Naval Facilities Engineering Systems Command

BRAC Program Management Office East
Philadelphia, Pennsylvania

Final
Work Plan for SCWO Treatability Study for Destruction of PFAS on Spent GAC and IX Resin

Former Naval Air Station Joint Reserve Base Willow Grove
Horsham Township, Pennsylvania

November 2023

FINAL
WORK PLAN FOR SCWO TREATABILITY STUDY FOR DESTRUCTION OF PFAS ON SPENT GAC AND IX RESIN

FORMER NAVAL AIR STATION JOINT RESERVE BASE WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Department of the Navy
Base Closure and Realignment Program Management Office East
4911 S. Broad Street
Philadelphia, Pennsylvania 19112

Submitted by:
Tetra Tech
4433 Corporation Lane, Suite 300
Virginia Beach, Virginia 23462

CONTRACT NUMBER N6247016D9008
CONTRACT TASK ORDER WE04

NOVEMBER 2023

PREPARED UNDER THE DIRECTION OF:

Tricia E Moore

TRICIA E. MOORE, PG
PROJECT MANAGER
TETRA TECH
KING OF PRUSSIA, PENNSYLVANIA

APPROVED FOR SUBMISSION BY:

STEVEN H. RUFFING, P.E.
PROGRAM MANAGER
TETRA TECH
VIRGINIA BEACH, VIRGINIA

This page intentionally left blank

Table of Contents

List of Appendices

List of Tables

List of Figures

Acronyms and Abbreviations

°C	Degrees Celsius
µg/hr	Microgram per hour
µg/kg	Microgram per kilogram
µg/L	Microgram per liter
µM	Micromoles
AFFF	Aqueous film-forming foam
APP	Accident Prevention Plan
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLEAN	Comprehensive Long-Term Environmental Action Navy
CTO	Contract Task Order
DE	Defluorination efficiency
DL	Detection limit
DO	Dissolved oxygen
DoD	Department of Defense
DOT	Department of Transportation
DRE	Destruction and removal efficiency
DV	Data validation
DVM	Data Validation Manager
EDD	Electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
ELLE	Eurofins Lancaster Laboratories Environment Testing, LLC
EMS	Electromagnetic Systems

EPA	Environmental Protection Agency
FOL	Field operations leader
g	Gram
GA	General Atomics
GAC	Granular activated carbon
GLS	Gas-liquid separator
GWETS	Groundwater extraction and treatment system
HP	High pressure
HSM	Health and Safety Manager
IDW	Investigation-derived waste
IX	Ion exchange
L/hr	Liter per hour
LOD	Limit of detection
LOQ	Limit of quantitation
LP	Low pressure
mL	Milliliter
MS	Matrix spike
MSD	Matrix spike duplicate
NASJRB	Naval Air Station Joint Reserve Base
NAVFAC	Naval Facilities Engineering Systems Command
NIRIS	Naval Installation Restoration Information Solution
NPL	National Priorities List
ORP	Oxidation-reduction potential
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl

PDF	Portable document format
PFAS	Per- and polyfluoroalkyl substances
PM	Project Manager
PMO	Program Management Office
PPE	Personal protective equipment
Psig	Pound per square inch gauge
PSL	Project screening level
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QC	Quality control
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RPM	Remedial Project Manager
SCWO	Supercritical water oxidation
SME	Subject Matter Expert
SOP	Standard operating procedure
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SVOC	Semi-volatile organic compound
TBD	To be determined
TOF	Total organic fluorine
VOC	Volatile organic compound

This page intentionally left blank

1.0 Introduction

This supercritical water oxidation (SCWO) treatability study work plan was prepared for the Hangar 680 pilot test system at the Former Naval Air Station Joint Reserve Base (NASJRB) Willow Grove, Horsham Township, Pennsylvania, under the United States Navy Comprehensive Long-term Environmental Action Navy Contract (CLEAN) Contract Number N6247016D9008, Contract Task Order (CTO) WE04.

1.1 Purpose and Scope

The purpose of the treatability study is to evaluate the effectiveness of SCWO treatment for the destruction of per- and polyfluoroalkyl substances (PFAS) on spent granular activated carbon (GAC) and ion exchange (IX) resin generated from PFAS treatment at the Hangar 680 pilot test system. This work plan presents details of the sampling required to establish the baseline characterization prior to treatment and demonstrate the destruction efficiency of the SCWO treatment. The GAC used for PFAS treatment at Hangar 680 pilot test system was Hydrosil HS-AC coconut shell activated carbon. IX resin used for treatment was Purolite PFA694 polystyrene crosslinked with divinylbenzene. This treatability study will be conducted at the General Atomics (GA) facility located in San Diego, California. The scope of work governed by this work plan is for collecting solid, liquid, and air samples, as detailed below.

Matrix: Solid	Matrix: Liquid	Matrix: Gas
Spent Media (solid)	Free (liquid)	Effluent (gas)
Filter Residue (solid)	Influent (liquid)	
	Influent (slurry)	
	Effluent (liquid)	
	Condensate (liquid)	

This work plan documents the sampling activities and performance monitoring to be conducted to establish baseline characterization and evaluate the SCWO treatment to destroy PFAS in the spent GAC and IX resin for full-scale applicability. It also includes a summary of background information.

1.2 SCWO Treatability Study Objectives

The following are the objectives of the SCWO Treatability Study:

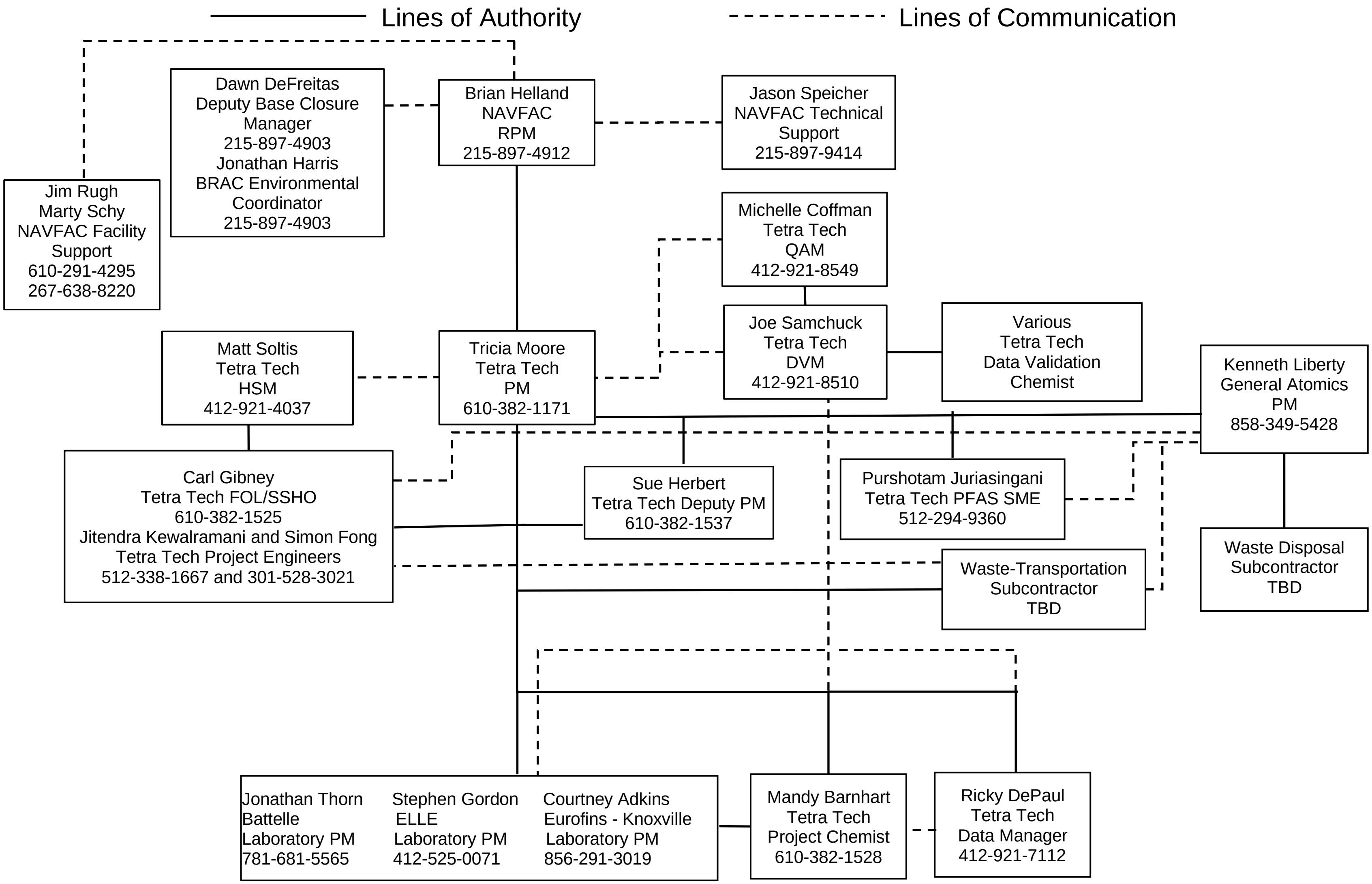
- Evaluate the performance of SCWO treatment for destroying PFAS on spent GAC and IX resin.
- Identify any operational constraints for implementing a full-scale SCWO treatment for destruction of PFAS on spent media.
- Evaluate the performance information on both the suitability and process cost of SCWO treatment.

1.3 Project Team Organization

The chart on the next page shows the project team, roles, and contact information. The communication pathways for the project team are detailed in Appendix A.

1.4 Facility and Site Location and Overview

The former NASJRB Willow Grove is located in Horsham Township in Montgomery County, Pennsylvania (Figure 1-1). Former NASJRB Willow Grove occupied approximately 900 acres of the 1,100 acres of land the Department of Defense (DoD) maintained at the Air Station. The primary mission of former NASJRB Willow Grove was to provide support for aviation training operations and to train Navy reservists. Former NASJRB Willow Grove supported other DoD tenants, such as the Marine Reserve and the Army Reserve, and shared facilities and services with the Air Force Reserve. Former NASJRB Willow Grove was placed on the National Priorities List (NPL) in September 1995. The NPL identifies facilities that appear to warrant remedial action financed under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), also known as the federal Superfund program. The former NASJRB Willow Grove was selected for closure in 2005 by the Base Realignment and Closure (BRAC) Commission and was officially disestablished on March 30, 2011. The Base continued to provide services and facilities on a limited basis until September 2011, at which time it was transferred to the BRAC Program Management Office (PMO) and entered caretaker status (a non-operational condition in which the facility undergoes limited preservation status to protect it against fire, vandalism/theft, and damage from the elements). The Horsham Land Redevelopment Authority coordinates decisions regarding future land use at the former NASJRB Willow Grove.



Note: All Tetra Tech staff have communication access to the HSM and QAM at all times, especially if health and safety or quality incidents adverse to personnel safety or work performance are identified.

BRAC – Base Closure and Realignment
FOL – Field Operations Leader
PM – Project Manager
SME – Subject Matter Expert
NAVFAC – Naval Facilities Engineering Systems Command
DVM – Data Validation Manager
HSM – Health and Safety Manager
QAM – Quality Assurance Manager
TBD – To be determined
RPM – Remedial Project Manager
SSHO – Site Safety and Health Officer
QAO – Quality Assurance Officer
ELLE – Eurofins Lancaster Laboratories Environment Testing, LLC

Tetra Tech is currently conducting the Phase II Remedial Investigation (RI) for PFAS. The highest concentrations of PFAS in soil and groundwater at the former NASJRB are in the vicinity of Hangar 680 and nearby structures. This collective area is referred to as the Hangar 680 Area. A fire station was also located approximately 1,000 feet upgradient of the hangar area (Figure 1-1). The Hangar 680 Area was used for aircraft maintenance. Aqueous film-forming foam (AFFF) fire suppression systems were used in this area, and AFFF concentrate was stored in aboveground tanks.

In 2018, the Navy approved implementing an on-base pilot testing system for the control and treatment of high PFAS concentrations in groundwater at the Hangar 680 Area. The Hanger 680 pilot test system started in August 2019 and is still operating as of October 2023. The system has been monitored continuously during operation, and some maintenance and design optimization changes have been made over time. The Hangar 680 pilot test system is being implemented in anticipation of a new groundwater extraction and treatment system (GWETS). Other co-contaminants present in the groundwater, at low concentrations, are volatile organic compounds (VOC), semi-volatile organic compounds (SVOC), phenol, and metals. The Hangar 680 pilot test system is treating co-contaminants, along with PFAS, and these co-contaminants can accumulate on the GAC over time.

In June 2023, the Navy approved a media changeout for a portion of the Hangar 680 pilot test system, which is comprised of lead and lag GAC vessels followed by a series of four IX resin vessels (lead, mid-1, mid-2, and lag vessels). Spent GAC in lead and lag GAC vessels was replaced with new GAC. Similarly, spent IX resin from lead and mid-1 IX resin vessels were replaced with new IX resin. The product specification sheets for GAC and IX resin are included in Appendix B. Several drums with spent media were generated during the June 2023 changeout event, and these drums are currently stored at Hangar 680 Area. Two drums with spent GAC and two drums with spent IX resin will be shipped to the GA facility for use in the SCWO treatability testing.

1.5 Document Organization

The remainder of this document is organized as follows:

Section 2.0 – SCWO Treatability Study Description.

Section 3.0 – Project Implementation.

Section 4.0 – References.

2.0 SCWO Treatability Study Description

This section describes the design for sampling spent GAC and IX resin to establish the baseline characterization prior to the treatability study, as well as the design of post-treatment analysis to meet the SCWO treatability study objectives.

2.1 Problem Statement

The Hangar 680 pilot test system for the extraction and treatment of high PFAS concentrations in groundwater is underway, and as part of this pilot test, GAC and IX resin are used to remove PFAS from extracted groundwater. Periodically, the spent GAC and IX resin needs to be replaced with new media to allow continuous PFAS removal. The spent media can be sent off-site for disposal or treatment. The SCWO treatability study will test the efficacy of destroying PFAS on spent GAC and IX resin used in the Hangar 680 pilot test system. The Navy plans to collect data to establish baseline characterization and demonstrate the efficacy of the SCWO treatment. The design of the SCWO treatability study is explained in detail in the GA work plan (Appendix C).

2.2 Sampling Design and Rationale

This section provides the site-specific sampling approach that will be used for the SCWO treatability study. Sampling activities will be performed to establish baseline characterization of the spent media (GAC and IX resin) before SCWO treatment. Sampling of media after SCWO treatment will evaluate the PFAS destruction efficacy of the SCWO treatment. It will enable the Project Team to calculate the percent destruction and removal efficiency (DRE), the percent defluorination efficiency (DE), and percent of organic fluorine removal. This work plan has been developed to ensure the amount, type, and quality of data are sufficient to determine the rate and extent of PFAS degradation or defluorination achieved in the waste stream using the SCWO treatment.

2.2.1 Sampling of spent GAC and IX Resin from Drums at Hangar 680 Area for Baseline Characterization

The Tetra Tech field team will collect two composite solid samples to evaluate baseline characterization, one from the drums filled with spent GAC and one from the drums filled with spent IX resin. The composite samples will be prepared by taking sample aliquots from the material at the top of the drums and from twelve inches below the media surface. Aliquot samples will be collected from two depths in each drum to get representative samples of GAC or IX resin at the media-air/water interface and a small distance (12 inches) from the interface. The total mass of each aliquot sample (for both IX resin and GAC) should be 150 grams (g). The aliquot sample will be collected from two drums with spent GAC and two drums with spent IX resin that will be shipped to the GA facility for use in the SCWO treatability testing. The composite solid samples for spent media (IX resin or GAC) will be prepared by mixing the aliquots collected from the drums, thereby providing representative composite samples. Composite samples will be analyzed for PFAS concentrations and other chemical characteristics, including VOC, SVOC, polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB), anions (bromide, chloride, fluoride, sulfate, nitrate, nitrite), metals, percent solid, and total organic fluorine (TOF).

The Tetra Tech field team will also collect aliquot samples of free liquid in the drums filled with spent IX resin. These aliquots will be mixed to prepare a composite liquid sample for baseline characterization. The total volume of each aliquot sample should be 250 milliliters (mL). The composite liquid sample will be analyzed for PFAS, TOF, VOC, PCB, anions, and metals. There is no free liquid in the drums filled with spent GAC media; therefore, no liquid sample will be collected from those drums. Table 2-1 shows the rationale for sampling spent media stored at the Hangar 680 Area. Field quality control (QC) samples will be collected as part of the investigation, including field duplicates, field blanks, matrix spike (MS), and matrix spike duplicates (MSD).

2.2.2 Transportation of Drums to GA facility and RCRA Sampling of Spent GAC and IX Resin from Drums

Tetra Tech will hire a subcontractor to provide transportation of the GAC and IX resin drums to the GA facility. The subcontractor will sample and conduct Resource Conservation and Recovery Act (RCRA) analyses for spent GAC and IX resin beads according to Department of Transportation (DOT) regulations for non-hazardous waste material shipping. This task involves sampling two drums containing spent GAC and two drums containing spent IX resin that will be shipped to the GA facility for the SCWO treatability study. Although the baseline sampling and analysis of spent GAC and IX resin before SCWO treatment will be performed by Tetra Tech, the sampling, and analysis for RCRA and DOT regulations will be performed by the subcontractor hired by Tetra Tech. Sampling and analysis for RCRA and DOT regulations are outside the scope of this work plan.

As stated above, the subcontractor will transport two drums containing spent IX resin and two drums containing spent GAC to the GA facility. The subcontractor is responsible for providing the necessary equipment and materials for pickup, loading, and securing the drums and for the transport of the drums to their destination. These drums will be placed on secondary containment pallets provided by the subcontractor. The subcontractor will provide Tetra Tech with a contact number for the transporter and a bill of lading/shipping manifest.

2.2.3 SCWO Treatment

The standard GA-Electromagnetic Systems (EMS) SCWO treatment combines organic materials with water, fuel, and air at a temperature of 650°C (degree Celsius) to 700°C and a pressure of 221 bar (approximately 3,200 pounds per square inch gauge [psig]) in a continuous flow reactor configuration. At supercritical conditions, water exhibits unique properties that facilitate its waste destruction capabilities. Typically, organics that are insoluble in water at ambient conditions are miscible with supercritical water. Similarly, gaseous oxygen and oxidation products are miscible with supercritical water. The oxidant and organic waste are, therefore, combined in a single, dense phase with minimal mass transport limitations, thus allowing rapid and complete destruction of virtually any organic waste feed.

The SCWO process effectively oxidizes organic materials to yield carbon dioxide, water, and nitrogen. Inorganic salts and metal oxides can also be found in the liquid effluent stream if anions and metal cations are present in the feed materials. The GA SCWO system has been shown to oxidize organic compounds, including chemical wastes, PFAS, pesticides, petrochemical solvents, and oily sludge, into inert liquids, gases, and salts.

The typical SCWO skid configuration consists of various pumps that deliver the desired fluids to the reactor, a high pressure (HP) air compressor, a startup fuel-fired preheater, a HP reactor, a pressure letdown system, a low-pressure (LP) gas-liquid separator (GLS), and various holding tanks for feeds and effluent as shown in Figure 2-1.

2.2.4 Sampling Conducted at GA During SCWO Treatment

At the GA facility, SCWO treatment will be performed on (spent) GAC and IX resin slurry. An influent (slurry) sample for each test (i.e., for both the GAC and IX resin tests) will be prepared by mixing spent media with soft water (with 0.2 percent xanthan gum). Soft water is the city tap water that passes through a soft water tank to remove minerals that cause hardness. The slurry/spent media and soft water mixture will be ground via an in-line grinder to prepare the tested influent (slurry) mix. Before each influent slurry test, a startup test will be performed using soft water only. Influent (liquid), effluent (liquid), and effluent (gas) samples will be collected from the SCWO treatment system during the startup test to demonstrate the absence of PFAS in the treatment chamber.

Post-treatment samples of GAC and IX resin effluent (liquid), condensate (liquid), filter residue (solid), and effluent (gas) will be collected from the SCWO treatment system. Tetra Tech field operation leader (FOL) will be present at the GA facility during the treatability study to oversee the treatment and collect the samples. These samples will be collected and analyzed to demonstrate the destruction efficiency of the SCWO treatment. Depending on the performance of the SCWO treatment, a filter may not be used, or filter residue may not be generated. The decision to use a filter will be made based on the visual inspection of the effluent generated from the study.

PFAS analytical data for effluent (liquid) and condensate (liquid) are needed to evaluate the DRE of the SCWO treatment system, and anion concentration data is needed to evaluate the DE of SCWO treatment. TOF analytical data for effluent (liquid) and condensate (liquid) are needed to evaluate the organic fluorine mass removal efficiency of SCWO treatment. In contrast, metal data is needed to evaluate the water chemistry of the effluent liquid.

PFAS analytical data for filter residue (solid) and effluent (gas) will be used to evaluate the DRE of SCWO treatment. TOF analytical data for both will be used to evaluate the organic fluorine mass removal efficiency of SCWO treatment. Analysis of anions from filter residue (solid) sample will be used to evaluate the DE of SCWO treatment. Sampling locations for influent (liquid), influent (slurry), effluent (liquid), condensate (liquid), filter residue (solid), and effluent (gas) on the SCWO treatment system are shown in Figure 2-1.

All samples collected during the study will be conducted in accordance with the GA work plan (Appendix C). Samples at startup and testing and during the operation of the SCWO system to destroy PFAS on each spent medium (GAC and IX resin) will be collected by the Tetra Tech FOL:

For startup testing (testing performed on soft water [only])

- Influent (liquid) sample will be collected at the beginning of startup testing
- Effluent (liquid) sample will be collected at the end of startup testing
- Effluent (gas) sample will be collected during the entire startup testing period

For testing performed on GAC and IX resin

- Two influent (slurry) samples will be collected. The first sample will be collected once a steady state condition is reached (operating temperature and pressure are reached), and the second sample will be collected after one hour of run time.

- Five effluent (liquid) samples will be collected. The first sample will be collected once a steady state condition is reached, and the rest of the samples will be collected at intervals every 45 minutes over the treatment time.
- One condensate (liquid) sample will be collected at the end of the test.
- One filter residue (solid) sample will be collected at the end of the test.
- One effluent (gas) sample will be collected once per test during the entire startup testing period.

The two influent (slurry) samples will be collected and held throughout the test, as this matrix presents an analytical challenge. PFAS analysis of slurry samples is currently unreliable. This is because the solid content is too high in the slurry for extraction as a water, and the water content is too high for extraction as a solid. This is amplified by the fact that the solid portion is GAC and IX resin, which will hold onto the PFAS. The phases would need to be analyzed separately, and 100 percent separation is not possible and the surfactant nature of PFAS can result in non-uniform distribution of PFAS. The samples are being collected for potential PFAS analysis if more analytical techniques are developed. Samples will be stored at the GA facility for the duration of the project period. Samples will be disposed of properly after the final report is submitted to the Navy. Table 2-2 shows rationales for sampling activity at GA facility. Field QC samples will be collected as part of the GA facility investigation, including field duplicates, field blanks, MS, and MSDs.

These data will be used to evaluate the performance of the SCWO treatment for PFAS-impacted spent media. If possible, fluorine mass balance will be calculated using the DRE, DE, and percent organic fluorine removal.

Destruction Removal Efficiency (DRE): The DRE calculation is based on the percent difference between the influent (slurry) mass flow rate for individual PFAS and the summed mass flow rates for individual PFAS from the effluent (liquid), condensate (liquid), filter residue (solid), and effluent (gas) (McDonough et al., 2021; Chiang et al., 2023; Krause et al., 2022; EPA, 2022).

The influent mass flow rate for an individual PFAS in the influent (slurry) feed will be calculated using Equation 2-1:

$$M_{x,inf}\left(\frac{\mu g}{hr}\right) = C_{x,inf}\left(\frac{\mu g}{L}\right) * Q_{inf}\left(\frac{L}{hr}\right) \tag{2-1}$$

Where:

$M_{x,inf}$ is the influent (slurry) mass flow rate (microgram per hour [µg/hr]) for an individual PFAS
$C_{x,inf}$ is the concentration of an individual PFAS in the influent (slurry) in micrograms per liter (µg/L)
Q_{inf} is the influent (slurry) flow rate (liters per hour [L/hr])

Individual PFAS concentrations in the spent media (GAC and IX resin) and influent (liquid [soft water]) will be used to determine the concentration for influent PFAS ($C_{x,inf}$) using Equation 2-2. Please note that the slurry processed in the SCWO reactor will be prepared by mixing soft water and grounded spent media (see GA workplan, Appendix C).

$$C_{x,inf}\left(\frac{\mu g}{L}\right) = \left(C_{x,SM}\left(\frac{\mu g}{kg}\right) * S\left(\frac{kg}{L}\right)\right) + C_{x,SW}\left(\frac{\mu g}{L}\right) \tag{2-2}$$

Where:

$C_{x,SM}$ is the analytically determined concentration for an individual PFAS in the spent media (micrograms per kilogram [µg/kg])
S is the solid concentration of spent media (GAC or IX resin) in feed influent (slurry) (kilogram per liter [kg/L])
$C_{x,SW}$ is analytically determined concentration for individual PFAS in soft water (µg/L)

The summed mass flow rate of individual PFAS in the effluent (liquid), condensate (liquid), effluent (gas), and filter residue (solid) will be calculated using Equation 2-3:

$$M_{x,tot-eff}\left(\frac{\mu g}{hr}\right) = M_{x,liq}\left(\frac{\mu g}{hr}\right) + M_{x,gas}\left(\frac{\mu g}{hr}\right) + M_{x,cond}\left(\frac{\mu g}{hr}\right) + M_{x,filt}\left(\frac{\mu g}{hr}\right) \tag{2-3}$$

Where:

$M_{x,tot-eff}$ is the total effluent mass flow rate for individual PFAS $\left(\frac{\mu g}{hr}\right)$
$M_{x,liq}$ is the effluent (liquid) mass flow rate for an individual PFAS $\left(\frac{\mu g}{hr}\right)$
$M_{x,gas}$ is the effluent (gas) mass flow rate for individual PFAS $\left(\frac{\mu g}{hr}\right)$
$M_{x,cond}$ is the condensate (liquid) mass flow rate for individual PFAS $\left(\frac{\mu g}{hr}\right)$
$M_{x,filt}$ is the filter residue (solid) mass flow rate for individual PFAS $\left(\frac{\mu g}{hr}\right)$
$M_{x,liq},\ M_{x,gas},\ M_{x,cond},\ and\ M_{x,filt}$ will be calculated using Equations 2-4, 2-5, 2-6, and 2-7, respectively.

$$M_{x,liq}\left(\frac{\mu g}{hr}\right) = C_{x,liq}\left(\frac{\mu g}{L}\right) * Q_{liq}\left(\frac{L}{hr}\right) \tag{2-4}$$

$$M_{x,gas}\left(\frac{\mu g}{hr}\right) = \frac{C_{x,gas}\left(\frac{\mu g}{sample}\right)}{V_{gas}(L)} * Q_{gas}\left(\frac{L}{hr}\right) \tag{2-5}$$

$$M_{x,cond}\left(\frac{\mu g}{hr}\right) = \frac{C_{x,cond}\left(\frac{\mu g}{L}\right) * V_{cond}(L)}{t_{runtime}(hr)} \tag{2-6}$$

$$M_{x,filt}\left(\frac{\mu g}{hr}\right) = \frac{C_{x,filt}\left(\frac{\mu g}{kg}\right) * M_{filt}(kg)}{t_{runtime}(hr)} \tag{2-7}$$

Where:

$C_{x,liq}$ is the analytically determined concentration for an individual PFAS in effluent (liquid) $\left(\frac{\mu g}{L}\right)$
Q_{liq} is the effluent (liquid) flow rate $\left(\frac{L}{hr}\right)$
$C_{x,gas}$ is analytically determined concentration for an individual PFAS in effluent (gas) sample (in micrograms per sample [$\mu g/sample$])
V_{gas} is the volume of gas sampled for PFAS analysis (liter [L])
Q_{gas} is the effluent (gas) flow rate $\left(\frac{L}{hr}\right)$
$C_{x,cond}$ is the analytically determined concentration for an individual PFAS in condensate (liquid) $\left(\frac{\mu g}{L}\right)$
V_{cond} is the volume of condensate (liquid) sampled (L)
$t_{runtime}$ is the run time for the test (hour [hr])

$C_{x,filt}$ is the analytically determined concentration for an individual PFAS in filter residue (solid) $\left(\frac{\mu g}{kg}\right)$
M_{filt} is the mass of filter residue collected (kg)

The variables above will be used to calculate percent DRE using Equation 2-8.

$$\%DRE = \frac{M_{x,inf}\left(\frac{\mu g}{hr}\right) - M_{x,tot-eff}\left(\frac{\mu g}{hr}\right)}{M_{x,inf}\left(\frac{\mu g}{hr}\right)} * 100\% \qquad (2\text{-}8)$$

Defluorination Efficiency (DE): The DE calculation is based on the percent of the PFAS molecule in influent (slurry) that is converted into the fluoride ions (i.e., the PFAS destruction product) in the effluent stream (the sum of effluent [liquid], condensate [liquid], and filter residue [solid]). DE. will be calculated using Equation 2-9 (McDonough et al., 2021, Chiang et al., 2023, Krause et al., 2022; EPA, 2022). Please note that any fluoride released in effluent gas (e.g., the fluoride ion dissolved in the steam being discharged from the reactor) will not be measured in this treatability study, as measurement of hydrogen fluoride is outside the scope of this project.

$$\sum overall\ \%deF_x = \frac{C_{tot-eff\ F^-}(\mu M)}{\sum C_{organic-F}(\mu M)} * 100\% \qquad (2\text{-}9)$$

Where:

$C_{tot-eff\ F^-}$ is the summed molar concentration (micromoles [µM]) of fluoride in the total effluent (liquid), condensate (liquid,) and filter residue (solid), which will be calculated using Equation 2-10

$$C_{tot-eff\ F^-}(\mu M) = C_{liq\ F^-}\ (\mu M) + C_{cond\ F^-}(\mu M) + C_{filt\ F^-}(\mu M) \qquad (2\text{-}10)$$

Where:

$Cliq\ F-$ is the analytically determined molar concentration (µM) of fluoride in the effluent (liquid)
$Ccond\ F-$ is the analytically determined molar concentration (µM) of fluoride in the condensate (liquid)
$Cfilt\ F-$ is the analytically determined molar concentration (µM) of fluoride in the filter residue (solid)
$Corganic{-}F$ is the initial molar concentration (µM) of organic fluorine (initially bound in PFAS), which will be calculated using Equation 2-11

$$\sum C_{organic-F} = \sum [C_{x,inf,\mu\mathrm{M}}(\mu\mathrm{M}) * N_{c-F}] \qquad (2\text{-}11)$$

Where:

$C_{x,inf,\mu\mathrm{M}}$ is the molar concentration (µM) of an individual PFAS in the influent (slurry)

The molar concentration (µM) for an analyte will be determined using Equation 2-12 and analytically determined concentration in ($\frac{\mu g}{L}$) for the analyte.

$$\mu M = PPB/mm \qquad (2\text{-}12)$$

Where:

μM is the concentration of analyte in micromole/liter (µM)
PPB is the analytically determined concentration of analyte in $\left(\frac{\mu g}{L}\right)$
mm is the molar mass of the analyte
N_{c-F} is the number of carbon-fluorine bond within that respective PFAS compound (unitless, positive whole number)

Percent Organic Fluorine Removal: The percent organic fluorine calculation is based on the percent difference between the TOF mass of influent (slurry) feed and the summed TOF mass in the effluent stream (i.e., the sum of effluent [liquid], condensate [liquid], effluent [gas], and filter residue [solid]). This value will be calculated using Equation 2-13.

$$\%TOF_{removal} = \frac{M_{TOF,inf}(\mu\mathrm{g}) - M_{TOF,tot-eff}(\mu\mathrm{g})}{M_{TOF,inf}(\mu\mathrm{g})} * 100\% \qquad (2\text{-}13)$$

Where:

$M_{TOF,inf}$ is the mass of TOF mass in the influent (slurry) (microgram[µg])
$M_{TOF,tot-eff}$ is the summed mass (µm) of TOF in the effluent (liquid), condensate (liquid), effluent (gas), and filter reside (solid), which can be calculated using Equation 2-14

The mass of TOF in the spent media (GAC and IX resin) and influent (liquid [soft water]) will be used to determine the mass of TOF for influent PFAS ($M_{TOF,inf}$) using Equation 2-15. Please note that the slurry processed in the SCWO reactor will be prepared by mixing soft water and grounded spent media (see GA workplan, Appendix C).

$$\begin{aligned} M_{TOF,tot-eff}(\mu\mathrm{g}) &= M_{TOF,liq}\,(\mu\mathrm{g}) + M_{TOF,gas}\,(\mu\mathrm{g}) \\ &\quad + M_{TOF,cond}\,(\mu\mathrm{g}) + M_{TOF,filt}\,(\mu\mathrm{g}) \end{aligned} \tag{2-14}$$

$$M_{TOF,inf}(\mu\mathrm{g}) = M_{TOF,SM}\,(\mu\mathrm{g}) + M_{TOF,SW}\,(\mu\mathrm{g}) \tag{2-15}$$

Where:

$M_{TOF,liq}$ is the mass (µg) of TOF in the effluent (liquid)
$M_{TOF,gas}$ is the mass (µg) of TOF in the effluent (gas)
$M_{TOF,filt}$ is the mass (µg) of TOF in the filter residue (solid)
$M_{TOF,SM}$ is the mass (µg) of TOF in the spent media (solid)
$M_{TOF,Sw}$ is the mass (µg) of TOF in the soft water (liquid)

$M_{TOF,SM}$, $M_{TOF,Sw}$, $M_{TOF,liq}$, $M_{TOF,gas}$, $M_{TOF,cond}$, and $M_{TOF,filt}$ will be calculated using Equations 2-16, 2-17, 2-18, 2-19, 2-20, and 2-21 respectively.

$$M_{TOF,SM}(\mu g) = C_{TOF,SM}\left(\frac{\mu g}{kg}\right) * S\left(\frac{kg}{L}\right) * V_{Slurry}(L) \tag{2-16}$$

$$M_{TOF,Sw}(\mu g) = C_{TOF,Sw}\left(\frac{\mu g}{L}\right) * V_{Slurry}(L) \tag{2-17}$$

$$M_{TOF,liq}(\mu g) = C_{TOF,liq}\left(\frac{\mu g}{L}\right) * V_{liq}(L) \tag{2-18}$$

$$\begin{aligned} M_{TOF,gas}(\mu g) = {} & \left(C_{TOF,gas}\left(\frac{\mu g}{Sample}\right)/V_{gas}(L)\right) * Q_{gas}\left(\frac{L}{hr}\right) \\ & * t_{runtime}(hr) \end{aligned} \tag{2-19}$$

$$M_{TOF,cond}\,(\mu g) = C_{TOF,cond}\left(\frac{\mu g}{L}\right) * V_{cond}(L) \tag{2-20}$$

$$M_{TOF,filt}\,(\mu g) = C_{TOF,filt}\left(\frac{\mu g}{kg}\right)\star * M_{filt}(kg) \tag{2-21}$$

Where:

$C_{TOF,SM}$ is the analytically determined concentration of TOF in the spent media ($\frac{\mu g}{kg}$)
V_{Slurry} is the volume of slurry processed in SCWO (L)
$C_{TOF,Sw}$ is the analytically determined concentration of TOF in the soft water (liquid) ($\frac{\mu g}{kg}$)
$C_{TOF,liq}$ is the analytically determined concentration of TOF in the effluent (liquid) ($\frac{\mu g}{kg}$)
V_{liq} is the volume of effluent processed in SCWO (L)

$C_{TOF,gas}$ is the analytically determined concentration of TOF in the effluent (gas) ($\frac{\mu g}{kg}$)

$C_{TOF,cond}$ is the analytically determined concentration of TOF in the condensate (liquid) ($\frac{\mu g}{kg}$)

$C_{TOF,filt}$ is the analytically determined concentration of TOF in the filter residue (solid) ($\frac{\mu g}{kg}$)

A list of equation variables used, associated samples, and analyte group are included in Appendix D.

2.2.5 Project Screening Levels

No project screening levels (PSL) are applicable to this study, as it is being conducted to establish the baseline characterization of spent media and to demonstrate the destruction efficiency of the SCWO treatment. The selected laboratories will report detection limits (DL) for PFAS and non-PFAS target analytes, as presented in Appendix E. The following conventions must be used to report analytical laboratory data:

- Report all results for solid media on a dry-weight basis.
- Classify all results less than the DL as non-detect.
- Report non-detects at the limit of detection (LOD) with a “U” flag on the final electronic data deliverables (EDD).
- Report positive results at concentrations between the DL and limit of quantitation (LOQ) with a “J” flag. These results will be used as reported but with consideration for the additional uncertainty represented by the J flags.

2.3 Boundaries of the Study

Spatial Boundaries

There are no spatial boundaries for the study.

Temporal Boundaries

There are no temporal boundaries for the study. Sample collection is expected to take place during two sampling events. One sampling event will occur for one day in fall 2023 for collecting spent GAC and IX resin (solid) and free (liquid) samples from the drums at the Hangar 680 Area for establishing baseline characterization. The second sampling event will occur over two days in early spring 2024 and will involve collecting influent (liquid), influent (slurry), effluent (liquid), condensate (liquid), filter residue (solid), and effluent (gas) samples for demonstrating the SCWO treatment's destruction efficiency of PFAS on spent GAC and IX resin.

3.0 Project Implementation

This section provides information about project tasks that will be completed in the field. The field tasks are summarized below.

- Mobilization/demobilization (including site-specific health and safety training)
- Monitoring equipment calibration
- Collecting field measurements
- Sample management
- Data handling and management
- Investigation-derived waste (IDW) management

3.1 Mobilization/Demobilization

This task involves preparing for the field activities and demobilizing from the Hangar 680 Area and GA facility upon completion. Following approval of this work plan, Tetra Tech will begin mobilizing the necessary field support equipment and supplies. Site mobilization will consist of preparation for field activities and will include (but is not limited to) the completion of the following tasks:

- Coordinate site access
- Perform sampling training and orientation
- Obtain all equipment required to perform field activities and sample collection
- Identify and prepare locations for all field activities
- Coordinate sample types, analyses, and sampling schedules with the laboratory

As part of demobilization, equipment and supplies will be collected, inventoried, and returned as appropriate. All field investigation paperwork will be filed and docketed in the project file.

Tetra Tech will prepare a list of all equipment and supplies necessary for the field team to perform the field activities. The equipment and supplies will include (but are not limited to) the following:

- Documents, forms, logbooks, log sheets, labels, custody seals, airbills, and other paperwork required by the work plan and Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP).

- Vehicles for personnel, equipment, and sample transport.

- Personnel and equipment decontamination supplies and equipment required by the work plan and APP/SSHP.
- Media sampling field analytical equipment and calibration standards for all required parameters of the work plan.
- Required sample containers.
- Equipment and supplies for sample custody, preservation, and packaging.
- Other miscellaneous office and field supplies.

Tetra Tech FOL will collect samples at Hangar 680 Area for establishing baseline characterization and at the GA facility to demonstrate PFAS destruction in spent media. For sample collection at the GA facility during the SCWO treatment, site access to the sampling points will be coordinated through the GA project engineer, who will assist the Tetra Tech FOL during sample collection.

During the required training and orientation, all field team members will review the work plan and will be given site-specific health and safety training based on the APP/SSHP. It will also be necessary to provide orientation and health and safety training for any additional or replacement field team members assigned after the initial mobilization. A field team orientation meeting will be held to familiarize personnel with the scope of the field activities.

The field team will obtain the required equipment and supplies from the Tetra Tech offices and transport them to the GA facility for staging. Any equipment not available at the Tetra Tech offices will be purchased or rented by Tetra Tech. Equipment will be re-stocked, replaced, or repaired as needed.

3.2 Monitoring Equipment Calibration

The calibration of monitoring, measuring, or testing equipment is necessary to ensure the proper operation and response of equipment, to document the accuracy, sensitivity, or precision of the measurements, and to determine if correction should be applied to the readings. Each instrument requiring calibration will have its own equipment calibration log documenting the calibration, including the frequency and type of standard or calibration procedure. Monitoring equipment calibration frequency, maintenance, and inspection requirements are provided in Table 3-1.

All instrument calibration will be recorded on an equipment calibration log sheet. During calibration, a maintenance check will be performed on each piece of equipment. If damaged or defective parts are identified during the maintenance check, and it is determined that the damage could have an impact on the instrument’s performance, the instrument will be removed from service until the defective parts can be repaired or the instrument replaced.

3.3 Collecting Field Samples

Composite samples of free (liquid from IX resin only) and spent media (solid) will be collected from drums stored at the Hangar 680 Area before shipping to the GA facility for the treatability study. The following Tetra Tech standard operating procedures (SOP), included in Appendix F, will be used with appropriate modification by Tetra Tech FOL and project engineer and with approval by Tetra Tech PM before collecting samples:

- Tetra Tech *SOP SA-1.2 - Surface Water and Sediment Sampling* (Revision 9, 07/15/2020).
- Tetra Tech *SOP SA-1.3 - Soil Sampling* (Revision 12, 07/15/2020).
- Tetra Tech *SOP SA-1.8 - Sample Acquisition for Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) Analysis* (Revision 6, 10/12/2020).

Influent (slurry), influent (liquid), effluent (liquid), condensate (liquid), filter residue (solid), and effluent (gas) samples will be collected at GA facility during the SCWO treatment by the Tetra Tech FOL. Tetra Tech SOPs and Eurofins-Knoxville SOP attached in Appendix F, will be used with appropriate modification by Tetra Tech FOL and project engineer and with approval by Tetra Tech PM before collecting samples.

- Tetra Tech *SOP SA-2.2 - Air Monitoring and Sampling* (Revision 4, 01/15/2021).
- Eurofins-Knoxville *TO-13 – (Draft) Modified TO-13 Sampling Procedure for the Determination of PFAS Compounds in Ambient Air, Process Vents, Tank Headspaces, and Thermal Treatment System Stack Air* (Revision 1, 03/20/2023).

If the field crew suspects that high concentrations of target analytes exist in any of the samples, the chain of custody form should be marked to identify those samples to the laboratory. This will help the laboratory prevent cross-contamination of other samples and instrument downtime that can be caused when high concentration samples are analyzed.

3.3.1 Collecting Field Measurements

Field measurements of oxidation-reduction potential (ORP), pH, dissolved oxygen (DO), temperature, specific conductivity, and turbidity will be collected for liquid effluent during sampling. The volume of gas sampled, using an air pump, will be logged during gas effluent sampling. The total mass of the filter residue(solid) (if any) and volume of condensate effluent (liquid) and condensate (liquid) generated during SCWO treatment will be logged.

3.4 Sample Management

Sample labeling and recording methods will be performed in accordance with Tetra Tech SOP SA-6.3 (Field Documentation, Tetra Tech, Revision 8, 08/26/21) attached in Appendix F. All sampling events will include completing the chain of custody records and proper packaging to ensure safe arrival at the designated laboratory, and to comply with Tetra Tech SOP SA-6.3. Specifications provided in this SOP comply with Department of Transportation regulations. Sample coolers will be secured using nylon tape, duct tape, or clear packaging tape. Two signed custody seals will be applied on the opposite corners of the cooler under the clear tape. The coolers will be delivered to a local courier company location for priority overnight delivery to the selected laboratory for analysis.

The Tetra Tech FOL will be responsible for the care and custody of the samples until they are delivered to the laboratory or are entrusted to a courier (e.g., FedEx). The samples will then remain in the custody of the commercial courier until they reach the laboratory. The location of the sample cooler(s) will be tracked by the Tetra Tech project chemist or designee via the commercial courier’s tracking number. When transferring samples, the individuals relinquishing and receiving them must sign, date, and note the time of transfer on the chain of custody form. Chain of custody forms should be provided to the Tetra Tech PM and project chemist for the next working day after sample collection.

In addition to the required documentation (e.g., chain of custody documents) and QC of samples, certain standard forms will be completed for sample description and documentation. These will include the sample log sheet and project sample shipping logs. Examples of these forms can be found in Tetra Tech SOP SA-6.3 (Appendix F). The sample bottles and preservative(s) used for each analyte group are shown in Table 2-3. They will also be noted in the logbook during sampling. The source of the preservatives and any other reagents will be documented in the site logbook.

3.4.1 Analytical Tasks

Fixed-base laboratory chemical analyses for this project will be conducted by the laboratories shown below.

Laboratory	Analysis	DoD ELAP accreditation (Yes/No), if yes, Accreditation Expiration Date
Eurofins Lancaster Laboratories Environment Testing, LLC (ELLE) 2425 New Holland Pike Lancaster, PA 17601	TOF, VOC, SVOC, PCB, anions, metals, percent solid	Yes, with the exception of TOF and percent solid 11/30/24
Eurofins – Knoxville 5815 Middlebrook Pike Knoxville, TN 37921	PFAS in gas	No
Battelle 141 Longwater Drive, Suite 202 Norwell, MA 02061	PFAS in solid and liquid matrices	Yes 04/30/25

Associated laboratory accreditations are provided in Appendix E.
ELAP = Environmental Laboratory Accreditation Program
ELLE = Eurofins Lancaster Laboratories Environment Testing LLC

Analyses will be performed in accordance with the analytical methods specified in Tables 2-1 and 2-2 and information in Appendix E. The laboratories will perform chemical analysis in accordance with the requirements of the DoD Quality Systems Manual (QSM) and DoD PFAS data validation guidelines, where applicable (DoD, 2021; DoD, 2019; DoD, 2022), and this work plan follows laboratory-specific SOPs (Appendix F) developed based on the analytical methods listed in Table 2-1 and Table 2-2. Should a conflict between the requirements contained in the DoD QSM and this work plan and the laboratory SOPs occur, the DoD QSM and this work plan will be followed.

Laboratory data will be delivered to Tetra Tech in the form of an EDD and portable document format (PDF) data package. This information will be captured in the project database.

3.5 Data Handling and Management

After the field investigation is completed, the field sampling log sheets will be organized by date and medium and filed in the project files. The field logbooks will be used only for this project. They will be categorized and maintained in the project files after the completion of the field program. Project personnel completing concurrent sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity. The electronic data will be automatically downloaded into the Tetra Tech database in accordance with proprietary Tetra Tech processes.

3.5.1 Data Tracking

Data are tracked from generation to archiving in the Tetra Tech project-specific files. The Tetra Tech project chemist (or designee) will be responsible for tracking the samples collected and shipped to the subcontracted laboratory. Upon receipt of the data packages from the analytical laboratories, the Tetra Tech project chemist will coordinate and monitor the data verification effort on behalf of the Project Team, which includes verifying that the data packages are complete and that the analytical laboratories have delivered results for all samples. One hundred percent of EDD results for PFAS analysis will be verified for accuracy and completeness against the chain of custody records. If required elements are missing, missing elements will be obtained from the laboratory. If any element cannot be obtained, document the omission and identify the missing elements to the Tetra Tech project chemist or PM as early as possible (DoD, 2019).

3.5.2 Data and Records Storage, Archiving, and Retrieval

After the data are verified, the data packages will be entered into the Tetra Tech Navy CLEAN file system and archived in secure files. The field records, including field logbooks, sample logs, chain of custody records, and field calibration logs, will be submitted by the Tetra Tech FOL to be entered into the Navy CLEAN file system prior to archiving in secure project files. Project files are audited for accuracy and completeness. As documents are finalized, all relevant data and records are uploaded electronically to Naval Installation Restoration Information Solution (NIRIS) and retained there indefinitely.

3.5.3 Data Security

The Tetra Tech project files are restricted to designated personnel only. Records may only be borrowed temporarily from the project file using a sign-out system. The Tetra Tech data manager maintains the electronic data files. Access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

3.5.4 Data Evaluation

Data collected from the SCWO treatability study will be compiled and analyzed to evaluate the efficacy of treatment. At the completion of data review and resolution of anomalies, should they occur, the data will be shared with the Navy. Results from the sampling associated with this work plan will be included in the final report developed by GA and Tetra Tech, demonstrating the efficacy of the SCWO treatment for the destruction of PFAS on spent GAC and IX resin media.

3.6 IDW Management

IDW materials will be generated during the field investigation. These wastes must be disposed of in such a manner that does not contribute to further environmental contamination or pose a threat to public health or safety. Tetra Tech SOP attached in

Appendix F provides information on the handling of IDW, including material potentially containing PFAS. Disposal of the IDW following receipt of the analytical data will be coordinated with the Navy.

- *Tetra Tech SOP SA-7-1 (Decontamination of Field Equipment and Management of Investigation Derived Waste, Revision 9, 04/30/2020).*

IDW that will be generated from the field activities includes personal protective equipment (PPE) and aqueous waste consisting mostly of liquid generated during sample collections. PPE-related waste will be double-bagged and disposed of as municipal solid waste, and all aqueous IDW (if any) generated during sample collection at Hangar 680 Area will be containerized and treated on-site using the aqueous IDW treatment system in place at the Hangar 680 pilot test system. All aqueous IDW (if any) generated during sample collection at GA facility will be disposed of by an environmental firm (waste disposal contractor) hired by GA.

3.7 Schedule

Table 3-2 shows the current treatability study schedule. Performance testing is tentatively scheduled to occur during the week of January 8, 2024. However, dates may be impacted by variables, including the arrival of test material and stakeholder observation schedules. Changes are also possible to accommodate Navy personnel needs. If any issues arise, that may prevent the system from operating as expected.

Following the testing, gas and liquid samples will be submitted to the analytical labs for analyses, which can take up to six weeks, depending on their schedule and demand. After receiving all analytical data, a draft report will be prepared to incorporate analytical results, operational data, and conclusions from testing. Once the draft report is submitted, the Navy will have up to ten working days to provide comments on the report. GA and Tetra Tech will then address these comments and issue the final report within 15 working days. Once the final report is submitted to the Navy, the project will be considered complete.

