization, regulatory requirements, project schedule, and other key information is included in the *BPSOU Subdrain Pump Station Remedial Design Work Plan* (RDWP) to which this document is attached.

2.0 BACKGROUND

The Site is located at 1000 George Street within the BPSOU in Butte, Montana (Figure 1) Originally constructed between 2003 and 2005, the primary objective of the subdrain system is to intercept groundwater from the surrounding alluvial aquifer and pump it to the Butte Treatment Lagoons (BTL) system for treatment. Site infrastructure was upgraded in 2008, 2010, and 2014 to optimize performance and provide redundancy. Currently, the Site is comprised of 3 below-grade concrete vault structures and a precast concrete aboveground control building. The Ongoing Remedial Elements Statement of Work requires the Atlantic Richfield Company (Atlantic Richfield) to evaluate the performance, capacity, and opportunities for optimization of the existing groundwater collection and treatment system. As a result, Atlantic Richfield will reconstruct the Site to provide additional redundant capacity for post-remedy influent flow and eliminate unnecessary confined space. The proposed Site investigation is aided by previous work performed since 2003, including data from initial construction and the various upgrades. As such, this PDI Work Plan simply includes a focused geotechnical investigation to address the few remaining data gaps necessary to complete the design of a new concrete wet well and new control building structure.

Additional description of the Site and relevant Site features is included in Section 1.2 of the RDWP. Background information relating the history of the remedy, the construction of the BPSOU Subdrain Pump Station, and proposed additional work can be found in Section 1.3 of the RDWP. Additional details regarding the purpose of the Site PDI work are included in the QAPP, and background context relevant to the investigation work items will be provided as necessary.

3.0 EXISTING DATA SUMMARY

Several documents related to previous work and investigations performed at the BPSOU Subdrain Pump Station contain information relevant to the current design. Construction for the original BPSOU Subdrain Pump Station was completed in 2005 and major upgrades were performed in 2008 and 2014. As part of this prior work, extensive excavation has been performed at the Site, including excavation below the water table with requisite dewatering activities. The building Site can be considered well characterized given the previous work; however, this PDI Work Plan and appended QAPP address the remaining geotechnical data gaps left for Site design efforts. The following sections include information on some of the key related documents and a brief summary of the existing relevant data they contain. This information is not meant to be comprehensive but to give a brief overview of the work activities performed at the Site in previous years.

3.1 2006 Draft Final Horseshoe Bend Effluent Pipeline/Metro Storm Drain Construction Completion Report

This document summarizes the installation of the Metro Storm Drain (MSD) subdrain, now referred to as the BPSOU subdrain, among other work performed in the area at that time. This work included the construction of the original BPSOU Subdrain Pump Station system and conveyance infrastructure to the BTL. The construction completion report included as-built drawings of the original pumping system and infrastructure, which were substantially replaced shortly thereafter.

3.2 2007 Final Butte Metro Storm Drain Vault Design Report/Work Plan

This document outlines the upgrades performed to the BPSOU Subdrain Pump Station soon after the initial construction was completed. Captured groundwater chemistry data and flow data gathered during initial operation of the BPSOU Subdrain Pump Station informed upgrades to the pumps, which were undersized and exhibiting rapid corrosion. The work outlined in this effort included the installation of new pumps located in an adjacent dry vault, a bypass line, and numerous other operational equipment upgrades.

3.3 2011 Final Butte Treatment Lagoons and Metro Storm Drain Geotechnical Investigation Work Plan

As part of work performed to investigate subsurface conditions in areas of Lower Area One (LAO) and the SBC above BTC corridor, geotechnical data was gathered to support the planning and design of a potential contingency overflow pond in the BPSOU subdrain area. Data collected included geotechnical boreholes drilled across the BPSOU subdrain in the former wetlands demonstration program area (Buffalo Gulch Stormwater Basin Area), providing some regional lithology data nearby the Site.

3.4 2014 Final Metro Storm Drain Pump Station Upgrade Work Plan

The most recent Site investigation involved installation of an alternate discharge line from the wet vault to the BTL at LAO via directional drilling techniques. The work also included installation of additional piping configurations, pig launcher, and modifications to the dry vault. Surveyed Site infrastructure, existing utilities, and construction drawings from these activities inform the current investigation and design of the BPSOU Subdrain Pump Station.

4.0 BPSOU SUBDRAIN PUMP STATION INVESTIGATION

It is anticipated that additional capture flow will result from the remedial action outlined in the BPSOU CD indicating the need for additional capacity in the BPSOU Subdrain Pump Station. Additional wet well volume, increased pump capacity, and improved maintenance access will all be part of the BPSOU Subdrain Pump Station work. Available data from previous investigations and work performed at the Site include general subsurface conditions, groundwater elevations, and infrastructure. Data collected from other analyses related to anticipated future flows and flow increases (resulting from Groundwater Remedy Optimization and hydraulic control installed as part of work at the Blacktail Creek Remediation and Contaminated Groundwater Hydraulic Control) will be incorporated and included in future design documents. However, additional geotechnical data are needed to confirm the subsurface conditions in the area proposed for construction of the new wet well and BPSOU Subdrain Pump Station building structure, which is the focus of this QAPP.

4.1 Geotechnical Investigation

The geotechnical investigation is being performed to define underlying soil characteristics within the boundaries of the Site. The data and recommendations obtained from the investigation will be used to support future Site design. Data collected during previous work and investigations includes general subsurface conditions, groundwater elevations and dewatering volumes, previous boring logs, plot plans of Site infrastructure, and other information. The geotechnical investigation is therefore a focused investigation into the particular subsurface conditions in the location proposed for excavation and construction of the new BPSOU Subdrain Pump Station building structure and wet well. Analysis of samples collected as part of the geotechnical investigation is described in the QAPP (Appendix A).

Geotechnical analysis of Site conditions and Site soil encountered during the investigation will be performed following the geotechnical investigation and receipt of laboratory results. The geotechnical analysis will be consolidated in the form of a geotechnical report and will include construction recommendations for storm water management infrastructure, seismic considerations, groundwater table information, shrink/swell characteristics, and other native soil properties. A detailed discussion of the geotechnical investigation is provided in the QAPP (Appendix A).

4.1.1 Borehole Investigation

The geotechnical investigation will include drilling of up to four boreholes in the locations proposed for construction of the BPSOU Subdrain Pump Station building and the wet well (Figure 2). Boreholes will be drilled and logged under the supervision of the geotechnical engineer to gain information about subsurface in the areas proposed for construction of the pump building and wet well. Additional information about the borehole investigation, including data quality objectives, equipment, proposed depth, and more is included in the attached QAPP (Appendix A).

4.1.2 Test Pit Investigation

Test pits will be excavated in the area proposed for construction of additional parking at the Site (Figure 2). Test pits will be excavated by the contractor under supervision of the geotechnical engineer following the procedures outlined in the QAPP. Additionally, the contractor may pothole some locations at the Site to confirm the location of critical utilities prior to advancement of the design.

4.1.3 Equipment List

Drilling equipment that may be used to complete the geotechnical investigation at the Site are described in the QAPP (Appendix A). The construction contractor's roles and responsibilities are described in Section 4.1.6 of the RDWP. All contractors performing borehole and test pit activities will follow safety procedures and protocols of the BPSOU Site-Specific Health and Safety Plans (SSHASP), as discussed in Section 4.1.5 below.

4.1.4 Security

The area will be secured with 6-foot chain link fencing around the entire perimeter prior to any work starting. This fencing will be posted with warning signs not to enter the area and the access gate will be secured during operation and overnight hours to prevent unauthorized access.

4.1.5 Health and Safety

All work associated with the geotechnical investigation will follow applicable Remediation Management (RM) Health, Safety, Security, and Environment (HSSE) Management System defined practices and applicable Occupational Safety and Health Administration (OSHA) regulations. Pioneer Technical Services, Inc. (Pioneer) will be responsible for preparing and updating SSHASPs, risk assessments, and applying functional standards to protect the safety of the workforce through prescriptive practices and processes that meet or exceed applicable RM HSSE Defined Practices and OSHA regulations. Required personal protective equipment will include appropriate gloves, long-sleeved shirt, high visibility clothing, hard hat, safety glasses with side shields, safety-toed boots, and hearing protection when working around or operating equipment.

All work completed by Pioneer during the execution of this work will be performed in accordance with all procedures outlined in Pioneer's internal Health and Safety Plan developed for the BPSOU.

4.2 Property Access Agreements

Investigation activities planned for the BPSOU Subdrain Pump Station design will occur on Atlantic Richfield property, and no necessary property access agreements are anticipated at this time.

5.0 QUALITY CONTROL

The QAPP for this project is provided in Appendix A and contains additional information on the following:

- Sampling process and design
- Quality assurance and QC, including laboratory QC samples.
- Instrument/equipment testing, inspection, maintenance, and calibrations.
- Data management.
- Assessment and oversight.
- Data validation and usability.

Atlantic Richfield will provide the personnel to oversee all drilling, sampling, excavation, and abandonment activities. If third parties want a representative on-Site, they will be required to check-in and check-out with the Field Team Leader daily. The Atlantic Richfield representative will be responsible for logging the borehole, collecting the appropriate samples, and managing on-Site activities.

6.0 GEOTECHNICAL EVALUATION REPORT

A Geotechnical Investigation Evaluation Report will be developed and submitted upon completing sample analyses and criteria evaluation. The Geotechnical Investigation Evaluation Report will provide the following information:

1. Investigation summary.
2. Investigation results.
3. Data validation (tables).

4. Data validation reports.
5. Laboratory analyses reports.
6. Investigation documentation (field logs, soil boring logs, photos, etc.).
7. Data interpretation and analyses.
8. Conclusions and remedial design recommendations.

The Geotechnical Investigation Evaluation Report will be submitted to the Agencies as an attachment to the Intermediate (60%) BPSOU Subdrain Pump Station Design Report.

7.0 REFERENCES

Atlantic Richfield Company, 2014. Silver Bow Creek/Butte Area NPL Site, Butte Priority Soils Operable Unit, Final Metro Storm Drain (MSD) Pump Station Upgrade Work Plan. Prepared by Pioneer Technical Services, April 3, 2014.

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Atlantic Richfield Company, 2006. Silver Bow Creek/Butte Area NPL Site, Mine Flooding Operable Unit Butte Priority Soils Operable Unit, Draft Final Horseshoe Bend Effluent Pipeline/Metro Storm Drain (HBEL/MSD) Construction Completion Report (CCR). Prepared by Pioneer Technical Services, April 18, 2006.

EPA, 2020. Consent Decree for the Butte Priority Soils Operable Unit. Partial Remedial Design/Remedial Action and Operation and Maintenance. U.S. Environmental Protection Agency. February 13, 2020. Available at https://www.co.silverbow.mt.us/2161/ButtePriority-Soils-Operable-Unit-Conse.

EPA, 1995. Remedial Design/Remedial Action Handbook, EPA 540/R-95/059. U.S. Environmental Protection Agency June 1995.

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LEGEND:

- BPSOU SUBDRAIN
- BPSOU SUBDRAIN DISCHARGE LINE

N

DISPLAYED AS:	
COORD SYS/ZONE:	MONTANA STATE PLANE
DATUM:	NAD 83
UNITS:	FEET
SOURCE:	2020 QSI

SCALE IN FEET
0 250 500

FIGURE 1

PIONEER TECHNICAL SERVICES, INC.
www.pioneer-technical.com
(406) 782-5177

BPSOU SUBDRAIN SITE LOCATION MAP

DATE: 4/2022

4/29/2022 8:52:08 AM Z:\SHARED\ACTIVE PROJECTS\ARCO\BPSOU\DENST\CADD\FIGURES\DE-NST-FG-PLN-066-22.DWG

LEGEND:

- PROPOSED BOREHOLE LOCATIONS
- APPROXIMATE BOUNDARY AREA FOR LOCATION OF PROPOSED TEST PIT EXCAVATION

N

DISPLAYED AS:

COORD SYS/ZONE:	MSP83
DATUM:	NAVD88
UNITS:	IF
SOURCE:	QSI 2020/PTS

SCALE IN FEET
0 10 20

FIGURE 2

PIONEER TECHNICAL SERVICES, INC.
www.pioneer-technical.com
(406) 782-5177

PROPOSED GEOTECHNICAL INVESTIGATION LOCATIONS

DATE: 4/2022

5/3/2022 3:33:30 PM Z:\SHARED\ACTIVE PROJECTS\ARCO\BPSOU\MSD_VAULTUPGRADES\CADD\FIGURES\VU-FG-PLN-002-22.DWG

Appendix A
BPSOU Subdrain Pump Station QAPP

SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

2022

Draft Final

BPSOU Subdrain Pump Station
Quality Assurance Project Plan (QAPP)

Atlantic Richfield Company

June 2022

SILVER BOW CREEK/BUTTE AREA NPL SITE
BUTTE PRIORITY SOILS OPERABLE UNIT

2022

Draft Final

BPSOU Subdrain Pump Station
Quality Assurance Project Plan (QAPP)

Prepared for:

Atlantic Richfield Company
317 Anaconda Road
Butte, Montana 59701

Prepared by:

Pioneer Technical Services, Inc.
1101 S. Montana Street
Butte, Montana 59701

June 2022

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ACRONYMS

Acronym	Definition	Acronym	Definition
ASTM	American Society for Testing Materials	**PDI**	Pre-Design Investigation
Atlantic Richfield	Atlantic Richfield Company	**Pioneer**	Pioneer Technical Services, Inc.
BH	Borehole (for sample identification)	**QA**	Quality Assurance
BMP	Best Management Practices	**QAO**	Quality Assurance Officer
BPSOU	Butte Priority Soils Operable Unit	**QAPP**	Quality Assurance Project Plan
BTC	Blacktail Creek	**QC**	Quality Control
CAR	Corrective Action Report	**RD**	Remedial Design
CPM	Contractor Project Manager	**RDWP**	Remedial Design Work Plan
DQO	Data Quality Objective	**SOP**	Standard Operating Procedure
EPA	Environmental Protection Agency	**SSHASP**	Site-Specific Health and Safety Plan
GPS	Global Positioning System	**SPT**	Standard Penetration Test
ID	Identification		

1.0 INTRODUCTION

This Site-specific Butte Priority Soils Operable Unit (BPSOU) Subdrain Pump Station Quality Assurance Project Plan (QAPP) provides the procedures and protocols necessary to conduct a Site investigation as a part of the necessary data collection to support the design and reconstruction of the BPSOU Subdrain Pump Station (Site) infrastructure. The Site investigation will include a geotechnical investigation to summarize subsurface soil and provide foundation recommendations. The BPSOU Subdrain Pump Station and associated infrastructure is part of existing remedy infrastructure within the BPSOU (Figure 1).

This QAPP includes Data Quality Objectives (DQOs) specific to the investigation of the subsurface in the area of the proposed reconstruction of the BPSOU Pump Station infrastructure. The DQOs were identified according to U.S. Environmental Protection Agency (EPA) *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006). The DQOs detailed in this QAPP cover the geotechnical investigation activities planned to support advancement of the Site design effort.

1.1 Purpose of the Site Investigation

The Site investigation will fill in data gaps in order to advance the design of the BPSOU Subdrain Pump Station system and meet the requirements of the Ongoing Remedial Elements Scope of Work (EPA, 2020). Due to performance of previous work in the area, the remaining design-related data gaps for this investigation are focused on the geotechnical considerations related to the preliminary design. The geotechnical investigation will characterize the geotechnical properties of subsurface materials to confirm the location and design of Site infrastructure.

To support the Site investigation, this document includes the following information:

1. DQOs (Section 2.0).
2. Sampling Process and Design (Section 3.0).
3. Assessment and Oversight (Section 4.0).
4. Health and Safety (Section 5.0).
5. Data Validation and Usability (Section 6.0).

This document references Pioneer Technical Services, Inc. (Pioneer) Standard Operating Procedures (SOPs) for activities that outline specific procedures to safely complete tasks included in the Site investigation. Table 1 lists the applicable SOPs.

1.2 Objectives of the Investigation

The main objective of the Site investigation is to collect data regarding the physical properties of the soil within the Site to inform the designs of Site excavation, infrastructure, and buildings. Existing Site infrastructure are illustrated on Figure 2. To meet the objectives in Table 2, a geotechnical analysis of Site conditions and soil will be completed to identify subsurface soil conditions that will be encountered during construction activities. The data obtained will support the excavation design and future Site design, which will include construction of a new concrete wet well and aboveground pump and control building. Work activities will include the following:

- Drill boreholes at locations identified based on the preliminary building and vault location.
- Complete Standard Penetration Tests (SPTs) and collect soil samples, possibly including Shelby Tube samples, for specified analysis from each borehole.
- Dig test pits in the proposed parking area to confirm subsurface conditions, determine the extent of uncontrolled fill at the Site and perform any necessary potholing to confirm the location of any critical infrastructure in the proposed construction area.

2.0 DATA QUALITY OBJECTIVES

The DQOs are statements that define the type, quality, quantity, purpose, and use of data to be collected. EPA developed a seven-step process for establishing DQOs to help ensure that data collected during a field sampling program will be adequate to support reliable Site-specific decision making or estimation, whichever is appropriate (EPA, 2006). The DQOs for the geotechnical investigation at the Site were developed for the Site investigation according to the EPA process and are provided in Table 2.

3.0 SAMPLING PROCESS AND DESIGN

The Site investigation will include obtaining geotechnical data to support remaining data gaps in the design of the pump station. The following subsections provide the procedures and protocols necessary to complete these tasks.

3.1 Preparation for Fieldwork

The following tasks will be completed prior to conducting field activities.

3.1.1 Training

All field personnel will have a current certification for the 40-hour Occupational Safety and Health Administration Hazardous Waste Site and Emergency Response Training. Current certification records will be maintained at Pioneer's headquarters at 1101 S. Montana Street in Butte, Montana.

In a project meeting held prior to fieldwork, all field personnel will review this QAPP and receive any specified training. Field personnel will review sampling and monitoring procedures and requirements prior to field activities to ensure collecting and handling methods are completed according to the QAPP requirements. Field personnel will be trained on how to properly use field equipment and complete activities according to field data collection SOPs in Appendix A, and field forms are in Appendix B.

The Field Team Leader will review the internal BPSOU Site-Specific Health and Safety Plan (SSHASP) with all field personnel prior to fieldwork to assess the Site's specific hazards and the control measurements put in place to mitigate these hazards. The SSHASP review will cover all other safety aspects related to the Site including personnel responsibilities and contact information, additional safety requirements and procedures, and the emergency response plan.

Personnel will perform hazard identification/task risk assessments prior to performing specific tasks related to the Site investigation. One hard copy of the current approved version of the QAPP will be maintained for reference purposes in the field vehicle and/or field office. All field team personnel will have access to electronic PDF format files of all documents pertaining to fieldwork.

3.1.2 Utility Locates

There is a possibility that investigation points could shift once underground utilities are located throughout the Site. Utility locates will be performed prior to any fieldwork and will follow BP Remediation Management Defined Procedures for ground disturbance in addition to applicable control measures addressed in the SSHASP. Final utility locates for the work area will be completed prior to any ground disturbance activities.

3.1.3 Best Management Practices

Although a Joint Application for Proposed Work in Montana's Streams, Wetlands, Floodplains, and other Water Bodies (Joint Application) is not required for Superfund related activities, Atlantic Richfield Company (Atlantic Richfield) has identified measures that will be taken to ensure that the substantive requirements of the Joint Application and applicable requirements are met during the field activities. Protection of the environment during field activities will be addressed through implementation of short-term construction Best Management Practices (BMPs). General descriptions of the BMPs to be implemented to minimize the project impacts to the riparian area adjacent the Site are provided in the sections below.

During Site work activities, standard BMPs will be followed/installed, as appropriate, to minimize off-Site sediment tracking and to prevent storm water runoff from transporting sediments and/or pollutants (e.g., construction related oils, fuels, and other materials) downgradient into Silver Bow Creek (SBC) and/or Blacktail Creek (BTC). These BMPs may include, but are not limited to, the following:

- A vegetative buffer of native soil/vegetation will help attenuate any sediments and/or pollutants in storm water flowing from the investigation area into SBC/BTC.
- Spillguard® secondary containment systems (or equivalent) will be used, as necessary, to contain any inadvertent spills or leaks.
- Sediment cores from every borehole drilled during this project will be stored in their entirety (in increments) at the Pioneer field office at 244 Anaconda Road in Butte, Montana, or an alternate suitable location.

- Sediments, drill cuttings, materials from potholing, etc. that are not sent to a laboratory will be loaded for disposal at the Butte Mine Waste Repository, or other viable option at the discretion of the Contractor Project Manager (CPM). Boreholes will be backfilled with bentonite hole plug.
- General good housekeeping practices.

The Field Team Leader will be responsible for ensuring BMPs are installed properly at appropriate locations. Additionally, the Field Team Leader will be responsible for initiating corrective actions, as necessary.

3.1.4 Site-Specific Borehole Installation Concerns

Past drilling and probing at the Site found heaving sands to be a concern. Therefore, potable water may be added to the drill and/or probe strings as they are advanced to prevent formation heave inside the drill and/or probe rod. The added water provides a positive pressure inside the sample string, minimizing the amount of water and soil invading the annulus of the drill and/or probe rod as the core sample is retrieved. Water will be added only when needed and not on a routine basis.

3.2 Geotechnical Characterization

Up to 6 boreholes will be drilled as part of the geotechnical investigation (Figure 3). *In-situ* field tests will be conducted to determine the strength of the soil at 5-foot interval depths and soil samples will be collected from the boreholes and analyzed for geotechnical properties listed in Table 3. The SPT in general accordance with American Society for Testing and Materials (ASTM) D1586 will be conducted at the 5-foot sample intervals. The split spoons from the SPT samples will be opened, logged, and visually classified on-Site for soil classification by ASTM D2488, as well as receive a Munsell color description and moisture condition (Munsell, 2009). This information will be used to fill the data gaps related to designing the excavation surface and end land use features.

The number and location of the boreholes may be modified as determined by the Field Team Leader and/or CPM in consultation with the Contractor Quality Assurance Officer (QAO). Drilling and sampling are to be conducted as per all relevant and applicable SOPs in Appendix A. Specific to this investigation, certain modifications to the SOP are provided in this section.

3.2.1 Scope of Work

To meet the objectives in Table 2, the proposed scope of work to be completed under this Work Plan consists of the following tasks:

- Pothole water and sewer lines to accurately locate and determine depth of adjacent utilities.
- Perform updated survey of Site, including Site surface topography and relevant Site features.
- Conduct geotechnical drilling and sampling at the proposed locations (Figure 3).

- Collect and prepare laboratory samples of all geotechnical drilling and test pit locations.
- Provide geotechnical recommendations for the forthcoming BPSOU Subdrain Pump Station, compiled into the Geotechnical Investigation Evaluation Report, as outlined in the Pre-Design Investigation (PDI) Work Plan.

3.2.2 Proposed Location Staking and Survey

Prior to any ground disturbance, the proposed borehole, test pit, and any required potholing locations identified on Figure 3 will be surveyed and staked. These locations will be reviewed for accessibility and safety concerns by Atlantic Richfield and/or their representatives and modified accordingly. As described in the Remedial Design Work Plan (RDWP), an updated site-survey will be performed to update the existing light detection and ranging (LiDAR) survey with a topographical survey suitable for design.

3.2.3 Drilling Equipment

Based on field conditions and recommendations from the geotechnical engineer, an appropriate drill rig will be used to log and sample solids for field testing and laboratory analysis. The drilling methods available for the boreholes proposed at the Site (Figure 3) include the Geoprobe, sonic drilling rig, and the hollow stem auger. While the hollow stem auger is the preferred method for collecting geotechnical data on the alluvial material at the Site, the Geoprobe or sonic rig may also be used and will provide data that meets the DQOs. The sonic rig may be used to drill through tougher materials (i.e., asphalt), if needed. Core samples will be examined to produce a detailed lithologic characterization log of the subsurface materials at each borehole location.

The following paragraphs include output details and general practices for each instrument as they apply to the geotechnical investigation.

Hollow Stem Auger
Where appropriate, a hollow stem auger will be used for the geotechnical investigation. Drilling will be conducted using a 6- to 8-inch outer-diameter hollow stem auger system. SPT samples will be collected every 5 feet and drill cuttings can also be collected as necessary for laboratory testing.

Sonic Drilling Rig
Where appropriate, the sonic drilling rig will provide continuous core samples, which are anticipated to be 5 feet in length by 4 inches in diameter. To temporarily store the sediment core, polyethylene sleeves designed to fit over the core barrels will be used. Each 5-foot length will be properly labeled to split the core into manageable units for storage.

Geoprobe
The Geoprobe unit can provide continuous core samples using the dual tube soil sampling system. These core samples are anticipated to be up to 5 feet in length. The Geoprobe unit is equipped with 2 sampling systems, one that collects 2-inch core and one that collects 3-inch core, which will allow collection of Shelby tube samples. Using either of the systems will be

determined by the Field Team Leader and CPM in consultation with the geotechnical engineer. To temporarily store the sediment core from the Geoprobe unit, plastic liners will be used within the inner core barrel to collect the core samples. Each 5-foot length core sample will be properly labeled for storage.

All three potential drill rigs can be equipped with the appropriate system to conduct SPTs. The SPTs will be conducted with a split spoon sampler using the hammer to drive the sampler to the ground in a minimum of 3 6-inch increments. The drill rigs (auger, sonic, and Geoprobe unit) will also be equipped to take standard Shelby tube samples. Based on field conditions, the Field Team Leader and CPM in consultation with the geotechnical engineer will determine the appropriate drilling equipment to use.

3.2.4 General Procedures

The following general procedures will be performed at each geotechnical investigation borehole (Figure 3) location (at the depth intervals). Note that this list is not intended to be a complete list.

- Prepare drill equipment for operation. This includes, but is not limited to, decontaminating drilling tools and sampling equipment, leveling the rig, preparing the down-hole tool, and establishing the drill location.
- Perform SPTs at 5-foot intervals in general accordance with the *Standard Method for Standard Penetration Test and Split-Barrel Sampling of Soils* (ASTM D1586; ASTM, 2017a included in Appendix C). Note that the SPTs will be performed by a subcontractor. The geotechnical engineer or Field Team Leader will log the number of blow counts for each test.
- Advance the auger/barrel segment (anticipated to be 5 feet) to complete field testing and collect samples. Boreholes will be advanced at the direction of the Field Team Leader, CPM, or the geotechnical engineer.
- Shelby tube samples will be collected to obtain samples of clay or silt, at the discretion of the Field Team Leader or geotechnical engineer, in accordance with the *Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes* (ASTM D1587; ASTM, 2017b included in Appendix C).
- Classification and lithology of the sample or core from each borehole will be logged and sampled following the general procedures listed below.
- Continue adding auger/barrel segments and collecting samples until desired depth has been reached.
- Based on review of existing data and preliminary design, target depths for the geotechnical boreholes in the building location are shown in Table 4.
- Target depth in the wet well area will extend 10 feet past the preliminary bottom depth of the wet well (Table 4).
- Decontaminate the drill equipment between borehole locations by rinsing with tap water and/or using a high-pressure washer.
- Backfill borehole with bentonite hole plug.

The general depth of each borehole is specified in Table 4 and may be limited or increased based on field personnel observations.

The following general procedures will be performed at each geotechnical investigation test pit (Figure 3) location (at the depth intervals). The proposed test pits shown on Figure 3 will be excavated in accordance with the Atlantic Richfield Ground Disturbance Defined Practice (Remediation Management Defined Practice, Ground Disturbance, BP Health, Safety, Security and Environment Management System 2010) using either a rubber-tired backhoe or track-mounted excavator under the direction of a geotechnical engineer from Pioneer. Note that this list is not intended to be a complete list.

- Prepare test pit equipment for operation, including mobilizing equipment to pit area, preparing the surface, and putting in place all required safety precautions.
- Excavate test pits to required depth as outlined in Table 4 and as determined by the geotechnical engineer.
- Excavation of soil samples from discrete intervals will be placed a safe distance away from the test pit for inspection by the geotechnical engineer.
- Once the soil samples have been placed off to the side of the test pit, the engineer will photograph the completed test pit and samples and select representative samples for laboratory testing.
- The engineer will prepare detailed lithologic logs of the test pits with particular focus in noting boundaries between debris and suitable backfill and native soil.
- After the test pit has been photographed, the materials classified, and the soil sampled, the test pit will be backfilled with suitable fill material and excavated soil will be disposed of at the Butte Mine Waste Repository.

Equipment

Equipment used to collect core samples will include, but not be limited to, the following:

- Field logbook and pens.
- Measuring tape.
- Ziplock bags.
- Chain of custody forms.
- 5-gallon buckets.
- Large brush to remove soil from split spoon sampler.
- Duct tape.
- Shelby tubes and plastic end caps.
- Decontamination equipment (pressure washer, tap water, paper towels, and scrub brushes) (refer to SOP-DE-02 in Appendix A).
- Camera and film, digital camera, and/or digital video camera.
- Global Positioning System (GPS) unit.
- Appropriate safety personal protective equipment (PPE).

Logging
A geotechnical engineer will log the number of blow counts during the SPT, log soil lithology, collect soil samples for field and laboratory testing, observe existing groundwater conditions (where encountered), inform the driller when to take Shelby tube samples, note the ease or difficulty of drilling, and record any other notable features.

Sampling and Analysis Procedures
The following general procedures will be performed at each location at the discretion of the geotechnical engineer, Field Team Leader, or CPM:

- Between boreholes, drilling equipment will be washed using tap water and a pressure washer.
- Upon receiving the split spoon from the driller, open the split spoon, measure the length of recovered material, take a photograph from directly overhead, log the soil, and place in a Ziplock bag labeled with the location name, soil depth interval, and date.
- Upon receiving the 5-foot core from the driller (if Geoprobe or sonic rig is used), open the bag, take a photograph from directly overhead, and log the soil. Samples may be collected at the discretion of the geotechnical engineer, Field Team Leader, or CPM.
- Upon receiving a Shelby tube from the driller, keep the Shelby tube in an upright position, place the plastic caps over the top and bottom of the Shelby tube and use duct tape or a similar material to secure and seal the caps to the Shelby tube. Place the Shelby tube in a location where it will remain upright and will be subject to minimal movement.
- Select samples may be analyzed at Pioneer's Material Testing Laboratories for moisture content, resistivity, pH, sulfate, particle size distribution, Atterberg Limits, standard proctor, California bearing ratio, triaxial shear strength, and consolidation (Table 3) depending on borehole location and the potential infrastructure that might be located in that area.
- Place the core samples in properly labeled sample buckets for transport (the labels will include location, depth interval, and core orientation).

At the completion of each borehole and before retrieving the augers, the groundwater elevation will be measured and recorded. Boreholes will be backfilled with bentonite. Any auger cuttings not collected for laboratory testing will be disposed of at the Mine Waste Repository or other viable option at the discretion of the CPM (Section 3.2.5).

Samples from every borehole drilled during this project will be stored at the Pioneer field office at 244 Anaconda Road in Butte, Montana, or an alternate suitable location. Geotechnical samples for moisture content, resistivity, pH, sulfate, particle size distribution, Atterberg Limits, standard proctor and/or California Bearing Ratio will be analyzed by Pioneer's Material Testing Laboratories as indicated in Table 3. Samples will be placed in storage at Pioneer's facilities until the time of disposal.

3.2.5 Disposal and Backfill

The soil encountered in drilling boreholes and test pits is assumed to contain historical mine waste, and any excess material will be consolidated by the Contractor and disposed of at the Mine Waste Repository. Boreholes will be carefully backfilled using bentonite chips or pellets

The bentonite will be slowly applied within the borehole in a fashion that prevents bridging. If bridging does occur the driller will be responsible for removing the bridge and resuming backfill. If the borehole is located in an area with asphalt surfacing, the borehole will be capped with the appropriate replacement material, as specified by the engineer. Test pits will be backfilled with suitable borrow material and equipment compacted to minimize future settlement.

3.3 Standard Operating Procedures

This QAPP includes SOPs that apply to particular field activities, and the SOPs are referenced in the appropriate sections throughout this report and are included in Appendix A. Depending on circumstances and needs, it may not be possible or appropriate to follow the SOPs exactly in all situations due to Site conditions, equipment limitations, and limitations of the standard procedures. When necessary to perform an activity that does not have a specific SOP, or when the SOP cannot be followed, existing SOPs may be used as a general guidance or similar SOPs (not listed in this report) may be adopted if they meet the project DQOs. All modifications or adoptions will be approved by the Field Team Leader, CPM, and Contractor QAO and documented in the field logbook and/or the final project report, as appropriate.

3.4 Documents and Records

The following sections detail the handling and procedures for documents and records produced as part of the Site investigation.

3.4.1 Sample Labeling and Identification

Soil Samples

A sample number system will be used to uniquely identify the project Site, the sample medium, and the specific sample location and depth interval. The sample identification number will be derived from the borehole number with the Site name followed by the sample interval enclosed in parentheses. For example, a sample designated PS22-BH02(1.6-3.1) describes a sample from borehole PS22-BH02 taken from a depth of 1.6-3.1 feet below existing grade. All measurements will be decimal feet. There will be no blank spaces permitted in the identification. The following is an example of the sample numbering system:

Sample Number: **PS22-BH02(1.6-3.1)-05252022**

Location/Year:	*"PS22"* – BPSOU Pump Station project area, installed in 2022.
Type:	*"BH"* – Borehole
Location/Number:	*"02"* – Sample Location (corresponds with Borehole Identification [ID] No.). All sample locations will be plotted on the sampling maps.
Depth Interval:	*"(1.6-3.1)"* (upper limit-lower limit). Intervals will be recorded in the field log or logbook.
Date:	*"05252022"* – sample collected on May 25, 2022.

All subsample locations and depths will be described in the data log. All samples will be labeled in the field with documentation of the date and time of sample collection, the sample number, sample container type, analyses requested, and the sampler's initials. A permanent marker will be used for labeling. No duplicate samples will be required for the geotechnical sample collection.

All soil samples will be collected in the proper sample container. The sample ID, date, and depth interval of the sample will be written on the sample container with an indelible marker. Samples will be stored, handled, and packaged as described in Section 3.4.3 and Table 3. A copy of the chain of custody record will accompany the samples during shipment and will serve as the laboratory request form. The chain of custody form will specify the type of analysis requested for each individual sample. The original form will be maintained with the field notes and in the project records.

3.4.2 Field Documentation

The following sections outline the required procedures and protocols for documentation of field activities, including record taking using the field logbook and field photography.

3.4.2.1 Field Logbook

To provide a permanent record of all field activities, field personnel will document all activities in a bound field logbook (refer to field SOPs in Appendix A). This will include a description of conditions during sampling activities. When field logbooks are used, each logbook will have a unique document control number, be bound, and have consecutively numbered pages. All entries will be in waterproof ink, and any mistakes will be lined out with a single line and initialed by the person making the correction. Whenever a sample is collected or a measurement is made, a detailed description of the sample location and any additional observations will be recorded. The GPS coordinates will be recorded when appropriate. Individual field team members may be responsible for required documentation based on specific tasks assigned by the Field Team Leader or CPM.

All significant observations, measurements, relevant data, and results will be clearly documented in the data log or the field logbook. At a minimum, the following will be recorded:

- A description of the field task.
- Time and date fieldwork started.
- Location and description of the work area including sketches, if possible, map references, and references to photographs collected.
- Names and titles of field personnel.
- Name, address, and phone number of any field contacts or site visitors (e.g., Agency representatives, auditors, etc.).
- Meteorological conditions at the beginning of fieldwork and any ensuing changes in the weather conditions.
- Details of the fieldwork performed, and the field data sheets used.

- All field measurements made.
- Any field analysis results.
- Personnel and equipment decontamination procedures.
- Deviations from the QAPP or applicable field SOPs (Appendix A).

For boreholes the following entries will be made:

- Lithologic log of the boring indicating material types, from and to depths, rock content, color, presence of water, etc.
- Depth intervals from the ground surface for each soil horizon and total depth of the boring.
- Photograph or video of each boring with a staff gage or tape measure for scale to document existing conditions. Include site name ID in photograph using a white board or note pad.
- Abnormal occurrences or materials, deviations from the QAPP, or other relevant observations.

For any field sampling work the following entries will be made:

- Sample location and ID number.
- Sample type collected.
- Date and time of sample collection.
- Sample location descriptions and designations, soil type and texture (e.g., sand, silt, etc.), grain-size, and color (in the field). Further sample information will be included with the laboratory results.
- Sampling method, particularly any deviations from the field SOPs (Appendix A).
- Documentation or reference of preparation procedures for reagents or supplies that will become an integral part of the sample (if any used in the field).
- Sample preservation (if used).
- Decontamination procedure.
- Sample custody.

The lithologic information for boreholes will be transcribed into a spreadsheet or database that can be used with Strater® or other appropriate lithologic log software.

3.4.2.2 Field Photographs

Photographs will be taken of sampling locations and field activities. When practical, photographs should include a scale in the picture as well as a white board with relevant information (e.g., time, date, location, sample number, etc.). Additional photographs documenting Site conditions will be taken, as necessary. Documentation of all photographs taken during sampling activities will be recorded in the bound field logbook or appropriate field data sheets (refer to field SOPs in Appendix A), and will specifically include the following for each photograph taken:

- Time, date, and location.
- Photograph or video number from the camera or video recorder.
- The identity of the person taking the photograph or video.
- Direction that the photograph was taken, and description of the subject photographed.

The digital files will be placed with the electronic project files with copies of supporting documentation from the bound field logbooks.

3.4.3 Sample Handling, Documentation, and Shipping

Samples will be hand delivered to the appropriate laboratory under strict EPA chain of custody procedures. Samples will be delivered in appropriate containers that will prevent detrimental effects to the sample.

Sample containers and holding times are listed in Table 3. All procedures will strictly follow appropriate protocols and field SOPs in Appendix A. Chain of custody records will be kept with the samples and custody seals will be placed on the sample storage containers (coolers).

All samples not submitted to the laboratory will be archived. When it is determined that the samples are no longer needed, they will be disposed of at the Butte Mine Waste Repository.

3.4.4 Chain of Custody

The SOP for chain of custody (SOP-SA-04) is in Appendix A. Maintaining the integrity of the sample from collection through data reporting is critical to the sampling and analytical program. This process includes the ability to trace the possession and handling of samples from the time of collection through analysis and final disposition. This documentation of the sample's history is referred to as chain of custody. A sample is considered to be under an individual's custody if it is in that individual's physical possession, in view of the individual after taking possession, or secured by that individual so that no one can tamper with the sample.

The components of the field chain of custody (chain of custody form, labels, and custody seals) and laboratory chain of custody (chain of custody form, custody seals, and laboratory custody) are described in this section.

3.4.4.1 Chain of Custody Form

A chain of custody form will be completed and will accompany samples as appropriate. A standard form will be provided from each laboratory. The form will include the following information:

- Project code.

- Project name.
- Sampler's signature.
- Sample ID.
- Date sampled.
- Time sampled.
- Analysis requested.
- Remarks.
- Relinquishing signature, data, and time.
- Receiving signature, date, and time.

3.4.4.2 Custody Seals

Custody seals are used to detect unauthorized tampering with samples following sample collection up to the time of analysis. Custody seals will be applied to the shipping containers when the samples are not in the sampler's custody.

3.4.4.3 Laboratory Custody

Laboratory custody procedures will conform to procedures established for the EPA Contract Laboratory Program (EPA, 2016). These procedures include the following:

- Designation of sample custodian.
- Correct completion of the chain of custody form, recording of sample ID numbers, and documentation of sample condition upon receipt.
- Laboratory sample tracking and documentation procedures.
- Secure sample storage.

The samples will be delivered to the laboratory for analysis in a timely manner to ensure the requested analyses can be performed within the specified allowable holding times. The sample will be hand delivered or addressed to a person in the laboratory who is authorized to receive samples (laboratory sample custodian).

3.5 Instrument/Equipment Testing, Inspection, Maintenance and Calibration

To ensure continual quality performance of all instruments and equipment, testing, inspection, and maintenance will be performed and recorded as described in this section. All field and laboratory equipment will be operated, maintained, calibrated, and standardized in accordance with all EPA and manufacturer's recommended procedures.

3.5.1 Field Equipment

Field equipment will be examined to verify that it is in proper operating order prior to its first use. Equipment, instruments, tools, gages, and other items requiring preventative maintenance will be serviced and/or calibrated in accordance with the manufacturer's specified recommendations, as necessary. Field equipment will be cleaned (decontaminated) and safely stored between each use. Any routine maintenance recommended by the equipment manufacturer will also be performed and documented in field logbooks. Calibration of field equipment will be completed in the field at the beginning of each day and recorded in the field logbooks. Any equipment deficiencies or malfunctions during fieldwork will be recorded as appropriate in the field logbooks. The SOPs for the field equipment are in Appendix A.

3.5.2 Laboratory Equipment

Instruments used by the laboratory will be maintained in accordance with the laboratory quality assurance (QA) plan requirements and analytical method requirements. All analytical measurement instruments and equipment used by the laboratory will be controlled by a formal calibration and preventive maintenance program. The laboratory will keep maintenance records and make them available for review, if requested. Laboratory preventive maintenance will include routine equipment inspection and calibration at the beginning of each day or each analytical batch, per the laboratory internal SOPs and method requirements.

3.6 Inspection/Acceptance of Supplies and Consumables

All supplies and consumables received for the project (e.g., sampling equipment, calibration standards, etc.) will be checked to ensure their condition is satisfactory, such as free of defects that would affect performance. The types of equipment needed to complete sampling activities are described in the relevant field SOPs (Appendix A). Inspections of field supplies will be performed by the Field Team Leader or field team members. The personnel at each laboratory will be responsible for inspecting laboratory supplies in accordance with the laboratory QA program.

3.7 Data Management Procedures

This section describes how the data for the project will be managed, including field and laboratory data. Data will be managed in accordance with the BPSOU *Draft Final 2022 Data Management Plan* (Atlantic Richfield Company, 2022).

The QAPP quality records will be maintained by Atlantic Richfield. These records, in either electronic or hard copy form, may include the following:

- Project work plans with any approved modifications, updates, and addenda.
- Project QAPP with any approved modifications, updates, addenda, and any approved corrective or preventative actions.
- Field documentation (including logbooks, data sheets, and photographs) in accordance with SOP-SA-05 in Appendix A.
- Chain of custody records in accordance with SOP-SA-04 in Appendix A.
- Field forms, which are provided in Appendix B.

- Laboratory documentation (results received from the laboratory will be documented in hard copy and in an electronic format).
- RDWP report.

Hard copy field and laboratory records will be maintained in the project's central data file, where original field and laboratory documents are filed chronologically for future reference. These records will also be scanned to produce electronic copies. The electronic versions of these records will be maintained on a central Microsoft structured query language (SQL) server system that is backed up regularly. The data will be stored on the SQL server and a Microsoft Access database will be set up to access the data, which can then be exported to Excel, if necessary, for further graphing and interpretive analysis. Using a Microsoft-based software configuration is widely accepted with support from Microsoft and allows for easy data sharing with most hardware configurations.

All field and laboratory data and supporting documentation will be subject to appropriate review to ensure the accuracy and completeness of original data records prior to uploading into the project database. Field data that have been reviewed and approved in a hard copy format will be entered into an electronic system to be uploaded to the project database. Laboratory electronic data deliverables provided in Microsoft Excel format will be reviewed as part of the internal data review process. Following these review steps, field and laboratory electronic data files will be imported to the project database.

Standardized data import formats and procedures will be used to upload both field and laboratory data into the electronic database. Standardized parameter names, numerical formats, and units of measure will be applied to the original information to facilitate comparability across all data sets and within the database. Using these standardized formats will allow for quick and easy querying to retrieve data. Data can be retrieved by exporting into an Excel file and, because the data will be formatted with parameter names, easily made into a pivot table for data processing.

4.0 ASSESSMENT AND OVERSIGHT

Assessment and oversight of data collection and reporting activities are designed to verify that sampling and analyses are performed in accordance with the procedures established in this QAPP. The audits of field and laboratory activities include two independent parts: internal and external audits. Internal audits will be performed by Atlantic Richfield, their contractor, or a contracted laboratory consultant as necessary. External audits will be performed by EPA as necessary. Performance and systems audits of field and laboratory data collection and reporting procedures are described in this section.

4.1 Field Activities Oversight

Oversight personnel will have the ability to inspect each soil boring and determine the appropriateness of the recorded data and ensure that the appropriate samples are collected. Any deviations from this QAPP will be brought to the attention of oversight personnel. If the deviation is first determined by oversight personnel, Atlantic Richfield and/or field representatives will be immediately notified. Reasons for such deviations will be recorded in the field logbook along with corrective actions to be implemented, if required. If oversight personnel request a deviation from the QAPP, the deviation and the reasons for the deviation will be noted and then signed by the agency personnel.

4.2 Corrective Action Procedures

Corrective action is the process of identifying, recommending, approving, and implementing measures to counter unacceptable procedures or out-of-quality control (QC) performance, which can affect data quality. Corrective action can occur during field activities, laboratory analyses, and data assessment.

Non-conforming equipment, items, activities, conditions, and unusual incidents that could affect data quality and attainment of the project's quality objectives will be identified, controlled, and reported in a timely manner. A non-conformance is defined as a malfunction, failure, deficiency, or deviation that renders the quality of an item unacceptable or indeterminate in meeting the project's quality objectives. Corrective actions implemented by field personnel will follow appropriate field SOPs (Appendix A), as necessary.

Corrective action in the laboratory may occur prior to, during, and after initial analyses. A number of conditions (such as broken sample containers) may be identified during sample log in or just prior to analyses. Corrective actions to address these conditions will be taken in consultation with the CPM and reported on a Corrective Action Report (CAR) form included in Appendix D, as necessary. In the event that corrective action requests are not in complete accordance with approved project planning documents, EPA will be consulted and concurrence will be obtained before the change is implemented.

If during sample analyses, the associated laboratory QC results fall outside of the project's performance criteria, the laboratory should initiate corrective actions immediately. If laboratory QC results are outside of the project specifications, the laboratory should take the appropriate corrective actions for the specific analytical method. Following consultation with laboratory analysts and section leaders, it may be necessary for the CPM to approve implementing a corrective action. These conditions may include reanalysis when certain QC criteria are not met. If the laboratory cannot correct the situation that caused the non-conformance and an out-of-control situation continues to occur or is expected to occur, then the laboratory will immediately contact the CPM and request instructions regarding how to proceed with sample analyses.

Completion of any corrective action should be evidenced by data once again falling within the project's performance criteria. If this is not the case, and an error in laboratory procedures or sample collection and handling procedures cannot be found, the results will be reviewed by the CPM and Field Team Leader in consultation with the Contractor QAO to assess whether reanalysis or re-sampling is required.

All corrective actions taken by the laboratory will be documented in writing by the Laboratory Project Manager and reported to the Field Team Leader and CPM. In the event that corrective action requests are not in complete accordance with approved project planning documents, EPA will be consulted and concurrence will be obtained before the change is implemented. All corrective action records will be included with the QAPP records.

4.3 Corrective Action During Data Assessment

During data assessment, the Contractor QAO could identify the need for corrective action. Potential types of corrective action include re-sampling by the field team or reanalyzing samples by the laboratory. The appropriate and feasible corrective actions will depend on the ability to mobilize the field team and whether the data to be collected are necessary to meet the required QA objectives (e.g., the holding time for samples is not exceeded, etc.). If corrective action requests are not in complete accordance with approved project planning documents, EPA will be consulted and concurrence will be obtained before the change is implemented. Corrective actions of this type will be documented by the Contractor QAO on a CAR and will be included in any subsequent reports.

4.4 Quality Assurance Reports to Management

After the investigation is complete, the Atlantic Richfield contractor will incorporate the results into the Geotechnical Investigation Evaluation Report summarizing and interpreting the sampling activities. The report will include the following:

- Summary of the investigations performed.
- Summary of investigation results.
- Summary of collected data (i.e., tables and graphics).
- Laboratory data reports.
- Narrative interpretation of data and results.
- Photographs documenting the work conducted.
- Conclusions and recommendations for Remedial Design (RD), including design parameters and criteria.
- Recommendations for an additional phase(s) (if necessary).

The CPM and Contractor QAO are responsible for preparing the PDI Evaluation Report, including the Geotechnical Investigation Evaluation Report. All Site investigations will be incorporated into the report as the design progresses, and the report will be submitted in draft final form to EPA and Montana Department of Environmental Quality for review approximately 30 days prior to the Intermediate 60% RD Report for the Site.

5.0 HEALTH AND SAFETY

All work completed by Pioneer and its subcontractor during execution of the investigation will be performed in accordance with all procedures outlined in the BPSOU SSHASP. The BPSOU SSHASP may be updated to include unique hazards that materialize during field activities for the investigation, including identifying necessary Task Risk Assessments to perform prior to field work.

6.0 DATA VALIDATION AND USABILITY

This section addresses the final project checks conducted after the data collection phase of the project is completed to confirm that the data obtained meet the project objectives and to estimate the effect of any deviations on data usability for the express purposes of achieving the stated DQOs (Section 2.0). For the estimation of geotechnical properties, no formal data validation will be required to answer the primary study questions (e.g., Stage 2B Validation Manual). Data collected in the field and analyzed in the materials laboratory will be sufficient to make appropriate estimations of geotechnical characteristics necessary for the BPSOU Pump Station design.

The laboratory will follow all standard operating procedures, including sample handling, equipment calibration, and reporting and documentation requirements. Data reported by the laboratory will be reviewed by the CPM and QAO to ensure the data meets sufficient quality standards for the purposes of answering the estimation statement. Field logbook documentation will be verified against the reported sample results and chain-of-custody forms to verify there are no discrepancies between reported sample analysis and that outlined in this QAPP and recorded in the field by the geotechnical engineer. Types of information collected in the field logbook that will be checked by the CPM and/or QAO include:

- Sampling date.
- Sample team and/or leader.
- Physical description of sample location.
- Sample depth (soil).
- Sample collection technique.
- Sample shipping records.
- Sample containers preparations.
- Proper and decontaminated sampling equipment.
- Field custody documentation.
- Shipping custody documentation.
- Traceable sample designation number.
- Field notebook(s), custody records in secure location.
- Complete field forms.

The data packages from the laboratory will contain the following minimum information, as ensured by the CPM and/or QAO:

- A narrative addressing any anomalies encountered during sample analysis.
- Analytical method references.
- Chain of custody documentation signed and dated by the laboratory to indicate sample receipt.

- Reporting limits, as applicable.
- Analytical results for each field sample.

Basic data verification checks performed by the CPM and/or QAO will include an evaluation of the following, as applicable for each analytical method:

- Completeness of laboratory data package.
- Requested analytical methods performed.
- Holding times.
- Reported detection limits, as applicable.
- Instrument calibration.
- Internal standards.