This page intentionally left blank

4.0 References

Chiang, D. S., M. Saba, M. Leighton, D. Ballenghien, D. Hatler, J. Gal, and M. Deshusses, 2023. *Supercritical water oxidation for the destruction of spent media wastes generated from PFAS treatment*. Journal of Hazardous Materials. August.

DoD (Department of Defense), 2019. *General Data Validation Guidelines, Environmental Data Quality Workgroup, Revision 1*. November.

DoD, 2021. *Quality Systems Manual for Environmental Laboratories (DoD QSM), Version 5.4*. October.

DoD, 2022. *Data Validation Guidelines Module 6: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-24, Environmental Data Quality Workgroup*. October.

EPA (U.S. Environmental Protection Agency), 2022. Industrial SCWO for the treatment of PFAS/AFFF Within a water matrix. study. EPA/600/R-22/257. September.

Krause, M. J., E. Thoma, E. Sahle-Damesessie, B. Crone, A. Whitehill, E. Shields, and B. Gullett, 2022. *Supercritical water oxidation as an innovative technology for PFAS destruction – Case Study*. Journal of Environmental Engineering. February.

MacDonough, J.T., J. Kirby, C. Bellona, J. A. Quinnan, N. Welty, J. Follin, and K. Liberty, 2021. *Validation of supercritical water oxidation to destroy perfluoroalkyl acids*. Remediation. September.

This page intentionally left blank

TABLES

Table 2-1: Sampling Locations and Rationale for Sampling Activity at Hangar 680 Area
Former NASJRB Willow Grove
Horsham Township, Pennsylvania
Page 1 of 2

Media	Matrix	Sample ID[1]	Analytical Group	Method	Number of Samples	Concentration Level	Rationale for Sampling
IX Resin	Free - Liquid	HA-SpentIX-L-YYMMDD-SN	PFAS	Draft EPA 1633	1	High	Characterize spent media to establish baseline concentration for PFAS and other chemicals for SCWO treatability study.
			TOF	In-house method	1	High	
			VOC	SW-846 8260D	1	Medium	
			Anions	SW-846 9056A	1	Low	
			Metals (target analyte list [TAL])	SW-846 6020B / 7470A (Mercury)	1	Low	
GAC	Spent Media – Solid	HA-SpentGAC-Composite-S - YYMMDD-SN	PFAS	Draft EPA 1633	1[2,3]	High	Characterize spent media to establish baseline concentration for PFAS and other co-contaminants for SCWO treatability study.
			TOF	In-house method	1	High	
			VOC	SW-846 8260D	1	Medium	
			SVOC (including PAH)	SW-846 8270E	1	Low	
			PCB	SW-846 8082A	1	Low	
			Anions	SW-846 9056A	1	Low	
			Metals (TAL])	SW-846 6020B / 7471B (Mercury)	1	Low	
			Percent Solids	SM2540G-2011	1	Medium	
IX Resin	Spent Media – Solid	HA-SpentIX-Composite-S - YYMMDD-SN	PFAS	Draft EPA 1633	1[2,3]	High	Characterize spent media to establish baseline concentration for PFAS and other co-contaminants for SCWO treatability study.
			TOF	In-house method	1	High	
			VOC	SW-846 8260D	1	Medium	
			SVOC (including PAH)	SW-846 8270E	1	Low	
			PCB	SW-846 8082A	1	Low	
			Anions	SW-846 9056A	1	Low	
			Metals (TAL)	SW-846 6020B / 7471B (Mercury)	1	Low	
			Percent Solid	SM2540G-2011	1	Medium	

(1) Sample ID =Designation: HA-SpentIX-L-20231101-01 represents an example ID for a sample collected at Hangar 680 spent IX resin drums free liquid composite on November 1, 2023, sample number 1

(2) Field Duplicate samples will be collected at a frequency of 1 per discrete field sample as a precision data quality indicator. If both the original and duplicate results are greater than or equal to two times LOQ, the RPD must be less than or equal to 50 percent for solid samples. If either the original or duplicate result is less than two times LOQ, use professional judgment.

(3) Quality control sample counts are in addition to the number of parent samples noted in the table above.

EPA – Environmental Protection Agency
GAC – Granular activated carbon
IX – Ion exchange
LOQ – Limit of quantitation
PAH – Polycyclic aromatic hydrocarbon
PCB – Polychlorinated biphenyl

Table 2-1: Sampling Locations and Rationale for Sampling Activity at Hangar 680 Area
Former NASJRB Willow Grove
Horsham Township, Pennsylvania
Page 2 of 2

PFAS – Per- and polyfluoroalkyl substances
RPD – Relative percent difference
SCWO – Supercritical water oxidation
SVOC – Semivolatile organic compound
TAL – Target analyte list
TOF – Total organic fluorine
VOC – Volatile organic compound

Table 2-2: Sampling Locations and Rationale for Sampling Activity at GA Facility
Former NASJRB Willow Grove
Horsham Township, Pennsylvania
Page 1 of 3

Media	Matrix	Sample ID[1]	Analytical Group	Method	Number of Samples	Concentration Level	Rationale for Sampling
Soft Water	Influent - Liquid	HA-SW-Influent-L-YYMMDD-SN	PFAS	Draft EPA 1633	2[2,3,4,6]	Low	Background sample to establish baseline. Demonstrate the absence of PFAS in the SCWO treatment chamber.
			TOF	In-house method	2		
			Anions	SW846 9056A	2		
			Metals (TAL)	SW-846 6020B / 7470A (Mercury)	2		
	Effluent - Liquid	HA-SW-Effluent-L-YYMMDD-SN	PFAS	Draft EPA 1633	2[2,3,4,6]	Low	
			TOF	In-house SOP	2		
			Anions	SW-846 9056A	2		
			Metals (TAL)	SW-846 6020B / 7470A (Mercury)	2		
	Effluent - Gas	HA-SW-Effluent-G-YYMMDD-SN	PFAS	TO-13 / OTM-45	2[5,6]	Low	Demonstrate the absence of PFAS in the SCWO treatment chamber.
GAC	Influent - Slurry (10 percent solid Content)	HA-GAC-Influent-S--YYMMDD-SN	PFAS-to be held at GA	Draft EPA 1633	2	High	Backup samples are stored to support the project objectives if needed.
	Effluent - Liquid	HA-GAC-Effluent-L-YYMMDD-SN	PFAS	Draft EPA 1633	5[,2,3,4,6]	Low	Demonstrate the effectiveness of SCWO treatment for the destruction of PFAS and other chemicals in the waste stream.
			TOF	In-house method	5		
			Anions	SW-846 9056A	5		
			Metals (TAL)	SW-846 6020B / 7470A (Mercury)	5		
	Condensate - Liquid	HA-GAC-Effluent-C- YYMMDD-SN	PFAS	Draft EPA 1633	1	Low	Demonstrate no PFAS/ other chemical products emission in the gas-condensate emission.
			TOF	In-house method	1		
			Anions	SW-846 9056A	1		
IX Resin	Influent - Slurry (10 percent solid Content)	HA-IX-Influent-S--YYMMDD-SN	PFAS-to be held at GA facility	Draft EPA 1633	2	High	Backup samples are stored to support project objectives if needed.
	Effluent - Liquid	HA-IX-Effluent-L-YYMMDD-SN	PFAS	Draft EPA 1633	5[,2,3,4,6]	Low	Demonstrate the effectiveness of SCWO treatment for the destruction of PFAS and other chemicals in the waste stream.
			TOF	In-house method	5		
			Anions	SW-846 9056A	5		
			Metals (TAL)	SW-846 6020B / 7470A (Mercury)	5		
	Condensate - Liquid	HA-IX-Effluent-C-YYMMDD-SN	PFAS	Draft EPA 1633	1	Low	Demonstrate no PFAS/ other non-benign products emission in the gas-condensate emission.
			TOF	In-house method	1		
			Anions	SW-846 9056A	1		

Table 2-2: Sampling Locations and Rationale for Sampling Activity at GA Facility
Former NASJRB Willow Grove
Horsham Township, Pennsylvania

Media	Matrix	Sample ID[1]	Analytical Group	Method	Number of Samples	Concentration Level	Rationale for Sampling
GAC	Effluent - Gas	HA-GAC-Effluent-G-YYMMDD-SN	PFAS	TO-13 / OTM-45	1[5,6]	Low	Demonstrate no PFAS/ other chemical product emissions in the gas phase Quantify organic fluorine emission in the gas phase for fluorine mass balance.
			TOF	TO-13 / In-house method	1		
IX Resin	Effluent - Gas	HA-IX-Effluent-G-YYMMDD-SN	PFAS	TO-13 / OTM-45	1[5,6]	Low	Demonstrate no PFAS/ other chemical product emissions in the gas phase. Quantify organic fluorine emission in the gas phase for fluorine mass balance.
			TOF	TO-13 / In-house method	1		
GAC	Filter Residue - Solid	HA-GAC-Effluent-S-YYMMDD-SN	PFAS	Draft EPA1633	1	Low	Demonstrate no PFAS/ other chemical product emissions in the filter residue-solid phase. Quantify organic fluorine and inorganic fluoride emission in the filter residue-solid phase for fluorine mass balance.
			TOF	In-house method	1		
			Anions	SW-846 9056A	1		
IX Resin	Filter Residue - Solid	HA-IX-Effluent-S-YYMMDD-SN	PFAS	Draft EPA 1633	1	Low	Demonstrate no PFAS/ other chemical product emissions in the filter residue-solid phase. Quantify organic fluorine and inorganic fluoride emission in the filter residue-solid phase for fluorine mass balance.
			TOF	In-house method	1		
			Anions	SW-846 9056A	1		

(1) Sample ID =Designation: HA-SpentIX-L-20231101-01 represents an example ID for a sample collected at Hangar 680 spent IX resin drums free liquid composite on November 1, 2023, sample number 1

(2) Field Duplicate samples will be collected at a frequency of 1 per 20 discrete field samples as a precision data quality indicator. If both the original and duplicate results are greater than or equal to two times LOQ, the RPD must be less than or equal to 50 percent for solid samples. If either the original or duplicate result is less than two times LOQ, use professional judgment.

(3) Matrix Spike samples will be collected at a frequency of 1 per 20 discrete field samples as an accuracy/bias data quality indicator. For measurement performance criteria, refer to the laboratory quality control (QC) samples table in Appendix D.

(4) Matrix Spike Duplicate samples will be collected at a frequency of 1 per 20 discrete field samples as an accuracy/bias data quality indicator. For measurement performance criteria, refer to the laboratory quality control (QC) samples table in Appendix D.

(5) Field Blank samples will be collected at a frequency of 1 per 20 discrete field samples as an accuracy/bias/contamination data quality indicator. No analytes greater than or equal to one-half LOQ.

(6) Quality control sample counts are in addition to the number of parent samples noted in the table above.

EPA – Environmental Protection Agency
GA – General Atomics

Table 2-2: Sampling Locations and Rationale for Sampling Activity at GA Facility
Former NASJRB Willow Grove
Horsham Township, Pennsylvania

GAC – Granular activated carbon
IX – Ion exchange
LOQ – Limit of quantitation
PFAS – Per- and polyfluoroalkyl substances
RPD – Relative percent difference
SCWO – Supercritical water oxidation
SOP – Standard operating procedure
TAL – Target analyte list
TOF – Total organic fluorine

Table 2-3: Sampling Bottle and Preservation Requirements
Former NASJRB Willow Grove
Horsham Township, Pennsylvania
Page 1 of 3

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference	Containers (number, size, and type)	Sample Volume (units)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time[1] (preparation/analysis)
Solid	PFAS	Draft EPA 1633 / 5-381-03	8-ounce HDPE jar	20 – 30 g	Temperature must be above freezing and less than or equal to 6 °C when received at the laboratory. Samples stored in the lab at 0-6 °C or at less than or equal to -20 °C and protected from light until sample preparation	90 days
Solid	TOF	In-house SOP / WI43681	4-ounce HDPE bottles with minimal headspace	100 mg	None, 2-6°C	28 days
Solid	VOC	SW-846 8260D/ WI8236	TerraCore samplers plus 3 x 40 mL glass vials	15 g	Methanol, DI water, and/or Sodium Bisulfate; 2-6°C	14 days
Solid	SVOC (including PAH)	SW-846 8270E / WI9617	4 or 8-ounce glass jar	100 g	None, 0-6°C	14 days to extraction; 40 days to analysis
Solid	PCB	SW-846 8082A/ WI10004	4 or 8-ounce glass jar	100 g	None, 0-6°C	365 days
Solid	Anions	SW-846 9056A / WI11626	4-ounce glass jar	10 g	Cool, 6°C	SO_4, Br, Cl, F less than or equal to 28 days, NO_3, NO_2 less than or equal to 48 hours
Solid	Metals	SW-846 6020B / WI11933	4 or 8-ounce glass jar	100 g	None, 2-6°C	6 months
Solid	Mercury	SW-846 7471B /	4 or 8-ounce glass jar	100 g	None, 0-6°C	28 days
Solid	Percent solid	SM2540G-2011 / WI11509	4-ounce glass jar	30 g	None, 0-6°C	7 days

Table 2-3: Sampling Bottle and Preservation Requirements

Former NASJRB Willow Grove
Horsham Township, Pennsylvania
Page 2 of 3

Matrix	Analytical Group	Analytical and Preparation Method / SOP Reference	Containers (number, size, and type)	Sample Volume (units)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time[1] (preparation/analysis)
Liquid	PFAS	Draft EPA 1633 / 5-381-03	2 x 500 mL HDPE bottle 1 x 125 mL HDPE bottle	2 x 500 mL 1 x 125 mL	Temperature must be above freezing and less than or equal to 6 °C when received at the laboratory. Samples stored in the lab at 0-6 °C or at less than or equal to -20 °C and protected from light until sample preparation	28 days from sampling to extraction stored 0-6 °C , 90 days if stored ≤ -20 °C
Liquid	TOF	In-house SOP / WI38299	2 x 250 mL HDPE bottle with minimal headspace	250 mL	None, 2-6°C	28 days
Liquid	VOC	SW-846 8260D/ WI8194	3 x 40 mL glass vials	120 mL	HCl or None, 2-6°C; pH less than 2	14 days preserved; 7 days not preserved
Liquid	Anions	SW-846 9056A / WI11626	50 ml plastic vial	50 mL	Cool, 6°C	SO4, Br, Cl, F less than or equal to 28 days, NO3, NO2 less than or equal to 48 hours
Liquid	Metals	SW-846 6020B / WI11933	250 mL plastic	250 mL	HNO_3, 2-6°C; pH less than 2	Six months
Liquid	Mercury	SW-846 74710A/	250 mL plastic	250 mL	HNO_3, 2-6°C; pH less than 2	28 days
Air	PFAS	OTM 45 / KNOX-LC-0007, Rev 2	CORBO PUF/XAD-2 Sandwich Media Tube	--	Cool, 6°C	28 days
Air	TOF	TO-13/ In-house SOP	CORBO PUF/XAD-2 Sandwich Media Tube	--	Cool, 6°C	28 days

(1) Maximum holding time is calculated from the time the sample is collected to the time the sample is prepared/extracted.

°C – Degrees Celsius
Br – Bromide
Cl - Chloride
DI – Deionized
EPA – Environmental Protection Agency
F - Fluoride
g – Gram
HCl – Hydrochloric acid
HDPE – High-density polyethylene

Table 2-3: Sampling Bottle and Preservation Requirements
Former NASJRB Willow Grove
Horsham Township, Pennsylvania
Page 3 of 3

HNO_3 – Nitric acid
mL – Milliliter
NO_2 – Nitrite
NO_3 - Nitrate
PAH – Polycyclic aromatic hydrocarbons
PFAS – Per- and polyfluoroalkyl substances
SO_4 - Sulfate
SOP – Standard operating procedure
SVOC – Semivolatile organic compound
TOF – Total organic fluorine
VOC - Volatile organic compound

Table 3-1: Field Equipment Calibration, Maintenance, Testing, and Inspection
Former NASJRB Willow Grove
Horsham Township, Pennsylvania

Field Equipment	Activity	Frequency	Acceptance Criteria	Corrective Action	Resp. Person	SOP Reference	Comments
Multi-parameter Water Quality Meter	Visual inspection and calibration in accordance with the manufacturer's instructions. Calibration verification with second source standard; use calibration check standard in the middle of the calibration range. Keep spare batteries and calibration solutions in the carrying case.	Calibration prior to use on each day of use. Calibration verification immediately after calibration and at the end of the day of use.	Calibration in accordance with manufacturer's instructions. Calibration check values should fall within these tolerances of the true value: Temperature: calibrated by instrument supplier; verify calibration is valid during use. pH: plus or minus 0.2 standard units (SU) Specific conductance: plus or minus 5.0 percent DO: plus or minus 0.3 milligrams per liter (mg/L)	Adjust calibration. If unable to calibrate, replace the meter.	FOL or designee	Manufacturer's Manual	Horiba U-50 (or equivalent)
High/Low Flow Pump for Air Sampling	Visual inspection for functionality; no calibration.	Daily before use.	The pump is operational, and the flow rate appears to be constant and is sufficiently low to not draw down the air too quickly.	Replace pump.	FOL or designee	Manufacturer's Manual	GeoTech Series II (or equivalent)

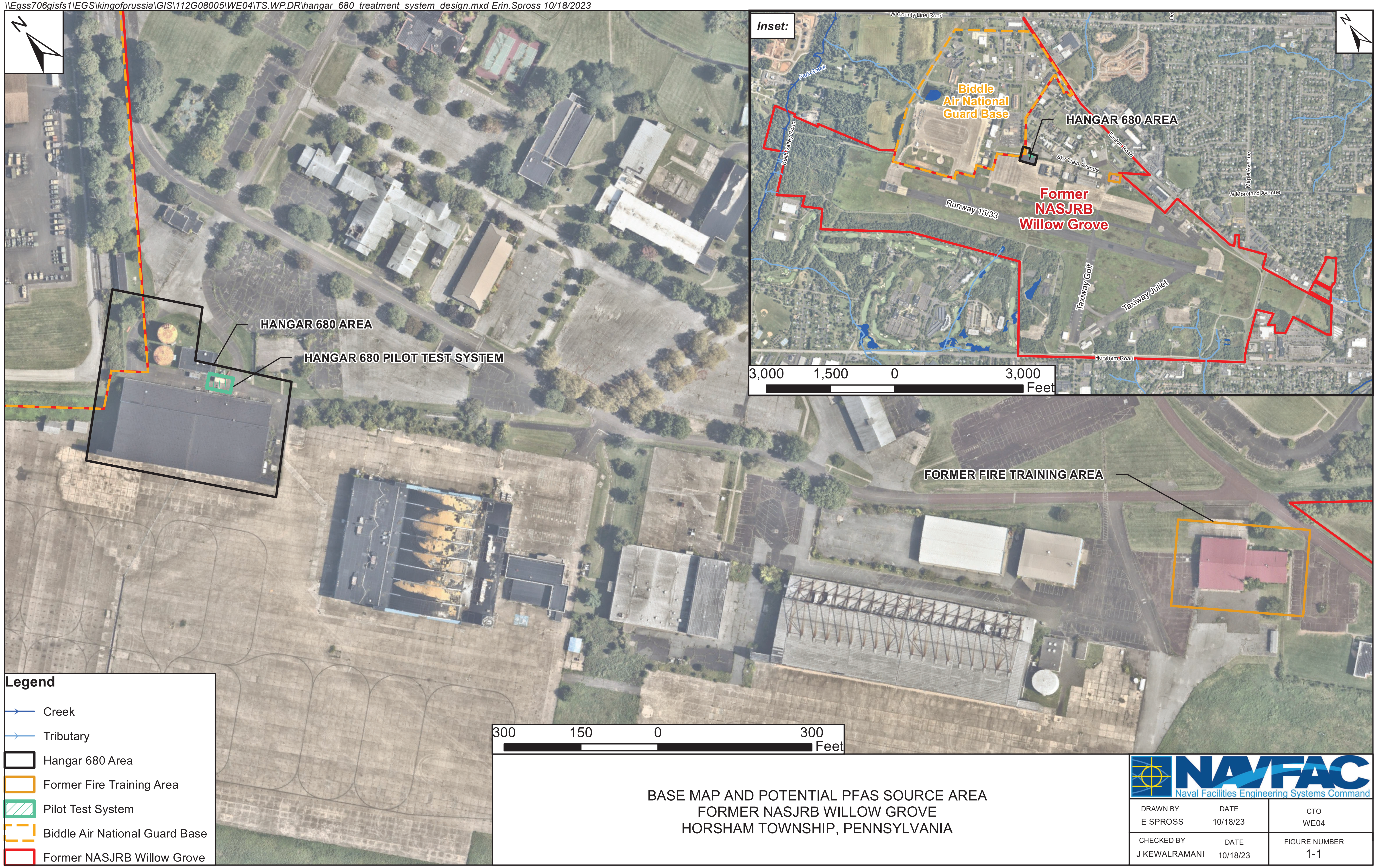
DO – Dissolved oxygen
FOL – Field Operations Leader
mg/L – Milligrams per liter
SOP – Standard operating procedure
SU – Standard units

Table 3-2: Treatability Study Schedule
Former NASJRB Willow Grove
Horsham Township, Pennsylvania

Task Number	Description	Start/Actual Date	End/Actual Date
1	**Contract Award**	**6 Jun 2023**	—
2	**Project Kickoff Meeting**	—	**10 Jun 2023**
3	**Workplan/SAP**	**12 Jun 2023**	11 Dec 2023
3-1	Draft Development	12 Jun 2023	20 Oct 2023
3-2	Draft Navy Review	23 Oct 2023	06 Nov 2023
3-3	Revisions/Final Development	07 Nov 2023	21 Nov 2023
3-4	Final Navy Review	22 Nov 2023	08 Dec 2023
3-5	Navy Approval	11 Dec 2023	11 Dec 2023
4	**Media Transport**	**15 Sep 2023**	**03 Jan 2024**
4-1	SOW Development	15 Sep 2023	13 Oct 2023
4-2	Procurement	16 Oct 2023	30 Oct 2023
4-3	Bid Review	31 Oct 2023	03 Nov 2023
4-4	Award	06 Nov 2023	08 Nov 2023
4-5	Sampling	15 Nov 2023	16 Nov 2023
4-6	Laboratory Analysis	17 Nov 2023	12 Dec 2023
4-7	Transport Documentation Process	13 Dec 2023	20 Dec 2023
4-8	Navy Signature	21 Dec 2023	22 Dec 2023
4-9	Transport to Facility	26 Dec 2023	03 Jan 2024
5	**Performance Test**	**04 Jan 2024**	**31 Jan 2024**
5-1	Work-up Testing	04 Jan 2024	25 Jan 2024
5-2	Test Execution	26 Jan 2024	31 Jan 2024
6	**Sample Analysis**	02 Feb 2024	26 Feb 2024
7	**Data Validation**	01 Feb 2024	01 Mar 2024
7.1	Test Report	04 Mar 2024	45468
7-2	Draft Development	04 Mar 2024	29 Apr 2024
7-3	Draft Navy Review	30 Apr 2024	14 May 2024
7-4	Revisions/Final Development	15 May 2024	30 May 2024
7-5	Final Navy Review	31 May 2024	14 Jun 2024
7-6	Navy Approval	17 Jun 2024	25 Jun 2024
8	**Project Completion**	—	**25 Jun 2024**

FIGURES

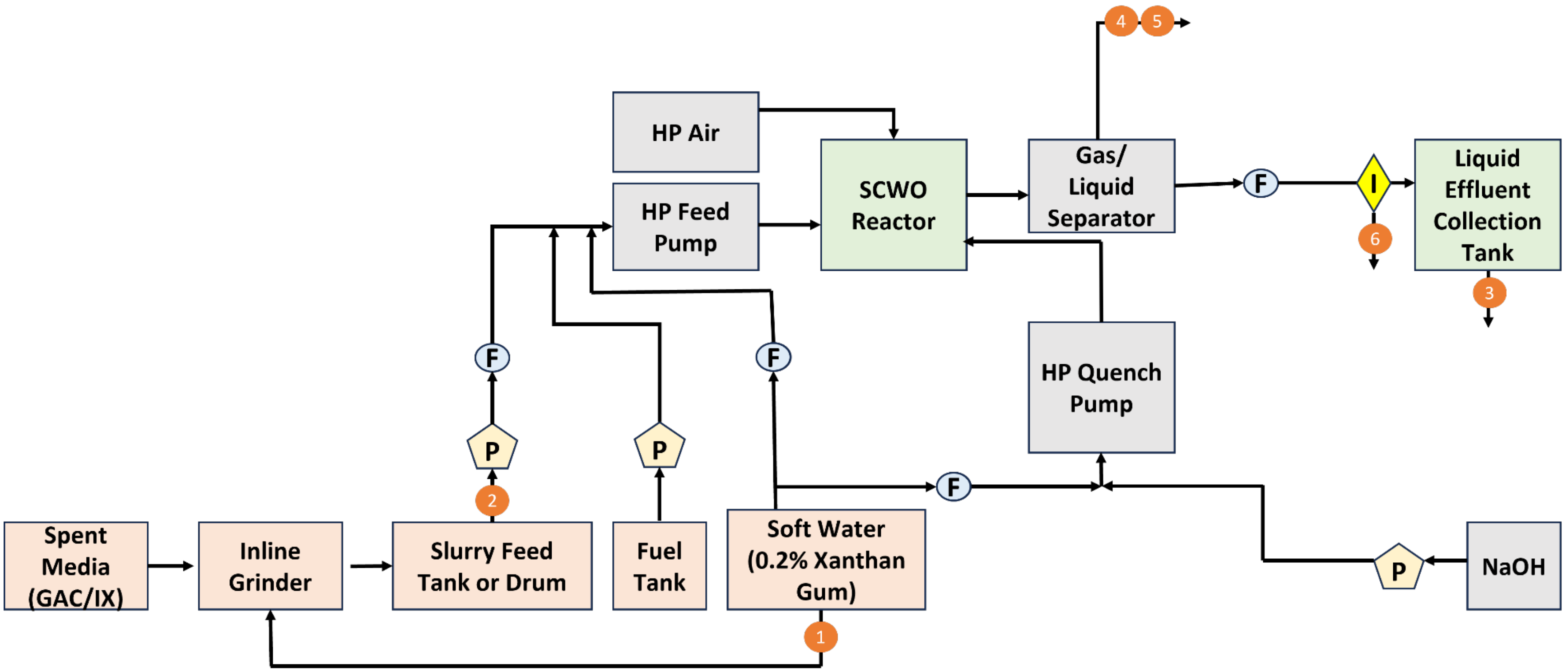
\\Egss706gisfs1\EGS\kingofprussia\GIS\112G08005\WE04\TS.WP.DR\hangar_680_treatment_system_design.mxd Erin.Spross 10/18/2023



BASE MAP AND POTENTIAL PFAS SOURCE AREA
FORMER NASJRB WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

NAVFAC
Naval Facilities Engineering Systems Command

DRAWN BY	DATE	CTO
E SPROSS	10/18/23	WE04
CHECKED BY	DATE	FIGURE NUMBER
J KEWALRAMANI	10/18/23	1-1



Legend

P = Pump

F = Flow Indicator

I = Inline Filter

① = Influent Sample Location (liquid)

② = Influent Sample Location (slurry)

③ = Effluent Sample Location (Liquid)

④ = Condensate Sample Location (Liquid)

⑤ = Effluent Sample Location (Gas)

⑥ = Filter Sample Location (Solid Residue)

Acronyms and Abbreviations

GAC = Granular Activated Carbon

SCWO = Supercritical Water Oxidation

HP = High Pressure

IX = Ion Exchange

NaOH = Sodium Hydroxide

BLOCK FLOW DIAGRAM FOR SCWO TREATMENT SYSTEM
FORMER NASJRB WILLOW GROVE
HORSHAM TOWNSHIP, PENNSYLVANIA

NAVFAC
Naval Facilities Engineering Systems Command

DRAWN BY E SPROSS	DATE 10/18/23	CTO WE04
CHECKED BY J KEWALRAMANI	DATE 10/18/2023	FIGURE NUMBER 2-1

APPENDIX A
COMMUNICATION PATHWAYS

Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Draft Sampling and Analysis Plan (SAP) Review/Revisions	Tetra Tech Project Manager (PM) Naval Facilities Engineering Systems Command (NAVFAC) Remedial Project Manager (RPM) NAVFAC Technical Support NAVFAC Quality Assurance Officer (QAO)/Chemist	Tricia Moore Brian Helland Jason Speicher NAVFAC QAO/Chemist	610-382-1171 215-897-4912 215-897-9414 Not available (NA)	Within two days of completing the draft SAP, the SAP will be submitted (with NAVFAC RPM approval) to Naval Installation Restoration Information Solution (NIRIS) by the Tetra Tech PM. NAVFAC QAO/Chemist comments, received via NIRIS, will be resolved to the satisfaction of the NAVFAC QAO/Chemist, and the SAP will be uploaded to NIRIS for NAVFAC QAO/Chemist signature.
Preparation for Sampling	Tetra Tech Deputy PM Tetra Tech Project Chemist Tetra Tech Project Engineer Tetra Tech Project Engineer Tetra Tech FOL Laboratory PMs	Sue Herbert Mandy Barnhart Jitendra Kewalramani Simon Fong Carl Gibney and to be determined (TBD) Jonathan Thorn (Battelle) Stephen Gordon (ELLE) Courtney Adkins (Eurofins-Knoxville)	610-382-1537 610-382-1528 512-338-1667 301-528-3021 610-382-1525 781-681-5565 412-525-0071 856-291-3019	At a time that ensures sample bottles will be available on-site early enough to collect samples, the Tetra Tech Project Chemist will contact the laboratory PMs via email or teleconference to request bottles. The project chemist will maintain weekly contact with the laboratory throughout the project to ensure project goals, including changes to laboratory-specific limits, are acceptable prior to and during the analyses.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Preparation for Field Activities	NAVFAC RPM NAVFAC Technical Support Naval Air Station Joint Reserve Base (NASJRB) Caretakers Office Tetra Tech PM Tetra Tech Deputy PM Tetra Tech Project Engineer Tetra Tech Project Engineer Tetra Tech Field Operations Leaders (FOL) Tetra Tech Per- and Polyfluoroalkyl Substances (PFAS) Subject Matter Expert (SME) General Atomics (GA) PM	Brian Helland Jason Speicher Jim Rugh Marty Schy Tricia Moore Sue Herbert Jitendra Kewalramani Simon Fong Carl Gibney TBD Purshotam Juriasingani Kenneth Liberty	215-897-4912 215-897-9414 610-291-4295 267-638-8220 610-382-1171 610-382-1537 512-338-1667 301-528-3021 610-382-1525 TBD 512-294-9360 858-349-5428	The Tetra Tech FOL will contact facility support prior to field activities to let the facility know of upcoming activities. The NAVFAC RPM and NAVFAC Technical Support will be included in the communication.

Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
SAP Changes Prior to Field/ Laboratory Work	Tetra Tech FOLs Tetra Tech Project Engineer Tetra Tech Project Engineer Tetra Tech Project Chemist Tetra Tech PM Tetra Tech Deputy PM NAVFAC RPM NAVFAC Technical Support NAVFAC QAO/Chemist	Carl Gibney TBD Jitendra Kewalramani Simon Fong Mandy Barnhart Tricia Moore Sue Herbert Brian Helland Jason Speicher NAVFAC QAO/Chemist	610-382-1525 TBD 512-338-1667 301-528-3021 610-382-1528 610-382-1171 610-382-1537 215-897-4912 215-897-9414 NA	The Tetra Tech Project Chemist or FOL will document the required change via a field task modification request (FTMR) form within five days. The Tetra Tech PM will send it to the NAVFAC RPM and technical support. If necessary, the Tetra Tech PM will submit a concurrence letter on a schedule agreeable to the NAVFAC RPM. The Tetra Tech PM will submit SAP amendments to the NAVFAC RPM for review and approval. SAP changes will be submitted to the NAVFAC QAO/Chemist via NIRIS for approval when significant Data Quality Objective [DQO]-related changes or significant changes to the conceptual site model (CSM) occur, analytes or matrices are added to the sampling plan, analytical methods are added, the laboratory Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) Quality Systems Manual (QSM) accreditation changes, or the laboratory is changed. The Tetra Tech PM will communicate scope changes to the Project Team via email within one business day.

Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Field Progress Reports	Tetra Tech FOLs	Carl Gibney TBD	610-382-1525 TBD	The Tetra Tech FOL will provide an email to the Tetra Tech PM and project chemist by 12:00 PM EST the following working day.
	Tetra Tech Project Engineer	Jitendra Kewalramani	512-338-1667	
	Tetra Tech Project Engineer	Simon Fong	301-528-3021	
	Tetra Tech Project Chemist	Mandy Barnhart	610-382-1528	
	Tetra Tech PFAS SME	Purshotam Juriasingani	512-294-9360	
	Tetra Tech PM	Tricia Moore	610-382-1171	
	Tetra Tech Deputy PM	Sue Herbert	610-382-1537	
Stop Work Due to Safety Issues	Tetra Tech FOLs	Carl Gibney TBD	610-382-1525 TBD	If Tetra Tech is the responsible party for a stop work command, the Tetra Tech FOL will inform on-site personnel, subcontractor(s), the NAVFAC RPM, and the identified Project Team members within 1 hour (verbally or by email). Any field team member may issue a stop work command due to safety issues.
	Tetra Tech Health and Safety Manager (HSM)	Matt Soltis	412-921-4037	
	Tetra Tech PFAS SME	Purshotam Juriasingani	512-294-9360	
	GA PM	Kenneth Liberty	858-349-5428	
	Tetra Tech PM	Tricia Moore	610-382-1171	
	NAVFAC RPM	Brian Helland	215-897-4912	
	NAVFAC Technical Support	Jason Speicher	215-897-9414	
	Field Team	Various	Various	

Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
SAP Changes in the Field	Tetra Tech FOLs	Carl Gibney	610-382-1525	The Tetra Tech FOL will verbally inform the Tetra Tech PM within 24 hours of realizing the need for a change. The Tetra Tech Project Chemist or FOL will document the change via an FTMR form within five days. The Tetra Tech PM will send it to the NAVFAC RPM and technical support. If the change involves laboratory analysis, the FTMR will also be send to the laboratory PM. If necessary, a concurrence letter will be submitted within seven days of identifying the need for change. SAP changes will be submitted to the NAVFAC QAO/Chemist via NIRIS for approval when significant DQO-related changes or significant changes to the CSM occur, analytes or matrices are added to the sampling plan, analytical methods are added, the laboratory DoD ELAP QSM accreditation changes, or the laboratory is changed.
		TBD	TBD	
	Tetra Tech Project Engineer	Jitendra Kewalramani	512-338-1667	
	Tetra Tech Project Engineer	Simon Fong	301-338-1667	
	Tetra Tech Project Chemist	Mandy Barnhart	610-382-1528	
	Tetra Tech PFAS SME	Purshotam Juriasingani	512-294-9360	
	GA PM	Kenneth Liberty	858-349-5428	
	Tetra Tech PM	Tricia Moore	610-382-1171	
	Tetra Tech Deputy PM	Sue Herbert	610-382-1537	
	NAVFAC RPM	Brian Helland	215-897-4912	
	NAVFAC Technical Support	Jason Speicher	215-897-9414	
	NAVFAC QAO/Chemist	NAVFAC QAO/Chemist	NA	
	Laboratory PMs	Jonathan Thorn (Battelle)	781-681-5565	
		Stephen Gordon (ELLE)	412-525-0071	
		Courtney Adkins (Eurofins-Knoxville)	856-291-3019	

Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Field Corrective Actions in Response to Unusual Field Conditions or Conditions Otherwise Adverse to Quality (e.g., sample representativeness, comparability, or other quality concerns)	Tetra Tech FOLs	Carl Gibney TBD	610-382-1525 TBD	The Tetra Tech FOL will alert the Tetra Tech PM verbally of the condition adverse to quality as soon as it is safe to do so. The Tetra Tech PM and FOL will immediately develop appropriate corrective actions to preserve quality. This may require consulting with other Tetra Tech technical staff (such as the project chemist). If an appropriate action cannot be developed quickly or upon developing an appropriate action, the Tetra Tech PM will notify the NAVFAC RPM verbally or via email and, at the NAVFAC RPM's discretion, other NAVFAC personnel such as the NAVFAC QAO/Chemist. Upon agreement between the Tetra Tech PM and NAVFAC RPM regarding appropriate corrective actions, significant deviations from this SAP (if any) will be documented in the field logbook and on an FTMR form.
	Tetra Tech PFAS SME	Purshotam Juriasingani	512-294-9360	
	Tetra Tech Project Engineer	Jitendra Kewalramani	512-338-1667	
	Tetra Tech Project Engineer	Simon Fong	301-528-3021	
	GA PM	Kenneth Liberty	858-349-5428	
	Tetra Tech PM	Tricia Moore	610-382-1171	
	Tetra Tech Deputy PM	Sue Herbert	610-382-1537	
	Tetra Tech Project Chemist	Mandy Barnhart	610-382-1528	
	Laboratory PMs	Jonathan Thorn (Battelle)	781-681-5565	
		Stephen Gordon (ELLE)	412-525-0071	
		Courtney Adkins (Eurofins-Knoxville)	856-291-3019	
	NAVFAC RPM	Brian Helland	215-897-4912	
	NAVFAC Technical Support	Jason Speicher	215-897-9414	
	NAVFAC QAO/Chemist	NAVFAC QAO/Chemist	NA	

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Sample Receipt Variances	Laboratory PMs	Jonathan Thorn (Battelle)	781-681-5565	The Laboratory PM will report variances to the Tetra Tech FOL, project chemist, or PM verbally or via email within 24 hours of identifying a variance. Those individuals will attempt to resolve the variance with the laboratory. If the variance cannot be resolved, the Tetra Tech PM will notify the NAVFAC RPM verbally or via email within one business day of the variances being brought to his attention. If necessary, the NAVFAC RPM will take corrective action commensurate with the deficiency.
		Stephen Gordon (ELLE)	412-525-0071	
		Courtney Adkins (Eurofins-Knoxville)	856-291-3019	
	Tetra Tech FOLs	Carl Gibney	610-382-1525	
		TBD	TBD	
	Tetra Tech Project Chemist	Mandy Barnhart	610-382-1528	
	Tetra Tech PM	Tricia Moore	610-382-1171	
	NAVFAC RPM	Brian Helland	215-897-4912	
	NAVFAC Technical Support	Jason Speicher	215-897-9414	
Laboratory Quality Variances	Laboratory PMs	Jonathan Thorn (Battelle)	781-681-5565	The laboratory PM will notify (verbally or via email) the Tetra Tech project chemist within one business day of discovering an issue related to laboratory data. The Tetra Tech project chemist will notify (verbally or via email) the Tetra Tech DVM and PM within one business day. The laboratory PM will document all quality variances in the case narrative of the analytical laboratory report. Corrective actions may include a consult with the NAVFAC RPM, technical support, and NAVFAC QAO/Chemist.
		Stephen Gordon (ELLE)	412-525-0071	
		Courtney Adkins (Eurofins-Knoxville)	856-291-3019	
	Tetra Tech Project Chemist	Mandy Barnhart	610-382-1528	
	Tetra Tech Data Validation Manager (DVM)	Joe Samchuck	412-921-8510	
	Tetra Tech PM	Tricia Moore	610-382-1171	
	NAVFAC RPM	Brian Helland	215-897-4912	
	NAVFAC Technical Support	Jason Speicher	215-897-9414	
	NAVFAC QAO/Chemist	NAVFAC QAO/Chemist	NA	

Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Analytical Corrective Actions	Laboratory PMs	Jonathan Thorn (Battelle) Stephen Gordon (ELLE) Courtney Adkins (Eurofins-Knoxville)	781-681-5565 412-525-0071 856-291-3019	If the impact of an identified deficiency is limited to this project, it will be resolved between the laboratory PM and Tetra Tech Project Chemist QAM, and PM. The resolution will be documented in the project report. If the deficiency is systemic and potentially affects other projects, the Tetra Tech PM will verbally advise the NAVFAC RPM within 24 hours of notification from the project chemist or DVM. The NAVFAC RPM will take corrective action appropriate for the identified deficiency. Corrective actions may include a consult with NAVFAC technical support and the QAO/Chemist and coordination with the laboratory.
	Tetra Tech Project Chemist	Mandy Barnhart	610-382-1528	
	Tetra Tech PM	Tricia Moore	610-382-1171	
	Tetra Tech Quality Assurance Manager (QAM)	Michelle Coffman	412-921-8549	
	NAVFAC RPM	Brian Helland	215-897-4912	
	NAVFAC Technical Support	Jason Speicher	215-897-9414	
	NAVFAC QAO/Chemist	NAVFAC QAO/Chemist	NA	

Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Reporting Data Validation (DV) Issues	Tetra Tech DV Chemist Tetra Tech Project Chemist Tetra Tech PM NAVFAC RPM NAVFAC Technical Support	Various Mandy Barnhart Tricia Moore Brian Helland Jason Speicher	Various 610-382-1528 610-382-1171 215-897-4912 215-897-9414	The Tetra Tech DV Chemist will document data qualifications in the DV report and database. For serious deficiencies, including any time data is qualified with an “X” or “UX” qualifier, the Tetra Tech DV Chemist will notify the Tetra Tech Project Chemist and PM verbally or via email within 48 hours of recognizing that a significant laboratory quality deficiency has been detected that could affect this project and/or other projects. The Tetra Tech PM will relay information regarding serious data concerns or laboratory concerns and “X” and “UX” qualified data to the NAVFAC RPM and technical support.
DV Corrective Actions	Tetra Tech DV Chemist Tetra Tech Project Chemist Tetra Tech PM NAVFAC RPM NAVFAC Technical Support NAVFAC QAO/Chemist	Various Mandy Barnhart Tricia Moore Brian Helland Jason Speicher NAVFAC QAO/Chemist	Various 610-381-1528 610-382-1171 215-897-4912 215-897-9414 NA	If a DV issue cannot be resolved between the Tetra Tech DV Chemist and the laboratory or if the issue appears to be systemic, the Tetra Tech DV Chemist will alert, verbally or via email, the Tetra Tech PM who will verbally advise the NAVFAC RPM within 24 hours of notification. The NAVFAC RPM will take corrective action that is appropriate for the identified deficiency. This may include a consult with NAVFAC technical support and the QAO/Chemist.

Communication Pathways

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Identification of Systemic Quality Deficiencies on the Project	Tetra Tech PM Tetra Tech Deputy PM Tetra Tech PFAS SME Tetra Tech Project Engineer Tetra Tech Project Engineer Tetra Tech Support Staff Tetra Tech QAM	Tricia Moore Sue Herbert Purshotam Juriasingani Jitendra Kewalramani Simon Fong Various Michelle Coffman	610-382-1171 610-382-1537 512-294-9360 512-338-1667 301-528-3021 Various 412-921-8549	The person identifying the concern will communicate to the Tetra Tech PM and Tetra Tech QAM in a timeframe that supports the correction of the concern as soon as practicable and sharing of “lessons learned” to prevent the propagation of deficiencies.

CSM – Conceptual site model
DOD – Department of Defense
DQO – Data quality objective
DV – Data validation
DVM – Data Validation Manager
ELAP – Environmental Laboratory Accreditation Program
ELLE – Eurofins Lancaster Laboratories Environment Testing, LLC
EST – Eastern Standard Time
FOL – Field operations leader
FTMR – Field task modification request
GA – General Atomics
HSM – Health and Safety Manager
NA – Not applicable
NASJRB – Naval Air Station Joint Reserve Base
NAVFAC – Naval Facilities Engineering Systems Command
NIRIS – Naval Installation Restoration Information Solution
PM – Project Manager
QAM – Quality Assurance Manager
QAO – Quality Assurance Officer
QSM – Quality Systems Manual
RPM – Remedial Project Manager
SAP – Sampling and Analysis Plan
SME – Subject Matter Expert
TBD – To be determined

APPENDIX B
PRODUCT SPECIFICATION SHEETS

Hydrosil International LTD.
125 Prairie Lake Road - East Dundee, IL 60118
Phone: 847-844-0680
Emergency Phone: 847-844-0680
Fax: 847-844-0799

HS-AC Air

Activated Carbon

What is HS-AC

HS-AC is coconut shell activated carbon that is commonly used in industry for removing pollutants in vapor phase. Hydrosil's **HS-AC** is highly active granular activated carbon (GAC) manufactured via high temperature steam activation from selected grades of coconut shell. Coconut shell activated carbon is known for its high hardness, low dust, and low ash content. The **HS-AC** has high activity and large surface area ideal for removing constituents in vapor phase.

Hydrosil's packaging ranges from bulk carbon in supersacks to one cubic foot boxes.

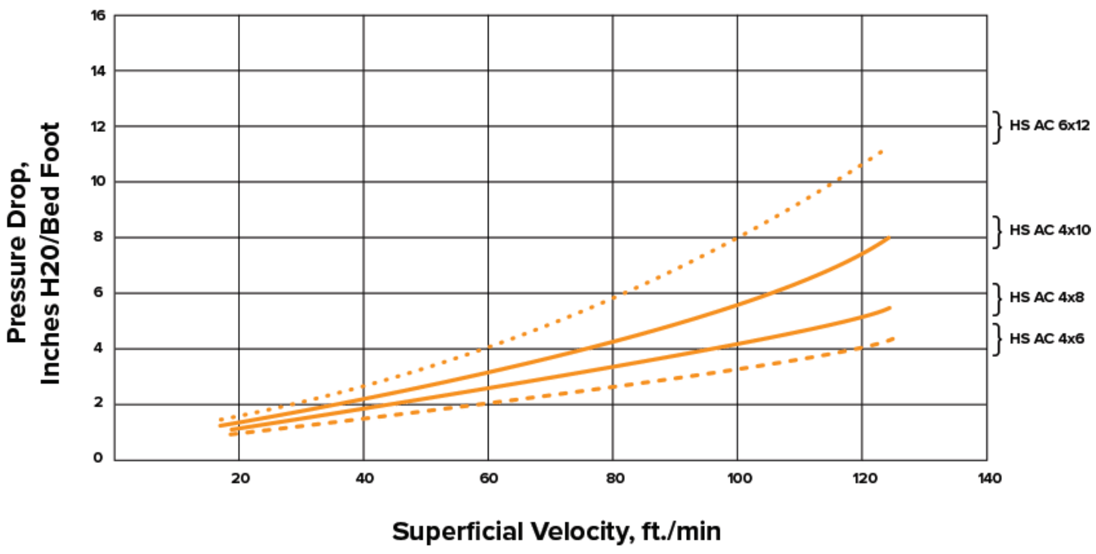
Where is HS-AC Used

The **HS-AC** is commonly used in chemical processing, air stripper off-gas VOC removal, tank or sump air vents, respirators, API separator vents, modules, trays and air filtration housings. Activated carbon typically adsorbs organic compounds as well as larger inorganic compounds. To see if the Spectrum **HS-AC** removes a specific pollutant please see our Air Pollutants page, or contact a representative today.

What is Activated Carbon

Activated carbon commonly referred to as activated charcoal is a highly porous material used to remove pollutants from contaminated liquid and gas streams. Activated carbon is derived from a variety of raw materials such as coconut, wood, coal (bituminous, anthracite, sub-bituminous, and lignite), peat, and bamboo. Each raw material has unique properties which effect the resulting pore structure, carbon content, and ash content, which are important characteristics when removing a contaminant of concern. The material is used in remediation, medical, and industrial applications where adsorption is required. Activated carbon has strong physical adsorption properties known as London Dispersion Forces which is a Van der Waals Force. The attraction between the activated carbon and the pollutant are highly dependent on the vapour pressure of the adsorbing molecules. Activated carbon is often altered or impregnated by chemicals to enhance the surface area of the carbon. When the carbon is chemically altered the bonds are much stronger than London Dispersion Forces. Chemicals often impregnated on activated carbon include potassium hydroxide, phosphoric acid, or sulfur. With the addition of chemicals the activated carbon will have an affinity for select compounds such acidic or basic pollutants.

HS-AC For Air Pressure Drop



Typical Physical Properties

Property:	Value:
Iodine Number, mg/gm	1100 - 1200
Apparent Density, lb/ft3	29 - 31
U.S. Standard Sieve Size (Mesh Size)	4 x 8
Butane Number, % ww	23.5 (60 CTC)
Hardness, Min. (ASTM D-3802)	98
Total Surface Area (BET), m2/gm	1150 □1250
Ash, Max (ASTM D-2866)	3%

PRODUCT DATA SHEET

Purofine®
PFA694

Polystyrenic Gel

PRINCIPAL APPLICATIONS

- Removal of perfluoroalkyl substances
- Removal of polyfluoroalkyl substances

ADVANTAGES

- Very high operating capacity
- Excellent kinetics

SYSTEMS

- Industrial
- Wastewater
- Process

TYPICAL PACKAGING

- 1 ft³ Sack
- 25 L Sack
- 5 ft³ Drum (Fiber)
- 1 m³ Supersack
- 42 ft³ Supersack

** Reduces PFAS to non-detect levels ranging from 1 – 5 parts per trillion*

TYPICAL PHYSICAL & CHEMICAL CHARACTERISTICS:

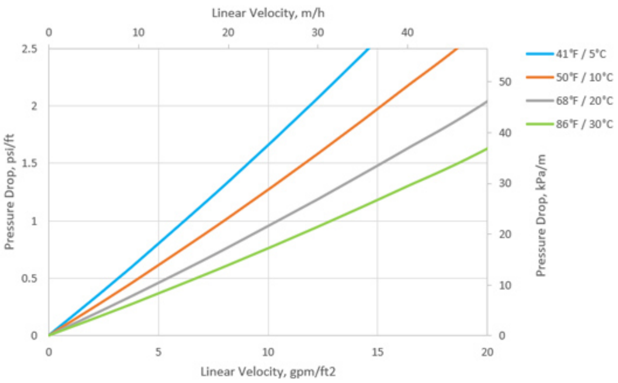
Polymer Structure	Polystyrene crosslinked with divinylbenzene
Appearance	Spherical Beads
Functional Group	Complex Amino
Mean Diameter	675 ± 75 µm
Uniformity Coefficient (max.)	1.3
Specific Gravity	1.05
Shipping Weight (approx.)	650 - 700 g/L (40.6 - 43.8 lb/ft³)
Temperature Limit	100 °C (212.0 °F) (Cl^- form)
Temperature Limit	60 °C (140.0 °F) (OH^- form)

Hydraulic Characteristics

PRESSURE DROP

The pressure drop across a bed of ion exchange resin depends on the particle size distribution, bed depth, and voids volume of the exchange material, as well as on the flow rate and viscosity of the influent solution. Factors affecting any of these parameters—such as the presence of particulate matter filtered out by the bed, abnormal compressibility of the resin, or the incomplete classification of the bed—will have an adverse effect, and result in an increased head loss. Depending on the quality of the influent water, the application and the design of the plant, service flow rates may vary from 10 to 40 BV/h.

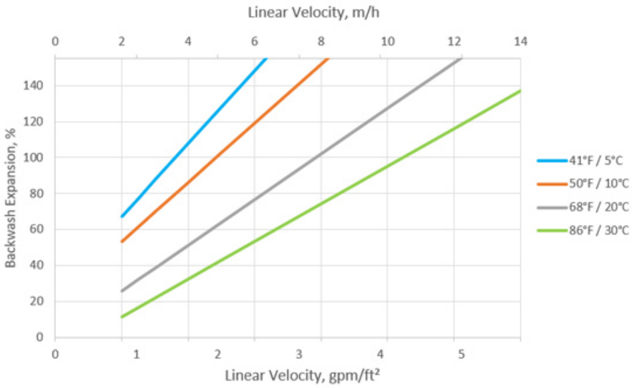
PRESSURE DROP ACROSS RESIN BED



BACKWASH

A 20 BV downflow rinse is required before the vessel is put into service. This rinse can be done onsite or offsite pre-installation. Once the resin is put into service, backwashing is not permitted as this will lead to shortened bed life.This is a uniform grade resin with beads of similar size and will not require backwashing for classification / stratification before use. If it is determined, before startup, that air bubbles or particulate matter are trapped within the bed, then backwashing can be done. In that case, the resin bed should be expanded by 50-70% for 10-15 minutes. Please note that bed expansion increases with higher flow rate and lower water temperature. Avoid loss of resin through the top of the vessel by over expansion of the bed.

BACKWASH EXPANSION OF RESIN BED



Purolite, an Ecolab company, is a leading manufacturer of quality ion exchange, catalyst, adsorbent and specialty high-performance resins with global sales support.

We're ready to solve your process challenges.

For further information on Purolite products and services,
visit www.purolite.com or contact us at the addresses below.

Americas
americas@purolite.com

Asia Pacific
asiapacific@purolite.com

EMEA
emea@purolite.com

APPENDIX C
GENERAL ATOMICS WORK PLAN

Project 39998

DEMONSTRATE DESTRUCTION OF GRANULATED ACTIVATED CHARCOAL AND ION EXCHANGE RESIN BEADS USING INDUSTRIAL SUPERCRITICAL WATER OXIDATION

TEST PLAN

Prepared by General Atomics

September 2023

GENERAL ATOMICS

TEST PLAN SIGNATURE SHEET

Director, Kevin Downey

Project Manager, Ken Liberty

Lead Test Engineer/ Safety Representative, Louie Wong

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
%	Percent
AFFF	Aqueous film-forming foam
APS	Applied process systems
As	Arsenic
Be	Beryllium
BTU/lb	British thermal unit per pound
CAPEX	Capital expense
Cd	Cadmium
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
DAS	Data acquisition system
DRE	Destruction and removal efficiency
DoD	Department of Defense
ELAP	Environmental Laboratory Accreditation Program
g/kg	Gram per kilogram
GA	General Atomics
GA-EMS	General Atomics – Electromagnetic Systems
GAC	Granular activated carbon (or charcoal)
GLS	Gas-liquid separator
GPM	Gallons per minute
HCl	Hydrochloric acid
HF	Hydrofluoric acid
HMI	Human machine interface
HP	High pressure
hrs	Hours
HWA	Hazardous Work Authorization
iSCWO	Industrial supercritical water oxidation
IX	Ion exchange
kg	Kilogram
L	Liter
L/min	Liter per minute
LP	Low pressure
M&EB	Material and energy balance

MACT	Maximum achievable control technology
MDLs	Method detection limits
MJ/kg	Megajoules per kilogram
MRL	Method reporting limit
N_2	Nitrogen
NaOH	Sodium hydroxide
ng/DSCM	Nanogram per dry standard cubic meter
Ni	Nickel
NO_x	Nitrogen oxides
PAC	Powdered activated carbon
O_2	Oxygen
OPEX	Operating expense
Pb	Lead
PFAS	Per- and polyfluoroalkyl substances
PLC	Programmable logic controller
ppmv	Part per million by volume
psia	Pounds per square inch absolute
psig	Pounds per square inch gauge
RCRA	Resource Conservation and Recovery Act
Sb	Antimony
SOP	Standard operating procedure
TEQ	Toxic equivalency
Ti	Titanium
TOC	Total organic carbon
TDS	Total dissolved solids
TSS	Total suspended solids
Tetra Tech	Tetra Tech, Inc.
PPM	Parts per million
SCWO	Supercritical water oxidation
VOC	Volatile organic compound

1. BACKGROUND AND SUMMARY

A contract between General Atomics – Electromagnetic Systems (GA-EMS) and Tetra Tech, Inc. (Tetra Tech) was finalized in June 2022 to process material provided by Tetra Tech through the GA-EMS industrial supercritical water oxidation (iSCWO) and demonstrate destruction efficacy. The materials to be provided are granulated activated charcoal (GAC) and polymeric ion exchange resin (IX) beads saturated with per- and polyfluoroalkyl substances (PFAS) and may be contaminated with volatile organic compounds (VOCs). Both materials are solid wastes that currently do not fall within the Resource Conservation and Recovery Act (RCRA) waste category.

Based on previous experience, GA-EMS believes that the PFAS compounds can be adequately destroyed while the non-combustible content (metals, salt, etc.) will be left intact. Testing includes a workup phase to ensure a well-mixed slurry can be generated and processed at the appropriate feed rates followed by a performance test for Tetra Tech to witness and evaluate. Experience has shown that some char residue may be present when processing GAC or IX but at very low content.

Destruction of PFAS was observed in prior tests processing an aqueous feed material containing an aqueous film-forming foam (AFFF) at various concentrations. While the input feed concentration was shown to approach several hundred parts per million of PFAS (a dilution rate of 34x from AFFF concentrate), the liquid effluent demonstrated only tens of parts per trillion (in some cases to non-detect at the 2 parts per trillion method detection limit) resulting in a >99.9999% (6-9's) destruction efficiency. This testing will attempt to achieve the same or similar destruction efficiency. The gas effluent showed at or below non-detect for nearly all target PFAS compounds.

The test series will be carried out using GA's iSCWO demonstration facility in Building 36 at the Torrey Pines site located in San Diego, California. Test execution is expected to occur over a 2-day period and will include liquid and gas sample collections for submittal to Tetra Tech's contracted analytical company for PFAS analysis. Parallel liquid samples will be collected and transferred to Tetra Tech for their independent analysis.

This document presents the Test Plan for processing the material provided by Tetra Tech using GA's iSCWO technology. As with any test program, alterations of operating conditions and times may be necessary to stabilize operations while maintaining throughput and destruction efficiency.

2. ISCWO SYSTEM DESCRIPTION

The standard GA-EMS iSCWO process combines organic materials with water, fuel, and air at a temperature of 650°C to 700°C and a pressure of 221 bar (~3,200 psig) in a continuous flow reactor configuration. At supercritical conditions, water exhibits unique properties that facilitate its waste destruction capabilities. Typically, organics that are insoluble in water at ambient conditions are miscible with supercritical water. Similarly, gaseous oxygen and oxidation products are miscible with supercritical water. The oxidant and organic waste are therefore combined in a single, dense phase with minimal mass transport limitations, thus allowing rapid and complete destruction of virtually any organic waste feed.

The iSCWO process effectively oxidizes organic materials to yield CO_2, water, and N_2. Inorganic salts and metal oxides can also be found in the liquid effluent stream if anions and metal cations are present in the feed materials. The GA iSCWO system has been shown to oxidize organic compounds including chemical wastes, pesticides, petrochemical solvents, and oily sludge into inert liquids, gases, and salts. The GA iSCWO system provides an environmentally friendly alternative to incineration and is especially suitable for applications where on-site treatment is preferred or required.

The typical iSCWO skid configuration consists of various pumps that deliver the desired fluids to the reactor, a high-pressure (HP) air compressor, a startup fuel-fired preheater, a HP reactor, a pressure letdown system, a low-pressure (LP) gas-liquid separator (GLS), and various holding tanks for feeds and effluent as shown in *Figure 1*.

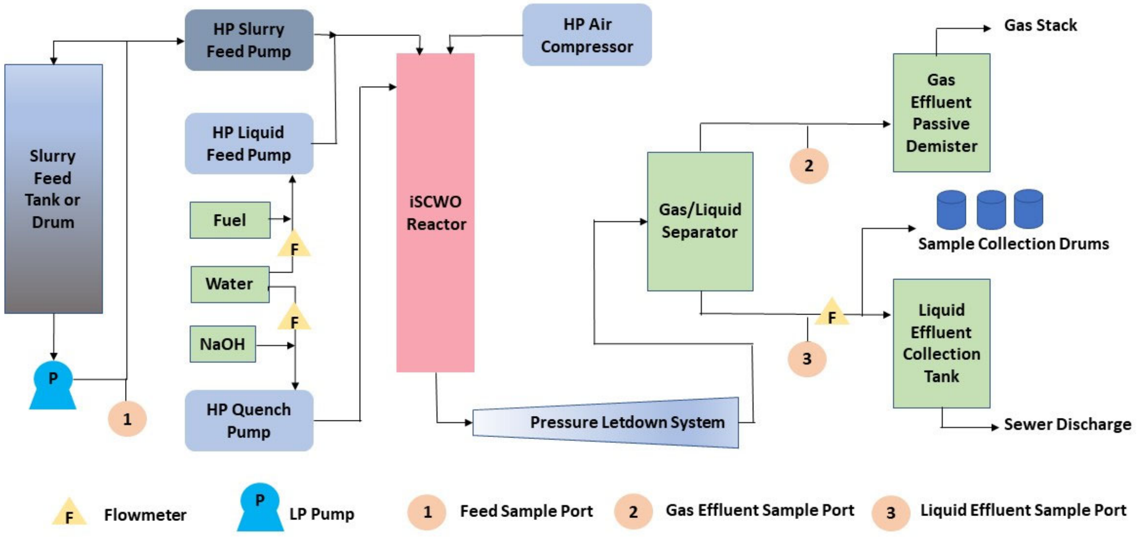


Figure 1. Block Flow Diagram for Pilot-Plant

During normal operation at capacity, the waste feed, and either water and/or fuel, are injected into the reactor through a feed nozzle, which is also used to inject an oxidant (air). Fuel (typically low-sulfur diesel) is used when the waste native heating value is below ~5.1 MJ/kg (2,200 BTU/lb) to ensure adequate reactor temperatures in support of high destruction rates. Water is added when the waste heating value is higher than ~5.1 MJ/kg to prevent overheating of the reactor. The feed nozzle is designed to ensure effective mixing of the oxidant with the fuel/water/waste feed at the inlet of the reactor.

The iSCWO reactor is sized to provide adequate residence time at temperature to maintain high destruction efficiencies, typically >99.99%. The reactor consists of a high-strength steel, pressure-bearing outer shell surrounding an easily removable, pressure-balanced liner. The liner can be fabricated from a number of corrosion-resistant alloys to allow tailoring of the reactor corrosion protection system to a wide range of feed compositions. A titanium liner will be used for the present iSCWO tests based on previous successful experience involving a wide range of waste feeds.

Quench water is introduced near the reactor bottom to reduce the reactor effluent temperature to well below the critical point. The quenched liquid effluent exits through the bottom of the reactor and proceeds to a pressure letdown system.

After exiting the pressure letdown system, the effluent passes to a GLS, where it is separated into its gas and liquid components at near-atmospheric pressure. The gaseous effluent, typically comprised of N_2, CO_2, O_2, and saturated water vapor (steam), is vented to the atmosphere through two demisters in series. The liquid effluent passes through a heat exchanger before being discharged at ~45°C to the user's desired location. The liquid effluent consists of clean water and various dissolved and/or suspended solids depending on constituents in the feed.

The iSCWO system has been shown to destroy many organic chemicals to concentrations that are below detection limits. In these situations, the percent destruction and removal efficiency (DRE) is based on the Method Detection Limit (MDL) and can result in a >99.9999% (six-9's) DRE depending on inlet feed concentrations.

As shown in *Figure 1*, an option to add alkali as sodium hydroxide (NaOH) with the quench stream is available. Alkali addition is useful to neutralize acid-forming wastes and will be used during this demonstration program.

Figures 2 and *3* show views of the two skids that make up the iSCWO pilot-plant to be used for this testing. A fully automated human-machine interface (HMI) controls the iSCWO pilot-plant. All data channels for temperature, pressure, flow, and online analytical instruments are scanned and stored at a prescribed time interval, typically every 2 seconds, on a data acquisition system (DAS). The data can be accessed at any time and used for analysis and data plots. The operator view of the main control screen is shown in *Figure 4*.

The oxidation process within SCWO is vastly different than combustion found in typical incineration. The pressure within an iSCWO reactor creates an environment where the fluid has a high density, somewhere between a liquid and a gas, while still maintaining compressibility like a gas. Oxidation reactions are significantly faster as a result. In addition, the iSCWO reactor only goes to 650°C which precludes the generation of NO_x from dinitrogen (N_2) that is common in high temperature incinerators (850°C).

The iSCWO system is supplied with 650 to 700 standard cubic feet per minute (scfm) dry compressed air at or near ambient temperature with pressures up to 4,000 psia (significant pressure drop can occur through the length of the delivery tubing). After the oxidation process within the iSCWO reactor, the dry gas flow rate is essentially conserved and exits the gas stack effluent at the same 650 to 700 scfm. The recommended gas stack diameter is 12 inches resulting in a dry gas velocity of 2,600 to 2,800 feet per minute. Steam is also part of the gas effluent but concentration can vary depending on feed rate, reactor temperature, quench temperature, and inclusion of any spray or passive demisters.

Figure 2. Pilot-Plant iSCWO Main Skid

Figure 3. Pilot-Plant iSCWO Compressor Skid

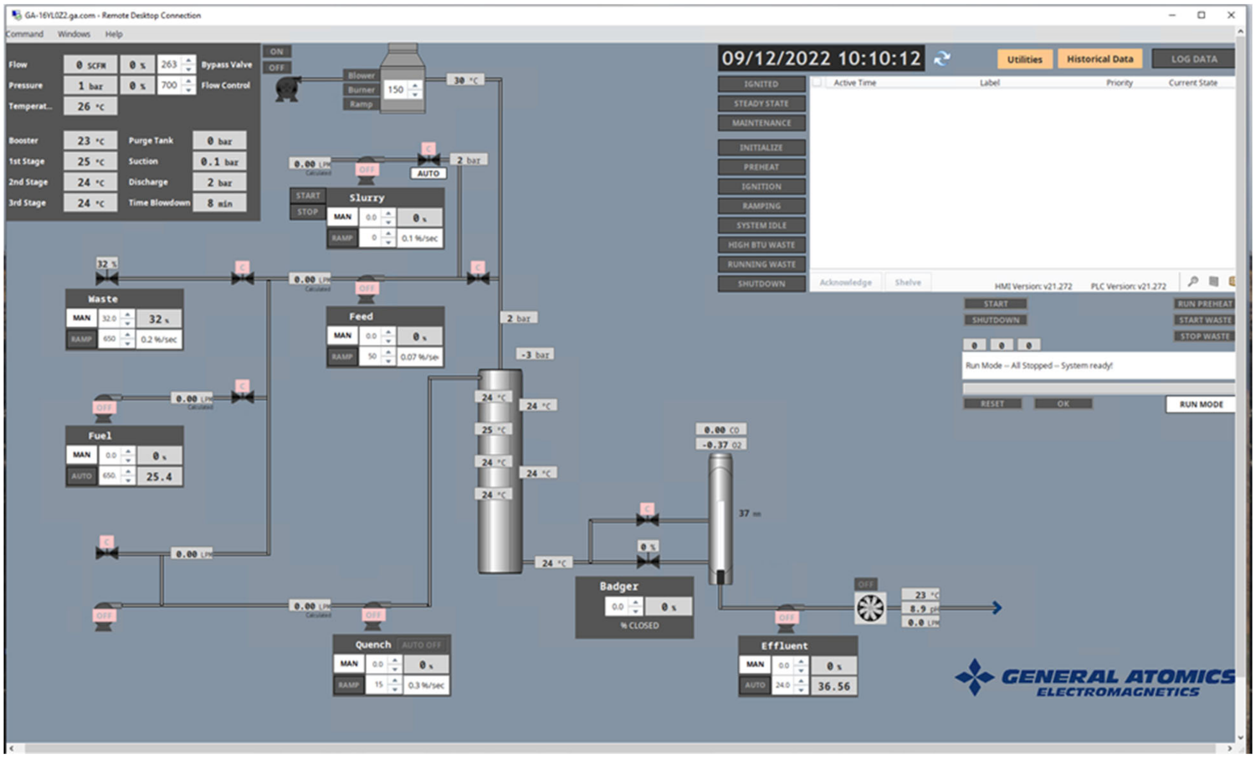


Figure 4. Pilot-Plant iSCWO HMI Screen

GA-EMS has performed multiple studies on the gas emissions of SCWO and determined that in most cases, a secondary pollution abatement system is not needed. A comparison of traditional SCWO emissions to a typical incinerator is shown below in Table 1.

TABLE 1. TYPICAL GAS ANALYSIS FROM SCWO GASEOUS EFFLUENT

Emissions Types in Gas Effluent	MACT/Air Standards	Typical Incinerator Emissions Controls to Meet MACT Standards	SCWO Inherent Performance (no gas cleanup)
Dioxins/furans, ng/DSCM (TEQ)	< 0.2	Rapid quench, powdered activated carbon (PAC) with fabric filter baghouse	< 0.006
Particulate matter, mg/DSCM	< 34	Fabric filter baghouse or electrostatic precipitator	< 4
Toxic metals, mg/DSCM	< 0.010 for Cd + Pb < 0.023 for Sb+As+Be+Cr	Wet electrostatic precipitator	< 0.015 for Cd + Pb < 0.015 for Sb+As+Be+Cr
DRE, %	> 99.99	Afterburner	> 99.9999
HCl, ppmv	< 21	Packed tower wet scrubber	< 0.4
NO_x, ppm	Depends on air district; can be < 100 ppm	Only local regulations apply; ammonia or urea injection may be required	< 1
CO, ppm	< 100	Afterburner	< 10
Hydrocarbons, ppm	< 10	Afterburner	< 10

3. ISCWO PROCESS TEST PLAN

This test plan is a recommended guideline. During actual testing, the test matrix and sampling plan may be updated or modified based on test observations to ensure a high level of destruction efficiency while optimizing the feed throughput. Any modifications to the testing will be discussed with and approved by Tetra Tech prior to implementing. Adjustments may include different temperatures or pressures, changes in feed solids content, changes in thickening agent concentrations, etc.

3.1. Roles and Responsibilities

Table 2 lists the members of the Test Team. Each member has actively worked with SCWO technology for many years including technology development for the iSCWO.

Table 2. Test Team

Function	Name
GA Project Manager	Ken Liberty
GA Safety Manager/Lead Engineer	Louie Wong
GA Test Engineers	Ron Gallego, Juan Salcedo
Subcontractors	
M&EB, Data Analysis, Testing	Glenn Hong (CounterCurrent Systems)
Liquid Effluent Analysis	ALS Global

The functions of the team members are as follows:

GA PROJECT MANAGER: Shall have responsibility for performance of the test, and shall direct test activities, review and approve test documents, and ensure all safety prerequisites have been met prior to start of any test segments.

GA SAFETY MANAGER: shall have overall safety responsibility for test operations.

GA LEAD ENGINEER: shall be responsible for equipment readiness and operations, conduct day-to-day operation of the test, set-up the required equipment to perform the test sequences set forth in the Test Plan, record all pertinent data in a GA laboratory book and/or data sheets, ensure that all safety requirements are met at all times during testing, sign off on all test data collection forms and GA laboratory book pages, and maintain the test equipment and test area in an orderly manner that fully complies with all safety requirements.

GA TEST ENGINEER: Test Engineers shall perform tasks in support of Test Plan operations at the direction of the Lead Engineer. Tasks include directing preparation of feed solutions, inspection and maintenance of test equipment, collection of samples, and other required tasks. Test Engineers shall be responsible for maintaining the equipment and test area in an orderly manner that fully complies with all safety requirements.

CounterCurrent Systems (CCS) has been involved with SCWO systems for over 40 years in both industrial and academic settings. CCS will provide the material and energy balance (M&EB) used to describe the various throughputs and anticipated reactor retention times.

ALS Global is a Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP)-certified analytical lab that has provided services to GA-EMS iSCWO for many years.

3.2. Safety Considerations and Requirements

A safety meeting will be held with all test personnel and observers prior to the start of testing. The specific goals and objectives of the test will be stressed, as well as any changes from prior operations. Safety meetings will ensure all safety rules and regulations are understood and clear to everyone. Specific safety issues relevant to the testing are as follows:

- The iSCWO process utilizes high temperatures and pressures (up to 700°C and 276 bar). The iSCWO components have been designed to meet the applicable code requirements, and the high-pressure/high-temperature portions of the process are enclosed within a protective barrier.
- The iSCWO process requires a detailed operational procedure. All operations personnel will be familiar with this operational procedure and with the Hazardous Work Authorization (HWA, Ref. 3). All personnel handling hazardous chemicals will wear safety shoes, safety glasses, and lab coats, and secondary spill containment will be provided.
- Emergency shower and eye wash facilities will be provided.
- All GA-EMS personnel involved in the operations will be familiar with the applicable Safety Data Sheets.
- Testing will be carried out in accordance with the iSCWO standard operating procedure (SOP, Ref. 5).
- Observers are required to wear sturdy shoes (no open-top) and no loose clothing. Safety glasses and ear protection are also required and can be provided if needed.
- Guest personnel that will be performing limited activities within the laboratory are required to wear safety shoes, safety glasses and ear protection. Nitrile gloves can be provided for handling liquids. A lab coat is recommended.
- The test facility is located in a narrow ravine surrounded by brush and chaparral. Wildlife such as rattlesnakes, black widow spiders, scorpions, etc., are known to live within the area. Though encountering these animals is rare, all personnel should be aware of their surroundings and avoid reaching into dark or obstructed view spaces.

3.3. Quality Assurance

GA-EMS maintains a quality management program consistent with AS9100 and ISO 9001, where applicable. Testing activities will be performed in compliance with GA-EMS' Quality Management System (QMS) which covers the following areas:

- Training and qualification of personnel.
- Nonconformance control and corrective actions.
- Documentation and record keeping.
- Qualification of equipment, processes, and procedures.

Quality assurance for the iSCWO program includes the hazardous work authorization (HWA) document (ref. 3) that is updated annually. A copy of the HWA and additional QMS documentation can be provided upon request.

3.4. Process Monitoring Procedure

All process monitoring within the iSCWO system is performed automatically by the Programmable Logic Controller (PLC), and data are automatically logged to a computer. Analytical instruments will be calibrated prior to testing by the test engineer, or vendor, using calibration gases and pH buffer solutions. Any additional monitoring or sampling requirements are specific to each project and are identified in Section 3.8.

3.5. Test Objectives

The purpose of this test program is to establish reasonable operating conditions that will destroy the test material sufficiently while maintaining appropriate emissions.

The specific test objectives for this test include:

- Demonstrate a method for preparing solid media through a grinding process, and processing ground GAC and IX resin beads as a slurry feed to the iSCWO system.
- Operate the system for several hours under steady state conditions and confirm destruction of PFAS compounds. Steady state conditions are achieved when the slurry feed is at a consistent solids content with a feed rate of 2 gallons per minute (gpm) (see Section 3.7).
- Verify that air and liquid effluent quality meets customer needs.

3.6. Feed Composition

GA-EMS anticipates 2 (two) waste feeds to be developed using solid media material provided by Tetra Tech. The constituents of concern within the solid media are shown below in Table 3 based on data provided by Tetra Tech on 14 September 2023.

Table 3. Feed Composition and Concentrations

Test Material	Structure	Estimated Particle Size (microns)	Anticipated PFAS Concentration (g/kg)*	Anticipated Organic Chlorine Concentration (g/kg)*
GAC	Coconut Shell	420 - 840	3.29	0.064
IX	Polystyrene–Divinylbenzene (Amine-based)	675 ± 75	0.44	0.163

* - Estimated based on 15 months (11,536,015 gallons) operations and 100% capture.

The PFAS and chlorine content were calculated based on the solid media capturing components from influent water until saturation, estimated at 15 months of operation. These values do not express actual concentrations but will only be used as a guide for estimating the sodium hydroxide addition to neutralize acids (HF, HCl and possibly H_2SO_4) formed in the supercritical water environment.

Upon arrival, the GAC media will first be mixed with water and Xanthan gum thickening agent within a large tank to a concentration that allows for material to be pumped by a diaphragm pump. The water is a city tap water that will pass through a soft water tank to remove minerals that cause hardness. This is performed to prevent scale buildup within the iSCWO reactor that might interfere with the testing.

For grinding, the slurry mix will pass through an inline grinder connected to the diaphragm pump with a return line to the mixed tank. After several hours of grinding, the slurry will then pass through the grinder one more time and distributed into holding bins (drums or totes) until ready for processing. The grinder is important to ensure that particle sizes are small enough to ensure passage through the high-pressure slurry pump and adequately destroyed within the iSCWO reactor. This process will be repeated for the IX resin beads.

The inline grinder to be used is a Greerco Colloid Mill, model W250H-B. A picture of the grinder is shown below in *Figure 5*. An adjustable wheel allows for grinding to fine particles at or below 100 microns.

Figure 5. Greerco grinder

Once the material has completed the grinding process, additional water and thickening agent will need to be added such that the final solids content is at 10%. Prior to making each feed batch, a smaller batch will be made (~1 Liter) with each test material to ensure sufficient solids suspension in preparation for the larger batches. Once the small batch is confirmed appropriate, the remaining batch will be mixed with water and Xanthan gum.

3.7. Test Matrix

The test matrix, shown below in Table 4, was developed based on material provided, appropriate solids content and providing for a sufficient steady state period of greater than 2 hours to acquire gas and liquid effluent samples. Changes can be discussed prior to making each batch of feed material depending on Tetra Tech requests. Changes made during the treatability study will be documented throughout the test and reasons for changes will be discussed in the final report.

Feed rate target for all tests will be approximately 2 gpm but can be slightly different depending on system variations such as slurry viscosity, system pressure, etc. Tank height measurements will be taken to confirm actual feed rates.

Table 4. Test Matrix

Test	Feed	Solids Mass (kg)	Xanthan gum (kg)	Volume (L)	Feed Rate (L/min)	Anticipated Run Time (hrs)
1	10% IX	201	2.01	2010	7.4	4
2	10% GAC	161	1.61	1610	7.4	3

Before the performance tests, GA-EMS will process a portion of the prepared slurry as workup tests. These workup tests are performed to ensure that all components are operating properly, and the slurry is feeding in a steady manner. Enough material will be retained for the performance tests. Test execution is expected to occur over a 2-day period. Operators anticipate that the first waste stream to process will be the ground IX bead slurry followed by the ground GAC slurry.

Prior to starting the iSCWO system, a preliminary checkout (Ref. 5) will be performed to ensure all systems are functioning. This includes checking oil levels, turning on/off pneumatic valves, and turning on low pressure air compressors or feed pumps. Once the checkout is complete, the system is ready for startup. Startup is performed using water (with 0.2% xanthan gum) and diesel and temperature is then ramped up until operating temperatures and pressures (steady state conditions) are reached. Slurry feed is then ramped up while reducing water flow. The slurry feeds are anticipated to have some energy content and will likely demonstrate a reduced diesel flow for maintaining temperature while processing.

Table 5 below describes the planned test procedure in more detail. Once the iSCWO system is running steady state on diesel and water (baseline conditions) for 30 minutes, a baseline sample will be taken prior to introducing the slurry feed. Additional samples will be taken, either duplicate or at other times, as requested by Tetra Tech.

Table 5. Tetra Tech Performance Testing Steps and Sampling

Process Step	Duration (hrs)	Sampling Description	Sample Type	Sample Time(s) from Startup (hrs)
System startup (water and diesel)	0.5	Startup	Soft water	T=0.5
HP Slurry Pump startup (water and diesel with 0.2% xanthan gum)	0.5	NA	NA	NA
Steady state (water and diesel with 0.2% xanthan gum)	0.5	Baseline* (no waste feed)	Liquid effluent	T=1.5
Ramp up Feed	1.0	Feed	Feed	T=2.5
Steady state on Feed	3.0	Steady State	Liquid Effluent Gas Effluent	T= 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0
Ramp down Feed	1.0	NA	NA	NA
Flush System	0.5	NA	NA	NA
Shutdown	0	NA	NA	NA
Total time	**~7.0**			

Nominal operating conditions anticipated for the Tetra Tech testing are shown in Table 6. Operating conditions can vary depending on pressure within the reactor, which is affected by total throughput, viscosity of solution, quench flow, temperature, etc. Other parameters that can be adjusted, based on experience from the workup tests, include solids content, thickening agent content, and particle size (process through the grinder multiple times).

Table 6. iSCWO Operating Conditions

Operating Parameters	Range in Values	Typical Values
Reactor Internal Temperature	600°C – 700°C	650°C
Reactor Internal Pressure	165 bar – 240 bar	225 bar
Reactor Residence Time	10-13 sec	10 sec
Excess O_2 in gas effluent	2-10 vol %	3%
Quench Temperature	275°C - 325°C	300°C

3.8. Sample Collection and Analysis

GA-EMS will collect liquid effluent samples throughout the test and stored until ready for shipment to the corresponding laboratory for analysis not longer than standard holding times. Representative feed samples will also be collected at the beginning of each test. GA-EMS will assist with the gas and liquid effluent sample collection that Tetra Tech has requested.

Table 7 provides a summary of the analytical methods to be employed by GA for each chemical species being analyzed, including the anticipated concentration. It should be noted that if the analysis shows a non-detect for a certain compound within the liquid effluent, then the destruction efficiency calculation will be based on the method detection limit (MDL). Analytical results collected will be used to support and verify the M&EB model that should provide confidence in the destruction capability.

Table 7. Effluent Analytical Details

Sample	Chemical Species	Method	Expected Concentration
Gas Effluent	CO	Online, Testo	< 10 ppm
	O_2	Online, Testo	2–10 vol %
	NO_x, SO_x, VOC	Testo	0 ppm
Liquid Effluent	TOC	9060A/5310C	< 10 mg/L
	Total Dissolved Solids (TDS)	2540C	TBD
	Total Suspended Solids (TSS)	2540D	TBD
	Metals (Cr, Cd, Ni, Cu, Ti)	6010C	TBD

Liquid effluent will be collected in 1-Liter sample bottles for distribution into containers for the analyses shown in Table 7. These sample bottles are not meant for the PFAS analyses and will be shipped out within appropriate holding times. Duplicate liquid samples will be collected into separate PFAS-free bottles, supplied by Tetra Tech, and provided to Tetra Tech for their independent analysis. The shipping of liquid effluent for PFAS analyses will be performed by Tetra Tech with assistance by GA-EMS as needed.

The liquid effluent is anticipated to contain a small amount of solid particulates when processing both the ground IX and GAC. Previous work has shown that up to 50 mg/L of total suspended solids (TSS) has been identified when processing a 10% slurry feed with ground IX beads. Solids residue, when processing ground GAC, is yet undetermined but will likely be similar. The liquid effluent solids are known to settle within a 24-hr time period, at which time the clarified water can be decanted into a separate container allowing access to the solids. Alternatively, a filter system can be used to collect the solids.

During operations, gas effluent is continuously pulled through a sampling line from the stack at a rate of approximately 10 liters per minute (lpm). This gas passes through a condenser to collect water vapor, travels to the gas analysis cabinet, then to any number of external devices for gas analysis.

A Testo 350 (Testo) gas analyzer, connected to the gas sampling line, monitors and records typical criteria pollutants as shown in Table 7. The chemical sensors within the Testo 350, a rented unit, will be pre-calibrated by the vendor prior to shipping to GA.

Accommodations will be made to allow for sorbent tubes, provided by Tetra Tech, to be connected in parallel with the Testo 350. Assistance will be provided to make the connection. The shipping of sorbent tubes for PFAS analyses will be performed by Tetra Tech with assistance by GA-EMS as needed. Up to 9 L/min of air flow should be available. If additional air flow is needed, GA-EMS has the ability to update the air diaphragm pumps for increased capacity.

Real-time liquid effluent analysis includes the inline pH meter to monitor liquid effluent discharge and a gas analyzer that measures O_2 and CO concentrations on a real-time basis as indicated in Table 8. As a check, pH strips or litmus paper will be used frequently to confirm pH readings. Caustic NaOH addition will be adjusted as necessary to maintain neutral liquid effluent.

Table 8. Online Analytical Methods

Sample Type	Species	Online Analytical Method
Liquid Effluent Monitoring	pH	Electrode
Gas Effluent Monitoring	CO	Electrochemical
Gas Effluent Monitoring	O_2	Electrochemical

Additional liquid effluent analyses may be necessary and compared to the San Diego sewer release criteria. If sample analysis demonstrates that the liquid effluent is below the release criteria, then the collected liquid effluent can be discharged.

3.9. Other Data

Other non-analytical data required for evaluating operating expense (OPEX) and capital expense (CAPEX) will be collected. These data items include past operating experience, PLC data (temperatures, pressures, flow rates, etc.), and system modifications, if any. System electrical consumption has been previously measured, and 96% of the power consumption has been found to be due to the HP air compressor. Once tests are complete, the system data will be downloaded, reviewed and configured for easy reading to be included in the technical test report.

3.10. Testing Challenges

During Workup and Performance testing, several challenges may be encountered that will require careful attention. These topics may include, but are not limited to:

- Though some chemical data is available, there is still some uncertainty as to the content of various elements within the solids matrices that can result in additional acids forming within the reactor. These acids will be neutralized at the reactor outlet using a 5 wt% or 35 wt% solution of NaOH to prevent downstream corrosion and any releases out the stack. In order to ensure a safe environment, excess caustic will be added at the beginning of each test, then reduced over time until the liquid effluent reaches neutrality (pH ~7). This will result in high sodium content in the liquid effluent toward the beginning of feeding each test material.
- Gas effluent will pass through the dual demister stages to collect any condensate. This condensate can be analyzed for PFAS similar liquid effluent samples. Throughout testing, the condensate may have to be emptied from the demisters. This material can be collected in drums and allowed to cool prior to sampling. Tetra Tech should request this sample in advance to ensure enough containers are made available.
- Previous testing has shown that feed with high solids content may require a high concentration of thickening agent (Xanthan gum) to keep solids suspended. This creates

a high viscosity feed matrix which presents additional challenges for supplying the suction side of the high-pressure slurry feed pump. Previous work has shown that a 0.2% xanthan gum is sufficient for the IX beads, however, a different concentration may be needed for the GAC. The feed matrix may have to be altered from that shown on Table 3 to ensure stable slurry feed rates.

4. WASTE DISPOSAL

The iSCWO system is intended to be operated such that all the feed material will be used up. However, in the event that some feed is not processed, an environmental agency will be employed to collect and dispose of the residual process feed as a hazardous waste. This material will be transported to an appropriate treatment facility where it will be destroyed. If Tetra Tech requires an alternate path, such as returning the material to the origination point, then arrangements can be made.

5. SCHEDULE

Table 9 below shows the current project schedule. Performance testing is scheduled to occur during the week of 6 November, however, this time can be moved to a different date depending on when test materials arrive and schedules for stakeholder observation. Changes are also possible to accommodate Tetra Tech personnel needs, as well as if any issues arise that may prevent the system from operating as expected.

Table 9. Performance Testing Schedule

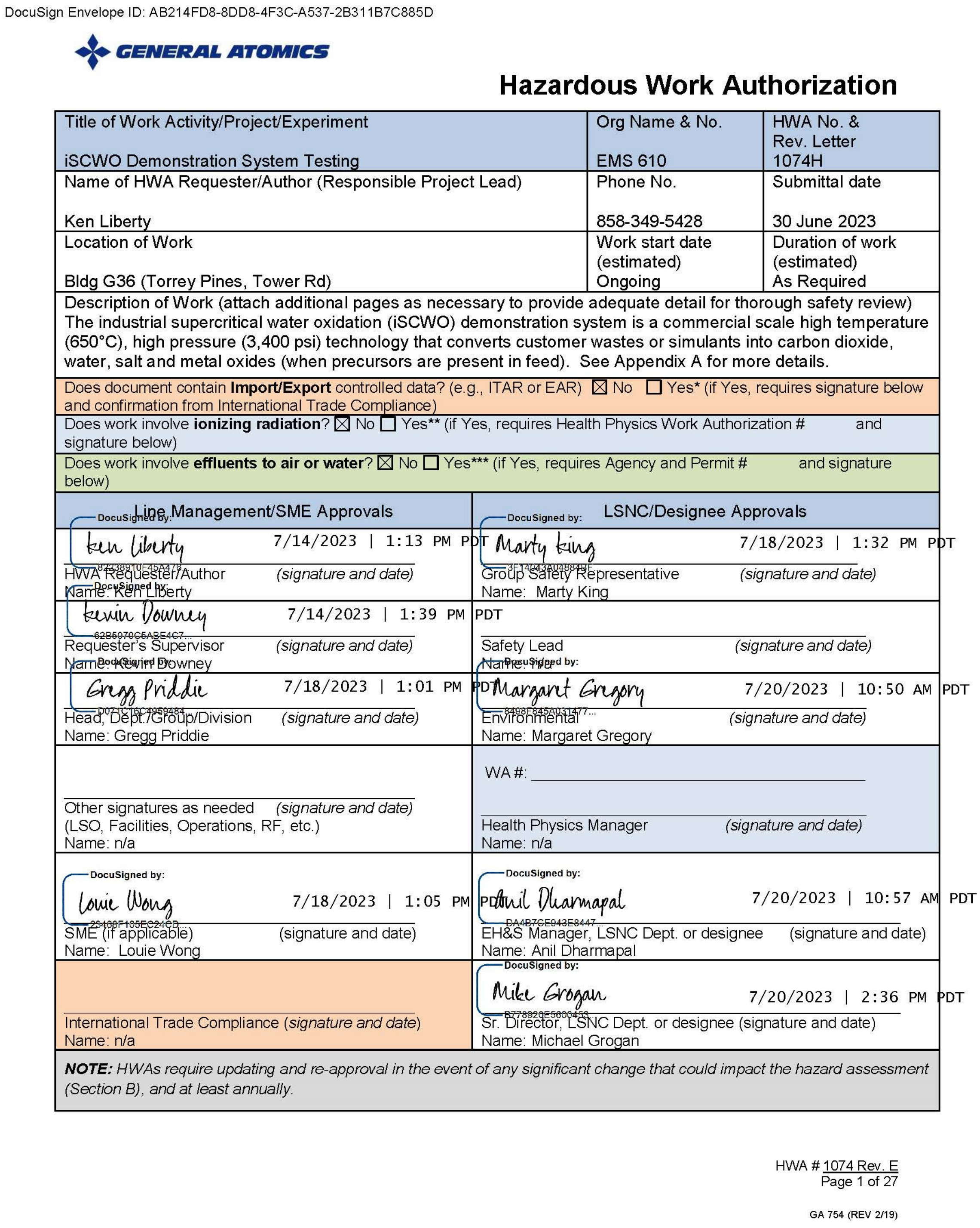
Description	Start/Actual Date	End/Actual Date
Contract Award	**6 Jun 2023**	—
Project Kickoff Meeting	—	**10 Jun 2023**
Test Matrix	**12 Jun 2023**	22 Sep 2023
Receipt of simulants for testing	2 Oct 2023	13 Oct 2023
Work-up Testing	23 Oct 2023	3 Nov 2023
Performance Test Execution	6 Nov 2023	9 Nov 2023
Sample Analysis	13 Nov 2023	27 Nov 2023
Test Report	13 Nov 2023	15 Dec 2023
Project Complete	—	15 Dec 2023

Following the testing, gas and liquid samples will be submitted to the analytical lab for analyses which can take up to 6 weeks depending on their schedule and demand. After receiving all analytical data, a draft report will be prepared to incorporate analytical results, operational data, and conclusions from testing. Once the draft report is submitted, Tetra Tech will have up to 10 working days to provide comments on the report. GA will then address these comments and issue the final report within 15 working days. Once the final report is submitted to Tetra Tech, the project will be considered complete.

6. REFERENCES

1. Industrial SCWO for the Treatment of PFAS/AFFF Within a Water Matrix; EPA/600/R-22/257, September 2022; Sahle-Demessie, Berg, Shields, Jackson, George, Liberty, Follin. (https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=CESER&dirEntryId=357639)
2. Validation of Supercritical Water Oxidation to Destroy Perfluoroalkyl Acids, Remediation Journal, 20 Jan 2022; 1-16; McDonough, Kirby, Bellona, Quinnan, Welty, Follin, Liberty.
3. Hazardous Work Authorization, GA Document No. HWA 1074, Rev. H, July 2023.
4. 3 GPM iSCWO Hazards Analysis, Rev A, iSCWOT030004
5. iSCWO Standard Operating Procedure, Rev B,
6. City of San Diego Public Utilities Department, Local Limit for Industrial Wastewater

Reference 3.



DocuSign Envelope ID: AB214FD8-8DD8-4F3C-A537-2B311B7C885D

GENERAL ATOMICS

Hazardous Work Authorization

Title of Work Activity/Project/Experiment iSCWO Demonstration System Testing	Org Name & No. EMS 610	HWA No. & Rev. Letter 1074H
Name of HWA Requester/Author (Responsible Project Lead) Ken Liberty	Phone No. 858-349-5428	Submittal date 30 June 2023
Location of Work Bldg G36 (Torrey Pines, Tower Rd)	Work start date (estimated) Ongoing	Duration of work (estimated) As Required

Description of Work (attach additional pages as necessary to provide adequate detail for thorough safety review)
The industrial supercritical water oxidation (iSCWO) demonstration system is a commercial scale high temperature (650°C), high pressure (3,400 psi) technology that converts customer wastes or simulants into carbon dioxide, water, salt and metal oxides (when precursors are present in feed). See Appendix A for more details.

Does document contain **Import/Export** controlled data? (e.g., ITAR or EAR) ☒ No ☐ Yes* (if Yes, requires signature below and confirmation from International Trade Compliance)

Does work involve **ionizing radiation**? ☒ No ☐ Yes** (if Yes, requires Health Physics Work Authorization # and signature below)

Does work involve **effluents to air or water**? ☒ No ☐ Yes*** (if Yes, requires Agency and Permit # and signature below)

Line Management/SME Approvals	LSNC/Designee Approvals
DocuSigned by: Ken Liberty 7/14/2023 | 1:13 PM PDT 82238910F45A476... HWA Requester/Author *(signature and date)* Name: Ken Liberty	DocuSigned by: Marty King 7/18/2023 | 1:32 PM PDT 3F14043A04884BF... Group Safety Representative *(signature and date)* Name: Marty King
DocuSigned by: Kevin Downey 7/14/2023 | 1:39 PM PDT 62B6070C6ABE4C7... Requester's Supervisor *(signature and date)* Name: Kevin Downey	Safety Lead *(signature and date)* Name: n/a
DocuSigned by: Gregg Priddie 7/18/2023 | 1:01 PM PDT D071C16C4959484... Head, Dept./Group/Division *(signature and date)* Name: Gregg Priddie	DocuSigned by: Margaret Gregory 7/20/2023 | 10:50 AM PDT 8498F845A0314477... Environmental *(signature and date)* Name: Margaret Gregory
Other signatures as needed *(signature and date)* (LSO, Facilities, Operations, RF, etc.) Name: n/a	WA #: __________ Health Physics Manager *(signature and date)* Name: n/a
DocuSigned by: Louie Wong 7/18/2023 | 1:05 PM PDT 23406F105EC24CD... SME (if applicable) (signature and date) Name: Louie Wong	DocuSigned by: Anil Dharmapal 7/20/2023 | 10:57 AM PDT DA4B7CE043E8447... EH&S Manager, LSNC Dept. or designee (signature and date) Name: Anil Dharmapal
International Trade Compliance (*signature and date*) Name: n/a	DocuSigned by: Mike Grogan 7/20/2023 | 2:36 PM PDT B778920E5000453... Sr. Director, LSNC Dept. or designee (signature and date) Name: Michael Grogan

NOTE: *HWAs require updating and re-approval in the event of any significant change that could impact the hazard assessment (Section B), and at least annually.*

HWA # 1074 Rev. E
Page 1 of 27

GA 754 (REV 2/19)

Reference 4.

iSCWOT030004
REVISION A

Industrial Supercritical Water Oxidation (iSCWO)
3 GPM System

Hazards Analysis

GENERAL ATOMICS

Reference 5.

SOP
Revision B

Industrial Supercritical Water Oxidation (iSCWO)
3 GPM System

Standard Operating Procedure (SOP)

Prepared for General Purposes

GENERAL ATOMICS

TABLE OF CONTENTS

APPENDIX

ACRONYMS AND ABBREVIATIONS

GA	General Atomics
iSCWO	Industrial Supercritical Water Oxidation
SOP	Standard Operating Procedure

Standard Operating Procedure

SOP
REV. B

1 BACKGROUND

General Atomics (GA) sells 3-gpm industrial supercritical water oxidation (iSCWO) systems for customers requiring an advanced technology for waste disposal. The iSCWO system can be used to process a variety of waste streams provided that the waste feed can be pumped (liquid, slurry, etc.). The purpose of this document is to provide a general step-by-step procedure for the safe and effective operation of the iSCWO systems for pre-operation check, startup, waste processing, sampling, shutdown, and emergency shutdown procedures.

1.1 Assumptions

- All required utilities and inlet/outlet process streams are connected and available to the iSCWO skid and container, including:
  - Power
  - Soft Water
  - High Pressure Air
  - Instrument Air
  - Propane
  - Diesel
  - Effluent Line
  - CO calibration Gas
  - N_2 calibration Gas

2 GENERAL SAFETY REQUIREMENTS

- All personnel involved in operating the iSCWO systems must go through training so that they are familiar with the equipment.
- Applicable portions of the SOP are available for reference when operating the test equipment. They are located in the control booth. Supervisory personnel shall maintain complete copies of the SOP and be responsible for the enforcement of its provisions.
- All personnel, at a minimum, must wear safety glasses when working in the vicinity of the iSCWO equipment. Hearing protection is strongly recommended when working near the high-pressure air compressor (HPAC).

3 NORMAL OPERATION PROCEDURES

3.1 Pre-Operation Procedure

3.1.1 Check availability of required safety equipment (gloves, face shield, safety glasses, hearing protection and eyewash, etc.)

3.1.2 Ensure power is turned on to the iSCWO skid.

3.1.3 Turn on iSCWO HMI computer and start iSCWO HMI program.

3.1.4 Disengage control room and iSCWO skid e-stops.

3.1.5 Clear any active limit switches at the local display for the following transmitters:
PISH-600
TISH-502
TISH-601

TISH-620
TISH-651
XA-503 (Burner Fault)

3.1.6 Clear active HMI alarms by pressing clear alarms button. See Control Description (Ref. 1) for explanation of alarms.

3.1.7 Check that effluent tank can accept additional effluent for the planned run.

3.1.8 Ensure HPAC oil level is at the appropriate level.

3.1.9 Ensure screw compressor oil level is above minimum level on sight gauge.

3.1.10 Ensure gas sampling chiller and pump are operational.

3.1.11 Ensure manual valves in Appendix A are in the listed position.

3.1.12 Ensure instrument air is available.

3.1.13 Ensure diesel fuel is available.

3.1.14 Ensure propane gas is available.

3.1.15 Ensure waste feed is available.

3.1.16 Ensure low pressure water is available.

3.1.17 Ensure CO and O2 analyzers are calibrated (if required) and operational.

3.1.18 Ensure the sample pump for the CO and O2 analyzers are providing adequate flow to each analyzer (~0.5 to 1.0 L/min)

3.1.19 Bleed out air from the low pressure water supply line using HV-204.

3.1.20 Bleed out air from the low pressure diesel fuel supply line using HV-305.

3.1.21 Bleed out air from the waste feed line using HV-107.

3.1.22 Power up HP/screw compressor skid and reset any faults.

3.2 Startup Procedure

3.2.1 Press start button on Main Logic Control Screen popup window. System initializes: Controls reset, HP feed pump and quench pump provide water to the reactor, and HP air compressor starts.

3.2.2 Main Logic Control Screen popup window will notify operator when system is pressurize and ready to start preheat. Press OK button to start preheat.

3.2.3 System preheats: HP feed pump will reduces water flow to reactor as preheater heats incoming air.

3.2.4 Main Logic Control Screen popup window will notify operator when reactor reaches auxiliary fuel ignition temperature and system is ready to start ignition. Press OK button to start ignition.