7.0 REFERENCES

ASTM, 2017a. ASTM D1586 - 11, Standard Test Method for Standard Penetration Test (SPT), and Split-Barrel Sampling of Soils, ASTM International, West Conshohocken, PA, 2017, www.astm.org

ASTM, 2017b. ASTM D1587/D1587M - 15, Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical, ASTM International, West Conshohocken, PA, 2017, www.astm.org

Atlantic Richfield Company, 2022. Butte Area NPL Site Butte Priority Soils Operable Unit Draft Final Draft Data Management Plan. Prepared by TREC Inc. February, 2022.

EPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4). Washington DC: EPA, Office of Environmental Information. EPA/240/B-06/001. Available at *http://www.epa.gov/quality/qs-docs/g4-final.pdf*.

EPA, 2016. Contract Laboratory Program (CLP) Statement of Work for Inorganic Superfund Methods (Multi-Media, Multi-Concentration) ISM02.4. U.S. Environmental Protection Agency, October 2016.

EPA, 2020. Consent Decree for the Butte Priority Soils Operable Unit. Partial Remedial Design/Remedial Action and Operation and Maintenance. U.S. Environmental Protection Agency. February 13, 2020. Available at https://www.co.silverbow.mt.us/2161/ButtePriority-Soils-Operable-Unit-Conse.

Munsell, 2009. Munsell Soil Color Book. 2009 Revision.

FIGURES

LEGEND:

BPSOU SUBDRAIN

BPSOU SUBDRAIN DISCHARGE LINE

N

DISPLAYED AS:

COORD SYS/ZONE:	MONTANA STATE PLANE
DATUM:	NAD 83
UNITS:	FEET
SOURCE:	2020 QSI

SCALE IN FEET

0 250 500

FIGURE 1

PIONEER TECHNICAL SERVICES, INC.
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(406) 782-5177

BPSOU SUBDRAIN SITE LOCATION MAP

DATE: 4/2022

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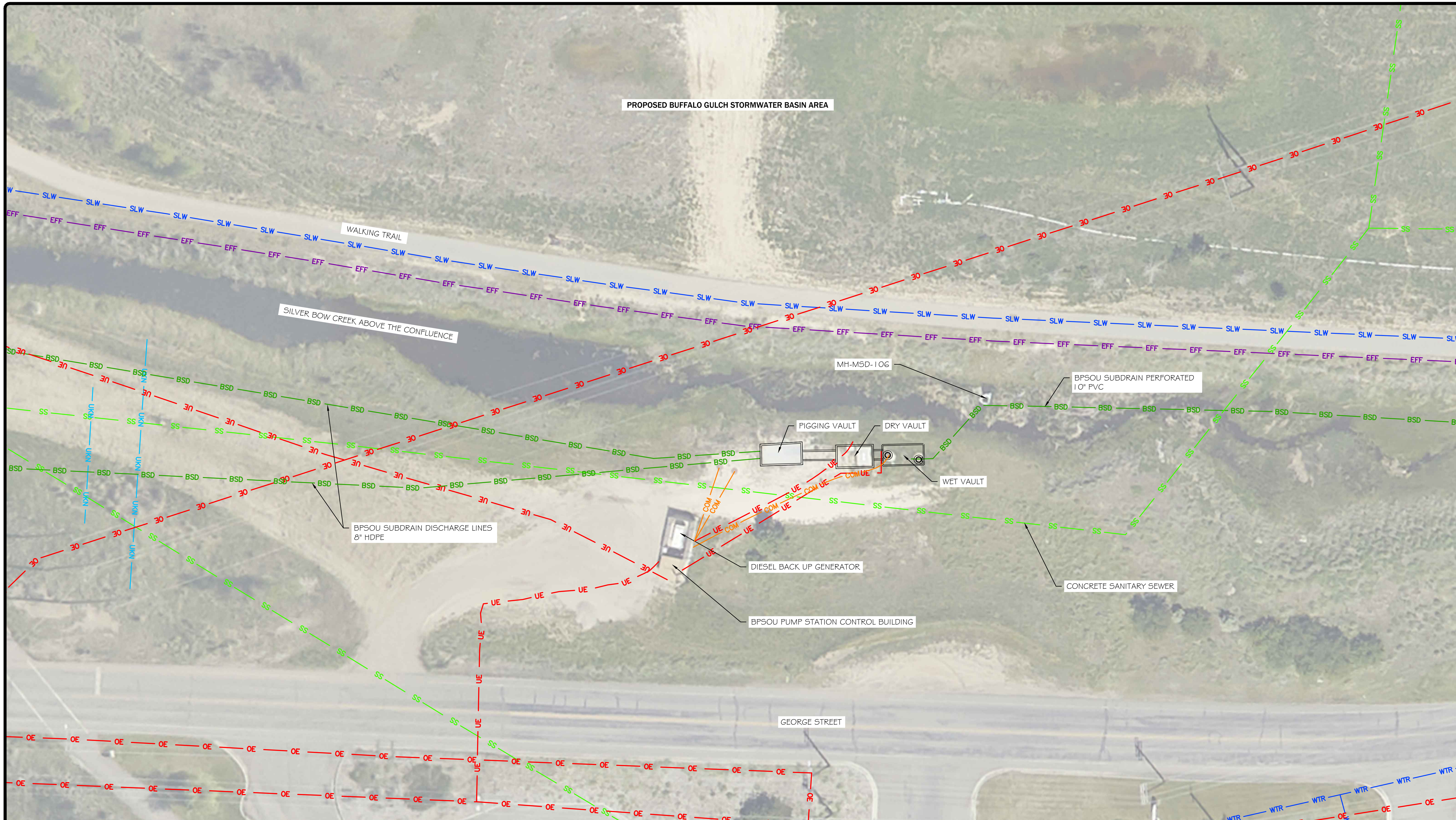

LEGEND:

- SLW — SILVER LAKE WATER LINE
- EFF — HORSESHOE BEND EFFLUENT LINE
- SS — SANITARY SEWER LINE
- BSD — BPSOU SUBDRAIN
- UE — UNDERGROUND ELECTRICAL LINE
- OE — OVERHEAD ELECTRICAL LINE
- WTR — WATER LINE
- COM — COMMUNICATION LINE
- UKN — UNKNOWN LINE

N

DISPLAYED AS:
COORD SYS/ZONE: MSP83
DATUM: NAVD88
UNITS: IF
SOURCE: QSI 2020/PTS

SCALE IN FEET
0 20 40

FIGURE 2

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BPSOU SUBDRAIN PUMP STATION EXISTING INFRASTRUCTURE

DATE: 4/2022

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LEGEND:

- PROPOSED BOREHOLE LOCATIONS
- APPROXIMATE BOUNDARY AREA FOR LOCATION OF PROPOSED TEST PIT EXCAVATION

N

DISPLAYED AS:
COORD SYS/ZONE: MSP83
DATUM: NAVD88
UNITS: IF
SOURCE: QSI 2020/PTS

SCALE IN FEET
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FIGURE 3

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PROPOSED GEOTECHNICAL INVESTIGATION LOCATIONS

DATE: 4/2022

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TABLES

Table 1. Applicable and Relevant Standard Operating Procedures

SOP Number	Title	Version
PIONEER TECHNICAL SERVICES, INC. STANDARD OPERATING PROCEDURES		
SOP-DE-01	PERSONAL DECONTAMINATION PROCEDURES	12/03/2014
SOP-DE-02	EQUIPMENT DECONTAMINATION	09/08/2020
SOP-DE-03	INVESTIGATION DERIVED WASTE HANDLING	12/02/2014
SOP-GW-03	DEPTH TO WATER LEVEL MEASUREMENTS	12/03/2014
SOP-S-02	SUBSURFACE SOIL SAMPLING	12/11/2014
SOP-S-12	SAMPLING SOILS FROM A GEOPROBE® LINER	09/25/2020
SOP-S-13	SAMPLING SOILS FROM A CORE GENERATED BY A SONIC DRILL	05/31/2018
SOP-SA-01	SOIL AND WATER SAMPLE PACKAGING AND SHIPPING	12/11/2014
SOP-SA-04	CHAIN OF CUSTODY FORMS FOR ENVIRONMENTAL SAMPLES	11/12/2020
SOP-SA-05	PROJECT DOCUMENTATION	12/17/2014
SOP-SURVEY-01	STAKING AND SURVEYING	10/24/2016
PIONEER TECHNICAL SERVICES, INC. STANDARD OPERATING PROCEDURES (GEOPROBE)		
SOP-GEOPROBE-01	MOBILIZATION AND LOADING/UNLOADING THE GEOPROBE	11/16/2020
SOP-GEOPROBE-02	PRE AND POST JOB INSPECTION	11/16/2020
SOP-GEOPROBE-03	STARTING AND STOPPING THE KUBOTA ENGINE	11/16/2020
SOP-GEOPROBE-04	DRIVING AND POSITIONING THE GEOPROBE® MODEL 66DTX	11/16/2020
SOP-GEOPROBE-05	GEOPROBE® DT-22 DUAL TUBE SAMPLING SYSTEM	11/16/2020

SOP-GEOPROBE-06	GEOPROBE® DT-325 DUAL TUBE SAMPLING SYSTEM	11/16/2020
SOP-GEOPROBE-07	OPERATING THE GEOPROBE® DURING PROBING OPERATIONS	11/16/2020
SOP-GEOPROBE-08	GEOPROBE 0.5-IN. X 1.4-IN. OD AND 0.75-IN. X 1.4-IN. OD PREPACKED SCREEN MONITORING WELLS	11/05/2013
SOP-GEOPROBE-09	DH66 AUTOMATIC DROP HAMMER	11/16/2020
SOP-GEOPROBE-10	EQUIPMENT DECONTAMINATION - INORGANIC CONTAMINANTS	11/16/2020

Table 2. Data Quality Objectives

This table lists the data quality objectives (DQOs) for the BPSOU Pump Station Redesign Investigation (Site Investigation). The Site Investigation is detailed in the BPSOU Pump Station Redesign Remedial Design Work Plan (RDWP) and BPSOU Pump Station Redesign Quality Assurance Project Plan (QAPP). The tables, figures, and sections referenced in this table are part of the QAPP. The DQOs address how the investigation activities will meet the data gaps discussed in the RDWP.

Step 1: State the Problem: *The purpose of this step is to describe the problem to be studied so that the focus of the investigation will not be ambiguous.*

Problem: The BPSOU Pump Station Redesign will involve construction of a subgrade wet vault and a new pump house building. Subsurface geotechnical information will be required to inform the excavation and construction of these Site features prior to advancing the redesign. Investigating the geotechnical details of the Site will ensure adequate soil stability around existing structures as well as in areas of proposed structural features. Past investigations have collected data related to the soil lithologies within the Site; however, a geotechnical investigation focused on evaluating the physical properties of the soil in the area of the additional construction has not been completed. This information is needed to properly design the excavation surface, and any structural features such as foundations, parking lots, etc. that may be part of the design for the Site. The RDWP contains detailed description of the Site history, previous investigations, and the preliminary work plan.

Available Resources and Schedule: Pioneer Technical Services Inc. (Pioneer) is the contractor responsible for conducting the elements of the Site Investigation under the direction of Atlantic Richfield Company. All personnel completing field work will be properly trained in how to perform their tasks. The laboratory(s) selected to analyze the soil samples will be an Atlantic Richfield-approved laboratory(s). The Site Investigation work will be completed in summer 2022 to meet the current required design schedule for the RA.

Planning Team: The RDWP includes a detailed description on the project organization and responsibilities (Section 7.0).

Step 2: Identify the Goals of the Study: *This step identifies the principal questions that the study will attempt to resolve and what actions may result.*

Principal Study Questions:

- What are the geotechnical properties of the subsurface material that will be encountered during construction?
- How will the physical characteristics (shear strength, bearing capacity, chemistry, etc.) of the soil impact the design of the excavation surface and infrastructure such as parking lots, walking trails, structural foundations, etc.?

Estimation Statement: A geotechnical investigation will address the principal study questions. Analysis of lithological logs and sample results will inform quantitative and qualitative estimates for design elements and material needed to achieve proper soil stability.

Table 2. Data Quality Objectives

Step 3: Identify Information Inputs*: The purpose of this step is to identify the informational variables that will be required to answer the principal study questions and determine which variables require environmental measurements.*

Types of Information that are Needed:

- Classification and lithology recorded for each borehole.
- Field geotechnical evaluation of soils from selected boreholes, and physical laboratory results for moisture content, resistivity, pH, sulfate, particle size distribution, Atterberg Limits, Standard Proctor, California Bearing Ratio, Triaxial and consolidation analysis for samples at the discretion of the geotechnical engineer and as listed in Table 3.
- Standard Penetration Tests.
- Shelby Tube samples.
- Survey-grade GPS location coordinates for additional boreholes.

Source of Additional Information:

- BPSOU Pump Station Redesign RDWP
- BPSOU Pump Station Redesign Pre-Design Investigation Work Plan (PDI Work Plan)
- Results from any other investigation activities where borehole and test pit data were collected from the Site and surrounding area (if data meet applicable performance or acceptance criteria).

Applicable Limits/Thresholds:

- This is a preliminary investigation to gather information.

Appropriate Sampling and Analysis Methods:

Sampling and analysis methods are detailed in Table 3.

Step 4: Define the Boundaries of the Study*: The purpose of this step is to define the spatial and temporal boundaries of the study.*

Target Population: Figure 3 shows the areas to be analyzed during the Site Investigation.

Specific Spatial Boundaries, Temporal Boundaries, and Other Practical Constraints: Personnel will coordinate with ongoing remedy operations during drilling. Actual placement and/or completion of the borehole locations in the field will be subject to change based on field conditions (including existing infrastructure and land use in the area), changes to the design (including potential changes to the pumphouse building or wet well locations), or as deemed necessary by Field Team Leader and/or CPM in consultation with the Contractor QAO.

Scale of Estimates to be Made: Geotechnical evaluation from soil data will inform the design of excavation and construction of the wet well and pumphouse building.

General Spatial Boundaries, Temporal Boundaries, and Other Practical Constraints: Fieldwork will begin once Agency approval has been received. A proposed schedule is provided in the RDWP. Work will be performed as weather conditions permit. Contractor will coordinate with the operations team to minimize any potential disruption to remedy operation. Potential constraints that could delay fieldwork include adverse weather conditions, contractor availability, challenges with drilling caused by Site conditions, or other unforeseen issues. Major project delays resulting from these constraints will be recorded in the field logbooks and reported to the Agencies.

Step 5: Develop the Analytical Approach*: The purpose of this step is to specify the appropriate population parameters for making estimates.*

Population Parameters:

- Description of soil properties and characteristics.
- Soil shear strength, unit weight, consolidation, and results of the California Bearing Ratio test.
- Groundwater table location and pore water pressure.
- Soil bearing capacity, lateral earth loads, and soil corrosivity.
- Seismic Zone.
- General geotechnical modeling and calculations.
- Liquefaction analysis (if warranted).

Table 2. Data Quality Objectives
Specification of the Estimator: A geotechnical analysis will yield quantitative and qualitative results needed to inform the excavation and construction design.
Step 6: Specify Performance or Acceptance Criteria*: The purpose of this step is to define the performance or acceptance criteria that the collected data will need to achieve.*
Specify Acceptable Limits on Estimation Uncertainty: While some uncertainty in the estimate is inevitable and a minimum level of uncertainty is preferred, traditional statistics do not apply to the qualitative aspects of the Site Investigation. Therefore, non-statistical (expert judgement) methods will be used primarily as the basis for geotechnical evaluation.
General Performance or Acceptance Criteria: For estimation problems (Step 6B of EPA guidance), the collected data will be used to estimate unknown parameters, together with some reported measure of uncertainty in the estimate. Errors occur when data mislead the Site managers into choosing an inappropriate response. The potential for errors exists because all field and analytical measurements inherently contain sampling error and/or measurement errors. • ***Sampling Error:*** Sampling design errors occur when the data collection scheme does not adequately address the inherent variability of the matrix being sampled. Sampling design errors will be minimized by following the procedures outlined in the QAPP. • ***Measurement Error:*** Measurement errors occur from the inherent variability in taking field measurements and/or collecting, preparing, and analyzing an environmental sample. Field measurement errors will be minimized by following the relevant Standard Operating Procedures (SOPs) (e.g., SOP for test pit excavation). All analytical data gathered during the Site Investigation will be reviewed by the CPM and QAO to ensure that the data are suitable for their intended purpose. Types of data review processes that will be followed to ensure analytical results meet project objectives are detailed in Section 6.0. If significant issues with the data are found, results will be discussed with the EPA.
Step 7: Develop the Plan for Obtaining the Data*: This step identifies a resource-effective data collection design for generating data expected to satisfy the DQOs.* Summaries of the data collection design are listed here. A more detailed description is listed in the QAPP and RDWP.
Sampling Design: Log, screen, and sample the soil cores, as listed in Table 3. Log the results of the standard penetration test (SPT). Details are discussed in Section 3.2. Evaluating Key Assumptions: The focus of this objective for the Site Investigation is to collect additional useable data for a Site Investigation. The data review procedures (Section 6.0) will ensure the data collected is useable for this intended purpose. If design criteria are not met, if design criteria change, or if more information is needed, additional geotechnical boreholes may be installed. Any additional work will be proposed in an RFC for Agencies' review and approval.

References:

EPA, 2020. Consent Decree for the Butte Priority Soils Operable Unit. Partial Remedial Design/Remedial Action and Operation and Maintenance. U.S. Environmental Protection Agency. February 13, 2020. Available at https://www.co.silverbow.mt.us/2161/ButtePriority-Soils-Operable-Unit-Conse. Sections referenced in this text include Table 1 of Appendix 1 of Attachment C to Appendix D and Table 2-1 of Attachment A to Appendix D.

Table 3. Sample Collection

Analytical Group	Analytical Lab/Company[1]	Analyte	Analytical Method	Container Size	Preservation
Soil Laboratory Samples					
(1)	Pioneer's Material Testing Laboratory	Moisture Content	ASTM D2216	500 grams	None
		Resistivity	AASHTO T288	1500 grams	
		pH	AASHTO T289	300 grams	
		Sulfate (SO_4)	EPA Method 300 or MT 232-04	1 five gallon bucket	
		Particle Size Distribution	ASTM D6913	20000 grams. Approx. 3/4 of five gallon	
		Atterberg Limits	ASTM D4318	200 grams	
		Standard Proctor	ASTM D698	30000 grams. Approx. 1 five gallon bucket	
		California Bearing Ratio	ASTM D1883	2 five gallon buckets	
		Consolidated Undrained Triaxial Compression	ASTM D4767	1 Shelby tube	
		Consolidation of Soils	ASTM D2435		

[1]Atlantic Richfield may choose to use a different laboratory based on project needs. Regardless of the laboratory chosen, Atlantic Richfield will ensure the necessary reporting limits, required methodology, and the specified quality assurance/quality control requirements are followed as detailed in the QAPP. Agencies will be informed of any changes in the reporting limits, methodology, or the quality assurance/quality control procedures.

Table 4. Sample Proposed Locations, Type and Depth

Location Name	Northing[1] (Approximate)	Easting[1] (Approximate)	Target Depth[1] (ft)	Installation Method	Measuring Point Elevation	Geotechnical Investigation Samples
Proposed Geotechnical Boreholes						
PS22-BH01	651160.9	1197769.6	>20 feet	Geoprobe/HSA/Sonic	TBD	Y
PS22-BH02	651128.0	1197766.0	>20 feet	Geoprobe/HSA/Sonic	TBD	Y
PS22-BH03	651123.3	1197809.4	>20 feet	Geoprobe/HSA/Sonic	TBD	Y
PS22-BH04	651156.0	1197813.0	>40 feet	Geoprobe/HSA/Sonic	TBD	Y
Proposed Test Pits						
PS22-TP01	TBD	TBD	<8 feet	Excavator	TBD	N
PS22-TP02	TBD	TBD	<8 feet	Excavator	TBD	N
PS22-TP03	TBD	TBD	<8 feet	Excavator	TBD	N

[1]The final location and installation depth of the proposed boreholes and test pits may be modified by the geotechnical engineer in the field, in consultation with the CPM and QAO.
HSA - hollow stem auger, TBD - to be determined

Appendix A
Standard Operating Procedures

PURPOSE	To provide standard instructions for decontamination of all personnel leaving a contaminated area.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Wash/ Remove outer contaminated items.	Remove nitrile or latex gloves by grasping the outside of the opposite glove near the wrist. Pull and peel the glove away from the hand, turning the glove inside out with the contaminated side now on the inside. Hold the removed glove in the opposite gloved hand. Slide one or two fingers of the ungloved hand under the wrist of the remaining glove. Peel glove off from the inside, creating a bag for both gloves. If wearing protective coveralls such as Tyvec suites, brush built up material off the suit, only if in designated decontamination zone. Unzip the coverall and begin rolling that outwards, rolling it down over your shoulders. Place both hands behind your back and pull down each arm until completely removed. Sit down and remove each shoe then roll the coveralls down (ensuring the contaminated side is not touched or comes into contact with clothing) over your knees until completely removed. If there is not a designated decontamination zone, remove personal protective equipment (PPE) carefully to contain material and place it in the appropriate disposal container. For instructions to remove additional PPE not described in this document, refer to the project's HASP. Wash with soap (nonphosphate) and tap water the outer, more heavily contaminated items, such as boots. Rinse the items in tap water.
2. Wash inner contaminated items.	If necessary, wash with soap (nonphosphate) and tap water the inner, less contaminated items. Rinse the items in tap water.
3. Store/ transport items.	Store/transport contaminated items in a separate designated area to prevent cross contamination prior to disposal.

4. Dispose of contaminated items.	Dispose of contaminated clothing and equipment in accordance with site/project, client, and/or federal and state requirements.
5. Contact the Safety and Health Manager.	For contaminants other than those found typically at uncontrolled hazardous waste sites, such as asbestos, PCB, PCE, etc. see the Safety and Health Manager.
Information about Emergency Decontamination	
1. During life-saving process.	If the decontamination procedure is essential to the life-saving process, decontamination must be performed immediately.
2. During heat-related illness.	If heat-related illness develops, protective clothing should be removed as soon as possible. Wash, rinse, and/or cut off protective clothing/equipment.
3. When medical treatment is needed.	If medical treatment is required to save a life, decontamination should be delayed until the victim is stabilized. Wrap the victim to reduce contamination of others. Alert medical personnel to the emergency and instruct them about potential contamination. Instruct medical personnel about specific decontamination procedures.

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	Potential contact with contaminated items and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated items and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will follow decontamination procedures as described above. Employees will wear nitrile gloves and safety glasses when handling contaminated items.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Not applicable.			
GRAVITY	Slips and falls.	Areas designated for decontamination procedures.	Slips and falls could occur while performing decontamination procedures due to slippery surfaces resulting in bruises, scrapes, or broken bones.	Workers will wear work boots with good traction and ankle support. Keep work area as dry as possible. Wear muck boots as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day.
	Hypothermia/frost bite.	Sites where air temperature is 35.6°F (2°C) or	Workers whose clothing becomes wet	Employees will change clothing, if it becomes wet.

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

		less.	during decontamination procedures may be exposed to hypothermia and/or frostbite.	
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			effects and/or property damage.	
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	In general, the following items will be needed: soap, tap water, tarps, decontamination tubs, brushes, and sprayers. The Sampling and Analysis Plan (SAP) or Quality Assurance Project Plan (QAPP) will describe additional items needed for decontamination.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/03/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/03/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for equipment decontamination.
SCOPE	Pioneer Technical Services, Inc. (Pioneer) prepared this practice for the workforce and this Standard Operating Procedure (SOP) applies to all work performed by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent (as defined by OSHA) in the risk-assessed procedure described below before performing the work.
NOTES	All equipment leaving the contaminated area of a site must be decontaminated. Decontamination methods include removal of contaminants through physical, chemical, or a combination of both methods. Decontamination procedures are to be performed at the same level of protection used in the contaminated area of a site. In some cases, decontamination personnel may be sufficiently protected by wearing one level lower protection. The information for site-specific equipment decontamination and personnel protection levels, as detailed in the Sampling and Analysis Plan (SAP), work plan (WP), and Site-Specific Health and Safety Plan (SSHASP), should be followed. The following decontamination procedures are for typical uncontrolled hazardous waste sites. For a specific or unusual contaminant, such as dioxins, see the SSHASP and consult with the Safety and Health Manager. Decontamination procedures should be used in conjunction with methods to prevent contamination of sampling and monitoring equipment. If practical, particularly with organic contaminants, one-time-use equipment should be used and disposed of in accordance with the SAP, WP, and SSHASP. This SOP covers all equipment decontamination EXCEPT for submersible pumps. Decontamination of pumps is detailed in SOP-DE-02A – Equipment Decontamination - Pumps for Well Sampling.

WORK INSTRUCTIONS

The following instructions provide guidance to perform the task in a safe, accurate, and reliable manner. If these instructions present information that is inaccurate or unsafe, personnel must notify the Project Manager, Safety Manager, and the SOP Technical Author to initiate appropriate revisions. Personnel will perform all work under this SOP in a manner that is consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plans (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Set up decontamination station.	a. Review the SAP or WP and determine if decontamination fluids need to be contained and the need for special decontamination requirements (i.e., chemical rinse). b. If the fluids require containment, set up the decontamination station so that it is located within a small plastic swimming pool or on plastic sheeting with turned up edges to contain water that may slop over during the decontamination process.

	c. If pressurized or gravity flow water is available, attach a hose or piping to reach the decontamination area. If no water is available, bring 5-gallon containers of tap and deionized water (DI) to the decontamination area to clean the equipment. d. Label empty 5-gallon buckets: *gross wash, soap wash, DI rinse, final rinse, and chemical rinse* (if required). e. Lay out clean plastic or foil to place cleaned equipment on to allow for air drying. f. If a chemical rinse is required, fill a spray bottle with the appropriate chemical and label the spray bottle with the chemical's name. g. Pour approximately 2.5 to 3 gallons of tap water into the buckets labeled: *gross wash* and *soap wash*. h. Add a **few drops** (1-3 drops) of Liquinox© soap to the bucket marked *soap wash*. i. Pour 2.5-3 gallons of DI water into the buckets labeled: *DI rinse* and *final rinse.* If a chemical rinse is required, pour DI water into the bucket labeled: *chemical rinse.*
2. Remove gross contamination.	Remove gross contamination using pressurized or gravity flow tap water, if available. If not, manually scrub the equipment using the 5-gallon bucket of water marked *gross wash* and a stiff brush (dedicated to the gross wash step).
3. Wash equipment.	Move the equipment to the 5-gallon bucket marked *soap wash*. Wash equipment with a stiff brush (dedicated to the soap wash step).
4. Triple rinse equipment.	In the bucket marked *DI rinse*, triple rinse the equipment with DI water to remove any soap residue.
5. Second rinse with deionized water.	Using DI water, triple rinse the equipment again in the bucket marked *final rinse* if a chemical rinse is not required.
6. Rinse equipment with chemicals.	In many cases, the tap water and DI water rinses will be sufficient. However, if specified in the SAP, WP, or SSHASP, chemical rinses of the equipment may be required. For inorganic contaminants, a mixture of 10:1 nitric acid in distilled water (10 parts water to 1 part nitric acid) may be specified. A methanol rinse may be required for some organic contaminants, such as hydrocarbons. Spray bottles, clearly marked with the appropriate chemical name, are an acceptable means of rinsing most equipment. **To perform the chemical rinse:** a. Hold the equipment over a collection container (5-gallon bucket or bowl). b. Make sure that all personnel and vehicles are upwind of the spray. c. Spray the piece of equipment inside and out starting at the top and working down to the bottom. d. Dispose of the contained chemicals as described in the SAP, WP or SSHASP. The Safety and Health Manager and/or Project Manager must approve the disposal method used.

7. Rinse equipment with deionized water.	After a required chemical rinse, rinse the equipment again with the DI water in the bucket marked *chemical rinse*. This DI water will need to be retained (i.e., do not dispose of this water on the site), tested, and disposed of according to federal and state requirements for the chemical used. The Safety and Health Manager and/or Project Manager must approve the disposal method used. After the rinse in the *chemical rinse* bucket, triple rinse the equipment again in the bucket marked *final rinse.*
8. Air dry equipment.	Place equipment on plastic sheeting or foil to air dry.
9. Transport/ store equipment.	Wrap equipment in foil or plastic wrap to transport or store.
10. Clean decontamination equipment.	a. Triple rinse equipment from the *gross wash* and *soap wash* (brushes and buckets) with clean tap water, preferably with pressurized water. Soap can be used on particularly dirty equipment. b. Triple rinse all decontamination equipment with DI water, including *DI rinse* and *final rinse* buckets. c. Store decontamination equipment, labeled and in a clean location so they are used only for decontamination purposes.
11. Dispose of decontamination solutions.	Storage of contained decontamination fluids as required by the SAP, QAPP, or WP or of residue from a chemical rinse should have been arranged on site prior to sampling. Once the sampling and associated decontamination is complete, sampling of the stored fluids for hazardous waste criteria will be required. If the fluids are determined to be hazardous (e.g., meet the characteristics of a hazardous waste [ignitability, corrosivity, reactivity, or toxicity] or contain listed wastes from title 40 of the Code of Federal Regulations [CFR] in part 261.4), dispose of them according to federal and state requirements. The Safety and Health Manager and/or Project Manager must approve the disposal method used. Note: when using other than the above-mentioned solutions, check with the Safety and Health Manager and the Project Manager.
12. Measure effectiveness of procedures.	Measure the effectiveness of the decontamination procedures using field equipment rinsate blanks as discussed in the SAP, QAPP, or WP.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated items and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated items and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene (wash hands prior to eating/drinking and when leaving the site); follow decontamination procedures as described above; and wear nitrile gloves and safety glasses when handling contaminated items.
	Chemical rinse (e.g., dilute nitric acid, methanol, and hexane).	Sites.	Personnel could be exposed to chemicals via ingestion and skin/eye contact when decontaminating equipment. Exposure could cause irritation of skin/eye and adverse health effects.	Personnel will check and follow safety procedures as outlined in the chemical-specific Safety Data Sheets. Personnel will prevent skin/eye contact with chemicals and they will wear nitrile gloves and eye protection when handling chemicals. Personnel will practice proper personal hygiene (wash hands prior to eating/drinking, after decontaminating equipment, and when leaving the site). All personnel and vehicles will stand upwind when spraying equipment with chemicals. Refer to the Chemical Flushing Guidelines available inside any Pioneer vehicle's first aid kit for first-aid procedures in case of contact with chemicals.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry 5-gallon containers.	Personnel will use proper lifting techniques: get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two people will lift awkward/heavy tools and equipment.
GRAVITY	Falls from slips and trips.	Areas designated for decontamin-ation procedures.	Slips and falls could occur while performing decontamination procedures due to slippery surfaces resulting in bruises, scrapes, or broken bones.	Personnel will wear work boots with good traction and ankle support. Personnel will also be aware of working/ walking surfaces and choose a path to avoid hazards, keep work areas as dry as possible, and wear muck boots as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors, remain hydrated, and have sufficient caloric intakes during the day. Personnel will also follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/ frostbite.	Sites where air temperature is 35.6 °F (2 °C) or less.	Personnel whose clothing becomes wet during decontamination procedures may be exposed to hypothermia and/or frostbite.	Personnel will change clothing if it becomes wet.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Personnel will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Personnel could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Personnel will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Personnel should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Personnel will avoid contact with plants, insects, and animals. First-aid kits will be available on the site. Personnel with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Contact with hot surfaces.	Foil and decontamination equipment.	If foil and decontamination equipment are placed directly in the sun, they could get hot. Contact with hot surfaces could result in personal injury.	Personnel will not set decontamination stations directly in the sun.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
HUMAN FACTORS	Inexperienced and improperly trained personnel.	Sites.	Inexperienced personnel and improper training could cause incidents resulting in injuries and/or property damage.	Personnel will be properly trained in this procedure and other applicable procedures. Personnel will implement stop work procedures, if necessary.
SIMOPS (Simultaneous Operations)	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

REQUIRED PPE	**Personnel Protection Equipment** (PPE)**:** Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDSs	**Safety Data Sheets** (SDSs) for corresponding chemicals used during chemical rinse will be maintained based on the site characterization and contaminants. Safety Data Sheets are available to Pioneer personnel at the link below: https://pioneertechnicalservices.sharepoint.com/Safety/SafetyDataSheets
REQUIRED PERMITS/ FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT

The following documents should be referenced to assist in completing the associated task.

DRAWINGS	
RELATED SOPs/ PROCEDURES/ WORK PLANS	

TOOLS/ EQUIPMENT	Five empty 5-gallon buckets, tap water, stiff brushes, Liquinox soap, four 5-gallon containers of DI (or distilled water if DI water is not available), chemicals for chemical rinse (if required), small plastic swimming pool/plastic sheeting or foil, tarps, and sprayers (if available). If additional items for decontamination are needed, they will be listed on the SAP.
FORMS/ CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**09/08/2020**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**09/08/2020**

PURPOSE	To provide standard instructions for handling investigation-derived waste in accordance with the US Environmental Protection Agency (EPA) protocols and Department of Environmental Quality (DEQ) guidance. Investigation-derived waste may be generated during a Site Assessment (SA), Site Investigation (SI), or Remedial Investigation (RI).
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Collect and dispose of decontamination fluids.	Collect and dispose of decontamination fluids by using one of the following methods: - Send fluids to a Treatment, Storage, and Disposal (TSD) facility. - Evaporate fluids. - Tread fluids using an activated carbon or air sparging unit. - Temporarily store fluids until determined if they are contaminated. Dispose of decontamination fluids, generated from cleaning equipment used in background sampling or for sampling in areas where past results indicate that contaminants are below standards, to the ground surface.
2. Discharge groundwater from developing and purging wells.	If past monitoring results and laboratory analysis indicate that all contaminants are below groundwater standards, discharge groundwater generated from developing and purging monitoring wells to the ground surface.
3. Collect/label/ store contaminated groundwater from developing and purging wells.	If past monitoring results indicate that one or more contaminants are above groundwater standards, collect the purged water and potentially contaminated water. There may be instances (e.g., inclement weather) where purge water and/or decontamination water will be temporarily stored in drums or tanks to be treated on site with granulated activated carbon or air sparging. If the water is determined by laboratory analysis to contain contaminants above groundwater standards and cannot be treated on site, store the water on site until shipping/disposal arrangements can be made. If the water is visibly contaminated, drum, label, and store the water on site until

	shipping/disposal arrangements are made. Label all containers stored on site with the following information: date, time, contents, any corresponding analytical data, collection location, contact person, and contact agency, etc.
4. Return soils back to borehole.	Unless it is visibly contaminated, place soil and/or cuttings from monitoring well installation back in the borehole.
5. Collect/label/ store contaminated soils from installing wells.	If the soil is visibly contaminated, drum, label, and store the soil/cuttings on site until shipping/disposal arrangements are made. Drum and label soils from borings/well installations located in previously sampled areas that are known to be contaminated. Leave these soils on site until shipping/disposal arrangements are made.
6. Pack and dispose of one-time use equipment and PPE.	Pack disposable equipment intended for one-time use and personal protective equipment (PPE) materials for appropriate disposal. Double bag the disposable equipment and PPE utilized for sampling and dispose of it as a solid waste in the local landfill. Package, drum, and label disposable equipment and PPE utilized for sampling visibly contaminated sites or sites known to be contaminated from previous monitoring. Leave equipment and PPE on site until shipping/disposal arrangements are made.
7. Dispose of samples not used for analysis.	Laboratories will dispose of the portions of the samples submitted, but not used for analysis. If samples are retained and not sent for analysis, they need to be returned to the site prior to remediation or disposed of according to federal and state regulations.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated soils and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will follow decontamination procedures as described above. Employees will wear nitrile gloves and safety glasses when handling contaminated items.
	Nitric acid.	Sites.	Employees could be exposed to nitric acid via ingestion and skin/eye contact when decontaminating equipment. Exposure could cause irritation of skin/eye and adverse health effects.	Employees will prevent skin/eye contact with nitric acid and they will wear nitrile gloves and eye protection when handling nitric acid. Employees will practice proper personal hygiene – wash hands prior to eating/drinking, after decontaminating equipment, and when leaving the site. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with nitric acid.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper shoveling techniques.	Sites.	Personnel could be injured if using improper shoveling techniques to store contaminated soils/cuttings in drums, causing back injuries and muscle/back strains.	Personnel will use proper shoveling techniques: keep feet wide apart, place front foot close to shovel, put weight on front foot, use leg to push shovel, shift weight to rear foot, keep load close to body, and turn feet in direction of throw.

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry 5-gallon containers of tap water.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Hypothermia/frost bite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers whose clothing becomes wet during decontamination procedures may be exposed to hypothermia and/or frostbite.	Employees will change clothing, if it becomes wet.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be	Employees will follow the 30/30 rule during lightning storms.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			caused by lightning strike.	
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants. Nitric acid.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-DE-02 Equipment Decontamination.
TOOLS	Five 5-gallon buckets, tap water, stiff brushes, soap, de-ionized or distilled water, nitric acid (if required), plastic sheeting or foil, tarps, decontamination tubs and buckets, sprayers, storage containers, labels, and shovels.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang	**12/03/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman	**12/03/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for mobilizing and loading/unloading the Geoprobe® Model 7822DT.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Trailer hook-up	1. Turn on the diesel work truck to allow the glow plugs to warm up. To warm the glow plugs, turn the ignition switch to the first setting on the truck and there will be a light on the dashboard that looks like a pig tail. When this light goes off, the glow plugs are warmed, and the truck can be started. 2. Before backing up the truck, ensure that the gooseneck is high enough that it won't hit the truck when backing up. Using a spotter, back the truck up so the ball on the truck's hitch is right below the coupler on the trailer hitch. 3. When the ball of the truck's hitch is located under the coupler on the trailer, ensure that the coupler is unlatched. To do this, make sure the pin, which is normally locked in the down position is raised up and flipped over into the catch and you will see it has locked in the up position. 4. Turn the front trailer jack's crank counterclockwise to lower trailer onto the truck's hitch . 5. To make sure coupler is latched securely to ball, swing pin out of the catch and let it drop straight down through the hole in the plate and then swing it to the side. 6. When the trailer is locked to the truck's hitch, pull the clip and safety pin from the front jack's foot plate and move the spring-loaded foot plate up into the jack and replace the safety pin and clip. 7. Attach the trailer's safety chains and break away system to the truck's hitch system. 8. Inspect and attach the trailer's brake and trailer's lights cord to the power output connection on the truck. Verify that the trailer's lighting and braking system are

	working. 9. Ensure that the trailer's doors are all locked during transport. 10. Verify that all jacks (two on the front of the trailer) are up off the ground and secured. Also verify that the safety chains, pins, and power cord are attached and secured. 11. Remove the chocks out from under the trailer's tires and place them in the back of the truck. The Geoprobe® trailer is now ready for mobilization to and from job sites.
Unloading the Geoprobe®	1. Park the trailer on level ground. Set the parking brake on the truck and place tire chocks under the front and rear of one set of trailer's tires. Verify that the trailer's hitch is securely fastened to the truck. 2. Remove the safety pin and then pull down the spring assisted ramps. 3. Take the front and back ratchet straps off of the Geoprobe®. 4. Start the Geoprobe® and allow its fluids sufficient time to warmup to prevent unnecessary wear on the engine and hydraulic systems. While the Geoprobe® is going through the warmup, the system will lock out the Geoprobe® so that it can't be moved until the warmup is completed. 5. Prior to backing out of the trailer, ensure the blade and/or toolbox are raised so that they do not drag or get caught on anything during the unloading process. Slowly back the Geoprobe® out of the trailer using the remote control. For proper alignment, split the middle of the two tracks when unloading the Geoprobe®. Use the slow speed on the remote control when unloading the Geoprobe® from the trailer. **Note:** when the Geoprobe's center of gravity is at the end of the trailer, the front portion of the tracks will lift off the trailer's floor and the back portion of the tracks will lower onto the ramps, however the operator is controlling the Geoprobe® from the remote control and is not operating the Geoprobe® from a driver's seat on the machine. 6. Back the Geoprobe® 4 to 5 feet off the ramp and perform the pre-job inspection. Refer to SOP-GEOPROBE-02 Pre-Job and Post-Job Inspection for this procedure.
Loading the Geoprobe®	1. Perform the post-job inspection per SOP-GEOPROBE-02 Pre-job and Post-job Inspection as necessary. 2. Connect the truck to the trailer and park the trailer on level ground. Set the truck's parking brake and place tire chocks under the front and rear of one set of trailer's tires.

	3. Remove the safety pin and then pull down the spring assisted ramps. 4. Cool down of the Geoprobe® may be necessary before loading into the trailer. There are two fans that are used to cool the machine and will be visible on the control panel if they are turned on. If either fan is operating, do not turn off the Geoprobe®. The fans will turn off automatically when the Geoprobe® reaches the necessary cool down temperature. 5. Slowly move the Geoprobe® forward into the trailer using the remote control. For proper alignment, split the middle of the two tracks when loading the Geoprobe®. Ensure the Geoprobe® blade is up as high as it can go so the job box does not drag or get caught during the loading process. Use the slow speed on the remote control when loading the Geoprobe® into the trailer. 6. Flip the spring assisted Ramps back up and put the safety pin back in place. Loading the Geoprobe® is complete.
Securing the Geoprobe® in the trailer	1. Ensure the Geoprobe® is centered in the trailer. Refer to SOP-GEOPROBE-04 Driving the Geoprobe® Model 7822DT for driving procedures. 2. Make sure the Geoprobe® tracks are 3-4 inches in front of where the black strips start on the trailer floor. This will put the Geoprobe® in an optimal position for weight distribution on the trailer axles and tongue. 3. Attach the two front ratchet straps to the front strap connection on the Geoprobe® and the front strap rings located on the floor towards the front of the trailer. Tighten the ratchet strap so there is no slack in the strap. 4. Attach the two ratchet straps to the back-strap rings located at the rear of the trailer. Tighten the strap so there is no slack in the strap.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and safety glasses, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe's trailer. Cleanup materials will be disposed of according to state's regulations. All components of the Geoprobe® will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
NOISE	Elevated noise levels.	Geoprobe®.	Employees could be exposed to elevated noise levels when driving the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel within a 20-foot buffer of the Geoprobe® will wear single hearing protection (e.g., ear muffs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
BODY MECHANICS	Not Applicable			

GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn.
	Geoprobe® falling off of ramps.	Geoprobe®.	The Geoprobe® could fall off of the ramps when loading/ unloading it resulting in personal injuries and/or property damage.	Use a spotter when loading/unloading the Geoprobe®. Workers will use special caution when loading the Geoprobe® onto a trailer with wet ramps. It is significantly easier for the tracks to slip under such conditions.
WEATHER	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g., layers). Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms. When the Geoprobe® is running, the Geoprobe's helper will watch for thunder/lightning.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long

			summer months causing sun burns, skin damage, and eye damage.	pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.
MECHANICAL	Backing up the work truck.	Sites.	Incidents could occur when backing up the work truck to connect the trailer to the truck resulting in personal injury and/or property damage.	Use a spotter when backing up the work truck. If a spotter is not available, walk around the truck to check distances and look for obstacles that may be in your blind spots. The spotter will wear high visibility clothing.
	Unloading the Geoprobe®.	Sites.	Incidents could occur when backing up the Geoprobe® to unload it from the trailer resulting in personal injury and/or property damage.	As a precaution, the operator should be ready to move the track control levers forward to stop the reverse motion. The operator will use the slow speed on the remote control when backing up the Geoprobe®.
	Towing the Geoprobe's trailer.	Road.	Incidents could occur when towing the Geoprobe's trailer to and from the job site resulting in personal injury and/or property damage.	Driver will follow defensive driving techniques and will be trained on how to tow a trailer. Driver will verify that the trailer's safety chains are attached to the truck's hitch system.

	Pinch points.	Loading/unloading the Geoprobe®.	Employees could be exposed to hand injuries, such as lacerations, punctures, cuts, and pinched fingers, when connecting the trailer to the work truck and when setting up the trailer's ramps.	Personnel will wear work gloves and will watch for hand placement when performing these tasks.
	Struck by/caught between the work truck, trailer, and/or Geoprobe®.	Loading/ unloading the Geoprobe®.	Personnel could be struck by/caught between the work truck, trailer, and/or Geoprobe® resulting in injury and/or property damage.	Set the truck's parking brake and place the tire chalks under the tires of the trailer before unloading and loading the Geoprobe®. When unloading the Geoprobe®, the helper will maintain a 20-foot buffer zone from the Geoprobe®. All employees will wear high visibility clothing. Non-essential personnel will maintain a 20-foot buffer zone around the rig. Use traffic cones to delineate the space needed to load/unload the Geoprobe®.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the Geoprobe® will be inspected prior to and at the completion of the task. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe's trailer. Cleanup materials will be disposed of according to state's regulations. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
THERMAL	Not applicable.			

HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperience workers and improper training could cause incidents resulting in personal injuries and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. When loading/unloading for the first time, an experienced operator should be on site to help coach the loading/unloading process. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE (hard hat, safety glasses, high-visibility work shirt or vest, long pants, steel-toed boots), work gloves, and single hearing protection (e.g., ear muffs).
APPLICABLE SDS	SDSs will be maintained based on-site characterization and contaminants. Hydraulic Fluid and diesel.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-02 Pre-Job and Post-Job Inspection SOP-GEOPROBE-03 Starting and Stopping the Kubota Engine SOP-GEOPROBE-04 Driving the Geoprobe® Model 7822DT
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date
1	Updates to SOP to reflect Geoprobe ® Model 7822DT	11/16/2020

PURPOSE	To provide standard instructions for conducting a pre-job and post-job Geoprobe® inspection.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Pre-job Geoprobe® setup.	Note: this procedure assumes that the Geoprobe® is out of the trailer. Refer to SOP-GEOPROBE-01 Mobilization and Loading/Unloading the Geoprobe® for instructions on how to back the Geoprobe® out of the trailer. The pre- and post-job inspections cannot be fully performed while the Geoprobe® is in the trailer due to the mast being folded over and preventing the removal of the engine cover lid. 1. Place the Geoprobe® on flat ground. 2. Unfold the derrick by pushing the fold lever downward. Unfold the derrick until the foot of the Geoprobe® is parallel to the ground. 3. Lower the foot of the Geoprobe® until it touches the ground by pushing the foot lever downward. 4. Turn off the Geoprobe®.
Pre-job engine hours.	1. Locate the run time odometer on the control panel and write down the machine's current hours on the Geoprobe's pre-operation inspection sheet. A Geoprobe's pre-operation inspection form is attached to this SOP as an example.
Pre-job engine compartment inspection.	1. Open the engine compartment by removing the rear upper engine cover. 2. Check the engine oil level using the oil dip stick. The oil level should be between the marks on the dip stick. If the oil level is below the lowest mark, additional engine oil is required for engine protection. 3. Check the engine's coolant fluid level inside the radiator by checking where the fluid is in relation to the "Full" and "Low" line on the reservoir.