3.2.5 System ignites: Auxiliary fuel enters reactor and the system demonstrates ignition (temperature is sustained by auxiliary, preheating is no longer necessary). Auxiliary fuel controller controls reactor temperature to setpoint.

3.2.6 Main Logic Control Screen popup window will notify operator when system is ready to start ramping up water flow. Press OK button to start ramp.

3.2.7 Ramp: HP feed pump increases water flow until setpoint is reached. Auxiliary fuel pump controls reactor internal temperature. The auto control system will automatically stop ramp if any flow disturbances are detected. Observe reactor temperature and restart ramp by pressing the auto/manual button on feed pump control detail popup window.

3.2.8 When feed pump setpoint is reached, Main Logic Control Screen popup window will notify operator that the system is at steady state.

3.3 Waste Processing Procedure

3.3.1 When waste is ready for processing, press ramp button next to FCV-104 to bring up waste control popup window. Adjust waste feed ramp rate then press Start low BTU waste button on Main Logic Control Screen popup window. This will start transition from water to waste feed.

3.3.2 Observe that water flow decreases as waste feed increases. Adjust waste feed ramp rate and setpoint as necessary to prevent temperature swings. Main Logic Control Screen popup window will notify operator when system has completed transition to waste feed.

3.3.3 Allow iSCWO system to run at steady state until ready to transition off of waste feed. Press OK button on Main Logic Control Screen popup window to start transition back to water/auxiliary fuel.

3.4 Effluent Sampling Procedure

3.4.1 Open HV-809 to purge the stagnant liquid from the sample line into a bucket. Place sample bottle underneath HV-809 and open valve to collect sample.

3.4.2 Close HV-809.

3.5 Shutdown Procedure

3.5.1 The iSCWO system shutdown sequence can be started by pushing the Shutdown button on the Main Logic Control Screen popup window.

3.5.2 If system is processing waste, it will automatically switch off waste and transfer back to water/diesel feed. It will sit idle until waste is cleared from the reactor.

3.5.3 Feed pump (P-100) will stop.

3.5.4 Quench pump (P-400) will stop.

3.5.5 HP air compressor (C-500) will stop.

4 EMERGENCY SHUTDOWN AND RECOVERY PROCEDURES

In case of emergency or upset condition, the iSCWO system can be shutdown manually using an E-Stop button or automatically by interlock logic. In case of unplanned shutdown, the recovery procedure will need to be performed.

4.1 E-Stop Button Shutdown

Press E-Stop button in the control room or on the local panel at the iSCWO skid. (Note: the E-Stop button on the preheater panel (H-501) will only stop the preheater).

4.2 Interlock Logic Shutdown

In the event of an upset operation the system interlocks will stop the system. See Controls Document (Ref. 1) for explanation of interlocks.

4.3 Unplanned Shutdown Recovery Procedure

4.3.1 Slowly open hand valve (HV-101) to drain diesel/water/waste mixture in feed pump discharge line.

4.3.2 When reactor pressure (PT-600) drops below 5 bar, on the main control screen open FV-103 for ~8 sec then close FV-103 (this drains the remaining diesel/water/waste liquid from the reactor inlet line).

4.3.3 Close HV-101 and close HV-201 (closing HV-201 prevents building up excess liquid in the system while flushing the feed pump).

4.3.4 On the main control computer, change mode selector switch to “Maintenance”, then open FV-200, and then cycle HV-101 to flush out the feed pump discharge line. Close FV-200 after cycling HV-101 a few times.

4.3.5 Close HV-101, open HV-201, and on the main computer, change the mode selector switch back to “Run”.

4.3.6 Check for any alarms or interlocks on the HMI. Use Controls document (Ref. 1) to help identify root cause of unplanned shutdown.

4.3.7 Correct problem.

4.3.8 Go through pre-operation and startup procedures to restart the system.

5 REFERENCES

1. Controls Description with Alarms & Interlocks,

APPENDIX A

Manual Valve Pre-Operation Position

Standard Operating Procedure SOP
REV. B

Manual Valve Pre-Operation Position

Tag #	Description	Position
HV-108	Waste Feed Supply Valve	Open
HV-200	Skid Water Supply Valve	Open
HV-201	Quench Water Supply	Open
HV-205	Water Supply Interface Valve	Open
HV-301	iSCWO Fuel Supply Interface Valve	Open
HV-501	Preheater Fuel Supply Interface Valve	Open
HV-801	GLS Outlet Block Valve	Open
HV-803	Liquid Effluent Sample Block Valve	Open
HV-804	pH Electrode Inlet Isolation Valve	Open
HV-805	pH Electrode Outlet Isolation Valve	Open
HV-806	Liquid Effluent Block Valve	Open
HV-807	LT-801 Isolation Valve	Open
HV-811	Liquid Effluent Valve	Open
HV-812	Off Spec Effluent Valve	Open
HV-506	Quench Purge Air Needle Valve	Leave @ Current Position
HV-800	Gas Sampling Shutoff Valve	Open to Sample Position
HV-101	Waste Purge Valve	Closed
HV-102	Waste Tank Drain Valve	Closed
HV-104	Waste Feed Drain Valve	Closed
HV-105	Waste Feed Recycle Valve	Closed
HV-109	Waste Feed High Point Vent	Closed
HV-110	Waste Recycle Discharge Valve	Closed
HV-202	Water Low-Point Drain Valve	Closed
HV-204	Low Pressure Water High Point Vent	Closed
HV-304	iSCWO Fuel Low Point Drain	Closed
HV-305	Fuel Line Vent Valve	Closed
HV-502	Preheater Fuel Low Point Drain	Closed
HV-802	GLS Drain Valve	Closed
HV-808	LT-801 Drain Valve	Closed
HV-809	Liquid Effluent Sample Valve	Closed
HV-810	Liquid Effluent Drain Valve	Closed

Reference 6.

City of San Diego
Public Utilities Department
Environmental Monitoring & Technical Services Division
Industrial Wastewater Control Program
Current Local Limits

POLLUTANT	LOCAL LIMIT
pH	5-12.5
O&G	500 mg/L
Dissolved Sulfides	1.0 mg/L
Flash Point	> 140 ºF
Temperature	< 150 ºF
Cyanide (Total)	1.9 mg/L
Cadmium	1.0 mg/L
Chromium	5.0 mg/L
Copper	11.0 mg/L
Lead	5.0 mg/L
Nickel	13.0 mg/L
Silver	n/a
Zinc	24.0 mg/L

Local limits are re-evaluated annually and subject to change.

Note: City of San Diego local limits are applicable to Significant Industrial Users (SIUs) only.

Y:\EMTS\41.Sections\IWCP\Web Files\Local Limits.doc Rev. 04/04/12w

APPENDIX D
LIST OF VARIABLE AND ASSOCIATED SAMPLE ID

List of Variable and Associated Sample ID

Equation Variable	Variable Definition	Associated Sample ID/ Data Source	Analytical Group
$M_{x,inf}\left(\frac{\mu g}{hr}\right)$	Influent (slurry) feed mass flow rate for an individual PFAS	Equation (1)	NA
$C_{x,inf}\left(\frac{\mu g}{L}\right)$	Concentration for an individual PFAS in the influent (slurry)	Equation (2)	NA
$Q_{inf}\left(\frac{L}{hr}\right)$	Influent (slurry) flow rate	SCWO Treatment Parameter/ GA Workplan	NA
$C_{x,SM}\left(\frac{\mu g}{kg}\right)$	Concentration for an individual PFAS in the spent media	HA-SpentGAC-Composite-S -YYMMDD-SN HA-SpentIX-Composite-S -YYMMDD-SN	PFAS
$S\ \left(\frac{kg}{L}\right)$	Solid concentration of spent media (GAC or IX resin) in influent (slurry) feed	SCWO Treatment Parameter/ GA Workplan	NA
$C_{x,SW}\left(\frac{\mu g}{L}\right)$	Concentration for individual PFAS in soft water	HA-SW-Influent-L-YYMMDD-SN	PFAS
$M_{x,tot-eff}\left(\frac{\mu g}{hr}\right)$	Summed mass flow rate of individual PFAS in the effluent (liquid), condensate (liquid), effluent (gas), and filter residue (solid)	Equation (3)	NA
$M_{x,liq}\left(\frac{\mu g}{hr}\right)$	Effluent (liquid) mass flow rate for an individual PFAS	Equation (4)	NA
$M_{x,gas}\left(\frac{\mu g}{hr}\right)$	Effluent (gas) mass flow rate for individual PFAS	Equation (5)	NA
$M_{x,cond}\left(\frac{\mu g}{hr}\right)$	Condensate (liquid) mass flow rate for individual PFAS	Equation (6)	NA
$M_{x,filt}\left(\frac{\mu g}{hr}\right)$	Filter residue (solid) mass flow rate for individual	Equation (7)	NA
$C_{x,liq}\left(\frac{\mu g}{L}\right)$	Concentration for an individual PFAS in effluent (liquid)	HA-GAC-Effluent-L-YYMMDD-SN HA-IX-Effluent-L-YYMMDD-SN	PFAS
$Q_{liq}\left(\frac{L}{hr}\right)$	Effluent (liquid) flow rate	SCWO Treatment Parameter/ GA Workplan	NA
$C_{x,gas}\left(\frac{\mu g}{sample}\right)$	Concentration for an individual PFAS in effluent (gas)	HA-GAC-Effluent-G-YYMMDD-SN HA-IX-Effluent-G-YYMMDD-SN	PFAS
$V_{gas}(L)$	Volume of gas sampled for PFAS analysis	Sample Collection Log Parameter/ Eurofins-Knoxville *TO-13*	NA
$Q_{gas}\left(\frac{L}{hr}\right)$	Effluent (gas) flow rate	SCWO Treatment Parameter/ GA Workplan	NA

List of Variable and Associated Sample ID

Equation Variable	Variable Definition	Associated Sample ID/ Data Source	Analytical Group
$C_{x,cond}\left(\frac{\mu g}{L}\right)$	Concentration for an individual PFAS in condensate (liquid)	HA-GAC-Effluent-C- YYMMDD-SN HA-IX-Effluent-C- YYMMDD-SN	PFAS
$V_{cond}(L)$	Volume of condensate (liquid)	SCWO Treatment Parameter/ GA Workplan	NA
$t_{runtime}(hr)$	Run time for test	SCWO Treatment Parameter/ GA Workplan	NA
$C_{x,filt}\left(\frac{\mu g}{kg}\right)$	Concentration for an individual PFAS in filter residue (solid)	HA-GAC-Effluent-S-YYMMDD-SN HA-IX-Effluent-S-YYMMDD-SN	PFAS
$M_{filt}(kg)$	Mass of filter residue collected	Sample Collection Log Parameter	NA
%DRE	Percent Destruction and Removal Efficiency	Equation (8)	NA
$\sum overall\ \%deF_x$	Percent Defluorination Efficiency	Equation (9)	NA
$C_{tot-eff\ F^-}(\mathrm{\mu M})$	Summed concentration of fluoride in the total effluent (liquid), condensate (liquid,) and filter residue (solid)	Equation (10)	NA
$\sum C_{organic-F}(\mathrm{\mu M})$	concentration of organic fluorine in the influent (slurry) feed	Equation (11)	NA
$C_{liq\ F^-}\ (\mathrm{\mu M})$	Concentration of fluoride in the effluent (liquid)	HA-GAC-Effluent-L-YYMMDD-SN HA-IX-Effluent-L-YYMMDD-SN	Anions -Total Analyte List (TAL) [including Fluoride]
$C_{cond\ F^-}(\mathrm{\mu M})$	Concentration of fluoride in the condensate (liquid)	HA-GAC-Effluent-C- YYMMDD-SN HA-IX-Effluent-C- YYMMDD-SN	Anions - TAL [including Fluoride]
$C_{filt\ F^-}(\mathrm{\mu M})$	Concentration of fluoride in the filter residue (solid)	HA-GAC-Effluent-S-YYMMDD-SN HA-IX-Effluent-S-YYMMDD-SN	Anions - TAL [including Fluoride]
N_{c-F}	Number of carbon-fluorine bond within respective that PFAS compound	List of 40 PFAS Analyte	NA
$C_{x,inf,\mathrm{\mu M}}(\mathrm{\mu M})$	Concentration for an individual PFAS in the influent (slurry)	Equation (2)	NA
$\%TOF_{removal}$	Percent Organic Fluorine Removal	Equation (12)	NA
$M_{TOF,inf}(\mathrm{\mu g})$	Mass of total organic fluorine mass in the influent (slurry)	Equation (14)	NA

List of Variable and Associated Sample ID

Equation Variable	Variable Definition	Associated Sample ID/ Data Source	Analytical Group
$M_{TOF,tot-eff}$ (µg)	Summed mass of total organic fluorine in the effluent (liquid), condensate (liquid), effluent (gas) and filter reside (solid)	Equation (15)	NA
$M_{TOF,SM}$ (µg)	Mass of total organic fluorine in the spent media (solid)	Equation (16)	NA
$M_{TOF,SW}$ (µg)	Mass of total organic fluorine in the soft water (liquid)	Equation (17)	NA
$M_{TOF,liq}$ (µg)	Mass of total organic fluorine in the effluent (liquid)	Equation (18)	NA
$M_{TOF,gas}$ (µg)	Mass of total organic fluorine in the effluent (gas)	Equation (19)	NA
$M_{TOF,cond}$ (µg)	Mass of total organic fluorine in the condensate (liquid)	Equation (20)	NA
$M_{TOF,filt}$ (µg)	Mass of total organic fluorine in the filter residue (solid)	Equation (21)	NA
$C_{TOF,SM}\ \left(\frac{\mu g}{L}\right)$	Concentration of total organic fluorine in the spent media (solid)	HA-SpentGAC-Composite-S -YYMMDD-SN HA-SpentIX-Composite-S -YYMMDD-SN	TOF
$V_{Slurry}\ (L)$	Volume of slurry processed	SCWO Treatment Parameter/ GA Workplan	NA
$C_{TOF,SW}\ \left(\frac{\mu g}{L}\right)$	Concentration of total organic fluorine in the soft water (liquid)	HA-SW-Influent-L-YYMMDD-SN	TOF
$V_{liq}\ (L)$	Volume of effluent liquid generated	SCWO Treatment Parameter/ GA Workplan	NA
$C_{TOF,liq}\ \left(\frac{\mu g}{L}\right)$	Concentration of total organic fluorine in the effluent (liquid)	HA-GAC-Effluent-L-YYMMDD-SN HA-IX-Effluent-L-YYMMDD-SN	TOF
$C_{TOF,gas}\ \left(\frac{\mu g}{L}\right)$	Concentration of total organic fluorine in the effluent (gas)	HA-GAC-Effluent-G-YYMMDD-SN HA-IX-Effluent-G-YYMMDD-SN	TOF
$C_{TOF,cond}\ \left(\frac{\mu g}{L}\right)$	Concentration of total organic fluorine in the condensate (liquid)	HA-GAC-Effluent-C- YYMMDD-SN HA-IX-Effluent-C- YYMMDD-SN	TOF
$C_{TOF,filt}\ \left(\frac{\mu g}{kg}\right)$	Concentration of total organic fluorine in the filter residue (solid)	HA-GAC-Effluent-S-YYMMDD-SN HA-IX-Effluent-S-YYMMDD-SN	TOF

APPENDIX E

LABORATORY LIMITS AND LABORATORY ACCREDITATION DOCUMENTATION

Reference Limits and Analytical Methods

Matrix: Solid - Spent Media, Filter Residue
Analytical Group: PFAS

Analyte	CASRN	Analytical Methods	PSL	PSL Reference	Laboratory-Specific Limits (Battelle)		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
Perfluorooctanoic acid (PFOA)	335-67-1	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0315
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0426
Perfluorobutanoic acid (PFBA)	375-22-4	EPA Draft Method 1633	NA	NA	0.640	0.250	0.0872
Perfluoropentanoic acid (PFPeA)	2706-90-3	EPA Draft Method 1633	NA	NA	0.320	0.250	0.0842
Perfluorohexanoic acid (PFHxA)	307-24-4	EPA Draft Method 1633	NA	NA	0.160	0.150	0.0375
Perfluoroheptanoic acid (PFHpA)	375-85-9	EPA Draft Method 1633	NA	NA	0.160	0.150	0.0675
Perfluorononanoic acid (PFNA)	375-95-1	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0459
Perfluorodecanoic acid (PFDA)	335-76-2	EPA Draft Method 1633	NA	NA	0.160	0.150	0.0618
Perfluoroundecanoic acid (PFUnA)	2058-94-8	EPA Draft Method 1633	NA	NA	0.160	0.150	0.0240
Perfluorododecanoic acid (PFDoA)	307-55-1	EPA Draft Method 1633	NA	NA	0.160	0.150	0.0648
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0339
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0408
Perfluorobutanesulfonic acid (PFBS)	375-73-5	EPA Draft Method 1633	NA	NA	0.160	0.150	0.0624
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	EPA Draft Method 1633	NA	NA	0.160	0.150	0.0690
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	EPA Draft Method 1633	NA	NA	0.160	0.0800	0.0363
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0483
Perfluorornonanesulfonic acid (PFNS)	68259-12-1	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0495

Analyte	CASRN	Analytical Methods	PSL	PSL Reference	Laboratory-Specific Limits (Battelle)		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
Perfluorordecaanesulfonic acid (PFDS)	335-77-3	EPA Draft Method 1633	NA	NA	0.160	0.125	0.0597
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0309
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	EPA Draft Method 1633	NA	NA	0.640	0.500	0.238
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	EPA Draft Method 1633	NA	NA	0.640	0.500	0.193
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	EPA Draft Method 1633	NA	NA	0.640	0.250	0.102
Perfluorooctanesulfonamide (PFOSA)	754-91-6	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0273
N-Methylperfluorooctanesulfonamide (NMeFOSA)	31506-32-8	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0468
N-Ethylperfluorooctanesulfonamide (NEtFOSA)	4151-50-2	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0417
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	EPA Draft Method 1633	NA	NA	0.160	0.100	0.0318
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	EPA Draft Method 1633	NA	NA	0.160	0.150	0.0510
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	EPA Draft Method 1633	NA	NA	1.60	0.750	0.290
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	EPA Draft Method 1633	NA	NA	1.60	0.750	0.309
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	EPA Draft Method 1633	NA	NA	0.640	0.250	0.125
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	EPA Draft Method 1633	NA	NA	0.640	0.250	0.110
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	EPA Draft Method 1633	NA	NA	0.320	0.250	0.103

Analyte	CASRN	Analytical Methods	PSL	PSL Reference	Laboratory-Specific Limits (Battelle)		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	EPA Draft Method 1633	NA	NA	0.320	0.250	0.0788
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	EPA Draft Method 1633	NA	NA	0.320	0.250	0.0911
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	EPA Draft Method 1633	NA	NA	0.640	0.250	0.0986
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	EPA Draft Method 1633	NA	NA	0.640	0.250	0.118
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	113507-82-7	EPA Draft Method 1633	NA	NA	0.320	0.150	0.0378
3-Perfluoropropyl propanoic acid (3:3 FTCA)	356-02-5	EPA Draft Method 1633	NA	NA	0.800	0.500	0.165
2H,2H,3H,3H-Perfluorooctanoic acid (5:3 FTCA)	914637-49-3	EPA Draft Method 1633	NA	NA	4.00	1.500	0.645
3-Perfluoroheptyl propanoic acid (7:3 FTCA)	812-70-4	EPA Draft Method 1633	NA	NA	4.00	1.500	0.741

µg/kg = Microgram per kilogram
CASRN = Chemical Abstract Service Registry Number
EPA = Environmental Protection Agency
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PSL = Project screening level

Matrix: Liquid – Free, Influent, Slurry, Effluent, Condensate
Analytical Group: PFAS

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (Battelle)		
					LOQ (ng/L)	LOD (ng/L)	DL (ng/L)
Perfluorooctanoic acid (PFOA)	335-67-1	EPA Draft Method 1633	NA	NA	1.60	0.75	0.290
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	EPA Draft Method 1633	NA	NA	1.60	0.50	0.248
Perfluorobutanoic acid (PFBA)	375-22-4	EPA Draft Method 1633	NA	NA	6.40	1.25	0.597
Perfluoropentanoic acid (PFPeA)	2706-90-3	EPA Draft Method 1633	NA	NA	3.20	1.25	0.563
Perfluorohexanoic acid (PFHxA)	307-24-4	EPA Draft Method 1633	NA	NA	1.60	1.00	0.412
Perfluoroheptanoic acid (PFHpA)	375-85-9	EPA Draft Method 1633	NA	NA	1.60	0.50	0.173
Perfluorononanoic acid (PFNA)	375-95-1	EPA Draft Method 1633	NA	NA	1.60	0.50	0.250
Perfluorodecanoic acid (PFDA)	335-76-2	EPA Draft Method 1633	NA	NA	1.60	0.50	0.223
Perfluoroundecanoic acid (PFUnA)	2058-94-8	EPA Draft Method 1633	NA	NA	1.60	0.50	0.203
Perfluorododecanoic acid (PFDoA)	307-55-1	EPA Draft Method 1633	NA	NA	1.60	0.75	0.301
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	EPA Draft Method 1633	NA	NA	1.60	0.75	0.301
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	EPA Draft Method 1633	NA	NA	1.60	1.00	0.429
Perfluorobutanesulfonic acid (PFBS)	375-73-5	EPA Draft Method 1633	NA	NA	1.60	0.50	0.177
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	EPA Draft Method 1633	NA	NA	1.60	0.50	0.129
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	EPA Draft Method 1633	NA	NA	1.60	0.75	0.291
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	EPA Draft Method 1633	NA	NA	1.60	0.50	0.204
Perfluorornonanesulfonic acid (PFNS)	68259-12-1	EPA Draft Method 1633	NA	NA	1.60	0.50	0.249
Perfluorordecaanesulfonic acid (PFDS)	335-77-3	EPA Draft Method 1633	NA	NA	1.60	0.50	0.162
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	EPA Draft Method 1633	NA	NA	1.60	0.50	0.18

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (Battelle)		
					LOQ (ng/L)	LOD (ng/L)	DL (ng/L)
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	EPA Draft Method 1633	NA	NA	6.40	2.75	1.32
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	EPA Draft Method 1633	NA	NA	6.40	0.003	1.48
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	EPA Draft Method 1633	NA	NA	6.40	0.002	0.916
Perfluorooctanesulfonamide (PFOSA)	754-91-6	EPA Draft Method 1633	NA	NA	1.60	0.50	0.188
N-Methylperfluorooctanesulfonamide (NMeFOSA)	31506-32-8	EPA Draft Method 1633	NA	NA	1.60	0.50	0.199
N-Ethylperfluorooctanesulfonamide (NEtFOSA)	4151-50-2	EPA Draft Method 1633	NA	NA	1.60	0.25	0.0998
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	EPA Draft Method 1633	NA	NA	1.60	1.50	0.655
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	EPA Draft Method 1633	NA	NA	1.60	1.25	0.571
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	EPA Draft Method 1633	NA	NA	1.60	3.50	1.65
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	EPA Draft Method 1633	NA	NA	1.60	3.00	1.45
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	EPA Draft Method 1633	NA	NA	6.40	1.50	0.748
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	EPA Draft Method 1633	NA	NA	6.40	1.50	0.694
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	EPA Draft Method 1633	NA	NA	3.20	1.50	0.628
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	EPA Draft Method 1633	NA	NA	3.20	1.25	0.600
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	EPA Draft Method 1633	NA	NA	3.20	1.75	0.760
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	EPA Draft Method 1633	NA	NA	6.40	1.50	0.699
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	EPA Draft Method 1633	NA	NA	6.40	2.25	1.09

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (Battelle)		
					LOQ (ng/L)	**LOD (ng/L)**	**DL (ng/L)**
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	113507-82-7	EPA Draft Method 1633	NA	NA	3.20	0.50	0.212
3-Perfluoropropyl propanoic acid (3:3 FTCA)	356-02-5	EPA Draft Method 1633	NA	NA	8.00	3.50	1.67
2H,2H,3H,3H-Perfluorooctanoic acid (5:3 FTCA)	914637-49-3	EPA Draft Method 1633	NA	NA	40.0	9.00	4.46
3-Perfluoroheptyl propanoic acid (7:3 FTCA)	812-70-4	EPA Draft Method 1633	NA	NA	40.0	10.50	5.22

CASRN = Chemical Abstract Service Registry Number
EPA = Environmental Protection Agency
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
ng/L = Nanogram per liter
PSL = Project screening level

Matrix: Gas – Effluent
Analytical Group: PFAS

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (Eurofins – Knoxville)	
					LOQ (ng/sample)	DL (ng/sample)
Perfluorooctanoic acid (PFOA)	335-67-1	OTM-45	NA	NA	1.00	0.170
Perfluorooctanesulfonic acid (PFOS)	1763-23-1	OTM-45	NA	NA	1.00	0.150
Perfluorobutanoic acid (PFBA)	375-22-4	OTM-45	NA	NA	3.00	2.80
Perfluoropentanoic acid (PFPeA)	2706-90-3	OTM-45	NA	NA	1.00	0.600
Perfluorohexanoic acid (PFHxA)	307-24-4	OTM-45	NA	NA	1.00	0.810
Perfluoroheptanoic acid (PFHpA)	375-85-9	OTM-45	NA	NA	5.00	3.30
Perfluorononanoic acid (PFNA)	375-95-1	OTM-45	NA	NA	1.00	0.200
Perfluorodecanoic acid (PFDA)	335-76-2	OTM-45	NA	NA	1.00	0.210
Perfluoroundecanoic acid (PFUnA)	2058-94-8	OTM-45	NA	NA	1.00	0.270
Perfluorododecanoic acid (PFDoA)	307-55-1	OTM-45	NA	NA	1.00	0.120
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	OTM-45	NA	NA	1.00	0.170
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	OTM-45	NA	NA	1.00	0.230
Perfluorobutanesulfonic acid (PFBS)	375-73-5	OTM-45	NA	NA	1.00	0.440
Perfluoropentanesulfonic acid (PFPeS)	2706-91-4	OTM-45	NA	NA	1.00	0.210
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	OTM-45	NA	NA	1.00	0.260
Perfluoroheptanesulfonic acid (PFHpS)	375-92-8	OTM-45	NA	NA	1.00	0.200
Perfluorornonanesulfonic acid (PFNS)	68259-12-1	OTM-45	NA	NA	1.00	0.160
Perfluorordecaanesulfonic acid (PFDS)	335-77-3	OTM-45	NA	NA	1.00	0.200
Perfluorododecanesulfonic acid (PFDoS)	79780-39-5	OTM-45	NA	NA	1.00	0.180
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72-4	OTM-45	NA	NA	1.00	0.0640
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	OTM-45	NA	NA	20.0	11.0
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	OTM-45	NA	NA	1.00	0.160

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (Eurofins – Knoxville)	
					LOQ (ng/sample)	DL (ng/sample)
Perfluorooctanesulfonamide (PFOSA)	754-91-6	OTM-45	NA	NA	1.00	0.230
N-Methylperfluorooctanesulfonamide (NMeFOSA)	31506-32-8	OTM-45	NA	NA	1.00	0.770
N-Ethylperfluorooctanesulfonamide (NEtFOSA)	4151-50-2	OTM-45	NA	NA	1.00	0.660
N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	2355-31-9	OTM-45	NA	NA	1.00	0.120
N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	2991-50-6	OTM-45	NA	NA	1.00	0.190
N-Methyl perfluorooctanesulfonamidoethanol (NMeFOSE)	24448-09-7	OTM-45	NA	NA	50.0	26.0
N-Ethyl perfluorooctanesulfonamidoethanol (NEtFOSE)	1691-99-2	OTM-45	NA	NA	1.00	0.470
Hexafluoropropylene oxide dimer acid (HFPO-DA)	13252-13-6	OTM-45	NA	NA	3.00	2.80
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	919005-14-4	OTM-45	NA	NA	3.00	1.10
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	OTM-45	NA	NA	1.00	0.120
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	OTM-45	NA	NA	1.00	0.130
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	151772-58-6	OTM-45	NA	NA	1.00	0.160
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (9Cl-PF3ONS)	756426-58-1	OTM-45	NA	NA	1.00	0.180
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	763051-92-9	OTM-45	NA	NA	1.00	0.180
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	113507-82-7	OTM-45	NA	NA	1.00	0.100
3-Perfluoropropyl propanoic acid (3:3 FTCA)	356-02-5	OTM-45	NA	NA	1.00	0.310
2H,2H,3H,3H-Perfluorooctanoic acid (5:3 FTCA)	914637-49-3	OTM-45	NA	NA	1.00	0.700
3-Perfluoroheptyl propanoic acid (7:3 FTCA)	812-70-4	OTM-45	NA	NA	1.00	0.560

CASRN = Chemical Abstract Service Registry Number
DL = Detection limit
LOQ = Limit of quantitation
NA = Not applicable
ng/sample = Nanogram per sample
PSL = Project screening level

Matrix: Solid – Spent Media

Analytical Group: VOCs

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
1,1,1-Trichloroethane	71-55-6	8260D	NA	NA	5.00	2.00	0.600
1,1,2,2-Tetrachloroethane	79-34-5	8260D	NA	NA	5.00	2.00	0.700
1,1,2-Trichloroethane	79-00-5	8260D	NA	NA	5.00	2.00	0.500
1,1-Dichloroethane	75-34-3	8260D	NA	NA	5.00	2.00	0.500
1,1-Dichloroethene	75-35-4	8260D	NA	NA	5.00	2.00	0.500
1,2-Dichloroethane	107-06-2	8260D	NA	NA	5.00	2.00	0.600
1,2-Dichloropropane	78-87-5	8260D	NA	NA	5.00	2.00	0.500
2-Chloroethyl vinyl ether	110-75-8	8260D	NA	NA	10.0	3.00	1.50
Acrolein	107-02-8	8260D	NA	NA	100	16.0	8.00
Acrylonitrile	107-13-1	8260D	NA	NA	20.0	4.00	2.00
Benzene	71-43-2	8260D	NA	NA	5.00	2.00	0.500
Bromodichloromethane	75-27-4	8260D	NA	NA	5.00	1.00	0.700
Bromoform	75-25-2	8260D	NA	NA	10.0	8.00	5.00
Bromomethane	74-83-9	8260D	NA	NA	5.00	2.00	0.700
Carbon tetrachloride	56-23-5	8260D	NA	NA	5.00	2.00	0.700
Chlorobenzene	108-90-7	8260D	NA	NA	5.00	2.00	0.700
Chloroethane	75-00-3	8260D	NA	NA	5.00	4.00	1.00
Chloroform	67-66-3	8260D	NA	NA	5.00	2.00	0.600
Chloromethane	74-87-3	8260D	NA	NA	5.00	2.00	0.600
cis-1,2-Dichloroethene	156-59-2	8260D	NA	NA	5.00	2.00	0.500
cis-1,3-Dichloropropene	10061-01-5	8260D	NA	NA	5.00	1.00	0.400
Dibromochloromethane	124-48-1	8260D	NA	NA	5.00	1.00	0.500
Ethylbenzene	100-41-4	8260D	NA	NA	5.00	2.00	0.700
Methylene Chloride	75-09-2	8260D	NA	NA	5.00	4.00	2.00
Tetrachloroethene	127-18-4	8260D	NA	NA	5.00	2.00	0.700
Toluene	108-88-3	8260D	NA	NA	5.00	2.00	0.600
trans-1,2-Dichloroethene	156-60-5	8260D	NA	NA	5.00	2.00	0.500
trans-1,3-Dichloropropene	10061-02-6	8260D	NA	NA	5.00	1.00	0.500

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (µg/kg)	LOD (µg/kg)	DL (µg/kg)
Trichloroethene	79-01-6	8260D	NA	NA	5.00	2.00	0.500
Trichlorofluoromethane	75-69-4	8260D	NA	NA	5.00	2.00	1.00
Vinyl chloride	75-01-4	8260D	NA	NA	5.00	2.00	0.600
Xylenes, Total	1330-20-7	8260D	NA	NA	10.0	2.00	0.700

µg/kg = Microgram per kilogram
CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PSL = Project screening level
VOC = Volatile organic compound

Matrix: Solid – Spent Media
Analytical Group: SVOCs (including PAHs)

Analyte	CAS Number	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (µg/Kg)	LOD (µg/Kg)	DL (µg/Kg)
1,2-Dichlorobenzene	95-50-1	8270E	NA	NA	36.7	33.3	16.7
1,2-Diphenylhydrazine	122-66-7	8270E	NA	NA	36.7	33.3	16.7
1,3-Dichlorobenzene	541-73-1	8270E	NA	NA	36.7	33.3	16.7
1,4-Dichlorobenzene	106-46-7	8270E	NA	NA	36.7	33.3	16.7
2,2'-Oxybis[1-chloropropane]	108-60-1	8270E	NA	NA	43.3	40.0	20.0
2,4,6-Trichlorophenol	88-06-2	8270E	NA	NA	36.7	33.3	16.7
2,4-Dichlorophenol	120-83-2	8270E	NA	NA	43.3	40.0	20.0
2,4-Dimethylphenol	105-67-9	8270E	NA	NA	36.7	33.3	16.7
2,4-Dinitrophenol	51-28-5	8270E	NA	NA	1000	333	167
2,4-Dinitrotoluene	121-14-2	8270E	NA	NA	167	66.7	33.3
2,6-Dinitrotoluene	606-20-2	8270E	NA	NA	36.7	33.3	16.7
2-Chloronaphthalene	91-58-7	8270E	NA	NA	33.3	26.7	13.3
2-Chlorophenol	95-57-8	8270E	NA	NA	36.7	33.3	16.7
2-Nitrophenol	88-75-5	8270E	NA	NA	50.0	40.0	20.0
3,3'-Dichlorobenzidine	91-94-1	8270E	NA	NA	167	66.7	33.3
4,6-Dinitro-2-methylphenol	534-52-1	8270E	NA	NA	500	333	167
4-Bromophenyl-phenylether	101-55-3	8270E	NA	NA	36.7	33.3	16.7
4-Chloro-3-methylphenol	59-50-7	8270E	NA	NA	50.0	40.0	20.0
4-Chlorophenyl-phenyl ether	7005-72-3	8270E	NA	NA	36.7	33.3	16.7
4-Nitrophenol	100-02-7	8270E	NA	NA	500	333	167
Acenaphthene	83-32-9	8270E	NA	NA	16.7	6.66	3.33
Acenaphthylene	208-96-8	8270E	NA	NA	16.7	8.00	4.00
Anthracene	120-12-7	8270E	NA	NA	16.7	6.66	3.33
Benzidine	92-87-5	8270E	NA	NA	833	333	167
Benzo[a]anthracene	56-55-3	8270E	NA	NA	16.7	13.3	3.33
Benzo[a]pyrene	50-32-8	8270E	NA	NA	16.7	6.66	3.33
Benzo[b]fluoranthene	205-99-2	8270E	NA	NA	16.7	6.66	3.33
Benzo[g,h,i]perylene	191-24-2	8270E	NA	NA	16.7	6.66	3.33
Benzo[k]fluoranthene	207-08-9	8270E	NA	NA	16.7	6.66	3.33
Bis(2-chloroethoxy)methane	111-91-1	8270E	NA	NA	36.7	33.3	16.7

Analyte	CAS Number	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (µg/Kg)	LOD (µg/Kg)	DL (µg/Kg)
Bis(2-chloroethyl)ether	111-44-4	8270E	NA	NA	36.7	33.3	16.7
Bis(2-ethylhexyl) phthalate	117-81-7	8270E	NA	NA	167	133	66.7
Butylbenzylphthalate	85-68-7	8270E	NA	NA	167	133	66.7
Chrysene	218-01-9	8270E	NA	NA	16.7	6.66	3.33
Di-n-butylphthalate	84-74-2	8270E	NA	NA	167	133	66.7
Di-n-octylphthalate	117-84-0	8270E	NA	NA	167	133	66.7
Dibenz(a,h)anthracene	53-70-3	8270E	NA	NA	16.7	13.3	6.67
Diethyl phthalate	84-66-2	8270E	NA	NA	167	133	66.7
Dimethyl phthalate	131-11-3	8270E	NA	NA	167	133	66.7
Fluoranthene	206-44-0	8270E	NA	NA	16.7	6.66	3.33
Fluorene	86-73-7	8270E	NA	NA	16.7	6.66	3.33
Hexachlorobenzene	118-74-1	8270E	NA	NA	16.7	13.3	6.67
Hexachlorobutadiene	87-68-3	8270E	NA	NA	50.0	40.0	20.0
Hexachlorocyclopentadiene	77-47-4	8270E	NA	NA	500	333	167
Hexachloroethane	67-72-1	8270E	NA	NA	167	66.7	33.3
Indeno[1,2,3-cd]pyrene	193-39-5	8270E	NA	NA	16.7	8.00	4.00
Isophorone	78-59-1	8270E	NA	NA	66.7	33.3	16.7
N-Nitrosodi-n-propylamine	621-64-7	8270E	NA	NA	66.7	50.0	33.3
N-Nitrosodimethylamine	62-75-9	8270E	NA	NA	167	66.7	33.3
N-Nitrosodiphenylamine	86-30-6	8270E	NA	NA	36.7	33.3	16.7
Naphthalene	91-20-3	8270E	NA	NA	16.7	13.3	6.67
Nitrobenzene	98-95-3	8270E	NA	NA	36.7	33.3	16.7
Pentachlorophenol	87-86-5	8270E	NA	NA	167	133	66.7
Phenanthrene	85-01-8	8270E	NA	NA	16.7	8.00	4.00
Phenol	108-95-2	8270E	NA	NA	36.7	33.3	16.7
Pyrene	129-00-0	8270E	NA	NA	16.7	6.66	3.33

µg/kg = Microgram per kilogram
CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PAH = Polyaromatic hydrocarbon
PSL = Project screening level
SVOC = Semivolatile organic compound

Matrix: Solid – Spent Media
Analytical Group: Total Solids

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (%)	LOD (%)	DL (%)
Total Solids	NA	SM2540G	NA	NA	0.100	0.100	0.100

CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PSL = Project screening level

Matrix: Solid – Spent Media
Analytical Group: PCBs

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (ug/kg)	LOD (ug/kg)	DL (ug/kg)
Aroclor 1016	12674-11-2	8082A	NA	NA	17.0	10.0	5.30
Aroclor 1221	11104-28-2	8082A	NA	NA	17.0	10.0	5.30
Aroclor 1232	11141-16-5	8082A	NA	NA	17.0	10.0	5.30
Aroclor 1242	53469-21-9	8082A	NA	NA	17.0	10.0	5.30
Aroclor 1248	12672-29-6	8082A	NA	NA	17.0	10.0	5.30
Aroclor 1254	11097-69-1	8082A	NA	NA	17.0	10.0	6.40
Aroclor 1260	11096-82-5	8082A	NA	NA	17.0	10.0	6.40
Total PCBs	NA	8082A	NA	NA	NA	NA	NA

µg/kg = Microgram per kilogram
CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PCB = Polychlorinated biphenyl
PSL = Project screening level

Matrix: Solid – Spent Media, Filter Residue
Analytical Group: Total Organic Fluorine

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (ug/kg)	LOD (ug/kg)	DL (ug/kg)
Total Organic Fluorine	NA	In-House method	NA	NA	300	NA	140

µg/kg = Microgram per kilogram
CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PSL = Project screening level

Matrix: Solid – Spent Media
Analytical Group: Metals (including Mercury)

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (mg/kg)	LOD (mg/kg)	DL (mg/kg)
Aluminum	7429-90-5	6020B	NA	NA	10.0	9.90	4.95
Antimony	7440-36-0	6020B	NA	NA	0.100	0.0800	0.0400
Arsenic	7440-38-2	6020B	NA	NA	0.200	0.160	0.0669
Barium	7440-39-3	6020B	NA	NA	0.200	0.180	0.0915
Beryllium	7440-41-7	6020B	NA	NA	0.0500	0.0250	0.0119
Cadmium	7440-43-9	6020B	NA	NA	0.0500	0.0400	0.0200
Calcium	7440-70-2	6020B	NA	NA	20.0	19.6	9.80
Chromium	7440-47-3	6020B	NA	NA	0.200	0.190	0.0950
Cobalt	7440-48-4	6020B	NA	NA	0.100	0.0800	0.0400
Copper	7440-50-8	6020B	NA	NA	0.200	0.180	0.0900
Iron	7439-89-6	6020B	NA	NA	10.0	9.00	4.61
Lead	7439-92-1	6020B	NA	NA	0.100	0.0800	0.0380
Magnesium	7439-95-4	6020B	NA	NA	5.00	4.90	2.45
Manganese	7439-96-5	6020B	NA	NA	0.250	0.200	0.100
Mercury	7439-97-6	7471B	NA	NA	0.0600	0.0400	0.0200
Nickel	7440-02-0	6020B	NA	NA	0.200	0.190	0.0950
Potassium	7440-09-7	6020B	NA	NA	20.0	16.0	8.00
Selenium	7782-49-2	6020B	NA	NA	0.200	0.100	0.0500
Silver	7440-22-4	6020B	NA	NA	0.0500	0.0400	0.0203
Sodium	7440-23-5	6020B	NA	NA	25.0	24.0	12.0
Thallium	7440-28-0	6020B	NA	NA	0.0500	0.0400	0.0196
Vanadium	7440-62-2	6020B	NA	NA	0.400	0.200	0.100
Zinc	7440-66-6	6020B	NA	NA	15.0	4.00	2.00

CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
mg/kg = Milligram per kilogram
NA = Not applicable
PSL = Project screening level

Matrix: Solid – Spent Media, Filter residue
Analytical Group: Anions

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (mg/Kg)	LOD (mg/Kg)	DL (mg/Kg)
Bromide	24959-67-9	9056A	NA	NA	5.00	4.50	2.50
Chloride	16887-00-6	9056A	NA	NA	15.0	12.0	6.00
Fluoride	16984-48-8	9056A	NA	NA	2.00	1.80	0.900
Sulfate	14808-79-8	9056A	NA	NA	15.0	13.0	6.50
Nitrite	14797-65-0	9056A	NA	NA	1.00	0.900	0.500
Nitrate	14797-55-8	9056A	NA	NA	2.10	2.00	1.00

CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
mg/kg = Milligram per kilogram
NA = Not applicable
PSL = Project screening level

Matrix: Liquid - Free
Analytical Group: VOCs

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
1,1,1-Trichloroethane	71-55-6	8260D	NA	NA	1.00	0.600	0.300
1,1,2,2-Tetrachloroethane	79-34-5	8260D	NA	NA	1.00	0.600	0.300
1,1,2-Trichloroethane	79-00-5	8260D	NA	NA	1.00	0.600	0.300
1,1-Dichloroethane	75-34-3	8260D	NA	NA	1.00	0.600	0.300
1,1-Dichloroethene	75-35-4	8260D	NA	NA	1.00	0.600	0.300
1,2-Dichloroethane	107-06-2	8260D	NA	NA	1.00	0.600	0.300
1,2-Dichloropropane	78-87-5	8260D	NA	NA	1.00	0.600	0.300
2-Chloroethyl vinyl ether	110-75-8	8260D	NA	NA	10.0	0.600	0.300
Acrolein	107-02-8	8260D	NA	NA	100	6.00	3.00
Acrylonitrile	107-13-1	8260D	NA	NA	20.0	3.20	1.60
Benzene	71-43-2	8260D	NA	NA	1.00	0.600	0.300
Bromodichloromethane	75-27-4	8260D	NA	NA	1.00	0.500	0.200
Bromoform	75-25-2	8260D	NA	NA	4.00	2.00	1.00
Bromomethane	74-83-9	8260D	NA	NA	1.00	0.600	0.300
Carbon tetrachloride	56-23-5	8260D	NA	NA	1.00	0.600	0.300
Chlorobenzene	108-90-7	8260D	NA	NA	1.00	0.600	0.300
Chloroethane	75-00-3	8260D	NA	NA	1.00	0.600	0.300
Chloroform	67-66-3	8260D	NA	NA	1.00	0.600	0.300

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Chloromethane	74-87-3	8260D	NA	NA	2.00	1.10	0.550
cis-1,2-Dichloroethene	156-59-2	8260D	NA	NA	1.00	0.600	0.300
cis-1,3-Dichloropropene	10061-01-5	8260D	NA	NA	1.00	0.500	0.200
Dibromochloromethane	124-48-1	8260D	NA	NA	1.00	0.500	0.200
Ethylbenzene	100-41-4	8260D	NA	NA	1.00	0.800	0.400
Methylene Chloride	75-09-2	8260D	NA	NA	1.00	0.600	0.300
Tetrachloroethene	127-18-4	8260D	NA	NA	1.00	0.600	0.300
Toluene	108-88-3	8260D	NA	NA	1.00	0.600	0.300
trans-1,2-Dichloroethene	156-60-5	8260D	NA	NA	2.00	1.40	0.700
trans-1,3-Dichloropropene	10061-02-6	8260D	NA	NA	1.00	0.500	0.200
Trichloroethene	79-01-6	8260D	NA	NA	1.00	0.600	0.300
Trichlorofluoromethane	75-69-4	8260D	NA	NA	1.00	0.600	0.300
Vinyl chloride	75-01-4	8260D	NA	NA	1.00	0.600	0.300
Xylenes, Total	1330-20-7	8260D	NA	NA	1.00	0.800	0.400

µg/L = Microgram per liter
CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PSL = Project screening level
VOC = Volatile organic compound

Matrix: Liquid – Free, Influent, Effluent, Condensate
Analytical Group: Anions

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (mg/L)	LOD (mg/L)	DL (mg/L)
Bromide	24959-67-9	9056A	NA	NA	0.750	0.500	0.250
Chloride	16887-00-6	9056A	NA	NA	1.50	1.20	0.600
Fluoride	16984-48-8	9056A	NA	NA	0.200	0.180	0.0900
Sulfate	14808-79-8	9056A	NA	NA	1.50	1.00	0.500
Nitrite	14797-65-0	9056A	NA	NA	0.110	0.100	0.0500
Nitrate	14797-55-8	9056A	NA	NA	0.110	0.100	0.0500

CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
mg/L = Milligram per liter
NA = Not applicable
PSL = Project screening level

Matrix: Liquid – Free, Influent, Effluent
Analytical Group: Metals (including Mercury)

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory-Specific Limits (ELLE)		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Aluminum	7429-90-5	6020B	NA	NA	30.0	24.0	12.0
Antimony	7440-36-0	6020B	NA	NA	1.00	0.500	0.200
Arsenic	7440-38-2	6020B	NA	NA	2.00	1.70	0.680
Barium	7440-39-3	6020B	NA	NA	2.00	1.60	0.746
Beryllium	7440-41-7	6020B	NA	NA	0.500	0.300	0.119
Cadmium	7440-43-9	6020B	NA	NA	0.500	0.400	0.151
Calcium	7440-70-2	6020B	NA	NA	120	100	50.0
Chromium	7440-47-3	6020B	NA	NA	2.00	1.10	0.550
Cobalt	7440-48-4	6020B	NA	NA	0.500	0.400	0.156
Copper	7440-50-8	6020B	NA	NA	1.00	0.900	0.362
Iron	7439-89-6	6020B	NA	NA	50.0	40.0	20.0
Lead	7439-92-1	6020B	NA	NA	0.500	0.200	0.120
Magnesium	7439-95-4	6020B	NA	NA	50.0	32.0	16.0
Manganese	7439-96-5	6020B	NA	NA	2.00	1.90	0.950
Mercury	7439-97-6	7470A	NA	NA	0.200	0.160	0.0790
Nickel	7440-02-0	6020B	NA	NA	1.50	0.800	0.400
Potassium	7440-09-7	6020B	NA	NA	200	180	65.0
Selenium	7782-49-2	6020B	NA	NA	1.00	0.600	0.278
Silver	7440-22-4	6020B	NA	NA	0.500	0.300	0.100
Sodium	7440-23-5	6020B	NA	NA	200	180	90.0
Thallium	7440-28-0	6020B	NA	NA	0.500	0.300	0.130
Vanadium	7440-62-2	6020B	NA	NA	4.00	2.00	0.794
Zinc	7440-66-6	6020B	NA	NA	15.0	8.00	4.00

µg/L = Microgram per liter
CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PSL = Project screening level

Matrix: Liquid – Standing, Influent, Effluent, Condensate
Analytical Group: Total Organic Fluorine

Analyte	CASRN	Analytical Method	PSL	PSL Reference	Laboratory Limits (ELLE)		
					LOQ (µg/L)	LOD (µg/L)	DL (µg/L)
Total Organic Fluorine	NA	In house method	NA	NA	2.00	NA	1.00

µg/L = Microgram per liter
CASRN = Chemical Abstract Service Registry Number
ELLE = Eurofins Lancaster Laboratories Environment Testing, LLC
DL = Detection Limit
LOD = Limit of detection
LOQ = Limit of quantitation
NA = Not applicable
PSL = Project screening level

Matrix: Gas – Effluent
Analytical Group: Total Organic Fluorine

Analyte	CAS Number	Analytical Method	PSL	PSL Reference	Laboratory Limits (Eurofins – Knoxville)	
					LOQ (ug/sample)	DL (ug/sample)
Total Organic Fluorine	NA	In house method	NA	NA	NA	NA

µg/sample = Microgram per sample
CASRN = Chemical Abstract Service Registry Number
DL = Detection limit
LOQ = Limit of quantitation
NA = Not applicable
PSL = Project screening level

APPENDIX F
STANDARD OPERATING PROCEDURES

This page intentionally left blank

TETRA TECH	**STANDARD OPERATING PROCEDURE**	Number SA-1.2	Page 1 of 20
		Effective Date 7/15/2020	Revision 9
		Applicability EGS Operating Unit	
		Prepared Earth Sciences Department	
Subject SURFACE WATER AND SEDIMENT SAMPLING		Approved T. Johnston T. E. Johnston 7/15/2020	

TABLE OF CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes procedures and equipment commonly used for collecting environmental samples of surface water and aquatic sediment either for onsite examination and chemical testing or for offsite laboratory analysis.