	4. Check the hydraulic fluid level by reading the sight glass located On the control panel. Maintain the hydraulic fluid at or within 0.5 inches below the upper solid black line on the glass. If the hydraulic fluid level is below, new hydraulic oil must be added to the hydraulic oil tank until the fluid rises to the upper mark on the site glass. 5. Check diesel fuel level by removing the fuel cap and visually inspecting fuel level or by turning ignition switch to energize fuel gage on the control panel. 6. Ensure the hydraulic fluid cap, fuel cap, and radiator cap are all in place. 7. Check the radiator for leaks, cracks, and cleanliness. Inspect radiator's hoses and radiator's body for coolant leaks and inspect the engine's compartment for signs of coolant leakage. 8. Inspect the engine belts for cracking and glazing, indicators that the belts are worn and will need replacement. Also, check the belts for tension by pushing on the longest length of belt to determine the amount deflection. If the deflection is greater than 0.5 inches, the belt tension will require adjustment. 9. Document fluid levels and other notable conditions on the pre-operation inspection sheet. 10. Close the engine compartment.
Pre-job machine chassis inspection.	1. Inspect the rubber tracks for cracks and nicks, indicating that the tracks will need to be replaced soon. Also, check for proper tension by raising the tracks off the ground. The tracks should have 3 inches of slack in them at the midpoint of the track. 2. Grease three Zirk fittings on Geoprobe® as required. A single Zirk fitting is located under the rig in the rotation bearing. The bearing requires 5 pumps of multipurpose grease every 100 hours of operation. To gain access to the grease fitting, first make sure the engine is off and the ignition key is removed. Slide in between the tracks from under the front of the vehicle. Two additional Zirk fittings are located on the fold bracket pivot points. These fittings require 3 pumps of grease every 50 hours of operation. 3. Visually check the hydraulic cylinders for leaks. The hydraulic cylinders will require little to no maintenance. Under normal use, hydraulic cylinder rods will have some fluid accumulation. Excessive leaks between the cylinder rod and cylinder rod seal indicates that service is necessary by Geoprobe® Systems or a qualified hydraulic cylinder

	service. 4. Locate the battery and fuse/relay box by opening the side door behind the pipe rack. Check the battery and fuse/relay box. Ensure they are clean and free of corrosion. 5. Visually check the hydraulic hoses and fittings for leaks. Operator should look for hydraulic hoses that are leaking, cut, collapsed, or bulged. **Note:** if hydraulic fittings are loose, tighten them. If hoses are leaking or fittings cannot be tightened, immediately stop work, and have the given fittings and/or hoses replaced. 6. Check the Geoprobe's frame for cracks or damage. 7. Ensure the rear-tool basket (if used) is attached to rear blade of the Geoprobe®. 8. Ensure the fire extinguisher is inspected and located in the basket or with the Geoprobe® at all times during Geoprobing activities. 9. Ensure the five emergency stop buttons are functioning properly. Test each button individually by starting the Geoprobe® and pushing that individual emergency stop button. If the engine quits, that emergency stop button is working. If the emergency stop buttons are not working, field work will be halted until the stop buttons are repaired and functioning properly. 10. Inspect Geoprobe's assembly bolts and look for loose screws and nuts. The hammering operations tend to loosen fasteners over time making it important to visually check chassis screws, nuts, and bolts. Tighten any loose fasteners that are identified. 11. Check the hose carriers/housings for breaks in brackets.
Pre-job control panel and accessories inspection.	1. Ensure all gauges are operating properly by examining each gauge to see if the measurement is normal or the dial indicator is moving. 2. Ensure all control levers are in the neutral position and are secure. 3. Ensure all control switches are operating properly by testing each switch to determine if function control is maintained. 4. Visually inspect the winch line and winch safety hook for any damage or fraying. 5. If the drop hammer is being used make sure it is secured. Check the

	hoses coming from the drop hammer to ensure there are no leaks and also make sure the auxiliary hydraulic line and fittings are free of leaks. Refer to SOP-GEOPROBE-09 DH133 Drop Hammer to see the drop hammer securing procedures.
Post-job Geoprobe® inspection.	1. Move Geoprobe to a flat, safe location. 2. With the engine running and cooling down, perform a visual inspection of the Geoprobe®, looking for leaking oil, coolant, or hydraulic fluid. Additionally, look for loose bolts, nuts, and screws that may have come loose during the day's operation. This inspection will identify any new issues with the Geoprobe® that could be repaired or replaced before the next work day. **Note:** a thorough inspection is not usually performed at the end of the day when the Geoprobe® components are hot. Checking fluid levels in a hot engine is hazardous, especially coolant levels.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Diesel, Oil, hydraulic fluid, coolant, and fitting grease.	Geoprobe®.	Employees could be exposed to diesel, hydraulic fluid, coolant, and/or fitting grease via inhalation, ingestion, and skin/eye contact, when inspecting the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and safety glasses, if contact with diesel, oil, hydraulic fluid, coolant or fitting grease is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe's trailer. Cleanup materials will be disposed of according to state's regulations. All components of the Geoprobe® will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
NOISE	Elevated noise levels.	Geoprobe®.	Employees could be exposed to elevated noise levels when the Geoprobe® is running resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel within a 20-foot buffer of the Geoprobe® will wear single hearing protection (e.g., earmuffs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task. Do not operate the Geoprobe® if defective electrical lines are found during the pre/post job inspection.
BODY MECHANICS	Not applicable.			
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet	Walking on slick/muddy/wet	Workers will wear work boots with good traction and ankle

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

		surfaces and steep slopes.	and uneven terrain could cause slips and trips resulting in falls and injuries.	support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn.
WEATHER	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke. Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g. layers). Employees will remain hydrated and will have sufficient caloric intake during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP. Employees will follow the 30/30 rule during lighting storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, animals, and insects.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available in work trucks. Employees with allergies should notify their supervisor.
MECHANICAL	Pinch Points from folding and	Geoprobe®	Employees could be exposed to	Personnel will wear work gloves and will watch for hand

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

	unfolding the Geoprobe.		hand injuries, such as lacerations, punctures, cuts, and pinched fingers, when folding and unfolding the Geoprobe® during pre/post job inspection.	placement when performing these tasks. All non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in injury/ exposure and hydraulic fluid release.	All components of the Geoprobe® will be inspected prior to and at the completion of the task. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe's trailer. Cleanup materials will be disposed of according to state's regulations. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
THERMAL	Hot fluids in the engine compartment.	Geoprobe®.	Employees could be exposed to hot fluids in the engine compartment that if contact occurs could result in injury/exposure or fluid release.	All components of the Geoprobe® will be inspected prior to and at the completion of the task. Allow time for the engine and fluids to cool prior to performing the pre/post job inspection. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe's trailer. Cleanup materials will be disposed of according to state's regulations. Employees will use Level D PPE and proper gloves when preforming pre/post job inspections. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in personal injuries and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. When performing the pre/post job inspection for the first time, an experienced operator should be on site to help coach the pre/post job inspection process. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency kill switch button. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE (hard hat, safety glasses, high-visibility work shirt or vest, long pants, steel-toed boots), work gloves, and single hearing protection (e.g., earmuffs).
APPLICABLE SDS	SDSs will be maintained based on-site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/	SOP-GEOPROBE-01 Mobilization and Loading/Unloading the Geoprobe® SOP-GEOPROBE-09 DH133 Drop Hammer

WORK PLANS	
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date
1	Updates to SOP to reflect Geoprobe ® Model 7822 DT	11/16/2020

PURPOSE	To provide standard instructions for starting and stopping the Kubota Diesel Engine on the Geoprobe®.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Preparing the Engine for Start Up	1. Make sure the Geoprobe® is in an open area for ventilation. When starting the Geoprobe® in the trailer completely open the front and back doors to provide ventilation. 2. Ensure as the operator you are familiar with all five kill switches on the Geoprobe®. There is a kill switch located on the remote control, on the control panel, one on each side of the Geoprobe®, and the last kill switch is a pull latch cable located next to the control panel.
Starting the Kubota Engine.	1. Warm the glow plugs before starting. To warm the glow plugs, turn the key counterclockwise. A message will appear on the control panel when the machine is ready. **Note:** In cold weather conditions, it is good practice to warm the glow plugs twice. Also, if the machine has been warmed up and been running, then there is no need to warm the glow plugs again before start up. 2. Turn ignition key clockwise to activate the starter motor. Release the ignition key when the engine starts and runs on its own power. **IMPORTANT: Do not run the starter motor for longer than 10 seconds. If the engine does not start running, then allow 30 seconds to pass and repeat the starting procedure.** 3. Verify the oil pressure gauge is reading in the white on the pressure gauge and the battery gauge is also reading in the white. **(Refer to the Kubota Manual for troubleshooting procedures).**

	4. Allow the engine to run approximately 5 to 10 minutes, or through a complete warm up cycle, to bring the coolant and hydraulic fluid up to running temperature. The machine will be locked out until the warm up cycle is completed and fluids are at correct operating temperatures. The control panel has gauges that show hydraulic fluid temperature, hydraulic tank temperature, and coolant temperature.
Running the Kubota Engine	1. When the engine is running between pushing and/or sampling procedures, the machine is equipped with an automatic throttle and will lower the throttle. This will help to conserve fuel, prolong the engine life, and reduce noise levels.
Stopping the Kubota Engine	1. Check the control panel to see if the two fans are running. If either fan is on, the Geoprobe® needs to stay on to allow the fan(s) to cool the engine and fluids. Once both fans are turned off, the Geoprobe® is cool and can be turned off. 2. Turn the ignition key to the "OFF" position. **IMPORTANT: Familiarize yourself with the engine kill switches so in case of an emergency these switches can be easily used!!!**

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Carbon Monoxide	Geoprobe®.	Employees could be exposed to carbon monoxide via inhalation when operating the Geoprobe®, resulting in adverse health effects.	Employees will make sure the Geoprobe® is started in an open area to provide good ventilation. If the Geoprobe® is started in the trailer, make sure both doors are open. Do Not work around the exhaust area (back of the rig) while the Geoprobe® is running. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to	Employees will wear work gloves and safety glasses, if contact with hydraulic

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			hydraulic fluid and or diesel via inhalation, ingestion and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe's trailer. Cleanup materials will be disposed of according to state's regulations. All components of the Geoprobe® will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
NOISE	Elevated noise levels.	Geoprobe®	Employees could be exposed to elevated noise levels when driving the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel within a 20-foot buffer zone of the Geoprobe® will wear single hearing protection (e.g. earmuffs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
ELECTRICAL	Defective electrical lines.	Geoprobe®	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
BODY MECHANICS	Not applicable.			
GRAVITY	Falls from slips and trips.	Uneven terrain, slick, muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. If conditions are wet/muddy, muck boots may be worn Keep work area free of tools/rods.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
WEATHER	Cold/heat stress	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g. layers). Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms. When the Geoprobe® is running, the Geoprobe helper will watch/listen for lightning and thunder.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, Animals, Insects and Humans	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First aid kits will be available in the work truck. Employees with allergies should notify their supervisor.
MECHANICAL	Not applicable.			
PRESSURE	Pressurized hydraulic lines.	Geoprobe®	Faulty pressurized hydraulic lines could burst	All components of the Geoprobe® will be inspected prior to and at the completion of the task. In the event of a

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
			resulting in injury/exposure and hydraulic fluid release.	spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe's trailer. Cleanup materials will be disposed of according to state's regulations. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperience and improperly trained worker.	Sites.	Inexperience workers and improper training could cause incidents resulting in personal injuries and/or property damage.	Employees will be properly trained int his procedure and other applicable procedures. When starting/stopping for the first time, an experienced operator should be on site to help coach the process. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency kill switch button. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE (hard hat, safety glasses, high-visibility work shirt or vest, long pants, steel toed boots), work gloves, and single hearing protection (e.g. earmuffs).
APPLICABLE SDS	SDSs will be maintained based on-site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date
1	Updates to SOP to reflect Geoprobe ® Model 7822DT	11/16/2020

PURPOSE	To provide standard instructions for driving and positioning the Geoprobe® for probing.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Driving and Braking Controls on the Advance 7822DT	***Brakes*** The Geoprobe® Model 7822DT is equipped with automatic track brakes. When the engine is not running the track brakes are automatically engaged. ***Hydraulic Steering Controls*** The Model 7822DT has two steering control levers on the remote control. There are two additional steering control levers on the control panel but to use these levers the safety enable button must also be engaged. The two steering controls levers control two independently controlled tracks. The left lever controls the left track and the right lever controls the right track. To move forward move both control levers forward. To move in reverse move both control levers towards the back of the machine. There are three types of turns the Model 7822DT can accomplish. These turns are listed and described below. 1. **Gradual Turn** This turn is used when the Geoprobe® is in motion. By moving the control levers in the same direction but to different degrees will produce a gradual turn. This turn is possible in both forward and reverse directions. 2. **Pivot Turn** This turn is used when the Geoprobe® is stationary. By moving one control lever and leaving the other control lever in neutral position will produce a pivot turn. The turn will center around the track that is stationary. This turn is used a lot when positioning the Geoprobe® over probe-hole locations. This turn is possible in both forward and reverse directions. 3. **Counter-Rotation Turn** This turn is used when the Geoprobe® is stationary. By moving both controls

	but in opposite directions will produce a Counter-Rotation Turn. This turn will center around the center of the Geoprobe®. This turn is used widely in congested areas with limited room to turn.
Driving the Geoprobe® Model 7822DT	**CAUTION: When driving the Geoprobe®, check job site for obstacles if not readily visible.** 1. Start the Geoprobe® Model 7822DTas stated in the Starting and Stopping the Kubota Engine SOP (SOP-GEOPROBE-03). 2. Make sure to do a complete walk around to make sure the blade is in the upright position and that all other rig extremities are free of debris/obstacles. 3. Make sure the Geoprobe® is in transport position. Transport position is when the rig is completely folded up. • The probe cylinder must be lowered all the way to the foot. To lower the foot, place the probe lever in the downward position until motion has halted. • The foot must be completely raised up to the folding bracket. To raise the foot, place the foot lever in the upward position until motion has halted. • The mast must be completely lowered to the folding bracket. To lower the mast, place the mast lever (in the downward position until motion has halted. • In order to raise the mast, the winch must be lowered. Once the mast is raised, the slack can be taken out of the winch. The opposite happens when lowering the mast, and there will be slack in the winch line. **NOTE:** Do Not pull all the winch line in. Allow a couple inches of slack in the winch line so the line or winch does not get damaged. • The Geoprobe® should now be completely folded up. To fold up the Geoprobe®, place the fold lever in the upward position until motion has halted. 4. Move the Geoprobe® to the specified location using the Track Control Levers and turns as necessary. Use best judgement on type of terrain for travel speed, generally when moving to specific location medium speed is sufficient.

	5. Use a spotter when necessary to obtain the best and safest route to the probe-hole locations. **IMPORTANT: DO NOT SIDE HILL WITH THE RIG!! When traversing through mountainous and hilly areas drive straight up or down the terrain.**
Positioning the Geoprobe® Model 7822DT	1. After the Geoprobe® has been driven close to the new probe hole location (no farther than five feet away), unfold the derrick of the machine. To unfold the derrick, place the fold lever in the downward position until the foot of the machine is parallel to the existing ground. 2. Raise the mast completely up. To raise the mast, place the mast lever in the upward position until motion is halted. 3. Lower the foot until there is roughly six to twelve inches between the bottom of the foot and the existing ground. To lower the foot, place the foot lever in the downward position until the desired position is reached. 4. Raise the probe cylinder three to four feet off of the foot. To raise the probe cylinder, place the probe lever in the upward position until the desired position is reached. 5. Make sure the machine is extended in about half-way (six to seven and a half inches). To extend the machine in and out, place the extend lever in the upward position to move the machine in and place the extend lever in the downward position to extend out. 6. Level the machine using the oscillating head and moving the foot. Use the magnetic level. **CAUTION: When driving the Geoprobe®, check job site for obstacles if not readily visible.**

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and safety glasses, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to state regulations. All components of the Geoprobe® will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
NOISE	Elevated noise levels.	Geoprobe®.	Employees could be exposed to elevated noise levels when driving the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel within a 20-foot buffer zone of the Geoprobe® will wear single hearing protection (e.g. earmuffs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Overhead Power Lines	Sites.	Contact with overhead power lines could result in serious injury or property	Employees will maintain sufficient distance from any overhead power lines on the site. Employees will also not drive the Geoprobe® with the

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			damage.	mast raised.
BODY MECHANICS	Not applicable.			
GRAVITY	Not applicable.			
WEATHER	Cold/heat stress. Lightning.	Outdoors. Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke. Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Training on the signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g. layers). Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlines in applicable SSHASP and/or Pioneer corporate HASP. Employees will follow the 30/30 rule during lightning storms. When the Geoprobe® is running, the Geoprobe helper will watch/listen for lightning and thunder.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, animals, insects and humans.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available in the work trucks. Employees with allergies should notify their supervisor.
MECHANICAL	Driving on unstable ground	Sites.	Incidents could occur when	Employees will avoid side hilling in the Geoprobe® to

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
	or sloped surfaces.		driving on unstable ground or sloped surfaces which could result in personal injury and/or property damage.	prevent tipping the machine. Employees will do a site walk around before mobilizing to the probing location to determine the best route to drive the Geoprobe®. Employees will use the remote control to move the Geoprobe®.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the Geoprobe® will be inspected prior to and at the completion of the task. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe's trailer. Cleanup materials will be disposed of according to state's regulations. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperience workers and improper training could cause incidents resulting in personal injuries and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. When driving the Geoprobe® for the first time, an experienced operator should be on site to help coach the driving process. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			
ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE (hard hat, safety glasses, high-visibility work shirt or vest, long pants, steel-toed boots), work gloves, and single hearing protection (e.g. earmuffs).
APPLICABLE SDS	SDSs will be maintained based on-site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-03 Starting and Stopping the Kubota Engine
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

Revisions:

Revision	Description	Date
1	Updates to SOP to reflect Geoprobe ® Model 7822DT	11/16/2020

PURPOSE	To provide standard instructions for constructing tool strings and sampling procedures using the Geoprobe® Model DT-22 Dual Sampling System.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
DT-22 Expendable Cutting Shoe Tool String Set Up	The procedure for operating the Geoprobe® can be reviewed in SOP-GEOPROBE-07 (Operating the Geoprobe® During Probing Operations). Figure 1 depicts the DT-22 tool string diagram. The expendable cutting shoes are used to collect soil samples. When sampling is complete, tooling or materials (e.g., monitoring wells) can be placed or constructed inside the probe rod string. The following instructions describe how to set up the expendable cutting shoe tool string. 1. The expendable cutting shoe has two spaces on the neck portion of the tool. Lubricate a single O-ring with Liquinox soap solution. Place the lubricated O-ring on the top most groove. 2. Take the expendable cutting shoe, with the O-ring inserted, and place the cutting shoe into the expendable cutting shoe holder. 3. Thread the expendable cutting shoe holder onto the female end of the 2.25-inch probe rod. 4. Attach the 1.125-inch clear plastic core liner to the liner driver head. • Take a small piece of light weight inner rod and secure it in the pipe tri-stand. • Thread the liner driver head into the piece of lightweight inner rod. • Push the core liner onto the liner driver head and line up the hole on the top part of the core liner with the set screw hole on the liner drive head. • Place a set screw in the hole and tighten it down with a 3/32 allen wrench.

	5. Unscrew the liner drive head with the sample core liner attached and place it inside the probe rod. **NOTE:** if the bore hole is deeper than four feet, then additional light weight center rods need to be attached to the liner drive head so that four feet of lightweight center rod protrudes out of the outer probe rod in the ground. 6. Place an extra four feet of light weight center rod onto the center rods or sample drive head. 7. Place another outer probe rod over the light weight center rod and thread it onto the lower probe rod until the joint is tight. Tighten joint with a pipe wrench. 8. Place the rubber bumper onto the top light weight center rod or the liner drive head. 9. Place the drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
DT-22 Attached Cutting Shoe Tool String Set Up	The attached cutting shoes are used to collect soil samples. 1. Thread the attached cutting shoe onto the female end of the DT-22 probe rod. 2. Attach the 1.125-inch clear plastic core liner to the liner driver head. • Take a small piece of light weight inner rod and secure it in the pipe tri-stand. • Thread the liner driver head into the piece of lightweight inner rod. • Push the core liner onto the liner driver head and line up the hole on the top part of the core liner with the set screw hole on the liner drive head. • Place a set screw in the hole and tighten it down with a 3/32 allen wrench. 3. Unscrew the liner drive head with the sample core liner attached and place it inside the probe rod. **NOTE:** if the bore hole is deeper than four feet, then additional light weight center rods need to be attached to the liner drive head so that four feet of lightweight center rod protrude out of the probe rod in the ground. 4. Place an extra four feet of light weight center rod onto the center rods or sample drive head. 5. Place another outer probe rod over the light weight center rod and thread it onto the lower probe rod until the joint is tight. Use pipe wrench to

	tighten the joint. 6. Place the rubber bumper onto the top light weight center rod or the liner drive head. 7. Place the drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
DT-22 Expendable Point Tool String Set Up	The expendable points are used when collection of soil samples is not needed, but tooling or materials (e.g., monitoring wells) are to be placed or constructed inside the hole. 1. The expendable point has two grooves on the neck portion of the tip. Lubricate a single O-ring with Liquinox soap solution. Place the lubricated O-ring in the upper groove. 2. Take the expendable point, with the O-ring inserted, and place the cutting shoe into the expendable point holder. 3. Thread the expendable point holder onto the female end of the 2.25-inch probe rod. 4. Place the drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
Threaded Point Tool String Set Up	The threaded point is used when collecting samples is not needed and tooling or equipment (e.g., monitoring wells) will not be placed or constructed inside the hole. 1. Thread the attached point holder onto the female end of the 2.25-inch probe rod. 2. Place the drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
Cutting the DT-22 Sample Liners	1. Unfold and setup the sample table. 2. Place the aluminum sample core liner holder on the table and fasten the holder to the table with hand clamps. 3. Place the core liner that needs to be sampled in the aluminum holder tray. Place the liner so that the core catcher end of the liner slides over the sample tray retaining pin. 4. Place the DT-22 core liner cutter at the top of the core liner and pulled the length of the core liner. This operation will cut the core liner and make it possible to acquire the soil samples inside the core liner.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Contact with impacted soils and water.	Impacted sites, during sample collection and handling.	Adverse health effects could result from ingesting, inhaling, and/or skin/eye contact with impacted soils and water.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Employees will wear work gloves when handling probe rods. Work will be suspended during high wind conditions that produce large amounts of visible impacted dust.
	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Lubricating grease.	Probing location.	Employees could be exposed to lubricating grease via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.

	Liquinox	Probing location.	Employees could be exposed to Liquinox via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.
NOISE	Elevated noise levels.	Geoprobe®.	Employees could be exposed to elevated noise levels when operating the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel within a 20-foot buffer zone of the Geoprobe® will wear single hearing protection (e.g. earmuffs or earplugs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task. Do not operate the Geoprobe® if defective electrical lines are found.
BODY MECHANICS	Lifting and moving rods.	Probing location.	Employees could be exposed to back or muscle strains or sprains when lifting or connecting the Geoprobe® rods.	Employees will follow good lifting techniques including lifting with the legs and not the back, get a good grip, and keep the load close to your body. Two employees will lift the rods if necessary.

GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
	Falling rods.	Probing location.	Heavy rods could slip off of worker's hands while carrying and assembling tool strings causing personal injury.	Employees will use work gloves when assembling and handling rods. Two workers will carry rods, if necessary. All personnel will wear steel-toe boots.
WEATHER	Cold/heat stress	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g. layers). Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms. When the Geoprobe® is running, the Geoprobe helper will watch/listen for lightning and thunder.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.

			burns, skin damage, and eye damage.	
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.
MECHANICAL	Improper body mechanics.	Assembling and handling rods/sample tubes.	Improper lifting, bending, squatting, and kneeling could result in muscle/back strains or other injuries.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift, if necessary. Employees should stretch prior to starting work and they will take breaks when necessary.
	Pinch points.	During equipment assembly and when cutting sample liners.	Employees could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched	Employees will wear work gloves when assembling probe rods and sample casings, using the liner cutter, and handling plastic core liners after they have been cut open.

			fingers when assembling probe rods and sample casings, and when using the liner cutter.	Workers will be trained on how to properly use the liner cutter.
	Flying debris.	Probing location.	Eye injuries could result from flying debris when assembling probe rods and sample casings.	Employees will wear safety glasses at all times during Geoprobe® operations.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
HUMAN FACTORS	Inexperience and improperly trained worker.	Sites.	Inexperience workers and improper training could cause incidents resulting in personal injuries and/or property damage.	Employees will be properly trained int his procedure and other applicable procedures. When starting/stopping for the first time, an experienced operator should be on site to help coach the process. All employees operating the Geoprobe® will be familiar with the basic

				controls of the machine including the Emergency kill switch button. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE.
APPLICABLE SDS	SDSs will be maintained based on site characterization and contaminants. Hydraulic fluid, diesel, Liquinox, and lubricating grease.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-07 Operating the Geoprobe® During Probing Operations
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	

Revisions:

Revision	Description	Date
1	Updates to SOP to reflect Geoprobe ® Model 7822DT	11/16/2020

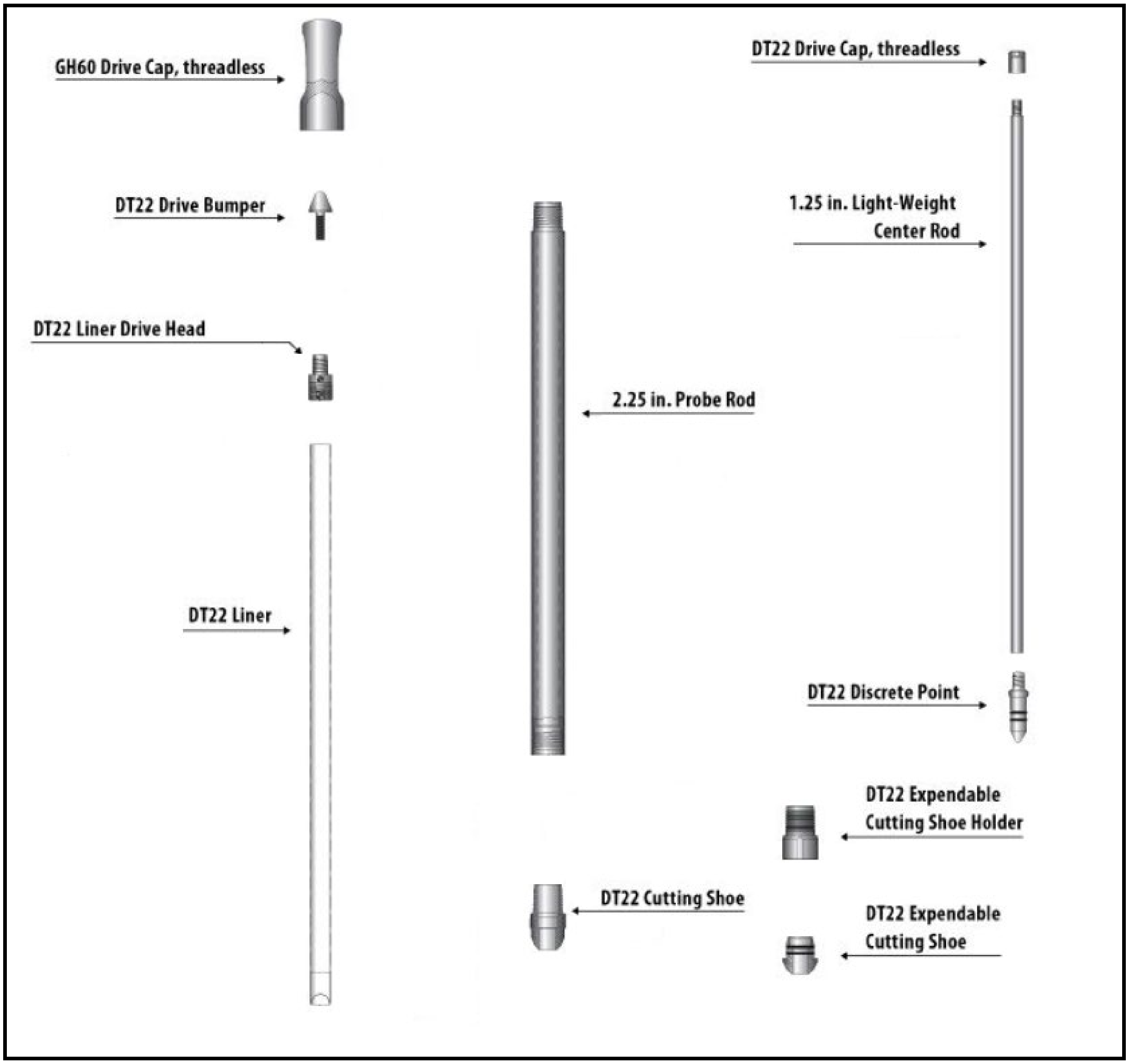

Figure 1 - The DT-22 Tool String Diagram

PURPOSE	To provide standard instructions for constructing tool strings and sampling procedures using the Geoprobe® DT-325/375 Dual Tube Sampling System and the 3.25 and 3.75-inch probe rod. Both the 3.25- and 3.75-inch rods follow the same procedure for set up and operation. Each system has unique cutting shoes, expandable points, etc. specific to the size probe rods being used, but set up and operations are identical.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
DT-325/375 Expendable Cutting Shoe Tool String Set Up	The procedure for operating the Geoprobe® can be reviewed in SOP-GEOPROBE-07 (Operating the Geoprobe® During Probing Operations). Figure 1 depicts the DT-325/375 tool string diagram. The expendable cutting shoes are used to collect soil samples during probe string advancement. When soil sampling is complete, tooling or materials (e.g., monitoring wells) can be placed or constructed inside the probe rod string, leaving the expendable cutting shoe at the bottom of the probe hole as the probe rod is removed from the hole. The following instructions describe how to assemble the expendable cutting shoe tool string. 1. The expendable cutting shoe has two grooves on the neck portion of the cutting shoe. Lubricate a single O-ring with Liquinox soap solution. Place the lubricated O-ring on the top-most groove. 2. Take the expendable cutting shoe, with the O-ring installed, and push the cutting shoe into the expendable cutting shoe holder. Thread the expendable cutting shoe holder onto the female end of the 3.25/3.75-inch probe rod. 3. Prepare the soil sample sheath assembly using the following steps: • Press a DT-325/375 ring retainer onto the bottom end of the 2.1-inch diameter clear plastic core liner. • Slide the sample tube assembly into the sample sheath and thread the ring retainer into the sample sheath. If a core catcher is used, ensure it is on the end with the ring retainer. • Thread sheath drive head on top portion of the sample sheath.

	• Place the sample sheath assembly into the lead probe rod with the expendable cutting shoe. • Place the centering drive cap on the sheath drive head. • Place 3.25/3.75-inch drive cap on the outer probe string. • The tool string is now ready to drive and samples the first interval. 4. Drive the tool string to depth. 5. Remove outer drive cap and then the inner centering drive cap. 6. Thread the 1.25-inch Tee-handle on to the sheath drive head and pull the sample sheath from the outer rod. 7. Unthread the ring retainer to remove the plastic liner containing the soil core. Decontaminate the sample sheath and components as required and reassemble using a new plastic liner as described in step 3 above. 8. Place a four (or five) foot light weight center rod onto the sample drive head and lower the sampler back into the outer probe rod remaining in the ground until it seats into the outer rod assembly. This will leave a light weight center rod sticking 4 (or 5) feet above the top of the outer rod. 9. Place another outer probe rod over the light weight center rod and thread it onto the lower probe rod until the joint is tight. Tighten joint with a pipe wrench if necessary. 10. Place the inner drive cap onto the top of the light weight center rod followed by the placement of the outer drive cap over the threads of the probe rods. The tool string is now complete and ready to probe and sample the next interval. The process is repeated by adding a light weight center rod and outer probe rod each interval until final depth is achieved. Installation of a well or other equipment can now proceed.
DT-325/375 Threaded Cutting Shoe Tool String Set Up	The threaded cutting shoes are used to collect soil samples. The fixed cutting shoe limits the size and placement of well materials, and therefore is typically used only for collecting soil cores. However, small diameter wells or piezometers can be placed through the center of the cutting shoe. 1. Thread the cutting shoe onto the female end of the DT-325/375 probe rod. 2. Prepare the sample sheath assembly using the following steps:

	• Press a DT-325/375 ring retainer onto the bottom end of the 2.1-inch diameter clear plastic core liner. • Slide the sample tube assembly into the sample sheath and thread the ring retainer into the sample sheath. If a core catcher is used, ensure it is on the end with the ring retainer. • Thread sheath drive head on top portion of the sample sheath. • Place the sample sheath assembly into the lead probe rod with the threaded cutting shoe. • Place the centering drive cap on the sheath drive head. • Place 3.25/3.75-inch drive cap on the outer probe string. • The tool string is now ready to drive and samples the first interval. 3. Drive the tool string to depth. 4. Remove outer drive cap and then the inner centering drive cap. 5. Thread the 1.25-inch Tee-handle on to the sheath drive head and pull the sample sheath from the outer rod. 6. Unthread the ring retainer to remove the plastic liner containing the soil core. Decontaminate the sample sheath and components as required and reassemble using a new plastic liner as described in step 2 above. 7. Place a four (or five) foot light weight center rod onto the center rods or sample drive head and lower the sampler back into the outer probe rod remaining in the ground until it seats into the outer rod assembly. This will leave a light weight center rod sticking 4 (or 5) feet above the top of the outer rod. 8. Place another outer probe rod over the light weight center rod and thread it onto the lower probe rod until the joint is tight. Tighten joint with a pipe wrench if necessary. 9. Place the inner drive cap onto the top light weight center rod followed by the placement of the outer drive cap over the threads of the probe rods.
DT-325/375 Expendable Point Tool String Set Up	The expendable points are used when collection of soil samples is not needed, but tooling or materials (e.g., monitoring wells) are to be placed or constructed through the outer rods. 1. The expendable point has two grooves on the neck portion of the tip. Lubricate a single O-ring with Liquinox soap solution. Place the lubricated O-ring in the upper groove.

	2. Take the expendable point, with the O-ring inserted, and place the point into the expendable point holder 3. Thread the expendable point holder onto the female end of the 3.25/3.75-inch probe rod. 4. Place the outer drive cap over the threads of the probe rods. The tool string is now ready for probing. 5. Drive the probe rod the full interval. 6. Continue to add a new 3.25/3.75-inch probe rod as the probe string is advanced each interval. 7. Continue driving the 3.25/3.75-inch rods until the desired depth is reached.
Threaded Point Tool String Set Up	The threaded point is used when collecting samples is not needed and tooling or equipment (e.g., monitoring wells) will not be placed or constructed inside the hole. 1. Thread the solid point onto the female end of the 3.25/3.75-inch probe rod. 2. Place the outer drive cap over the threads of the probe rods. The tool string is now complete and ready for probing.
Cutting the DT-325/375 Sample Liners	1. Unfold and setup the sample table. 2. Place the aluminum sample core liner holder on the table and fasten the holder to the table with hand clamps. 3. Place the core liner that needs to be sampled in the aluminum holder tray. Place the liner so that the core catcher end of the liner slides over the sample tray retaining pin. 4. Place the DT-325/375 core liner cutter at the top of the core liner and pull the length of the core liner. This operation will cut the core liner and make it possible to acquire the soil samples inside the core liner.

Pulling 3.25/3.75-inch rods from the ground using threaded pull cap	1. Thread pull cap on top of the rod string to be extracted from the ground. 2. Move Geoprobe head with rod puller into position to pull the rod. 3. Begin pulling rod out of ground until the pull cap is at full height. 4. Place rod clamp around rods at ground level and clamp tightly. 5. Relax the pull on the rods by moving the Geoprobe head down slightly, allowing the pull bar to be moved away from the pull cap. 6. Remove pull cap. 7. Remove upper rod from the rod string. 8. Replace threaded pull cap on remaining rod string and repeat the process until all the rods have been removed from the ground.
Pulling 3.25/3.75-inch rods from the ground using external rod grip system	1. Move Geoprobe head into position to where the leaf pull plates line up on rod. If the rod was originally driven to ground level, thread a 2-foot rod on the string to extend the string, allowing the rod grip system to grab the rod string. 2. Install rod grip tool by aligning the pull pins on the head with the tool. 3. Begin pulling rods from the ground. 4. Once at the top of the pull, install the rod clamp at ground level to secure the rod string. 5. Relax the pull of the Geoprobe head and remove the rod grip tool. 6. Move the Geoprobe head back away from the rod and remove the upper rod. 7. Repeat the procedure until all rods have been removed from the ground.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Contact with impacted soils and water.	Impacted sites, during sample collection and handling.	Adverse health effects could result from ingesting, inhaling, and/or skin/eye contact with impacted	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Employees

			soils and water.	will wear work gloves when handling probe rods. Work will be suspended during high wind conditions that produce large amounts of visible impacted dust.
	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Lubricating grease.	Probing location.	Employees could be exposed to lubricating grease via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.
	Liquinox	Probing location.	Employees could be exposed to Liquinox via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.
NOISE	Elevated noise levels.	Geoprobe®.	Employees could be exposed to	Personnel within a 20-foot buffer zone of the Geoprobe®

			elevated noise levels when operating the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	will wear single hearing protection (e.g. earmuffs or earplugs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
ELECTRICAL	Defective electrical lines. Lightning.	Geoprobe®. All sites.	Contact with defective electrical lines could result in personal injury. Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task. Employees will follow the 30/30 rule during lightning storms.
BODY MECHANICS	Lifting and moving rods.	Probing location.	Employees could be exposed to back or muscle strains or sprains when lifting or connecting the Geoprobe® rods.	Employees will follow good lifting techniques including lifting with the legs and not the back, get a good grip, and keep the load close to your body. Two employees will lift the rods if necessary.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may

				be worn. Site can be cleared of snow, if applicable.
	Falling rods.	Probing location.	Heavy rods could slip off of worker's hands while carrying and assembling tool strings causing personal injury.	Employees will use work gloves when assembling and handling rods. Two workers will carry rods, if necessary. All personnel will wear steel-toe boots.
WEATHER	Cold/heat stress	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g. layers). Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms. When the Geoprobe® is running, the Geoprobe helper will watch/listen for lightning and thunder.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic

			property damage.	controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.
MECHANICAL	Improper body mechanics.	Assembling and handling rods/sample tubes.	Improper lifting, bending, squatting, and kneeling could result in muscle/back strains or other injuries.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift, if necessary. Employees should stretch prior to starting work and they will take breaks when necessary.
	Pinch points.	During equipment assembly and when cutting sample liners.	Employees could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched fingers when assembling probe rods and sample casings, and when using the liner cutter.	Employees will wear work gloves when assembling probe rods and sample casings, using the liner cutter, and handling plastic core liners after they have been cut open. Workers will be trained on how to properly use the liner cutter.
	Flying debris.	Probing location.	Eye injuries could result from flying debris when assembling probe rods and sample casings.	Employees will wear safety glasses at all times during Geoprobe® operations.

PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
HUMAN FACTORS	Inexperience and improperly trained worker.	Sites.	Inexperience workers and improper training could cause incidents resulting in personal injuries and/or property damage.	Employees will be properly trained int his procedure and other applicable procedures. When starting/stopping for the first time, an experienced operator should be on site to help coach the process. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency kill switch button. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE.
APPLICABLE SDS	SDSs will be maintained based on site characterization and contaminants. Hydraulic fluid, diesel, Liquinox, and lubricating grease.

REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-07 Operating the Geoprobe® During Probing Operations
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date
1	Update to SOP to reflect Geoprobe ® Model 7822DT	11/16/2020

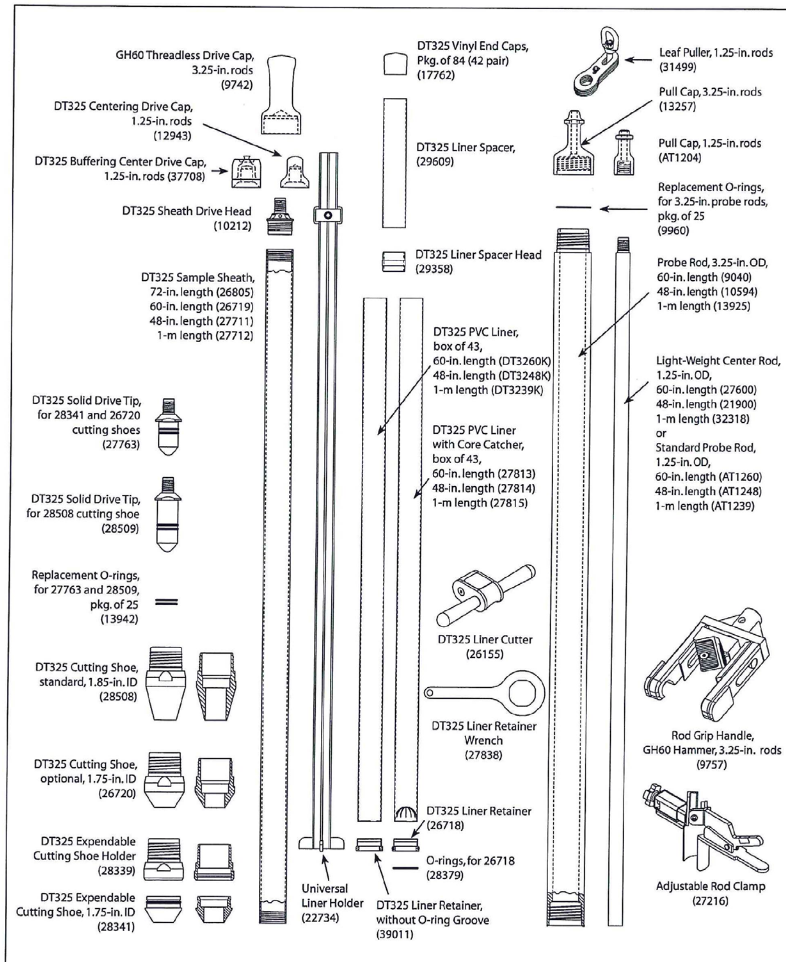

Figure 3.1
DT325 parts and accessories.

Standard Operating Procedure 7 DT325 Sampling System

Figure 1 - The DT-325 Tool String Diagram

PURPOSE	To provide standard instructions for operating the Geoprobe® Model 7822DT during probing operations.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Probe Operating Controls	***Probe*** The Probe Control Lever operates the probe cylinder. The probe control lever will lower and raise the probe cylinder and the hammer assembly. Place the probe control lever in the downward position to lower the probe cylinder and place the probe control lever in the upward position to raise the probe cylinder. The probe cylinder uses the static weight of the machine to push/hammer the rig tooling into the ground to either conduct sampling or install wells. ***Hammer/Rotation*** The Hammer/Rotation Control Lever activates and deactivates the hammer percussion and also will allow rotation when percussion is conducted. The Hammer/Rotation is used when the static weight of the machine is not enough force to push the tooling into the ground. Sometimes the hammer function is helpful when sampling and not getting very good recovery just with the static weight of the rig. The rotation is generally not used during probing operations. The rotation is typically used when using a special concrete bit to drill holes through concrete in a roto-hammer fashion. ***Auger*** The Auger Control Lever controls the speed and direction of the auger head. This tool is not used in Pioneer's probing operations. ***Regen (Two-Speed Pull System)*** The Regen Control Switch activates the regenerating probe cylinder circuit. By activating the circuit, the probe cylinder will move up and down much faster. With the low speed setting (full pulling power), the full pull stroke takes 11 seconds, while on the fast speed setting, the full stroke takes 5 seconds. When using the high-speed setting, the probe cylinder will lose a lot of its pulling force. This switch is mainly used on shallow holes or at the end of the tool string on deeper holes when heavy pulling is not required.

Probing Using Static Weight	When using static weight, the Geoprobe® only uses the weight of the unit to advance probe rods. 1. Drive and position the Model 7822DT at the desired sampling location. Refer to SOP-GEOPROBE-04 Driving and Positioning the Geoprobe® Model 7822DT for instructions. 2. Put a magnetic bullet level on the front of the derrick on the rig. Ensure the derrick is vertical in the fore and aft position. To plumb the derrick vertically, use the Fold Control Lever until the derrick is plumb. 3. Set up the tool string using the desired configuration for the DT-22 or the DT-325/375 dual tube systems. Refer to SOP-GEOPROBE-05 Geoprobe® DT-22 Dual Tube Sampling System and SOP-GEOPROBE-06 Geoprobe® DT-325/375 Dual Tube Sampling System for tool string diagrams and set-up procedures. 4. Position the initial pipe/tool string under the Geoprobe hammer. Lower the hammer onto the drive cap by placing the probe lever into the downward position. ***CAUTION:*** *do not hold onto the drive cap; make sure to hold onto the push rod when lowering the probe hammer onto the drive head. This will make sure that no appendages can be pinched between the metal.* 5. Place the magnetic bullet level on the front of the pipe. Use the extend lever to get the pipe plumb fore and aft. 6. Place the magnetic bullet level on the side of the pipe . Use the swing lever to get the pipe plumb from side to side. ***IMPORTANT:*** *ensure that the first pipe entering the ground is plumb. This will ensure there is no angle to the probe hole and will make for easier extraction when pulling the tool string out of the ground. It is best to initially check the pipe for level and then push the pipe approximately one foot into the ground and check the level again. In some instances, it may be necessary to check the rod plumb every half foot due to difficult probing conditions. Do not try to force the pipe level after the first pipe has entered the ground. This may damage the threads on the pipe and can break the pipe itself.* 7. When the first pipe/tool string is plumb, begin the push by pulling the probe lever down to start pushing the rod into the ground. Stop approximately one foot into the push and check for rod plumbness. Then continue to push the rod into the ground by pulling down on the probe lever. Check for rod plumb as necessary as the first rod is advanced. During static weight probing, the foot of the Geoprobe

	derrick may or may not slightly lift off of the ground. To get a feel for the machine and how hard the soil is, the operator should place their left foot on the front portion of the foot of the rig to provide feedback on how the push is progressing. **NOTE:** if the operator is recovering small soil samples, try to use the hammer lever slightly to try and vibrate the soil into the sample tube. It is very unlikely that just the static weight of the rig will be able to push the rod into the ground past four to eight feet. If the operator is collecting soil caps as per SOP-GEOPROBE-05 Geoprobe® DT-22 Dual Tube Sampling System and/or SOP-GEOPROBE-06 Geoprobe® DT-325/375 Dual Tube Sampling System. The remainder of the push will be completed following the appropriate SOP. If the operator is collecting soil cores, follow SOP-GEOPROBE-05 Geoprobe® DT-22 Dual Tube Sampling System and/or SOP-GEOPROBE-06 Geoprobe® DT-325/375. **NOTE:** as stated before, generally the static weight alone is not enough to reach the total depth of the hole. Do not just use static weight if one believes they have reached refusal. Refusal is when the piping will not go into the ground anymore.
Probing Using Percussion and Static Weight	The tool string cannot be advanced only of the Geoprobe weight in most soil formations. In these situations, hammer percussion must be employed as described in this section. 1. Follow steps in task "Probing using only the static weight of the Geoprobe" prior to starting probing using percussion. 2. Put a magnetic bullet level on the front of the derrick on the rig. Ensure the derrick is vertical in the fore and aft position. To plumb the derrick vertically, use the Fold Control Lever until the derrick is plumb. 3. Place the magnetic bullet level on the side of the derrick to check the verticality side to side. Use lever to rotate derrick until plumb. Position the initial pipe/tool string under the Geoprobe hammer. Lower the hammer onto the drive cap by placing the probe lever into the downward position. NOTE: Ensure that the first pipe entering the ground is plumb. This will ensure there is no angle to the probe hole and will make for easier extraction when pulling the tool string out of the ground. It is best to initially check the pipe for level and then push the pipe approximately one foot into the ground and check the level again. In some instances, it may be necessary to check the rod plumb every half foot due to difficult probing conditions. Do not try to force the pipe level after the first pipe has entered the ground. This may damage the threads on the pipe and can break the pipe itself.

	When the first rod/tool string is plumbed, begin to pull the probe lever and the hammer/rotation lever down simultaneously to start pushing and hammering the rod into the ground. Stop part way through the push of the rod and re-plumb the pipe. Then continue to push the rod into the ground by pulling down on the probe lever and hammer/rotation lever. During percussion probing, the foot of the derrick should be lifted roughly an inch off of the ground. To get a feel for the machine and how hard the soil is, the operator should place their left foot on the front portion of the foot of the rig. 4. ***NOTE:*** *the operator needs to make sure that the foot of the derrick comes off of the ground during percussion probing. If the foot is not coming off of the ground, the rubber bumpers will melt and deteriorate. This is because not enough static weight is being applied to the tool string.* 5. If the operator is collecting soil cores, the next step would be to pull off the drive caps and use the extraction "T" to pull the sample out of the outside casing as per SOP-GEOPROBE-05 Geoprobe® DT-22 Dual Tube Sampling System and/or SOP-GEOPROBE-06 Geoprobe® DT-325/375 Dual Tube Sampling System SOP-Geoprobe. The remainder of the push will be completed following the appropriate SOP. Note: Depending on subsurface conditions, there may be instances where probe refusal is encountered. Continued hammering on a rod that is not advancing can cause damage to the rod string. The Pioneer operator needs to recognize refusal and determine the best course of action. In some instances when the probe rod encounters a small subsurface cobble, hammering on the rod will break the cobble allowing the probe string will advance. Knowing subsurface stratigraphy in advance if possible will assist in making good field decisions when it comes to refusal.
Adding Probe Rods, Inner Rods, and Sample Liners or Sheaths	Probe rods must be added to the tool string to reach the desired depth below ground surface. 1. Using the probe control lever, raise the hammer assembly to its full height. 2. Using the extend lever, extend back as far as the rig will go. This will allow for easy access to the in-ground tool string and will allow for easy addition of probe rods and sampling equipment. 3. Remove the outer drive cap from the probe rod that was driven into the existing ground followed by removing rubber bumper and/or inner rod drive cap.

	4. Thread the extraction "T" to the inner rod string and use "T" to pull up to remove the inner rods and sample liner or sample sheath out of the existing probe rod string. The inner rods simply thread onto each other and to the sample core or sample sheath. Refer to SOP-GEOPROBE-05 to see the procedure and diagrams of how to set up the DT-22 Sample Core. Refer to SOP-GEOPROBE-06 to see the procedure and diagrams of how to set up the DT-325/375 Sample Sheath. 5. If retrieving cores, replace the sample core or sample sheath with a clean set and attach enough inner rod to leave an extra length of inner rod (4 feet) out of the in-ground probe rod. 6. Place a new piece of outer probe rod over the 4-foot length of inner rod sticking out of the existing hole and thread the new probe rod to the existing probe rod in the ground. Tighten the threaded joint with a pipe wrench. 7. Place inner rod drive cap and/or rubber bumper followed by the outer rod drive cap. Use the extend lever to extend the rig outward until the Geoprobe hammer is above the drive cap. 8. Slowly lower the probe cylinder onto the top probe rod with the probe control lever. 9. Advance the tool string into the ground. 10. Repeat steps 1- 9 until the desired sampling depth or refusal is reached. ***IMPORTANT:*** *do not continue probing if the tool string meets refusal. Prolonged hammering at refusal can cause damage to the tool string.*
Pulling Probe Rods with the Pull Cap	A pull cap is used to retract probe rods from an existing bore hole, when monitoring well materials through and the rods do not need to be lifted over the well casing are not being set 1. Raise the hammer assembly just high enough to provide access to the top probe rod. 2. Remove the drive cap from the top probe rod of the tool string. 3. Attach a pull cap to the top probe rod by threading the pull cap securely onto the probe rod. 4. Ensure that the probe foot is in contact with the ground surface. This provides support for the unit. The downward force resulting from pulling the rods may damage the unit if the foot is not supported.

	NOTE: if when pulling the probe rods out of the ground the foot begins to sink into the ground, then lengths of blocking should be placed under the foot to allow for more surface area to support the force on the ground. 5. Hold down on the probe control lever until the drive head is close to the pull cap. 6. Pull the pin upward to release the extraction latch and place it around the pull cap. 7. Retract the probe rod by placing the probe control lever in the upward position until motion has stopped. 8. Once the probe cylinder is all the way up and the first probe rod has been retracted, place the Kwik Klamp-pipe clamp on the lower section of the pipe. A pipe clamp is used to support the weight of the rod string so that when the extraction latch is taken off, the top piece of pipe can be unattached from the tool string without losing the rest of the tool string down the hole. 9. Lower the probe cylinder slightly so the extraction latch is free from the pull cap. Pull the extraction latch and lock it back into its locked position. 10. Place the section of pipe that was taken off of the tool string to the side or in the rod rack out of the way. 11. Repeat steps 3 through 10 until the entire tool string has been extracted from the ground. Note: The last rod out of the ground is relatively unsupported. Special care must be taken to avoid dropping the rod back down the hole. One method to prevent rod loss is to leave the Kwik Klamp tool on the rod until the rod is well away from the probe hole. If the rod slips, the Kwik Klamp prevents the rod from getting loose and falling back into the hole.
Pulling Probe Rods with the Rod Grip Pull System	The rod grip pull system is used when installing monitoring wells and other applications when the inside of the tool string needs to be available during extraction of the probe rods. There are three handle assemblies and jaws to accommodate the various rod sizes: 1.0-inch, 1.25-inch, 2.125-inch, 3.25-inch and 3.75-inch. ***Pulling Probe Rods*** In order to pull with this system, there must be enough exposed probe rod above the ground surface to allow the puller jaws to engage the outside of

the rod. Approximately 18 inches of exposed rod is needed. If the tool string is driven too far and the puller cannot fully engage the top probe rod, simply add another rod to the tool string and reattach the handle assembly.

IMPORTANT: it is very important that the puller jaws never grip over the threaded section of a probe rod. Severe damage to the threads will result. Furthermore, avoid placing the puller near rod joints as gripping is not as effective at this location and rod deformation can occur.

1. Lower the extraction latch so it will not bind up the pipe when extracting with the rod grips.

2. Position the hammer with the jaws directly behind the top probe rod and below the threads. Take the appropriate handle assembly (according to rod diameter) and orientate the jaw cutout toward the probe rod as shown in.

3. Hook the handle over the socket head cap screws on each side of the probe cylinder.

4. To start pulling, lower the end of the handle assembly and raise the probe cylinder. This tightly clamps the jaws of the handle and probe cylinder around the probe rod. If slipping occurs, step on the end of the handle assembly to encourage the gripping action.