2.0 SCOPE AND APLICABILITY

The information presented in this document is applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.5), except where the analyte(s) may interact with the sampling equipment or may leach from the sampling equipment into the collected samples. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein and should be described in site-specific planning documents.

WARNING:
Sample containers can be contaminated during storage if nearby volatile substances infiltrate the surrounding air and migrate into the containers. This can occur even when containers are capped. Therefore, containers that have been stored on site for longer than 6 months should not be used.

Note: Whereas most air-borne contaminants are likely to be associated with organic substances, inorganic substances such as hydrochloric acid (muriatic acid) can emit inorganic vapors that infiltrate sample containers.

3.0 GLOSSARY

Analyte – Chemical or radiochemical material whose concentration, activity, or mass is measured.

Composite Sample – A sample representing a physical average of grab samples.

Environmental Sample – A quantity of material collected in support of an environmental investigation that does not require special handling or transport considerations as detailed in SOP SA-6.1.

Grab Sample – A portion of material collected to represent material or conditions present at a single unit of space and time.

Hazardous Waste Sample – A sample containing (or suspected to contain) concentrations of contaminants that are high enough to require special handling and/or transport considerations per SOP SA-6.1.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of soil samples. The Project Manager also has the overall responsibility for seeing that all surface water and sediment sampling activities are properly conducted by appropriately trained personnel in accordance with applicable planning documents.

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface water and sediment samples. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self-acquisition or through the management of a field team of samplers.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- OSHA 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Some important precautions to preserve the health and safety of field personnel implementing this SOP are distributed throughout. However, the site specific HASP and daily tailgate meeting should be used to provide clear guidance to safely perform the project specific surface water and sediment sampling.

Bridge/Boat Sampling – Potential hazards associated with this activity include:

- Traffic – one of the primary concerns as samplers move across a bridge because free space of travel is not often provided. Control measures should include:
    - When sampling from a bridge, if the samplers do not have at least 6 feet of free travel space or physical barriers separating them and the traffic patterns, the HASP will include a Traffic Control Plan, which may include obtaining permits from local authorities.
    - The use of warning signs and high-visibility vests are required to warn oncoming traffic and to increase the visibility of sample personnel.

- If it is necessary to work from elevated surfaces above the water body to collected water or sediment samples, and the HASP does not have fall protection and other precautions then the SSO should contact Tetra Tech H&S Management. In addition, personnel entering the water from an elevated surface (such as a bridge or dock) and when sampling from a boat, shall wear a Coast Guard (USCG)-approved floatation device and a Type IV Throwable Personal Floatation Device with at least 90 feet of 3/8-inch rope shall be accessible. See Section 5.5.2 of this SOP.

- If a boat is needed, the site specific HASP should describe the requirements of a Safe Vessel Certification, boat inspection, requirements for boat operator and other pertinent information for safe sampling from and use of a boat. If the HASP does not contain use of a boat, then the Tetra Tech H&S Management should be consulted before sampling from a boat.

Entering Water to Collect Samples – Several hazards are associated with this activity and can be mitigated as follows:

- Personnel must wear a USCG-approved Floatation Device (selected and identified in the HASP). The SSO shall ensure that the device selected is in acceptable condition and suitable for the individual using it. This includes consideration of the weight of the individual.

- Lifelines shall be employed from a point on the shore. This activity will always be conducted with a Buddy. See Section 6.5.2.

- Personnel shall carry a probe to monitor the bottom ahead of them for drop offs or other associated hazards.

- The person in the water shall exercise caution concerning the path traveled so that the lifeline does not become entangled in underwater obstructions such as logs, branches, stumps, etc., thereby restricting its effectiveness in extracting the person from the water.

- Consult the site specific HASP for precautions regarding potential biological hazards, high water flows, or submerged debris, or other hazards potentially associated with surface water body and bottom conditions.

Sampling in marshes or tidal areas in some instances can be accomplished using an all-terrain vehicle (ATV). This is not the primary recommended approach because the vehicle may become disabled, or weather conditions or tidal changes could result in environmental damage as well as loss of the vehicle. The primary approach is recommended to be on foot where minimal disturbance would occur.

6.0 PROCEDURES

NOTE: If documentation such as a Certificate of Analysis is provided with sample containers to demonstrate their cleanliness, submit the documentation to the project manager for inclusion in the project file.

NOTE: If sample containers that have been stored on site for more than 6 months are used for sampling, a note should be entered into the field log to explain why the containers were used. In such cases, collection of additional field blanks may be useful. These blanks may be used to identify the contamination source.

6.1 INTRODUCTION

Collecting a representative sample of surface water or sediment may be difficult because of water movement, stratification, or heterogeneous distribution of the targeted analytes. To collect representative samples, one must standardize sampling methods related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are no better than the confidence that can be placed in the representativeness of the samples. Consult Appendix C for guidance on sampling that should be considered during project planning and that may be helpful to field personnel.

6.1.1 Surface Water Sampling Technique

Surface water samples collected during site investigations may be grab samples or composite samples. The following general procedures apply to various types of surface water collection techniques:

- If a pre-preserved sample container is not used and the container is not pre-cleaned (See Section 6.1.2), rinse the sample container at least once with the surface water to be sampled before the sample is collected. This is not applicable when sample containers are provided pre-preserved with chemicals because doing so will wash some or all of the preservative out of the bottle. For sample containers that are certified to be clean, pre-rinsing is not recommended.

- When sampling moving water, collect the farthest downstream sample first, and continue sample collection in an upstream direction. In general, work from zones suspected of low contamination to zones of high contamination.

- Take care to avoid excessive agitation of water samples because loss of volatile constituents could result.

- When obtaining water samples in 40 mL vials with septum-lined lids for volatile organics analysis, fill the container completely (with a meniscus) to exclude any air space in the top of the vial and to be sure that the Teflon liner of the septum faces in after the vial is filled and capped. Turn the vial upside down and tap gently on your wrist to check for air bubbles. If air bubbles rise in the bottle, add additional sample volume to the container or recollect the sample in a new vial (if pre-preserved) to obtain a representative sample that has not lost VOCs through volatilization and is properly preserved.

- Do not sample at a water surface, unless sampling specifically for a known constituent that is immiscible with, and on top of, the water.

- Do not sample at the bottom of the water column unless sampling specifically for a known constituent that is immiscible with, and is expected to be found at the bottom of, the water column.

6.1.2 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type to be acquired. In general, the most representative surface water samples are obtained from mid-channel at a stream depth of 0.5 foot below water surface in a well-mixed stream; however, project-specific planning documents will address site-specific sampling requirements including sample collection points and sampling equipment. The most frequently used samplers include the following:

- Peristaltic pump
- Bailer
- Dip sampler
- Weighted bottle
- Hand pump
- Kemmerer
- Depth-integrating sampler

The criteria for selecting a sampler include:

1. Disposability and/or easy decontamination.

2. Inexpensive cost (if the item is to be disposed).

3. Ease of operation.

4. Non-reactive/non-contaminating properties. Samples may be contaminated by contaminated sample containers, and analytes may be lost through precipitation, decomposition, adsorption or other mechanisms that result from interaction with the sample container. Decomposition also may occur when analytes volatilize out of a sample or react with light. Correct sample container selection and use of preservation such as chemical preservatives, cooling, and protection from light are necessary to retard the degradation of samples.

Measurements collected for each sample (grab or each aliquot collected for compositing) shall include but not be limited to:

- Specific conductance
- Temperature
- pH
- Dissolved oxygen

Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample log sheets (see Attachment A) or an equivalent electronic form(s). These analyses may be selected to provide information on water mixing/stratification and potential contamination. Various types of water bodies have differing potentials for mixing and stratification.

In general, the following equipment is necessary for obtaining surface water samples. Additional equipment may be necessary depending on circumstances and field conditions.

- Required sampling equipment and associated documentation, which may include:

  - Remote sampling pole.

  - Sample containers Sample containers shall conform to the guidelines in SOP SA-6.1.

  - Weighted bottle sampler.

  - Kemmerer sampler, or other device.

  - Decontamination equipment.
  - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).
  - Required decontamination equipment.
  - Sealable polyethylene bags (e.g., Ziploc® baggies).
  - Heavy-duty cooler.
  - Ice.
  - Paper towels and garbage bags.
  - Chain-of-custody records and custody seals.
- Real-time air monitoring instrument (e.g., PID, FID), if required, as directed in the governing SAP.
- Required PPE as directed in the project-specific planning document, which may include:
  - Nitrile surgeon's or latex gloves (layered as necessary).
  - Safety glasses.
  - Other items identified in the site specific HASP that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the site specific HASP or addressed by the FOL and/or SSO.

Dip Sampling

Specific procedures for collecting a dip or grab sample of surface water can vary based on site-specific conditions (e.g., conditions near the shore and how closely a sampler can safely get to the shore). In some cases, e.g., when a sample container does not fit onto an available remote sampling pole, or pre-preserved sample containers are required, a transfer bottle must be used to collect sample material that is then transferred to the actual sample container. The general procedure for collecting a sample using a pole or directly from the water body is as follows:

1. Select the appropriate sample container based on the governing SAP.

NOTE: Samples designated for volatile chemical analyses should be collected first.

2. Remove the sample container cap. Do not place the cap where it might become contaminated (e.g., on the ground).

3. If sample material will be collected directly into an unpreserved container that can be dipped below the water surface, follow the steps immediately below; otherwise, proceed to Step 4.

   a. Securely attach the sample container to a remote sampling pole of sufficient length to reach below the surface of the water to be sampled.

   b. While facing upstream, invert the sample container connected to the pole so the opening faces downward, and carefully dip it to a stream depth of 0.5 foot below the water surface (or as directed by project-specific planning documents). If possible, avoid contacting the bottom of the water body because this could disturb sediment that may compromise the integrity of the surface water sample.

   c. Slowly turn the bottle right-side up allowing the bottle to fill.

   d. Replace the cap quickly and securely on the sample container. In the case of samples designated for VOC analysis, ensure that the cumulative size of air bubbles in the 40 mL vial is no greater than the size of a pea. It is best to exclude all air, if possible.

4. When using a transfer bottle (e.g., because the final sample container contains preservative or does not fit securely onto a dip pole), follow the steps below:

   a. Attach a transfer bottle to a remote sampling dip pole or plan to fill the transfer bottle directly. This bottle may be a large- or wide-mouth bottle, but small openings may be better for shallow surface water bodies to prevent inclusion of surface debris.

   b. While facing upstream, invert the transfer bottle so the opening faces downward and carefully dip it to a stream depth of 0.5 foot below the water surface (or as directed by project-specific planning documents). If possible, avoid contacting the bottom of the water body because this could disturb sediment that may compromise the integrity of the surface water sample.

   c. While avoiding contact between the transfer bottle and sample container, transfer the surface water sample from this intermediate container to the appropriate sample container with minimal agitation. For samples to be analyzed for VOCs, minimal agitation is especially important to prevent loss of the volatiles.

   d. Replace the cap quickly and securely on the sample container. In the case of samples designated for VOC analysis, ensure that the cumulative size of air bubbles in the 40 mL vial is no greater than the size of a pea. It is best to exclude all air, if possible.

5. Use a paper towel to clean and dry the outside of the sample container.

6. Affix a sample label to each sample container, ensuring that each label is completed legibly in accordance with SOP SA-6.3.

7. Proceed with the handling and processing of each sample container as described in SOP SA-6.1.

Constituents measured in grab samples collected near the water surface may not be a true representation of the total concentration distributed throughout the water column and in the horizontal cross section. Therefore, as possible based on site conditions, the sampler may be required to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

Weighted Bottle Sampling

A grab sample can also be collected using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects a sample throughout the total water column depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of glass or plastic bottle with a stopper, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).

2. When the desired depth is reached, pull out the stopper with a sharp jerk of the stopper line.

3. Allow the bottle to fill completely, as evidenced by the absence of air bubbles.

4. Raise the sampler and cap the bottle quickly and securely. In the case of samples designated for VOC analysis, ensure that the cumulative size of air bubbles in the 40 mL vial is no greater than the size of a pea. It is best to exclude all air, if possible.
5. Use a paper towel to clean and dry the outside of the container. This bottle may be used as the sample container as long as the bottle is an approved container type. If this bottle is not the sample bottle, transfer the sample from this intermediate container to the appropriate sample container with minimal agitation while avoiding contact between the two sample containers. For samples to be analyzed for VOCs, minimal agitation is especially important to prevent loss of the volatiles.

6. Affix a sample label to each sample container, ensuring that each label is completed legibly in accordance with in SOP SA-6.3.

7. Proceed with the handling and processing of each sample container as described in SOP SA-6.1.

Kemmerer Sampler

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon-coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while it is lowered in a vertical position (thus allowing free passage of water through the cylinder). A "messenger" is sent down the line when the sampler is at the designated depth to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth.

2. When the desired depth is reached, send down the stopper release messenger to close the cylinder and then raise the sampler.

3. Open the sampler valve to fill each sample bottle (filling bottles for volatile analysis first, with minimal agitation). For samples to be analyzed for VOCs, minimal agitation is required to prevent loss of the VOCs.

4. Cap the bottle quickly and securely. Ensure that the cumulative size of air bubbles in 40 mL VOC vials is no greater than the size of a pea. It is best to exclude all air, if possible.

5. Use a paper towel to clean and dry the outside of the sample container.

6. Affix a sample label to each sample container, ensuring that each label is completed legibly in accordance with SOP SA-6.3.

7. Proceed with the handling and processing of each sample container as described in SOP SA-6.1.

6.2 ONSITE WATER QUALITY TESTING

Onsite water quality testing shall be conducted as described in SOP SA-1.1.

6.3 SEDIMENT SAMPLING

6.3.1 General

If composite surface water samples are collected, sediment samples are usually collected at the same locations as the associated surface water samples. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body, in a depositional area if possible based on sample location restraints (see below), unless the SAP states otherwise.

Generally, coarser-grained sediments are deposited near the headwaters of reservoirs. Bed sediments near the center of a water body will be composed of fine-grained materials that may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathymetry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled, in general, and areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials shall be generally avoided. Follow instructions in the SAP, as applicable.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are less than detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

Samples collected for volatile organic compound (VOC) analysis must be collected prior to any sample homogenization. Regardless of the method used for collection, the aliquot for VOC analysis must be collected directly from the sampling device (hand auger bucket, scoop, trowel), to the extent practical. If a device such as a dredge is used, the aliquot should be collected after the sample is placed in the mixing container prior to mixing.

In some cases, the sediment may be soft and not lend itself to collection by plunging Encore or syringe samplers into the sample matrix. In these cases, it is appropriate to open the sampling device, (Encore barrel or syringe) prior to sample collection, and carefully place the sediment in the device, filling it fully with the required volume of sample.

On active or former military sites, ordnance items may be encountered in some work areas. Care should be exercised when handling site media (such as if unloading a dredge as these materials may be scooped up). If suspected ordnance items are encountered, stop work immediately, move to shore and notify the Project Manager and Health and Safety Manager.

All relevant information pertaining to sediment sampling shall be documented in accordance with SOP SA-6.3 and Attachment B or an equivalent electronic form.

6.3.2 Sampling Equipment and Techniques for Sampling Bottom Materials

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

SAFETY REMINDER

Refer to discussion in Section 5.0 Health and Safety.

The following sampling devices may be used to collect sediment samples:

- Scoop sampler
- Dredge sampler
- Coring sampler
- Stainless steel or disposable trowel

Each type of sampler is discussed below.

In general, the following equipment if necessary for obtaining sediment samples:

- Required sampling equipment, which may include a scoop sampler, dredge sampler, coring sampler, or stainless steel or pre-cleaned disposable trowel.

- Stainless steel bowl or pre-cleaned disposable bowl to homogenize sample.

- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.

- Required PPE as directed in the project-specific planning document, which may include:

    - Nitrile surgeon’s or latex gloves (layered as necessary).

    - Safety glasses.

    - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.

    - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).

    - Required decontamination equipment.

    - Required sample containers.

    - Sealable polyethylene bags (e.g., Ziploc® baggies).

    - Heavy-duty cooler.

    - Ice.

    - Paper towels and garbage bags.

    - Chain-of-custody records and custody seals.

Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood, PVC, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if the sampler can safely wade to the required location, the easiest and best way to collect a sediment sample is to use a scoop sampler. Scoop sampling also reduces the potential for cross-contamination. The general scoop sampling procedure is as follows:

1. Starting at the furthest downstream location, reach over or wade into the water body.
2. While facing upstream (into the current), scoop the sampler along the bottom in an upstream direction. Although it is very difficult not to disturb fine-grained materials at the sediment-water interface when using this method, try to keep disturbances to a minimum.
3. If collecting sediment for VOC analysis, fill the sample container(s) for VOC analysis at this time and quickly and securely replace the cap(s) on the container(s).
4. Transfer the remaining sediment sample material to the bowl and homogenize the sediment.
5. Fill the containers for all remaining analyses and quickly and securely replace the caps on the containers as they are filled.
6. Use a paper towel to clean and dry the outside of each container.
7. Affix a sample label to each container, ensuring that each label is completed legibly in accordance with SOP SA-6.3.
8. Proceed with the handling and processing of each sample container as described in SOP SA-6.1.

Dredge Samplers

Dredges are generally used to sample sediments that cannot easily be obtained using coring devices (e.g., coarse-grained or partially cemented materials) or when large quantities of sample are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger." Some dredges are heavy and may require use of a winch and crane assembly for sample retrieval. The three common types of dredges are Peterson, Eckman, and Ponar.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The Peterson dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends, thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

The general procedure for using a dredge sampler is as follows:

1. Gently lower the dredge to the desired depth.

2. When the desired depth is reached, send the messenger down the cable to close the cylinder and then carefully raise the sampler.

3. Open the sampler to retrieve the sediment.

4. If collecting sediment for VOC analysis, fill the sample container(s) for VOC analysis at this time and quickly and securely replace the cap(s) on the container(s).

5. Transfer the remaining sediment sample material to the bowl and homogenize the sediment.

6. Fill the containers for all remaining analyses and quickly and securely replace the caps on the containers as they are filled.

7. Use a paper towel to clean and dry the outside of each container.

8. Affix a sample label to each container, ensuring that each label is completed legibly in accordance with SOP SA-6.3.

9. Proceed with the handling and processing of each sample container as described in SOP SA-6.1.

Coring Samplers

Coring samplers are used to sample vertical columns of sediment. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand-push tubes to electronic vibrational core tube drivers.

Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus the fines at the sediment-water interface are only minimally disturbed. The sample is withdrawn intact, permitting the removal of only those layers of interest.

In shallow, wadeable waters, the use of a core liner or tube manufactured of Teflon or plastic is recommended for the collection of sediment samples. Caution should be exercised not to disturb the bottom sediments when the sample is obtained by wading in shallow water. The general procedure to collecting a sediment sample with a core tube is as follows:

1. Push the coring tube into the substrate until 4 inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction.

2. Cap the top of the tube to provide suction and reduce the chance of losing the sample.

3. Slowly extract the tube so as not to lose sediment from the bottom of the tube during extraction, and cap the bottom of the tube before removing it from the water. This will also help to minimize loss of sample.

4. If collecting sediment for VOC analysis, fill the sample container(s) for VOC analysis at this time and quickly and securely replace the cap(s) on the container(s).

5. Transfer the remaining sediment sample material to the bowl in which it will be homogenized and homogenize the remainder of the sediment.

6. Fill the containers for all analyses other than VOCs, and quickly and securely replace their caps as they are filled.

7. Use a paper towel to clean and dry the outside of each container.

8. Affix a sample label to each container, ensuring that each label is completed legibly in accordance with SOP SA-6.3.

9. Proceed with the handling and processing of each sample container as described in SOP SA-6.1.

In deeper, non-wadeable water bodies, sediment cores may be collected from a bridge or boat using different coring devices such as Ogeechee Sand Pounders, gravity cores, and vibrating coring devices. All three devices utilize a core barrel with a core liner tube system. The core liners can be removed from the core barrel and replaced with a clean core liner after each sample. Before extracting the sediment from the coring tubes, the clear supernatant above the sediment-water interface in the core should be decanted from the tube. This is accomplished by turning the core tube to its side and gently pouring the liquid out until fine sediment particles appear in the waste liquid. Post-retrieval processing of samples is the same as above.

7.0 REFERENCES

American Public Health Association, 2017, Standard Methods for the Examination of Water and Wastewater, 23rd Edition, APHA, Washington, D.C.

Feltz, H. R., 1980. Significance of Bottom Material Data in Evaluating Water Quality in Contaminants and Sediments. Ann Arbor, Michigan, Ann Arbor Science Publishers, Inc., V. 1, p. 271-287.

Kittrell, F. W., 1969. A Practical Guide to Water Quality Studies of Streams. U.S. Federal Water Pollution Control Administration, Washington, D.C., 135 p.

U.S. EPA, Test Method for Evaluating Solid Waste: Physical/Chemical Method Compendium, SW-846 Compendium, 2020, May, Online at www.epa.gov.

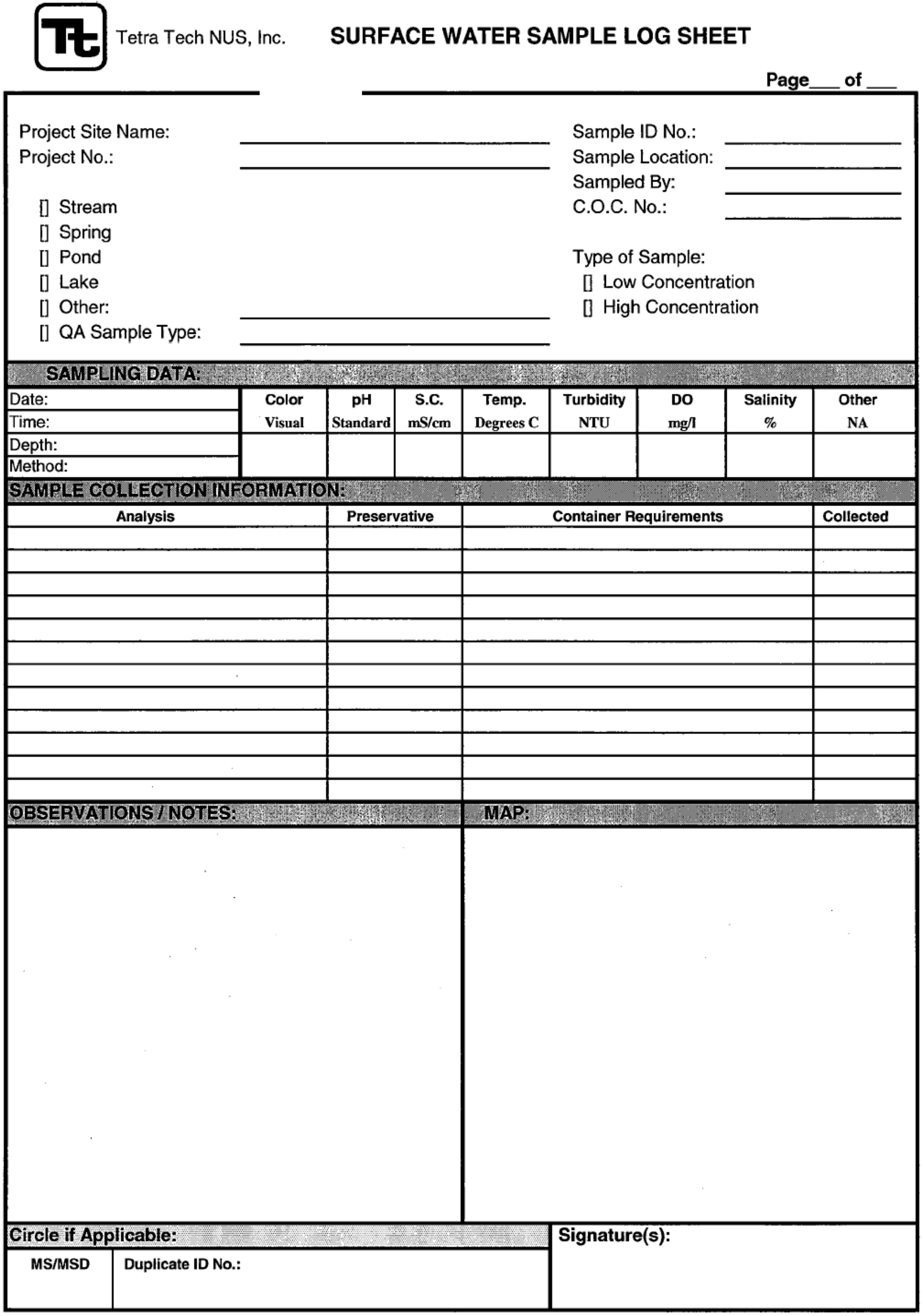
U.S. EPA, 1992. Specifications and Guidance for Contaminant-Free Sample Containers. EPA-540/R-93/051.

U.S. EPA, Region 4, 2016. Surface Water Sampling SOP SESDPROC-201-R4. Science and Ecosystem Support Division, Athens, Georgia, December.

U.S. EPA, Region 4, 2020. Sediment Sampling SOP LSASDPROC-200-R4. Laboratory Services and Applied Science Division, Athens, Georgia, February.

U.S. Geological Survey, 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Office of Water Data Coordination, USGS, Reston, Virginia.

ATTACHMENT A
SURFACE WATER SAMPLE LOG SHEET (EXAMPLE)



Tetra Tech NUS, Inc.

SURFACE WATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________________

Project No.: ____________________

☐ Stream

☐ Spring

☐ Pond

☐ Lake

☐ Other: ____________________

☐ QA Sample Type: ____________________

Sample ID No.: ____________________

Sample Location: ____________________

Sampled By: ____________________

C.O.C. No.: ____________________

Type of Sample:

☐ Low Concentration

☐ High Concentration

SAMPLING DATA:

Date:	**Color**	**pH**	**S.C.**	**Temp.**	**Turbidity**	**DO**	**Salinity**	**Other**
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	%	NA
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

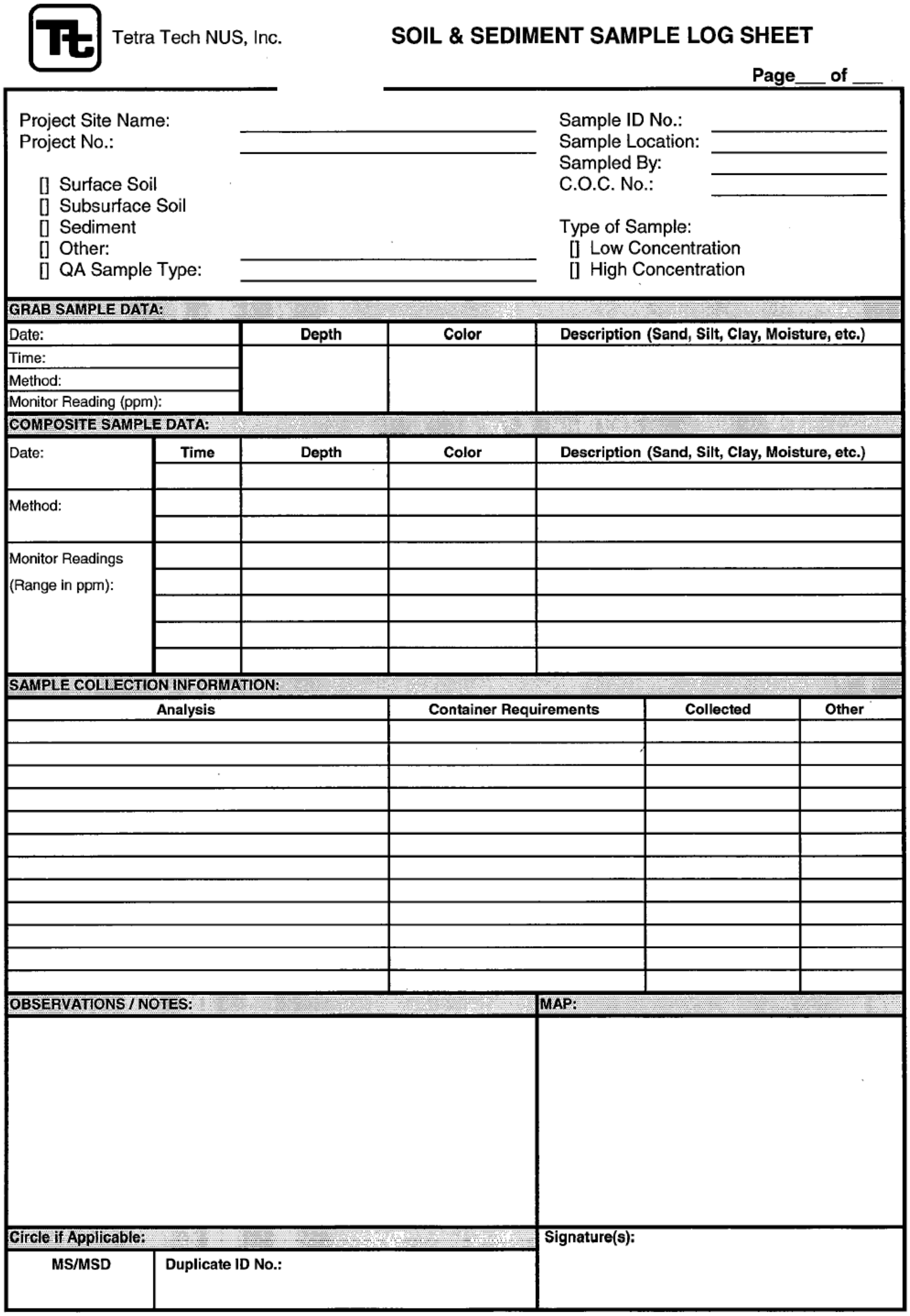
MAP:

Circle if Applicable:

MS/MSD **Duplicate ID No.:**

Signature(s):

ATTACHMENT B
SOIL & SEDIMENT SAMPLE LOG SHEET (EXAMPLE)



Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ______________
Project No.: ______________

☐ Surface Soil
☐ Subsurface Soil
☐ Sediment
☐ Other: ______________
☐ QA Sample Type: ______________

Sample ID No.: ______________
Sample Location: ______________
Sampled By: ______________
C.O.C. No.: ______________

Type of Sample:
☐ Low Concentration
☐ High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:			
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:				
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

APPENDIX C
GUIDANCE ON SAMPLING DESIGN AND SAMPLE COLLECTION

C.1 Defining the Sampling Program

Many factors are considered in developing a sampling program for surface water and/or sediment, including study objectives, accessibility, site topography, physical characteristics of the water body (e.g., flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on vertical and lateral mixing within the body of water. For sediment, dispersion depends on bottom current or flow characteristics, sediment characteristics (e.g., density, size), and geochemical properties (that affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes but must also understand the role of fluvial-sediment transport, deposition, and chemical sorption.

C.1.1 Sampling Program Objectives

The scope of the sampling program must consider the contaminant sources and potential pathways for transport of contamination to or within a surface water body. Contaminant sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., contaminated runoff). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the water body, direct waste disposal (solid or liquid) into the water body, and groundwater flow influx from upgradient contaminant sources. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompasses the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the locations of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc. shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation include: (1) moving the sampling location far enough downstream to allow for adequate mixing, or (2) collecting integrated samples in a cross section. Also, non-homogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

C.1.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and consideration of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes, reservoirs, or larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each contaminant would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling locations in streams. Stream flow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrogeologist shall explore the possibility of obtaining stream flow data by direct or indirect methods. Remember these locations are also where you may encounter natural hazards as these are areas where they hunt. Always exercise extreme caution.

C.1.3 Frequency of Sampling

The sampling frequency and objectives of the sampling event will be defined by the project planning documents. For single-event site or area characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of a contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes (i.e., consisting of repetitive, continuing measurements to define variations and trends at a given location), water samples should be collected at a pre-established and constant interval as specified in the project plans (often monthly or quarterly and during droughts and floods). Samples of bottom material should generally be collected from fresh deposits at least yearly, and preferably seasonally, during both spring and fall.

The variability in available water quality data shall be evaluated before determining the number and collection frequency of samples required to maintain an effective monitoring program.

C.2 Surface Water Sample Collection

C.2.1 Streams, Rivers, Outfalls, and Drainage Features

Methods for sampling streams, rivers, outfalls, and drainage features (ditches, culverts) at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, and discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of dissolved oxygen (DO), pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project planning documents.

C.2.2 Lakes, Ponds, and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, measurement of DO, pH, temperature, etc. is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample if a sample representative of the water column is required. These vertical composites are often collected along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline that is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer that is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several vertical composites with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality because it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, DO, some cations and anions, and light penetration.

C.2.3 Estuaries

Estuarine areas are, by definition, zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Knowledge of the estuary type may be necessary to determine sampling locations.

Estuaries are generally categorized into one of the following three types dependent on freshwater inflow and mixing properties:

- Mixed Estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically, this type of estuary is shallow and is found in major freshwater sheet flow areas. Because this type of estuary is well mixed, sampling locations are not critical.

- Salt Wedge Estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally back and forth with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic Estuary - characterized by salinities approaching full-strength oceanic waters. Seasonally, freshwater inflow is small, with the preponderance of the fresh-saline water mixing occurring near or at the shore line.

Sampling in estuarine areas is normally based on the tidal phase, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1- to 5-foot increments, coupled with vertical DO and temperature profiles.

TETRA TECH

STANDARD OPERATING PROCEDURE

Number SA-1.3		Page 1 of 28	
Effective Date 07/15/2020		Revision 12	
Applicability EGS Operating Unit			
Prepared Earth Sciences Department			
Subject SOIL SAMPLING	Approved T. Johnston	T.E. Johnston	07/15/2020

TABLE OF CONTENTS

ATTACHMENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the procedures to be used to collect surface, near-surface, and subsurface soil samples. Additionally, it describes the methods for sampling of test pits and trenches to determine subsurface soil and rock conditions and for recovery of small-volume or bulk samples from pits.

2.0 SCOPE AND APPLICABILITTY

This document applies to the collection of surface, near-surface, and subsurface soil samples obtained through hand digging, hand augering, drilling, or machine excavating at sites for which laboratory testing, onsite visual examination, and onsite testing is required.

3.0 GLOSSARY

Composite Sample - A composite sample is a combination of more than one grab sample from various locations and/or depths and times that is homogenized and treated as one sample. This type of sample is usually collected when determination of an average waste concentration for a specific area is required. Composite samples shall not be collected for volatile organics analysis.

Confined Space - As stipulated in 29 Code of Federal Regulations (CFR) 1910.146, a confined space means a space that: (1) is large enough and so configured that an employee can bodily enter and perform assigned work; (2) has limited or restricted means for entry or exit (e.g., tanks, vessels, silos, storage bins, hoppers, vaults, pits, and excavations); and (3) is not designed for continuous employee occupancy. Tetra Tech considers all confined space as permit-required confined spaces.

Grab Sample - One sample collected at one location and at one specific time.

Hand Auger - A sampling device used to extract soil from the ground.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Sample for Non-Volatile Analyses - Includes all chemical parameters other than volatile organics (e.g., semivolatiles, pesticides/PCBs, metals, etc.) and those engineering parameters that do not require undisturbed soil for their analysis.

Split-Barrel Sampler - A steel tube, split in half lengthwise, with the halves held together by threaded collars at either end of the tube. Also called a split-spoon sampler, this device can be driven into resistant materials using a drive weight mounted in the drilling string. A standard split-barrel sampler is typically available in two common lengths, providing either 20-inch or 26-inch longitudinal clearance for obtaining 18-inch or 24-inch-long samples, respectively. These split-barrel samplers commonly range in size from 2 to 3.5 inches outside diameter (OD). The larger sizes are commonly used when a larger volume of sample material is required (see Attachment B).

Test Pit and Trench - Open, shallow excavations, typically rectangular (if a test pit) or longitudinal (if a trench), excavated to determine shallow subsurface conditions for engineering, geological, and soil chemistry exploration and/or sampling purposes. These pits are excavated manually or by machine (e.g., backhoe, clamshell, trencher, excavator, or bulldozer).

Thin-Walled Tube Sampler - A thin-walled metal tube (also called a Shelby tube) used to recover relatively undisturbed soil samples. These tubes are available in various sizes, ranging from 2 to 5 inches OD and from 18 to 54 inches in length.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The project manager, who is qualified by having completed project management training and by being appointed by the program or office manager, is responsible for determining the sampling objectives, selecting planned sampling locations, and selecting field procedures used in the collection of soil samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the project manager establishes the need for test pits or trenches and determines their approximate locations and dimensions.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP) or equivalent. This will include (but not be limited to) performing air quality monitoring during sampling, boring, and excavation activities and to ensure that workers and off-site (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO/designee may also be required to advise the Field Operations Leader (FOL) on other safety-related matters regarding boring, excavation, and sampling, such as mitigative measures to address potential hazards from unstable trench walls, puncturing of drums or other hazardous objects, etc.

Field Operations Leader (FOL) - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for and qualified to execute the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface, near-surface, and subsurface (hand and machine borings, test pits/trenches) soil samples. He/she is ultimately responsible for the sampling and backfilling of boreholes, test pits, and trenches and for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self-acquisition or through the management of a field team of samplers.

Project Geologist/Sampler - The Project Geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and/or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, test pit logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Competent Person - A Competent Person, as defined in 29 CFR 1929.650 of Subpart P - Excavations, means one who is capable of identifying existing and predictable hazards in the surroundings, or working conditions that are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- OSHA 40-hour and applicable refresher training.

- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Some health and safety precautions are identified for individual sample collection procedures throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard or uneven surfaces

- Slips, trips, and falls

- Cuts and lacerations

- Traffic hazards associated with sampling in parking areas, along railroads, roadways and highways.

Consult the site specific HASP for methods of avoiding the above hazards.

6.0 PROCEDURES

The following procedures address surface and subsurface sampling. Equipment lists specific to each type of sampling are provided in the applicable sections below.

NOTE: If documentation such as a Certificate of Analysis is provided with sample containers to demonstrate their cleanliness, submit the documentation to the project manager for inclusion in the project file.

NOTE: If sample containers that have been stored on site for more than 6 months are used for sampling, a note should be entered into the field log to explain why the containers were used. In such cases, collection of additional field blanks may be useful. These blanks may be used to identify the contamination source. Certain programs (e.g., Navy CLEAN) also may have program-specific requirements or policies affecting bottle storage that must be satisfied.

Section 6.1 provides an overview of the sampling processes. The procedures described In Section 6.2 begin with transferring sample material from a sampling device or directly from the ground surface into a sample container. Beginning with Section 6.3, various sample collection techniques and processes that are used for collecting surface or subsurface soil samples prior to transferring to sample containers are described.

CAUTION

Each situation must be evaluated individually to determine the applicability and necessity for obtaining a utility clearance ticket/dig permit. Common sense dictates, prior to digging or boring with power equipment, no matter what the depth, or digging by hand in a manner that could damage unprotected underground utilities, that a dig permit is required. See SOP HS-1.0, Utility Locating and Excavation Clearance, for additional clarification. If you do not know or are unsure as to whether a ticket is necessary – **Get the Ticket**.

6.1 OVERVIEW

Soil sampling is an important adjunct to groundwater monitoring. Sampling of the soil horizons above the groundwater table can detect contaminants before they migrate to the water table, and can establish the amount of contamination absorbed or adsorbed on aquifer solids that have the potential of contributing to groundwater contamination.

Soil types can vary considerably on a site. These variations, along with vegetation, can affect the rate of contaminant migration through the soil. It is important, therefore, that a detailed record be maintained during sampling operations, particularly noting sampling locations, depths, and such characteristics as grain size, color, and odor. Subsurface conditions are often stable on a daily basis and may demonstrate only slight seasonal variation especially with respect to temperature, available oxygen and light penetration. Changes in any of these conditions can radically alter the rate of chemical reactions or the associated microbiological community, thus further altering specific site conditions. Certain vegetation species can create degradation products that can alter contaminant concentrations in soil. This is why vegetation types and extent of degradation of this foliage must be recorded. To prevent degradation, samples must be kept at their at-depth temperature or lower, protected from direct light, sealed tightly in approved glass containers, and be analyzed as soon as possible after collection. In addition, to the extent possible, vegetation should be removed from the sample.

The physical properties of the soil, its grain size, cohesiveness, associated moisture, and such factors as depth to bedrock and water table, will limit the depth from which samples can be collected and the method required to collect them. It is the intent of this document to present the most commonly employed soil sampling methods used at environmental investigation sites.

6.2 SOIL SAMPLE COLLECTION

6.2.1 Procedure for Preserving and Collecting Soil Samples for Volatile Organic Compound Analysis

Samples collected using traditional methods such as collection in a jar with no preservation have been known to yield non-representative samples due to loss of volatile organic compounds (VOCs). To prevent such losses, preservation of samples with methanol or sodium bisulfate may be used to minimize volatilization and biodegradation. This preservation may be performed either in the field or laboratory, depending on the sampling methodology employed. Because of the large number of sampling methods and associated equipment required, careful coordination between field and laboratory personnel is necessary.

Soil samples to be preserved by the laboratory and analyzed for VOCs may be collected using Method SW-846, 5035. EnCore or equivalent samplers are used for this. For samples preserved in the field, laboratories are currently performing low-level analyses (sodium bisulfate preservation) and high- to medium-level analyses (methanol preservation) depending on the needs of the end user.

The following procedures outline the necessary steps for collecting soil samples to be preserved at the laboratory, and for collecting soil samples to be preserved in the field with methanol or sodium bisulfate.

6.2.1.1 Soil Samples to be Preserved at the Laboratory

Soil samples collected for volatile organic analysis that are to be preserved at the laboratory shall be obtained using a hermetically sealed sample vial such as an EnCore sampler. Each sample shall be obtained using a reusable sampling handle (T-handle) that can be provided with the EnCore sampler when requested and purchased. Be aware that these types of samples require preservation by the laboratory within 48 hours of sample collection. Collect the sample in the following manner for each EnCore sampler:

1. Scene Safety - Evaluate the area where sampling will occur. Ensure that the area is safe from physical, chemical, and natural hazards. Clear or barricade those hazards that have been identified.
2. Wear the appropriate personal protective equipment (PPE) as discussed in daily tailgate meeting and described in site specific HASP. This will include, at a minimum, safety glasses and nitrile surgeon’s gloves.
3. Load the EnCore sampler into the T-handle with the plunger fully depressed.
4. Expose the area to be sampled using a hand trowel or similar device to remove surface debris that could interfere with collection of a representative sample.
5. Press the T-handle against the freshly exposed soil surface, forcing soil into the sampler. The plunger will be forced upward as the cavity fills with soil.
6. When the sampler is full, rotate the plunger and lock it into place. If the plunger does not lock, the sampler is not full. This method ensures there is no headspace. Soft soil may require several plunges or forcing soil against a hard surface such as a sample trowel to ensure that headspace is eliminated.
7. Use a paper towel to remove soil from the side of the sampler so a tight seal can be made between the sample cap and the rubber O-ring.
8. With soil slightly piled above the rim of the sampler, force the cap on until the catches hook the side of the sampler.
9. Remove any surface soil from the outside of the sampler and place in the foil pouch provided with the sampler.
10. Affix a label to the outside of each of the foil pouches with appropriate sample information in accordance with SOP SA-6.3. A good practice is to place the two or three foil pouch EnCore samplers for each sample into a single small Ziplok (or equivalent) baggie to avoid mixing foil pouches with other sample locations.
11. Place the samples inside a lined cooler with ice and cool to <6˚C. Make sure any required trip blanks and temperature blanks are also in the cooler. Maintain secure custody of the cooler in accordance with SOP SA-6.3.

Typically, collect three EnCore samplers at each location. Consult the governing SAP or project manager to determine the required number of EnCore Samplers to be collected.
The T-handle shall be decontaminated before moving to the next interval or location using a soap and water wash and rinse, and where applicable, the selected solvent as defined in the governing SAP.

Using this type of sampling device eliminates the need for field preservation and the shipping restrictions associated with preservatives. A complete set of instructions is included with each EnCore sampler.

6.2.1.2 Soil Samples to be Preserved in the Field

Soil samples preserved in the field may be prepared for analyses using both the low-level (sodium bisulfate preservation) and high- to medium-level (methanol preservation) methods.

Methanol Preservation (High to Medium Level):

Bottles will be pre-spiked with methanol and pre-weighed by the laboratory.

Soil shall be collected with the use of a decontaminated (or disposable), small-diameter coring device such as a disposable tube/plunger-type syringe with the tip cut off. The outside diameter of the coring device must be smaller than the inside diameter (ID) of the sample bottle neck.

A small electronic balance or manual scale will be necessary for measuring the volume of soil to be added to the methanol-preserved sample bottle. Calibration of the scale shall be performed prior to use and intermittently throughout the day according to the manufacturer’s requirements.

The sample should be collected as follows:

1. Pull the plunger back and insert the syringe into the soil to be sampled.
2. Collect 8 to 12 grams of soil by pushing the syringe barrel into the soil.
3. Extrude the soil sample into the methanol-preserved sample bottle taking care not to contact the sample container with the syringe.
4. If dirty, wipe soil particles from the threads of the bottle and cap. Cap the bottle tightly.
5. After capping the bottle, swirl the sample (do not shake) in the methanol and break up the soil such that all of the soil is covered with methanol.
6. Place the sample on ice immediately and prepare for shipment to the laboratory as described in SOP SA-6.1.

Sodium Bisulfate Preservation (Low Level):

CAUTION

Care should be taken when adding the soil to sodium bisulfate solution. A chemical reaction of soil containing carbonates (limestone) may cause the sample to effervesce or the vial to possibly explode. To avoid this hazard or hazards of this type, a small sample aliquot should be subjected to the sample preservative. If it effervesces in an open air environment, utilize an alternative method such as EnCore or 2-ounce jar.

Bottles will be prepared by the laboratory to contain sodium bisulfate solution and will be pre-weighed by the laboratory. When collecting samples in vials that are pre-preserved with sodium bisulfate, collect the samples as described above for methanol-preserved samples.

6.2.2 Procedure for Collecting Soil Samples for Non-Volatile Analyses

Samples collected for non-volatile analyses may be collected as either grab or composite samples as follows:

1. To ensure collection of a representative sample, use a stainless steel trowel or other approved tool, to transfer the entire depth interval of the soil to be sampled to a stainless steel bowl, re-sealable plastic bag, or disposable inert plastic tray.

NOTE: Contact with plastic materials, especially if the contact is prolonged, may cause contamination of samples with phthalates and other contaminants contained in the plastic. Loss of analytes due to adsorption or reaction with plastics also is possible. When in doubt about contamination potential, or potential loss of analyte due to adsorption/reaction, consult the project manager or use non-plastic bowls or other equipment to the extent possible when mixing samples.

2. Remove roots, vegetation, sticks, and stones larger than the size of a green pea.

3. Thoroughly mix the soil to obtain as uniform a texture and color as practicable. The soil type, moisture content, amount of vegetation, and other factors may affect the amount of time required to obtain a properly mixed sample. In some cases (e.g., highly plastic clay soil), it may be impossible to obtain a uniform sample appearance. Use the field logbook to describe any significant difficulties encountered in obtaining a uniform mixture.

4. Transfer a portion of the mixed soil to the appropriate sample containers and close the containers.

5. Label the sample containers in accordance with SOP SA-6.3.

6. Place the containers in a cooler of ice as soon after collection as possible.

7. Prepare the sample shipment and ship the samples in accordance with SOP SA-6.1.

NOTE

Cooling may not be required for some samples depending on the scheduled analyses. Consult the governing SAP if in doubt regarding correct sample preservation conditions. When in doubt – Cool to <6 °C.

NOTE

Head space is permitted in soil sample containers for non-volatile analyses to allow for sample expansion.

6.2.3 Procedure for Collecting Undisturbed Soil Samples Using a Shelby Tube

NOTE

Use of thin-walled undisturbed tube samplers is restricted by the consistency of the soil to be sampled. Often, very loose and/or wet samples cannot be retrieved by the samplers, and soil with a consistency in excess of very stiff cannot be penetrated by the sampler. Devices such as Dennison or Pitcher core samplers can be used to obtain undisturbed samples of stiff soil. Using these devices normally increases sampling costs, and therefore their use should be weighed against the need for acquiring an undisturbed sample. These devices are not discussed in this SOP because they are not commonly used.

When it is necessary to acquire undisturbed samples of soil for purposes of engineering parameter analysis (e.g., permeability), a thin-walled, seamless tube sampler (Shelby tube) shall be employed using the following collection procedure:

1. In preparation for sampling utilizing a drill rig, field personnel must complete the following activities:

    - Ensure that all subsurface drilling activities are preceded by a utility clearance for the area to be investigated. This includes activities described in SOP HS-1.0, Utility Location and Excavation Clearance, as well as any location-specific procedures that may apply.

    > ***REMEMBER***
    > If you are digging near a marked utility (within the diameter of an underground utility that has been marked plus 18 inches), you must first locate the utility through vacuum extraction or hand digging to ensure that your activities will not damage the utility.

    - Complete an Equipment Inspection Checklist for the drill rig or direct-push technology (DPT) rig. This checklist will be provided in the site specific HASP.

    - Review the Safe Work Permit prior to conducting the activity.

    - Review the activity to be conducted.

2. Remove all surface debris (e.g., vegetation, roots, twigs, etc.) from the specific sampling location and drill and/or clean out the borehole to the desired sampling depth. Be careful to minimize potential disturbance of the material to be sampled. In saturated material, withdraw the drill bit slowly to prevent loosening of the soil around the borehole and to maintain the water level in the hole at or above groundwater level.

    > ***CAUTION***
    > The use of bottom-discharge bits or jetting through an open-tube sampler to clean out the borehole shall not be allowed. Only the use of side-discharge bits is permitted.