5. Once fully raised, place a pipe vice on top of the probe rod string below the retracted rod connection and slightly lower the probe cylinder to release the pressure on the probe rod. Lift the end of the handle to rotate the assembly on the cap screws. This moves the handle jaw away from the probe rod and disengages the puller. The probe cylinder can now be lowered to pull another section of rod. Once the rod grip puller is engaged on the next rod, the rod above is removed. Alternatively, and especially if rod deviation took place during probing operations, the rod grip puller is removed, the Geoprobe is extended inward, and the hammer is lowered into the pulling position. The Geoprobe is then extended out until the rod grips are aligned with the probe rod. The rod grip puller then is installed and used to pull the next section of probe rod. In some cases, the rod grip handle gets very tight and does not want to loosen when ready for removal. In that case, a hammer can be used on the outer end of the handle with an upward motion to loosen the puller. Before extracting the next rod, the pipe clamp is loosened. One at the top of the pull, the pipe clamp is reattached to support the rod string before releasing the rod grip system.

6. Repeat steps 2 through 5 until the in-hole tool string is fully extracted.

Note: The last rod out of the ground is relatively unsupported. Special care must be taken to avoid dropping the rod back down the hole. One method

	to prevent rod loss is to leave the Kwik Klamp tool on the rod until the rod is well away from the probe hole. If the rod slips, the Kwik Klamp prevents the rod from getting loose and falling back into the hole.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Contact with impacted soils and water.	Impacted sites, during sample collection and handling.	Adverse health effects could result from ingesting, inhaling, and/or skin/eye contact with impacted soils and water.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Employees will wear work gloves when handling probe rods. Work will be suspended during high wind conditions that produce large amounts of visible impacted dust.
	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Lubricating grease.	Probing location.	Employees could be exposed to lubricating grease via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.

NOISE	Elevated noise levels.	Geoprobe®.	Employees could be exposed to elevated noise levels when operating the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel within a 20-foot buffer zone of the Geoprobe® will wear single hearing protection (e.g. earmuffs or earplugs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Contact with overhead utilities.	Probing location.	Injury, death, or property damage could occur from contact with overhead utilities when the hammer assembly is raised to its highest position.	If overhead hazards are present, established overhead utility procedures will be followed. Probe locations will be moved to avoid working around overhead utilities. Employees will maintain the required minimal radial clearance distances based on voltage when working around overhead lines.
	Contact with underground utilities.	Probing location.	Injury, death or property damage could occur from contact with underground utilities when geoprobing.	Prior to starting work, employees will call for a utility locate (i.e., call 811). If underground utilities are present, established underground utility procedures will be followed. Probe locations will be moved to avoid working around underground utilities.
BODY MECHANICS	Lifting and moving rods.	Probing location.	Employees could be exposed to back or muscle strains or sprains when lifting or connecting the Geoprobe® rods.	Employees will follow good lifting techniques including lifting with the legs and not the back, get a good grip, and keep the load close to your body. Two employees will lift the rods if necessary.

GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
	Falling rods.	Probing location.	Heavy rods could slip off of worker's hands while carrying and assembling tool strings causing personal injury.	Employees will use work gloves when assembling and handling rods. Two workers will carry rods, if necessary. All personnel will wear steel-toe boots.
WEATHER	Cold/heat stress	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g. layers). Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms. When the Geoprobe® is running, the Geoprobe helper will watch/listen for lightning and thunder.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.

BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.
MECHANICAL	Geoprobe® shifting.	Probing location, when probing with percussion and working on a sloped surface.	Personal injury and equipment damage could occur if the Geoprobe® shifts while probing with percussion and when working on a sloped surface.	When probing with percussion, do not raise the machine foot more than approximately 6 inches off the ground or the vehicle may become unstable and shift. When working on a sloped surface, position the rig so that it is facing upslope. In the event that the probe unit loses stability, it will roll away from the operator without causing injury.
	Struck by the Geoprobe®.	Operating the Geoprobe®.	Personnel could be injured if struck by the Geoprobe®.	Non-essential personnel will maintain a 20-foot buffer zone around the rig.
	Improper body mechanics.	Assembling, handling, and retrieving rods/sample tubes.	Improper lifting, bending, squatting, and kneeling could result in muscle/back strains or other	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift, if

			injuries.	necessary. Employees will also use good body mechanics when retrieving rods/sample tubes: bend knees, lean slightly away from the object, keep back and wrists straight, use legs to move the objects. Employees should stretch prior to starting work and they will take breaks when necessary.
	Contact with rotating and moving parts of the Geoprobe®.	Operating the Geoprobe®.	Fingers/hands could become pinched or caught in moving/rotating parts of the Geoprobe® resulting in cuts, scrapes, and/or broken bones.	Employees will not touch moving/rotating parts of the rig. Personnel will tie back long hair and will not wear loose clothing when operating the machine. Work gloves are required when operating the rig. Operators will stand to the control side of the machine, clear of the probe foot and derrick, while operating the controls. Personnel will never reach across the probe assembly to manipulate the machine controls. All employees on site will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Pinch points.	During equipment assembly, advancing the Geoprobe®, and extracting probe rods.	Employees could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched fingers when assembling probe rods and sample	Employees will always wear work gloves when operating the Geoprobe® and handling its components. Employees will never place their hands-on top of the tool string while raising or lowering the hammer. Workers will not place thumb or fingers between latch and hammer when raising

			casings, pulling probe rods and sampling devices with the hammer latch and/or the rod grip pull assembly, and when the Geoprobe hammer is in motion.	latch to pull probe rods and sampling devices from the ground. Grind or file sharp burrs that can be developed on the outside of probe rods if the rod grip puller is allowed to slip during tool retrieval.
	Flying debris.	Probing location.	Eye injuries could result from flying debris when driving tool strings into the ground.	Employees will wear safety glasses at all times during Geoprobe® operations.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
THERMAL	Contact with hot drive head and caps.	Probing location.	The drive head and caps can become hot during probing operations and direct contact with these components could cause skin injuries.	Employees will let the drive head and caps cool down before removing them from the tool string. Workers will also wear work gloves when handling these components.
HUMAN FACTORS	Inexperience and improperly trained worker.	Sites.	Inexperience workers and improper training could cause incidents resulting in personal injuries and/or property damage.	Employees will be properly trained int his procedure and other applicable procedures. When starting/stopping for the first time, an experienced operator should be on site to help coach the process. All employees operating the Geoprobe® will be familiar with the basic controls of the

				machine including the Emergency kill switch button. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE, earplugs, and earmuffs.
APPLICABLE SDS	SDSs will be maintained based on site characterization and contaminants. Hydraulic fluid, diesel, and lubricating grease.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-GEOPROBE-04 Driving and Positioning the Geoprobe® Model 7822DT SOP-GEOPROBE-05 Geoprobe® DT-22 Dual Tube Sampling System SOP-GEOPROBE-06 Geoprobe® DT-325/375 Dual Tube Sampling System
TOOLS	
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

Revisions:

Revision	Description	Date
1	Updates to SOP to reflect Geoprobe ® Model 7822DT	11/16/2020

PURPOSE	The purpose of this SOP is to provide instructions to install a permanent, small-diameter groundwater monitoring well that can be used to collect water quality samples, conduct hydrologic and pressure measurements, or perform any other sampling event that does not require large amounts of water over a short period of time (e.g., flow rate > 1 liter/minute). These methods meet or exceed the specifications discussed for direct push installation of permanent monitoring wells with prepacked screens in the U.S. Environmental Protection Agency's guidance document, *Expedited Site Assessment Tools For Underground Storage Tank Sites*, (EPA, 1997) and ASTM Standards *D 6724* (ASTM, 2002) and *D 6725* (ASTM, 2002).
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.
DEFINITIONS	**Geoprobe® Direct Push Machine:** a vehicle-mounted, hydraulically-powered machine that uses static force and percussion to advance small-diameter sampling tools into the subsurface for collecting soil core, soil gas, or ground water samples. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling, soil conductivity and contaminant logging, grouting, materials injection, and to install small-diameter permanent monitoring wells or temporary piezometers. **0.5-inch x 1.4-inch OD Prepacked Well Screen (0.5-inch prepack):** an assembly consisting of a slotted PVC pipe surrounded by environmental grade sand contained within a stainless steel wire mesh cylinder. The inner component of the prepacked screen is a flush-threaded, 0.5-inch Schedule 80 PVC pipe with 0.01-inch (0.25 mm) slots. Stainless steel wire mesh with a pore size of 0.011 inches (0.28 mm) makes up the outer component of the prepack. The space between the inner slotted pipe and outer wire mesh is filled with 20/40 mesh silica sand. Geoprobe® 0.5-inch x 1.4-inch prepacks are available in 3-foot and 5-foot sections and have an outside diameter of 1.4 inches (36 mm) and a nominal inside diameter of 0.5 inches (13 mm). **0.75-inch x 1.4-inch OD Prepacked Well Screen (0.75-inch prepack):** an assembly consisting of a slotted PVC pipe surrounded by environmental grade sand contained within a stainless steel wire mesh cylinder. The inner component of the prepacked screen is a flush-threaded, 0.75-inch Schedule 40 PVC pipe with 0.01-inch (0.25 mm) slots. Stainless steel wire mesh with a pore size of 0.011 inches (0.28 mm) makes up the outer component of the prepack. The space between the inner slotted pipe and outer wire mesh is filled with 20/40 mesh silica sand. Geoprobe 0.75-inch x 1.4-inch prepacks are available in 3-foot and 5-foot sections and have an outside diameter of 1.4 inches (36 mm) and a nominal inside diameter of 0.75 inches (19 mm).

DISCUSSION	Conventional monitoring wells are typically constructed through hollow stem augers by lowering slotted PVC pipe (screen) to depth on the leading end of a string of threaded PVC riser pipe. A filter pack is then installed by pouring clean sand of known particle size through the tool string annulus until the slotted section of the PVC pipe is sufficiently covered. Installing the entire filter pack through the tool string annulus becomes a delicate and time-consuming process when performed with small-diameter direct push tooling. Sand must be poured very slowly in order to avoid bridging between the riser pipe and probe rod. When bridging does occur, considerable time can be lost in attempting to dislodge the sand or possibly pulling the tool string and starting over. Prepacked screens decrease the volume of loose sand required for well installation as each screen assembly includes the necessary sand filter pack. Sand must still be delivered through the casing annulus to provide a minimum 2-foot grout barrier, but this volume is significantly less than for the entire screened interval. The procedures outlined in this document describe construction of a permanent groundwater monitoring well using Geoprobe® 2.125-inch (54 mm) outside diameter (OD) probe rods and 1.4-inch OD prepacked screens. Geoprobe®1.4-inch prepacks are available with either nominal 0.5-inch schedule 80 or 0.75-inch schedule 40 PVC components. Further options include running lengths of 3 and 5 feet for both 0.5- and 0.75-inch prepacks. Installation of a prepack monitoring well begins by advancing 2.125-inch (54 mm) outside diameter (OD)probe rods to depth with a Geoprobe® direct push machine. Prepacked screen(s) are then assembled and installed through the 1.5-inch (38 mm) inside diameter (ID) of the probe rods using corresponding 0.5-inch schedule 80 or 0.75-inch schedule 40 PVC riser (Fig. 2.1-A). The prepack tool string is attached to an expandable anchor point with a locking connector that is threaded to the bottom of the leading screen. Once the connector is locked onto the anchor point, the rod string is slowly retracted until the lower end of the rods is approximately 3 feet above the top prepack. Regulations generally require a minimum 2-foot grout barrier above the top prepack (Fig. 2.1-B) to avoid contaminating the well screens with bentonite or cement during installation. In some instances, natural formation collapse will provide the required barrier. If the formation is stable and does not collapse around the riser as the rod string is retracted, environmental grade 20/40 mesh sand may be installed through the probe rods to provide the minimum 2-foot grout barrier. Granular bentonite or bentonite slurry is then installed in the annulus to form a well seal (Fig. 2.1-B). A high-pressure grout pump (Geoprobe® Model GS1000 or GS500) may be used

to tremie high-solids bentonite slurry or neat cement grout to fill the well annulus as the probe rods are retracted (Fig. 2.1-B). The grout mixture must be installed with a tremie tube from the bottom up to accomplish a tight seal without voids to meet regulatory requirements.

In certain formation conditions, the prepacked screens may bind inside the probe rods as the rods are retracted. This is most common in sandy formations sometimes called flowing or heaving sands. This binding can generally be overcome by lowering extension rods down the inside of the well riser and gently, but firmly, tapping the extension rods against the base of the well as the rods are slowly retracted. If the binding persists, clean tap water or distilled water may be poured down the annulus of the rods to increase the hydraulic head inside the well. This, combined with the use of the extension rods, will free up the prepacked screen and allow for proper emplacement.

Once the well is set, conventional flush-mount or aboveground well protection can be installed to prevent tampering or damage to the well head (Fig. 2.1-B). These wells can be sampled by several available methods (bladder pump, peristaltic pump, mini-bailer, Geoprobe® tubing check valve, etc.) to obtain high integrity water quality samples. These wells also provide accurate water level measurements and can be used as observation wells during aquifer pump tests.

When installed properly, these small-diameter wells generally meet regulatory requirements for a permanent monitoring well. While a detailed installation procedure is given in this document, it is by no means totally inclusive. **Always check local regulatory requirements and modify the well installation procedure accordingly**. These methods meet or exceed the specifications discussed for direct push installation of permanent monitoring wells with prepacked screens in the U.S. Environmental Protection Agency's guidance document, *Expedited Site Assessment Tools For Underground Storage Tank Sites,* (EPA, 1997) and ASTM Standards D 6724 (ASTM, 2002) and *D 6725* (ASTM, 2002).

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Anchoring the Well Assembly	In this portion of the well installation procedure, an expandable anchor point is driven to depth on the end of a 2.125-inch (54 mm) OD probe rod string (Fig. 4.1). A prepacked screen assembly is inserted into the I.D. of the rod string with 5-foot (1.5 m) sections of PVC riser pipe (Fig. 4.2). The screens and riser pipe are attached to the

anchor point via a snap-lock connector.

1. If the monitoring well is to have a flush-mount finish, it is a good practice to prepare a hole large enough to accept a standard well protector before driving the probe rods.

2. Move the Geoprobe® direct push machine into position over the proposed monitoring well location. Unfold the probe and place in the proper probing position as shown in the unit Owner's Manual. Access to the top of the probe rods will be required. It is therefore important to allow room for some derrick retraction when placing the unit in the probing position.

3. Referring to Figure 4.3, place an O-ring in the groove of a 2.125-inch Expendable Anchor Point (GW2040). Insert the point into the unthreaded end of a 2.125-inch Expendable Point Holder. Note that expendable point holders are available in lengths of 36 inches/0.9 meters (AT2110), 48 inches/1.2 meters (AT2111), or 60 inches/1.5 meters (AT2112).

4. Attach a 2.125-inch Drive Cap (AT2101) to the threaded end of the point holder (Fig. 4.3).

5. Place the extendable point holder under the probe hammer in the driving position (refer to unit Owner's Manual). Drive the point holder into the ground utilizing percussion if necessary. It is important that the rod string is driven as straight as possible to provide a plumb monitoring well. If the point holder is not straight, pull the assembly and start over with Step 2.

6. Remove the drive cap from the expendable point holder. Install an O-ring (AT2100R) on the point holder in the groove located at the base of the male threads (Fig. 4.4).

Note: the operator may choose to lubricate the O-ring with a small amount of clean water. Lubricating the O-ring makes it easier to threat the probe rods together and nearly eliminate torn O-rings. A small spray bottle works well for applying the water.

7. Thread a 2.125-inch Probe Rod (AT2136, AT2139, AT2148, or AT2160) onto the expendable point holder. Place the drive cap on the probe rod and advance the rod string.

8. Remove the drive cap and install an O-ring (AT2100R) at the base of the male threads of the probe rod (Fig. 4.4). Add another probe rod and replace the drive cap. Once again, advance the rod string.

9. Repeat Step 8 until the end of the rod string is 4 inches (102 mm) below the

bottom of the desired screen interval. The additional depth allows for the connection between the expendable anchor point and screen assembly. The top probe rod must also extend at least 1 foot (25 mm) above the ground surface to allow room for the rod grip puller later in this procedure. Move the probe foot back to provide access to the top of the rod string.

10. With the probe rods and anchor point drive to the proper depth, the next step is to deploy the screen(s) and riser pipe. Thread together 1.4-inch OD prepack sections to achieve the desired screen interval. As shown in Figure 4.5, 1.4-inch OD prepacks are available with 0.5-inch Schedule 80 PVC or 0.75-inch Schedule 40 PVC components and in lengths of 3 or 5 feet (0.9 or 1.5 m). O-rings (GW430R) can be installed between the screen sections if desired.

11. Thread a Snap-look Connector (0.5-inch, GW2030 or 0.75-inch 17469) into the female end of the assembled prepacks (Fig. 4.5). An O-ring can be placed on the male threads of the connector if desired.

12. Insert the screen assembly into the probe rod string with the connector facing toward the bottom of the rod as shown in Figure 4.2.

13. With the assistance of a second person, attach 5-foot (1.5 m) sections of 0.5-inch Schedule 80 or 0.75-inch Schedule 40 PVC Riser (GW2050 or 11747) to the top of the screen assembly. O-rings are required at each riser joint to prevent groundwater from seeping into the well from above the desired monitoring interval. Continue adding riser sections until the assembly reaches the bottom on the rods (Fig. 4.2). At least 1 foot (0.3 m) of riser should extend past the top probe rod.

14. Install a PVC top cap or locking well plug on the top riser (Figure 4.5). If using the vinyl cap, secure the cap with two wraps of duct tape or electrical tape.

15. Raise the screen and riser assembly a few inches and then quickly lower it onto the expendable anchor point. This should force the snap-lock connector over the mushroomed tip of the anchor (Fig. 4.6). Gently pull up the riser to ensure that the connector and anchor are firmly attached. Approximately 0.25 inches (6 mm) of play is normal.

16. It is now time to pull up the probe rods from around the well screen and riser. Reposition the probe unit so that the Rod Grip Puller can be attached to the rod string.

17. Retract the rod string the length of the screens plus an additional 3 feet (1 m). While pulling the rods, observe whether the PVC risers stay in place or move up with the rods.

	a. If the risers stay in place, stable formation conditions are present. Continue retracting the rods to the depth specified above. Go to Section "Sand Pack and Grout Barrier." b. If the risers move up with the probe rods, have a second person hold it in place while putting up the rods. An additional section of PVC riser may be helpful. Once the probe rods have cleared the anchor point and part of the screen, the screen and riser assembly should stop raising with the rods. Continue retracting to the depth specified above. Go to Section "Sand Pack and Grout Barrier." c. If the risers continue to move up with the probe rods and cannot be held in place by hand, the anchor point is most likely located in heaving sands. Extension rods are now required. (Refer to Figure 4.6 for an illustration of extension rod accessories.) d. Place a Screen Push Adapter (GW 1535) on the end of an Extension Rod. Insert the adapter and extension rod into the PVC riser and hold by hand or with an Extension Rod Jig (AT690). Attach additional extension rods with Extension Rod Couplers (AT68) or Extension Rod Quick Links (AT694K) until the push adapter contacts the bottom of the screens (Fig. 4.8). Place an Extension Rod Handle (AT69) on the top extension rod after leaving 3 to 4 feet (1 to 1.2 m) of extra height above the last probe rod. e. Slowly retract the probe rods while another person pushes and taps on the screen bottom with the extension rods (Fig. 4.8). To ensure proper placement of the screen interval and prevent damage to the well, be careful not to get ahead while pulling the probe rods. The risers should stay in place once the probe rods are withdrawn past the screens. Retrieve the extension rods. Place the cap back on the top riser and secure the cap with duct tape if necessary.
Sand Pack and Grout Barrier	The natural formation will sometimes collapse around the well screens as the probe rod string is withdrawn. This provides an effective barrier between the screens and grout material used to seal the well annulus. If the formation does not collapse, a sand barrier must be placed from the surface. This portion of the well installation procedure is important because an inadequate barrier will allow grout to reach the well screens. Nonrepresentative samples and retarded groundwater flow into the well may result from grout intrusion. 1. Using a Water Level Sounder (GW 1200) or flat tape measure, determine the depth from the top of the PVC riser to the bottom of the annulus between the riser and probe rods. Two scenarios are possible: a. Measured depth is 2 to 3 feet (0.6 to 0.9 m) less than riser length. This indicates that unstable conditions have resulted in formation collapse. A

natural grout barrier has formed as material collapsed around the PVC riser when the probe rods were retracted. This commonly occurs in heaving sands. No further action is required. Proceed to Section "Bentonite Seal Above Screen" and perform Step 2 (for unstable formations).

b. Measured depth is equal to or greater than riser length. This indicates that stable conditions are present and the cohesive formation did not collapse. The probe hole has remained open and void space exists between the riser (and possibly the screen) and formation material. Clean sand must be placed downhole to provide a suitable grout barrier. Continue with Step 2 below.

2. Begin slowly pouring 20/40 mesh sand down the annulus between the PVC riser and probe rod string. Reduce spillage by using a funnel or flexible container as shown in Figure 4.8. Add approximately 2.0 liters of sand for each 3-foot (1 m) screen section or 3.25 liters of sand for each 5-foot (1.5 m) screen, plus 1.75 – 2.0 liters for a minimum 2-foot (0.6 m) layer of sand above the top screen section.

Note: the sand volumes specified above assume maximum annular space where no formation collapse has occurred. Actual volumes may be less in field conditions.

3. Measure the annulus depth after each 1.0 – 1.5 liters of sand. The sand may not fall all the way past the screens due to the tight annulus and possible water intrusion. This is acceptable, however, since the prepacked screens do not require the addition of sand. The important thing is that a sand barrier is provided above the screens.

4. Sand may also bridge within the annulus between the risers and probe rods and consequently fail to reach total depth (Fig. 4.9). This most likely occurs when the sand contacts the water inside the probe rods during well installations below the water table. Wet probe rods also contribute to sand bridging. If the annulus is open, skip to Section "Bentonite Seal Above Screen," Step 1. If bridging is evident, continue with Step 5 below.

5. In case of a sand bridge above the screens (wet rods, high water table, etc.), insert clean extension rods into the well annulus to break up the sand (Fig. 4.9). Simultaneously retracting the probe rods usually helps. Check annulus depth again. If sand is no longer bridged, proceed to Section "Bentonite Seal Above Screen." If bridging is still evident, continue with Step 6 below.

6. If the sand bridge cannot be broken up with extension rods, inject a small amount of clean water into the annulus. This is accomplished with a Geoprobe® Model GS1000 or GS500 Grout Machine and 3/8-inch (9.5 mm) OD nylon tubing

	(11633). Simply insert the nylon tubing down the well annulus until the sand bridge is contacted. Attach the tubing to the grout machine and pump up to one gallon of clean water while moving the tubing up and down. The jetting action of the water will loosen and remove the sand bridge. Check annulus depth again. The distance should be 2 to 3 feet (0.6 to 0.9 m) less than the riser length when the sand barrier is completed. Proceed with Section "Bentonite Seal Above Screen."
Bentonite Seal Above Screen	Bentonite is a clay material which exhibits very low permeability when hydrated. When properly placed, bentonite can prevent contaminants from moving into the well screens from above the desired monitoring interval. The seal is formed either by pouring granular bentonite into the annulus from the ground surface, or by injecting a high-solids bentonite slurry directly above the grout barrier. The use of bentonite chips is limited to cases in which the top of the screen ends above the water table (no water is present in the probe rods). Whichever method is used, at least 2 feet (0.6 m) of bentonite must be placed above the sand pack. 1. **(Stable Formation)** Granular bentonite is recommended if the following conditions are met: i. Top of screen interval is above the water table. ii. Formation remained open when probe rods were retracted. iii. Bridging was not encountered while installing the sand pack and grout barrier in Section "Sand Pack and Grout Barrier." a. Withdraw the probe rod string another 3 to 4 feet (0.9 to 1 m) and ensure that the PVC riser does not rise with rods. It is important that the bottom of the rod string is above the proposed seal interval. If positioned too low, dry bentonite will backup into the expendable point holder. Bridging then results if moisture is present inside the probe rods. b. Pour approximately 1.5 liters of granular bentonite between the probe rods and PVC riser as was done with the sand in Section "Sand Pack and Grout Barrier." c. Measure the riser depth to the bottom of the annulus. The distance should now equal the installed riser length minus the minimum 2 feet (0.6 m) of sand pack and 2 feet (0.6 m) of bentonite seal. As was stated with the sand pack, if the measured depth is significantly less than expected, the bentonite has more than likely bridged somewhere along the rod string. A procedure similar to that identified for bridged sand (Section "Sand Pack and Grout Barrier," Steps 5 and 6) may be utilized to dislodge the granular bentonite. d. Once it has been determined that the bentonite seal is properly emplaced, add 1 liter of clean water to hydrate the dry bentonite according to regulations. This is not necessary if water was used to clear

	bridged bentonite. 2. **(Unstable Formation)** A grout machine is required to install the bentonite seal if the formation collapsed when the roads were retracted or the sand bridged when installing the grout barrier. The pump is able to supply a high-solids bentonite slurry under sufficient pressure to displace formation fluids. Void places often develop when poured (gravity installed) granular bentonite is used under this conditions, resulting in an inadequate annular seal. Wet rods will often lead to bridging problems as well. a. Mix 1 gallon (3.8 L) of high-solids bentonite (20 to 25 percent by dry weight) and place in the hopper of the grout machine. b. Insert 3/8-inch nylon tubing (see note below) to the bottom of the annulus between the probe rods and well riser. Leaving at least 15 feet (5 m) extending from the top of the rod string, connect the tubing to the grout machine. This extra length will allow rod extraction later in the procedure. <u>Note:</u> the side-port tremie method is recommended to prevent intrusion of grout into the sand barrier. To accomplish side-port discharge of grout, cut a notch approximately one inch up from the leading end of the tubing and then close the leading end with a threaded plug of suitable size. c. Activate the grout pump and fill the tremie tube with bentonite. Begin slowly pulling the rod string approximately 3 feet (1 m) while operating the pump (Fig. 4.10). This will place bentonite in the void left by the retracted rods before it is filled by the collapsing formation. Continue to watch that the PVC riser does not come up with the rod string. When removing the retracted probe rod, slide the rod over the nylon tubing and place it on the ground next to the grout machine. This eliminates cutting and reattaching the tubing for each rod removed from the string. Take care not to "kink" the tubing during this process as it will create a weak spot in the tubing which may burst when pressure is applied. d. Measure the annulus depth to ensure that at least 2 feet (0.6 m) of bentonite was delivered. Pump additional bentonite slurry if needed.
Grouting Well Annulus	The placement of grout material within the remaining well annulus provides additional protection from vertical contaminant migration. Most grout mixes are composed of neat cement, high-solids bentonite slurry, or a combination of cement and bentonite. Such mixes must be delivered with a high-pressure grout pump. When stable formations exist, the well may be sealed by pouring dry granular bentonite directly into the annulus from the ground surface. Consult the appropriate regulatory agency to determine approved grouting methods.

This section presents the procedure for grouting the well annulus with the Geoprobe® Model GS1000 or GS500 Grout Machines. Refer to Figure 4.11 as needed.

1. Mix an appropriate amount of grout material and place it in the hopper on the grout machine. (Refer to the Geoprobe® Yellow Field Book for tables on volume requirements.)

Note: it is recommended that an additional 25 to 30 percent of the calculated annulus volume is included in the total grout volume. This allows for material that is left in the grout hose and tubing or moves into the formation during pumping. An approximate range is 0.25 to 0.30 gallons (0.9 to 1.1 L) of grout for each foot of riser below ground surface.

2. A side-port tremie tube may be made from a roll of 3/8-inch OD Nylon Tubing (11633) by cutting a notch in the side of the tubing approximately 1 inch (25 mm) up from the discharge end. Thread a bolt or screw of suitable diameter into the end of the tubing so that pumped grout is forced out through the notch in a side-discharge manner.

Insert the side-port tremie tube into the well annulus until the leading end of the tube reaches the top of the bentonite seal. At least 15 feet (5 m) of tubing should extend from the top of the rod string. This extra length allows rod extraction with the tubing attached to the pump.

3. Attach the tubing to the grout machine and begin pumping. If the bentonite seal was below the water table (deep well installation), water will be displaced and flow from the probe rods as the annulus is filled with grout. Continue operating the pump until undiluted grout flows from the top probe rod.

4. Reposition the direct push machine and prepare to pull rods.

5. Begin pulling the probe rods while continuing to pump grout. Match the pulling speed to grout flow so that the rods remain filled to the ground surface. This maintains hydraulic head within the probe rods and ensures that the space left by the withdrawn rods is completely filled with grout.

Note: slide the probe rods over the nylon tubing and place neatly on the ground next to the grout machine. **Be careful not to pinch or bind the tubing as this forms weak spots which may burst when pressure is applied.**

Note: try to avoid filling the upper 12 inches (305 mm) of well annulus with grout when pulling the expendable point holder. This will make for cleaner well protector installation.

	6. When all probe rods have been retrieved and the well is adequately grouted, unstring the tremie tube and begin cleanup. It is important to promptly clean the probe rods, grout machine, and accessories. This is especially true of cement mixes as they quickly set up and are difficult to remove once dried.
Surface Cover/Well Protection	A surface cover protects the PVC well riser from damage and tampering. Although aboveground and flush-mount well covers may be used, most Geoprobe® prepack monitoring wells have been installed with flush-mount covers (Fig. 4.12). Consult the project planners and/or appropriate regulators to determine the approved well cover configuration for your specific application. 1. In order to fit under a flush-mount cover, the top of the well riser must be below the ground surface. Place the well cover over the riser to mark the cover diameter. Remove the cover and excavate the soil around the well head to install the protector. 2. The top of the riser should be located several inches above the bottom of the hole (but below the adjacent ground surface) before installation of the well cover. If a riser joint is near this level, the operator may choose to unthread the top riser and adjust the depth of the hole to fit the riser height. Most prepack installations will instead require trimming the top riser to the appropriate height with PVC cutters. Note: do not cut off the riser with a hacksaw as cuttings may fall down into the screens. 3. In most areas, regulations specify that a locking plug be installed on the top riser of permanent monitoring wells. Insert a locking well plug into the riser and tighten the hex bolt with a ½-inch T-handle wrench or nut driver until the cap fits snugly. 4. Position the well cover so that it is centered over the well riser. Provide at least 0.5 inches (13 mm) of space between the top of the locking plug and bottom of the well cover lid. If flush-mount protection is used, install the cover slightly above grade to prevent ponding of runoff water at the well head. 5. Support the well cover by installing a concrete pad according to project requirements. Pads are commonly square-shaped with a thickness of 4 inches (102 mm) and sides measuring 24 inches (610 mm) or greater. Finish the pad so that the edges slope away from the center to prevent ponding of surface water on the well cover. 6. Fill the inside of the well cover with sand up to approximately 2 to 3 inches (51

	to 76 mm) from the top of the riser and locking plug.
Well Development	"The development serves to remove the finer grained material from the well screen and filter pack that may otherwise interfere with water quality analyses, restore groundwater properties disturbed during the (probing) process, and to improve the hydraulic characteristics of the filter pack and hydraulic communication between the well and the hydrologic unit adjacent to the well screen." (ASTM D 5092). The two most common methods of well development are bailing or pumping (purging) and mechanical surging. **Purging** involves removing at least three well volumes of water with either a Tubing Bottom Check Valve (GW42) or a Stainless Steel Mini-Bailer Assembly (GW41). Include the entire 2.125-inch (54 mm) diameter of disturbed soil at the screen interval when calculating the well volume. **Mechanical Surging** utilizes a surge block or swab which is attached to extension rods and lowered inside the riser to the screen interval. The extension rods and surge block are moved up and down, forcing water into and out of the screen. A tubing bottom check valve or peristaltic pump is then used to remove the water and loosened sediments (Figure 4.13). **<u>Note:</u>** mechanical surging may damage the well screen and/or reduce groundwater flow across the filter pack if performed incorrectly or under improper conditions. Refer to ASTM D 5521. "Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers" for a detailed discussion of mechanical surging. **Fine Grained Formations:** many times field conditions or regulations require us to install monitoring wells in fine-grained formations that would not be considered a true aquifer. Development in these conditions is difficult at best. There are various development methods that may be useful depending on the specific grain size distribution of the formation. In formations with a good proportion of sand, using a rod brush slightly larger than the ID of the well as a swab may help in surging the well without clogging the filter pack. Caution is required. Adding water to slow-yielding wells may also help to loosen fines and improve recharge when swabbing. Purging wells in fine-grained formations with a peristaltic pump or bladder pump may offer the best means of development as high-energy surging can clog the screens. For more information on this topic request the Geoprobe® bulletin titled *Groundwater Quality and Turbidity vs. Low Flow.* Development should continue until representative water is obtained and natural flow is established into the well. Previously, representative water was defined primarily on the basis of consistent pH, specific conductance, temperature

	measurements, and visual clarity (ASTM D 5092). To meet the more stringent requirements of the low-flow sampling protocol (EPA 1996), monitoring of additional parameters such as dissolved oxygen (DO) and oxidation/reduction potential (ORP or Eh), and quantitative measurement of turbidity may be required.
Sample Collection	As the federal EPA and more state agencies are recommending or requiring use of the "low-flow" sampling protocol (EPA 1996), the ability to sample small-diameter, direct push (DP) installed monitoring wells with bladders pumps has significantly increased. There are two Geoprobe® bladder pumps (Model A for ½" wells and Model B for ¾" or larger wells) available that permit low-flow sampling in the small-diameter DP installed monitoring wells. The low-flow sampling method is preferred when sampling for volatile contaminants or metal analytes. Both pumps can be used with any of the available flow-through-cells and water quality monitoring probes. Smaller volume flow-through-cells are recommended when available. Use of the bladder pump and flow-through-cell allows you to meet the stringent requirements for monitoring pH, specific conductance, DO, and ORP, and obtaining low-turbidity samples for metals analysis. Groundwater samples may be collected with a tubing bottom check valve (with 3/8-inch OD poly tubing as shown in Fig. 4.12) or a stainless steel mini-bailer assembly when appropriate. While the check valve is the quicker and more economical sampling device, some operators still prefer the traditional mini-bailer. <u>Note:</u> the up and down motion of the check valve may introduce error when collecting samples for volatiles analysis. To avoid volatiles loss, lower the check valve and tubing to the target monitoring zone without the check ball. Drop the check ball to the bottom of the tubing from the ground surface. This seals the check valve and captures the sample inside the tubing without stripping away volatiles. To collect the sample, simply retrieve the tubing from the well riser, remove the check valve, and place the groundwater in an approved container. Before going into the field to sample monitoring wells (or groundwater samplers), be sure to know the level of sample quality that will be required. For high-integrity samples that must meet strict data quality objectives, sampling with a bladder pump may be required. Conversely, if screening level data is required (is it there and about how much?) bladder pumps will be slow and ineffective while the tubing check valve would be sufficient and save time and money. For more information on this topic, request the Geoprobe® bulletin titled *Groundwater Quality and Turbidity vs. Low Flow.*
Equipment Decontamination	Before and after each use, thoroughly clean all parts of the soil sampling system according to project requirements. A clean, new liner is recommended for each use. Parts should also be inspected for wear or damage at this time.

Personnel Decontamination	1. All personnel must go through decontamination procedures whenever leaving a contaminated area. Decontamination procedures should be used in conjunction with methods to prevent contamination including minimizing contact with wastes and maximizing worker protection. Personnel must follow PTS-SOP-DE-01 Personnel Decontamination Procedures.

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SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	1. Contact with contaminated soils and underground water.	1. Contaminated sites, during sample collection and handling.	1. Adverse health effects could result from ingesting, inhaling, and/or skin/eyes contact with contaminated soils and underground water.	1. Personnel will practice proper personal hygiene – wash hands prior to eating and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Work will be suspended during high wind conditions that produce large amounts of visible dust.
	2. Carbon Monoxide (CO).	2. Vehicle and equipment.	2. Potential exposure to CO when working around idling vehicles/ equipment could result in irritated eyes, headache, nausea, weakness and dizziness.	2. Employees will minimize the time sitting in idling vehicles and will open a window to increase ventilation. Employees will avoid working around idling vehicles/equipment and stay up wind.
	3. Hydraulic fluid.	3. Testing sites, when using the Geoprobe.	3. Employees could be exposed to hydraulic fluid via inhalation, ingestion, and skin/eyes contact when checking the hydraulic system of the machine or during spills/leaks resulting in adverse health	3. Employees will prevent skin/eyes contact with hydraulic fluids and they will wear nitrile gloves and eye protection. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available at the site. Cleanup materials will be disposed of according to the appropriate regulations. All components

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			effects.	of the Geoprobe will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	4. Granular bentonite.	4. Testing sites.	4. Employees could be exposed to granular bentonite via inhalation, ingestion, and skin/eyes contact when sealing well screens resulting in adverse health effects.	4. Personnel will practice proper personal hygiene – wash hands prior to eating and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling granular bentonite. Work will be suspended during high wind conditions that could produce large amounts of visible bentonite dust.
	5. Silica sand.	5. Testing sites.	5. Employees could be exposed to silica sand via inhalation, ingestion, skin/eyes contact when installing a grout/sand barrier for the well resulting in adverse health effects.	5. Personnel will practice proper personal hygiene – wash hands prior to eating and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling silica sand. Work will be suspended during high wind conditions that could produce large amounts of visible silica dust.
	6. Fresh concrete.	6. Testing sites.	6. Employees could be exposed to fresh concrete when installing a concrete pad to support the well cover. Contact with fresh concrete may	6. Employees will wear work boots, gloves, and safety glasses when handling fresh concrete. Workers will also avoid direct contact with fresh concrete and prevent fresh concrete soak into clothing or rub against skin. Proper personal hygiene is

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			result in irritation and/or chemical burns of eyes, skin, and nose. It may also cause dermatitis.	also required when handling fresh concrete.
PRESSURE	1. Pressurized hydraulic lines.	1. Testing sites.	1. Adverse health effects could result from faulty pressurized hydraulic lines.	1. All components of the Geoprobe will be inspected prior to and at the completion of the task.
	2. Pressurized lines from the high-pressure grout pump (Geoprobe® Model GS1000 or GS500).	2. Testing sites.	2. Adverse health effects could result from faulty pressurized lines if using the high-pressure grout pump to inject grout to the bottom of well screens.	2. All components of the high-pressure grout pump will be inspected prior to and at the completion of the task.
	3. Excessive noise levels.	3. Testing sites.	3. Employees could be exposed to excessive noise levels when operating the Geoprobe resulting in irritability, decreased concentration, and noise-induced hearing loss.	3. Personnel operating the Geoprobe will wear double hearing protection (i.e., earplugs and earmuffs). Non-essential personnel will wear hearing protection (e.g., earplugs) and will maintain a 20-foot buffer zone around the Geoprobe when possible.
ELECTRICAL	1. Lightning.	1. Outdoor sites.	1.Electrocution, injury, death, or equipment damage could be caused by	1. Employees will follow the 30/30 rule during lightning storms.

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			lightning strike.	
	2. Contact with overhead utilities.	2. Testing sites.	2. Injury, death or property damage could occur from contact with overhead utilities while operating the Geoprobe.	2. If overhead hazards are present, established overhead utility procedures will be followed. When possible, employees will avoid areas with overhead hazards. Employees will avoid contact with overhead lines when raising the probe unit hammer assembly to its highest position. Employees will not drive the machine with the probe cylinder extended.
	3. Contact with underground utilities.	3. Testing sites.	3. Injury, death or property damage could occur from contact with underground utilities when lowering probe rods into the ground to insert and install monitoring wells.	3. Prior to starting work, employees will call for a utility locate (e.g., call 811 or corresponding phone number). If underground utilities are present, established underground utility procedures will be followed.
MOTION	1. Driving to each site.	1. Road.	1. Incidents could occur when driving resulting in personal injury and/or property damage.	1. Employees will follow defensive driving techniques when operating a vehicle.
	2. Slips and trips.	2. Uneven terrain, slick/muddy/wet surfaces and/or steep slopes.	2. Personal injury such as sprains and muscle/back strains could result from slips	2. Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously.

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			and trips.	
	3. Bending, squatting and kneeling.	3. Testing sites, when assembling and retrieving probe rods and well components from the subsurface.	3. Bending, squatting and kneeling could result in muscle/back strains or other injuries.	3. Employees should stretch prior to starting work and they will take breaks when necessary.
	4. Improper body mechanics.	4. Testing sites.	4. Back injuries and muscle/back strains could result when using improper techniques to lift and carry probe rods and bags of granular bentonite, silica sand, and other grouting materials. Back injuries and muscle/back strains could also result from using improper techniques when pulling probe rods from the subsurface.	4. Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift if necessary. Employees will also use good body mechanics when pulling probe rods from the subsurface: bend knees, lean slightly away from the object, keep back and wrists straight, use legs to move the objects. If necessary, personnel will also use the adjustable rod clamps to facilitate the process of retrieving probe rods from the subsurface.
	5. Struck by and/or caught in between heavy equipment or vehicles.	5. Testing sites.	5. Personnel could be injured if struck by and/or caught in between heavy equipment or vehicles.	5. When applicable, employees will communicate with the contact person of other contractors on site. Personnel will avoid working near other heavy equipment and/or vehicles, when possible. High visibility

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				clothing will be worn.
	6. Contact with moving components of the Geoprobe.	6. Testing sites, when operating the machine.	6. Adverse health effects could result from touching moving components when operating the Geoprobe.	6. Employees will not touch moving components of the machine. Personnel will tie back long hair and will not wear loose clothing and jewelry. Work gloves are required when operating the machine. All personnel will be clear of all moving parts before starting the engine. Operators will stand to the control side of the machine, clear of the probe foot and derrick, while operating the controls. Personnel will never reach across the probe assembly to manipulate the machine controls.
	7. Pinch points.	7. During equipment assembly.	7. Employees could be exposed to hand injuries such as lacerations, punctures, cuts and pinched fingers when assembling the probe rods and well components.	7. Employees will always wear work gloves when operating the Geoprobe and handling its components.
	8. Flying debris/grout material.	8. During equipment assembly and installation of monitoring wells.	8. Eye injuries could result from flying debris/grout material.	8. Employees will wear safety glasses at all times.

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		Also, when using the high-pressure grout pump (Geoprobe® Model GS1000 or GS500).		
GRAVITY	1. Falls from slips and trips. 2. Falling equipment and/or tools.	1. Uneven terrain, slick/muddy/ wet surfaces and steep slopes. 2. Testing sites.	1. Workers could be injured if they fall causing bruises, scrapes, or broken bones. 2. Personnel could be injured if exposed to falling equipment and/or tools (e.g., probe rods) when operating the Geoprobe.	1. Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. 2. Employees will wear steel-toed boots and hard hat when operating the Geoprobe. Personnel will practice good housekeeping at all times and keep the work area organized.
THERMAL	1. Cold/heat stress. 2.Hypothermia/ frostbite.	1. Sites. 2. Sites where air temperature is 35.6°F (2°C) or less.	1. Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke. 2. Workers whose clothing becomes wet may be exposed to hypothermia and/or frostbite.	1. Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. 2. Employees will change clothing if it becomes wet.

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RADIATION	1. Ultraviolet (UV) radiation.	1. Outdoors.	1. Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	1. Employees should wear sunscreen. Employees will wear long-sleeve work shirts and long pants. Employees should also use safety glasses with tinted lenses.
BIOLOGICAL	1. Untrained worker. 2. Plants, insects, and animals.	1. Sites. 2. Sites.	1. Adverse health effects or injury could result from lack of training. 2. Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, swelling and other personal injuries.	1. Employees will be properly trained in this procedure and other applicable procedures. All employees operating the machine will be familiar with the basic controls of the machine including the Emergency Kill switch button. 2. Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety Officer.	
REQUIRED PPE	Level D: hard hat, safety glasses, high-visibility work shirt or vest, long pants, steel-toed boots, and work gloves.
APPLICABLE MSDS	MSDSs will be maintained based on site characterization and contaminants. Hydraulic Fluids. Carbon Monoxide. Granular Bentonite. Silica Sand.

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	Cement.
REQUIRED PERMITS/FORMS	Daily Toolbox Meeting Record and TSEA, where applicable.
ADDITIONAL TRAINING	OSHA 40-hour HAZWOPER/8-hour Refresher.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
ROUTINE TASKS	Bending, squatting, kneeling, lifting, pulling, visual verification of performance, and data recording.
RELATED SOPs/PROCEDURES/ WORK PLANS	Related SOPs: PTS-SOP-DE-01 Personnel Decontamination Procedures.
TOOLS	The following equipment is required to install a permanent monitoring well with the Geoprobe® 1.4-inch OD prepacked screens and direct push system. Refer to Figures 3.1 and 3.2 for illustrations of well components.

0.5-IN. X 1.4-IN. OD PREPACK WELL COMPONENTS	**Quantity**	**Part Number**
0.5-in. x 1.4-in. OD Prepacked Screen, 3-ft. length	variable	GW2010
0.5-in. x 1.4-in. OD Prepacked Screen, 5-ft. length	variable	GW2020
Snap-Lock Connector Assembly, 0.5-in. sch. 80	-1-	GW2030
Expandable Anchor Point, 2.5-in. OD	-1-	GW2040
PVC Riser, 0.5-in. sch. 80, 5-ft. length	variable	GW2050
O-rings for 0.5-in. PVC Riser, Pkg. of 25	variable	GW430R
PVC Top Cap, 0.5-in. sch. 80 Flush Thread	-1-	GW2055
Locking Well Plug, for 0.5-in. sch. 80 riser	-1-	WP1750
Vinyl Cap, 0.812-in. ID (optional)	-1-	AT441
PVC Bottom Plug, 0.5-in. sch. 80 Flush Thread (optional)	-1-	GW2056
Expandable Drive Point, 2.125-in. rods / 2.5-in.	-1-	AT2015

OD (optional)		

0.75-IN. X 1.4-IN. OD PREPACK WELL COMPONENTS	Quantity	Part Number
0.75-in. x 1.4-in. OD Prepacked Screen, 3-ft. length	variable	11678
0.75-in. x 1.4-in. OD Prepacked Screen, 5-ft. length	variable	17466
Snap-Lock Connector Assembly, 0.75-inch sch. 40	-1-	17469
Expendable Anchor Point, 2.5-in. OD	-1-	GW2040
PVC Riser, 0.75-in. sch. 40, 5-ft. length	variable	11747
O-rings for 0.75-in. PVC Riser, pkg. of 25	variable	GW4401R
Vinyl Cap, 1.0-in. ID	-1-	12258
Locking Well Plug, for 0.75-in. sch. 40 riser	-1-	WP1775
PVC Bottom Plug, 0.75-in. sch. 40 Flush Thread (optional)	-1-	12385
Expendable Drive Point, 2.125-in. rods / 2.5-in. OD (optional)	-1-	AT2015

MONITORING WELL ACCESSORIES	Quantity	Part Number
Well Cover, flush-mount, 4-in. x 12-in., cast iron / ABS skirt (optional)	-1-	WP1741
Well Cover, flush-mount, 7-in. x 10-in., cast iron / galvanized skirt (optional)	-1-	WP1771
Sand, environmental grade (20/40 mesh)	variable	AT95
Bentonite, granular (8 mesh)	variable	AT91
Bentonite, powdered (200 mesh)	variable	AT92
Portland Cement, Type I	variable	
Concrete Mix (premixed cement and aggregate)	variable	
Clean Water (of suitable quality for exposure to well components)	variable	

GEOPROBE® TOOLS AND EQUIPMENT	Quantity	Part Number
O-rings for 2.125-in. Probe Rod, pkg. of 25	variable	AT2100R
Drive Cap, 2.125-in.	-1-	AT2101
Expendable Point Holder, 2.125 x 36, 48 or 60 in.	-1-	AT2110, AT2111, or AT2112
Probe Rod, 2.125-in. x 36, 48, or 60 in.	variable	AT2136, AT2148, or AT2160
Probe Rod, 2.125-in. x 1 meter (optional)	variable	AT2139
Rod Grip Puller Assembly (GH40) or Rod Grip Handle (GH60)	-1-	GH2150K or 9640
Extension Rod, 36-, 48-, or 60-in.	variable	AT67, AT671, or 10073
Extension Rod, 1 meter (optional)	variable	AT675
Extension Rod Coupler	variable	AT68
Extension Rod Handle	-1-	AT69
Extension Cord Quick Links (optional)	variable	AT694K
Grout Machine	-1-	GS1000 or GS500
Grout System Accessories	-1-	GS1010 or GS1012
Water Level Sounder	-1-	GW1200
Screen Push Adapter	-1-	GW1535
Stainless Steel Mini-Bailer Assembly (optional)	-1-	GW41
Pneumatic Bladder Pump (optional)	-1-	GW1400 Series
Tubing Bottom Check Valve	-1-	GW42
Polyethylene Tubing, 3/8-in. OD (for sampling, etc.)	variable	TB25L
Nylon Tubing, 3/8-in. OD (for grouting)	variable	11633

Additional Tools and Equipment	Quantity
Locking Pliers	-2-
Pipe Wrench	-2-
Volumetric Measuring Cup	-1-
PVC Cutting Pliers	-1-
Weighted Measuring Tape (optional)	-1-
Small Funnel or Flexible Container (for pouring sand)	-1-

Duct or Electrical Tape Roll	-1-
Bucket or Tub (for dry grout material, water, and mixing)	-3-

FORMS/CHECKLIST	

APPROVALS/CONCURRENCE

By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.

PROJECT MANAGER	**DATE**
SAFETY OFFICER	**DATE**
CREW LEAD or SAMPLER LEAD	**DATE**
SAMPLER	**DATE**

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
OTHER	**DATE**
OTHER	**DATE**

Revisions:

Rev.	Description	Date	Approval

Geoprobe Prepacked Screen Monitoring Well - Figures

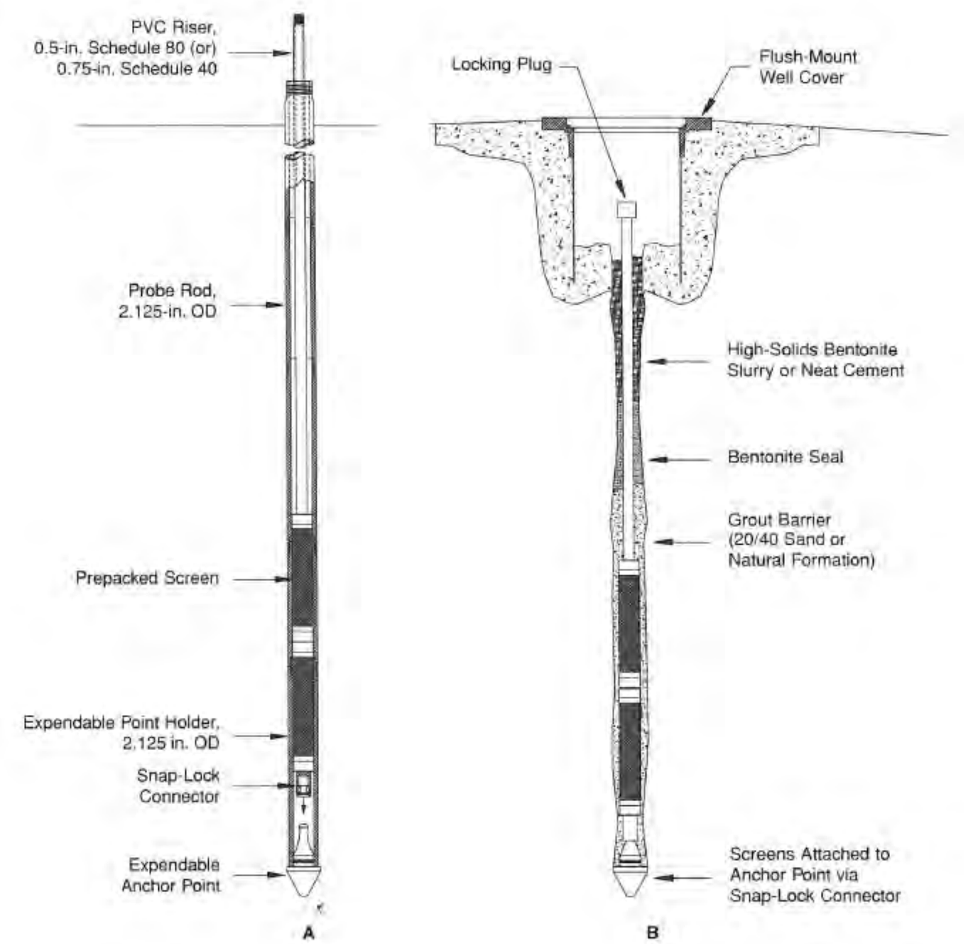


Figure 2.1:
Insertion of Prepacked Screens (A) and Installed Geoprobe Monitoring Well (B

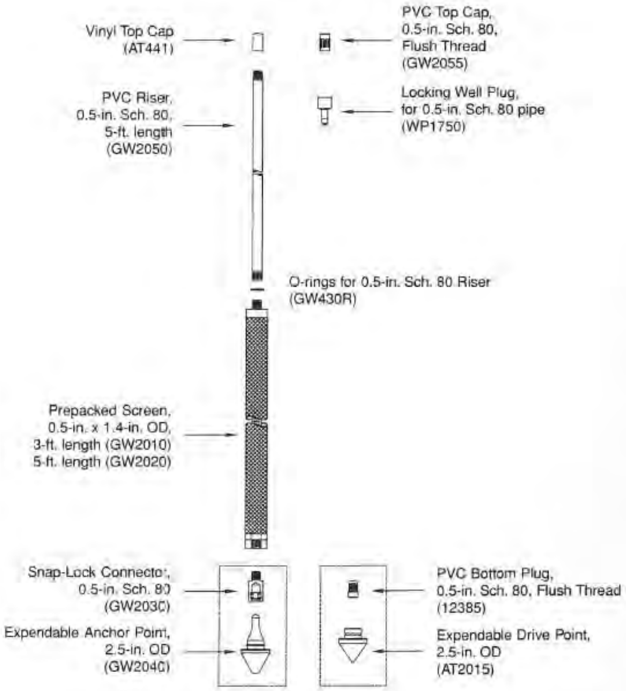


Figure 3.1:
0.7-in. x 1.4-in. OD Prepacked Screen Monitoring Well Parts

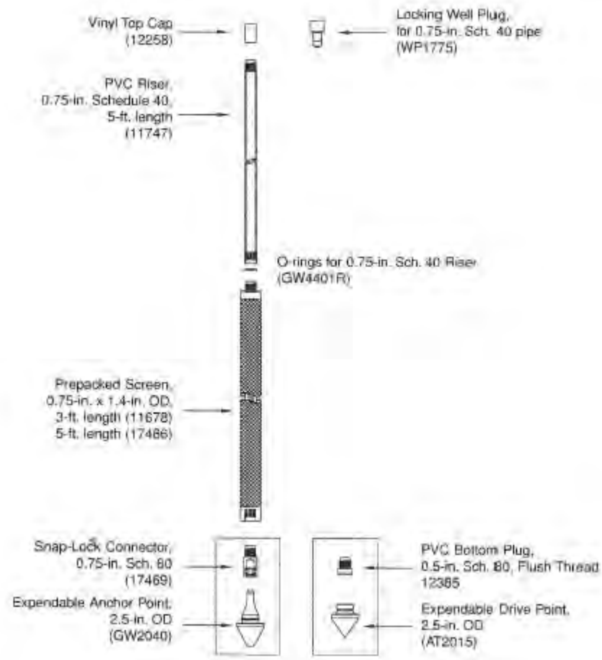


Figure 3.2:
0.75-in. x 1.4-in. OD Prepacked Screen Monitoring Well Parts

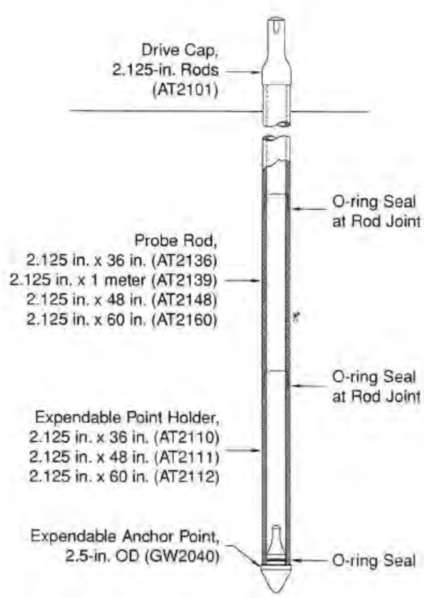


Figure 4.1:
Expendable Anchor Point Driven to Depth

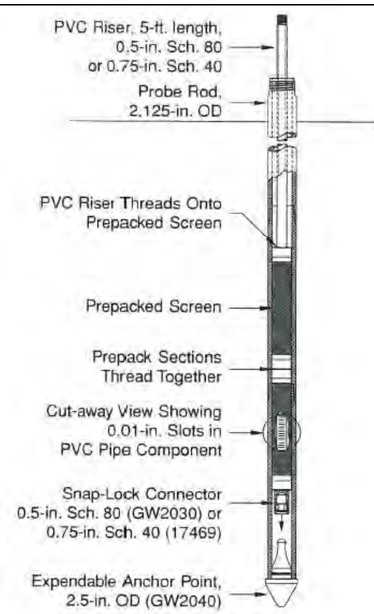


Figure 4.2:
Prepacked Screens Inside Probe Rod String

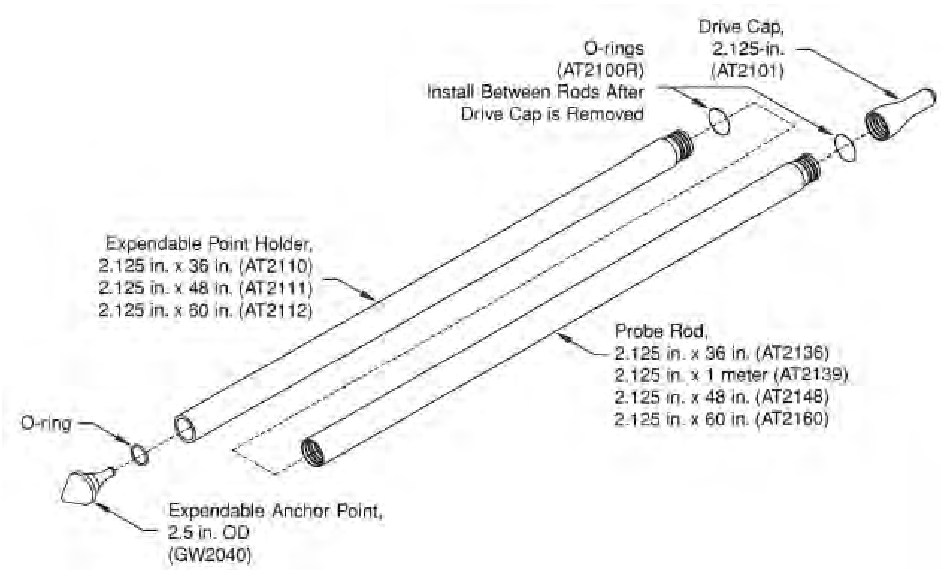


Figure 4.3:
2.125-inch OD Probe Rod Assembly

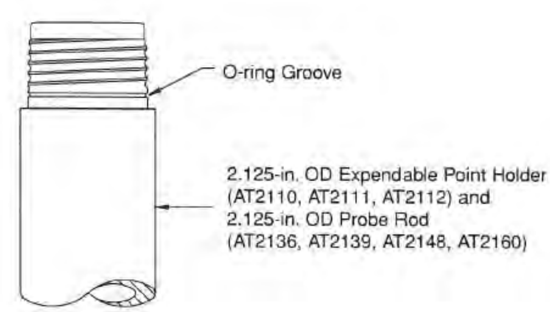


Figure 4.4:
O-ring Groove in 2.125-inch Expendable Point Holders and Probe Rods

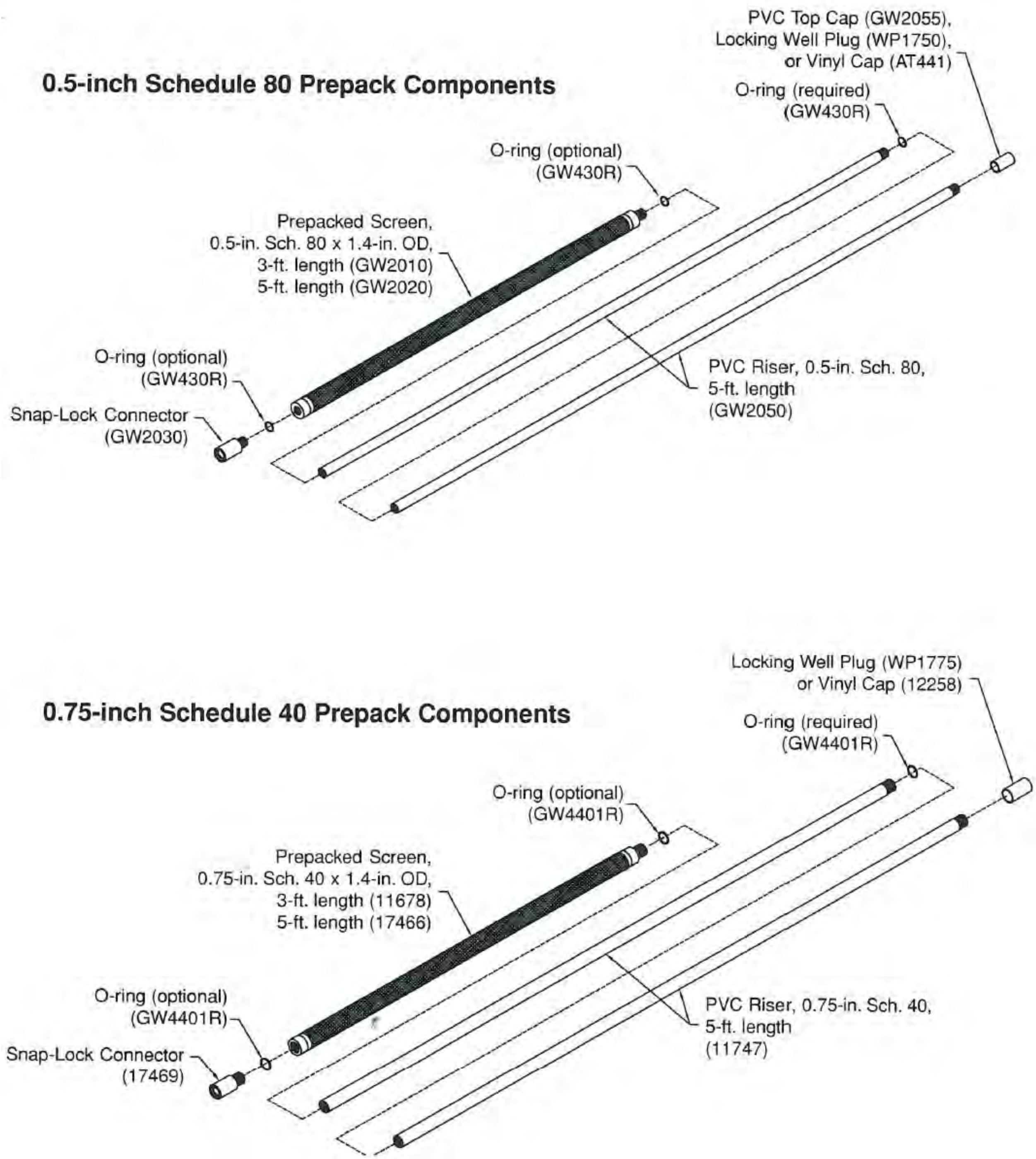


Figure 4.5:
0.5-inch Schedule 80 and 0.75-inch Schedule 40 Prepacked Screen Components

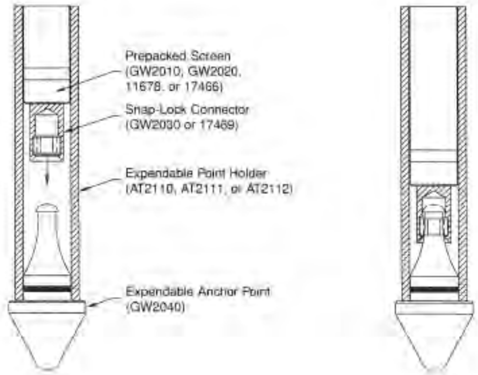


Figure 4.6:
Connecting Prepack(s) to Expendable Anchor Point

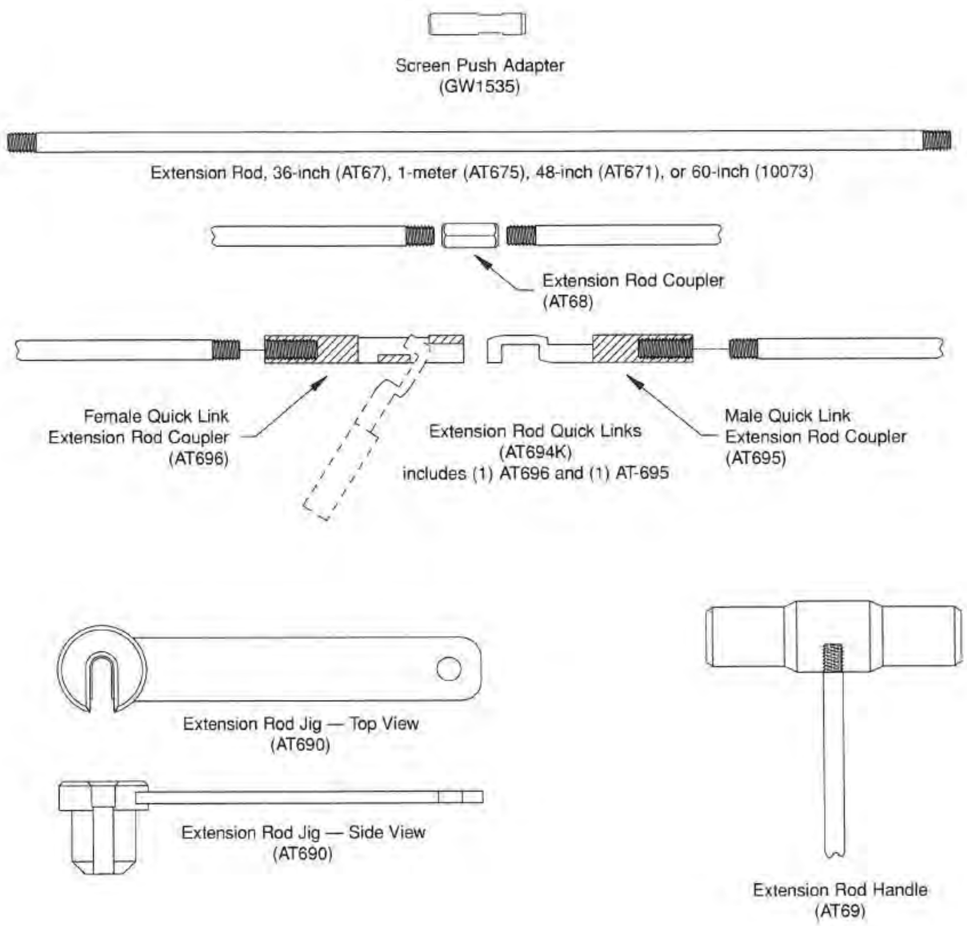


Figure 4.7:
Geoprobe Extension Rods and Accessories

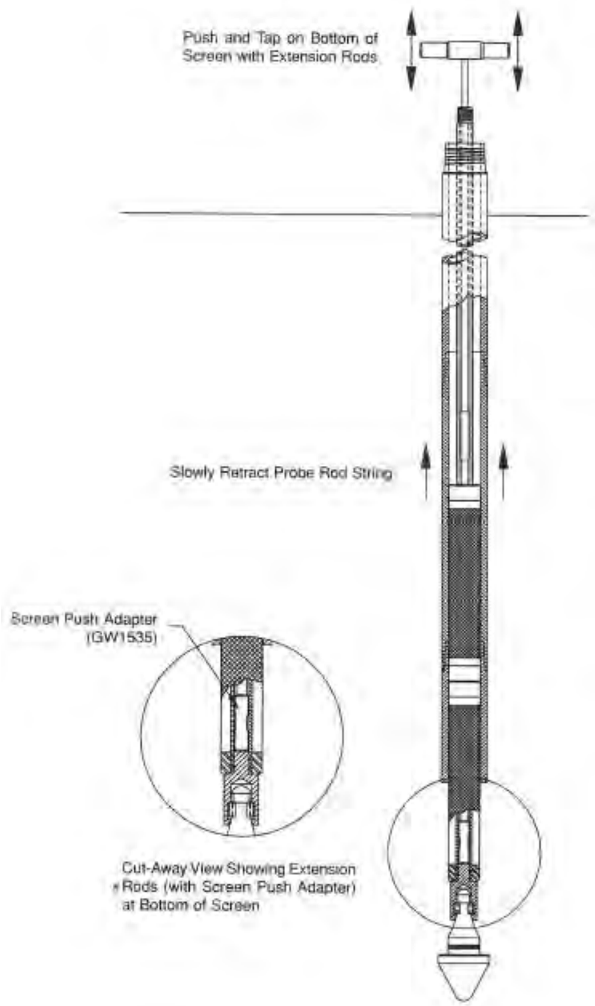


Figure 4.8:
Use Extension Rods to Tap Out Wedged Screens

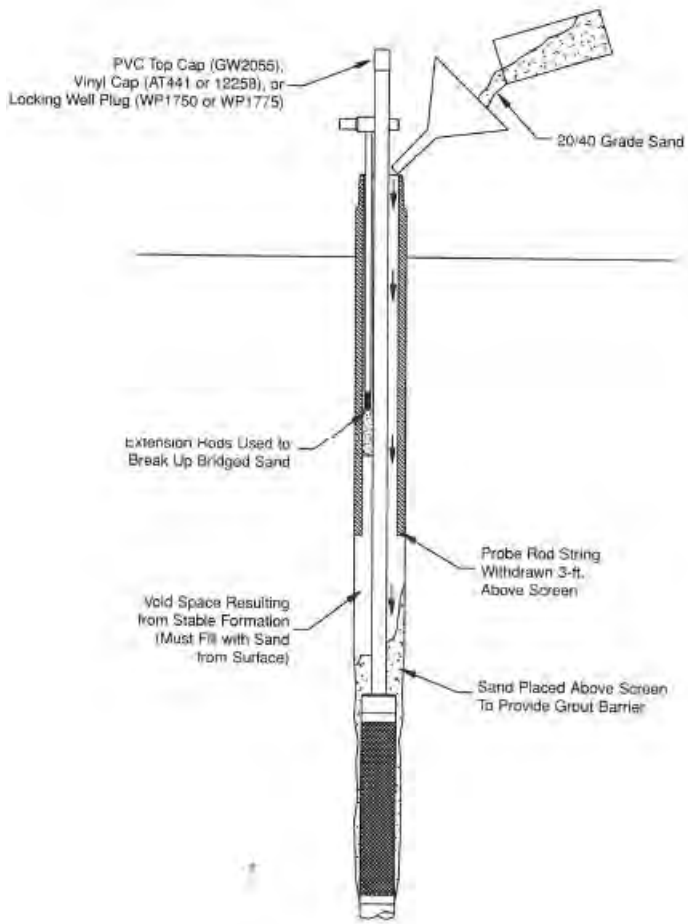


Figure 4.9:
Installing Grout Barrier from Ground Surface with 20/40 Mesh Sand

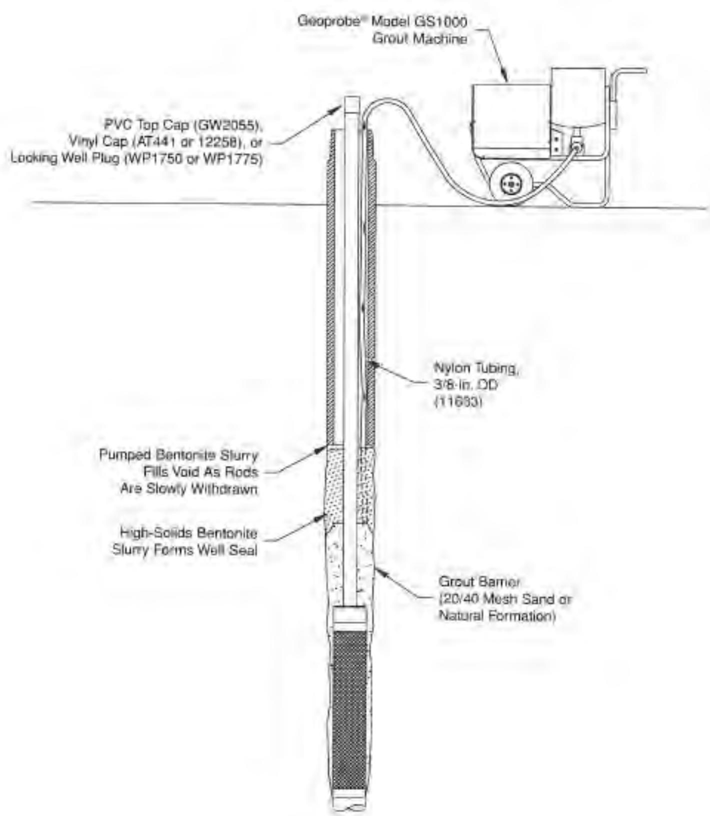


Figure 4.10:
Providing Bentonite Seal With Geoprobe® Model GS1000 Grout Machine

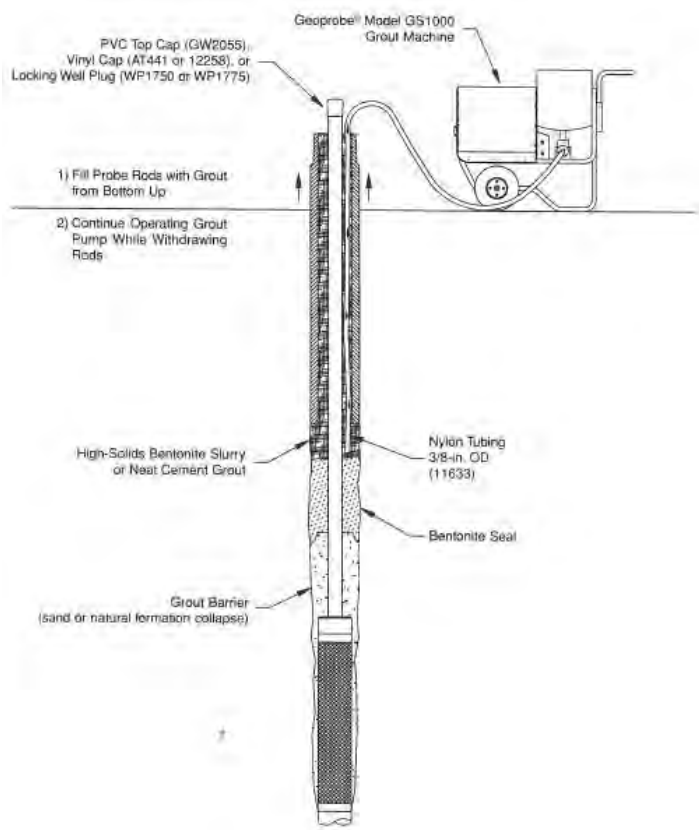


Figure 4.11:
Grouting Well Annulus with Geoprobe® Model GS1000 Grout Machine

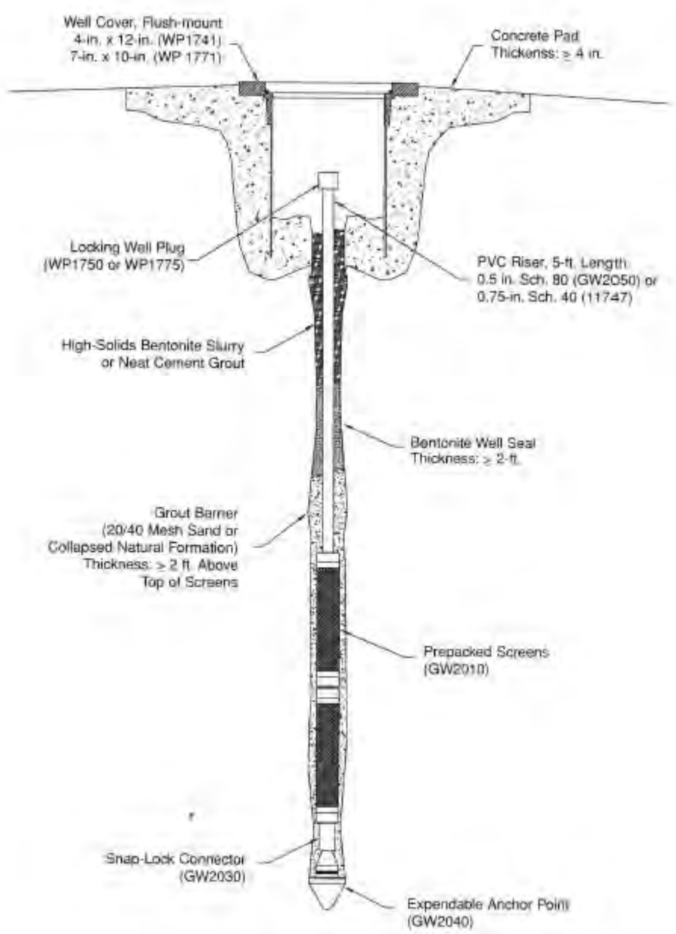


Figure 4.12:
A Properly Installed Geoprobe® Prepacked Screen Monitoring Well

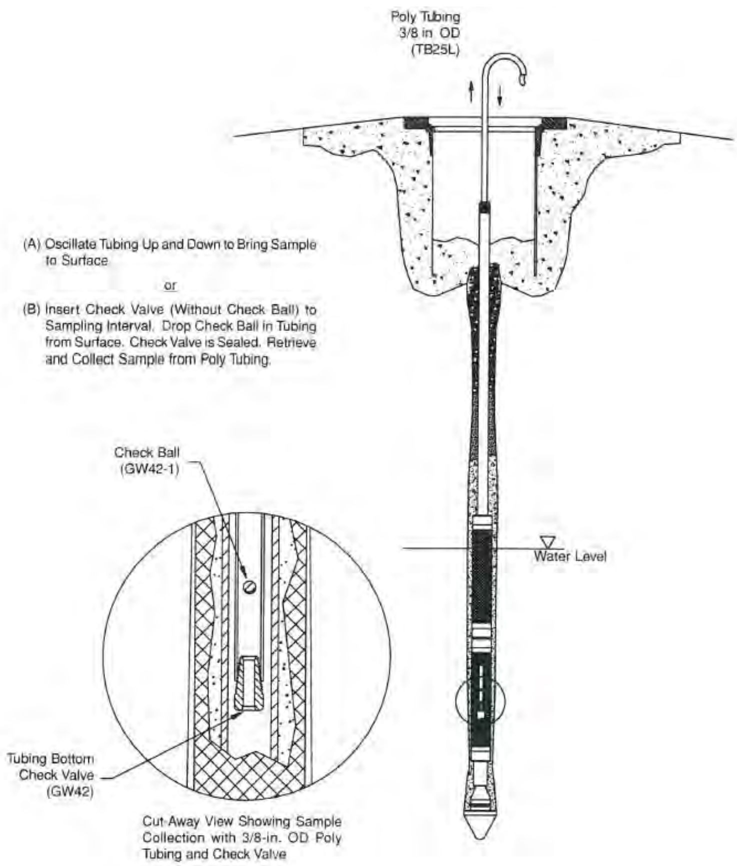


Figure 4.13:
Sampling with Polyethylene Tubing and a Tubing Bottom Check Valve

PURPOSE	To provide standard instructions for using a DH133 Automatic Drop Hammer to perform Standard Penetration Test (SPT).
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Assembling and Driving the Outer and Inner Rods	An outer casing is first driven through the undisturbed soil with the probe unit hammer assembly to reach the top of the testing intervals. Specific instructions are listed below. 1. Align the probe unit hammer assembly by pulling the hammer pin and swinging the hammer over to the identified/applicable location. 2. Thread the SPT cutting shoe to the leading end of a heavy-weight outer probe rod (3.25-in. ODx60-in. length). 3. Thread the SPT solid drive tip to the leading end of a heavy-weight inner rod (1.25-in ODx60-in length). 4. Insert the heavy-weight inner rod into the outer rod until the solid drive tip partially extends from the bottom of the cutting shoe. 5. Slip a threadless drive cap to the top of the heavy-weight inner rod. 6. Place a threadless drive cap on top of the heavy-weight outer rod. 7. Raise the probe unit hammer assembly to its highest position by fully extending the probe cylinder until it stops. 8. Position the assembled rods directly under the probe unit hammer assembly with the cutting shoe centered between the probe foot. The heavy-weight outer rod should now be parallel to the probe derrick. A magnetic level should be placed on the heavy-weight rod to check rod verticality. 9. Start the probe unit hammer assembly using both down feed and hammer levers to advance the assembled rods into the ground until reaching the desired testing depth below ground surface.

Using the DH133 Automatic Drop Hammer	Once the rod assembly has been driven into the ground to reach the top of the desired testing interval, the operator can start using the DH133 Automatic Drop Hammer (drop hammer). Step by step instructions are listed below. 1. Remove the threadless drive cap on top of the heavy-weight outer rod. 2. Remove the threadless inner rod drive cap. 3. Remove the heavy-weight inner rod and remove the solid drive tip. 4. Assemble split spoon sampler and thread it to the bottom of the heavy-weight inner rod. 5. Insert the heavy-weight inner rod and the split spoon string into the outer rod that was previous driven into the ground. Add inner rod as necessary until the split spoon sampler is resting on bottom. 6. Using a marker, mark the desired testing intervals (typically 6', 12", 18" and 24") on the heavy-weight inner rod. 7. Unlatch and swing the Geoprobe® hammer directly above the heavy-weight inner rod. 8. Activate the drop hammer on by using the axillary hydraulic switch to advance the heavy-weight inner rod and split spoon into the ground until reaching the desired testing depth. The operator will count and record the number of blow counts that is takes to reach each testing interval previously marked on the heavy-weight inner rod. If the blow count reaches 50 and the full 6-inch interval has not been sampled, it will be called refusal and the hammer will be stopped. 9. Reposition the Geoprobe® hammer by the swing function. Adjust Geoprobe ® so the probe unit hammer assembly is directly above the heavy-weight inner rod. Using the probe machine and a threaded pull cap, pull up the heavy-weight inner rod and split spoon. The outer rod remains in the ground. 10. Remove the split spoon from the heavy-weight inner rod. Disassemble the split spoon sampler by removing the cutting shoe and adapter pin from either end of the split spoon. Open the split spoon and collect the soil sample. Then, decontaminate the split spoon components as necessary, assemble the two halves of the sample tube, and thread the cutting shoe

back onto the leading end of the split spoon and the adapter pin onto the opposite end.

11. Thread a solid drive tip onto the leading end of a heavy-weight inner rod and connect an additional heavy-weight inner rod to other end of the rod.

12. Place the threadless drive cap onto the top of the heavy-weight inner rod tool string.

13. Insert the assembled heavy-weight inner rod tool string into the 3.25" outer rod that was previously driven into the ground.

14. Using the overhead winch, raise a heavy-weight outer rod and feed it over the protruding heavy-weight inner rods. Thread the heavy-weight outer rod onto the outer rod that was previously driven into the ground.

15. Place a threadless drive cap on top of the heavy-weight outer rod tool string.

16. Using the probe unit hammer assembly, drive the assembled rods into the ground to the top of the next SPT sample interval.

17. Remove the threadless drive cap from the heavy-weight outer rods and the threaded drive cap from the heavy-weight inner rods.

18. Thread a loop pull cap onto the tool string of heavy-weight inner rods.

19. Connect the overhead winch to the loop pull cap and remove the heavy-weight inner rod tool string.

20. Remove the solid drive tip from the heavy-weight inner rods and thread a split spoon sampler onto the assembled heavy-weight inner rods.

21. Replace the loop pull cap on the heavy-weight inner rods with a threaded drive cap.

22. Insert the assembled heavy-weight inner rod tool string into the 3.25" outer rod that was previously driven into the ground until it rests on bottom. Once on bottom, mark the inner rod string for the proper SPT intervals

23. Reposition the Geoprobe® so the drop hammer is directly above the heavy-weight inner rods.

24. Activate the drop hammer on to drive the tool string of heavy-weight inner rods and split spoon into the ground until reaching the desired testing depth. The operator will count the number of blow counts that is takes to reach each testing interval marked on the heavy-weight inner rod.

Repeat steps 9 to 24 until reaching the end of the testing depth.

	Note: as the assembled rods get longer and heavier, use the probe machine, the overhead winch, and/or the adjustable rod clamp to facilitate the process of placing and retrieving rods.
Outer Casing Retrieval	The outer casing may be retrieved in two ways: 1. Entire casing string removed from the ground and remaining probe hole sealed from ground surface with granular bentonite. The outer casing may be pulled from the ground with the probe machine and a pull cap, if the probe hole is to be sealed with granular bentonite from the ground surface. This method is used for shallow probe holes in stable formations only. Such conditions allow the entire probe hole to be sealed with granular bentonite. 2. Casing pulled with probe hole sealed from bottom-up during retrieval. Bottom-up grouting should be performed during casing retrieval in unstable formations where side slough is probable. Such conditions create void spaces in the probe hole if granular bentonite is installed from the ground surface.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Contact with impacted soils and water.	Impacted sites, during sample collection and handling.	Adverse health effects could result from ingesting, inhaling, and/or skin/eye contact with impacted soils and water.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves when collecting and handling samples. Employees will wear work gloves when handling probe rods. Work will be suspended during high wind conditions that produce large amounts of visible impacted dust.
	Hydraulic fluid and diesel.	Geoprobe®.	Employees could be exposed to hydraulic fluid and/or diesel via inhalation, ingestion, and skin/eye contact, when operating the Geoprobe®, or if equipment malfunctions resulting in adverse health effects.	Employees will wear work gloves and eye protection, if contact with hydraulic fluid/diesel is possible. In the event of a spill/leak, personnel will contain the fluid using the spill cleanup material available in the Geoprobe® trailer. Cleanup materials will be disposed of according to the appropriate regulations. All components of the rig will be inspected prior to and at the completion of the task. Non-essential personnel will maintain a 20-foot buffer zone around the equipment.
	Lubricating grease.	Probing location.	Employees could be exposed to lubricating grease via ingestion and skin/eye contact when assembling probe rods resulting in adverse health effects.	Employees will wear work gloves and eye protection when assembling probe rods.

NOISE	Elevated noise levels.	Geoprobe®.	Employees could be exposed to elevated noise levels when operating the Geoprobe® resulting in irritability, decreased concentration, and noise-induced hearing loss.	Personnel within a 20-foot buffer zone of the Geoprobe® will wear single hearing protection (e.g. earmuffs or earplugs). Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
ELECTRICAL	Defective electrical lines.	Geoprobe®.	Contact with defective electrical lines could result in personal injury.	Inspect electrical lines of the Geoprobe® prior to and at the completion of the task.
	Contact with overhead utilities.	Probing location.	Injury, death, or property damage could occur from contact with overhead utilities when the hammer assembly is raised to its highest position.	If overhead hazards are present, established overhead utility procedures will be followed. Probe locations will be moved to avoid working around overhead utilities. Employees will maintain the required minimal radial clearance distances based on voltage when working around overhead lines.
	Contact with underground utilities.	Probing location.	Injury, death or property damage could occur from contact with underground utilities when geoprobing.	Prior to starting work, employees will call for a utility locate (i.e., call 811). If underground utilities are present, established underground utility procedures will be followed. Probe locations will be moved to avoid working around underground utilities.
BODY MECHANICS	Lifting and moving rods.	Probing location.	Employees could be exposed to back or muscle strains or sprains when lifting or connecting the Geoprobe® rods.	Employees will follow good lifting techniques including lifting with the legs and not the back, get a good grip, and keep the load close to your body. Two employees will lift the rods if necessary.

GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Employees will plan their path and walk cautiously. Keep work area free of tools/rods. If conditions are wet/muddy, muck boots may be worn. Site can be cleared of snow, if applicable.
	Falling rods.	Probing location.	Heavy rods could slip off of worker's hands while carrying and assembling tool strings causing personal injury.	Employees will use work gloves when assembling and handling rods. Two workers will carry rods, if necessary. All personnel will wear steel-toe boots.
WEATHER	Cold/heat stress	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g. layers). Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms. When the Geoprobe® is running, the Geoprobe helper will watch/listen for lightning and thunder.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.

BIOLOGICAL	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies should notify their supervisor.
MECHANICAL	Geoprobe® shifting.	Probing location, when using the drop hammer and working on a sloped surface.	Personal injury and equipment damage could occur if the Geoprobe® shifts while using the drop hammer and when working on a sloped surface.	When using the drop hammer, do not raise the machine foot more than approximately 6 inches off the ground or the vehicle may become unstable and shift. When working on a sloped surface, position the rig so that it is facing upslope. In the event that the probe unit loses stability, it will roll away from the operator without causing injury.
	Struck by the Geoprobe®/drop hammer.	Operating the Geoprobe®/ drop hammer.	Personnel could be injured if struck by the Geoprobe®/drop hammer.	Non-essential personnel will maintain a 20-foot buffer zone around the rig.
	Improper body mechanics.	Assembling, handling, and retrieving	Improper lifting, bending, squatting, and	Personnel will use proper lifting techniques – get a good grip, keep the load close to the

		rods/sample tubes.	kneeling could result in muscle/back strains or other injuries.	body, lift with legs and not with back, and avoid lifting loads above shoulder height. Two people will lift, if necessary. Employees will also use good body mechanics when retrieving rods/sample tubes: bend knees, lean slightly away from the object, keep back and wrists straight, use legs to move the objects. Employees should stretch prior to starting work and they will take breaks when necessary.
	Back injuries.	Moving the drop hammer with hand dolly.	Back injuries and muscle/back strains could result when using the hand dolly to move the drop hammer.	Employees will inspect the hand dolly (including all wheels) before using it. Two employees will load the drop hammer on the hand dolly. Workers will use proper body mechanics when loading the drop hammer. Employees will make sure the weight is evenly distributed on all wheels of the hand dolly. Employees will always push a hand dolly to move the load, instead of pulling the hand dolly. Personnel will use a belt to keep the drop hammer from shifting or slipping.
	Contact with rotating and moving parts of the drop hammer.	When the drop hammer is in motion.	Fingers/hands could become pinched or caught in moving/rotating parts of the drop hammer resulting in cuts, scrapes, and/or broken bones.	Employees will not touch moving/rotating parts of the drop hammer. Work gloves are required when operating the drop hammer. Operators will stand to the control side of the machine, clear of the probe foot and drop hammer, while operating the

				controls. Personnel will never reach across the probe assembly to manipulate the machine controls. All employees on site will be familiar with the basic controls of the machine including the Emergency Kill switch button.
	Pinch points.	When mounting the drop hammer, while the drop hammer is in motion, assembling probe rods, and extracting probe rods.	Employees could be exposed to hand injuries such as lacerations, punctures, cuts, and pinched fingers.	Employees will always wear work gloves. Employees will never place their hands-on top of the tool string while raising or lowering the drop hammer.
	Flying debris.	Probing location.	Eye injuries could result from flying debris when driving tool strings into the ground with the drop hammer.	Employees will wear safety glasses at all times during Geoprobe® operations.
PRESSURE	Pressurized hydraulic lines.	Geoprobe®.	Faulty pressurized hydraulic lines could burst resulting in personal injury/exposure and hydraulic fluid release.	All components of the rig will be inspected prior to and at the completion of the task.
THERMAL	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will

			heat cramps, heat exhaustion, or heat stroke.	follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
HUMAN FACTORS	Inexperience and improperly trained worker.	Sites.	Inexperience workers and improper training could cause incidents resulting in personal injuries and/or property damage.	Employees will be properly trained int his procedure and other applicable procedures. When starting/stopping for the first time, an experienced operator should be on site to help coach the process. All employees operating the Geoprobe® will be familiar with the basic controls of the machine including the Emergency kill switch button. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Level D PPE, earplugs, and earmuffs.
APPLICABLE SDS	SDSs will be maintained based on-site characterization and contaminants. Hydraulic fluid, diesel, lubricating grease.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	DH133 automatic drop hammer: hitch mounted basket, counterweights, hand dolly, pipe wrench, safety pin, machine vise, work table, and deionized water.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

Revisions:

Revision	Description	Date
1	Updates to SOP to reflect Geoprobe ® Model 7822DT	11/16/2020

PURPOSE	To provide standard instructions for equipment decontamination (inorganic contaminants – heavy metals).
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.
NOTES	All equipment leaving the contaminated area of a site must be decontaminated. Decontamination methods include removal of contaminants through physical, chemical, or a combination of both methods. Decontamination procedures are to be performed in the same level of protection used in the contaminated area of a site. In some cases, decontamination personnel may be sufficiently protected by wearing one level lower protection. The information for site specific equipment decontamination and personnel protection levels, as detailed in the Sampling and Analysis Plan (SAP) or work plan, should be followed. The following decontamination procedures are for typical uncontrolled hazardous waste sites. For a specific or unusual contaminant, such as dioxins, see the Site-Specific Health and Safety Plan (SSHASP) and consult with the Safety and Health Manager. Decontamination procedures should be used in conjunction with methods to prevent contamination of sampling and monitoring equipment. If practical, one-time-use equipment should be used, and disposed of in accordance with the SAP, work plan, and SSHASP.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Remove gross contamination.	Remove gross contamination with a tap water rinse. If available, use pressurized or gravity flow tap water. If not, a 5-gallon bucket of tap water and a stiff brush may be used.
Wash equipment.	Wash equipment in a solution of soap (no phosphate) and tap water with a stiff brush.
Triple rinse equipment.	Triple rinse the equipment with tap water. Then, rinse the equipment with de-ionized or distilled water.
Rinse equipment with nitric acid/distilled water mixture.	If specified in the SAP, work plan, or SSHASP, rinse the equipment with a mixture of 10:1 nitric acid in distilled water (10 parts water to 1-part nitric acid). In many cases, the tap water and de-ionized water rinses will be sufficient. If a nitric rinse is used, rinse the equipment again with distilled water.

Air dry equipment.	Place equipment on plastic sheeting or foil to air dry.
Transport/ store equipment.	Wrap equipment in foil or plastic wrap to transport or store.
Triple rinse decontamination equipment.	Triple rinse equipment (i.e., brushes, buckets, tubs, etc.) used in the decontamination process with water, preferably pressurized.
Wash decontamination equipment.	Agitate the equipment used in the decontamination process in the soap/tap water solution. (The tub which holds the solution will only have the water rinse)
Triple rinse decontamination equipment.	Triple rinse equipment with tap water.
Store and label decontamination equipment.	Place equipment in appropriate areas, so they are used only for decontamination purposes. Label the equipment, if necessary.
Dispose of decontamination solutions.	Use a wastewater container to properly dispose of the soap/tap water solution, the tap water rinse, and the de-ionized water rinse. Use an organic solvent waste container to properly dispose of the solvent rinse. When contaminants have been identified, either in the solutions or elsewhere on the site, solutions should be disposed of appropriately as discussed in the SAP, work plan, or SSHASP. If they are hazardous (e.g., characteristic, listed, etc.), dispose of them as such. **Note:** when using other than the above-mentioned solutions, check with the Safety and Health Manager and the Project Manager. Some solvents must be evaporated.
Measure effectiveness of procedures.	Effectiveness of the decontamination procedures will be measured using field equipment rinsate blanks (see the Site-Specific Quality Assurance Project Plan).

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated items and resulting water from decontamination procedures.	Sites.	Inadvertent exposure to contaminated items and water resulting from decontamination procedures could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will follow decontamination procedures as described above. Employees will wear nitrile gloves when handling contaminated items.
	Nitric acid.	Sites.	Employees could be exposed to nitric acid via ingestion and skin/eye contact when decontaminating equipment. Exposure could cause irritation of skin/eye and dental erosion.	Employees will prevent skin/eye contact with nitric acid and they will wear nitrile gloves and eye protection when handling nitric acid and the nitric acid and distilled water mixture.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift decontamination equipment.	Personnel will use proper lifting techniques – get a good grip, hold the load close to the body, lift with the legs and not with the back, and avoid lifting above shoulder height. Use two employees to lift equipment when necessary.
GRAVITY	Slips and falls.	Sites.	Slips and falls could occur while performing decontamination procedures due to slippery surfaces resulting in	Workers will wear work boots with good traction and ankle support. Keep work areas as dry as possible. Wear muck boots, as necessary.

HSSE CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

			bruises, scrapes, or broken bones.	
WEATHER	Cold/heat stress.	Outdoors.	Exposure to cold climates may result in cold burns, frostbite, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g. layers). Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoors.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear sunscreen, long-sleeve work shirts and long pants. Employees will also use safety glasses with tinted lenses.
BIOLOGICAL	Plants, insects, and animals.	Sites	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Struck by and/or caught in between heavy equipment or	Sites.	Personnel could be injured if struck by and/or caught in	When applicable, employees will communicate with the contact person of other contractors on the site.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

	vehicles.		between heavy equipment or vehicles while performing decontamination procedures.	Personnel will avoid working near heavy equipment/vehicles, when possible. High visibility clothing will be worn. When possible, personnel will park field vehicles or use traffic cones to prevent third party vehicles from coming into the work area.
PRESSURE	Not applicable.			
THERMAL	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day.
	Hypothermia/fros tbite.	Sites where air temperature is 35.6°F (2°C) or less.	Workers whose clothing becomes wet during decontamination procedures may be exposed to hypothermia and/or frostbite.	Employees will change clothing if it becomes wet.
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SIMOPS	Not applicable			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	SDSs will be maintained based on-site characterization and contaminants. Nitric acid.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	5-gallon bucket of tap water, stiff brush, soap, de-ionized or distilled water, nitric acid (if required), plastic sheeting or foil, tarps, decontamination tubs and buckets, and sprayers.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
SAFETY AND HEALTH MANAGER	**DATE**

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	

Revisions:

Revision	Description	Date
1	Updates to SOP to reflect Geoprobe ® Model 7822DT	11/16/2020

PURPOSE	To provide standard instructions for conducting depth to water level measurements.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Electric Depth to Water Indicator	
1. Inspect well casing.	Inspect well and casing for a marked measuring point. If no measuring point is marked, locate the north side of the well and establish a marking point. Choose the point for ease of accurately reading the measuring tape.
2. Test the water level indicator.	Test that the water level indicator is on and working by pushing the test button on the indicator and checking the buzzer sound level and/or checking for the light. Make sure the equipment is clean and decontaminated per SOP-DE-02 Equipment Decontamination.
3. Lower the sensor.	Lower the sensor probe slowly into the well to minimized disturbance of water when it is encountered. As the sensor is lowered down the well, the buzzer and/or flashing light will indicate contact with water. Be aware that sensor may indicate water prior to actual water level, if the probe contacts condensation on the well casing.
4. Align probe cable.	Once the buzzer has sounded, align the marked probe cable with the designated marking point and gently raise and lower the probe until the exact mark on the probe cable, when water is encountered, is identified.
5. Record information.	Record this information in the project logbook as the depth to water (DTW). In addition, record where the marking point was located (e.g., top of casing [TOC], top of PVC [TOPVC], inner PVC [IPVC]) to help maintain continuity, if subsequent DTW readings are needed from this well.
6. Reel in equipment.	Reel in sensor probe.

7. Decontaminate equipment.	Decontaminate all equipment prior to re-use per SOP-DE-02 Equipment Decontamination.
Chalked Measuring Tape Depth to Water Measurements	
1. Coat tape with chalk.	Make sure the equipment is clean and decontaminated per SOP-DE-02 Equipment Decontamination. Coat the lower three to five feet of tape with chalk and lower into well. Listen for weight to contact water and lower tape an additional 0.5 foot.
2. Record information.	Record measure point and pull tape carefully from well. Read the wetted chalk mark and record. Subtract the wetted chalk mark from the measure point for true depth to water.
3. Decontaminate equipment.	Decontaminate all equipment prior to re-use per SOP-DE-02 Equipment Decontamination.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated water.	Sites.	Inadvertent exposure to contaminated soils and water could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when collecting and handling samples.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During depth measurements.	Bending, squatting, and kneeling during depth measurements could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Workers will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible. Wear muck boots, as necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors. Employees will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.

	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Sites and well casings.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Scrapes and cuts.	Well casing.	Scrapes and cuts could result, when taking measurements, from sharp edges in metals or PVC casings.	Employees will inspect well casing for sharp edges. If edges are very sharp, employees will wear leather gloves.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.

SIMOPS	Struck by and/or caught in between heavy equipment or vehicles.	Sites.	Personnel could be injured if struck by and/or caught in between heavy equipment or vehicles while collecting samples.	Employees will communicate with the contractors on site. Personnel will avoid working near heavy equipment/vehicles, when possible. Personnel will wear high visibility clothing. When possible, personnel will park field vehicles or use traffic cones to prevent third party vehicles from coming into the work area.