3. Determine whether a stationary piston-type sampler is required to limit sample disturbance and aid in retaining the sample. Either the hydraulically operated or control rod activated-type of stationary piston sampler may be used.

4. Prior to inserting the tube sampler into the borehole, check to ensure that the sampler head contains a check valve. The check valve is necessary to keep water in the rods from pushing the sample out the tube sampler during sample withdrawal. In addition, the check valve maintains a positive suction within the tube to help retain the sample.

5. A stainless steel tube sampler is typically used to minimize chemical reaction between the sample and the sampling tube.

6. Remove the plastic end caps from the sampling tube and, with the sampling tube resting on the bottom of the hole and the water level in the boring at groundwater level or above, push the tube into the soil with a continuous and rapid motion, without impacting or twisting. If the soil is too hard to penetrate by pushing alone, careful hammering may be used by minimizing drop distance (tapping) of the hammer. Before pulling the tube, turn it at least one revolution to shear the sample off at the bottom. In no case shall the tube be pushed farther than the length provided for the soil sample. Allow about 3 inches in the tube for cuttings and sludge.

7. Upon removal of the sampling tube from the hole, measure the length of sample in the tube and also the length penetrated.

8. Remove disturbed material in the upper end of the tube and measure the length of sample again.

9. After removing at least 1 inch of soil from the lower end, place enough packing material (clean inert material such as paper or cloth) tightly in each end of the Shelby tube and then pour melted wax into each end to make at least a ½-inch wax plug and then add more packing material to fill the voids at both ends.

10. Place plastic caps on the ends, tape the caps in place, and dip the ends in wax to prevent loss of soil.

11. Affix label(s) to the tube as required and record sample number, depth, penetration, and recovery length on the label.

12. Mark the "up" direction on the side and upper end of the tube with indelible ink.

13. Complete a chain-of-custody form (see SOP SA-6.3) and other required forms (including Attachment A of this SOP).

12. Ship samples protected with suitable resilient packing material to reduce shock, vibration, and disturbance.

> ***CAUTION***
>
> To preserve sample integrity do not allow tubes to freeze, and store the samples vertically with the same orientation they had in the ground, (i.e., top of sample is up) in a cool place out of the sun at all times.

6.3 SURFACE SOIL SAMPLING

The simplest, most direct method of collecting surface soil samples for subsequent analysis is by use of a stainless steel shovel, hand auger, soil corer, or stainless steel or disposable plastic trowel.

> ***NOTE***
>
> Multiple depth intervals are used to describe surface soil. Sometimes surface soil is defined as soil from 0 to 2 inches below ground surface (bgs), and sometimes it is defined as soil from other depths such as 0 to 2 feet bgs. Ensure that the definition of surface soil depth is clear before collecting surface soil samples.
>
> For the purposes of instruction, the terms “surface soil” and “near-surface soil” are used in this SOP as follows:
>
> - Surface soil - 0 to 6 inches bgs
> - Near-surface soil - 6 to 18 inches bgs
>
> If these intervals are defined differently in the governing SAP, substitute the appropriate depth ranges.

In general, the following equipment is necessary for obtaining surface soil samples:

- Stainless steel or pre-cleaned disposable trowel.
- Stainless steel hand auger, soil corer, or shovel.
- Real-time air monitoring instrument (e.g., photoionization or flame ionization detector [PID], [FID]) as directed in governing SAP.
- Required PPE.
  - Nitrile surgeon’s or latex gloves may be used, layered as necessary.
  - Safety glasses.
  - Other – Items identified on the Safe Work Permit may be required based on location-specific requirements such as hearing protection, steel-toed work boots, and a hard hat when working near a drill rig. These provisions will be listed in the HASP or directed by the FOL and/or SSO.

Safety Reminder

The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

- Required paperwork (see SOP SA-6.3 and Attachment A of this SOP).
- Required decontamination equipment.
- Required sample container(s).
- Wooden stakes or pin flags.
- Re-sealable plastic bags.
- Heavy duty cooler.
- Ice.
- Chain-of-custody records and custody seals.

When acquiring surface soil samples, use the following procedure:

1. Place padding or use knee pads when kneeling near the sample location. If necessary, place plastic sheeting to provide a clean surface for sample equipment to avoid possible cross-contamination.
2. Carefully remove vegetation, roots, twigs, litter, etc. to expose an adequate soil surface area to accommodate sample volume requirements.
3. Using a pre-cleaned syringe or EnCore samplers, follow the procedure in Section 6.2.1 for collecting surface soil samples for volatile analysis. Surface soil samples for volatile organic analysis should be collected deeper than 6 inches bgs because shallower material has usually lost most of the volatiles

through evaporation. Ensure that the appropriate surface soil depth is being analyzed in accordance with the governing SAP.

4. Using decontaminated sampling tools, thoroughly mix in place (or in a mixing bowl) a sufficient amount of soil to fill the remaining sample containers. See Section 6.5 of this procedure for hand auger instruction, as needed.

5. Transfer the sample into those containers utilizing a stainless steel trowel.

6. Cap and securely tighten all sample containers.

7. Affix a sample label to each container. Be sure to fill out each label carefully and clearly, addressing all the categories described in SOP SA-6.3.

8. Proceed with the handling and processing of each sample container as described in SOP SA-6.1.

9. Site restoration – Whenever removing sample materials, always restore the surface. It is our intent to leave the area better than we found it. Do NOT create trip hazards in areas where pedestrian traffic may exist.

6.4 NEAR-SURFACE SOIL SAMPLING

Collection of samples from near the surface (depth of 6 to 18 inches) can be accomplished with tools such as shovels, hand auger, soil corers, and stainless steel or pre-cleaned disposable trowels and the equipment listed under Section 6.5 of this procedure.

To obtain near-surface soil samples, the following protocol shall be used:

1. With a clean shovel, make a series of vertical cuts in the soil to the depth required to form a square approximately 1 foot by 1 foot.

2. Level out the formed plug and scrape the bottom of the freshly dug hole with a decontaminated stainless steel or pre-cleaned disposable trowel to remove any loose soil.

3. Follow steps 1 through 9 of Section 6.3.

6.5 SUBSURFACE SOIL SAMPLING WITH HAND AUGERS AND SOIL CORERS

Hand augering and Use of Soil Corers are similar. Hand augering requires turning the auger while it advances whereas soil corers are not necessarily turned during advancement.

6.5.1 Hand Augering

A hand augering system generally consists of a variety of stainless steel bucket bits (approximately 6.5 inches long and 2, 2.75, 3.25, and 4 inches in diameter), series of extension rods (available in 2-, 3-, 4- and 5-foot lengths), and a T-handle connected to extension rods and to the auger bucket. A larger diameter bucket bit is commonly used to bore a hole to the desired sampling depth and then it is withdrawn. The larger-diameter bit is then replaced with a smaller-diameter bit, lowered down the hole, and slowly turned into the soil to the completion depth (approximately 6 inches). The apparatus is then withdrawn and the soil sample collected.

The hand auger can be used in a wide variety of soil conditions. It can be used to sample soil either from the surface, or to depths in excess of 12 feet. However, the presence of subsurface rocks and landfill material and collapse of the borehole normally limit sampling depth.

To accomplish soil sampling using a hand augering system, the following equipment is required:

- Complete hand auger assembly (variety of bucket bit sizes).
- Stainless steel mixing bowls or re-sealable plastic bags.
- The equipment listed in Section 6.3.
- Miscellaneous hand tools as required to assemble and disassemble the hand auger units.

To obtain soil samples using a hand auger, use the following procedure:

1. Wearing designated PPE, attach a properly decontaminated bucket bit to a clean extension rod and attach the T-handle to the extension rod.
2. Clear the area to be sampled of any surface debris (vegetation, twigs, rocks, leaf litter, etc.).
3. Twist the bucket into the ground while pushing vertically downward on the auger. The cutting shoes fill the bucket as it is advanced into the ground.
4. As the auger bucket fills with soil, periodically remove any unneeded soil.
5. Add rod extensions as necessary to extend the reach of the auger. Also, note (in a field notebook, boring log, and/or on a standardized data sheet) any changes in the color, texture or odor of the soil as a function of depth. The project-specific planning document (SAP, HASP, etc.) describe requirements for scanning the soil with a real-time air monitoring instrument (e.g., PID, FID, etc.) and recording the measurements.
6. After reaching the desired depth (e.g., the top of the interval to be sampled), slowly and carefully withdraw the apparatus from the borehole to prevent or minimize movement of soil from shallower intervals to the bottom of the hole.
7. Remove the soiled bucket bit from the rod extension and replace it with another properly decontaminated bucket bit. The bucket bit used for sampling is to be smaller in diameter than the bucket bit employed to initiate the borehole.
8. Carefully lower the apparatus down the borehole. Care must be taken to avoid scraping the borehole sides.
9. Slowly turn the apparatus until the bucket bit is advanced approximately 6 inches.
10. Discard the top of the core (approximately 1 inch), which represents any loose material collected by the bucket bit before penetrating the sample material.
11. Using a pre-cleaned syringe or EnCore sampler, follow the procedure in Section 6.2.1 for collecting a soil sample for volatile compound analysis directly from the bucket bit.
12. Utilizing a properly decontaminated stainless steel trowel or dedicated disposable trowel, remove the remaining sample material from the bucket bit and place into a properly decontaminated stainless steel mixing bowl or re-sealable plastic bag.
13. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers. Refer to Section 6.2.2.

14. Follow steps 4 through 7 listed in Section 6.3.

6.5.2 Sampling Using Stainless Steel Soil Corers

A soil corer is a stainless steel tube equipped with a cutting shoe and sample window in the side. The soil corer is advanced into the soil by applying downward pressure (body weight). The soil is unloaded by then forcing a ram towards the cutting shoe, which results in the discharge of the soil core through a window in the sleeve.

Use, application, and sample protocol is the same as for hand augering provided above, but without necessarily rotating the corer while advancing it.

SAFETY REMINDER

Hand augering and soil corer sampling can be physically demanding based on the type of geology and subsurface encumbrances encountered. Soil coring has some added hazards such the corer collapsing under your weight. To reduce the potential for muscle strain and damage, the following measures will be incorporated:

- Stretch and limber your muscles before heavy exertion. This hazard becomes more predominant in the early morning hours (prior to muscles becoming limber) and later in the day (as a result of fatigue).

- Job rotation – Share the duties so that repetitive actions do not result in fatigue and injury.

- Increase break frequencies as needed, especially as ambient conditions of heat and/or cold stress may dictate.

- Do not force the hand tools or use cheater pipes or similar devices to bypass an obstruction. Move to another location near the sampling point. Exerting additional forces on the sampling devices can result in damage and/or failure that could potentially injure someone in the immediate vicinity.

- Do not over compromise yourself when applying force to the soil corer or hand auger. If there is a sudden release, it could result in a fall or muscle injury due to strain.

6.6 SUBSURFACE SOIL SAMPLING WITH A SPLIT-BARREL SAMPLER

A split-barrel (split-spoon) sampler consists of a heavy carbon steel or stainless steel sampling tube that can be split into two equal halves to reveal the soil sample (see Attachment B). A drive head is attached to the upper end of the tube and serves as a point of attachment for the drill rod. A removable tapered nosepiece/drive shoe attaches to the lower end of the tube and facilitates cutting. A basket-like sample retainer can be fitted to the lower end of the split tube to hold loose, dry soil samples in the tube when the sampler is removed from the drill hole. This split-barrel sampler is made to be attached to a drill rod and forced into the ground by means of a 140-pound or larger casing driver.

Safety Reminder

It is intended through the Equipment Inspection for Drill Rigs form provided in the HASP that the hammer and hemp rope, where applicable, associated with this activity will be inspected (no physical damage is obvious), properly attached to the hammer (suitable knots or sufficient mechanical devices), and is in overall good condition.

Split-barrel samplers are used to collect soil samples from a wide variety of soil types and from depths greater than those attainable with other soil sampling equipment.

The following equipment is used for obtaining split-barrel samples:

- Drilling equipment (provided by subcontractor).
- Split-barrel samplers (2-inch OD, 1-3/8-inch ID, either 20 inches or 26 inches long); Larger OD samplers are available if a larger volume of sample is needed.
- Drive weight assembly, 140-pound weight, driving head, and guide permitting free fall of 30 inches.
- Stainless steel mixing bowls or re-sealable plastic bags.
- Equipment listed in Section 6.3.

The following steps shall be followed to obtain split-barrel samples (Steps 1 through 4 are typically performed by the drilling subcontractor):

1. Attach the split-barrel sampler to the sampling rods.
2. Lower the sampler into the borehole inside the hollow stem auger bits.
3. Advance the split-barrel sampler by hammering the length (typically 18 or 24 inches) of the split-barrel sampler into the soil using 140-pound or larger hammer.
4. When the desired depth is achieved, extract the drill rods and sampler from the augers and/or borehole.
5. Detach the sampler from the drill rods.
6. Place the sampler securely in a vise so it can be opened using pipe wrenches.
7. Remove the drive head and nosepiece with the wrenches and open the sampler to reveal the soil sample.
8. Immediately scan the sample core with a real-time air monitoring instrument (e.g., FID, PID, etc.) (as project-specific planning documents dictate). Carefully separate (or cut) the soil core, with a decontaminated stainless steel knife or trowel, at about 6-inch intervals while scanning the center of the core for elevated readings. Also scan stained soil, soil lenses, and anomalies (if present), and record readings.
9. If elevated vapor readings were observed, collect the sample scheduled for volatile analysis from the center of the core where elevated readings occurred. If no elevated readings where encountered, the sample material should be collected from the core's center (this area represents the least disturbed area with minimal atmospheric contact) (refer to Section 6.2.1).
10. Using the same trowel, remove remaining sample material from the split-barrel sampler (except for the small portion of disturbed soil usually found at the top of the core sample) and place the soil into a decontaminated stainless steel mixing bowl or re-sealable plastic bag.
11. Homogenize the sample material as thoroughly as practicable then fill the remaining sample containers (refer to Section 6.2.2).

12. Follow steps 4 through 7 in Section 6.3.

6.7 SUBSURFACE SOIL SAMPLING USING DIRECT-PUSH TECHNOLOGY (DPT)

Subsurface soil samples can be collected to depths of 40+ feet using DPT. DPT equipment, responsibilities, and procedures are described in SOP SA-2.5.

6.8 EXCAVATION AND SAMPLING OF TEST PITS AND TRENCHES

6.8.1 Applicability

This subsection presents routine test pit or trench excavation techniques and specialized techniques that are applicable under certain conditions.

CAUTION

No personnel shall enter any test pit or excavation over 4 feet deep. If personnel entry into a trench greater than 4 feet deep is required, this constitutes a Confined Space Entry and must be conducted in conformance with OSHA standard 29 CFR 1910.146. Test pit or excavation entry by personnel shall have been planned prior to mobilization and in accordance with additional OSHA standards, and the site specific HASP will provide guidance to personnel if entry is required.

Excavations are generally not practical where a depth of more than about 15 to 20-feet is desired, and they are usually limited to a few feet below the water table. In some cases, a pumping system may be required to control water levels within the pit, providing that pumped water can be adequately stored or disposed. If soil data at depths greater than 15-feet are required, the data are usually obtained through test borings instead of test pits.

In addition, hazardous wastes may be brought to the surface by excavation equipment. This material, whether removed from the site or returned to the subsurface, must be properly handled according to any and all applicable federal, state, and local regulations.

6.8.2 Test Pit and Trench Excavation

Test pits or trench excavations are constructed with the intent that they will provide an open view of subsurface lithology and/or waste disposal conditions that a boring will not provide. These procedures describe the methods for excavating and logging test pits and trenches installed to determine subsurface soil and rock conditions. Test pit operations shall be logged and documented (see Attachment C).

Test pits and trenches may be excavated by hand or power equipment to permit detailed descriptions of the nature and contamination of the in-situ materials. The size of the excavation will depend primarily on the following:

- The purpose and extent of the exploration.
- The space required for efficient excavation.
- The chemicals of concern.
- The economics and efficiency of available equipment.

Test pits normally have a cross section that is 4 to 10 feet square; test trenches are usually 3 to 6 feet wide and may be extended for any length required to reveal conditions along a specific line. The following table provides guidelines for design consideration based on equipment efficiencies.

Equipment	Typical Widths, in Feet
Trenching machine	0.25 to 1.0
Backhoe/Track Hoe	2 to 6

The lateral limits of excavation of trenches and the position of test pits shall be carefully marked on area base maps. If precise positioning is required to indicate the location of highly hazardous materials, nearby utilities, or dangerous conditions, the limits of the excavation shall be surveyed. Also, if precise determination of the depth of buried materials is needed for design or environmental assessment purposes, the elevation of the ground surface at the test pit or trench location shall also be determined by survey. If the test pit/trench will not be surveyed immediately, it shall be backfilled and its position identified with stakes placed in the ground at the margin of the excavation for later surveying.

The **construction of test pits and trenches shall be planned and designed in advance** as much as possible. However, the following field conditions may necessitate revisions to the initial plans:

- Subsurface utilities.

- Surface and subsurface encumbrances.
- Vehicle and pedestrian traffic patterns.

- Purpose for excavation (e.g., the excavation of potential ordnance items).

The final depth and construction method shall be collectively determined by the FOL and designated Competent Person. The actual layout of each test pit, temporary staging area, and spoils pile may further be predicated based on site conditions and wind direction at the time the test pit is excavated. Prior to excavation, the area may be surveyed by magnetometer or metal detector or other passive methods specified in SOP HS1.0, Utility Location and Excavation Clearance, to identify the presence of underground utilities or drums. Where possible, the excavator should be positioned upwind and preferably within an enclosed cab.

No personnel shall enter any test pit or excavation except as a last resort, and then only under direct supervision of a Confined Space or Excavation Competent Person. If entrance is required, OSHA requirements must be met (e.g., walls must be braced with wooden or steel braces, ladders must be placed for every 25 feet of lateral travel and extended 3 feet above ground surface). A temporary guard rail or vehicle stop must be placed along the surface of the hole before entry in situations where the excavation may be approached by traffic. Spoils will be stockpiled no closer than 2 feet from the sidewall of the excavation. The excavation equipment operator shall be careful not to undercut sidewalls and will, where necessary, bench back to increase stability. The top cover, when considered clean, will be placed separately from the subsurface materials to permit clean cover. It is emphasized that the project data needs should be structured such that required samples can be collected without requiring entrance into the excavation. For example, samples of leachate, groundwater, or sidewall soil can be collected with telescoping poles or similar equipment.

Dewatering and watering may be required to ensure the stability of the side walls, to prevent the bottom of the pit from heaving, and to keep the excavation stable. This is an important consideration for excavations in cohesionless material below the groundwater table and for excavations left open greater than a day. Liquids removed as a result of dewatering operations must be handled as potentially contaminated materials. Procedures for the collection and disposal of such materials should be discussed in the site-specific project plans.

Where possible, excavations and test pits shall be opened and closed within the same working day. Where this is not possible, the following engineering controls shall be put in place to control access:

- Trench covers/street plates.
- Fences encompassing the entire excavation intended to control access.
- Warning signs warning personnel of the hazards.
- Amber flashing lights to demarcate boundaries of the excavation at night.

Excavations left open will have emergency means to exit should someone accidentally enter.

6.8.3 Sampling in Test Pits and Trenches

6.8.3.1 General

Log test pits and trenches as they are excavated in accordance with the Test Pit Log presented in Attachment C. These records include plan and profile sketches of the test pit/trench showing materials encountered, their depth and distribution in the pit/trench, and sample locations. These records also include safety and sample screening information.

Entry of test pits by personnel is extremely dangerous, shall be avoided unless absolutely necessary, and can occur only after all applicable health and safety and OSHA requirements have been met as stated above. These provisions will be reiterated as appropriate in the site specific HASP.

The final depth and type of samples obtained from each test pit will be determined at the time the test pit is excavated. Sufficient samples are usually obtained and analyzed to quantify contaminant distribution as a function of depth for each test pit. Additional samples of each waste phase and any fluids encountered in each test pit may also be collected.

In some cases, samples of soil may be extracted from the test pit for reasons other than waste sampling and chemical analysis, for instance, to obtain geotechnical information. Such information includes soil types, stratigraphy, strength, etc., and could therefore entail the collection of disturbed (grab or bulk) or relatively undisturbed (hand-carved or pushed/driven) samples that can be tested for geotechnical properties. The purposes of such explorations are very similar to those of shallow exploratory or test borings, but often test pits offer a faster, more cost-effective method of sampling than installing borings.

6.8.3.2 Sampling Equipment

The following equipment is needed for obtaining samples for chemical or geotechnical analysis from test pits and trenches:

- Backhoe or other excavating machinery.
- Shovels, picks, hand augers, and stainless steel trowels/disposable trowels.
- Sample container - bucket with locking lid for large samples; appropriate bottle ware for chemical or geotechnical analysis samples.

- Polyethylene bags for enclosing sample containers; buckets.

- Remote sampler consisting of 10-foot sections of steel conduit (1-inch-diameter), hose clamps, and right angle adapter for conduit (see Attachment D).

6.8.3.3 Sampling Methods

The methods discussed in this section refer to test pit sampling from grade level. If test pit entry is required, see Section 6.8.3.4.

- Excavate the trench or pit in several 0.5- to 1.0-foot depth increments. Where soil types support the use of a sand bar cutting plate, use of this device is recommended to avoid potentially snagging utilities with the excavator teeth. It is recommended that soil probes or similar devices be employed where buried items or utilities may be encountered. This permits the trench floor to be probed prior to the next cut.
- After each increment:

  - The operator shall wait while the sampler inspects the test pit from grade level.

  - The sampler shall probe the next interval where this is considered necessary. Practical depth increments for lithological evaluations may range from 2 to 4 feet or where lithological changes are noted.

- The backhoe operator, who will have the best view of the test pit, shall immediately cease digging if:

  - Any fluid phase, including groundwater seepage, is encountered in the test pit.

  - Any drums, other potential waste containers, obstructions, or utility lines are encountered.

  - Distinct changes of material being excavated are encountered.

This action is necessary to permit proper sampling of the test pit and to prevent a breach of safety protocol. Depending on the conditions encountered, it may be required to excavate more slowly and carefully with the backhoe.

For obtaining test pit samples from grade level, the following procedure shall be followed:

- Use the backhoe to remove loose material from the excavation walls and floor to the greatest extent possible.

- Secure the walls of the pit, if necessary. (There is seldom any need to enter a pit or trench that would justify the expense of shoring the walls. All observations and samples should be taken from the ground surface.)

- Samples of the test pit material are to be obtained either directly from the backhoe bucket or from the material after it has been deposited on the ground, as follows:

  a. The sampler or FOL shall direct the backhoe operator to remove material from the selected depth or location within the test pit/trench.

  b. The backhoe operator shall bring the bucket over to a designated location on the sidewall a sufficient distance from the pit (at least 5 feet) to allow the sampler to work around the bucket.

c. After the bucket has been set on the ground, the backhoe operator shall either disengage the controls or shut the machine down.

d. When signaled by the operator that it is safe to do, the sampler will approach the bucket.

e. The soil shall be monitored with a PID or FID as directed in the project-specific planning documents.

f. The sampler shall collect the sample from the center of the bucket or pile in accordance with surface soil sampling procedures of Section 6.3 or 6.4, as applicable. Collecting samples from the center of a pile or bucket eliminates cross-contamination from the bucket or other depth intervals.

- If a composite sample is desired, several depths or locations within the pit/trench will be selected, and the bucket will be filled from each area. It is preferable to send individual sample bottles filled from each bucket to the laboratory for compositing under the more controlled laboratory conditions. However, if compositing in the field is required, each sample container shall be filled from materials that have been transferred into a mixing bucket or re-sealable plastic bag and homogenized. Note that homogenization/compositing is not applicable for samples to be subjected to volatile organic analysis.

CAUTION

Care must be exercised when using the remote sampler described in the next step because of potential instability of trench walls. In situations where someone must move closer than 2 feet to the excavation edge, a board or platform should be used to displace the sampler's weight to minimize the chance of collapse of the excavation edge. Fall protection should also be employed when working near the edges or trenches greater than 6 feet deep. An immediate means to extract people who have fallen into the trench will be immediately available. These means may include ladders or rope anchor points.

- Using the remote sampler shown in Attachment D, samples can be taken at the desired depth from the sidewall or bottom of the pit as follows:

a. Scrape the face of the pit/trench using a long-handled shovel or hoe to remove the smeared zone that has contacted the backhoe bucket.

b. Collect the sample directly into the sample jar, by scraping with the jar edge, eliminating the need for sample handling equipment and minimizing the likelihood of cross-contamination.

c. Cap the sample jar, remove it from the remote sampler assembly, and package the sample for shipment in accordance with SOP SA-6.3.

- Complete documentation as described in SOP SA-6.3 and Attachment C of this SOP.

6.8.3.4 In-Pit Sampling

Under rare conditions, personnel may be required to enter the test pit/trench. This is necessary only when soil conditions preclude obtaining suitable samples from the backhoe bucket (e.g., excessive mixing of soil or wastes within the test pit/trench) or when samples from relatively small discrete zones within the test pit are required. This approach may also be necessary to sample any seepage occurring at discrete levels or zones in the test pit that are not accessible with remote samplers.

In general, personnel shall sample and log pits and trenches from the ground surface, except as provided for by the following criteria:

- There are no practical alternative means of obtaining such data.

- The **SSO and Competent Person** determine that such action can be accomplished without breaching site safety protocol. This determination will be based on actual monitoring of the pit/trench after it is dug (including, at a minimum, measurements of oxygen concentration, flammable gases, and toxic compounds, in that order). Action levels will be provided in project-specific planning documents.

- A company-designated Competent Person determines that the pit/trench is stable through soil classification evaluation/inspections or is made stable (by cutting/grading the sidewalls or using shoring) prior to entrance of any personnel. OSHA requirements shall be strictly observed.

If these conditions are satisfied, only one person may enter the pit/trench. On potentially hazardous waste sites, this individual shall be dressed in selected PPE as required by the conditions in the pit. He/she shall be affixed to a harness and lifeline and continuously monitored while in the pit.

A second and possible third individual shall be fully dressed in protective clothing including a self-contained breathing device and on standby during all pit entry operations to support self-rescue or assisted self-rescue. The individual entering the pit shall remain therein for as brief a period as practical, commensurate with performance of his/her work. After removing the smeared zone, samples shall be obtained with a decontaminated trowel or spoon.

6.8.3.5 Geotechnical Sampling

In addition to the equipment described in Section 6.8.3.2, the following equipment is needed for geotechnical sampling:

- Soil sampling equipment, similar to that used in shallow drilled boring (i.e., thin-walled tube samplers), that can be pushed or driven into the floor of the test pit.

- Suitable driving (e.g., sledge hammer) or pushing (e.g., backhoe bucket) equipment used to advance the sampler into the soil.

- Knives, spatulas, and other suitable devices for trimming hand-carved samples.

- Suitable containers (bags, jars, tubes, boxes, etc.), labels, wax, etc. for holding and safely transporting collected soil samples.

- Geotechnical equipment (pocket penetrometer, torvane, etc.) for field testing collected soil samples for classification and strength properties.

Disturbed grab or bulk geotechnical soil samples may be collected for most soil in the same manner as comparable soil samples for chemical analysis. These collected samples may be stored in jars or plastic-lined sacks (larger samples), which will preserve their moisture content. Smaller samples of this type are usually tested for their index properties to aid in soil identification and classification: larger bulk samples are usually required to perform compaction tests.

Relatively undisturbed samples are usually extracted in cohesive soil using thin-walled tube samplers, and such samples are then tested in a geotechnical laboratory for their strength, permeability, and/or compressibility. The techniques for extracting and preserving such samples are similar to those used in performing Shelby tube sampling in borings, except that the sampler is advanced by hand or backhoe, rather than by a drill rig. Also, the sampler may be extracted from the test pit by excavation around the tube when it is difficult to pull it out of the ground. If this excavation requires entry of the test pit, the requirements described in Section 6.8.3.4 shall be followed. The thin-walled tube sampler shall be pushed or driven vertically into the floor or steps excavated in the test pit at the desired sampling elevations. Extracting tube samples horizontally from the walls of the test pit is not appropriate because the sample will not have the correct orientation.

A sledge hammer or backhoe may be used to drive or push the tube into the ground. Place a piece of wood over the top of the sampler or sampling tube to prevent damage during driving/pushing of the sample. Pushing the sampler with a constant thrust is always preferable to driving it with repeated blows, thus minimizing disturbance to the sample. When using a sledge hammer, it is recommended that the sampler be stabilized using a rope/strap wrench or pipe wrench to replace the person's hands holding the sampler from the strike zone. If the sample cannot be extracted by rotating it at least two revolutions (to shear off the sample at the bottom), hook the sampler to the excavator or backhoe and extract. This means an alternative head will be used as a connection point or that multiple choke hitches will be applied to extract the sampler. If this fails and the excavator can dig deeper without potentially impacting subsurface utilities, excavate the sampler. If this fails or if the excavator cannot be used due to subsurface utilities, hand-excavate to remove the soil from around the sides of the sampler. If hand-excavation requires entry into the test pit, the requirements in Section 6.8.3.4 must be followed. Prepare the sample as described in Steps 9 through 13 in Section 6.2.3, and label, pack and transport the sample in the required manner, as described in SOPs SA-6.3 and SA-6.1.

6.8.4 Backfilling of Trenches and Test Pits

All test pits and excavations must be either backfilled, covered, or otherwise protected at the end of each day. No excavations shall remain open during non-working hours unless adequately covered or otherwise protected.

Before backfilling, the onsite crew may photograph, if required by the project-specific work plan, all significant features exposed by the test pit and trench and shall include in the photograph a scale to show dimensions. Photographs of test pits shall be marked to include site number, test pit number, depth, description of feature, and date of photograph. In addition, a geologic description of each photograph shall be entered in the site logbook. All photographs shall be indexed and maintained as part of the project file for future reference.

After inspection, backfill material shall be returned to the pit under the direction of the FOL. Backfill should be returned to the trench or test pit in 6-inch to 1-foot lifts and compacted with the bucket. Remote controlled tampers or rollers may be lowered into the trench and operated from top side. This procedure will continue to the grade surface. It is recommended that the trench be tracked or rolled in. During excavation, clean soil from the top 2 feet may have been separated to be used to cover the last segments. Where these materials are not clean, it is recommended that clean fill be used for the top cover.

If a low-permeability layer is penetrated (resulting in groundwater flow from an upper contaminated flow zone into a lower uncontaminated flow zone), backfill material must represent original conditions or be impermeable. Backfill could consist of a soil-bentonite mix prepared in a proportion specified by the FOL (representing a permeability equal to or less than original conditions). Backfill can be covered by "clean" soil and graded to the original land contour. Revegetation of the disturbed area may also be required.

6.9 RECORDS

The appropriate sample log sheet (see Attachment A of this SOP) must be completed by the site geologist/sampler for all samples collected. All soil sampling locations should be documented by tying in the location of two or more nearby permanent landmarks (building, telephone pole, fence, etc.) or obtaining global positioning system (GPS) coordinates; and shall be noted on the appropriate sample log sheet, site map, or field notebook. Surveying may also be necessary, depending on the project requirements.

Test pit logs (see Attachment C of this SOP) shall contain a sketch of pit conditions. If the project-specific work plan requires photographs, at least one photograph with a scale for comparison shall be taken of each pit. Included in the photograph shall be a card showing the test pit number. Boreholes, test pits, and trenches shall be logged by the field geologist in accordance with SOP GH-1.5.
Other data to be recorded in the field logbook include the following:

- Name and location of job
- Date of boring and excavation
- Approximate surface elevation
- Total depth of boring and excavation
- Dimensions of pit
- Method of sample acquisition
- Type and size of samples
- Soil and rock descriptions
- Photographs, if required
- Groundwater levels
- PID/FID/LEL/O2 meter readings
- Other pertinent information, such as waste material encountered

In addition, site-specific documentation to be maintained by the SSO and/or Competent Person will be required including:

- Calibration logs
- Excavation inspection checklists
- Soil type classification

7.0 REFERENCES

American Society for Testing and Materials, 1987. ASTM Standards D1587-83 and D1586-84. ASTM Annual Book of Standards. ASTM. Philadelphia, Pennsylvania. Volume 4.08.

USEPA, 1987. Compendium of Superfund Field Operations Methods, Volume 1. Aug

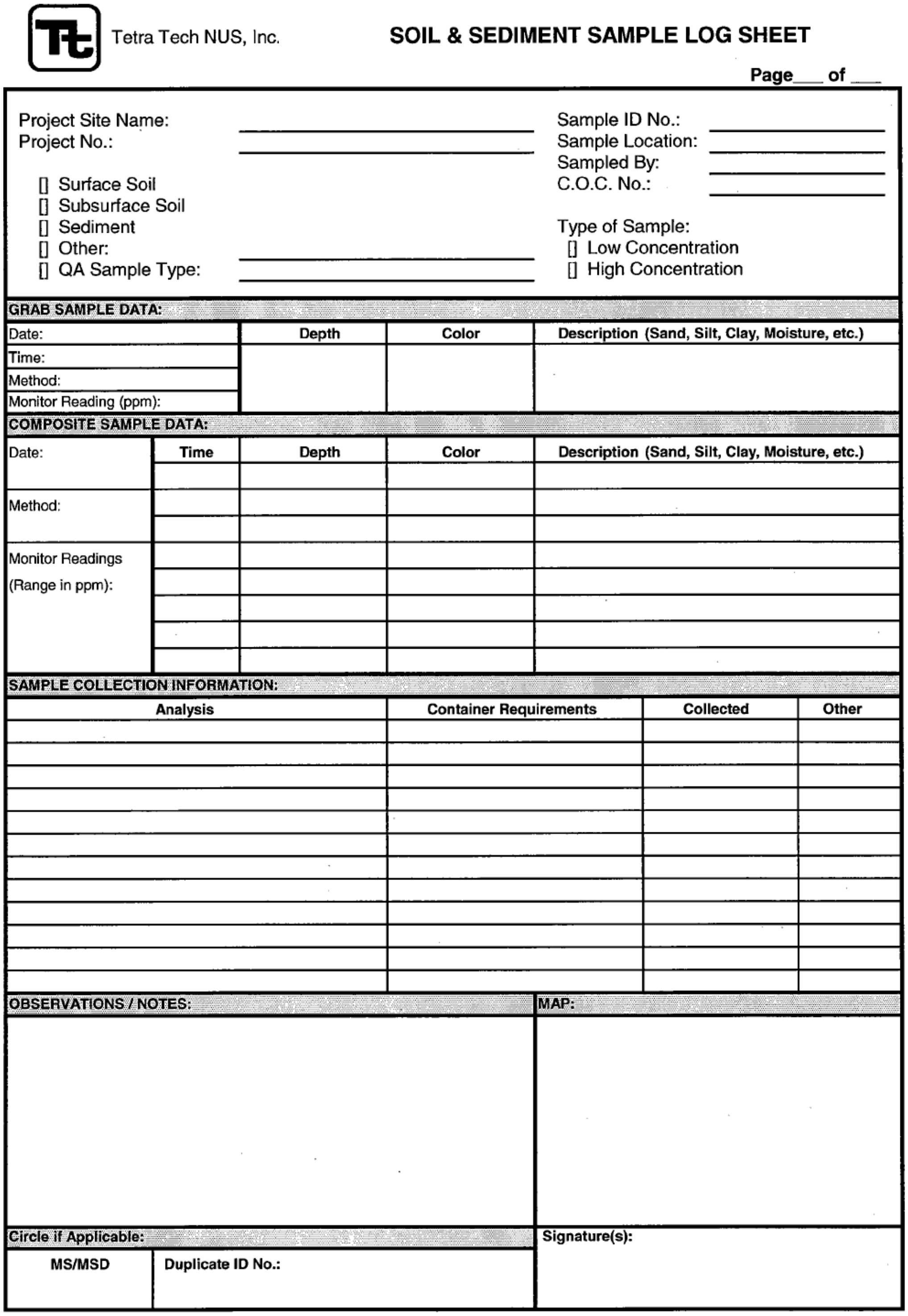
OSHA, Excavation, Trenching and Shoring 29 CFR 1926.650-653.

OSHA, Confined Space Entry 29 CFR 1910.146.

U.S. EPA, 1992. Specifications and Guidance for Contaminant-Free Sample Containers. EPA-540/R-93/051.

USEPA, Region 4, 2020. Field Branches Quality System and Technical Procedures.

ATTACHMENT A
SOIL & SEDIMENT SAMPLE LOG SHEET (EXAMPLE)



Tetra Tech NUS, Inc.

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________
Project No.: ____________

☐ Surface Soil
☐ Subsurface Soil
☐ Sediment
☐ Other: ____________
☐ QA Sample Type: ____________

Sample ID No.: ____________
Sample Location: ____________
Sampled By: ____________
C.O.C. No.: ____________

Type of Sample:
☐ Low Concentration
☐ High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date:			
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

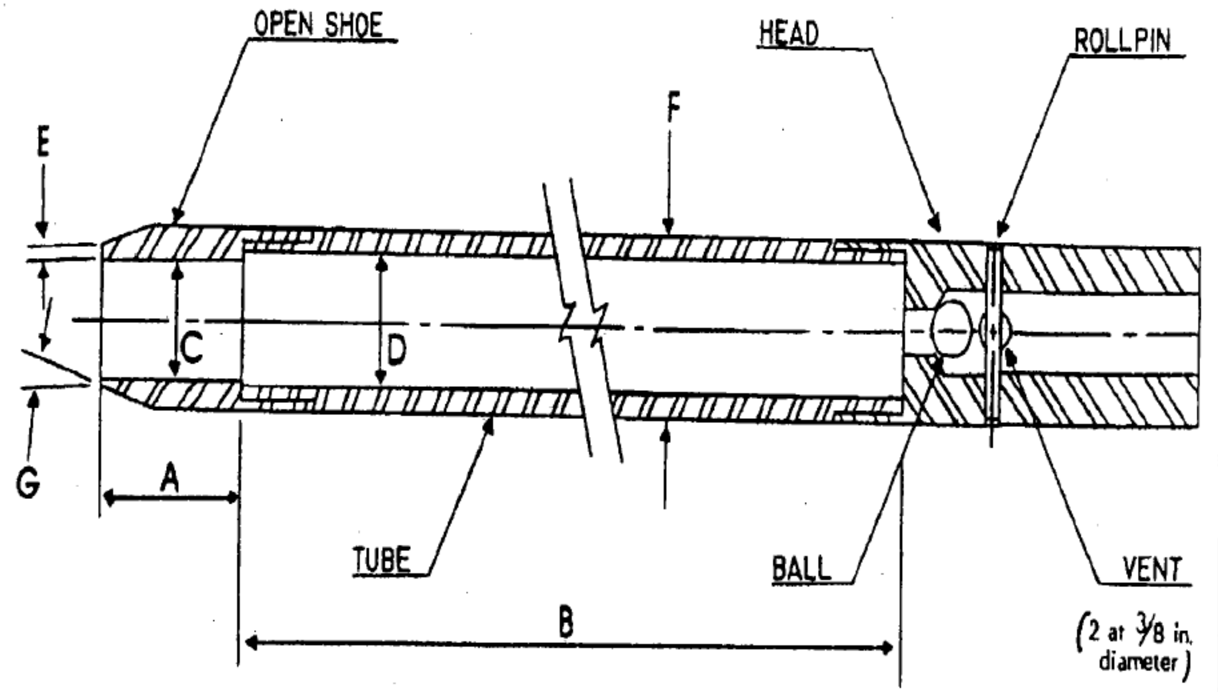
MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

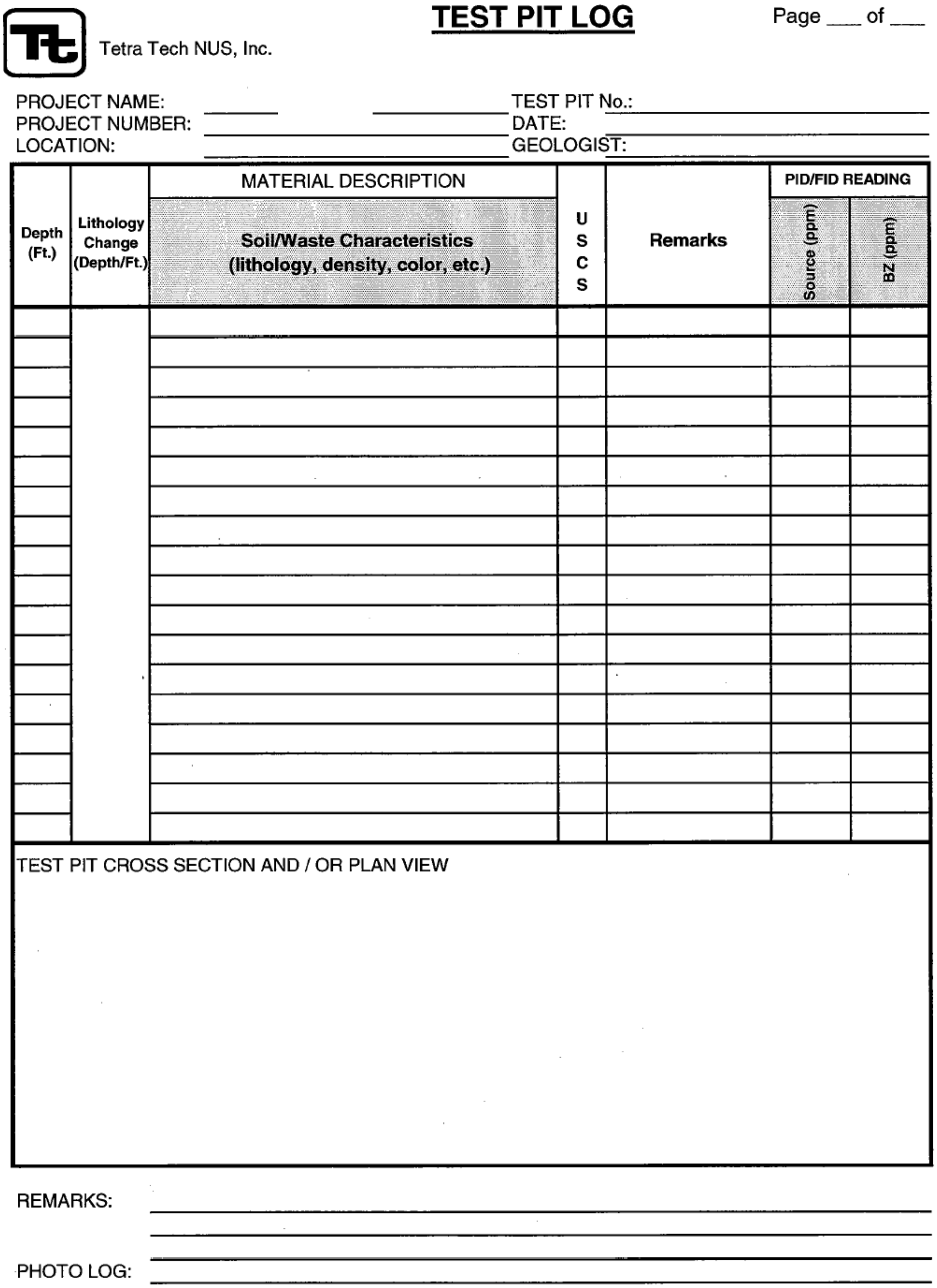
ATTACHMENT B
SPLIT-SPOON SAMPLER (EXAMPLE)



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°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

ATTACHMENT C
TEST PIT LOG (EXAMPLE)



Tetra Tech NUS, Inc.

TEST PIT LOG

Page ___ of ___

PROJECT NAME: ______ ______ TEST PIT No.: ______
PROJECT NUMBER: ______ DATE: ______
LOCATION: ______ GEOLOGIST: ______

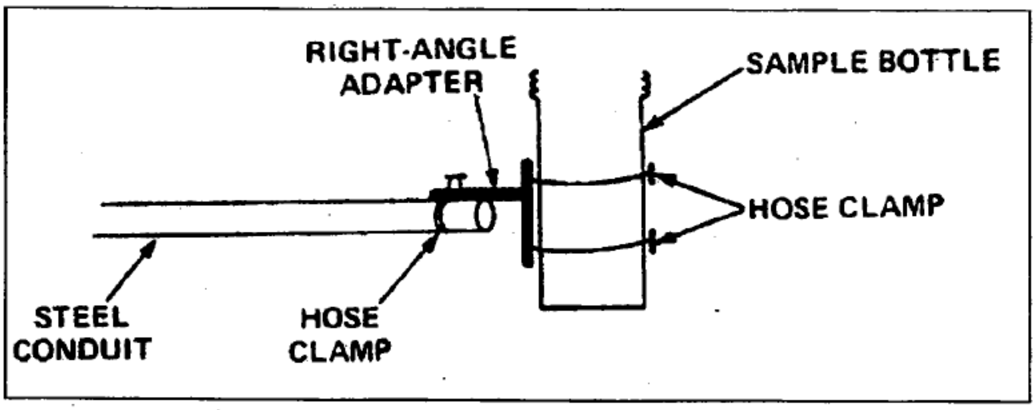
Depth (Ft.)	Lithology Change (Depth/Ft.)	MATERIAL DESCRIPTION	USCS	Remarks	PID/FID READING	
		Soil/Waste Characteristics (lithology, density, color, etc.)			Source (ppm)	BZ (ppm)

TEST PIT CROSS SECTION AND / OR PLAN VIEW

REMARKS: ______
______

PHOTO LOG: ______
______

ATTACHMENT D
REMOTE SAMPLE HOLDER FOR TEST PIT/TRENCH SAMPLING (EXAMPLE)



TETRA TECH

STANDARD OPERATING PROCEDURE

Number	SA-1.8
Page	1 of 15
Effective Date	10/12/2020
Revision	6
Applicability	EGS Operating Unit
Prepared	Earth Sciences Department
Subject	SAMPLE ACQUISITION FOR PERFLUOROALKYL AND POLYFLUOROALKYL SUBSTANCES (PFAS) ANALYSIS
Approved	T. Johnston T.E. Johnston 10/12/2020

TABLE OF CONTENTS

1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the methods and protocols to be used for collecting and handling samples to be analyzed for per- and polyfluoroalkyl substances (PFAS). PFAS are present in many consumer products including some typical sampling equipment and are widely present in the environment.

Low screening criteria and high cross-contamination potential require special precautions to be implemented to avoid compromising sample integrity. Instructions are provided herein for collection of environmental samples without contaminating them. This SOP is designed to supplement but not replace existing sampling SOPs SA-1.1, SA-1.2, SA-1.3, SA-1.7, and SA-5.1. In addition, some clients and/or projects may have specific PFAS-related sampling requirements that extend beyond the procedures described in this SOP. Such additional requirements typically are documented in work plans or similar documents.

2.0 SCOPE AND APPLICABILITY

This document provides information on selection of proper sampling equipment and techniques for groundwater, surface water, sediment, soil, and water supply sampling for PFAS analysis. Sampling of air or biota is not addressed in this SOP, but similar principles would apply for those media.

3.0 BACKGROUND

PFAS have been used since the 1940s as manufacturer-applied oil and water repellants on products such as clothing, upholstery, paper, and carpets and in making fluoropolymers for non-stick cookware. They are found in textiles and leather products, mist suppressants for metal plating, materials used in the photography industry, photolithography, semi-conductors, paper and packaging, coatings, cleaning products, pesticides, and cosmetics. They have been used in well-known consumer products including Teflon, StainMaster, Scotchgard, and GoreTex. In the 1960s, aqueous film-forming foam (AFFF) containing PFASs was developed for fighting flammable liquid fires, particularly petroleum-fueled (Class B) fires (ATSDR, 2009). The two most researched and most prevalent PFAS in the environment are perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) (ATSDR, 2009).

Military uses of PFAS have been primarily related to fire fighting and electroplating. AFFF meeting MIL-F-24385 specifications was developed by various manufacturers for use in extinguishing fires at military bases, airports, commercial facilities, and fire-fighting training facilities throughout the United States. Beginning in the late 1960s the United States Department of Defense (DoD) used large quantities of AFFF for shipboard and shore facility fire-suppression systems, on fire-fighting vehicles, and at fire-training facilities. AFFF concentrate that contains PFAS may still be in use at DoD facilities, and large quantities of AFFF may have been released to the environment at some facilities.

PFAS are persistent in the environment, tend to bioaccumulate, and demonstrate toxicity in laboratory animals, enough to raise concerns about their presence in the environment. Some areas where PFAS may have been released to the environment include the following:

- Fire-fighting training areas
- Areas where fire-fighting products/materials are stored (e.g., fire stations)
- Aircraft crash sites
- Refineries
- DoD sites/military bases

- Landfills (leaching from consumer products)
- Biosolids land applications
- Rail yards
- Textile/carpet manufacturing sites
- Septic systems
- Metal coating and plating facilities
- Water treatment systems and receiving water bodies
- Airport hangars and other facilities storing fire-fighting foams
- Chemical facilities, especially fluorochemical manufacturing, use, and disposal facilities

PFAS are ubiquitous in consumer products and are present in or on some materials used in environmental sampling (e.g., Teflon tubing, waterproof logbooks, and GoreTex field clothing). Laboratory detection limits are low for PFAS, and contact of sample material or sampling equipment with any one of the multitude of PFAS sources could result in detectable contamination. In addition, PFAS tend to adsorb to glass and some plastics, so certain glass or plastic sample collection containers are inappropriate for use in PFAS sample collection. Adsorption to sample containers or other materials (e.g., tubes or hoses) may result in a low bias for measured PFAS concentrations.

Collection and analysis of quality control blanks is an important aspect of verifying that samples have not been contaminated during sample collection and handling. Use of additional blanks or blanks of a different type than usual may be required, and the governing project planning documents should be consulted. Consult Section 7.7 of this SOP for instructions regarding collection of field reagent blanks (FRBs).