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with well locations.
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-DE-02 Equipment Decontamination.
TOOLS	Water level indicator or measuring tape and chalk, and field logbook.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**12/03/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**12/03/2014**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for collecting subsurface soil samples.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.
DEFINITIONS	Subsurface Soil Sample: it is defined as a mineral soil sample collected from 6 inches to 25 feet below ground surface. The need for biased sampling of subsurface soils should be evaluated by considering factors such as the precipitation, the type of soil and the length of time the site has been contaminated. If precipitation has moved contaminants into lower soil horizons, subsurface sampling may be appropriate. Several techniques can be used to collect samples from 6 inches to four or five feet below ground surface (bgs). A shovel and pry bar can be used to collect samples from 6 inches to 2 feet bgs. A hand auger may be used to collect subsurface samples up to four or five feet in depth. Because the auger is twisted into the soil the soil's cohesive structure and stratigraphic character are destroyed. An in situ soil recovery auger may also be used to collect subsurface samples up to five feet. The auger accommodates a liner and provides fast cutting of the soil with very little soil disturbance. In particularly rocky or hard soils a back hoe may be needed to excavate even shallow test pits. It is important to evaluate site conditions prior to choosing a subsurface sampling method. Each method of sampling will be discussed below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SDS
will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Hang Dug Test Pits	
1. Coordinate utility locates.	Prior to site entry have a utility locate performed.
2. Locate sample site.	Locate the site as directed in the appropriate Sampling and Analysis Plan (SAP).
3. Conduct site walk.	Conduct a site walk through and determine any site-specific hazards associated with the sampling area. Discuss these with the sampling crew and note in the field logbook. During the site walk through note possible locations for underground utilities. For example, identify where natural gas pipes enter any structures on the property or if yard lights or street lights are present with no overhead lines. If sample locations have not been assigned in the SAP, note the probable locations of

	underground utilities and try to avoid those areas when choosing sample locations. If sample locations are identified in the SAP use the appropriate survey method to locate.
4. Dig test pit.	Dig a 6 to 12-inch square pit to the depth specified in the SAP plus an additional 3 to 4 inches.
5. Identify sample intervals.	Measure the interval to be sampled with a stainless steel tape measure or a ruler and mark the appropriate interval.
6. Prepare sample location.	Scrape the walls of the sample pit within the marked interval with a decontaminated stainless steel trowel or scoop, a Teflon scoop, or a disposable plastic scoop to expose a clean surface.
7. Collect samples.	Place a stainless steel bowl or a clean decontaminated disposable foil pan adjacent to or in the sample pit and collect the sample by scraping the appropriate interval on the cleaned face of the pit with the sampling tool. If more than one interval is to be collected from the hole, collect the bottom or deepest interval first. If sampling for volatile organic compounds, the soil must be placed directly into the sample container with no head space and placed into a cooler with ice immediately.
8. Remove unnecessary material from sample.	Remove all coarse fragments greater than 0.5 inches from the bowl. Mix the remaining material in the bowl with the sampling tool.
9. Transfer sample to sample container.	Transfer the soil sample directly into the appropriate sample container according to SOP-SA-01 Soil and Water Sample Packaging and Shipping. Store samples in a cooler at 4°C or less.
10. Document sample information.	Record appropriate information about the sample and collection in the field logbook.
11. Decontami-nate sampling tools.	Decontaminate sampling tools according to procedures outlined in SOP-DE-02 Equipment Decontamination.
Hand Auger Sampling	
1. Coordinate utility locates.	Prior to site entry have a utility locate performed.
2. Locate sample site.	Locate the site as directed in the appropriate Sampling and Analysis Plan (SAP).
3. Conduct site	Conduct a site walk through and determine any site-specific hazards associated with

walk.	the sampling area. Discuss with the sampling crew and note in the field logbook. During the site walk through note possible locations for underground utilities. For example identify where natural gas pipes enter any structures on the property or if yard lights or street lights are present with no overhead lines. If sample locations have not been assigned in the SAP, note the probable locations of underground utilities and try to avoid those areas when choosing sample locations. If sample locations are identified in the SAP use the appropriate survey method to locate. Note the locations of overhead lines and overhead hazards and avoid those areas if possible.
4. Auger sample hole.	Place a large piece of plastic adjacent to the sample location. Choose the appropriate auger head for the soil type at the sample site (i.e., sand, mud, normal). Measure the length of the auger head to determine the advancement depth for each full auger. Place the auger at the sample location and begin turning, when the head is full remove the auger from the hole and empty the head onto the plastic. Measure the hole depth to determine the number of auger heads needed to reach the sample interval. Keep auguring and emptying the soil onto the plastic sheet until the top of the sampling interval is reached. The soil can be placed on the sheet in the order of removal for a general soil profile.
5. Collect sample.	Place a stainless steel bowl or a clean decontaminated disposable foil pan near the sample pit (preferably on a clean portion of the plastic) and collect the sample by emptying the auger head into the bowl or pan. Continue auguring and emptying the auger head into the sampling container throughout the entire sampling interval. If sampling for volatile organic compounds, the soil must be placed directly into the sample container with no head space and placed into a cooler with ice immediately.
6. Remove unnecessary material from sample.	Remove all coarse fragments greater than 0.5 inches from the bowl. Mix the remaining material in the bowl with the sampling tool.
7. Transfer sample to sample container.	Transfer the soil sample directly into the appropriate sample container according to SOP-SA-01 Soil and Water Sample Packaging and Shipping. Store samples in a cooler at 4°C or less.
8. Document sample information.	Record appropriate information about the sample and collection in the field logbook.
9. Decontami-nate sample tools.	Decontaminate sampling tools according to procedures outlined in SOP-DE-02 Equipment Decontamination.

In-Situ Soil Recovery at Depths Greater than Five Feet A direct push soil recovery rig mounted on a truck or trailer is the most common method for the In-Situ Soil Recovery at Depths Greater than Five Feet and can be used to sample up to 75 feet or more in depth. There are also several types of hand augers with liner tubes that can be used for sampling up to 5 feet depending on soil type. The steps described in this section are for sampling from the liner tube.	
1. Coordinate utility locates.	Prior to site entry have a utility locate performed.
2. Locate sample site.	Locate the site as directed in the appropriate Sampling and Analysis Plan (SAP).
3. Conduct site walk.	Walk through the site and determine any site-specific hazards associated with the sampling area. Discuss these with the sampling crew and note in the field logbook. During the site walk through note possible locations for underground utilities, for example identify where natural gas pipes enter any structures on the property or if yard lights or street lights are present with no overhead lines. If sample locations have not been assigned in the SAP, note the probable locations of underground utilities and try to avoid those areas when choosing sample locations. If sample locations are identified in the SAP, use the appropriate survey method to locate.
4. Probing or augering the sample hole.	Actual augering or drilling of the sampling holes will be conducted following the subcontractor's SOPs and safety protocols.
5. Collect sample.	As the plastic, Teflon or stainless steel liner is removed from the drill rod, make sure that the "top" of the liner, which represents the upper intervals is identified. If entire liner is being submitted for analysis seal both ends and mark the liner with the appropriate sample number and information. Place in a cooler and store at 4°C or less. If individual sample containers need to be collected or a composite sample over several intervals is to be collected place the liner on a work surface (portable table or plastic tarp on the ground). Cut the liner tube along its length. Label the top and bottom of the liner with the appropriate depths, index cards or pieces of paper placed at the top and bottom are acceptable. Photograph the core. Measure the amount of material present in the liner and if specified in the site-specific sampling plan log the core.
6. Prepare sample.	Place a stainless steel bowl or a clean decontaminated disposable foil pan near the liner. Using a decontaminated stainless steel trowel or scoop, a Teflon scoop, or a disposable plastic scoop remove the appropriate interval from the liner and put it in the bowl/pan. If sampling for volatile organic compounds, place the soil directly into the appropriate sampling container, fill the container so that there is no head space, seal and place in a cooler with ice immediately. For all other analyses remove all coarse fragments greater than 0.5 inches from the bowl. Mix the remaining material in the bowl with the sampling tool.

7. Transfer sample to sample container.	Transfer the soil sample directly into the appropriate sample container according to SOP-SA-01 Soil and Water Sample Packaging and Shipping. Store samples in a cooler at 4°C or less.
8. Document sample information.	Record appropriate information about the sample and collection in the field logbook.
9. Decontami-nate sample tools.	Decontaminate sampling tools according to procedures outlined in SOP-DE-02 Equipment Decontamination.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils.	Sample collection sites.	Inadvertent exposure to contaminated soils could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating and when leaving the site. Work will be suspended during high wind conditions that may produce large amounts of visible dust. Personnel will wear nitrile gloves and safety glasses when sampling and handling soil.
NOISE	Elevated noise levels.	Mechanized probing rig.	Personnel collecting soil samples can be exposed to elevated noise levels from the mechanized probing rig resulting in hearing damage.	Personnel collecting soil samples will set up the sampling station 25 feet away from the rig. The rig operator or helper will bring the plastic liner to the sampling station.
ELECTRICAL	Contact with underground utilities. Contact with overhead utilities.	Testing sites. Testing sites.	Serious injury could result from contact with a live buried utility. Walking near low hanging overhead utilities and generators on site could result in electrocution, shock, and burn due to contact or flashover.	Established ground disturbance procedures, as outlined in the Pioneer Corporate HASP will be followed. Visually inspect the sample location/yard prior to accessing. If overhead hazards are present, established overhead utility procedures will be followed. When possible, employees will avoid areas with overhead hazards.
BODY MECHANICS	Bending, squatting and kneeling.	During sample collection.	Bending, squatting and kneeling during sample collection and handling could result in	Personnel should stretch prior to starting work and they will take breaks when necessary. Personnel will use a foam pad or knee pads, if necessary.

			muscle/back strains or other injuries. Kneeling on gravel can result in bruises and knee injuries.	
	Lifting and carrying tools, equipment, and/or samples.	Testing sites.	Improper lifting and carrying tools, equipment, and/or samples could result in back injuries and muscle/back strains.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two people will lift, if necessary.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick surfaces and steep slopes.	Workers could get injured if they fall causing bruises, scrapes, or broken bones.	Workers will wear work boots with good traction and ankle support. Workers will plan their path and walk cautiously. Access areas will be established, if necessary.
WEATHER	Cold/heat stress.	Sites.	Exposure to cold climates may result in cold burns, frostbites, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress. Personnel will wear appropriate clothing when working outdoors. Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Testing sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Employees will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors.	Employees could be exposed to UV radiation during summer months causing sun	Employees will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Employees should wear sunscreen, if necessary.

			burns, skin damage, and eye damage.	
BIOLOGICAL	Plants, insects, and animals.	Sites.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First-aid kits will be available on site. Employees with allergies will notify their supervisor.
MECHANICAL	Pinch points.	Test pits.	Employees could cut their fingers if debris (e.g., glass, steel) is present in test pits. Personal injury to the hands could occur when using sampling equipment/tools.	Employees will wear nitrile gloves when sampling and handling soil. Employees will wear leather gloves while using sampling tools.
	Struck by shovel or auger.	Carrying tools.	Personnel can strike other workers or objects when carrying shovels and augers to/from sampling stations resulting in bodily injuries and/or property damage.	Personnel will be aware of their surroundings and, if needed, use a spotter. When carrying tools, maintain a safe distance (e.g., 4 feet or more depending on side of tool) from other workers.
	Hand injuries.	Liner cutter.	Employees could be exposed to hand injuries such as lacerations, punctures, and cuts when using the liner cutter and handling the cut liner.	Employees will wear work gloves when using the liner cutter. Be cautious of sharp edges when handling plastic core liners after they have been cut open. Workers will be trained on how to properly use the liner cutter. Two employees will cut liners,

				if needed.
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
	Public entering the work area.	Sites.	Third party members of the public could enter the work area resulting in an unsafe work environment.	Stop work if members of the public enter the work area.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and leather gloves.
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/PROCEDURES/	SOP-SA-01 Soil and Water Sample Packaging and Shipping and SOP-DE-02 Equipment Decontamination.

WORK PLANS	
TOOLS	Sampling tools (e.g., shovel, breaker bar, ruler, hand auger, plastic sheeting, trowel, sample containers, liner cutter, bowls, and camera) and field logbook. Decontamination equipment and fluids.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**05/22/2015**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**05/22/2015**

Revisions:

Revision	Description	Date

PURPOSE	To provide standard instructions for sampling soil from a liner using a Geoprobe® unit.
SCOPE	Pioneer Technical Services, Inc. (Pioneer) prepared this practice for the workforce and this Standard Operating Procedure (SOP) applies to all work performed by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent (as defined by OSHA) in the risk-assessed procedure described below before performing the work.

WORK INSTRUCTIONS

The following instructions provide guidance to perform the task in a safe, accurate, and reliable manner. If these instructions present information that is inaccurate or unsafe, personnel must notify the Project Manager, Safety Manager, and the SOP Technical Author to initiate appropriate revisions. Personnel will perform all work under this SOP in a manner that is consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plans (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Preparation	
1. Check of liner materials.	Make sure that the liner used to contain the soil in the Geoprobe® probe rods is made of material compatible with the contaminants being analyzed.
2. Set up the sample and staging area.	Cover a folding table with plastic. The table should be at least as long as the liners to be sampled. A tailgate covered with plastic can also be used. If the only available surface is the ground, place several layers of plastic a couple of feet longer than the liners. Secure the layers of plastic so they do not blow around during sampling. In addition to the sampling area, a staging area for unsampled core needs to be designated. This area should also be covered with plastic to keep the liners clean before placement on the sampling area.
3. Mark the liners.	As the Geoprobe® operator removes core (liners) from the probe rods, mark with a waterproof marker the “top” and “bottom” of the liner as well as the interval that the liner represents. Cap the liner ends with vinyl or Teflon end caps. Move core to the staging area.
4. Record information provided by the operator.	If possible, confer with the Geoprobe® operator for any issues associated with probing each interval. Potential problems they may report: • A loss of material due to a rock blocking the tube. • A section that drilled extremely easy indicating material that was easily compressed such as clay or debris. • The presence of a potential void. • A problem with recovery due to saturated soil. • Heaving sands, which could result in overestimation of the width or depth of a layer due to re-coring of the same interval.

	• Recognition of slough into the hole prior to drilling the next interval. Record any information provided by the operator in the field logbook or on the field data sheet. This information can be referenced when logging the core.
Sampling of Soil for Inorganic Constituents	
1. Cut the plastic liner lengthwise.	The Geoprobe® operator and/or helper will cut the top portion of the plastic liner lengthwise. The opening along the top should be at least 2 inches wide. Care should be taken when handling and working around the cut liner as the cut edges are sharp.
2. Place the liner on the prepared sampling surface.	Place the liner on the prepared sampling surface and take the cut portion off. The portion of the liner marked "top" should be placed in the same direction on the sample surface each time. Place the index cards marked "top" and "bottom" on the appropriate ends of the liner. Place an extended tape measure adjacent to the liner. Index cards marked with appropriate intervals can also be used. Take a picture of the exposed soil. Do not move the tape measure or core after the photo. If the core does not need to be photographed, and it is **NOT** being analyzed for organics, mark the liner at the appropriate foot intervals with a Sharpie®.
3. Measure and record material in the core.	Measure and record the number of inches of material in the core, this will be recorded in the field logbook or on the field data sheet as "length recovered" (e.g., 36 inches from a 4-foot push or 18 inches from a 2-foot push). This measurement should not include any material that appears to have sloughed from an upper interval (i.e., leaves or topsoil present at the top of deeper subsurface cores). Record this information in the field logbook or on a field data sheet as specified in the Sampling and Analysis Plan (SAP). Evaluate the recovery of the core based on the operator's comments. The preferred method is to determine the amount of material that represents 1 foot of the profile. For example, 36 inches of recovered soil from a 4-foot probe may indicate 9 inches were recovered per foot. An alternate method for determining interval depth is to assume that the 36 inches represents 36 inches from either the top or bottom of the probed interval and that there was no recovery for 4 inches of the interval. These are not precise ways to determine how far below ground surface a soil horizon lies, as different soil types and moisture levels will compress or expand differently when pushed with the probe. There is no way to determine where or whether compression / expansion in the soil profile occurred. Choose one of the methods and be consistent throughout the project. Another scenario that may occur is if the operator indicates an obstruction was encountered that may have blocked soil from entering the liner at the 2-foot interval in a probe. If there is only 24 inches of soil and a large rock present in the liner, this may represent only the 0-2 foot interval in that core and should be recorded that way in the field logbook or on the field data sheet along with the operator's comment.

4. Log the core.	Examine and log the material in the liner. Check the project specific documents for the amount of detail or type of information required from the core log. Pioneer has developed several different field data sheets to aid in collecting the correct information during core logging. Keep in mind that due to smearing of soil during probing, a coating of wet or fine material may be present on the outside of the soil core. Using a gloved finger, make indentations down the core noting differences in texture, color, staining, or odor; to avoid cross contamination, change fingers as you make indentations. Record this information in the field logbook or on the field data sheet.
5. Determine sample intervals.	Determine sample intervals as described in the SAP or Work Plan (WP). If the material is **NOT** being sampled for organics, the sample intervals can be marked on the liner using a Sharpie®. An alternate method would be to separate the sample intervals so that a gap exists between the intervals. This makes it easier to get the appropriate intervals in the sample if the tape measure is moved during sampling activities.
6. Collect soil samples.	Slide the tube to the end of the table or sampling surface. Using a new plastic disposable scoop, slide the appropriate marked sample interval into a new disposable foil pan, stainless steel bowl, or resealable plastic bag. Alternately, instead of a scoop you can use a gloved finger or a clean screwdriver. A screwdriver is particularly helpful if portions of the soil are hardpacked or compressed. Mix the material in the pan/bowl thoroughly and remove rock and debris greater than 0.5 inches. If more material is required to fill sample containers, a second hole can be probed immediately adjacent to the first and material from the second liner from the same interval can be added to the pan/bowl and mixed. Repeat this process for all intervals to be sampled. Decontaminated bowls and screwdrivers and new foil pans, new resealable plastic bags, and new disposable scoops should be used for each interval sampled. Be aware of the potential for cross contamination and if needed change gloves between intervals.
7. Put samples in containers.	Prepare the appropriate sample containers with a label as described in the SAP or the Quality Assurance Project Plan. Fill the sample containers with homogenized material from the pan/bowl using the associated sampling tool. After sampling, place the samples in a cooler with ice until they can be transported to the laboratory for analysis as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.
8. Record sampling information.	Record appropriate information about the sample collection (sample number and associated depth interval, time, date, sample containers, etc.) in the field logbook as discussed in SOP-SA-05 Project Documentation. Record additional information such as soil type and rock content if required by the SAP/WP.

9. Store or dispose of remaining core	Disposal or storage information should be available in the project-specific SAP/WP. In most cases, soil can be returned to the drill hole from which it came. If the information is not available in the SAP, discuss disposal requirements with the project manager.
Sampling of Soil for Organic Constituents	
1. Preparation prior to screening for volatile organic vapors in drill or Geoprobe® drill core.	**Photoionization detector (PID) meter readings are taken immediately upon opening the core, prior to any other sampling or logging activities. Soil samples can show significant losses in volatile organic compound (VOC) concentrations within only seconds of opening soil cores.** If measurements using an organic vapor detector, PID, are required, please refer to SOP-FM-01 Field Headspace Analysis and VOC Measurements with PID for information on calibrating and using a PID for headspace analysis and VOC measurements.
2. Place caps on the end of the core tubes.	Ensure that the Geoprobe® operator and/or helper place caps on the end of the core tubes immediately after removing the liner from the probe rod so that no VOCs escape prior to cutting open the core. Store capped core in the shade or on ice to avoid additional volatilization of VOCs. **Do not** have the operator/helper cut the tubes until just before core will be sampled.
3. Prepare the sample containers.	Based on information provided in the SAP/WP, prepare and label the appropriate sample containers. If samples are required, sample intervals may have been assigned in the SAP/WP, or samples may be collected based on PID or headspace readings or the presence of odor or staining. The sampler needs to understand sample collection protocol prior to opening the core liner. This is particularly important in collecting samples for VOC, volatile petroleum hydrocarbon (VPH), and/or extractable petroleum hydrocarbon [EPH] analysis. Ensure required sampling supplies are close at hand prior to opening core.
4. Cut the plastic liner lengthwise.	Have the Geoprobe® operator and/or helper cut the top portion of the plastic liner lengthwise. The opening should be at least 2 inches wide. **DO NOT REMOVE THE CUT PORTION OF THE LINER**. Care should be taken when handling and working around the cut liner as the cut edges are sharp.
5. Place the liner on the prepared sampling surface.	Place the liner on the prepared sampling surface. **Do not** remove the cut portion. Place the portion of the liner marked "top" in the same direction on the sample surface each time. Place the index cards marked "top" and "bottom" on the appropriate ends of the liner. Place an extended tape measure adjacent to the liner. Index cards marked with appropriate intervals can also be used.

6. Measure and record material in the core.	**Prior** to removing the cut portion of the liner, measure and record the number of inches of material in the core. See discussion in Step 3 of Sampling of Soil for Inorganic Constituents to determine how depth of sample intervals will be determined.
7. Take a picture of the exposed soil.	Remove the cut portion of the liner. Quickly take a picture of the exposed soil. Do not move the tape measure or core after the photo.
8. Conduct PID readings if required.	**The VOC and VPH samples need to be collected as quickly as possible after opening the tube.** If specified in the SAP/WP, use a PID to take readings of the length of the core, refer to SOP-FM-01 Field Headspace Analysis and VOC Measurements with PID for information on calibrating and using a PID for headspace analysis and VOC measurements.
9. Collect soil samples for VOC / VPH / EPH.	Collect the required VOC, VPH, or EPH samples directly from the tube using a plastic disposable scoop, gloved hand, or screwdriver. After VOC, VPH, and EPH samples are collected from all tubes/cores, collect inorganic (metals) samples if needed. The tape measure can be used to identify the intervals. Gaps from removed sample material should be left so that logging of the remaining core material can be completed. Place the soil directly into the sample container and fill the jar to the top allowing no head space (or as the laboratory directs). Be aware of the potential for cross contamination and if needed change gloves between intervals. New disposable scoops and a clean screwdriver should also be used for each sample interval. Immediately place the sample containers in a cooler with ice. Keep samples at 4 degrees Celsius (ºC) or less and under chain of custody protocols until they can be transported to the laboratory for analysis as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.
10. Record PID readings and VOC sample information in Logbook.	If PID screening is conducted, record results of the screening in the field documentation (project logbook or field data sheets) and include the highest reading from each interval, the actual location in the core (i.e., 10 inches from the bottom), and the calculated interval depth. Record the sample information for the VOC, VPH, or EPH samples in the logbook and include time, date, and type of containers collected.
11. Continue sampling cores for VOCs.	Once the VOC samples have been collected from a section of core, replace the end caps and put the cut portion of the liner back on the core. The core can then be moved back to the staging area so that the next section of core can be screened and sampled for VOCs as quickly as possible. Process all available core for VOC samples prior to collecting inorganic samples or logging the core.
12. Log the core.	Once all the VOC samples have been collected. Logging the core can begin. Move a piece of core to the sample table and remove the cut portion of the liner, *being careful to keep it horizontal so as not to shift "gap" areas*. Realign the tape measure with the bottom and top of the tube. Examine and log the material in the liner. Check the project-specific documents for the amount of detail or type of information required regarding the core log. Pioneer has developed several different field data sheets to aid

	in collecting the correct information during core logging. If the initial measurement of the length of core (Step 6 above) included slough, adjust the information on the field data sheet or logbook to reflect the actual length of core. Include information on material removed for VOC samples, as determined during sampling. Keep in mind that due to smearing of soil during probing, a coating of wet or fine material may be present on the outside of the soil core. Using a gloved finger, make indentations down the core and record the information in the field logbook or on the field data sheet; to avoid cross contamination, change fingers as you make indentations.
13. Prepare soil samples for additional analytes.	Sample intervals that are not going to be submitted for VOC, VPH, or EPH analysis can be sampled once logging of the core is completed. Ensure that all information from logging the core is recorded in the field logbook or on the field data sheet. Determine the intervals to be sampled for additional analytes. Separate the sample intervals for the inorganic samples, so that a gap is present between the intervals. This makes it easier to get the appropriate sections into the sample if the tape measure or core is moved. Record sample information and include interval sampled and associated sample number in the field logbook or on the field data sheet.
14. Collect soil samples.	Slide the tube to the end of the table or sampling surface. Using a new plastic disposable scoop, slide the appropriate marked sample interval into a new disposable foil pan or stainless steel bowl. Alternately, instead of a scoop you can use a gloved finger or a clean screwdriver. The screwdriver is particularly helpful if portions of the soil are hardpacked or compressed. Mix the material in the pan/bowl thoroughly and remove rock and debris greater than 0.5 inches. If more material is required to fill sample containers, a second hole can be probed immediately adjacent to the first and material from the second liner from the same interval can be added to the pan/bowl and mixed. Fill the sample containers with the homogenized materials from the pan/bowl using the associated sampling tool. Repeat this process for all intervals to be sampled. Be aware of the potential for cross contamination and if needed change gloves, screwdriver, or scoops between intervals.
15. Label the sample containers and store them in a cooler.	Make sure all sample containers are labeled correctly. These sample containers should also be placed in a cooler with ice (if required). Samples should be kept at 4 ºC or less (if required by the analytical method) and under chain of custody protocols until transport to the laboratory as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.

16. Record sampling information.	Record appropriate information about the sample collection (sample number and associated depth interval, time, date, sample containers, etc.) in the field logbook as discussed in SOP-SA-05 Project Documentation. Record additional information such as soil type and rock content if required by the SAP/WP.
17. Store or dispose of remaining core.	Disposal or storage information should be available in the project-specific SAP/WP. Soil with potential organic contamination will need to be contained for testing and potential landfarm treatment or disposal at an approved facility. If the information is not available in the SAP, discuss disposal requirements with the project manager. Removed soil may also be returned to the drill hole from which it came.
Decontamination of Equipment following both Organic or Inorganic Sampling	
1. Clean the plastic placed over the sample area.	Between each core, sweep or wipe down the plastic using paper towels wetted with deionized water (DI). If a particularly muddy core was sampled, the plastic may need to be replaced or a new piece placed over the sample area.
2. Decontaminate equipment.	Decontaminate the cutting tool, tape measure, and screwdrivers using paper towels wetted with a Liquinox/water mixture and the DI water spray bottle to rinse. If sampling for organics, use paper towels wetted with methanol for a final wipe down. If stainless steel bowls, spoons, and trowels were used, please follow instructions in SOP-DE-02 Equipment Decontamination.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soil and groundwater.	Sites.	Inadvertent exposure to contaminated soil and groundwater could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when contact with soil and groundwater is possible. Sampling will be conducted outdoors or in a trailer with open doors.
	Exposure to hydraulic fluids.	Geoprobe® operations.	Exposure to hydraulic fluids could occur while working around the Geoprobe® due to equipment malfunction/ failure resulting in personal injuries.	The operator will inspect the Geoprobe® and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids. Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
	Liquinox.	Equipment decontamination.	Personnel could be exposed to Liquinox via ingestion and skin/eye contact when decontaminating the equipment resulting in adverse health effects.	Personnel will wear nitrile gloves and eye protection when decontaminating the equipment.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
	Methanol.	Equipment decontamination.	Personnel could be exposed to methanol via skin/eye contact and ingestion/ inhalation when decontaminating equipment. Exposure could cause irritation of skin/eye. Adverse health effects can also result if methanol is ingested and/or inhaled. Direct contact with methanol during winter months can result in skin discomfort due to rapid evaporative cooling.	Personnel will prevent skin/eye contact with methanol and they will wear nitrile gloves and safety glasses when handling methanol. Personnel will use methanol in well-ventilated areas. Personnel will also practice proper personal hygiene – wash hands prior to eating/drinking, after decontamination procedures, and when leaving the site. During winter months, personnel will wear a pair of liner gloves underneath nitrile gloves.
NOISE	Elevated noise levels.	Geoprobe® operations.	Personnel could be exposed to elevated noise levels when working near the Geoprobe® operations resulting in hearing damage.	Personnel will wear hearing protection (e.g., ear plugs) when working near the Geoprobe®. Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®, when possible. Hearing protection will be administered and used in accordance with the policies and procedures outlined in the Pioneer Corporate HASP.
ELECTRICAL	Not applicable.			

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
BODY MECHANICS	Bending, squatting, and kneeling.	During fieldwork activities.	Bending, squatting, and kneeling during fieldwork activities could result in muscle / back strains or other injuries.	Personnel should stretch prior to starting work and they will take breaks when necessary.
	Improper lifting / handling of heavy items.	During field work activities.	Back injuries and muscle/back strains could result when using improper techniques to lift/carry heavy coolers and containers with core pieces.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/handle heavy items as needed.
	Flying debris.	Geoprobe® operations.	Eye injuries could result from flying debris when working around Geoprobe® operations.	Personnel will wear safety glasses when working around Geoprobe® operations. Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe® when possible.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces, and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. They will plan their path, walk cautiously, and keep work areas as dry as possible. Personnel will wear muck boots as necessary.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
WEATHER	Cold/heat stress.	Outdoor sites.	Exposure to cold climates may result in cold burns, frostbite, and hypothermia. Exposure to high temperatures may result in heat cramps, heat exhaustion, or heat stroke.	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g., layers and loose clothing). Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in the applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Personnel will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors sites.	Personnel could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Personnel will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Personnel should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First aid kits will be available in company vehicles. Personnel with allergies will notify their supervisor.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
MECHANICAL	Sharp edges and cutting tool.	Plastic liners and cutting tool.	Personal injury could result while cutting the plastic liners open to collect the soil samples. The plastic liners could also have sharp edges after they are cut. Cuts and scrapes could result from direct contact with sharp edges.	Personnel will use a specialized tool to cut the plastic liners and they will wear work gloves to prevent hand injuries. Personnel will use a tray and clamp to hold the plastic liner in place and keep it from moving around. Personnel will be aware of hand placement to prevent exposure to sharp edges and cutting tool.
PRESSURE	Pressurized hydraulic hoses.	Geoprobe®.	Hydraulic hoses could burst/rupture resulting in inadvertent contact with hydraulic fluid or personal injury due to being struck by hoses.	The operator will inspect the Geoprobe® and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids. Non-essential personnel will maintain a 20-foot buffer zone around the Geoprobe®.
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained personnel.	Sites.	Inexperienced personnel and improper training could cause incidents resulting in adverse health effects and/or property damage.	Personnel will be properly trained in the procedure described above and other applicable procedures. Personnel will follow the stop work policy if there are any issues.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
SIMOPS (Simultaneous Operations)	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	**Personal Protection Equipment** (PPE): Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and leather gloves.
APPLICABLE SDSs	**Safety Data Sheets** (SDSs) will be maintained based on the site characterization and contaminants. Safety Data Sheets are available to Pioneer personnel at the link below: https://pioneertechnicalservices.sharepoint.com/Safety/SafetyDataSheets
REQUIRED PERMITS/ FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/ PROCEDURES/ WORK PLANS	SOP-FM-01 Field Headspace Analysis and VOC Measurements with PID, SOP-SA-01 Soil and Water Sample Packaging and Shipping, SOP-DE-02 Equipment Decontamination (Inorganic Contaminants), and SOP-SA-05 Project Documentation.
TOOLS/ EQUIPMENT	Sample area – plastic sheeting, folding table (1 or 2), tape to secure plastic, tape measure, index cards to indicate top and bottom, camera, PID (if required), plastic disposable scoops or stainless steel spoons or spatulas, screwdrivers, filled DI water spray bottle, filled Liquinox/water spray bottle, methanol, paper towels, foil disposable pans or stainless steel bowls, sample containers, cooler, ice, dual blade cutter, and liner holders.
FORMS/ CHECKLIST	Field logbook and field data sheets.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
[signature] **Julie Flammang**	**09/25/2020**
SAFETY AND HEALTH MANAGER	**DATE**
[signature] **Tara Schleeman**	**09/25/2020**

PURPOSE	To provide standard instructions for sampling soil cores generated during sonic drilling.
SCOPE	This practice is for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.
DISCUSSION	Sonic drilling is accomplished by maintaining resonance of the drill string using an oscillator (the sonic drill head). As the resonance occurs, the soils immediately adjacent to the tooling are loosened and can move freely. Sonic drilling is particularly effective in areas where conventional drilling techniques might have problems, such as the presence of abundant cobbles or boulders, extremely dense till or cemented sands and gravels. The steps to soil sampling using a sonic drill rig are as follows: 1. Sonically advance a core barrel into undisturbed soils. Runs are typically 10 feet, but longer or shorter runs are also possible. 2. Sonically override the core barrel with casing to the same depth. 3. Remove the core barrel to the surface and extrude the sample into a plastic sleeve in short sections for easy handling.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work performed under this Standard Operating Procedure (SOP) will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Preparation	
1. Set up the sample area.	Designate an area near the drill rig that can be used for sampling and logging of core. The location should be out of the way of the drillers, but close enough to facilitate movement of the core to the area. Lay out sheets of plastic (visqueen) that are at least 15 feet long for 10 foot runs of core. Enough plastic should be laid out that all the core from the drill hole can be accommodated. The plastic sleeves containing the core need to be laid out with space to access them (walkways) for sampling and logging.
2. Determine the length of the cores.	Discuss with the drilling crew the length of core they will be providing in each plastic sleeve. In most cases, this will be about 10 feet. If Volatile Organic Compounds (VOC)/Volatile Petroleum Hydrocarbon (VPH) or other air sensitive analytes are being considered, a shorter length of core (e.g., 2 feet) might be appropriate for the best results.

3. Mark the core.	As the drilling crew brings the plastic sleeve containing core to the sampling area, they should identify the top of the interval and place it on the liner in the appropriate location to keep the core in order from top to bottom.
4. Record information provided by the operator.	If possible, confer with the Sonic Drill operator for any issues associated with coring each interval. For example, was there a loss of material due to a rock blocking the tube, was there a section that drilled extremely easy and may indicate material that was easily compressed or perhaps the presence of a void, was there a problem with recovery due to saturated soils, etc. Record any information provided by the operator in the field logbook or on a field data sheet. This information can be referenced when logging the core.
Sampling of Soils for Inorganic Constituents	
1. Slice the plastic along the top.	Using a utility knife or something similar slice the plastic along the top. Be aware that if the soil is saturated it may flow out of the plastic. In addition, water from saturated core may need to be "blocked" from flowing onto other sections of core. Place index cards or some other marker at intervals along the core. If possible, (plastic is not wet), intervals can be marked on the plastic. Place a reel tape measure along the core, so it can be easily referenced but out of the way.
2. Split the core and take pictures of the core.	If the core is cohesive, split the core lengthwise into two subsamples using a new disposable plastic spatula and/or stainless-steel blade. Photograph the complete length of the core in 2-foot segments from directly overhead using parallel camera movement and a high-resolution setting. These photographs can be stitched together later to provide a continuous photo record of the core. Take additional photographs of subsamples for documentation as necessary. If desired, take an overview picture of the exposed soils.
3. Measure and record material in the core.	Measure and record the number of inches of material in the core. This will be recorded in the field logbook or on the field data sheet as length recovered. This measurement should not include any material that appears to have sluffed from an upper interval (i.e., leaves or topsoil present at the top of deeper subsurface cores). Record this information in the field logbook or on a field data sheet as specified in the Sampling and Analysis Plan (SAP). Evaluate the recovery of the core based on the operator's comments. Be aware that once the core is cut open and released from the plastic, there may be some expansion. Recovery in general from sonic drill rigs is fairly complete. If there was trouble with the recovery, the operator should indicate in general where that might have occurred. Record any additional information in the field logbook or on a field data sheet. Determine the amount of material that represents one foot of the profile. For example, 26 inches of recovered soil from a 2-foot interval may indicate that 13 inches represents 1 foot. An alternate method for determining interval depth is to assume that 96 inches actually represents 96 inches from either the top or the bottom of a 120-inch interval and that there was no recovery for 12 inches of the interval. These are not precise ways to determine how far below ground surface a soil horizon lies, as different soil types

	and moisture levels will compress or expand differently when drilled and then released with the opening of the sleeve. There is no way to determine where or whether compression/expansion in the soil profile occurred. Choose one of these methods and be consistent throughout the project. Another scenario that may occur would be if the operator indicates that an obstruction was encountered that may have blocked soils from entering the casing at a specific depth. If there is only 60 inches of soil and a large rock present in the sleeve, this may represent only the 0-5 foot interval in that core and should be recorded that way in the field logbook or on the field data sheet along with the operator's comment.
4. Log the core.	Examine and log the material in the core. Keep in mind that sonic-generated samples are not "undisturbed." The oscillation during drilling causes movement in the soils immediately adjacent to the core barrel. In softer bedrock, this may open fractures or round off edges of the material. Material closer to the center of the core should be used for logging and sampling. Using a gloved finger or scoop, make indentations down the core noting differences in texture, color, staining or odor if needed. The core may be unconsolidated enough that this is not required. Record information in the field logbook or on a field data sheet. Be aware of potential cross contamination when logging intervals that may be sampled. Change gloves or scoops as required. If required by the SAP or Work Plan (WP), photograph areas of interest.
5. Determine sample intervals.	Determine sample intervals as described in the SAP or WP. Using the extended tape measure, identify the intervals to be sampled. Record the sample interval information and associated sample number in the field logbook or on a field data sheet. If required in the SAP/WP, photograph sample intervals.
6. Sample soils.	For composite samples: Don clean nitrile gloves and use a new plastic disposable scoop for each composite sample. Place an equal aliquot of soil from each area to be composited into a new disposable foil pan or stainless-steel bowl. Mix the material in the pan/bowl thoroughly and remove rock and debris >0.5 inches. Fill the appropriate sample containers. Depending on the number of sample containers to be filled and the size of the core, a 0-1 foot sample interval may require compositing. For grab samples: Don clean nitrile gloves and use a new plastic disposable scoop for each sample. If more than one jar is required, place the material to be sampled in a new disposable foil pan or stainless-steel bowl. Mix the material in the pan/bowl thoroughly and remove rock and debris >0.5 inches. Fill the appropriate sample containers. Alternately, a new scoop can be used to place material directly in the jar. Sample carefully so no particles larger than 0.5 inches are included in the sample. Grab sampling may occur when there is a small stained area or a small amount of a material of interest in a soil profile.

7. Put samples in containers.	Prepare the appropriate sample containers with a label as described in the SAP or the Quality Assurance Project Plan (QAPP). Fill the sample containers with homogenized material from the pan/bowl using the associated sampling tool. After sampling, place the samples in a cooler with ice until they can be transported to the laboratory for analysis as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.
8. Repeat this process as needed.	Repeat this process for each sleeve until the drill hole is complete.
Sampling of Soils for Organic Constituents	
1. Prepare the core.	Evaluate the plastic sleeve of core to be sampled but **DO NOT** cut the plastic. If the soil is saturated, water or soils may flow out of the plastic after it is cut. Saturated core may need to be "blocked" from flowing onto other sections of core. Place index cards or some other marker at intervals along the core. If possible (e.g., plastic is not wet), intervals can be marked on the plastic. Place a reel tape measure along the core, so it can be easily referenced but out of the way.
2. Prepare the sample container.	Based on information provided in the SAP/WP, prepare the appropriate sample containers with a label as described in the SAP/QAPP.
3. Measure material in the core.	**Prior** to cutting the plastic sleeve, measure and record the number of inches of material in the core. See discussion in Step 3 of Sampling of Soils for Inorganic Constituents to determine how depth of sample intervals will be determined.
4. Cut the plastic sleeve.	Once the sample collection supplies are organized, use a utility knife or something similar and slice the plastic along the top.
5. Split the core.	Split the core lengthwise into two subsamples using a new disposable plastic spatula and/or stainless-steel blade.
6. Conduct PID readings if required.	**Volatile Organic Compounds and VPH samples need to be collected as quickly as possible after opening the plastic.** If specified in the SAP/WP, use a photoionization detector (PID) to take readings of the length of the core. Move slowly and if volatiles are detected, return to those areas and record the highest number measured as well as the amount of core involved. Evaluate the core for staining or other indications of organic contamination.
7. Prepare and collect soil samples for VOCs/VPH.	Determine sample intervals for VOCs/VPH as described in the SAP/WP. Sample intervals may be assigned in the SAP or based on PID readings or the presence of odor or staining. Photograph sample areas prior to sample collection. Collect the VOC/VPH samples directly from the core using a plastic disposable scoop or gloved hand. Place the soil directly into the sample container and fill the jar to the top allowing no head space (or as the laboratory directs). Be aware of the potential for cross contamination

	and change gloves or scoops between intervals. The tape measure can be used to identify the intervals sampled and are recorded in the field logbook or on a field data sheet. Immediately place the sample containers in a cooler with ice until they can be transported to the laboratory for analysis as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.
8. Prepare soil samples for additional analytes.	Sample intervals that are not going to be submitted for VOC/VPH can be collected after VOC/VPH sampling is completed. Prior to completing the sampling, finish logging the core and record all the information in the field logbook or on a field data sheet. Determine the intervals to be sampled for additional analytes. Record the sample interval information in the field log book or field data sheet.
9. Take pictures of the core.	Photograph the complete length of the core in 2-foot segments from directly overhead using parallel camera movement and a high-resolution setting. These photographs can be stitched together later to provide a continuous photo record of the core. Take additional photographs of subsamples for documentation as necessary. If desired, take an overview picture of the entire length of core.
10. Sample soils.	For composite samples: Don clean nitrile gloves and use a new plastic disposable scoop for each composite sample. Place an equal aliquot of soil from each area to be composited into a new disposable foil pan or stainless-steel bowl. Mix the material in the pan/bowl thoroughly and remove rock and debris >0.5 inches. Fill the appropriate sample containers. Depending on the number of sample containers to be filled and the size of the core, a 0-1 foot sample interval may require compositing. For grab samples: Don clean nitrile gloves and use a new plastic disposable scoop for each sample. If more than one jar is required, place the material to be sampled in a new disposable foil pan or stainless-steel bowl. Mix the material in the pan/bowl thoroughly and remove rock and debris >0.5 inches. Fill the appropriate sample containers. Alternately, a new scoop can be used to place material directly in the jar. Sample carefully so no particles larger than 0.5 inches are included in the sample. Grab sampling may occur when there is a small stained area or a small amount of a material of interest in a soil profile. Repeat this process for all intervals to be sampled. Be aware of the potential for cross contamination and if needed change gloves or scoops between intervals.
11. Label the sample containers and store them in a cooler.	Make sure all sample containers are labeled correctly. These sample containers should also be placed in a cooler with ice for transport to the laboratory as described in SOP-SA-01 Soil and Water Sample Packaging and Shipping.

Decontamination of Equipment following both Organic or Inorganic Sampling	
1. Decontaminate equipment.	Decontaminate the cutting tool and tape measure, as well as any other reusable equipment using paper towels wetted with a Liquinox/water mixture and the deionized (DI) water spray bottle to rinse. If sampling for organics, use paper towels wetted with methanol for a final wipe down. If stainless steel bowls, spoons and trowels were used, please follow the SOP-DE-02 Decontamination of Equipment.

HSSE CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soils and groundwater.	Sites.	Inadvertent exposure to contaminated soils and groundwater could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when contact with soils and groundwater is possible. Sampling will be conducted outdoors or in a trailer with open doors.
	Exposure to hydraulic fluids.	Drilling operations.	Exposure to hydraulic fluids could occur while working around the drill due to equipment malfunction/ failure resulting in personal injuries.	The operator will inspect the drill and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids. Non-essential personnel will maintain a 20-foot buffer zone round the drill.
	Liquinox.	Equipment decontamination.	Personnel could be exposed to Liquinox via ingestion and skin/eye contact when decontaminating the equipment resulting in adverse health effects.	Personnel will wear nitrile gloves and eye protection when decontaminating the equipment.

CHEMICAL	Methanol.	Equipment decontamination.	Personnel could be exposed to methanol via skin/eye contact and ingestion/ inhalation when decontaminating equipment. Exposure could cause irritation of skin/eye. Adverse health effects can also result, if methanol is ingested and/or inhaled. Direct contact with methanol during winter months can result in skin discomfort due to rapid evaporative cooling.	Personnel will prevent skin/eye contact with methanol and they will wear nitrile gloves and safety glasses when handling methanol. Personnel will use methanol in well-ventilated areas. Personnel will also practice proper personal hygiene – wash hands prior to eating/drinking, after decontamination procedures, and when leaving the site. During winter months, personnel will wear a pair of liner gloves underneath nitrile gloves.
NOISE	Elevated noise levels.	Drilling operations.	Personnel could be exposed to elevated noise levels when working near the drilling operations resulting in hearing damage.	Personnel will wear hearing protection (e.g., ear plugs) when working near the drill. Non-essential personnel will maintain a 20-foot buffer zone around the drill when possible. Hearing protection will be administered and used in accordance with the policies and procedures outlined in the Pioneer Corporate HASP.
ELECTRICAL	Not applicable.			

BODY MECHANICS	Bending, squatting, and kneeling.	During fieldwork activities.	Bending, squatting, and kneeling during fieldwork activities could result in muscle/back strains or other injuries.	Personnel should stretch prior to starting work and they will take breaks when necessary.
	Improper lifting/handling of heavy items.	During field work activities.	Back injuries and muscle/back strains could result when using improper techniques to lift/carry heavy coolers and containers with core pieces.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/handle heavy items as needed.
	Flying debris.	Drilling operations.	Eye injuries could result from flying debris when working around drilling operations.	Personnel will wear safety glasses when working around drilling operations. Non-essential personnel will maintain a 20-foot buffer zone around the drill when possible.
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces, and steep slopes.	Walking/working on slick/muddy/wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. They will plan their path, walk cautiously, and keep work areas as dry as possible. Personnel will wear muck boots as necessary.
WEATHER	Cold/heat stress.	Outdoor sites.	Exposure to cold climates may result in cold burns, frostbite, and hypothermia. Exposure to high temperatures may result in heat cramps, heat	Training on signs and symptoms of cold/heat stress is required. Personnel will wear appropriate clothing when working outdoors (e.g., layers and loose clothing). Personnel will remain hydrated and will have sufficient caloric intakes during the day. Personnel will follow procedures outlined in

WEATHER			exhaustion, or heat stroke.	the applicable SSHASP and/or Pioneer corporate HASP.
	Lightning.	Outdoor sites.	Electrocution, injury, death, or equipment damage could be caused by lightning strike.	Personnel will follow the 30/30 rule during lightning storms.
RADIATION	Ultraviolet (UV) radiation.	Outdoors sites.	Personnel could be exposed to UV radiation during summer months causing sun burns, skin damage, and eye damage.	Personnel will wear safety glasses with tinted lenses, long-sleeve work shirts, and long pants. Personnel should wear sunscreen, if necessary.
BIOLOGICAL	Plants, insects, and animals.	Outdoors.	Exposure to plants, insects, and/or animals may cause rashes, blisters, redness, and swelling.	Training on the signs and symptoms of exposure to plants, insects, and animals is required. Avoid contact with plants, insects, and animals. First aid kits will be available in company vehicles. Personnel with allergies will notify their supervisor.
MECHANICAL	Blade from cutting tool.	Cutting tool.	Direct contact with the blade of the cutting tool used for slicing the plastic sleeves could result in cuts and scrapes.	Personnel will inspect the cutting tool prior to each use and be aware of hand placement to prevent exposure to the blade. Personnel will also wear work gloves.
PRESSURE	Pressurized hydraulic hoses.	Drilling operations.	Hydraulic hoses could burst/rupture resulting in inadvertent contact with hydraulic fluid or personal injury	The operator will inspect the drill and document inspections daily before starting work. The operator will also replace/repair all faulty equipment before starting work. When inspecting equipment, personnel will wear work gloves to prevent possible exposures to hydraulic fluids.

			due to being struck by hoses.	Non-essential personnel will maintain a 20-foot buffer zone round the drill.
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained personnel.	Sites.	Inexperienced personnel and improper training could cause incidents resulting in adverse health effects and/or property damage.	Personnel will be properly trained in the procedure described above and other applicable procedures. Personnel will follow the stop work policy, if there are any issues.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	**Personal Protective Equipment** (PPE): Hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, nitrile gloves, and leather gloves.
APPLICABLE SDSs	Liquinox and Methanol. Additional **Safety Data Sheets** (SDSs) will be maintained based on the site characterization and contaminants.
REQUIRED PERMITS/ FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
DRAWINGS	Map with site location and sample locations.
RELATED SOPs/ PROCEDURES /WORK PLANS	SOP-SA-01 Soil and Water Sample Packaging and Shipping and SOP-DE-02 Equipment Decontamination – Inorganic Contaminants.
TOOLS	Sample area – plastic sheeting, tape measure, index cards to indicate top and bottom, camera, PID (if required), plastic disposable scoops or stainless-steel spoons or spatulas, screwdrivers, DI water spray bottle, Liquinox/water spray bottle, methanol, paper towels, foil disposable pans or stainless-steel bowls, sample containers, cutting tool (e.g., utility knife).
FORMS/ CHECKLIST	Field logbook and field data sheets.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang	**05/31/2018**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman	**05/31/2018**

PURPOSE	To provide standard instructions for soil and water sample packaging and shipping.
SCOPE	This practice has been prepared for the Pioneer Technical Services, Inc. (Pioneer) workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Preserve the samples.	Water samples will be preserved, if required, according to SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples, and SOP-SA-02B Sample Preservation and Containerization for Aqueous Samples for VOAs.
2. Place the sample containers in Ziploc bags.	Based on the analytes requested (e.g., low level mercury, low level chromium, etc.), it may be necessary to place each filled sample container in separate Ziploc bags to prevent cross contamination, keep the container clean, dry, and isolated, and protect the sample label. In most cases, all sample containers collected from a specific sample location are placed in a large Ziploc bag and shipped together.
3. Package the samples.	Place samples in a cooler, which has been previously lined with a plastic bag. Surround the samples with non-contaminating packaging materials to reduce movement and absorb any leakage. Double bag the ice and place it in the cooler. Seal the plastic bag in the cooler to contain the samples, packing material, and ice.
4. Review and sign COC forms.	The Field Team Leader or their designated representative will double check the chain-of-custody (COC) forms to assure those samples recorded on the COC forms are in the cooler. The Field Team Leader or the designated representative will then sign the chain-of-custody form to relinquish custody. One copy of the signed COC form will remain with the Field Team Leader. Make a photocopy of the completed forms, if there are no carbon copies available.
5. Tape paper work to cooler.	Place paper work in a sealed Ziploc bag and tape it to the inside of the cooler lid.
6. Bag samples for separate analytical batches.	If the shipping cooler contains more samples than can be analyzed in one analytical batch, the laboratory may request that the samples in the cooler be bagged for separate analytical batches. This may be necessary so that the appropriate Quality Control/Quality Assurance samples are included in each analytical batch. In this case, fill out separate COC forms for each batch and include the forms in the

	appropriate plastic bags. Place the COC forms for each batch in a sealed Ziploc bag. The COC forms for each batch should be placed at the top of the plastic bag so that they are clearly visible to laboratory personnel when they open the plastic bags.
7. Label the cooler.	Label the cooler with the appropriate labels to describe the content of the cooler (e.g., NOS, flammable liquids, flammable solids, this side up, fragile, etc.). Close the cooler and place the appropriate shipping labels (e.g., overnight shipping from Federal Express, UPS, or the United States Postal Service or equivalent) on the lid of the cooler.
8. Sign COC seals.	The Field Team Leader or the designated representative will sign COC seals and place the signed seals over the opening edge of the cooler.
9. Tape the cooler.	Place tape over the custody seals and around the cooler.
10. Transport the cooler.	Transport the cooler(s) to a secure storage, to the shipping agent, or directly to the laboratory. If shipping the cooler, follow established federal and state regulations depending on cooler content.
Notes	Bagging of samples and lining of coolers is not necessary, if samplers transport the samples directly to the laboratory.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Potential contact with contaminated soil and water samples.	Sites.	Inadvertent exposure to contaminated soil and water samples could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Employees will wear nitrile gloves and safety glasses when handling sample containers.
	Preservatives (HCL, HNO3, H2SO4, Zinc, Acetate, NaOH).	In bottles or added to bottles through sampling process.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all employees on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when adding preservatives to samples bottles and when handling the bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Bending, squatting, and kneeling.	During sample packaging.	Bending, squatting, and could result in muscle/back strains or other injuries.	Employees should stretch prior to starting work and they will take breaks when necessary.
	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry coolers with samples.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/carry the coolers, if needed.

GRAVITY	Not applicable.			
WEATHER	Not applicable.			
RADIATION	Not applicable.			
BIOLOGICAL	Not applicable.			
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained worker.	Sites.	Inexperienced workers and improper training could cause incidents resulting in adverse health effects and/or property damage.	Employees will be properly trained in this procedure and other applicable procedures. Employees will implement stop work procedures, if necessary.
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	Sampling site: hard hat, safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves. Off site: nitrile gloves.
APPLICABLE SDS	HCL, HNO3, H2SO4, Zinc, Acetate, and NaOH. Additional Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples and SOP-SA-02B Sample Preservation and Containerization for Aqueous Samples for VOAs.
TOOLS	Plastic bags, Ziploc bags, non-contaminating packaging materials, tape, COC seals, ice, and cooler.
FORMS/CHECKLIST	Chain-of-custody (COC) forms.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang (signature) **Julie Flammang**	**12/11/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman (signature) **Tara Schleeman**	**12/11/2014**

Revisions:

Revision	Description	Date

PURPOSE	This Standard Operating Procedure (SOP) establishes the requirements for documenting and maintaining environmental sample chain of custody from point of origin to receipt of sample at the analytical laboratory. This procedure will apply to all types of air, soil, water, sediment, biological, and/or core samples collected in environmental investigations by Pioneer Technical Services, Inc. (Pioneer). It is applicable from the time of sample acquisition until custody of the sample is transferred to an analytical laboratory.
SCOPE	Pioneer prepared this practice for the workforce and this SOP applies to all work performed by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent (as defined by OSHA) in the risk-assessed procedure described below before performing the work.
DEFINITIONS	**Chain of custody** is an unbroken trail of accountability that ensures the physical security of samples, data, and records. Custody refers to the physical responsibility for sample integrity, handling, and/or transportation. Custody responsibilities are effectively met, if the samples are: • In the responsible individual's physical possession; • In the responsible individual's visual range after having taken possession; • Secured by the responsible individual so that no tampering can occur (usually for shipping); or • Secured or locked by the responsible individual in an area in which access is restricted to authorized personnel only.

WORK INSTRUCTIONS

The following instructions provide guidance to perform the task in a safe, accurate, and reliable manner. If these instructions present information that is inaccurate or unsafe, personnel must notify the Project Manager, Safety Manager, and the SOP Technical Author to initiate appropriate revisions. Personnel will perform all work under this SOP in a manner that is consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plans (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
Project Manager's Responsibilities	The Project Manager is responsible for overall management of environmental sampling activities, designating sampling responsibilities to qualified personnel, and reviewing any changes to the sampling plan.
Field Team Leader's Responsibilities	The Project Manager may act as the Field Team Leader or may choose to appoint a Field Team Leader. The Field Team Leader is responsible for general supervision of field sampling activities and ensuring proper storage/transportation of samples from the field to the analytical laboratory. The Field Team Leader is also responsible for maintaining sample custody as defined above until the sample has been properly relinquished as documented on the chain of custody form.

	The Field Team Leader will review chain of custody forms for accuracy and completeness to preserve sample integrity from collection to receipt by an analytical laboratory. The review of chain of custody forms may be delegated to qualified personnel.
Field Sampler's Responsibilities	The Field Sampler is responsible for sample acquisition in compliance with technical procedures, initiating the chain of custody, and checking sample integrity and documentation prior to transfer. Field samplers are also responsible for initial transfer of samples consisting of physical transfer of samples directly to the internal laboratory or transferred to a shipping carrier, (e.g., United Parcel Service or Federal Express) for delivery.
Laboratory Technician's Responsibilities	The receiving Laboratory Technician is responsible for inspecting transferred samples to ensure proper labeling and satisfactory sample condition. Unacceptable samples will be identified and segregated. The Laboratory Project Manager will be notified. The Laboratory Technician will review the chain of custody for completeness and file as part of the project's permanent record.
Fill out Chain of Custody Forms	The Field Team Leader or designated Field Sampler will initiate the chain of custody form for the initial transfer of samples. A chain of custody form will be completed and accompany every sample set. Only those samples included in the shipping container (cooler or box) should be listed on the chain of custody form included in the container. All chain of custody forms must be completed and include the following information: • Project code. • Project name. • Sampler's signature. • Sample identification. • Date sampled. • Time sampled. • Analysis requested. • Remarks column should contain information about a sample that the laboratory might need. Examples of remarks that should be included: ▪ If samples could have very high or low expected concentrations (outside of normal instrument calibration range). ▪ DO NOT USE FOR QA/QC (quality assurance/quality control) should be indicated for field blanks, bottle blanks, or equipment rinsate blanks. ▪ If a sample should be held for later analysis (i.e., if sample being analyzed requires results from another sample to determine analysis status).

	▪ The sample should be archived after initial analysis by the laboratory for potential additional analysis in the future. ▪ Requires filtering (if not completed in the field). ▪ Requires preservation (if not completed in the field). ▪ Any other sample specific information that will aid the laboratory in completing the appropriate analysis. • Relinquishing signature, data, and time. • Receiving signature, date, and time. Laboratory-provided chain of custody forms should be used if provided, and all required fields should be filled out. Pioneer also has generic chain of custody forms that can be used if no laboratory forms are available. Make sure that the above required information is on the form and include the laboratory name and address to which the samples are being shipped. The Field Sampler relinquishing custody and the responsible individual accepting custody will sign, date, and note the time of transfer on the chain of custody form. Note: if the transporter is not an employee of Pioneer, the Field Sampler may identify the carrier and reference the bill of lading number in lieu of the transporter's signature. One copy of the chain of custody form will be filed as a temporary record of sample transfer by the Field Sampler. The original form will accompany the sample set and will be returned to Pioneer as part of the contracted laboratory QA/QC requirements. The original form and the transporter's receipt will be filed as part of the project's permanent records. The Project Manager (or designee) will track the chain of custody to ensure timely receipt of samples by an analytical laboratory. Shipping information, including date shipped, laboratory shipped to, transporter's identity (i.e., Federal Express), and tracking number should be recorded in the field logbook. If more than one sample shipment occurs during a project, the associated samples per shipment should be referenced (sample numbers or samples collected on these dates).
Sample Handling.	All samples will be collected and handled in accordance with SOP-SA-01 Soil and Water Sample Packaging and Shipping and SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples, or methods described in the Sampling and Analysis Plan (SAP) or Work Plan (WP). Samples will be transported in insulated coolers with ice as necessary to maintain a temperature of 4 degrees Celsius (°C) plus or minus 2 °C until receipt by the analytical laboratory. Alternate shipping containers can be used if the analytical method, SAP, or WP does not have temperature requirements for the samples.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS
This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
CHEMICAL	Potential contact with contaminated water/soil samples.	Outside of bottles.	Inadvertent exposure to contaminated water/soil samples could lead to adverse health effects.	Personnel will practice proper personal hygiene – wash hands prior to eating/drinking and when leaving the site. Personnel will wear nitrile gloves and safety glasses when handling sample containers.
	Preservatives (HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH).	Outside of bottles.	Inadvertent exposure to preservatives could lead to adverse health effects.	Safety Data Sheets for each preservative chemical are available to all Personnel on the Pioneer company web site. Personnel will wear nitrile gloves and safety glasses when handling the bottles. Refer to the Chemical Flushing Guidelines available inside vehicle's first aid kit for first-aid procedures in case of contact with preservatives.
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Improper lifting.	Sites.	Back injuries and muscle/back strains could result when using improper techniques to lift and carry packaged samples and coolers.	Personnel will use proper lifting techniques – get a good grip, keep the load close to the body, lift with legs and not with back, and avoid lifting loads above shoulder's height. Two workers will lift/carry packaged samples and coolers, if needed.

HEALTH SAFETY SECURITY ENVIRONMENT (HSSE) CONSIDERATIONS

This section to be completed with concurrence from the Safety and Health Manager.

SOURCE	*HAZARDS*	*WHERE*	*HOW, WHEN, RESULT*	*CONTROLS*
GRAVITY	Falls from slips and trips.	Uneven terrain, slick/muddy/wet surfaces and steep slopes.	Walking/working on slick/muddy/ wet and uneven terrain could cause slips and trips resulting in falls and injuries.	Personnel will wear work boots with good traction and ankle support. Personnel will be aware of working/walking surfaces and choose a path to avoid hazards. Keep work areas as dry as possible.
WEATHER	Not applicable.			
RADIATION	Not applicable.			
BIOLOGICAL	Not applicable.			
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Inexperienced and improperly trained personnel.	Sites.	Inexperienced personnel and improper training could cause incidents resulting in adverse health effects and/or property damage.	Personnel will be properly trained in this procedure and other applicable procedures. Personnel will implement stop work procedures, if necessary.
SIMOPS (Simultaneous Operations)	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	**Personal Protection Equipment** (PPE): Safety glasses, high-visibility work shirt or vest, long pants, work boots, and nitrile gloves.
APPLICABLE SDSs	**Safety Data Sheets** (SDSs): HCL, HNO_3, H_2SO_4, Zinc, Acetate, and NaOH. Safety Data Sheets are available to Pioneer employees at the link below: https://pioneertechnicalservices.sharepoint.com/Safety/SafetyDataSheets
REQUIRED PERMITS/ FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
DRAWINGS	
RELATED SOPs/ PROCEDURES/ WORK PLANS	SOP-SA-01 Soil and Water Sample Packaging and Shipping and SOP-SA-02 Sample Preservation and Containerization for Aqueous Samples.
TOOLS/ EQUIPMENT	Seals and labels, chain of custody forms, chain of custody seals (provided by contracted laboratory), packing and shipping materials, cooler, and ice.
FORMS/ CHECKLIST	Chain of custody forms.

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang **Julie Flammang**	**11/12/2020**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman **Tara Schleeman**	**11/12/2020**

PURPOSE	This SOP establishes the requirements for documenting and maintaining field logbooks and photographs. These procedures shall apply to all types of air, soil, water, sediment, biological, and/or core samples collected in environmental investigation by Pioneer Technical Services, Inc. (Pioneer). These procedures apply from the time field work begins until site activities are completed.
SCOPE	This practice has been prepared for the Pioneer workforce and applies to work carried out by and on behalf of Pioneer. All members of the Pioneer workforce who conduct the work shall be trained and competent in the risk-assessed work described below.

WORK INSTRUCTIONS

The following instructions are intended to provide sufficient guidance to perform the task in a safe, accurate, and reliable manner. Should these instructions present information that is inaccurate or unsafe, operations personnel must bring the issue to the attention of the Project Manager and the appropriate revisions made. All work carried under this SOP will be consistent with procedures and policies described in the appropriate Operation, Maintenance, and Monitoring (O&M) Plan (where applicable), appropriate Site-Specific Health and Safety Plan (SSHASP), and Pioneer Corporate Health and Safety Plan (HASP).

TASK	INSTRUCTIONS
1. Logbooks.	A designated field logbook will be used for each field project. If requested by the Project Manager, use a separate field logbook for each field task within a larger project. Label each logbook with the project name, dates that it covers, and logbook number. Use a waterproof marker, such as a Sharpie©, to write down the information. The logbooks will be bound and have consecutively numbered pages. The information recorded in these logbooks shall be written in ink. Begin a new page for each days notes. Write on every line of the logbook. If a blank space is necessary for clarity, such as a change of subject, skip one line before beginning the new subject. Do not skip any pages or parts of pages unless a day's activity ends in the middle of a page. Draw a diagonal line on any blank spaces of four lines or more to prevent unauthorized entries. The author will initial and date entries at the end of each day. All corrections will consist of a single line-out deletion in ink, followed by the author's initials and the date. Information not related to the project should not be entered in the logbook. The language used in the logbook should be factual and objective. These bound logbooks shall include the following entries: 1. A description of the field task. 2. Time and date fieldwork started. 3. Location and/or a description of the work areas including sketches, if needed, any maps or references needed to identify locations, and sketches of construction activities. If the location has been documented in the logbook during/prior visits, only changes in conditions should be noted. 4. Names and company affiliations of field personnel.

	5. Name, company affiliation or address, and phone number of any field contacts or official site visitors. 6. Meteorological conditions at the beginning of fieldwork and any ensuing changes in these conditions. 7. Details of the fieldwork performed and reference to field data sheets, if used. 8. Deviation from the task-specific Sampling and Analysis Plan (SAP), Work Plan (WP), or Standard Operating Procedures (SOP). 9. All field measurements made. 10. Any field laboratory analytical results. 11. Personnel and equipment decontamination procedures, if appropriate. For any field sampling work, the following entries should be made: 1. Sample location and number. 2. Sample type and amount collected. 3. Date and time of sample collection. 4. Type of sample preservation. 5. Split samples taken by other parties. Note the type of sample, sample location, time/date, name of person for whom the split was collected, that person's company, and any other pertinent information. 6. Sampling method, particularly any deviations from the SOP. 7. Documentation or reference of preparation procedures for reagents or supplies that will become an integral part of the sample, if available. This information may not be available for water or soil sampling bottles that come preserved from the laboratory or for preservatives provided by the laboratory. Bottle blanks will need to be used to evaluate the provided reagents. 8. The laboratory where the samples will be sent. No bound field logbooks will be destroyed or thrown away even if they are illegible or contain inaccuracies that require a replacement document.
2. Photographs.	Take photographs of field activities using a digital camera. Photographs should include a scale in the picture when practical. Telephoto or wide-angle shots will not be used, since they cannot be used in enforcement meetings. The following items shall be recorded in the bound field logbook or on a field data sheet for each

	photograph taken: 1. The photographer's name, the date, the time of the photograph, and the general direction faced. 2. A brief description of the subject and the fieldwork portrayed in the picture. 3. Sequential number of the photograph. An electronic copy and/or a hard copy of the photographs shall be placed in task files in the field office after each day of field activities. Supporting documentation from the bound field logbooks or field data sheets shall be photocopied and placed in the task files to accompany the photographs once the field activities are complete.

HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.				
SOURCE	***HAZARDS***	***WHERE***	***HOW, WHEN, RESULT***	***CONTROLS***
CHEMICAL	Not applicable.			
NOISE	Not applicable.			
ELECTRICAL	Not applicable.			
BODY MECHANICS	Not applicable.			
GRAVITY	Not applicable.			
WEATHER	Not applicable.			
RADIATION	Not applicable.			
BIOLOGICAL	Not applicable.			
MECHANICAL	Not applicable.			
PRESSURE	Not applicable.			
THERMAL	Not applicable.			
HUMAN FACTORS	Not applicable.			
SIMOPS	Not applicable.			

ADDITIONAL HSSE CONSIDERATIONS This section to be completed with concurrence from the Safety and Health Manager.	
REQUIRED PPE	
APPLICABLE SDS	Safety Data Sheets (SDSs) will be maintained based on site characterization and contaminants.
REQUIRED PERMITS/FORMS	Per site/project requirements.
ADDITIONAL TRAINING	Per site/project requirements.

DRAWINGS, DOCUMENTS, AND TOOLS/EQUIPMENT The following documents should be referenced to assist in completing the associated task.	
P&IDS	
DRAWINGS	
RELATED SOPs/PROCEDURES/ WORK PLANS	
TOOLS	Field logbook, Sharpie©, black pen, digital camera, and field data sheets.
FORMS/CHECKLIST	

APPROVALS/CONCURRENCE By signing this document, all parties acknowledge the completeness and applicability of this SOP for its intended purpose. Also, by signing this document, it serves as acknowledgement that I have received training on the procedure and associated competency testing.	
SOP TECHNICAL AUTHOR	**DATE**
Julie Flammang	**12/17/2014**
SAFETY AND HEALTH MANAGER	**DATE**
Tara Schleeman	**12/17/2014**

Revisions:

Revision	Description	Date

Appendix B
Field Forms and Tables

FORMS

Geoprobe Soil Log

Project: ______________________ Hole No: ______________________

Contactor: Pioneer Technical Services Geoprobe: ______________________

Date: ______________________ Operator: ______________________

Logged By: ______________________ Weather: ______________________

Core:	Depth Core Represents	Actual Measured Length	Inches per 1 foot	Photo Number/ Description	Drillers Notes	Core Start Time	Samples Collected (XRF/LAB)

Measured Length (in)	**Length Represented**	**Color**	**Description**	**Time**	**PID Reading**

PIONEER TECHNICAL SERVICES, INC.

Project Name:	
Project Location:	
Project Number:	

Log of Boring ________

Date(s) Drilled		Logged By		Total Depth of Borehole (ft)	
Drilling Method		Diameter of Borehole (in)		Ground Surface Elevation (ft-msl)	
Drill Rig Type		Drilling Company		Groundwater Elevation (ft-msl)	
Driller's Name	Sampler Type	Checked By		Measuring Point Elevation (ft-msl)	
Locations / Comments				Northing Easting	

Depth (ft-bgs)	SAMPLES				Munsell Color	HCL Reaction	Drill Rate (ft/hr)	MATERIAL DESCRIPTION	REMARKS
	Sample Type	Blows/Foot	Recovery (ft)	Pentromenter (tsf)					
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									

PIONEER TECHNICAL SERVICES, INC.

Project Name:
Project Location:
Project Number:

Log of Boring ________

Depth (ft-bgs)	SAMPLES: Sample Type	SAMPLES: Blows/Foot	SAMPLES: Recovery (ft)	SAMPLES: Pentromenter (tsf)	Munsell Color	HCL Reaction	Drill Rate (ft/hr)	MATERIAL DESCRIPTION	REMARKS
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
32									
33									

PIONEER TECHNICAL SERVICES, INC.

Project Name:
Project Location:
Project Number:

Log of Boring ________

Depth (ft-bgs)	SAMPLES				Munsell Color	HCL Reaction	Drill Rate (ft/hr)	MATERIAL DESCRIPTION	REMARKS
	Sample Type	Blows/Foot	Recovery (ft)	Pentromenter (tsf)					
33									
34									
35									
36									
37									
38									
39									
40									
41									
42									
43									
44									
45									
46									
47									
48									
49									
50									
51									

TABLES

ORDER FOR DESCRIPTIONS

Density

- Very soft, Soft, Medium Stiff, Stiff, Stiff, Very Stiff, Hard
- Very loose, Loose, Medium Dense, Dense, Very Dense
- SEE TABLE

Moisture Content

- Dry, Moist, Wet
- See Table

General Color

Soil Description

- Minor soil type name with "y" added if ≥ 30 percent and ≤ 50%
- Descriptive adjective for main soil type
  - Particle-size distribution adjective for gravel and sand (fine – coarse)
  - Plasticity adjective (slight to high) and soil texture (silty or clayey) for inorganic and organic silts or clays
- Main soil type's name (**all capital letters**)
- Descriptive adjective such as trace (0-5%), slightly or some (5-12%), for minor soil type

Structures

- See Tables

Geologic Classification

- If applicable – alluvium, fill, tailings, slag, debris

USCS Classification

- See Tables

Examples:
Medium dense, wet, dark brown, sandy SILT, trace of clay, numerous organics and strong organic odor (marsh deposits) ML.

Medium stiff, moist, dark gray, medium plastic silty CLAY, slightly sandy, laminated with light gray silt (tailings), CL

Very dense, moist, light brown, slightly silty, sandy fine gravel, trace of cobbles, scattered roots, GP-GM

Density/Consistancy Word Choices

Consistency of Fine-Grained Soils-Silts, Clays

Consistency	Results of Manual Manipulation
Very Soft	Specimen (height = twice the diameter) sags under its own weight; extrudes between fingers when squeezed
Soft	Specimen can be pinched in to between the thumb and forefinger; remolded by light finger pressure
Medium stiff	Can be imprinted easily with fingers; remolded by strong finger pressure
Stiff	Can be imprinted with considerable pressure from fingers or indented by thumbnail
Very stiff	Can be barely imprinted by pressure from the fingers or indented by thumbnail
Hard	Cannot be imprinted by fingers or difficult to indent by thumbnail

Density of Coarse or Cohesionless Soils-Gravels/Sands and Silt
Very loose
Loose
Medium Dense
Dense
Very Dense

WATER CONTENT

Description	Conditions
Dry	No sign of water and soil dry to touch
Moist	Signs of water and soil is relatively dry to touch
Wet	Signs of water and soil definitely wet to touch; granular soil exhibits some free water when densified, saturated

SIZES FOR SOIL DESCRIPTIONS

Term	Example	Size
Boulders	> Basketball size	> 12"
Cobbles	Fist to Basketball size	3"-12"
Gravel – Coarse	**Thumb to fist size**	**¾"-3"**
Gravel – Fine	**Pea to Thumb size**	**5 mm to ¾"**
Sand – Coarse	**Rock salt to pea size**	**2 mm to 5 mm**
Sand – Medium	**Sugar to rock salt**	**0.4 mm to 2 mm**
Sand – Fine	**Flour to sugar**	**0.08 mm to 0.4 mm**
Fines – Clay and silt	**Grains are not visible**	**<0.08 mm**

Boulders and cobbles are not considered soil or part of the soil's classification or description, except under miscellaneous descriptions; i.e. --, with cobbles at about 5 percent (volume).

Well graded coarse-grained soil - contains a good representation of all particle sizes from largest to smallest, with **≤ 12% fines**.
Poorly graded coarse-grained soil is uniformly graded with most particles about the same size or lacking one or more intermediate sizes, with 12% fines.

Describe type and size of organic debris

Adjective	Presence as % by Volume
Occasional	0-1%
Scattered	1-10%
Numerous	10-30%
Organic – as a minor constituent in description	30-50%
PEAT – MAJOR constituent	50-100%

Highly Organic Materials

These materials containing a predominance of undecomposed plant or woody fiber are described as follows:

- *Root Mat*: Pronounced structure of living root fibers characteristic of marsh or swampy deposits.
- *Peat*: Fossiliferous root mat with a varying degree of decomposition, often containing a matrix of amorphous, colloidal organic clays and silts.
- *Humus*: Decomposed root and leaf litter, characteristic of organic forest cover in well-drained areas.

SOIL PLASTICITY DESCRIPTIONS

Plasticity Adjective	Dry Strength	Smear Test	Thread Smallest Diameter, in. (mm)	ML & MH (SILT)	CL & CH (CLAY)	OL & OH (ORGANIC SILT OR CLAY)
nonplastic	none-crumbles into powder with mere pressure	gritty or rough	ball crakcs	----	----	ORGANIC SILT
low plasticity	low-crumbles into powder with some finger pressure	rough to smooth	1/4 to 1/8 (3 to 6)	----	silty	ORGANIC SILT
medium plastic	medium - breaks into pieces or crumbles with considerable finger pressure	smooth and dull	1/16 (0.5 to 1)	clayey	silty to no adj.	ORGANIC clayey SILT
highly plastic	high- cannot be broken with finger pressure; will break into pieces between thumb and a hard surface	shiny	1/32 (0.75)	clayey	----	ORGANIC silty CLAY
very plastic	very high - can't be broken between thumb and a hard surface	very shiny and waxy	1/64 (0.5)	clayey	----	ORGANIC

Thread Test:

Moisture is added or worked out of a small ball (about 1 1/2-inch diameter) and the ball is kneaded until it consistency approaches medium stiff to stiff and it breaks, or crumbles. A thread is then rolled out to the smallest diameter possible before disintegration. The smaller the thread achieved, the higher the plasticity of the soil. Fine-grained soils of high plasticity will have threads smaller than 1/32 inch in diameter. Soils with low plasticity will have threads larger the 1/8 inch in diameter

Layered Soils

Type of Layer	Thickness	Occurrence
Parting	< 1/16 in.	
Lamination	< ¼ in.	
Seam	1/16 to ½ in.	
Layer	½ in. to 12 in.	
Stratum	> 12 in.	
Pocket	Small erratic deposit	
Lens	Lenticular deposit	
Varved (also layered)		Alternating seams or layers of silt and/or clay and sometimes f. sand
Occasional		One or less per foot of thickness or laboratory sample inspected
Frequent		More than one per foot of thickness or laboratory sample inspected

Place the thickness designation before the type of layer, or at the end of each description and in parentheses, whichever is more appropriate.

Examples of descriptions for layered soils are:

- Medium stiff, moist to wet 1/4"-3/4" interbedded seams and layers of: gray, medium plastic, silty CLAY (CL); and lt. gray, low plasticity SILT (ML); (Alluvium).

Other Layer Adjectives

Description	Criteria (thickness)
Stratified	Alternating Layers
Interbedded	Alternating Layers > ½" thick
Laminated	Alternating layers < ¼" thick
Fractured	Breaks easily along definite fractured planes
Slickensided	Polished, glossy, striated, fracture planes
Blocky	Easily breaks into small angular lumps
Lensed	Small pockets of different soils
Homogeneous	Same color and appearance throughout
Sheared	Disturbed texture, mix of strengths

Coarse- Grained Soils			
Coarse-Grained Soils	Gravel and Gravelly Soils	**GW**	Well-graded gravels or gravel- sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel- sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures (more than 12% fines)
		GC	Clayey gravels, gravel-sand- clay mixtures (more than 12% fines)
	Sand and Sandy Soils	**SW**	Well-graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures (more than 12% fines)
		SC	Clayey sands, sand-silt mixtures (more than 12% fines)

Well Graded - all particle sizes are present, less than 12% fines

Poorly Graded - most particles are about the same size or missing 1 or 2 sizes, 12% fines

FINE - GRAINED SOILS			
Fine-Grained Soils	Silts and Clays Liquid Limit < 50	**ML**	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	*Organic* silts and organic silt- clays of low plasticity
	Silts and Clays Liquid Limits ≥ 50	**MH**	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	*Organic* clays of medium to high plasticity, organic silts
Highly *Organic* Soils		**Pt**	Peat and other highly organic soils

ROCK DESCRIPTIVE TERMS

Term		Defining Characteristics	
Hardness	Soft	Scratched by fingernail	
	Moderately Hard	Scratched easily by penknife	
	Hard	Difficult to scratch with a penknife	
	Very Hard	Cannot be scratched by penknife	
Weathering	Unweathered	Rock is unstained. May be fractured, but discontinuities are not stained.	
	Slighty	Rock is unstained. Discontinuities show some staining on the surfaces of rocks, but discoloration does not penetrate rock mass.	
	Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.	
	High	Individual rock fragments are thoroughly stained and may be crumbly.	
	Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.	
Bedding Planes	Laminated	< .04 in.	< 1 mm
	Parting	.04 in. - .24 in.	1mm - 6mm
	Banded	.24 in. - 1in.	6 mm - 3 cm
	Thin	1 in. - 4 in.	3 cm - 9.1 cm
	Medium	4 in. - 12 in.	9.1 cm - 30.5 cm
	Thick	12 in.- 36 in.	30.5 cm - 1m
	Massive	> 36 in.	> 1 m
Joints and Fracture Spacing	Very tight	< 2 in.	< 5.1 cm
	Tight	2 in. - 1ft.	5.1 - 30.5 cm
	Moderately tight	1ft. - 3 ft.	30.5 cm - 91.4 cm
	Wide	3 ft. - 10 ft.	91.4 cm - 3 M
	Very wide	> 10 ft.	> 3 M
Voids	Porous	Smaller than a pinhead. Their presence is indicated by the degree of absorbency.	
	Pitted	Pinhead size to a 1/4 inch. If only thin walls separate the individual pits, the core may be described as honeycombed.	
	Vug	1/4 inch to the diameter of the core. The upper limit will vary with core size.	
	Cavity	Larger than the diameter of the core.	

Rock Particle Percent Composition Estimation

Figure 3 Rock Descriptive Terms

Appendix C
Geotechnical Investigation Reference Documents

INTERNATIONAL

Designation: D1587/D1587M – 15

Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes[1]

This standard is issued under the fixed designation D1587/D1587M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This practice covers a procedure for using a thin-walled metal tube to recover intact soil samples suitable for laboratory tests of engineering properties, such as strength, compressibility, permeability, and density. This practice provides guidance on proper sampling equipment, procedures, and sample quality evaluation that are used to obtain intact samples suitable for laboratory testing.

1.2 This practice is limited to fine-grained soils that can be penetrated by the thin-walled tube. This sampling method is not recommended for sampling soils containing coarse sand, gravel, or larger size soil particles, cemented, or very hard soils. Other soil samplers may be used for sampling these soil types. Such samplers include driven split barrel samplers and soil coring devices (Test Methods D1586, D3550, and Practice D6151). For information on appropriate use of other soil samplers refer to Practice D6169.

1.3 This practice is often used in conjunction with rotary drilling (Practice D1452 and Guides D5783 and D6286) or hollow-stem augers (Practice D6151). Subsurface geotechnical explorations should be reported in accordance with Practice D5434. This practice discusses some aspects of sample preservation after the sampling event. For more information on preservation and transportation process of soil samples, consult Practice D4220.

1.4 This practice may not address special considerations for environmental or marine sampling; consult Practices D6169 and D3213 for information on sampling for environmental and marine explorations.

1.5 Thin-walled tubes meeting requirements of 6.3 can also be used in piston samplers, or inner liners of double tube push or rotary-type soil core samplers (Pitcher barrel, Practice D6169). Piston samplers in Practice D6519 use thin-walled tubes.

1.6 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

1.7 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.8 The values stated in either inch-pound units or SI units presented in brackets are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A513/A513M Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing

A519 Specification for Seamless Carbon and Alloy Steel Mechanical Tubing

A787 Specification for Electric-Resistance-Welded Metallic-Coated Carbon Steel Mechanical Tubing

B733 Specification for Autocatalytic (Electroless) Nickel-Phosphorus Coatings on Metal

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Nov. 15, 2015. Published December 2015. Originally approved in 1958. Last previous edition approved in 2012 as D1587 – 08 (2012)$^{\varepsilon 1}$. DOI: 10.1520/D1587_D1587M-15.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1452 Practice for Soil Exploration and Sampling by Auger Borings
D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
D2166 Test Method for Unconfined Compressive Strength of Cohesive Soil
D2435 Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D2850 Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
D3213 Practices for Handling, Storing, and Preparing Soft Intact Marine Soil
D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils (Withdrawn 2016)[3]
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4186 Test Method for One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled-Strain Loading
D4220 Practices for Preserving and Transporting Soil Samples
D4452 Practice for X-Ray Radiography of Soil Samples
D4767 Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils
D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D6026 Practice for Using Significant Digits in Geotechnical Data
D6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations
D6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
D6519 Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler

[3] The last approved version of this historical standard is referenced on www.astm.org.

3. Terminology

3.1 *Definitions:*

3.1.1 For common definitions of terms in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *area ratio, A_r, %, n*—the ratio of the soil displaced by the sampler tube in proportion to the area of the sample expressed as a percentage (see Fig. 1).

3.2.2 *inside clearance ratio, C_r, %, n*—the ratio of the difference in the inside diameter of the tube, D_i, minus the inside diameter of the cutting edge, D_e, to the inside diameter of the tube, D_i expressed as a percentage (see Fig. 1).

3.2.3 *ovality, n*—the cross section of the tube that deviates from a perfect circle.

3.3 *Symbols:*

3.3.1 A_r—area ratio (see 3.2.1).

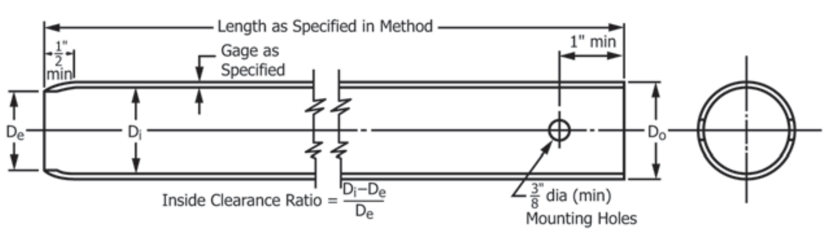
3.3.2 C_r—clearance ratio (see 3.2.2).

4. Summary of Practice

4.1 A relatively intact sample is obtained by pressing a thin-walled metal tube into the in-situ soil at the bottom of a boring, removing the soil-filled tube, and applying seals to the soil surfaces to prevent soil movement and moisture gain or loss.

5. Significance and Use

5.1 Thin-walled tube samples are used for obtaining intact specimens of fine-grained soils for laboratory tests to determine engineering properties of soils (strength, compressibility, permeability, and density). Fig. 2 shows the use of the sampler



$$\text{Area Ratio} = (D_o^2 - D_i^2)/D_i^2$$

NOTE 1—The sampling end of the tube is manufactured by rolling the end of the tube inward and then machine cutting the sampling diameter, D_e, on the inside of the rolled end of the tube.

NOTE 2—Minimum of two mounting holes on opposite sides for D_o smaller than 4 in. [100 mm]. Minimum of four mounting holes equally spaced for D_o equal to 4 in. [100 mm] and larger.

NOTE 3—Tube held with hardened set screws or other suitable means.

FIG. 1 Thin-Walled Dimensions for Measuring Tube Clearance Ratio, C_r (approximate metric equivalents not shown)

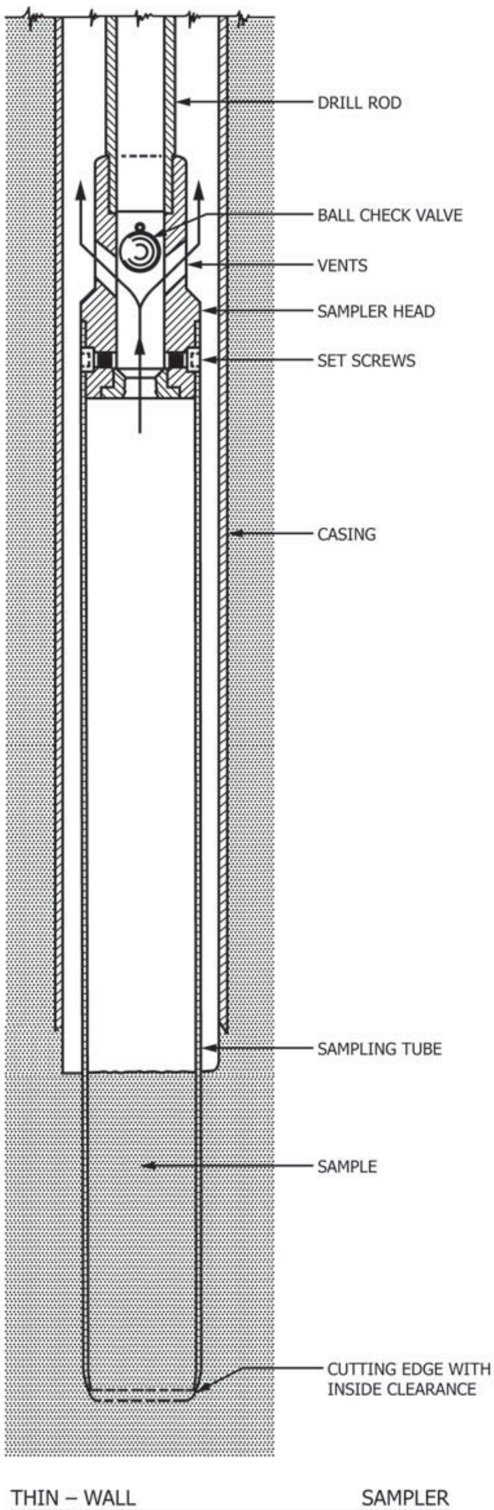


FIG. 2 Thin-Walled Tube Sampler Schematic and Operation (1)

in a drill hole. Typical sizes of thin-walled tubes are shown on Table 1. The most commonly used tube is the 3-in. [75 mm] diameter. This tube can provide intact samples for most laboratory tests; however some tests may require larger diameter tubes. Tubes with a diameter of 2 in. [50 mm] are rarely used as they often do not provide specimens of sufficient size for most laboratory testing.

TABLE 1 Suitable Thin-Walled Steel Sample Tubes[A]

Outside diameter (D_o):			
in.	2	3	5
mm	50	75	125
Wall thickness:			
Bwg	18	16	11
in.	0.049	0.065	0.120
mm	1.25	1.65	3.05
Tube length:			
in.	36	36	54
m	1.0	1.0	1.5

[A] The three diameters recommended in Table 2 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions. Wall thickness may be changed (5.2.1, 6.3.2). Bwg is Birmingham Wire Gauge (Specification A513/A513M).

5.1.1 Soil samples must undergo some degree of disturbance because the process of subsurface soil sampling subjects the soil to irreversible changes in stresses during sampling, extrusion if performed, and upon removal of confining stresses. However, if this practice is used properly, soil samples suitable for laboratory testing can be procured. Soil samples inside the tubes can be readily evaluated for disturbance or other features such as presence of fissures, inclusions, layering or voids using X-ray radiography (D4452) if facilities are available. Field extrusion and inspection of the soil core can also help evaluate sample quality.

5.1.2 Experience and research has shown that larger diameter samples (5 in. [125 mm]) result in reduced disturbance and provide larger soil cores available for testing. Agencies such as the U.S Army Corps of Engineers and US Bureau of Reclamation use 5-in. [125-mm] diameter samplers on large exploration projects to acquire high quality samples (**1, 2, 3**).[4]

5.1.3 The lengths of the thin-walled tubes (tubes) typically range from 2 to 5 ft [0.5 to 1.5 m], but most are about 3 ft [1 m]. While the sample and push lengths are shorter than the tube, see 7.4.1.

5.1.4 This type of sampler is often referred to as a "Shelby Tube."

5.2 Thin-walled tubes used are of variable wall thickness (gauge), which determines the Area Ratio (A_r). The outside cutting edge of the end of the tube is machined-sharpened to a cutting angle (Fig. 1). The tubes are also usually supplied with a machine-beveled inside cutting edge which provides the Clearance Ratio (C_r). The recommended combinations of A_r, cutting angle, and C_r are given below (also see 6.3 and Appendix X1, which provides guidance on sample disturbance).

5.2.1 A_r should generally be less than 10 to 15 %. Larger A_r of up to 25 to 30 % have been used for stiffer soils to prevent buckling of the tube. Tubes of thicker gauge may be requested when re-use is anticipated (see 6.3.2).

[4] The boldface numbers in parentheses refer to a list of references at the end of this standard.

5.2.2 The cutting edge angle should range from 5 to 15 degrees. Softer formations may require sharper cutting angles of 5 to 10 degrees, however, sharp angles may be easily damaged in deeper borings. Cutting edge angles of up to 20 to 30 degrees have been used in stiffer formations in order to avoid damage to the cutting edges.

5.2.3 Optimum C_r depends on the soils to be tested. Soft clays require C_r of 0 or less than 0.5 %, while stiffer formations require larger C_r of 1 to 1.5 %.

5.2.3.1 Typically, manufacturers supply thin-walled tubes with C_r of about 0.5 to 1.0 % unless otherwise specified. For softer or harder soils C_r tubes may require special order from the supplier.

5.3 The most frequent use of thin-walled tube samples is the determination of the shear strength and compressibility of soft to medium consistency fine-grained soils for engineering purposes from laboratory testing. For determination of undrained strength, unconfined compression or unconsoliden, undrained triaxial compression tests are often used (Test Methods D2166 and D2850). Unconfined compression tests should be only used with caution or based on experience because they often provide unreliable measure of undrained strength, especially in fissured clays. Unconsolidated undrained tests are more reliable but can still suffer from disturbance problems. Advanced tests, such as consolidated, undrained triaxial compression (Test Method D4767) testing, coupled with one dimensional consolidation tests (Test Methods D2435 and D4186) are performed for better understanding the relationship between stress history and the strength and compression characteristics of the soil as described by Ladd and Degroot, 2004 (**4**).

5.3.1 Another frequent use of the sample is to determine consolidation/compression behavior of soft, fine-grained soils using One-Dimensional Consolidation Test Methods D2435 or D4186 for settlement evaluation. Consolidation test specimens are generally larger diameter than those for strength testing and larger diameter soil cores may be required. Disturbance will result in errors in accurate determination of both yield stress (5.3) and stress history in the soil. Disturbance and sample quality can be evaluated by looking at recompression strains in the One-Dimensional Consolidation test (see Andressen and Kolstad (**5**)).

5.4 Many other sampling systems use thin-walled tubes. The piston sampler (Practice D6519) uses a thin-walled tube. However, the piston samplers are designed to recover soft soils and low-plasticity soils and the thin-walled tubes used must be of lower C_r of 0.0 to 0.5 %. Other piston samplers, such as the Japanese and Norwegian samplers, use thin-walled tubes with 0 % C_r (see Appendix X1).

5.4.1 Some rotary soil core barrels (Practice D6169-Pitcher Barrel), used for stiff to hard clays use thin-walled tubes. These samplers use high C_r tubes of 1.0 to 1.5 % because of core expansion and friction.

5.4.2 This standard may not address other composite double-tube samplers with inner liners. The double-tube samplers are thicker walled and require special considerations for an outside cutting shoe and not the inner thin-walled liner tube.

5.4.3 There are some variations to the design of the thin-walled sampler shown on Fig. 2. Figure 2 shows the standard sampler with a ball check valve in the head, which is used in fluid rotary drilled holes. One variation is a Bishop-type thin-walled sampler that is capable of holding a vacuum on the sampler to improve recovery (**1, 2**). This design was used to recover sand samples that tend to run out of the tube with sampler withdraw.

5.5 The thin-walled tube sampler can be used to sample soft to medium stiff clays[5]. Very stiff clays[5] generally require use of rotary soil core barrels (Practice D6151, Guide D6169). Mixed soils with sands can be sampled but the presence of coarse sands and gravels may cause soil core disturbance and tube damage. Low-plasticity silts can be sampled but in some cases below the water table they may not be held in the tube and a piston sampler may be required to recover these soils. Sands are much more difficult to penetrate and may require use of smaller diameter tubes. Gravelly soils cannot be sampled and gravel will damage the thin-walled tubes.

5.5.1 Research by the US Army Corps of Engineers has shown that it is not possible to sample clean sands without disturbance (**2**). The research shows that loose sands are densified and dense sands are loosened during tube insertion because the penetration process is drained, allowing grain rearrangement.

5.5.2 The tube should be pushed smoothly into the cohesive soil to minimize disturbance. Use in very stiff and hard clays with insertion by driving or hammering cannot provide an intact sample. Samples that must be obtained by driving should be labeled as such to avoid any advanced laboratory testing for engineering properties.

5.6 Thin-walled tube samplers are used in mechanically drilled boreholes (Guide D6286). Any drilling method that ensures the base of the borehole is intact and that the borehole walls are stable may be used. They are most often used in fluid rotary drill holes (Guide D5783) and holes using hollow-stem augers (Practice D6151).

5.6.1 The base of the boring must be stable and intact. The sample depth of the sampler should coincide with the drilled depth. The absence of slough, cuttings, or remolded soil in the top of the samples should be confirmed to ensure stable conditions (7.4.1).

5.6.2 The use of the open thin-walled tube sampler requires the borehole be cased or the borehole walls must be stable as soil can enter the open sampler tube from the borehole wall as it is lowered to the sampling depth. If samples are taken in uncased boreholes the cores should be inspected for any sidewall contamination.

5.6.3 Do not use thin-walled tubes in uncased fluid rotary drill holes below the water table. A piston sampler (Practice D6519) must be used to ensure that there is no fluid or sidewall contamination that would enter an open sampling tube.

5.6.4 Thin-walled tube samples can be obtained through Dual Tube Direct Push casings (Guide D6282).

[5] Soil Mechanics in Engineering Practice, Terzaghi, K. and R.B Peck, (1967) Second Edition, John Wiley & Sons, New York, Table 45.2, pg. 347.

5.6.5 Thin-walled tube samples are sometimes taken from the surface using other hydraulic equipment to push in the sampler. The push equipment should provide a smooth continuous vertical push.

5.7 Soil cores should not be stored in steel tubes for more than one to two weeks, unless they are stainless steel or protected by corrosion resistant coating or plating (6.3.2), see Note 1. This is because once the core is in contact with the steel tube, there are galvanic reactions between the tube and the soil which generally cause the annulus core to harden with time. There are also possible microbial reactions caused by temporary exposure to air. It is common practice to extrude or remove the soil core either in the field or at the receiving laboratory immediately upon receipt. If tubes are for re-use, soil cores must be extruded quickly within a few days since damage to any inside coatings is inevitable in multiple re-use. Extruded cores can be preserved by encasing the cores in plastic wrap, tin foil, and then microcrystalline wax to preserve moisture.

5.7.1 Soil cores of soft clays may be damaged in the extrusion process. In cases where the soil is very weak, it may be required to cut sections of the tube to remove soil cores for laboratory testing. See Appendix X1 for recommended techniques.

NOTE 1—The one to two week period is just guideline typically used in practice. Longer time periods may be allowed depending on logistics and the quality assurance requirements of the exploration plan.

NOTE 2—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective sampling. Users of this practice are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

6. Apparatus

6.1 *Drilling Equipment*—When sampling in a boring, any drilling equipment may be used that provides a reasonably clean hole; that minimizes disturbance of the soil to be sampled; and that does not hinder the penetration of the thin-walled sampler (Guide D6286). Open borehole diameter and the inside diameter of driven casing or hollow stem auger shall not exceed 3.5 times the outside diameter of the thin-walled tube.

6.2 *Sampler Insertion Equipment,* shall be adequate to provide a relatively rapid continuous penetration force.

6.3 *Thin-Walled Tubes*—The tubes are either steel or stainless steel although other metals may be used if they can meet the general tolerances given in Table 2 and have adequate strength for the soil to be sampled. Electrical Resistance Steel welded tubing meeting requirements of Specification A513/A513M are commonly used but it must meet the strict the SSID (Special Smooth Inside Diameter) and DOM (Drawn Over Mandrel) tolerances. Table 2 is taken from older versions of this standard, and is in general agreement with Specification A513/A513M with tubes meeting SSID and DOM requirements. Seamless steel tubing (Specification A519) meeting requirements of Table 2 may avoid problems associated with

TABLE 2 Dimensional Tolerances for Thin-Walled Tubes

Nominal Tube Diameters from Table 1[A] Tolerances						
Size Outside Diameter	2 in.	[50 mm]	3 in.	[75 mm]	5 in.	[125 mm]
Outside diameter, D_o	+0.007 -0.000	+0.179 -0.000	+0.010 -0.000	+0.254 -0.000	+0.015 -0.000	0.381 -0.000
Inside diameter, D_i	+0.000 -0.007	+0.000 -0.179	+0.000 -0.010	+0.000 -0.254	+0.000 -0.015	+0.000 -0.381
Wall thickness	±0.007	±0.179	±0.010	±0.254	±0.015	±0.381
Ovality	0.015	0.381	0.020	0.508	0.030	0.762
Straightness	0.030/ft	2.50/m	0.030/ft	2.50/m	0.030/ft	2.50/m

[A] Intermediate or larger diameters should be proportional. Specify only two of the first three tolerances; that is, D_o and D_i, or D_o and Wall thickness, or D_i and Wall thickness.

welded tube, such as improper or poor quality welds, and will have better roundness (ovality). Tubes shall be clean and free of all surface irregularities including projecting weld seams. Other diameters may be used but the tube dimensions should be proportional to the tube designs presented here. Tubes may be supplied with a light coating of oil to prevent rusting in storage. Measure the inside and outside diameters, and diameter of the cutting edge to check for ovality and C_r (6.3.2) with micrometers to ascertain that tubes meet these general tolerance requirements.

6.3.1 *Length of Tubes*—See Table 1, 7.5.1 amd Appendix X1. Use tubes at least 3 in. [75 mm] longer than the design push length to accommodate slough/cuttings.

6.3.2 *Wall Thickness of Tubes*—Table 1 shows typical wall thickness for the different diameter tubes. For heavy duty or anticipated re-use, the wall thickness can be increased. For example, a 3 in. [75 mm] tube may be increased from Bwg 16 (0.065 in.) to Bwg 14 (0.083 in). If tubes are to be re-used, they must be thoroughly cleaned and inspected prior to each re-use. Do not re-use tubes that are bent or out of round, or have damaged cutting edges, inside corrosion or corrosion coating damage. Repair re-used tube damage to the cutting edges that would disturb or obstruct passage of the core using a file to maintain a sharp cutting edge.

6.3.3 *Inside Clearance Ratio (C_r)*—Sample tubes are manufactured with the inward rolled end and machine cut inside diameter, De, to clearance ratios ranging from 0.5 to 1.0 % (Fig. 1). Special order tubes of less than 0.5%. Select the proper C_r for the soil to be tested when ordering tubes based on site conditions. Clearance ratio ranges from 0 % for very soft clays to 1.5 % for stiff soils as discussed in 5.2 and Appendix X1. In the field, if there is evidence of soil disturbance such as loose soil within the tube, samples falling out, compressed or expanded sample lengths, etc., change the C_r or push length.

6.3.3.1 A recommended tube for very soft clays with 0% C_r for 3-in. [75-mm] sample tubes is shown on Fig. 3 showing the recommended cutting angle. These special order tubes do not require the end rolling process.

6.3.4 *Corrosion Protection*—Subsection 5.7 recommends prompt extrusion of soil cores with no corrosion resistant coating. Corrosion, whether from galvanic or chemical reaction, can damage both the thin-walled tube and the soil sample. Severity of damage is a function of time as well as interaction between the sample and the tube. Thin-walled tubes should have some form of protective coating, unless the soil is

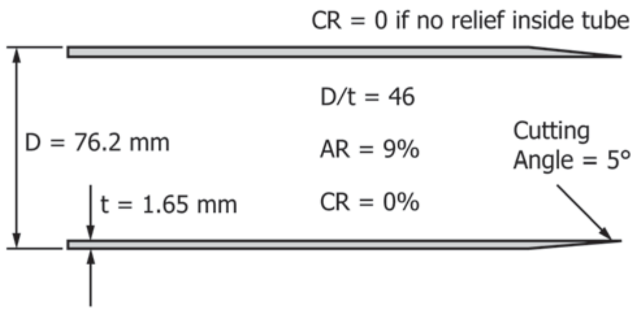


FIG. 3 Schematic of Standard 3-in. [75-mm] Thin-Walled Tube Modified by Removing the Beveled Cutting Edge and Machining a Five-Degree Cutting Angle (DeGroot and Landon (6)).

to be extruded in less than seven days. Organic or inorganic lubricants like penetrating oil and non-stick cooking spray have been used to lubricate the tube prior to sampling and also aid in extrusion and reduce friction. Tubes have been coated with lacquer or epoxy for reuse, but lacquer may not be suitable for longer storage periods and must be inspected for inside wear.