4.0 DEFINITIONS

AFFF – Aqueous film-forming foam.

Chemical of Emerging Concern – A chemical of emerging concern (previously called "emerging contaminant" and also called "contaminant of emerging concern" or "CEC") is a chemical or material that is characterized by a perceived, potential, or real threat to human health or the environment or by a lack of published health standards (U.S. EPA, 2014; U.S. Geological Service [USGS], 2019). A contaminant may also be of "emerging concern" because a new source or a new pathway for human exposure has been discovered or a new detection method or treatment technology has been developed (DoD, 2011).

FRB – Field Reagent Blank. A blank sample prepared in the field by transferring laboratory-supplied, chemically preserved, "PFAS-free" deionized water to an empty, laboratory-supplied, collection bottle. FRBs are typically analyzed only for PFAS and are treated as site samples in all respects, including shipment to the sampling site, exposure to sampling site conditions, storage, preservation, and all PFAS analytical procedures. The purpose of FRBs is to indicate whether PFAS measured in corresponding site samples may have been introduced during sample preservation, collection, and handling. Note that the term "FRB" may be inappropriate when sampling groundwater sources not used for drinking water. In those cases Field Blank (FB) may be more appropriate. Consult project-specific planning documents for direction.

PFAS – Per- and Polyfluoroalkyl Substances. A reference term currently in use, replacing "PFCs" in recent scientific and other technical literature. The term is inclusive of both perfluorinated chemicals like PFOA and PFOS and polyfluoroalkyl substances like fluorinated telomers. In all environmental matrices, these chemicals are CECs.

PFCs – Perfluorinated Compounds or Chemicals. PFCs are a family of man-made chemicals that have been used for commercial, industrial, and military applications because they resist thermal degradation and repel oil, stains, grease, and water.

PFOA – Perfluorooctanoic Acid. PFOA is used as an aqueous dispersion agent (surfactant) and in the manufacture of fluoropolymers (including Teflon) used in industrial components such as electrical wire casings, fire- and chemical-resistant tubing, and plumbing seal tape. PFOA is used in surface treatment products (e.g., paints) to impart oil, stain, grease, and water resistance. PFOA can also be produced by the breakdown of some fluorinated telomers.

PFOS – Perfluorooctane Sulfonic Acid. PFOS was a key ingredient in Scotchgard and used in the manufacture of Class B AFFF used per DoD military specifications. Phase out of AFFF by 3M occurred in 2002.

5.0 SAFETY PRECAUTIONS

Sample acquisition activities shall be conducted in accordance health and safety requirements identified in the project-specific Health and Safety Plan (HASP), Accident Prevention Plan (APP), and corporate health and safety policies. Alteration may be necessary to allow sample collection without cross contamination as dictated by site-specific conditions.

Caution

The use of personal protective equipment (PPE) containing PFAS (e.g., some insect repellants, sunscreens, traffic safety vests, etc.) should be avoided if possible or, if deemed necessary to control hazards, should be carefully considered as they can pose a potential cross-contamination risk for samples. Extra care (e.g., changing outer gloves) must be exercised to ensure that PFAS is not transferred directly or indirectly from PPE to samples or sample containers.

The Tetra Tech Project Manager (PM), in coordination with the Tetra Tech EGS Operating Unit Health and Safety Group, shall ensure that the development of project-specific plans balances the need to control exposure to safety hazards as well as address PFAS contamination risks.

6.0 PERSONNEL RESPONSIBILITIES, QUALIFICATIONS, AND TRAINING

Personnel implementing this SOP must read and understand this entire SOP prior to collection of samples designated for PFAS analysis.

Project Manager (PM) – The PM along with the management team are responsible for determining sampling objectives, initial sampling locations, and field procedures used in the collection of samples of environmental media. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the PM is responsible for selecting and detailing the specific sampling techniques and equipment to be used and for providing detailed input in this regard to the project planning documents. The PM has the overall responsibility for ensuring that sampling activities are properly conducted by appropriately trained staff.

Site Safety and Health Officer (SSHO) – The SSHO (or a qualified designee) is responsible for providing the technical support necessary to implement the project HASP, APP, or equivalent. The SSHO or SSHO designee may also be required to advise the Field Operations Leader (FOL) on safety-related matters regarding sampling, such as measures to mitigate potential hazards, hazardous objects, or conditions.

Field Operations Leader (FOL) – This individual is primarily responsible for faithful execution of the planning document that governs sampling. This is accomplished through management of a field sampling team for the proper acquisition of samples. The FOL is responsible for the supervision of onsite activities; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to sample collection protocols. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field support personnel) where credentials and time permit. The FOL is ultimately responsible for ensuring compliance with Occupational Safety and Health Administration (OSHA) regulations during these operations in accordance with the project Health and Safety Plan. The FOL person shall have significant hands-on experience with sample collection, handling, and documentation under the circumstances required for the current project.

Field Support Personnel – These individuals are responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, these personnel are responsible for completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of the samples.

General field personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- OSHA 40-hour; applicable refresher training; and, if applicable, supervisory training (HAZWOPER operations only).

- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

- Familiarity with sampling procedures, sample handling, sample documentation, and sample packaging and shipping as documented in project specific planning documents and this SOP.

7.0 PROCEDURE

The following sampling procedure establishes requirements for collection of samples designated for PFAS analysis while minimizing potential cross contamination of the samples and other materials or loss of PFAS.

7.1 Selection of Equipment

It is important to research available equipment and materials at the project planning stage to avoid last-minute problems in the field, for example, ensuring compatibility of high-density polyethylene (HDPE) tubing with fittings for use in a pump, or ensuring that equipment (e.g., a bladder pump) does not contain Teflon.

7.1.1 Sampling Equipment:

NOTE: PFAS cross-contamination of groundwater samples can be minimized through decontamination or conditioning of equipment left in a well. Use of dedicated equipment also is helpful so that handling during decontamination is unnecessary. Pre-labeling sample bottles before sample collection minimizes the number of glove changes required to prevent contamination of samples by PFAS that may be on the labels.

- Decontamination – All reusable equipment used in sample acquisition should be adequately decontaminated prior to use. Consult Safety Data Sheets (SDSs) to verify that soaps or detergents used in decontamination do not contain fluorosurfactants. Be aware that low levels of contaminants such as PFAS may be present in a product but not listed on the SDS.

- Unless project requirements indicate otherwise, use sampling equipment made of stainless steel, acetate, silicone, or HDPE. This applies to tubing, pumps and pump components, tape for plumbing fittings, trowels, mixing bowls, or other equipment that could contact the sample media. Gasket and O-ring components of sampling equipment may also contain fluoropolymers.

NOTE: PFAS on purchased or rented items is likely to occur predominantly in newly manufactured or rented items treated with chemicals containing PFAS. Therefore, all rental equipment that will make direct contact with the material being sampled must be thoroughly decontaminated prior to use, especially if the equipment items are new. Be cognizant of the potential for continued leaching of PFAS or other chemicals — even after decontamination.

- During sample handling, mobilization, and demobilization, avoid using sampling equipment that includes or contains polyvinylidene fluoride (PVDF) or contains “fluor” in the name such as:
    - Polytetrafluoroethylene (PTFE)
    - Teflon (DuPont brand name for PTFE)
    - Fluorinated ethylene propylene (FEP)
    - Ethylene tetrafluoroethylene (ETFE).

- Use products that are not made of low-density polyethylene products (LDPE) if contamination from those products can be transferred to environmental samples or QC samples.

- For collecting drinking water samples to be analyzed for PFAS, use polypropylene sample bottles with a polypropylene screw cap; for all other samples, use HDPE containers with unlined plastic screw caps.

7.1.2 Non-Sampling Field Equipment:

- Non-waterproof loose-leaf paper or notebooks are acceptable. Avoid using waterproof field books or paper during sampling activities. Do not use plastic clipboards, binders, or spiral hard-cover notebooks that may be coated; use Masonite or aluminum clipboards instead.

- Use ballpoint pens or pencils for note taking and sample bottle labeling.

- Avoid using:
    - Post-it notes or similar removable notes.
    - Sharpies or similar indelible markers.
    - Aluminum foil.

7.1.3 Field Personnel Clothing and Protective Gear:

- Wear clothing that has been washed at least six times without fabric softener to remove possible stain-resistant coatings. Clothing made of natural fibers such as cotton is preferred to other fabrics. Protective clothing must be washed in accordance with manufacturer recommendations to ensure that the protective properties necessary to control safety hazards (e.g., fire-retardant clothing) are not compromised.

- Wear non-powdered nitrile gloves at all times while collecting and handling samples, and change gloves often. Anecdotal evidence indicates that changing gloves is one of the most effective methods of reducing or eliminating sample contamination potential; therefore, change to a new pair of gloves prior to collecting each sample.

- As necessary, use sunscreens and insect repellants that are made with 100-percent natural ingredients and that the Air Force Civil Engineer Center has identified as acceptable for use. ***These products must be used in accordance with manufacturer recommendations and in combination with***

controls in the project-specific HASP, APP, and corporate health and safety policies. Multiple re-applications of these products per work shift may be required to ensure their effectiveness.

- Sunscreens: Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss My Face, baby sunscreens that are “free” or “natural.”

- Sunscreen and insect repellant: Avon Skin So Soft Bug Guard Plus – SPF 30 Lotion

- Insect Repellent: Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect Repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics.

NOTE: The suitability of these items has not been independently verified. Products containing N-diethyl-meta-toluamide **(**DEET), picaridin, and IR3535 and some oil of lemon eucalyptus (OLE) and para-menthane-diol products are known to provide longer-lasting protection than others. One of the products recommended by the Air Force Civil Engineer Center and listed above, Repel Lemon Eucalyptus Insect Repellant, contains OLE and is most likely to be effective.

An independent study (Bartlett and Davis, 2018) of three insect repellents (Sawyer do-it-yourself permethrin treatment for clothing, Off! Deep Woods spray for clothing/skin, and Insect Shield pretreated clothing) determined that these products were free of PFAS compounds (17 PFAS compounds were tested), thus they may be suitable for use on a project-specific basis.

- During wet weather, use rain gear made from polyurethane or wax-coated materials.

- Avoid unnecessary contact with upholstery in vehicles because many such fabrics may be treated with stain-resistant materials that could contain PFAS. Typically, rental vehicles are newer and more likely to pose a contamination risk to samples. Well-washed towels or rags may be placed on the seats to prevent contact with car seats and other materials that could transfer PFAS to clothing worn by samplers. If practical, cover clothing and skin that has been in contact with such upholstery with non-fluorinated clothing.

- Avoid wearing:

    - Water-resistant (e.g., Gore-Tex or similar material) clothing or footwear (e.g., boots) immediately prior to or during sample collection and management.

    - Coated Tyvek or similar coated PPE suits.

    - Cosmetics, shampoos, hair conditioners, moisturizers, hand cream, or other similar personal care products on the day of sampling.

7.1.4 Sample Containers and Shipping Materials:

- Collect samples in clean, laboratory-supplied, plastic bottles only, typically polypropylene for drinking water or HDPE for other matrices.

- Confirm that Teflon-lined caps are not used in sample containers; unlined polypropylene screw caps must be used. It is best to segregate sample containers with Teflon components (e.g., Teflon-lined septa) from PFAS sample containers.

- Use of commercially available plastic bags (e.g., 3-mil-thick trash can liners) for lining coolers to prevent leakage and to separate potential melt water from chain-of-custody forms is allowed.

- Avoid the use of glass or LDPE sample containers, which are believed to result in loss of PFAS through adsorption to the container inner walls.

- Avoid using Blue Ice or similar items to cool samples and avoid placing such items in sample coolers for shipping. Use commercially available (e.g., from convenience stores or supermarkets) double-bagged ice instead.

Caution

Samples designated for PFAS analysis must be cooled to achieve a storage temperature of less than 6 °C. Cooling to this temperature may take several hours, and sample temperatures may not achieve 6 °C by the time they arrive at the laboratory. If sample temperatures upon arrival at the laboratory are not less than 10 °C, the laboratory may conclude that the sample integrity is compromised and may reject the samples. Therefore, place samples on ice as soon after collection as possible. On warm days, or when a representative from a nearby laboratory picks up the samples, take extra care (e.g., use more ice or delay shipment, if necessary) to ensure that sample temperatures will not exceed 10 °C when the samples arrive at the laboratory.

7.2 Other Precautions for Sample Handling

- Wash hands thoroughly before sampling and after handling fast food, carryout food, snacks, food wrappers, or other items that may contain PFAS. Do not carry pre-packaged food items such as candy bars or microwave popcorn into sampling areas.

- Assume that shipping tape used for securing coolers could contain PFAS; therefore, take care not to transfer PFAS from tape to samples.

- Minimize exposure of samples to light. This can be done by placing the collected samples into a cooler (with ice) and closing the cooler lid.

- If in doubt about a particular product or item that comes into contact with environmental media to be sampled or is near to sampling operations, consider collecting and analyzing a rinsate blank using laboratory-supplied PFAS-free water to test the item for contamination potential. Consult the Tetra Tech PM in these cases to verify whether collection of additional blanks is warranted.

- Support personnel that are within 3 meters of the sample processing area are considered subject to the same restrictions related to precautionary measures for clothing and food as applied to sampling personnel.

These precautions must be observed during sampling activities, especially during water sample collection (groundwater, water supply, and surface water), given the high solubilities of PFAS in water. Examples of how these precautions may be applied to sampling of specific media are provided in the following sections.

7.3 Groundwater Sample Acquisition

The precautions and requirements identified in Sections 7.1 and 7.2 must be observed for groundwater sampling. Do not proceed any further without reviewing each of those precautions and requirements.

- Collect groundwater samples for PFAS analyses in accordance with this SOP, SOP SA-1.1, and/or project- or client-specific requirements.

- If non-dedicated non-disposable equipment is used between sampling locations, it should be decontaminated with Alconox or Liquinox, unless 1,4-dioxane (a potential component of Liquinox) is also a contaminant of concern. In that case, Liquinox should not be used. Products such as Decon 90, which contains fluorosurfactants, shall not be used. Alconox or Liquinox rinses should be followed by a potable water rinse then deionized water rinse. The final decontamination rinse for DoD projects must be with water certified by the laboratory to be PFAS-free.

- If sampling for multiple analytes using PFAS-appropriate equipment, collect samples for PFAS analysis last to ensure adequate purging and conditioning of sampling equipment. If practical to do so, suitable PPE (especially gloves) may also be changed out for PFAS sampling. For example, purge and sample a monitoring well for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and metals using a peristaltic pump with HDPE and silicone tubing, then collect the sample for PFAS analysis. If either the proper sampling sequence or proper equipment is unclear, consult the FOL or Tetra Tech PM and record the actual sequence in the field notes.

- If sampling wells that have or had dedicated Teflon or FEP tubing that potentially contained PFAS, remove the dedicated tubing and, using silicone or HDPE tubing, remove at least one well volume from the target sampling interval prior to sampling. Accomplish this removal in a manner that is rigorous enough to remove the entire water column from the well and not just a limited vertical interval of the water column. This will minimize the potential for collecting a sample that was in contact with the Teflon/FEP tubing.

- The use of detergents must be avoided during decontamination of drilling or other heavy equipment. All equipment must be scrubbed with a plastic brush or steam cleaned with potable water, and rinsed thoroughly in potable water to clean away any debris or material on exposed surfaces.

- Sample(s) representing any water collected at the point of use (e.g., a water truck or tank on site) used by the driller for drilling purposes may require analysis for PFAS. Check the governing planning document for guidance and see Section 7.8 of this SOP for guidance on waste management.

- Collect drinking water samples to be analyzed for PFAS in clean polypropylene sample bottles with a polypropylene screw cap; for all other samples, use clean, laboratory-supplied, HDPE bottles with unlined plastic screw caps.

- Pre-label all sample bottles with the correct sample identifier prior to sampling and, for each bottle at the time of sampling:
  - Verify that the correct bottle is being used.
  - Fill the bottle to slightly below the shoulder of the bottle.
  - Tightly close the bottle with the appropriate cap.
  - Repeat this process for subsequent sample bottles.

7.4 Soil Sample Acquisition

The precautions and requirements identified in Sections 7.1 and 7.2 must be observed for soil sampling. Do not proceed any further without reviewing each of those precautions and requirements.

- Collect soil samples for PFAS analyses in accordance with this SOP, SOP SA-1.3, and/or project- or client-specific requirements. Review client–specific (e.g., DoD component) guidance or previously approved Sampling and Analysis Plans (SAPs).

- Soil sampling equipment should not be constructed of or contain Teflon or other materials likely to contain or be coated with PFAS. Acceptable materials for sampling include stainless steel, acetate plastic, and HDPE.

- If non-dedicated non-disposable equipment is used between sampling locations, it should be decontaminated with Alconox or Liquinox, unless 1,4-dioxane (a potential component of Liquinox) is also a contaminant of concern. In that case, Liquinox should not be used. Products such as Decon 90, which contains fluorosurfactants, shall not be used. Alconox or Liquinox rinses should be followed by a potable water rinse then deionized water rinse. The final decontamination rinse for DoD projects must be with water certified by the laboratory to be PFAS-free.

- Collect samples in laboratory-provided HDPE containers specifically designated for PFAS analysis. Do not use glass jars typically used for soil sample collection because some PFAS may irreversibly adsorb to the glass and could create a negative bias (i.e., artificially low concentrations) in the measured PFAS concentrations.

- Pre-label all sample containers with the correct sample identifier prior to sampling and, for each container at the time of sampling:
    - Verify that the correct container is being used.
    - Fill the container to the appropriate level.
    - Tightly close the container with the proper cap.
    - Repeat this process for subsequent sample containers.

7.5 Surface Water and Sediment Sample Acquisition

The precautions and requirements identified in Sections 7.1 and 7.2 must be observed for surface water and sediment sampling. Do not proceed any further without reviewing each of those precautions and requirements.

- Collect surface water and sediment samples for PFAS analysis in accordance with this SOP, SOP SA-1.2, and/or project- or client-specific requirements.

- Surface water and sediment sampling equipment should not be constructed of or contain Teflon or LDPE materials. Acceptable materials for sampling include HDPE, silicone, stainless steel, and acetate plastic. Do not use glass. The bottleware should be supplied clean by the laboratory and specifically designated for PFAS analysis. If transfer bottles are required for collection of surface water samples, the transfer bottles used should be of the same material as the containers designated for submission to the laboratory.

- For surface water sample collection, invert the capped sample bottle, with the opening pointing downward, at least 10 cm below the water surface, at least 10 cm above the bottom of the water body, and as close to the center of the channel or water body as practical. To collect the sample, uncap the bottle underneath the water surface and point the bottle upward so that gloved hands, sample container, and sampler are downstream of where the sample is being collected.

- For aquatic samples collected from the shoreline or via wading, ensure that waders are constructed of fabric that has not been treated with waterproofing coatings, and stand downstream of the sample bottle during sample collection.

- Pre-label all sample bottles with the correct sample identifier prior to sampling and, for each bottle at the time of sampling:

    - Verify that the correct container is being used.
    - Fill the container to the appropriate level.
    - Tightly close the container with the proper cap.
    - Repeat this process for subsequent sample containers.

- If non-dedicated non-disposable sampling equipment is used between sampling locations, it should be decontaminated with Alconox or Liquinox, unless 1,4-dioxane (a potential component of Liquinox) is also a contaminant of concern. In that case, Liquinox should not be used. Products such as Decon 90, which contains fluorosurfactants, shall not be used. Alconox or Liquinox rinses should be followed by a potable water rinse then deionized water rinse. The final decontamination rinse for DoD projects must be with water certified by the laboratory to be PFAS-free.

- Avoid reusing non-stainless-steel equipment (e.g., porewater observation devices consisting of slotted PVC pipe and silicone tubing) when collecting porewater samples.

7.6 Water Supply Sampling

This section applies to sampling from taps, spigots, faucets, or similar devices for PFAS analysis. The precautions and requirements identified in Sections 7.1 and 7.2 must be observed for water supply sampling. Do not proceed any further without reviewing each of those precautions and requirements.

Caution

Do not use filters when collecting samples because the filters may introduce PFAS contamination or absorb/adsorb PFAS and thus reduce PFAS concentrations in the samples.

- Collect water supply samples for PFAS analysis in accordance with applicable portions of SOP SA-1.7 and/or project- or client-specific requirements.

- Water supply sampling equipment (if needed) should not be constructed of or contain Teflon or LDPE materials. Acceptable materials for sampling include HDPE, polypropylene (drinking water sampling only), small amounts of silicone (e.g., short runs of silicone tubing used in peristaltic pumps), stainless steel, and acetate plastic. Non-drinking water supply samples should be collected in clean, laboratory-supplied, HDPE bottleware specifically designated for PFAS analysis (not glass). Collect drinking water samples in clean polypropylene bottles supplied by the laboratory.

- Ensure that sample bottles used to collect chlorinated water samples contain the proper Trizma preservative (5 g/L to remove chlorine). Non-chlorinated water does not require chemical preservatives designed to remove chlorine; however, some projects may require the use of Trizma regardless of whether the water is chlorinated.

- Locate the sampling point. If a specific sampling point has already been designated (e.g., a kitchen tap or well head), plan to collect the sample from that point. Otherwise, identify a location in the water supply line that is as close as possible to the water's point of origination (e.g., a well or other water source) and upstream of any local water treatment unit(s) that could affect PFAS levels (e.g., water softeners, activated carbon, or reverse osmosis treatment units). If a treatment unit is in use, a post-treatment sample may also be required in some cases, per project requirements.

  NOTE: If treatment that could affect PFAS levels (e.g., carbon filtration or reverse osmosis) is part of the water distribution system, often a spigot will be present in the plumbing line between the water source and the treatment unit, and this spigot should be used for sample collection. If no local treatment is applied to the water, a convenient sampling point for private water supplies is often the cold water tap located at the point of use. If a sample cannot be collected from the planned location, collect the sample from an alternate, but equally representative sampling point, document the deviation in the field notes, and alert the project manager.

- Remove any aerator/diffuser from the faucet, if possible. If removal is not possible, record this observation in the field notes.

- Allow the water to run freely from the tap until project-specific requirements are achieved. This will often require purging for 3 to 5 minutes or may require monitoring of water quality parameters (e.g., temperature) until they stabilize.

- Reduce the water flow rate to minimize aeration of the sample. The water stream should be no wider than the diameter of a pencil.

- Pre-label all sample bottles with the correct sample identifier prior to sampling and, for each bottle at the time of sampling:

    - Verify that the correct bottle is being used
    - Fill the sample bottle directly from the tap to a point slightly below the shoulder of the bottle.
    - Cap the bottle tightly with the proper cap.
    - Repeat this process for subsequent sample bottles.

- After collecting the sample, ensure the bottle is capped tightly and, if solid chemical preservative is included, agitate by hand until the preservative is dissolved.

7.7 Field Reagent Blank Collection

NOTE: If PFAS are detected in site samples, FRBs may be analyzed to assess whether PFAS in site samples could be non-site-related contamination and whether resampling is necessary. U.S. EPA Method 537.1, and modifications or derivatives thereof for PFAS analysis in drinking water typically require an FRB to be handled along with each sample set. A sample set is described as samples collected from the same sample site and at the same time, but "sample site" and "same time" may not be precisely defined. Therefore, it is important to verify that the correct number of FRBs will be collected. The intent is to be able to verify whether samples have been contaminated and to help identify the source of contamination. In general, collecting one FRB at each sampling point is recommended when sampling drinking water; fewer

FRBs are recommended when sampling non-drinking water matrices. The actual number will depend on project needs. *Collection of an FRB at every non-drinking water sampling point* ***may*** *be required.*

- Verify the number of FRBs to be collected for the project and where those samples must be collected. This should be described in the governing project planning documents such as work plans or SAPs. If it is not, consult the PM. FRBs are commonly collected in pairs of sample bottles, similar to corresponding site samples.

NOTE: Chemical preservative may not be included in FRBs that are used when sampling non-drinking water matrices. In these cases the FRBs are more appropriately called Field Blanks (FBs) but the water transfers described below will be similar.

NOTE: It is important that FRB collection emulate as closely as possible the conditions surrounding collection of site samples. For example, when collecting FRBs from taps or spigots, collect each FRB either immediately before or after the corresponding site sample collection **without interrupting the water flow** until both the site sample and FRB have been collected.

- At the sampling site, when ready to collect an FRB, open the bottle of chemically preserved FRB reagent water provided by the laboratory and a corresponding clean empty bottle, also provided by the laboratory.

- Pour the preserved FRB reagent water into the empty sample bottle, close the cap, and label this filled bottle as the FRB.

- Pack and ship the FRB along with site samples and required documentation (e.g., chain-of-custody form) to the laboratory.

NOTE: Although chain-of-custody forms will indicate that FRBs must be analyzed for PFAS, analysis of an FRB will be required only if site samples contain PFAS greater than a certain concentration. If an FRB is analyzed and any PFAS concentration in the FRB exceeds one-third of the laboratory minimum reporting limit (or equivalent), all samples collected with that FRB may be considered invalid and may require recollection and reanalysis. Consult the project planning documents governing sample collection for specifics as to whether resampling is necessary. Care in collection and handling of site samples and FRBs in a way that avoids contamination cannot be overemphasized.

NOTE: It will be necessary to associate individual FRBs with corresponding site samples; otherwise, decisions about which samples to recollect (if recollection is indicated) could be compromised. Associations between FRBs and corresponding site samples may be accomplished by marking chain-of-custody forms with the associations, but other methods also may be useful. Consult the governing planning document or the PM for guidance, if necessary.

7.8 Disposal of Investigation-Derived Waste Potentially Containing PFAS

PFAS are not hazardous wastes as defined in the Resource Conservation and Recovery Act and Comprehensive Environmental Response, Compensation, and Liability Act. It may be possible to dispose of PFAS-containing solid waste as non-hazardous, but sampling solid waste material for PFAS analysis is not advised. Consult the client PM or on-site point of contact to verify their current disposal acceptance criteria and indicate on waste manifests that the waste potentially contains PFAS. Solid waste potentially containing PFAS should be identified as such on waste manifests. Wastewater potentially containing PFAS should be analyzed for PFAS to determine the appropriate disposal option. If the sum of PFOA and PFOS concentrations is less than the applicable criterion (e.g., 70 ng/L) the water may be disposed of without special handling if no other enforceable regulations apply; otherwise, the water should be treated to reduce the PFOA + PFOS concentration to an acceptable level or should be directed to an appropriate treatment facility for disposal. On-site treatment (e.g., granular activated carbon filtration) may be appropriate. Consult the client PM or on-site point of contact for direction regarding disposal.

NOTE: If aqueous investigation-derived waste (IDW) is expected to contain PFAS greater than the applicable criterion (e.g., captured residual AFFF or AFFF concentrate from an accidental release in a hangar), special actions may be necessary and the client PM should be consulted. For wastes that are dewatered and potentially contain PFAS, containerize the wastewater and analyze it for PFAS prior to disposal.

8.0 REFERENCES

ATSDR, (Agency for Toxic Substances and Disease Registry), Division of Toxicology and Environmental Medicine, 2009. Toxicological profile for perfluoroalkyls. U.S. Government Printing Office. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=1117&tid=237.

ASTSWMO (Association of State and Territorial Solid Waste Management Officials, Remediation and Reuse Focus Group), Federal Facilities Research Center, 2015. Perfluorinated Chemicals (PFCs): Perfluorooctanoic Acid (PFOA) and Perflurooctane Sulfonate (PFOS), Information Paper. August

Bartlett and Davis, 2018. Evaluating PFAS cross contamination issues. Remediation, 2018;28:53-57.

DoD (Department of Defense), 2011. Chemical & Material Emerging Risk Alert Aqueous Film Forming Foam (AFFF). Risk Alert # 03-11. Materials of Evolving Regulatory Interest Team.

Department of the Navy, 2014. Perfluorinated Compounds (PFCs) Interim Guidance/Frequently Asked Questions (FAQs). December.

Chemical & Material Emerging Risk Alert Aqueous Film Forming Foam (AFFF). Risk Alert # 03-11. Materials of Evolving Regulatory Interest Team.

NAVFAC, 2017. Interim Per-and Polyfluoroalkyl Substances (PFAS) Site Guidance for NAVFAC Remedial Project Managers (RPMs)/September 2017 Update.

New Hampshire Department of Health and Human Services, 2014. Fact Sheet, Perfluorinated Chemicals (PFCs). May.

U.S. EPA (United States Environmental Protection Agency), 2009. Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS), Version 1.1, EPA/600/R-08/092. September.

U.S. EPA (United States Environmental Protection Agency), 2014. Emerging Contaminants – Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). Emerging Contaminants Fact Sheet – PFOS and PFOA. EPA-50-F-14-001. March.

U.S. EPA, 2015. Perfluorooctanoic Acid (PFOA) and Fluorinated Telomers – Frequent Questions. http://www.epa.gov/oppt/pfoa/pubs/faq.html. Accessed April 27.

USGS, 2019. Contaminants of Emerging Concern in the Environment, https://toxics.usgs.gov/investigations/cec/index.php. Accessed August 2.

TETRA TECH	**STANDARD OPERATING PROCEDURE**	Number SA-2.2	Page 1 of 8
		Effective Date 01/15/2021	Revision 4
		Applicability EGS Operating Unit	
		Prepared Earth Sciences Department	
Subject AIR MONITORING AND SAMPLING		Approved T. Johnston T.E. Johnston 01/08/2021	

TABLE OF CONTENTS

SECTION **PAGE**

1.0 PURPOSE

The objective of this Standard Operating Procedure is to specify the proper approach and methodologies to identify and quantify airborne chemical contamination levels through the use of direct reading instrumentation and air/or sample collection. The results of these activities provide vital information for site characterization and risk assessment considerations.

2.0 SCOPE

Applies to all Tetra Tech EGS site activities where the potential for personnel exposures to respiratory health hazards exists.

3.0 GLOSSARY

Direct Reading Instruments (DRIs) – Instrumentation operating on various detection principles, such as flame ionization or photoionization providing real time readings of ambient contaminants in air.

Personal/Area Air Sampling – Personal/area air sampling is conducted utilizing an air sampling pump and a specific collection media to quantify airborne contaminants.

Meteorological Considerations – Meteorological information must be collected on site to properly interpret air sampling results, as well as aid in the characterization of contaminant potential plume migration and intensity. This information will also be used to support the selection of sampling locations and determine which samples should be analyzed. The meteorological information will be used to estimate downwind concentration levels based on short-term field levels encountered at the source.

4.0 RESPONSIBILITIES

Project Manager (PM) – Responsible for all aspects of project implementation and direction. Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) and requirements and for providing the necessary resources in support of all air monitoring and sampling applications.

Field Operations Leader (FOL) – Responsible for implementing the air monitoring program as detailed in approved project plans for the specific site. Air monitoring requirements will be included in both the Field Sampling and Analysis Plan (FSAP) and the site-specific Health and Safety Plan (HASP).

Health and Safety Officer (HSO) or Site Safety and Health Officer (SSHO) – The health and safety officer provides technical assistance to the FOL concerning air monitoring and sampling applications, collection methodologies, data interpretations, and establishes action items based on results. This information is further used to assess atmospheric migration of airborne chemical contaminants.

5.0 PROCEDURES

5.1 INTRODUCTION

Air monitoring is used to help establish criteria for worker safety, document potential exposures, and determine protective measures for the site personnel and the surrounding public. To accomplish this, it is necessary for an effective air surveillance program to be tailored to meet the conditions found at each work site.

During site operations, data are collected concerning air contaminants representative of site operations. Monitoring for vapors, gases, and particulates is performed using DRIs and /or air sampling systems, taking into account meteorological considerations. DRIs can be used to detect many organics as well as a few inorganics and can provide approximate total concentrations through applications of relative response ratios of contaminants to reference standards. If specific chemicals (organics and inorganics) have been identified, then properly calibrated DRIs can be used for more accurate onsite assessments.

The most accurate method for evaluating any air contaminant is to collect samples and analyze them at a qualified laboratory. Although accurate, this method presents two disadvantages: (1) cost and (2) the time required to obtain results. Analyzing large numbers of laboratory samples can be expensive, especially if results are needed quickly. Onsite laboratories tend to reduce the turnaround time, but unless they can analyze other types of samples, they may also be costly. In emergencies, time is often not available for laboratory analysis of air samples, either on site or off site.

To obtain air monitoring data rapidly at the site, DRI utilizing flame ionization detectors (FIDs), photoionization detectors (PIDs), and other detection methodology can be used. Some of these may be used as survey instruments or operated as gas chromatographs. As gas chromatographs, these instruments can provide real-time, qualitative/quantitative data when calibrated with standards of known air contaminants. Combined with selective laboratory analysis of samples, they provide a tool for evaluating airborne organic hazards on a real-time basis and at a lower cost than analyzing samples in a laboratory.

5.2 AIR SAMPLING

For more complete information about air contaminants, measurements obtained with DRIs can be supplemented by collecting and analyzing air samples. To assess air contaminants more thoroughly, air sampling devices equipped with appropriate collection media may be placed at various locations throughout the area and on persons with at-risk occupations. These samples provide air quality information for the period of time they are taken, and can indicate contaminant types and concentrations over the sampling period. As a result, careful selection of sampling types, numbers, and locations, by a qualified health and safety professional is essential to obtain representative information. As data is obtained (from the analysis of samples, DRIs, knowledge about materials involved, site operations, and the potential for airborne toxic hazards), adjustments can be in the location of samples, types of samples, number of samples collected, frequency of sampling, and analysis required. In addition to air samplers, area monitoring stations may also include DRIs equipped with data logging capabilities and operated as continuous air monitors.

Area air sampling locations may be located in various places as required by project and site needs. Area air sampling stations may include, but are not limited to:

- Upwind – Industrial operations, vehicle traffic, spills and other contributing sources may cause or otherwise result in the generation of air pollutants. Upwind samples establish background levels

- Support Zone (SZ) – Samples may be taken near the command post or other support facilities to ensure that they are, in fact, located in an unaffected area, and that the area remains clean throughout operations at the site.

- Contamination Reduction Zone (CRZ) – Air samples may be collected along the decontamination line to ensure that decontamination workers are properly protected and that onsite workers are not removing their respiratory protective gear in a contaminated area.

- Exclusion Zone (EZ) – The Exclusion Zone presents the greatest risk of release/generation of contaminants and requires the highest concern for air sampling. The location of sampling stations shall be based upon factors such as hot-spots detected by DRIs, types of substances present, and potential for airborne contaminants. The data from these stations, in conjunction with intermittent walk-around surveys with DRIs, are used to verify the selection of proper levels of worker protection and EZ boundaries as well as to provide a continual record of air contaminants.

- Downwind – One or more sampling stations may be located downwind from the site to indicate if any air contaminants are leaving the site. If there are indications of airborne hazards in populated areas, appropriate response action must be taken and additional samplers should be placed downwind. Downwind locations are further determined based on meteorological considerations concerning generation, air plume migration, and intensity.

5.3 MEDIA FOR COLLECTING AIR SAMPLES

Hazardous material incidents and abandoned waste sites can involve thousands of potentially dangerous substances, such as gases, vapors, and particulates that could become airborne. A variety of media are used to collect these substances. Sampling systems typically include a calibrated air sampling pump, which draws air into selected collection media. It is essential that appropriate, approved air sampling methodologies (such as those published by NIOSH, OSHA, and EPA) be followed for the collection of each specific analyte. Some of the most common types of samples and the collection media used for them are described in the following information:

One of the most common types of collection media is activated carbon which is an excellent adsorbent for most organic vapors. However, other solid adsorbents (such as Tenax, silica gel, and Florisil) are routinely used to sample specific organic compounds or classes of compounds that do not adsorb or desorb well onto activated carbon. To avoid stocking a large number of sorbents for collecting samples for various chemicals, a smaller number is generally chosen for collecting the widest range of materials or for chemicals known to be present. The vapors are collected using an industrial hygiene personal sampling pump with either one sampling port or a manifold capable of simultaneously collecting samples on several sorbent tubes (provided that sampling parameters such as flow rates and sample volumes are satisfied). For example, in a manifold with four sorbent tubes (or on individual pumps with varying flow rates), the tubes might contain:

- Activated carbon to collect vapors of materials with a boiling point above zero degrees Centigrade. Common materials collected on activated carbon include organic vapors such as solvents, BTEX, and ketones.

- A porous polymer, such as Tenax or Chromosorb, to collect substances (such as high-molecular-weight hydrocarbons, organophosphorus compounds, and the vapors of certain pesticides) that adsorb poorly onto activated carbon. Some of these porous polymers also absorb organic materials at low ambient temperatures more efficiently than carbon.

- A polar sorbent, such as silica gel, to collect organic vapors (aromatic amines, for example) that exhibit a relatively high dipole moment.

- Another specialty adsorbent selected for the specific site. For example, a Florisil tube could be used if polychlorinated biphenyls are expected.

- Liquid impingers – aldehydes, ketones, phosgene, phenols.

- Glass fiber filters, membrane filters, Teflon filters – Inorganics and other semivolatile compounds.

- Airborne particulates can be either solid or liquid. Examples of common particulate analytes include some metals, fibers such as asbestos, and condensed particulates such as welding fumes. Dusts, fumes, smoke, and fibers are dispersed solids; mists and fogs are dispersed liquids. For air sampling, most particulates are collected using glass fiber, mixed cellulose ester, or polyvinyl chloride filters, depending on the filter's ability to collect the subject material and its suitability for laboratory analysis. A cyclone is used to collect particles of respirable size. Atomic Absorption Spectrophotometry, Emission Spectroscopy, Phase Contrast Microscopy, and other techniques are used to analyze various types of particulates. Direct-reading monitors are also used to quantify particulate concentrations, and are usually based on the light-scattering properties of the particulate matter.

5.3.1 Other Methods

Colorimetric detector tubes can also be used with a sampling pump when monitoring for some specific compounds. A detector tube is a vial that contains a chemical preparation that reacts with the measured substance by changing color. Most detector tubes are scale tubes that permit a comparison of the length of the color change to an indicated concentration. Passive organic vapor monitors can be substituted for active monitoring if they are available for the types of materials suspected to be present at a given site.

5.3.2 NIOSH Methods

The National Institute for Occupational Safety and Health's (NIOSH) Manual of Analytical Methods, 5th ed., contains acceptable methods for collecting and analyzing air samples for a variety of chemical substances. Consult these volumes for specific procedures.

5.4 COLLECTION AND ANALYSIS

Collection and analysis of air samples is a multi-faceted task, and is part of the overall air surveillance program. The program is structured to cover the following air pathway analyses:

5.4.1 Selecting Monitoring Constituents

Applications within this program are accomplished using two considerations:

- Air surveillance for specific constituents is based on quantity of the pollutant and the likelihood for vapor release or generation.

- Controlling toxicity – These substances, even when represented in limited quantities, present the greatest threat to the public or worker safety, and influence environmental impact.

5.4.2 Specifying Meteorological Considerations

The following factors will influence sample collection:

- Wind direction and speed
- Sigma theta (atmospheric stability)
- Temperature
- Barometric pressure
- Humidity

These factors will provide information essential to properly arrive at accurate air sampling concentration results. This information is also used to identify how airborne chemical contaminants will react for modeling and for monitoring purposes. The results will provide indicators of plume movement, intensity, and dilution.

5.4.3 Design of Monitoring Network

The air surveillance network is structured to consider:

- Source characteristics (physical state; vapor release and/or generation; emission rates; and disturbance of the source impacting these aspects)
- Receptor sites (receptor sites are monitored and tracked based on priority)
- Meteorological consideration
- Air modeling input
- Data quality objectives

5.4.4 Air Monitoring Documentation/Data Reduction

5.4.4.1 Air Monitoring Documentation

Elements of the air surveillance program are used to provide documentation valuable to safely performing/containing site activities.

Air monitoring results from DRIs must be recorded, such as on instrument results reporting forms, or in the field logbook. This information, where applicable, will be correlated to air sampling information if/when collected.

Air sampling results for personnel and area measurement efforts must be validated, prior to notifying affected individuals. Personal air sampling results notification is accomplished through verbal or written communications.

Results of air monitoring/sampling activities can be identified on site maps. This information is used to structure operational zones and identify levels of protection.

5.4.4.2 Data Reduction

Data reduction combines and correlates the DRI results, air sampling results, and meteorological information to determine area and source airborne contaminant levels and movement.

All air sampling surveillance efforts must incorporate appropriate and approved NIOSH, OSHA, or EPA analytical methods. These procedures identify specific sample collection media, sampling methodologies, and analytical procedures. Sample analysis for health and safety considerations must be further supported by using American Industrial Hygiene Association accredited laboratories.

5.5 PERSONNEL MONITORING

In addition to area atmospheric sampling, personnel monitoring -- both active and passive -- can be used to sample for air contaminants. Representative workers must be identified, and equipped with appropriate personal sampling systems to determine contaminants at specific locations or for specific work being performed. When sampling devices are placed on workers (generally within 1 foot of the mouth and nose) the results are used to indicate worker exposures.

5.6 CALIBRATION

As a rule, the entire air sampling or monitoring system shall be calibrated. Proper pre-and post-calibration activities are essential for correct operation and for accurate data. In some instances, additional calibration during the sampling period may be required. The overall frequency of calibration will depend upon the particular sampling event, including the general handling and use of a given sampling system. Pump mechanisms shall be calibrated when newly purchased, after repair, and following suspected abuse. All DRIs will be calibrated according to manufacturer's instructions. All calibration activities for both air monitoring and sampling equipment must be properly documented, such as through the use of a calibration form. This form will be kept on site throughout the life of the project. The calibration log will be used as documentation that instrument calibration was performed on a regular basis.

5.7 METEOROLOGICAL CONSIDERATIONS

Meteorological information is an integral part of an air surveillance program. Data concerning wind speed and direction, temperature, barometric pressure, and humidity (singularly or in combination) are needed for:

- Selecting air sampling locations
- Calculating accurate air sampling results
- Calculating air dispersion
- Calibrating instruments
- Determining populations at risk for environmental exposure from airborne contaminants

Knowledge of wind speed and direction is necessary to effectively place air samplers. In source-oriented ambient air sampling, air samplers need to be located downwind (at different distances) of the source and others need to be placed to collect background samples. Shifts in wind direction must be known. Consequently, the air samplers must be relocated or corrections made for these shifts. In addition, atmospheric simulation models for predicting contaminant dispersion and concentration need windspeed and direction as inputs for predictive calculations. Information may be needed concerning the frequency and intensity that winds blow from certain directions (windrose data). Consequently, the wind direction must be continually monitored when use of this type of data is contemplated.

Air sampling systems need to be calibrated before use. This must include corrections in the calibration curves for actual temperatures and pressures during the sampling event. After sampling, collected air volumes are also mathematically corrected for temperature and pressure conditions.

Air sampling is sometimes designed to assess population exposure (and frequently potential worker exposure). Air samplers are generally located in population centers, irrespective of wind direction. Even in these instances, however, meteorological data is needed for air dispersion modeling. Models are then used to predict or verify population-oriented sampling results.

Proper data is collected by having meteorological stations on site or by obtaining the information from one or more of several government or private organizations, which routinely collect this data. The choice of how information is obtained depends on the availability of reliable data at the location desired, resources needed to obtain meteorological equipment, accuracy of information needed, and use of information.

The collection, handling, and analysis of air samples is an intricate, involved process. Appropriate methodologies, media, and equipment must be used to collect accurate data. Furthermore, selection of appropriate numbers, types, and locations of samples is essential if the data collected are to be used for personnel exposure criteria. For these reasons, air sampling activities must be coordinated and conducted by properly qualified and experienced industrial hygiene professionals. Air monitoring activities also need to be established and monitored carefully. However, as the proper use of these instruments is not as complicated as air sampling, it is commonly acceptable to cross-train capable environmental professionals to use DRIs, with adequate technical support provided by health and safety professionals.

6.0 REFERENCES

Standard Operating Safety Guides, EPA, November 1984.
NIOSH Manual of Analytical Methods, 5th Edition, February 2020.

7.0 ATTACHMENTS

None.

TETRA TECH	**STANDARD OPERATING PROCEDURE**	Number SA-6.3	Page 1 of 14
		Effective Date 08/26/2021	Revision 8
		Applicability EGS Operating Unit	
		Prepared Earth Sciences Department	
Subject FIELD DOCUMENTATION		Approved T. Chuhay	08/26/2021

TABLE OF CONTENTS

SECTION **PAGE**

ATTACHMENTS

1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs, and reports generally initiated and maintained for documenting EGS Operating Unit field activities.

2.0 SCOPE AND APPLICABILITY

Documents presented within this SOP (and related sampling SOPs) shall be used for all EGS Operating Unit field activities, as applicable. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling and documentation effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology. Other or additional documents may be required by specific client contracts or project planning documents. Use of SOPs from certain federal or state environmental agencies may take precedence over these SOPs, depending on the client requirements or jurisdiction of the project

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager (PM) – Responsible for all aspects of project implementation and direction. Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) and requirements and for providing the necessary resources in support of all air monitoring and sampling applications. The PM is responsible for obtaining hardbound controlled-distribution logbooks (from the appropriate source), as needed. In addition, the PM is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) – Responsible for implementing field activities as detailed in approved project plans. The FOL is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports included in this SOP (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time frame.

Site Safety Officer (SSO) – The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP) (or equivalent).

Project Geologist/Sampler – The Project Geologist/Sampler is responsible for the proper documentation of field activities in accordance with this SOP and/or other project-specific documents.

General personnel qualifications for field documentation activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for documentation, handling, packaging, and shipping.

5.0 PROCEDURES

5.1 SITE LOGBOOK

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, record or reference the following activities/events (daily) in the site logbook:

- All field personnel present
- Arrival/departure times and names of site visitors
- Times and dates of health and safety training
- Arrival/departure times of equipment
- Times and dates of equipment calibration
- Start and/or completion of borehole, trench, monitoring well installation activities, etc.
- Daily on-site activities
- Sample pickup information
- Health and safety issues (level of protection, personal protective equipment [PPE], etc.)
- Weather conditions

Maintain a site logbook for each project and initiate it at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Make entries every day that on-site activities take place involving EGS Operating Unit or subcontractor personnel. Upon completion of the fieldwork, provide the site logbook to the PM (or qualified designee) for inclusion in the project's central file.

Record the following information on the cover of each site logbook:

- Project name
- EGS Operating Unit project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2) but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A. Adding a note to the inside front cover similar to the following is recommended: “If this book is found, please return to:” followed by the office address and project manager’s name and phone number.

If measurements are made at any location, either record the measurements and equipment used in the site logbook or reference the field notebook or specific log sheet in which the measurements are recorded (see Attachment A).

Make all logbook, notebook, and log sheet entries in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, cross out the entry with a single strike mark, initial, and date it. At the completion of entries by any individual, the logbook pages used must be signed and dated by the person making the entries. Empty spaces generally should not be left on log sheets, forms, or notebooks. Instead, a line should be struck through them accompanied by the date and initials of the person adding the line. This signifies that the empty spaces are not inadvertent and marked them so no entries can be added at a later date. The site logbook must also be signed by the FOL at the end of each day.

5.1.2 Photographs and Other Images

Permission to take photographs, make movies, or otherwise record visual representations of site features, sampling activities, or facility personnel on certain properties such as military installations is a temporary privilege bestowed upon a person (i.e., the photographer) by the property owner and the particular facility at which the photographs are taken. In the case of U.S. military installations, the U.S. Government and Installation Command bestow this privilege. For the remainder of this section the term “image” is intended to represent all visual forms of documentation of site features, activities, or personnel, such as film and digital still images and movies.

It may be illegal to record images without proper authorization and the photographer may be criminally liable for their actions. This is especially true on or near U.S. Government property. A particular image alone may not constitute an act of espionage or a national security threat; however, nefarious persons and organizations could conceivably combine information from multiple sources to create a national security threat. Therefore, the photographer must comply with any and all restrictions imposed on them by authorized facility personnel.

The instructions below apply to formal and casual photography sessions conducted, for example, during on-site meetings, walkovers, and other visits. Persons recording images should be aware that images recorded on or near military installations, and possibly at other installations, may be subject to censorship and clearance, e.g., through Public Affairs or Public Relations Offices.

Caution

Fieldwork-specific SOPs establish safety precautions for the fieldwork that they govern. When recording images, adhere to all safety precautions associated with fieldwork described in those SOPs. Pay attention to your surroundings. Avoid unsafe locations and positions. Avoid walking or turning your body while looking through the lens or viewfinder of a camera unless the path of movement has been cleared in advance and the movements will be made safely. Be especially alert to trip and fall hazards. Dress appropriately for the weather, topography, and the flora and fauna. Stay hydrated, and be aware of the effects of heat and cold stress on the body. Consult the SSO if in doubt about your safety or the safety of others while recording images.

5.1.2.1 Prior to and during photography sessions, follow these steps:

NOTE: In general, avoidance of specialty photographic equipment reduces the amount of work required of the photographer. The photographer is not required to record aperture, shutter speed, ISO rating, or other camera settings within automatic exposure ranges available on digital cameras; however use of special lenses (e.g., tilt-and-shift), filters (e.g., neutral density, warming, and polarizing filters), and other image enhancement equipment or techniques must be noted in the logbook/notebook. If possible, use of such equipment items or special techniques should be avoided because they can adversely affect the accuracy of recorded images.

- By communicating with the facility point of contact prior to recording images, obtain permission directly from, or on behalf of, the property owner and/or operator to record the images. In the case of U.S. Government military installations, the point of contact typically represents the Installation Command or a higher authority. The actual point of contact is frequently a Public Works or Environmental Department staff member.

- Request from the facility point of contact a written pass that allows permission to record images (hereafter referred to as a photography pass) but do not insist on obtaining one if the facility declines to issue such a pass.

- If the facility does not issue a written photography pass, either do not record images or verify via written communication with the facility point of contact that image making will be permitted while on the Installation property.

  NOTE: The intent of these permissions and communications is to ensure that the photographer clearly communicates his or her intentions to the facility and to avoid disputes regarding appropriateness of images, ownership of images or property depicted in the images, violation of privacy, etc. During communication with the facility point of contact, ensure that they understand the types of scenes, activities, equipment, features, processes, etc., to be recorded visually and under what conditions the images will be made.

- If the facility issues a written photography pass:
  - Prior to recording images, verify that the photography pass is valid for the time period during which images will be made.
  - Carry the written photography pass in your possession when recording images.
  - Be prepared to produce the photography pass as proof of permission to record images.

- Prior to recording images, if using a digital recording medium, enable automatic collection of Exchangeable Image File (EXIF) data. Doing so will provide automatic documentation of the camera settings (ISO rating, shutter speed, aperture, focal length, etc.) used during image capture. Most digital cameras will record this information by default; but the use of special filters or other attachments to the image capture device is not recorded because such equipment is not an integral part of the device.

- While recording images, enter the name of the photographer, date, time, site location, and site description in the logbook/notebook and update this information as necessary to document important changes. Include other pertinent information such as weather conditions, if such information will support interpretation of the images.

- When orientation of the camera is important to interpreting the contents of the images, record the camera angles and positions for each image. This may be done by drawing an arrow on a site figure that points in the same direction the camera was pointed when the image was recorded. Alternatively, some digital cameras may automatically record the geographical coordinates and orientation angle during image capture.

- Sequentially number images of a site or monitoring location to correspond to logbook/notebook entries. Digital still image media typically provide automatic numbering of images. If desired, the image numbers may be altered later (e.g., during download to a computer) but it may be desirable to retain the original file name in the EXIF data for traceability.

5.1.2.2 After recording images follow these steps:

- Verify that the name of the photographer, date, time, site location, site description, and other pertinent notes were correctly entered in the logbook/notebook.

- Compile the images and associated information that will be necessary to interpret them in a manner suitable for the associated project. For example, consecutively number still images and label them according to the logbook/notebook descriptions. If camera angle, camera position, or camera settings are important, record this important information with the images. For moving images, edit and compile the images a manner consistent with the intended use.

- Docket the images and associated film negatives or digital files to the central project file and/or compact disk. If EXIF data were captured and are needed for the project, ensure the EXIF data are transferred along with the image to the final storage location. This final storage location may be a project file or a report compiled to document site conditions.

- If multiple versions of image files are generated (e.g., high resolution and low resolution), arrange for proper storage and management of all versions of files for ready retrieval and safe storage.

5.2 FIELD NOTEBOOKS

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the SSO may elect to maintain a separate field notebook. Where several drill rigs are in operation simultaneously, each Project Geologist/Sampler assigned to oversee a rig must maintain a field notebook.

5.3 FIELD FORMS

Field forms (see list in Section 6.0 of this SOP) can be found on the EGS Operating Unit intranet site under “Field Log Sheets.” Forms may be altered or revised for project-specific needs, subject to client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOPs.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample log sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. Complete a sample log sheet for each sample obtained, including field quality assurance (QA) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Complete the required information on the adhesive labels and apply them to every sample container. Obtain sample labels from the appropriate program/project source, request that they be electronically generated in house, or request them from the laboratory subcontractor. As much as practical, computer generated pre-printed sample labels containing as much specific sample information are preferred for efficiency and legibility.

5.3.1.3 Chain-of-Custody Record

Traditional, hardcopy chain-of-custody records are a multi-part forms that are initiated as samples are acquired and accompany a sample (or group of samples) as they are transferred from person to person. More recently computer generated forms are gaining popularity. Either format may be used. Hardcopy multi-part forms must be used as follows for any samples collected for chemical or geotechnical analysis whether the analyses are performed on-site or off-site:

- Retain one carbonless copy of the completed chain-of-custody form in the field.
- Send one copy to the PM (or qualified designee).
- Send the original (top, signed copy) to the laboratory with the associated samples. Place the original chain-of-custody copy inside a large Ziploc®-type bag taped inside the lid of the shipping cooler. If multiple coolers are sent, but are included on one chain-of-custody form, send the form with the cooler containing vials for volatile organic compounds (VOCs) analysis or the cooler with the air bill attached. Indicate on the air bill how many coolers are included with that shipment.

If electronic forms are used, they must be used and managed in accordance with the associated instructions. An example of a chain-of-custody form is provided as Attachment C. After the samples are received at the laboratory, the sample cooler and contents are checked, and any problems are noted on the enclosed chain-of-custody form. Any discrepancies between the sample labels and chain-of-custody form and any other problems that are noted are resolved as soon as practical through communication between the laboratory point-of-contact and the PM or qualified designee. The chain-of-custody form is signed by the laboratory sample custodian, and copied. The laboratory will retain the copy, and the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Custody Seal

Attachment D is an example of a custody seal. The custody seal is an adhesive-backed label that is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. Sign and date custody seals and affix them across the lid and body of each cooler (front and back of opposite sides) containing environmental samples (see SOP SA-6.1). Obtain custody seals from the laboratory (if available) or purchase them from a supplier.

NOTE: Some projects or contracts may require used of custody seals or wired tags on individual sample bottles.

5.3.1.5 Geochemical Parameters Log Sheets

Complete Field Analytical Log Sheets to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

Complete a Groundwater Level Measurement Sheet for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. Use a Pumping Test Data Sheet to facilitate this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be established in advance.

5.3.2.3 Packer Test Report Form

Complete a Packer Test Report Form for each well at which a packer test is conducted.

5.3.2.4 Boring Log

Complete a Summary Log of Boring, or Boring Log for each soil boring performed to document the materials encountered, operation and driving of casing, and locations/depths of samples collected. In addition, if volatile organic vapors are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a photoionization detector [PID] or flame ionization detector [FID]), enter these readings on the boring log at the appropriate depth. When they become available, enter the laboratory sample number, concentrations of key contaminants, or other pertinent information in the "Remarks" column. This feature allows direct comparison of contaminant concentrations with soil characteristics. Consult the site-specific sampling plan for level of detail to include, such as soil classification, color, or blow counts for Standard Penetration Test.

5.3.2.5 Monitoring Well Construction Details Form

Complete a Monitoring Well Construction Details Form for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible Project Geologist/Sampler.

5.3.2.7 Miscellaneous Monitoring Well Forms

Miscellaneous monitoring well forms that may be required on a project-specific basis include the Monitoring Well Materials Certificate of Conformance and Monitoring Well Development Record. Use a Monitoring Well Materials Certificate of Conformance to document all materials utilized during each monitoring well installation. Use a Monitoring Well Development Record to document all well development activities.

5.3.2.8 Miscellaneous Field Forms – Quality Assurance and Checklists

Miscellaneous field forms/checklists that may be required on a project-specific basis include the following:

- Container Sample and Inspection Sheet – use this form when a container (drum, tank, etc.) is sampled and/or inspected.

- QA Sample Log Sheet – use this form when a QA sample such as an equipment rinsate blank, source blank, etc. is collected.

- Field Task Modification Request (FTMR) – use this form to document deviations from the project planning document(s). The FOL is responsible for initiating the FTMRs. Maintain copies of all FTMRs with the on-site planning documents, and place originals in the final evidence file.

- Field Project Daily Activities Checklist and Field Project Pre-Mobilization Checklist – use these during both the planning and field effort to ensure that all necessary tasks are planned for and completed. These two forms are not requirements, but are useful tools for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring, or test equipment is necessary to ensure the proper operation and response of the equipment, to document the accuracy, precision, or sensitivity of the measurements, and to determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer or the equipment rental vendor, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log, which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. Maintain an Equipment Calibration Log for each electronic measuring device used in the field; make entries for each day the equipment is used or in accordance with manufacturer recommendations.

5.4 FIELD REPORTS

The primary means of recording on-site activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation but are not easily used for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain on site for extended periods of time and are thus not accessible for timely review by project management. Other reports useful for tracking and reporting the progress of field activities are described below.

5.4.1 Daily Activities Report

To provide timely oversight of on-site contractors, complete and submit Daily Activities Reports (DARs) as described below.

5.4.1.1 Description

The DAR documents the activities and progress for each day's field work. Complete this report on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring that involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the EGS Operating Unit intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the DAR to the FOL for review and filing. The DAR is not a formal report and thus requires no further approval. The DARs are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the PM.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

In addition to those described herein, other summary reports may also be contractually required.
Field forms can be found on the EGS Operating Unit intranet site.

6.0 LISTING OF FIELD FORMS ON THE EGS OPERATING UNIT INTRANET SITE

- Boring Log
- Chain of Custody
- Container Sample and Inspection Sheet
- Daily Activities Checklist
- Daily Activities Record
- Daily Activity Report
- Equipment Calibration Log
- Field Task Modification Request FTMR) Form
- Field Analytical Log Sheet - Geochemical Parameters
- Groundwater Level Measurement Sheet
- Groundwater Sample Log Sheet
- Hydraulic Conductivity Testing Data Sheet

- Infiltration Test Data Sheet
- Instream Velocity Measurements
- Instrument Cal. Log Sheet (Water Qual. Meter)
- Job Safety Analysis
- Monitoring Well Bedrock Construction (Open Hole)
- Monitoring Well Confining Layer Construction
- Monitoring Well Development Record
- Monitoring Well Inspection Sheet
- Overburden and Bedrock Monitoring Well Construction (Flush Mount)
- Overburden and Bedrock Monitoring Well Construction (Stick Up)
- Packer Test Report Form
- Photo Log
- Pre-Mob Checklist
- Private Water Supply Sample Log Sheet
- Private Well Sampling Log
- Pumping Test Data Sheet
- QA Sample Log Sheet
- Soil & Sediment Sample Log Sheet
- Surface Water Sample Log Sheet
- Tailgate Safety Meeting Attendance Form
- Test Pit Log
- Tetra Tech Certificate of Conformance (Monitoring Well Materials)

ATTACHMENT A

TYPICAL SITE LOGBOOK ENTRY (EXAMPLE)

START TIME: ______________________________ DATE: ______________________________

SITE LEADER: ____
PERSONNEL:

EGS	DRILLER	SITE VISITORS
________________	________________	________________
________________	________________	________________
________________	________________	________________

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

0900	Steam Jenney and fire hoses were set up.
0930	Drilling activities at well ____resumes. Rig geologist was ____________. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well ______.
1030	Drill rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _______.
1100	Well ______ drilled. Rig geologist was ___________________. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
1155	Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
1200	All personnel off -site for lunch break
1300	Personnel onsite performing decon and preparing to develop well.
1425	EPA remedial project manager arrives on site at 14:25 hours.
1445	Large dump truck arrives and is steam-cleaned. Backhoe and dump truck set up over test pit ______.
1500	Test pit ______ dug with cuttings placed in dump truck. Rig geologist was ______________. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
1750	Express carrier picked up samples (see Sample Logbook, pages 42 through 45).
1822	Site activities terminated. All personnel off site, gate locked.

____

Field Operations Leader/Date

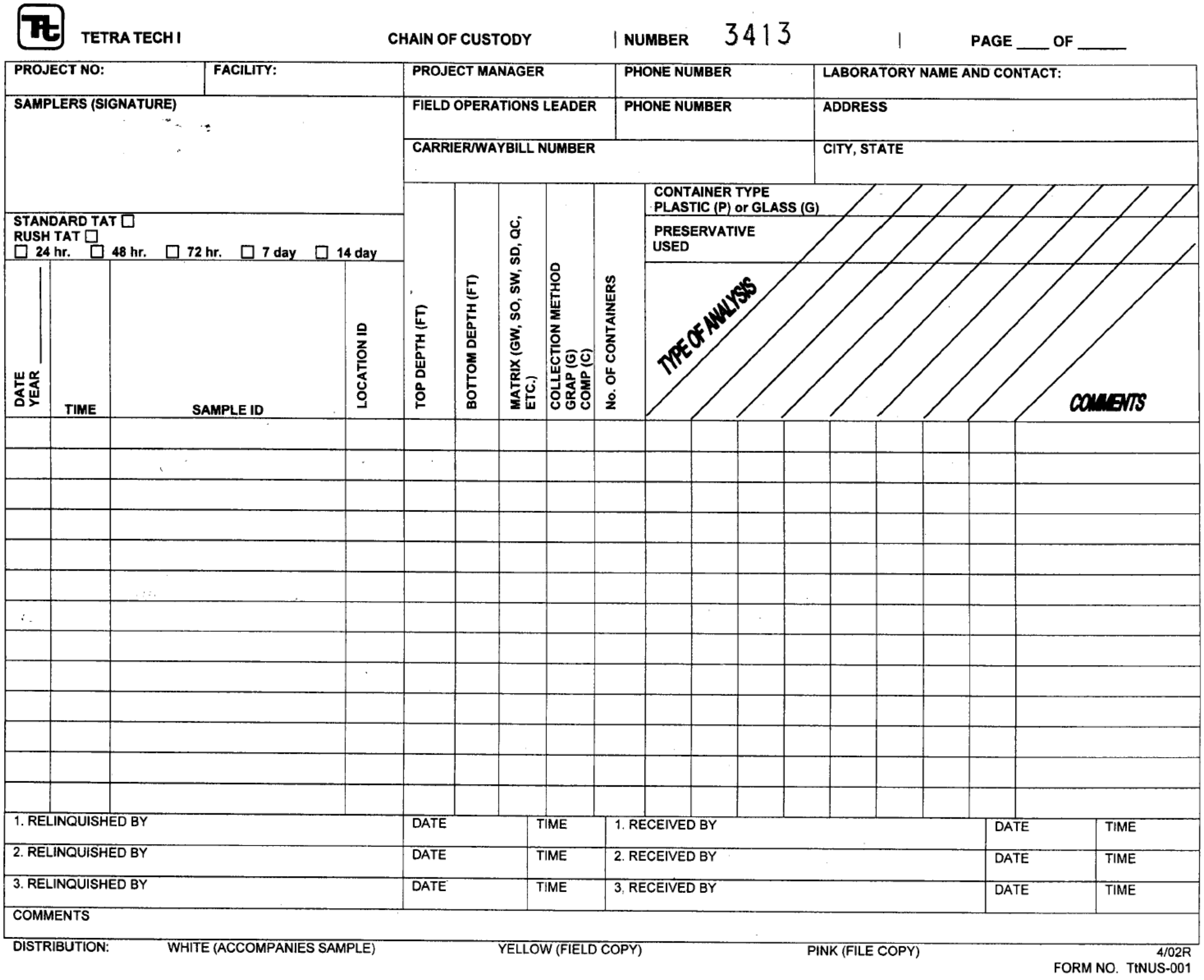
ATTACHMENT B

SAMPLE LABEL (EXAMPLE)

TETRA TECH	Tetra Tech EGS 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	**Project:** **Site:** **Location:**
Sample No.:		**Matrix:**
Date:	**Time:**	**Preserve:**
Analysis:		
Sampled By:		**Laboratory:**

ATTACHMENT C

CHAIN-OF-CUSTODY FORM (EXAMPLE)



TETRA TECH I **CHAIN OF CUSTODY** | **NUMBER** 3413 | **PAGE ____ OF ______**

PROJECT NO:	**FACILITY:**	**PROJECT MANAGER**	**PHONE NUMBER**	**LABORATORY NAME AND CONTACT:**
SAMPLERS (SIGNATURE)		**FIELD OPERATIONS LEADER**	**PHONE NUMBER**	**ADDRESS**
		CARRIER/WAYBILL NUMBER		**CITY, STATE**

STANDARD TAT ☐
RUSH TAT ☐
☐ **24 hr.** ☐ **48 hr.** ☐ **72 hr.** ☐ **7 day** ☐ **14 day**

CONTAINER TYPE PLASTIC (P) or GLASS (G)

PRESERVATIVE USED

DATE YEAR ____	**TIME**	**SAMPLE ID**	**LOCATION ID**	**TOP DEPTH (FT)**	**BOTTOM DEPTH (FT)**	**MATRIX (GW, SO, SW, SD, QC, ETC.)**	**COLLECTION METHOD GRAP (G) COMP (C)**	**No. OF CONTAINERS**	**TYPE OF ANALYSIS**								**COMMENTS**

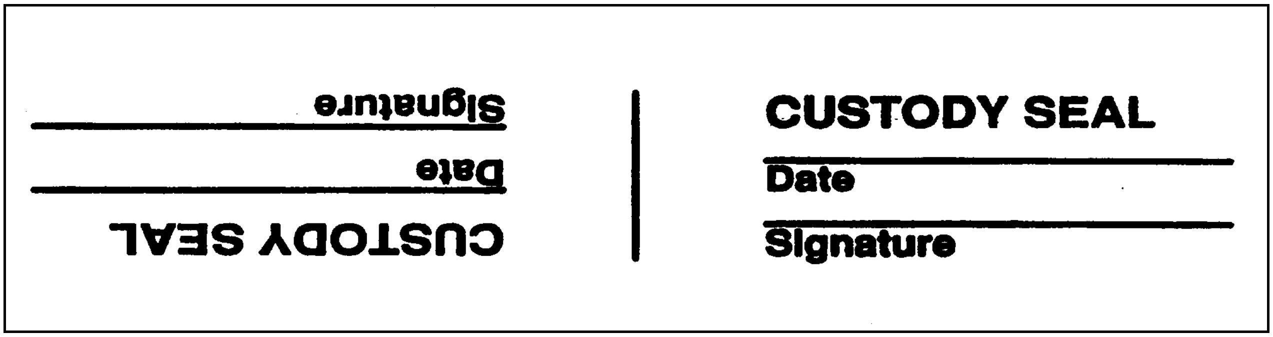
1. RELINQUISHED BY	DATE	TIME	1. RECEIVED BY	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3, RECEIVED BY	DATE	TIME
COMMENTS					

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D

CHAIN-OF-CUSTODY SEAL (EXAMPLE)



CUSTODY SEAL

Date ____________________

Signature ____________________

CUSTODY SEAL

Date ____________________

Signature ____________________

TETRA TECH

STANDARD OPERATING PROCEDURE

Number SA-7.1	Page 1 of 17
Effective Date 04/30/2020	Revision 9
Applicability Tetra Tech, Inc., EGS Operating Unit	
Prepared Earth Sciences Department	

Subject

DECONTAMINATION OF FIELD EQUIPMENT AND MANAGEMENT OF INVESTIGATION DERIVED WASTE

Approved

T. Johnston

T.E. Johnston

TABLE OF CONTENTS

SECTION **PAGE**

ATTACHMENTS

1.0 PURPOSE

Decontamination is the process of removing, or neutralizing contaminants that have contacted and/or accumulated on equipment and/or personnel. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination to prevent either direct or indirect contamination of drilling equipment, earth-moving equipment, chemical sampling equipment, and analytical equipment. It is also intended through the application of these principles to prevent cross-contamination of the environment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox/Luminox – Phosphate-free laboratory-grade detergent products by Alconox, Inc.

Chemical/Hygienic/Sanitizing wipes – These types of devices offer a portable solution when there are no sources of water and soap to allow hands, face, or equipment to be cleaned of gross contamination. Some of these wipes and solution based detergents are chemical specific such as D-Lead or D-Wipes are used to remove lead and other heavy metals from hands and face.

Decontamination Solution – A solution selected/identified in the Health and Safety Plan (HASP), Project-Specific Quality Assurance Project Plan (QAPP), or other governing document. The solution is selected and employed as directed by the project chemist/health and safety professional as it has been shown to be most effective in the removal, neutralization, and/or stabilization of the contaminants in question without creating unwanted byproducts.

Deionized Water (DI) – This is water that has been treated by passing it through a deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Dry decontamination – This method physically removes contaminates from the surface through the use of High Efficiency Particulate Filter vacuums employed for lead and asbestos operations.

Potable Water – Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing – Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from the surface of equipment. This process can be coupled with wash solutions or used solely as a pressure washer to physically remove surface artifacts.

Solvent – A solvent is a liquid that is able to dissolve other substances, or solutes, (gases, liquids and/or solids) to form a solution. A solution is a homogeneous mixture of solvent and solute. Water is often referred to as a universal solvent because of its ability to dissolve many different types of substances. The category "solvent" includes but is not limited to pesticide-grade isopropanol; methanol; acetone; and hexane. These solvents may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and **must be justified** in the project planning documents. **Methanol, acetone, hexane and isopropanol are highly flammable**. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, polychlorinated biphenyls (PCBs), or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on polyvinyl chloride (PVC) equipment or well construction materials. Acidic and caustic materials may also serve as solutes and when mixed with water may be used for the purpose of decontamination. A non-flammable option is available – see "Selection of Detergent" at the end of Section 6.0.

Steam Pressure Washing – A cleaning method employing a high-pressure spray of heated potable water (steam) to remove various organic/inorganic chemicals from equipment. This method is useful for removing organic substances such as pesticides, PCBs, oils, and fuels.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager (PM) – Responsible for all aspects of project implementation and direction. Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) and requirements.

Decontamination Personnel – Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process, including:

- A working knowledge of the use of all equipment involved (pressure washers, steam cleaners, etc.).
- Hazards associated with the solutions used for this purpose.
- The monitoring of the decontamination process to ensure that it is working properly. This is accomplished through:
    - Visual evaluation (i.e., answering the question: "Does it appear to be clean?"),
    - Employing monitoring instruments and scanning of decontaminated items to determine if off-gassing indicates the presence of contaminants , and/or
    - Through the collection of equipment rinsate blanks to verify contaminant removal.
    - Focusing on tools that contact sampled media as well as areas on those tools that trap dirt and contaminated water.
    - Diligent use of PPE and self-decontamination to minimize the potential for cross contamination.
- Replace wash waters often to minimize the collection of contaminants.

Field Operations Leader (FOL) – Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation as well as assigning or evaluating the decontamination process. Additionally, through concurrence with the PM, the FOL may:

- Initiate site investigation/remediation efforts in the area where the least amount of contamination is reported thereby minimizing the potential for cross contamination.
- Use disposable devices to collect sample aliquots to minimize cross contamination that might otherwise occur through the use of reusable items.

Site Safety and Health Officer (SSHO) – Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination process and evaluation. This is accomplished through visual examination and/or instrument screening, where contaminants can be detected to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour General Site Worker and/or applicable 8-Hour General Site Worker Refresher training.

- Capability of performing field work under the expected physical (heavy lifting and moving auger flights and drill rods) and environmental (i.e., weather – heat and/or cold extremes) conditions.

- Familiarity with appropriate decontamination procedures. Throughout this SOP, the procedures remove gross contamination from top down, outside in, then moving to what may be described as “polishing stages” where solvents including laboratory grade isopropanol and deionized water are used to remove residual levels of contaminants.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer’s/supplier’s Safety Data Sheet (SDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.

- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific HASP (or equivalent) for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).

- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).

- Plastic sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).

- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).

- PPE as specified in the project HASP (or equivalent).

- Soap and water for physical washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting equipment rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

Selection of Detergent

A non-phosphate detergent shall be used when a detergent rinse is required. For environmental sampling field decontamination, three options are available and selection depends on the anticipated contaminants. *Alconox* powder is suitable for general purposes. *Liquinox is a traditional anionic laboratory detergent, also useful for general cleaning and where there is a concern for the stability of the cleaned items in harsher cleaners. Luminox is a specialized detergent designed to remove oils and organic contamination, and is best used after an Alconox rinse in lieu of a solvent rinse when cleaning equipment for trace contaminant sampling.*

If the equipment being cleaned is not highly soiled, and residual trace organics are the primary concern, Luminox may be used alone. Liquinox detergent is the better choice as a sole cleaning agent for field sampling equipment because it is a powerful emulsifier.

CAUTION

Do not use Liquinox when collecting samples for 1,4-dioxane analysis as it may contain trace levels of 1,4-dioxane.
Do not use Luminox when collecting samples for PFAS or 1,4-dioxane analysis as it has not been demonstrated to be PFAS- or 1,4-dioxane-free.

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants or neutralization of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities
- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 DECONTAMINATION PAD DESIGN/CONSTRUCTION CONSIDERATIONS

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be and are generally employed for smaller articles (auger flights, drill rods, split spoons, etc.).

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – Establish the decontamination site far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or his/her designee, compliance with as many of the following characteristics as practicable:

  - Away from pedestrian/vehicle thoroughfares.

  - Avoidance of areas where control/custody cannot be maintained.

  - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.

  - Avoidance of potentially contaminated areas.

  - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

The selected decontamination site should include the following, where possible:

- Areas where potable water and electricity are provided.

SAFETY REMINDER

Use only electrical power sources and conduits/wires, either hard-wired or portable, that are:

- Routed through a Ground Fault Circuit Interrupter (GFCI).
- In good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.

- Areas where support activities such as removing decontamination waters, soil, and sediment are possible without entering an active exclusion zone.

- Areas that offer sufficient size to carry out the specific decontamination sequence.

- Decontamination pad (decontamination pad) – Construct the decontamination pad to meet the following characteristics:

  - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size of the decontamination pad should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.

  - Slope – An adequate slope should be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below. When preparing the pad, remove sticks, roots, stones, and debris that could puncture the liner. The area should be lightly graded and possibly covered with sand to minimize the possibility of puncture.

  - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with plastic sheeting to control overspray.

  - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.
  - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange, because dual tube or Macro-Core Samplers and drive rods require little space for decontamination

- Maintenance – Maintain the decontamination area by:
  - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.
  - Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.
  - PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

7.1.2.1 During subsurface sampling activities including drilling and DPT activities, conduct decontamination of drive rods, Macro Core Samplers, split spoons, etc. at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

7.1.2.2 Place buckets within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media.

7.1.2.3 Use drying racks where possible to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

7.1.3.1 When sampling at remote locations, evacuate sampling equipment such as trowels and pumps/tubing of potentially contaminated media to the extent possible.

7.1.3.2 Wrap this equipment in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition.

7.1.3.3 Flush and clean single-use equipment such as disposable trowels, tubing, and surgeon’s gloves to allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 EQUIPMENT DECONTAMINATION PROCEDURES

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

SAFETY REMINDER

Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.
2. Scrub the external components using soap and water and/or steam clean* the outside of the pump/bailer and, if applicable, the pump tubing.
3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.
4. Remove the pump and tubing/bailer from the container.
5. Rinse external pump components using tap water.
6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

CAUTION

Do not rinse polyethylene (PE), PVC, and associated tubing with solvents – These are considered single use items and can be removed and disposed of after use. Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 should be omitted and tubing or plastic components replaced.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol. If groundwater contains these contaminants employ single use sampling apparatus that can be wash, rinsed, and disposed of after use.
8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.
9. Drain residual deionized water to the extent possible.
10. Allow components of the equipment to air dry.
11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect an equipment rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for equipment rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as ultraviolet light may be used.
12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

> In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water and wiped with a rag or towel. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.

- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:

  1. Wash with soap and water
  2. Rinse with tap water
  3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

1. Remove loose soil using shovels, scrapers, etc.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

CAUTION

In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol

   ✎**NOTE***: Steam cleaning does the best job removing contaminants especially the more volatile components. Not only is the water pressure sufficient to remove caked on soils, the heat associated with the steam is very effective in removing contaminants (even those more stubborn ones such as PAHs and PCBs). Steam cleaning units, however, are more dangerous to use due to pressurized steam and water. Care must be taken to avoid thermal burns by ensuring all guards are in place and gloves are employed. When using steam, the items that have been washed dry relatively quickly because heated water and steam are applied.*

5. To the extent possible, allow components to air dry.

6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.

7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 ˚F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0˚ tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 15-25˚ fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.

2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high- temperature or high-pressure water.

3. Always wear PPE as specified in the HASP (or equivalent) such as:

   - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.

4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.

5. Do not modify equipment unless the manufacturer has approved the modifications.

7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.

3. Rinse the equipment with tap water.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol followed by steam cleaning. Where cleanliness is considered suspect, dispose and replace the suspect item.

5. Rinse the equipment with deionized water.

6. To the extent possible, allow components to air dry.

7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.

8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device. If sufficient surface water exists remove visible sediments by dunking within the water from where the sediment sample was obtained. Because of this always work from downstream to upstream

- Extract the dredge and wash it in soap and water per the project-specific planning documents.

CAUTION

When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

☞**NOTE***: In all cases when cleaning stainless steel sampling equipment minimize if not eliminate the use of acids as this will leach certain metals (e.g., chromium, nickel, iron, and antimony) and may result in sample contamination. Use soap and water wash and rinse and, where necessary, steam clean to remove stubborn contaminants.*

7.3 CONTACT WASTE/MATERIALS

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with project planning documents.

NOTE

Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

NOTE

Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers); frac tanks, or tankers that can be sealed until ultimate disposal at an approved facility.

3. Properly label waste storage containers (see Attachment A).

4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:

- Enclose areas accessible by the general public using construction fencing and signs.
- Store materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.
- Maintain the retaining bolt and label on the outside of storage containers where readily visible.

- Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.

- As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.

- Maintain spill response equipment at the IDW storage area in case it is required for immediate access.

- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

CAUTION

Each container of water or soil can weigh up to 750 pounds, constituting a safety hazard. To minimize hazards such as this as well as spillage and potential expansion due to freezing, limit the filling of drums and temporary containers to 80 percent of capacity. These containers should be managed with appropriate manual equipment like drum dollies or, preferably, powered equipment like drum grappler on forklift truck. See the governing health and safety documents for safe management of IDW.

Airborne Contaminant Exposure

To minimize potential airborne contaminant exposure, close and seal all containers transported inside the sampling support vehicle.

Periodically, decontaminate temporary portable containers to minimize off-gassing inside the vehicle. When working at a well or storage container always work from an upwind position.

7.4 DECONTAMINATION EVALUATION

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – Visually inspect equipment to verify the removal of particulate matter to ensure that the washing/rinsing process is working as intended. Pay particular attention to points where soils and sediments may become trapped, such as pipe threads, and other small/narrow openings. It is often necessary to combine multiple types of decontamination methods to ensure the decontamination is adequate and will ultimately yield a clean equipment rinsate blank.

- Instrument Screening – Use a properly calibrated PID/FID to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument’s capabilities.

NOTE

When required by project-specific planning documents, collection of equipment rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Equipment Rinsate Blanks – Collect equipment rinsate blanks to evaluate the decontamination procedure representing different equipment types (e.g., pumps versus drilling equipment) and different decontamination processes as follows:
  - Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.
  - The collection and the frequency of equipment rinsate blank samples are as follows unless specified differently in the project-specific planning documents:
    - Per decontamination method.
    - Per disposable article/batch number of disposable articles.

NOTE

It is recommended that an initial equipment rinsate blank sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

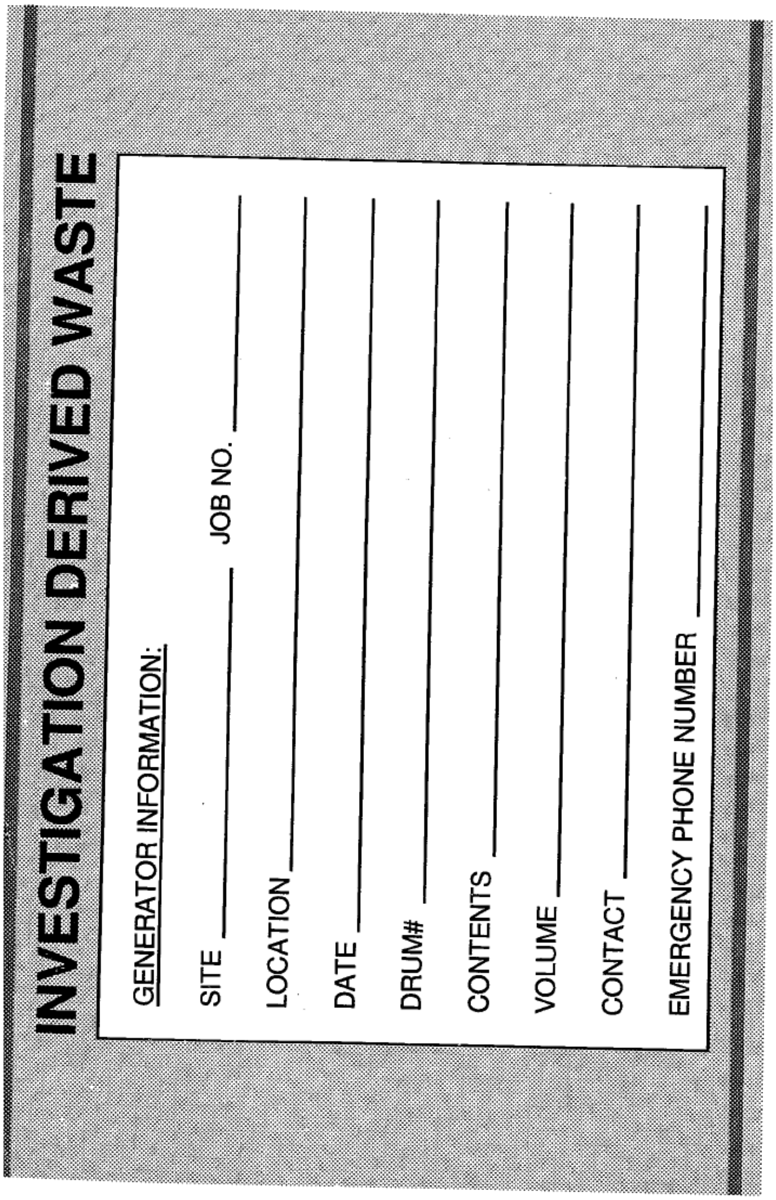
Equipment rinsate blank sample collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional equipment rinsate blank samples due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL supporting and/or resigning not to collect.

CAUTION

For equipment rinsate blanks, project-specific applications may require use of water certified to be contaminant free. Consult project planning documents or SOPs devoted to sampling for the particular contaminants (e.g., per- and polyfluoroalkyl substances).

ATTACHMENT A

IDW LABEL (EXAMPLE)



INVESTIGATION DERIVED WASTE

GENERATOR INFORMATION:

SITE ______ JOB NO. ______

LOCATION ______

DATE ______

DRUM# ______

CONTENTS ______

VOLUME ______

CONTACT ______

EMERGENCY PHONE NUMBER ______

ATTACHMENT B, INVESTIGATIVE DERIVED WASTE
DRUM/CONTAINER INVENTORY LOG (EXAMPLE)

This attachment should be completed as investigative derived waste is accumulated. An updated inventory should be provided to the site Point of Contact at the end of each 10-day shift. Add additional rows on extra pages, as needed.

Drum/ Container Number #	Drum/ Container Type	Media (Contents)	Location (SWMU and Well #, etc.)	Estimated Volume	Date Filled	*Comments*
1				( )-Gallons		
2				( )-Gallons		
3				( )-Gallons		
4				( )-Gallons		

Emergency Point of Contact: ____________ Phone Number: ____________

(Name of Facility) Point of Contact: ____________ Phone Number: ( ) ____________

Information Point of Contact (Name): ____________ Phone Number: ____________

Distribution of Inventory Log: Facility Point of Contact, Phone Number: ( )

Fire Dept/Emergency Services Provider, Phone Number: ( )

Comments: ____________

This page intentionally left blank

Modified TO-13 Sampling Procedure for the Determination of PFAS Compounds in Ambient Air, Process Vents, Tank Headspaces, and Thermal Treatment System Stack Gas

Non-isokinetic Field Sampling Procedure for the Collection of Method 537 PFAS Compounds in Various Locations

Field Sampling Procedure for the Collection of PFAS Compounds

Sample Name: Modified TO-13 PFAS Sampling Procedure

Sampler: Field Technician /Sampling Engineer

Sample Location: Ambient Air Point of Interest or Process Sampling Location

Sampling & Health & Safety Equipment: Sampling and safety equipment is as follows:

- ORBO/CORBO 1500 Sampling Apparatus (See Schematics Below)
- ¼" Teflon connecting tubing (if a CORBO configuration and a glass probe with connecting tubing is being used)
- 125 ml HDPE wide mouth sample bottle for probe and solvent rinse samples (if a CORBO configuration is being collected)
- MeOH/5% NH_4OH solvent for rinsing the probe and tubing
- PFAS free D.I. water for final rinses of the probe and tubing
- Sampling pump capable of sampling from 0.5 to 5 Liters per minute
- New HDPE Squirt bottles for Probe and Connecting Tubing Rinsing
- Safety glasses or face shield
- Latex gloves and other safety equipment as required

Sample Collection Frequency: The ambient air or process sampling location will generally be sampled on a continuous basis for approximately 1-3 hours, or until the testing objectives are achieved. The nominal sampling rate should be 0.5 and 5 liters per minute. Larger sampling rates are acceptable. If breakthrough needs to be evaluated, then two (2) resin tubes have to be coupled together during the sample collection, and analyzed separately. High sampling rates increase the ΔP across the sampling tube which can result in breakthrough of the most volatile target analytes. Also, lower sampling volumes may be appropriate for some projects when less aggressive objectives are encountered, or where high concentrations of the target analytes are known to be present.

Sampling Procedures: **ORBO/CORBO XAD-2 Resin Tube Preparation** - The performing analytical laboratory will prepare the ORBO/CORBO 1500 XAD-2 resin tubes, and deliver them to the sampling team. The procedures for preparing, handling, storing, and analyzing the tubes follow the guidance described in the U.S. EPA method referenced below. Pre-cleaned XAD-2 resin is commercially available (Supelco®) and requires additional cleanup before use in the ORBO PFAS sampling system. New XAD-2 resin contains several PFAS compounds as contaminates. Additional solvent cleaning of new resin is necessary to remove background levels of native PFAS. The specially prepared XAD-2 resin will be used to pack and prepare the ORBO resin tubes. Two (2) ORBO tubes using the same lot of pre-cleaned resin will be prepared with the field sampling tubes and archived at the laboratory until field samples return for analysis. These resin tubes are referred to as “Spiked Resin Blanks” or “Media Blanks.” The Media Blanks are coded for analysis with the field samples at laboratory check-in, and analyzed to confirm that the resin lot used for this project is free from background PFAS contamination. The Media Blanks also demonstrate that the XAD-2 resin displays appropriate recovery characteristics of the target analytes.

For storage and transport to the field-- the ORBO/CORBO resin tubes will have their ends sealed with Teflon® tape or end caps, wrapped in aluminum foil, sealed in Ziploc® bags or bubble wrap, and packed in a clean sample cooler. In the field, the cooler will be stored in the sample recovery area and the resin tubes are removed when ready for use at the sampling location.

Before each sampling run, the Sampling and Analysis Coordinator will supply the ORBO/CORBO tubes to the Sampling Technician who will direct the overall field operations of the sampling campaign. At the end of each run, the Sample Coordinator will receive back from the Sampling technician the ORBO sample tubes, and complete the RFA/CoC sample documentation. The ORBO /CORBO samples will be stored on ice at 4°C (± 2°C) in insulated coolers in a storage area away from sources of fugitive contamination.

In the field, all sampling train glassware, including probes and connecting tubing will receive a thorough rinsing with MeOH/5% NH_4OH before sampling is commenced. Glassware and tubing should subsequently receive a thorough D.I. Water rinse to remove any residual MeOH/5% NH_4OH solvent.

ORBO/CORBO Sampling Operations--The ORBO 1500 sampling tube is used for ambient air applications where no point source is being characterized. The tube may be fixed in a three finger clamp attached to a ring stand at the sampling location. If breakthrough data quality evaluation is being determined, then two (2) ORBO 1500 sampling tubes at connected in series. The back sampling tube will have to be the CORBO configuration in order to make the conections between the sampling tubes. Otherwise, the CORBO is simply connected to the sampling pump using ¼” tubing. The sampling rate is then set on the sampling pump, and the pump turned on for the time span required to collect the needed volume.

ORBO/CORBO Sample Recovery –

The ORBO/CORBO and probe rinse components are assigned unique sample tracking numbers, and given date and test run numbers, if applicable. The samples are recovered by the Sampling and Analysis Coordinator or Sampling Engineer. The sample collection RFA/CoC documentation is also completed. The Sampling and Analysis Coordinator will be responsible for the completion of the documentation records, including the Chain-of-Custody records, and for packaging the samples on ice in an insulated storage cooler.

Quality Assurance:

Field Blanks- A blank ORBO/CORBO will be prepared during the testing series to evaluate general area and handling cleanliness. It should be set up near the area of the actual sampling tube breakdown, a manner similar to the actual OOBO, and should receive the same handling and packaging. The testing objective for the data derived from these blanks is to evaluate the area cleanliness and the effectiveness of the method cleaning and handling procedures. The Field Blanks are to be set up during one of the actual PFAS sampling runs and maintained at the same location for the approximate duration of an actual run. The Field Blank samples are recovered using the same procedures, in the same sample recovery location, and by the same person as implemented for the actual samples.

Reagent Blanks- Samples of the Acetone/MeCl$_2$ (if used), methanol / 5% NH$_4$OH solution, and the D.I. Water used in the field is collected once for the test campaign as Reagent Blanks.

Media Blanks (or Spiked Resin Blanks)- Two (2) spiked resin blanks of the XAD-2 resin (archived at the time of the original media preparation) are prepared at the time of ORBO/CORBO tube preparation. They are retrieved from storage at the time that samples are coded into the laboratory and are processed with the sample lots from the field. They are analyzed with the field samples to display target PFAS analyte background in the XAD-2 resin, and to display the target analyte spike recovery characteristics.

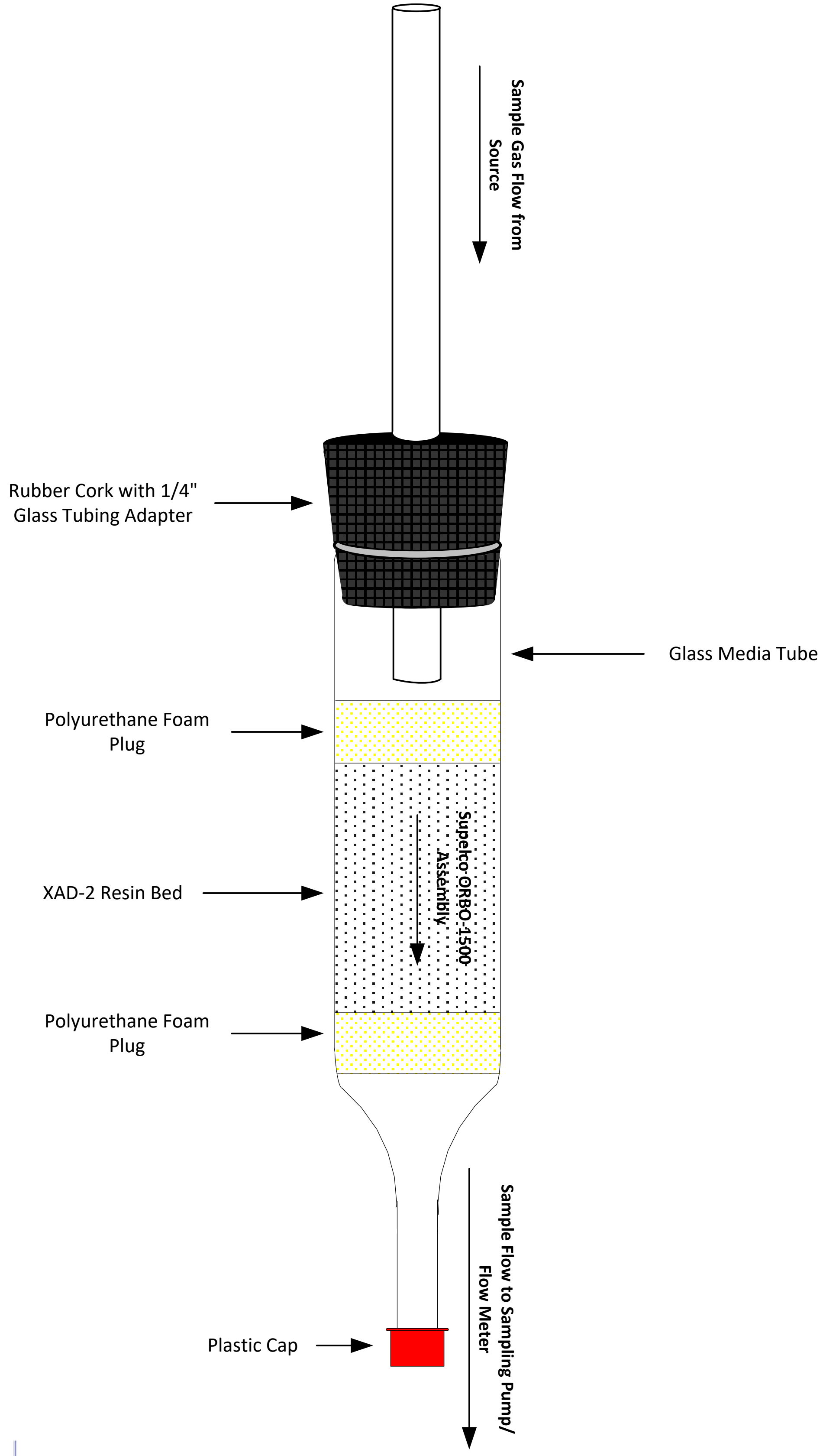
Liquid samples should have their liquid levels clearly marked on the outside of the sample bottles in the field to display the final sample content levels. Loss of sample can be determined using these marks by the laboratory sample check in personnel.

Sample Preservation: The holding times for PFAS samples collected in Modified TO-13 samples is 28 days from the time of sample collection to extraction. All samples should be preserved on ice at approximately 4°C (± 2C°.

Method References: EPA Method TO-13 “Determination of Benzo(a)Pyrene, and Other Polynuclear Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography (GC), and High Performance Liquid Chromatography (HPLC) Analysis, Revision 1.0, June 1988

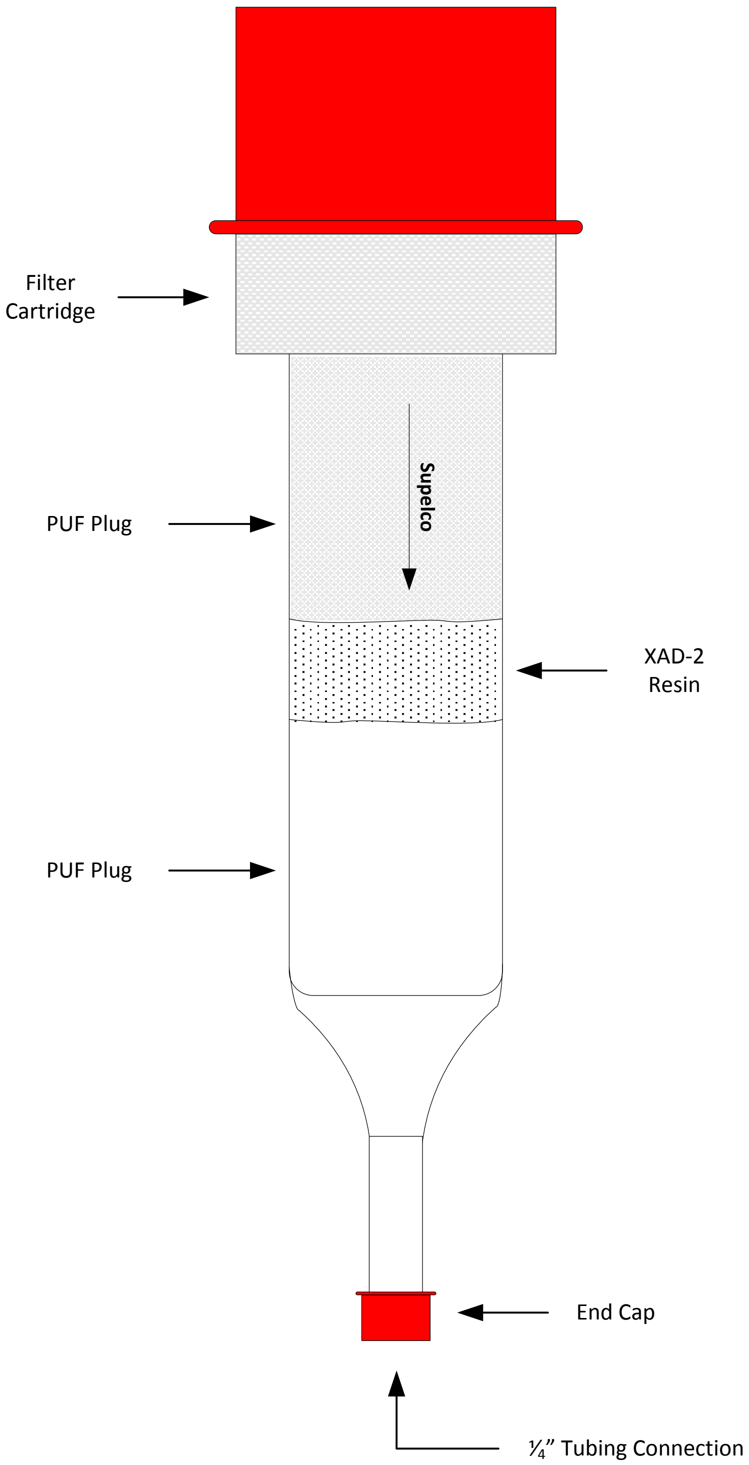
EPA Method 537 – “Determination of Selected Perfluorinated Alkyl Acids in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS) (Rev. 1.1)

CORBO PUF/XAD-2 Sandwich Media Tube for the Sampling and Analysis for Method 537 Compounds



P:\DRAWINGS\CORBO PUF_XAD-2 Sandwich Air Sampling Media for Method 537 Compounds_11062020.vsd
Created on 7/18/2006 by p.bales. Last Edited on 11/6/2020

ORBO PUF/XAD-2 Sandwich Media Tube for the Sampling and Analysis for Method 537 Compounds



P:\DRAWINGS\ORBO Sandwich Air Sampling Media for PFAS_051619.vsd
Author: balesp -- Last Edited on 5/16/2019
Drawing by Eurofins TestAmerica in Knoxville, TN