6.3.4.1 *Corrosion Resistant Tubing and Coatings*—Stainless steel and brass tubes are resistant to corrosion. Other types of coatings to be used may vary depending upon the material to be sampled. Plating of the tubes or alternate base metals may be specified. In general the coating should be of sufficient hardness and thickness to resist scratching that can occur from quartz sand particles, Nickel Electroless plating (Specification B733) has been used with good results. Galvanized tubes are often used when long term storage is required.

6.4 *Sampler Head,* serves to couple the thin-walled tube to the insertion equipment and, together with the thin-walled tube, comprises the thin-walled tube sampler. The sampler head shall contain a venting area and suitable ball check valve with the venting area to the outside equal to or greater than the area through the ball check valve. In some special cases, a ball check valve may not be required but venting is required to avoid sample compression. Fluid ports shall be designed to pass drill fluid or water through with minimal back pressure for push rates up to 1 ft [0.3 m] per second (fast push rate, 7.5).

7. Procedure

7.1 Remove loose material from the center of a casing or hollow stem auger as carefully as possible to avoid disturbance of the material to be sampled. If groundwater is encountered, maintain the liquid level in the borehole at or above groundwater level during the drilling and sampling operation.

7.2 Bottom discharge bits are not permitted. Side discharge bits may be used, with caution. Jetting through an open-tube sampler to clean out the borehole to sampling elevation is not permitted.

NOTE 3—Roller bits are available in downward-jetting and diffused-jet configurations. Downward-jetting configuration rock bits are not acceptable. Diffuse-jet configurations are generally acceptable.

7.3 Prepare and inspect the sampling tube and secure to the sampling head and drill rods. If desired or required, lubricate the inside of the tube just prior to sampling (see 6.3.4). Attachment of the head to the tube shall be concentric and coaxial to ensure uniform application of force to the tube by the sampler insertion equipment.

7.4 Lower the sampling apparatus so that the sample tube's bottom rests on the bottom of the hole and record depth to the bottom of the sample tube to the nearest 0.1 ft [0.03 m].

7.4.1 The depth at which the tube rests should agree with the previous depth of cleanout using the drill bit to within 0.2 to 0.4 ft [50 to 100 mm], indicating a stable borehole. If the depth is less than the cleanout depth there could be excessive cuttings, slough/cave, or heave of the borehole and the borehole must be re-drilled, re-cleaned and stabilized for sampling. If the depth is deeper than the cleanout depth this may be normal because the thin-walled tube will penetrate partially under the weight of the rods. If the sampler penetrates significantly while resting at the base of the boring, adjust (shorten) the push length.

NOTE 4—Using a piston sampler (D6519) may alleviate many of the problems listed above. It is useful if there is excessive slough collected in the open thin wall tubes in unstable boreholes. With the piston locked in place, the sampler can generally be pressed through slough or cuttings to the cleanout depth without sample contamination with disturbed soil.

7.4.1.1 Keep the sampling apparatus plumb during lowering, thereby preventing the cutting edge of the tube from scraping the wall of the borehole.

7.5 Advance the sampler without rotation by a continuous relatively rapid downward push using the drill head and record length of advancement to the nearest 1 in. [25 mm] or better. The push should be smooth and continuous. It should take less than 15 seconds to push a typical 3-ft [1-m] sample tube. Note any difficulties in accomplishing the required push length.

7.5.1 Determine the length of advance by the resistance and condition of the soil formation. In no case shall a length of advance be greater than the sample-tube length minus an allowance for the sampler head and a minimum of 3 in. [75 mm] for sludge and end cuttings.

7.5.2 If the drill equipment is equipped with a pressure gauge that reads the reaction to pushing at a smooth rate, this pressure can be recorded and noted during the sampling process. The noting of the difficulty or ease of pushing could be valuable to select samples for lab testing. Low pressure pushes may indicate softer or weaker soils.

NOTE 5—The mass of sample, laboratory handling capabilities, transportation problems, and commercial availability of tubes will generally limit maximum practical lengths to those shown in Table 1.

7.5.3 When the soil formation is too hard for push-type insertion, use rotary soil core barrels for stiff to hard deposits for obtaining intact samples. If a tube must be driven then record the driving method and label the tube "driven sample."

7.6 Withdraw the sampler from the soil formation as carefully as possible in order to minimize disturbance of the sample. There is no set requirement for removing the tube. The process used should avoid the loss of core and recover a full sample. Typical practice uses a waiting period of 5 to 15 minutes after sampling before withdraw. This is to both dissipate excess pore pressures from the push and to build some adherence/adhesion of the soil core inside the tube. Where the soil formation is soft, a delay before withdraw of the sampler may improve sample recovery. After the waiting period, typical practice is to rotate the sampler one revolution while in-place to shear off the bottom of the sample and relieve water or suction pressure prior to retraction. The waiting period and the shearing process may not be practical in some cases, such as deep marine sampling, and the sample can be removed without these steps as long as sample recovery is good.

7.6.1 Sometimes lower plasticity soils will fall out of the tube when the tube clears the water level inside the casing. If this occurs use a piston sampler (D6519) and/or reduce the C_r of the thin-walled tube. A lesser desired alternative is to maintain the borehole fluid level as the sample is retracted, and use a steel sheet plate or plywood to try to catch the soil core when the tube clears the fluid.

7.7 *Tube Re-Use*—If tubes are to be re-used, the soil cores must be extracted promptly and the tubes should be thoroughly cleaned using a high pressure washer or hand held cleaner that can reach fully inside the tube. Inspect the tubes for damage and discard any damaged tubes and repair the cutting edge if damaged (6.3.2).

8. Sample Measurement, Sealing and Labeling

8.1 Upon removal of the tube, remove the drill cuttings in the upper end of the tube using an insider diameter cutting tool and measure the length of the soil sample recovered to the nearest 1 in. [25 mm] or better in the tube. Recovery may be recorded, but may not be reliable due to uncertainty in removal of the upper slough, but it is important to note core loss and slippage. Seal the upper end of the tube. Remove at least 1 in. [25 mm] of material from the lower end of the tube. Use this material for soil description in accordance with Practice D2488. Measure the overall sample length to the nearest 1 in. [25 mm] or better. Seal the lower end of the tube. Alternatively, after measurement, the tube may be sealed without removal of soil from the ends of the tube.

NOTE 6—If the tubes are mass tared and their inside diameters are known, the mass of tube and soil can be determined and using the diameter and length for volume, the wet density of the soil core can be calculated. Further, the dry density can be determined using water content from the bottom trimmings. This extra information can be valuable in assisting lab selection of tubes for testing. The procedure is outlined in the Earth Manual (**3**).

8.1.1 *Sealing Tubes*—Seal and confine the soil in the tubes using either expandable packers or waxed wood discs inside the tube. Tubes sealed over the ends are generally poor quality, as opposed to those sealed with expanding packers, and should be provided with spacers or appropriate packing materials, or both prior to sealing the tube ends to provide proper confinement. Packing materials must be nonabsorbent and must maintain their properties to provide the same degree of sample support with time.

8.1.2 Samples of soft or very soft clays may require tube cutting in the laboratory for removal as opposed to extrusion (Appendix X1).

8.1.3 *Extruded Cores*—Depending on the requirements of the exploration, field extrusion and packaging of extruded soil samples can be performed. This allows for physical examination, photographing, and classification of the sample. Samples are extruded in special device equipped which includes hydraulic jacks with properly sized platens to extrude the core in a smooth continuous speed. In some cases, further extrusion may cause sample disturbance reducing suitability for testing of engineering properties. In other cases, if damage is not significant, cores can be extruded and preserved for testing (Practice D4220). Bent or damaged tubes should be cut off before extruding. Preservation of intact sections of core is normally accomplished with a layer of plastic wrap and several layers of tin foil and wax to support the soil core. The extruded cores can be placed in PVC half rounds to aid in stability. Do not seal damaged portions of the extruded cores, generally the end sections, if they are not suitable for testing.

8.2 Prepare and immediately affix labels or apply markings as necessary to identify the sample (see Section 9). Ensure that the markings or labels are adequate to survive transportation and storage.

9. Report: Field Data Sheet(s)/Log(s)

9.1 The methodology used to specify how data are recorded on the test data sheet(s)/log(s), as given below, is covered in 1.6.

9.2 Record the following general information that may be required for preparing field logs in general accordance with Guide D5434. This guide is used for logging explorations by drilling and sampling. Some examples of the information required include;

9.2.1 Name and location of the project,
9.2.2 Boring number,
9.2.3 Log of the soil conditions,
9.2.4 Location of the boring,
9.2.5 Method of making the borehole,
9.2.6 Name of the drilling foreman and company,
9.2.7 Name of the drilling inspector(s),
9.2.8 Date and time of boring-start and finish,
9.2.9 Description of thin-walled tube sampler: size, type of metal, type of coating,
9.2.10 Method of sampler insertion: push or drive, and any difficulties in accomplishing the required push length,
9.2.11 Push pressures if recorded,
9.2.12 Label any driven samples (7.5.3),
9.2.13 Method of drilling, size of hole, casing, and drilling fluid used,
9.2.14 Soil description in accordance with Practice D2488,
9.2.15 For each sample, label tubes with drill hole number and depth intervals at top and bottom and for extruded preserved cores, label the "top" and "bottom" for orientation along with the depths.

9.3 Record at a minimum the following sample data:
9.3.1 Surface elevation or reference to a datum to the nearest 0.1 ft [0.3 m] or better,
9.3.2 Drilling depths and depth to the nearest 0.1 ft [0.3 m] or better,
9.3.3 Depth to groundwater level: to the nearest 0.1 ft [0.3 m] or better, plus date(s) and time(s) measured,
9.3.4 Depth to the bottom or top of sample to the nearest 0.1 ft [0.03 m] and number of sample,

9.3.5 Length of sampler advance (push), to the nearest 0.05 ft [25 mm] or better, and

9.3.6 Recovery: length of sample obtained to the nearest 0.05 ft [25 mm] or better.

10. Keywords

10.1 geologic explorations; intact soil sampling; soil sampling; soil exploration; subsurface explorations; geotechnical exploration

APPENDIX

X1. INFORMATION REGARDING FACTORS AFFECTING THE QUALITY OF THIN-WALLED TUBE SOIL SAMPLING

(Nonmandatory Information)

X1.1 The most complete early study of soil sampling was performed by J.M. Hvorslev in 1949 (**1**) for the US Army Corps of Engineers (USACE). This study was comprehensive and reviewed all sampling methods including intact soil sampling. In this study he traces the origins of the thin-walled tube sampling practice and details regarding the design of thin-walled tubes to minimize disturbance of soils sampled for laboratory testing. This classic work is no longer available in print, however the USACE revised their Engineer Manual EM-1101-1-1804 in 2001 and it provides an excellent summary of this work.

X1.2 Either operator or mechanical factors affect the quality of thin-walled tube samples. Of course, the operator should use due care to properly drill the boreholes to ensure the soil is not disturbed at the base and to push the sampler at a smooth steady rate for proper sampling. Generally drilling too fast or pushing too fast can result in damage to the resulting sample.

X1.3 Mechanical factors include the sample diameter, sample push length, area ratio, Clearance Ratio, and edge cutting angle. It was clear in Hvorslev's work that large diameter samples 5 in. [125 mm] provided higher quality samples. The majority of soil sampling practice prefers the use of the smaller 3-in. [75-mm] tubes. When using these smaller tubes, more attention needs to be given to the factors listed above. If there are problems with sample quality, one should first consider going to a larger diameter sampler.

X1.4 Hvorslev defined and evaluated the Clearance ratio, C_r, of the sampler. Hvorslev suggested that C_r of 0 to 1 % may be used for very short samples, values of 0.5 to 3 % could be used for medium length samples, and larger may be needed for longer samples. If limited to a certain clearance ratio, the length of push can be shortened if there appears to be sample quality problems.

X1.5 For most soils, a C_r of 0.5 to 1.0 % can be used. C_r should be adjusted for the soil formation to be sampled. In general softer soils require lower C_r and stiffer soils require a higher C_r as they have a tendency to expand. Cohesive soils and slightly expansive soils require larger C_r, while soils with little or no cohesion require little or no clearance ratio.

X1.6 Piston samplers are designed to sample difficult to recover non-plastic or low plasticity soils and soft to very soft clays and thus require use of C_r of 0 to 0.5 %. Use of commercially supplied tubes with 1 % clearance ratio will result in complete core loss in low plasticity soils. A smaller clearance ratio of 0 to 0.5 % must be used or piston samplers can be used. Thin-walled tubes for rotary soil core barrels such as the Pitcher Sampler used in stiff soils generally require higher C_r of 1-2 % (**2**). Use of a larger C_r allows for larger push lengths. The US Army Corps of Engineers uses 5 in. [125 mm] diameter piston sampler tubes pushed 4 ft [1.2 m] with commercially available 0.5 to 1 % C_r with good success in soft normally consolidated clays. Having the larger diameter core allows one to tolerate some core annulus disturbance with good specimens still in the central portion of the core. Core annulus disturbance can be evaluated in lake deposits by allowing sections of cores to dry and evaluating the lake bed layering with attention to the damage at the annulus of the sample.

X1.7 Manufacturers supply thin-walled tubes with pre-made C_r of 0.5 to 1.0 %. You must custom order other clearance ratios. If you are going to sample a soft formation you need to custom order tubes with lower clearance ratios.

X1.8 Table X1.1 below shows some recommended C_r for various soil types and moisture conditions and was included in ASTM D6169 (Table 7). These are estimates from experienced drillers and may be used as a guide but the estimates are based on large diameter samples 5-in. [125 mm] with short push lengths (2.5 ft [0.8 m]) and may not apply to smaller diameter tubes.

X1.9 Research has been conducted comparing the ASTM D1587 thin-walled tubes to other samplers used around the world. Tanaka, et al. (**7**) compared the ASTM thin-walled tube to other samplers including the Japanese Piston sampler, Laval Sampler and NGI samplers. The results of this research showed very poor results with ASTM 3-in. [75-mm] tubes with very low Unconfined Compression test results (D2166). There are other studies on sample quality comparing the ASTM thin-walled tube to other samplers, but all these studies neglected

TABLE X1.1 General Recommendations for Thin-Wall, Open Push-Tube Sampling

Soil type	Moisture condition	Consistency	Length of push, cm [in.]	Bit clearance ratio, %	Push tube sampler recovery	Recommendation for better recovery
Gravel			Thin-wall, open push tube samplers not suitable			
Sand	Moist	Dense	46 [18]	0 to ½	Fair to poor	
Sand	Moist	Loose	30 [12]	½	Poor	Recommend piston sampler
Sand	Saturated	Dense	45 to 60 [18 to 24]	0	Poor	Recommend piston sampler
Sand	Saturated	Loose	30 to 45 [12 to 18]	0	Poor	Recommend piston sampler
Silt	Moist	Firm	45 [18]	½	Fair to good	
Silt	Moist	Soft	30 to 45 [12 to 18]	½	Fair	
Silt	Saturated	Firm	45 to 60 [18 to 24]	0	Fair to poor	Recommend piston sampler
Silt	Saturated	Soft	30 to 45 [12 to 18]	0 to ½	Poor	Recommend piston sampler
Clay and shale	Dry to saturated	Hard	Thin wall, open push tube sampler not suitable			Recommend double-tube sampler
Clay	Moist	Firm	45 [18]	½ to 1	Good	
Clay	Moist	Soft	30 to 45 [12 to 18]	1	Fair to good	
Clay	Saturated	Firm	45 to 60 [18 to 24]	0 to 1	Good	
Clay	Saturated	Soft	45 to 60 [18 to 24]	½ to 1	Fair to poor	Recommend piston sampler
Clay	Wet to saturated	Expansive	45 to 110 [18 to 44]	½ to 1-½	Good	

the determination of C_r of the thin-walled tubes used. Thin-walled tubes were likely purchased from manufacturers with the typical 0.5 to 1 % clearance ratio which is not recommended for soft clays.

X1.10 Lunne, et al., (8) published a study of samplers where the clearance ratios were noted. The study confirms that larger push lengths can be used successfully with higher C_r in the larger diameter the NGI sampler uses this.

X1.11 DeGroot and Landon (6) published recommendations for thin-walled tube sampling of soft clays. The recommendations stress the lower clearance ratios required for thin-walled tubes that are incorporated into this revision of the standard. Also contained in this report are recommendations by Ladd and DeGroot (4) that detail how to remove sections of the thin-walled tube without extrusion of the core.

X1.12 Evaluations of sample quality

X1.12.1 Soil samples inside the tubes can be readily evaluated for disturbance or other features such as presence of fissures, inclusions, layering or voids using X-ray Radiography (D4452) if facilities are available. The X-ray method is excellent for checking for badly disturbed specimens and also very advantageous to locate where to cut specimens for laboratory testing. Field extrusion of soil cores and also show any indications of excessive disturbance. When performing field extrusion and preservation, do not preserve areas that are excessively damaged, only seal and wax the most intact sections of the core.

X1.12.2 In the laboratory disturbance of the soil cores and overall sample quality can be evaluated using the One-Dimensional Consolidation test (D2435) using methods proposed by Andressen and Kolstad (5). The amount of recompression up to the estimated pre-stress or existing ground stress should be small in high quality samples. Recompression in consolidated shear strength tests can also be used.

(1) Hvorslev, M.J., 1949, Subsurface Exploration and Sampling of Soils for Engineering Purposes, report of a research project of the Committee on Sampling and Testing, Soil Mechanics and Foundations Division, American Society of Civil Engineers, Waterways Experiment Station, US Army Corps of Engineers, Vicksburg Mississippi, re-published by Engineering Foundation 1960

(2) Engineer Manual 1101-1-1804, 2001, Geotechnical Investigations, US Army Corps of Engineers, Washington D.C. http://140.194.76.129/publications/eng-manuals/

(3) Bureau of Reclamation, 1990, Earth Manual, 3rd Edition, Part 2, Test method USBR 7105 on Undisturbed Sampling of Soil by Mechanical Methods, Bureau of Reclamation, Denver CO.

(4) Ladd, C.C., and D.J., DeGroot, "Recommended Practice for Soft Ground Site Characterization: Arthur Casagrande Lecture," 12th Pan-American Conference on Soil Mechanics and Geotechnical Engineering, Massachusetts Institute of Technology, Cambridge, MA, June 22-25, 2003, revised May 9 2004.

(5) Andressen, A. AA., and Kolstad, P., 1979, "The NGI 154-mm Samplers for Undisturbed Sampling of Clays and representative Sampling of Coarser Materials," State of the Art on Current Practice of Soil Sampling, Proceedings of the International Symposium of Soil Sampling, The Subcommittee on Soil Sampling, International Society for Soil Mechanics and Foundation Engineering.

(6) DeGroot, D., J., and Landon, M., M., "Synopsis of Recommended Practice for Sampling and Handling of Soft Clays to Minimize Sample Disturbance," Geotechnical and Geophysical Site Characterization, Huang & Mayne (eds), Taylor and Francis Group, London, 2008

(7) Tanaka, H., Sharma, P., Tsuchida, T., and Tanaka, M., "Comparative Study on Sample Quality Using Several Types of Samplers," Soils and Foundations, Vol. 36, No. 2, 57-68, June 1996

(8) Lunne, T., Berre, T., Andersen, K.H., Strandvick, S., and M. Sjursen, (2006), "Effects of Sample Disturbance and Consolidation Procedures on Measured Shear Strength of Soft Marine Norwegian Clays, Can. Geotech. J 43: 726-750

INTERNATIONAL

Designation: D1586 – 11

Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils[1]

This standard is issued under the fixed designation D1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative disturbed soil sample for identification purposes, and measure the resistance of the soil to penetration of the sampler. Another method (Test Method D3550) to drive a split-barrel sampler to obtain a representative soil sample is available but the hammer energy is not standardized.

1.2 Practice D6066 gives a guide to determining the normalized penetration resistance of sands for energy adjustments of N-value to a constant energy level for evaluating liquefaction potential.

1.3 Test results and identification information are used to estimate subsurface conditions for foundation design.

1.4 Penetration resistance testing is typically performed at 5-ft depth intervals or when a significant change of materials is observed during drilling, unless otherwise specified.

1.5 This test method is limited to use in nonlithified soils and soils whose maximum particle size is approximately less than one-half of the sampler diameter.

1.6 This test method involves use of rotary drilling equipment (Guide D5783, Practice D6151). Other drilling and sampling procedures (Guide D6286, Guide D6169) are available and may be more appropriate. Considerations for hand driving or shallow sampling without boreholes are not addressed. Subsurface investigations should be recorded in accordance with Practice D5434. Samples should be preserved and transported in accordance with Practice D4220 using Group B. Soil samples should be identified by group name and symbol in accordance with Practice D2488.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this test method.

1.8 The values stated in inch-pound units are to be regarded as standard, except as noted below. The values given in parentheses are mathematical conversions to SI units, which are provided for information only and are not considered standard.

1.8.1 The gravitational system of inch-pound units is used when dealing with inch-pound units. In this system, the pound (lbf) represents a unit of force (weight), while the unit for mass is slugs.

1.9 Penetration resistance measurements often will involve safety planning, administration, and documentation. This test method does not purport to address all aspects of exploration and site safety. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Performance of the test usually involves use of a drill rig; therefore, safety requirements as outlined in applicable safety standards (for example, OSHA regulations,[2] NDA Drilling Safety Guide,[3] drilling safety manuals, and other applicable state and local regulations) must be observed.

2. Referenced Documents

2.1 *ASTM Standards:*[4]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D854 Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

[1] This method is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluations.

Current edition approved Nov. 1, 2011. Published December 2011. Originally approved in 1958. Last previous edition approved in 2008 as D1586 – 08a. DOI: 10.1520/D1586-11.

[2] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., NW, Washington, DC 20210, http://www.osha.gov.

[3] Available from the National Drilling Association, 3511 Center Rd., Suite 8, Brunswick, OH 44212, http://www.nda4u.com.

[4] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
D2216 Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4220 Practices for Preserving and Transporting Soil Samples
D4633 Test Method for Energy Measurement for Dynamic Penetrometers
D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D6026 Practice for Using Significant Digits in Geotechnical Data
D6066 Practice for Determining the Normalized Penetration Resistance of Sands for Evaluation of Liquefaction Potential
D6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
D6913 Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions of terms included in Terminology D653 specific to this practice are:

3.1.2 *cathead, n*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.1.3 *drill rods, n*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.1.4 *N-value, n*—the blow count representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows (*N*) required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.1.5 *Standard Penetration Test (SPT), n*—a test process in the bottom of the borehole where a split-barrel sampler having an inside diameter of either 1-1/2-in. (38.1 mm) or 1-3/8-in. (34.9 mm) (see Note 2) is driven a given distance of 1.0 ft (0.30 m) after a seating interval of 0.5 ft (0.15 m) using a hammer weighing approximately 140-lbf (623-N) falling 30 ± 1.0 in. (0.76 m ± 0.030 m) for each hammer blow.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *anvil, n*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2.2 *drive weight assembly, n*—an assembly that consists of the hammer, anvil, hammer fall guide system, drill rod attachment system, and any hammer drop system hoisting attachments.

3.2.3 *hammer, n*—that portion of the drive-weight assembly consisting of the 140 ± 2 lbf (623 ± 9 N) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.2.4 *hammer drop system, n*—that portion of the drive-weight assembly by which the operator or automatic system accomplishes the lifting and dropping of the hammer to produce the blow.

3.2.5 *hammer fall guide, n*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.2.6 *number of rope turns, n*—the total contact angle between the rope and the cathead at the beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.2.7 *sampling rods, n*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

4. Significance and Use

4.1 This test method provides a disturbed soil sample for moisture content determination, for identification and classification (Practices D2487 and D2488) purposes, and for laboratory tests appropriate for soil obtained from a sampler that will produce large shear strain disturbance in the sample such as Test Methods D854, D2216, and D6913. Soil deposits containing gravels, cobbles, or boulders typically result in penetration refusal and damage to the equipment.

4.2 This test method provides a disturbed soil sample for moisture content determination and laboratory identification. Sample quality is generally not suitable for advanced laboratory testing for engineering properties. The process of driving the sampler will cause disturbance of the soil and change the engineering properties. Use of the thin wall tube sampler (Practice D1587) may result in less disturbance in soft soils. Coring techniques may result in less disturbance than SPT sampling for harder soils, but it is not always the case, that is, some cemented soils may become loosened by water action during coring; see Practice D6151, and Guide D6169.

4.3 This test method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate blow count, or *N*-value, and the engineering behavior of earthworks and foundations are available. For evaluating the liquefaction potential of sands during an earthquake event, the *N*-value should be normalized to a standard overburden stress level. Practice D6066 provides methods to obtain a record of

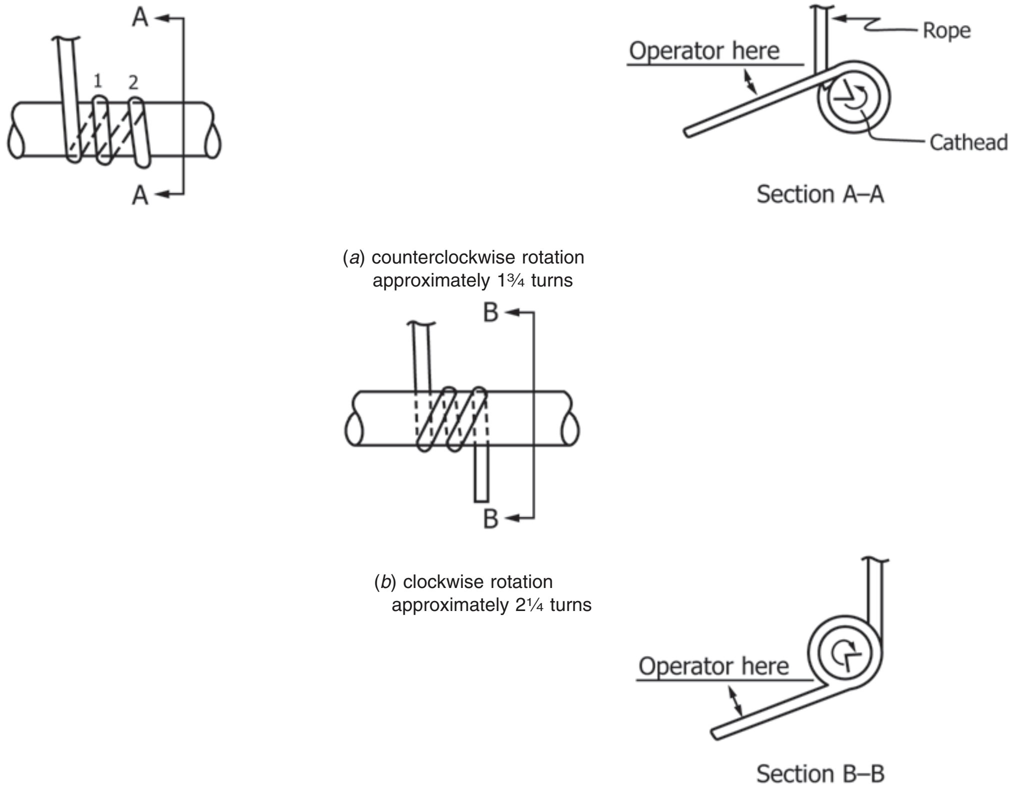


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead

normalized resistance of sands to the penetration of a standard sampler driven by a standard energy. The penetration resistance is adjusted to drill rod energy ratio of 60 % by using a hammer system with either an estimated energy delivery or directly measuring drill rod stress wave energy using Test Method D4633.

NOTE 1—The reliability of data and interpretations generated by this practice is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 generally are considered capable of competent testing. Users of this practice are cautioned that compliance with Practice D3740 does not assure reliable testing. Reliable testing depends on several factors and Practice D3740 provides a means of evaluating some of these factors. Practice D3740 was developed for agencies engaged in the testing, inspection, or both, of soils and rock. As such, it is not totally applicable to agencies performing this practice. Users of this test method should recognize that the framework of Practice D3740 is appropriate for evaluating the quality of an agency performing this test method. Currently, there is no known qualifying national authority that inspects agencies that perform this test method.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitable borehole before insertion of the sampler and ensures that the penetration test is performed on intact soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions:

5.1.1 *Drag, Chopping, and Fishtail Bits,* less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits,* less than 6½ in. (165 mm) and greater than 2¼ in. (57 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers,* with or without a center bit assembly, may be used to drill the borehole. The inside diameter of the hollow-stem augers shall be less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers,* less than 6½ in. (165 mm) and not less than 2¼ in. (57 mm) in diameter may be used if the soil on the side of the borehole does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod that has an outside diameter of 1-5/8 in. (41.3 mm) and an inside diameter of 1-1/8 in. (28.5 mm).

5.3 *Split-Barrel Sampler*—The standard sampler dimensions are shown in Fig. 2. The sampler has an outside diameter of 2.00 in. (50.8 mm). The inside diameter of the of the split-barrel (dimension D in Fig. 2) can be either 1½-in. (38.1 mm) or 1⅜-in. (34.9 mm) (see Note 2). A 16-gauge liner can be used inside the 1½-in. (38.1 mm) split barrel sampler. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The penetrating end of the drive shoe may be slightly rounded. The split-barrel sampler must be equipped with a ball check and vent. Metal or plastic baskets may be used to retain soil samples.

NOTE 2—Both theory and available test data suggest that *N*-values may differ as much as 10 to 30 % between a constant inside diameter sampler and upset wall sampler. If it is necessary to correct for the upset wall sampler refer to Practice D6066. In North America, it is now common practice to use an upset wall sampler with an inside diameter of 1½ in. At one time, liners were used but practice evolved to use the upset wall sampler without liners. Use of an upset wall sampler allows for use of retainers if needed, reduces inside friction, and improves recovery. Many other countries still use a constant ID split-barrel sampler, which was the original standard and still acceptable within this standard.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lbf (623 ± 9 N) and shall be a rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting an unimpeded fall shall be used. Fig. 3 shows a schematic of such hammers. Hammers used with the cathead and rope method shall have an unimpeded over lift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged as shown in Fig. 3. The total mass of the hammer assembly bearing on the drill rods should not be more than 250 ± 10 lbm (113 ± 5 kg).

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

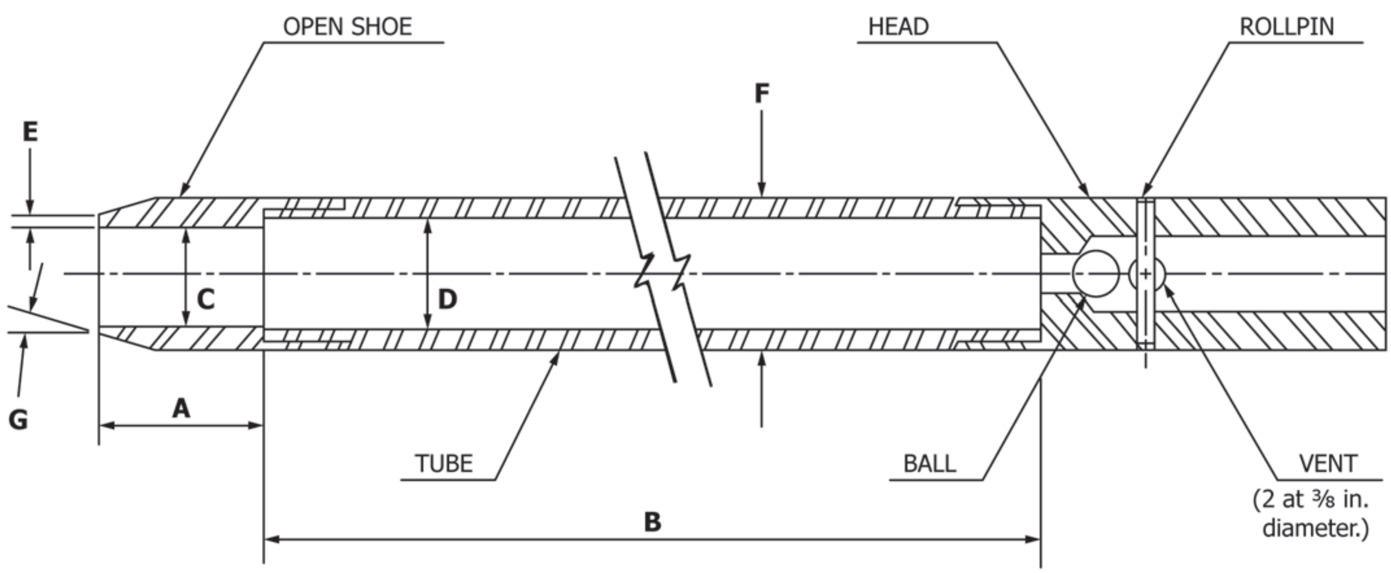
5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The borehole shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 m) or less in homogeneous strata with test and sampling locations at every change of strata. Record the depth of drilling to the nearest 0.1 ft (0.030 m).

6.2 Any drilling procedure that provides a suitably clean and stable borehole before insertion of the sampler and assures that the penetration test is performed on essentially intact soil shall be acceptable. Each of the following procedures has proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 – 0.00 in. (38.1 ± 1.3 – 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 – 0.00 in. (50.8 ± 1.3 – 0.0 mm)
G = 16.0° to 23.0°

FIG. 2 Split-Barrel Sampler

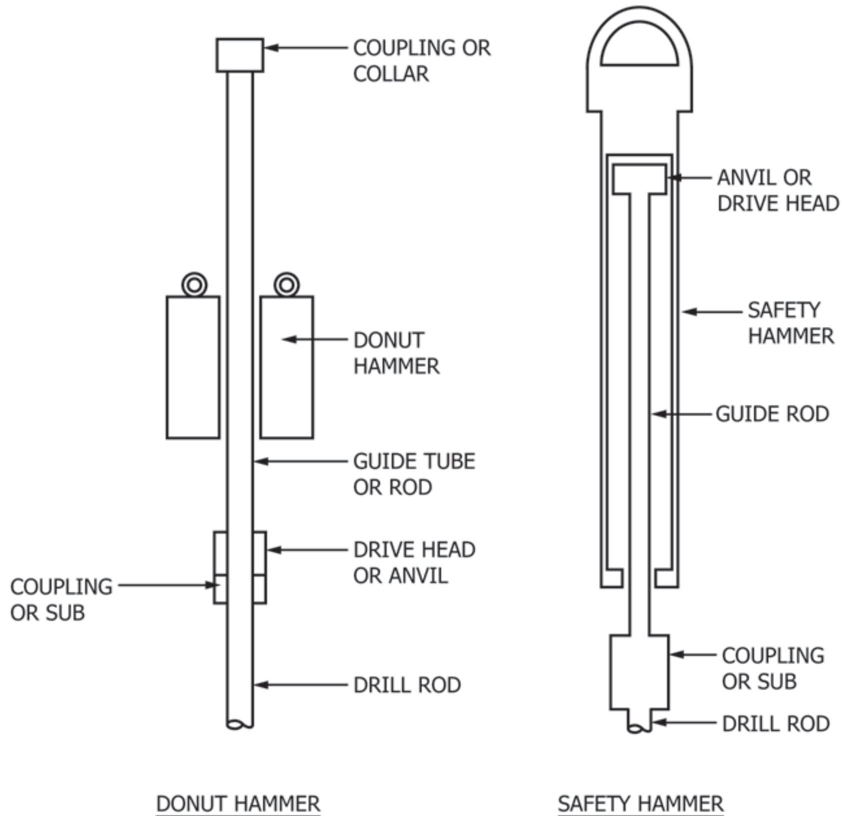


FIG. 3 Schematic Drawing of the Donut Hammer and Safety Hammer

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable boreholes. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the borehole below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a borehole with bottom discharge bits is not permissible. It is not permissible to advance the borehole for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the borehole or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the borehole has been advanced to the desired sampling elevation and excessive cuttings have been removed, record the cleanout depth to the nearest 0.1 ft (0.030 m), and prepare for the test with the following sequence of operations:

7.1.1 Attach either split-barrel sampler Type A or B to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the borehole. Record the sampling start depth to the nearest 0.1 ft (0.030 m). Compare the sampling start depth to the cleanout depth in 7.1. If excessive cuttings are encountered at the bottom of the borehole, remove the sampler and sampling rods from the borehole and remove the cuttings.

7.1.4 Mark the drill rods in three successive 0.5-ft (0.15 m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 0.5-ft (0.15 m) increment.

7.2 Drive the sampler with blows from the 140-lbf (623-N) hammer and count the number of blows applied in each 0.5-ft (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 0.5-ft (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 1.5 ft. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.2.5 If the sampler sinks under the weight of the hammer, weight of rods, or both, record the length of travel to the nearest 0.1 ft (0.030 m), and drive the sampler through the remainder of the test interval. If the sampler sinks the complete interval, stop the penetration, remove the sampler and sampling rods from the borehole, and advance the borehole through the very soft or very loose materials to the next desired sampling elevation. Record the *N*-value as either weight of hammer, weight of rods, or both.

7.3 Record the number of blows (*N*) required to advance the sampler each 0.5-ft (0.15 m) of penetration or fraction thereof. The first 0.5-ft (0.15 m) is considered to be a seating drive. The sum of the number of blows required for the second and third 0.5-ft (0.15 m) of penetration is termed the "standard penetration resistance," or the "*N*-value." If the sampler is driven less than 1.5 ft (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 0.5-ft (0.15 m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 0.1 ft (0.030 m) in addition to the number of blows. If the sampler advances below the bottom of the borehole under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lbf (623-N) hammer shall be accomplished using either of the following two methods. Energy delivered to the drill rod by either method can be measured according to procedures in Test Method D4633.

7.4.1 *Method A*—By using a trip, automatic, or semi-automatic hammer drop system that lifts the 140-lbf (623-N) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 0.030 m) with limited unimpedence. Drop heights adjustments for automatic and trip hammers should be checked daily and at first indication of variations in performance. Operation of automatic hammers shall be in strict accordance with operations manuals.

7.4.2 *Method B*—By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM.

7.4.2.3 The operator should generally use either 1-3/4 or 2-1/4 rope turns on the cathead, depending upon whether or not the rope comes off the top (1-3/4 turns for counterclockwise rotation) or the bottom (2-1/4 turns for clockwise rotation) of the cathead during the performance of the penetration test, as shown in Fig. 1. It is generally known and accepted that 2-3/4 or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be stiff, relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, limp, or burned.

7.4.2.4 For each hammer blow, a 30 ± 1.0 in. (0.76 m ± 0.030 m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically without holding the rope at the top of the stroke.

NOTE 4—If the hammer drop height is something other than 30 ± 1.0 in. (0.76 m ± 0.030 m), then record the new drop height. For soils other than sands, there is no known data or research that relates to adjusting the *N*-value obtained from different drop heights. Test method D4633 provides information on making energy measurement for variable drop heights and Practice D6066 provides information on adjustment of *N*-value to a constant energy level (60 % of theoretical, N60). Practice D6066 allows the hammer drop height to be adjusted to provide 60 % energy.

7.5 Bring the sampler to the surface and open. Record the percent recovery to the nearest 1 % or the length of sample recovered to the nearest 0.1 ft (30 mm). Classify the soil samples recovered as to, in accordance with Practice D2488, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 0.5-ft (150-mm) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel. Samples should be preserved and transported in accordance with Practice D4220 using Group B.

8. Data Sheet(s)/Form(s)

8.1 Data obtained in each borehole shall be recorded in accordance with the Subsurface Logging Guide D5434 as required by the exploration program. An example of a sample data sheet is included in Appendix X1.

8.2 Drilling information shall be recorded in the field and shall include the following:

8.2.1 Name and location of job,

8.2.2 Names of crew,

8.2.3 Type and make of drilling machine,

8.2.4 Weather conditions,

8.2.5 Date and time of start and finish of borehole,

8.2.6 Boring number and location (station and coordinates, if available and applicable),

8.2.7 Surface elevation, if available,

8.2.8 Method of advancing and cleaning the borehole,

8.2.9 Method of keeping borehole open,

8.2.10 Depth of water surface to the nearest 0.1 ft (30 mm) and drilling depth to the nearest 0.1 ft (30 mm) at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.2.11 Location of strata changes, to the nearest 0.5 ft (150 mm),

8.2.12 Size of casing, depth of cased portion of borehole to the nearest 0.1 ft (30 mm),

8.2.13 Equipment and Method A or B of driving sampler,

8.2.14 Sampler length and inside diameter of barrel, and if a sample basket retainer is used,

8.2.15 Size, type, and section length of the sampling rods, and

8.2.16 Remarks.

8.3 Data obtained for each sample shall be recorded in the field and shall include the following:

8.3.1 Top of sample depth to the nearest 0.1 ft (30 mm) and, if utilized, the sample number,

8.3.2 Description of soil,

8.3.3 Strata changes within sample,

8.3.4 Sampler penetration and recovery lengths to the nearest 0.1 ft (30 mm), and

8.3.5 Number of blows per 0.5 ft (150 mm) or partial increment.

9. Precision and Bias

9.1 *Precision*—Test data on precision is not presented due to the nature of this test method. It is either not feasible or too costly at this time to have ten or more agencies participate in an in situ testing program at a given site.

9.1.1 The Subcommittee 18.02 is seeking additional data from the users of this test method that might be used to make a limited statement on precision. Present knowledge indicates the following:

9.1.1.1 Variations in *N*-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent boreholes in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, *N*-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.1.1.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in *N*-values obtained between operator-drill rig systems.

9.2 *Bias*—There is no accepted reference value for this test method, therefore, bias cannot be determined.

10. Keywords

10.1 blow count; in-situ test; penetration resistance; soil; split-barrel sampling; standard penetration test

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE DATA SHEET

X1.1 See Fig. X1.1.

DRILLERS BORING LOG

Project: ______________________ **Project No:** ______________ **Boring No:** ________

Location: ______________________ Sheet ______ of ______

Date Started: __________ **Date Completed:** ______________

Drill Crew:

Boring Location
Station __________ Offset ________

Elevation

Strata Depth		Soil Description and Remarks	Sample Type	No.	Depth		Recovery	N-Values		
From	To				From	To		6"	5"	6"

Drill Rig Type ______________________

Method of Drilling:

Auger ____________ Size ________________

Wash _______ Water _______ Mud _______

Hammer Type

Auto ____________ Manual ____________

Split-Spoon Type

Length ____________ Liner Used ____________

Boring Size ____________ Bit Used ____________

Casing Size ____________ Length ________________

Weather ______________________

Non-Drilling Time (Hrs.)

Boring Layout ________ Moving ________

Hauling Water ________ Standby ________

Water Level @ ________ Date ______ Time ______

@ ________ Date ______ Time ______

@ ________ Date ______ Time ______

Cave-in Depth

@ ________ Date ______ Time ______

FIG. X1.1 Example Data Sheet

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this test method since the last issue, D1586–08a, that may impact the use of this test method. (Approved November 1, 2011.)

(*1*) Corrected misuse of significant digits.

Appendix D
Corrective Action Report

Corrective Action Report/ Corrective Action Plan

Project ID	Project Name	Document ID

Preparer's Signature/Submit Date	Submitted to:

Description of the requirement or specification	
Reason for the Corrective Action	
Location, affected sample, affected equipment, etc. requiring corrective action	
Suggested Corrective Action	(Continue on Back)
Corrective Action Plan	(Continue on Back) ☐ Approval signature/date:______ Approval of corrective actions required by EPA? ☐ Yes ☐ No ☐ EPA approval name/date:______ ☐ Corrective actions completed name/date:______
Preventative Action Plan	(Continue on Back) ☐ Preventative actions completed name/date:______

Corrective Action Report/
Corrective Action Plan

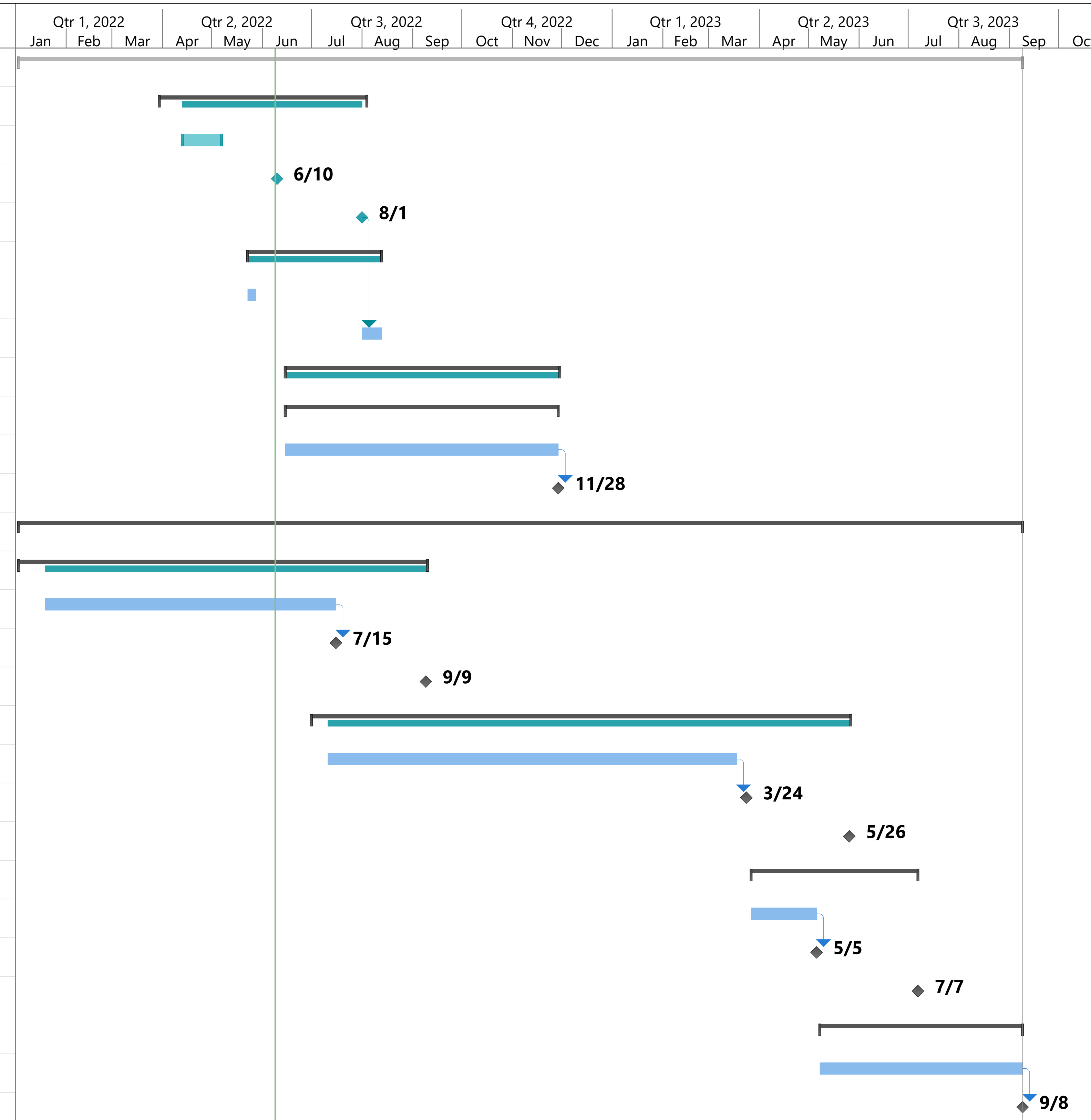
Suggested Corrective Action (Continued)	
Corrective Action Plan (Continued)	
Preventative Action Plan (Continued)	

Attachment 2
Draft BPSOU Subdrain Pump Station Project Schedule

Attachment 2

DRAFT BPSOU PUMP STATION PROJECT SCHEDULE

ID	Task Name	Duration	Start	Finish
0	**BPSOU Pump Station Design Schedule**	**440 days**	**Mon 1/3/22**	**Fri 9/8/23**
1	**Pre-Design Subdrain Pump Station Documentation**	**91 days**	**Wed 3/30/22**	**Wed 8/3/22**
2	Draft RDWP, PDI WP, and QAPP	18 days	Wed 4/13/22	Fri 5/6/22
3	Submit Draft RDWP, PDI WP and QAPP to Agencies	0 days	Fri 6/10/22	Fri 6/10/22
4	Submit Final RDWP, PDI WP, and QAPP	0 days	Mon 8/1/22	Mon 8/1/22
5	**Field Investigation**	**60 days**	**Mon 5/23/22**	**Fri 8/12/22**
6	Preliminary Safety Review	5 days	Mon 5/23/22	Fri 5/27/22
7	Geotechnical Investigation	10 days	Mon 8/1/22	Fri 8/12/22
8	**Reporting**	**120 days**	**Wed 6/15/22**	**Tue 11/29/22**
9	**PDI Evaluation Report**	**119 days**	**Wed 6/15/22**	**Mon 11/28/22**
10	Prepare Draft	119 days	Wed 6/15/22	Mon 11/28/22
11	Submit Draft Final to Agencies	0 days	Mon 11/28/22	Mon 11/28/22
12	**Design Activities**	**440 days**	**Mon 1/3/22**	**Fri 9/8/23**
13	**Preliminary (30%) Design Report**	**180 days**	**Mon 1/3/22**	**Fri 9/9/22**
14	Draft 30% Design Documents	128 days	Wed 1/19/22	Fri 7/15/22
15	Submit Draft Final to Agencies	0 days	Fri 7/15/22	Fri 7/15/22
16	Submit Comment Response to Agencies	0 days	Fri 9/9/22	Fri 9/9/22
17	**Intermediate (60%) Design Report**	**236 days**	**Fri 7/1/22**	**Fri 5/26/23**
18	Draft 60% Design	180 days	Mon 7/11/22	Fri 3/17/23
19	Submit Draft Final to Agencies	0 days	Fri 3/24/23	Fri 3/24/23
20	Submit Comment Response to Agencies	0 days	Fri 5/26/23	Fri 5/26/23
21	**Pre-Final (95%) Design Report**	**74 days**	**Mon 3/27/23**	**Fri 7/7/23**
22	Draft 95% Design	30 days	Mon 3/27/23	Fri 5/5/23
23	Submit Draft Final to Agencies	0 days	Fri 5/5/23	Fri 5/5/23
24	Submit Comment Response to Agencies	0 days	Fri 7/7/23	Fri 7/7/23
25	**Final (100%) Design Report**	**90 days**	**Mon 5/8/23**	**Fri 9/8/23**
26	Draft Final Design	90 days	Mon 5/8/23	Fri 9/8/23
27	Submit Final to Agencies	0 days	Fri 9/8/23	Fri 9/8/23



Project: BPSOU Pump Station Design Schedule
Date: Thu 6/9/22

Summary Progress	Summary	Inactive Summary	Manual Summary	External Milestone
Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress