National Aeronautics and Space Administration

Final

# Uniform Federal Policy for Sampling and Analysis Plan

## Operable Unit 2
## Former Fire Training Area
## Long Term Monitoring Plan
## Revision 4

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, Virginia

**September 2022**

www.nasa.gov

# Executive Summary

This Uniform Federal Policy for Sampling and Analysis Plan (UFP-SAP) outlines the site-specific organization, project management, objectives, planned activities, measurement, data acquisition, assessment, oversight, and data review procedures associated with the Operable Unit (OU 2) Former Fire Training Area (FFTA) Long Term Monitoring (LTM) Program for groundwater located at the Goddard Space Flight Center's (GSFC) Wallops Flight Facility (WFF) in Wallops Island, Virginia. General protocols for sample collection, handling, and storage; chain-of-custody, laboratory and field analyses; data validation; and reporting are also addressed in this SAP. This SAP will detail the sample locations, rationale, and methods needed to achieve the goals and objectives of monitoring groundwater at the FFTA. Currently, the only constituents of concern (COCs) included in the FFTA LTM program for groundwater are naphthalene, arsenic, and manganese. Field activities will be conducted in accordance with the Standard Operating Procedures (SOPs) identified in this SAP and will meet the requirements of the Health and Safety Plan (HASP) to be submitted under separate cover.

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# Acronyms and Abbreviations

| | |
|---|---|
| µg/L | microgram per liter |
| ºC | Degree Celsius |
| %R | Percent recovery |
| AAOC | Administrative Agreement on Consent |
| Ca | Analytical Data Completeness |
| CASRN | Chemical Abstract Service Registry Number |
| CCV | Continuing Calibration Verification |
| COC | Constituent of Concern |
| Cs | Sampling Completeness |
| DO | Dissolved Oxygen |
| DQI | Data Quality Indicator |
| DV | Data Validation |
| DVM | Data Validation Manager |
| EDD | Electronic Data Deliverable |
| EICP | Extracted Ion Current Profile |
| EPA | United States Environmental Protection Agency |
| FFTA | Former Fire Training Area |
| FOL | Field Operations Leader |
| FS | Feasibility Study |
| FTMR | Field Task Modification Request |
| GAC | Granular Activated Carbon |
| GC/MS | Gas Chromatograph/Mass Spectrometry |
| GSFC | Goddard Space Flight Center |
| HASP | Health and Safety Plan |
| HDPE | High-density Polyethylene |
| HI | Hazard index |
| HSM | Health and Safety Manager |
| ICAL | Initial Calibration |
| ICP-AES | Inductively Coupled Plasma- Atomic Emission Spectroscopy |
| IDIQ | Indefinite Delivery Indefinite Quantity |
| IDQTF | Intergovernmental Data Quality Task Force |
| IDW | Investigation-Derived Waste |
| IS | Internal Standard |
| LCS | Laboratory Control Sample |
| LCSD | Laboratory Control Sample Duplicate |
| LTM | Long-term monitoring |
| MB | Method Blank |
| MCL | Maximum Contaminant Level |
| MD | Matrix Duplicate |
| MDL | Method Detection Limit |
| mL | Milliliter |
| MPC | Measurement Performance Criteria |
| MS | Matrix Spike |
| MSA | Method of Standard Additions |
| MSD | Matrix Spike Duplicate |
| msl | Mean sea level |

| | |
|---|---|
| N/A | Not Applicable |
| NACA | National Advisory Committee for Aeronautics |
| NASA | National Aeronautics and Space Administration |
| NFG | National Functional Guidelines |
| NTU | Nephelometric turbidity unit |
| ORP | Oxidation-Reduction Potential |
| OU | Operable Unit |
| PA | Preliminary Assessment |
| PAL | Project Action Limit |
| PDF | Portable Document Format |
| PDS | Post digestion spike |
| PFAS | Per-and Polyfluoroalkyl Substances |
| PID | Photoionization Detector |
| PM | Project Manager |
| POC | Point of Contact |
| PPE | Personal Protective Equipment |
| PQLG | Project Quantitation Limit Goal |
| PRAP | Proposed Remedial Action Plan |
| QA | Quality Assurance |
| QAM | Quality Assurance Manager |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| RCRA | Resource Conservation and Recovery Act |
| RI | Remedial Investigation |
| ROD | Record of Decision |
| RPD | Relative Percent Difference |
| RPM | Remedial Project Manager |
| SAP | Sampling and Analysis Plan |
| SGS | SGS North America, Inc. – Orlando, Florida |
| SI | Site Inspection |
| SOP | Standard Operating Procedure |
| SSHO | Site-Specific Health and Safety Officer |
| SVOC | Semivolatile organic compound |
| TBD | To Be Determined |
| Tetra Tech | Tetra Tech, Inc. |
| TO | Task Order |
| UFP | Uniform Federal Policy |
| U.S. | United States |
| VDEQ | Virginia Department of Environmental Quality |
| VOC | Volatile organic compound |
| WFF | Wallops Flight Facility |
| WWTP | Wastewater Treatment Plant |

## SAP Worksheet #1 Title and Approval Page

(UFP-QAPP Manual Section 2.1- Worksheet #1)

**Document Title:** Uniform Federal Policy for Sampling and Analysis Plan, Operable Unit 2, Former Fire Training Area Long Term Monitoring Plan – Revision 4, Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, Virginia

**Lead Organization:** National Aeronautics and Space Administration (NASA)

**Preparer's Name and Organizational Affiliation:** Tetra Tech, Inc. (Tetra Tech)

**Preparer's Address, Telephone Number, and email Address:** 661 Andersen Drive, Pittsburgh, Pennsylvania 60769, (412) 921-8861; Chris.Pike@tetratech.com; prepared under Indefinite Delivery Indefinite Quantity (IDIQ) Contract 80KSC019D0011, Task Order (TO) 20

**Preparation Date (Day/Month/Year):** September 20, 2022

This Uniform Federal Policy (UFP) - Sampling and Analysis Plan (UFP-SAP) was prepared and submitted in accordance with the requirements of the 2004 Resource Conservation and Recovery Act (RCRA) Administrative Agreement on Consent (AAOC) between NASA and the United States (U.S.) Environmental Protection Agency (EPA) (EPA Docket Number RCRA-03-2004-0201TH).

Investigative Organization's Project Manager (PM):

09/20/2022
Signature/Date
Christopher Pike, Tetra Tech PM

Investigative Organization's Project Quality Assurance (QA) Manager (QAM):

Michelle Coffman 09/20/2022
Signature/Date
Michelle Coffman, Tetra Tech QAM/Project Chemist

Lead Organization's PM:

Signature/Date
David Liu, NASA Remedial Project Manager (RPM)

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## SAP Worksheet #2 Distribution List

(UFP-QAPP Manual Section 2.3.1-Worksheet #3)

| SAP Recipients | Title | Organization | Telephone Number | Email Address |
|---|---|---|---|---|
| David Liu | NASA RPM | NASA | 757-824-2141 | David.Liu-1@nasa.gov |
| Susan Dunn | Facility Point of Contact (POC) | NASA-Bluestone Environmental Group, Inc. | 757-824-1832 | Susan.K.Dunn@nasa.gov |
| Mark Speranza | Program Manager | Tetra Tech | 412-921-8916 | Mark.Speranza@tetratech.com |
| Andrea Colby | Laboratory PM | SGS North America, Inc. – Orlando, Florida (SGS) | 609-495-5321 | Andrea.Colby@sgs.com |
| Chris Pike | Tetra Tech Facility Coordinator/ PM | Tetra Tech | 412-921-8861 | Chris.Pike@tetratech.com |
| Michelle Coffman | Tetra Tech QAM/Project Chemist | Tetra Tech | 412-921-8549 | Michelle.Coffman@tetratech.com |
| Matt Soltis | Tetra Tech Health and Safety Manager (HSM) | Tetra Tech | 412-921-8912 | Matt.Soltis@tetratech.com |
| Kyle Newman | VDEQ RPM | State Regulator | 804-698-4452 | Kyle.Newman@deq.virginia.gov |
| Lorie Baker | EPA RPM | Federal Regulator | 215-814-3355 | Baker.Lorie@epa.gov |
| Lee Leck | Tetra Tech Data Manager | Tetra Tech | 412-921-8856 | Lee.Leck@tetratech.com |
| Joe Samchuck | Tetra Tech Data Validation Manager (DVM) | Tetra Tech | 412-921-8510 | Joseph.Samchuck@tetratech.com |
| To be determined (TBD) | Tetra Tech Field Operations Leader (FOL) Site-Specific Health and Safety Officer (SSHO) | Tetra Tech | TBD | TBD |

Note: Managers for individual organizations shall ensure that support staff have access to the current SAP prior to conducting work.

## SAP Worksheet #3 Project Personnel Sign-Off Sheet

(UFP-QAPP Manual Section 2.3.2- Worksheet #4)

Certification that project personnel have read the text will be obtained by one of the following methods, as applicable:

1. In the case of regulatory agency, personnel with oversight authority, approval letters or emails will constitute verification that applicable sections of the SAP have been reviewed. Copies of regulatory agency approval letters / emails will be retained in the project files as project records
2. Emails will be sent to the NASA, Tetra Tech, and subcontractor project personnel who will be requested to verify by email that they have read the applicable SAP / sections and the date on which they were reviewed. Copies of the verification email will be included in the project files
   A copy of the signed worksheet below will be retained in the project files and identified as a project document in **Worksheet #12**.

Key personnel will be instructed to read the SAP prior to attending the internal kick-off meeting for field activities. The Tetra Tech PM will track when the reviews have been completed, obtain signatures, and ensure that the completed sign-off sheet is included in the central project file.

| Name[1] | Organization/Title | Telephone Number | Signature | Date SAP Read |
|---|---|---|---|---|
| **NASA** | | | | |
| David Liu | NASA/RPM | 757-824-2141 | See **Worksheet #1** for signature | |
| Susan Dunn | NASA-Bluestone Environmental/ Facility POC | 757-824-1832 | Email receipt | |
| **Regulatory Agencies** | | | | |
| Kyle Newman | VDEQ/ RPM | 804-698-4452 | See Approval Letter/Email | |
| Lorie Baker | EPA Region 3/ RPM | 215-814-3355 | See Approval Letter/Email | |
| **Tetra Tech** | | | | |
| Michelle Coffman | Tetra Tech/ QAM and Project Chemist | 412-921-8549 | See **Worksheet #1** for signature | |
| Lee Leck | Tetra Tech/ Data Manager | 412-921-8856 | Email receipt | |
| Joe Samchuck | Tetra Tech/ DVM | 412-921-8510 | Email receipt | |
| Matt Soltis | Tetra Tech/ HSM | 412-921-8912 | Email receipt | |
| Chris Pike | Tetra Tech/ Facility Coordinator and PM | 412-921-8861 | See **Worksheet #1** for signature | |

| Name[1] | Organization/Title | Telephone Number | Signature | Date SAP Read |
|---|---|---|---|---|
| TBD | Tetra Tech/ FOL/SSHO | TBD | Email receipt | |
| **Subcontractor** | | | | |
| Andrea Colby | SGS/ Laboratory PM | 609-495-5321 | Email receipt | |

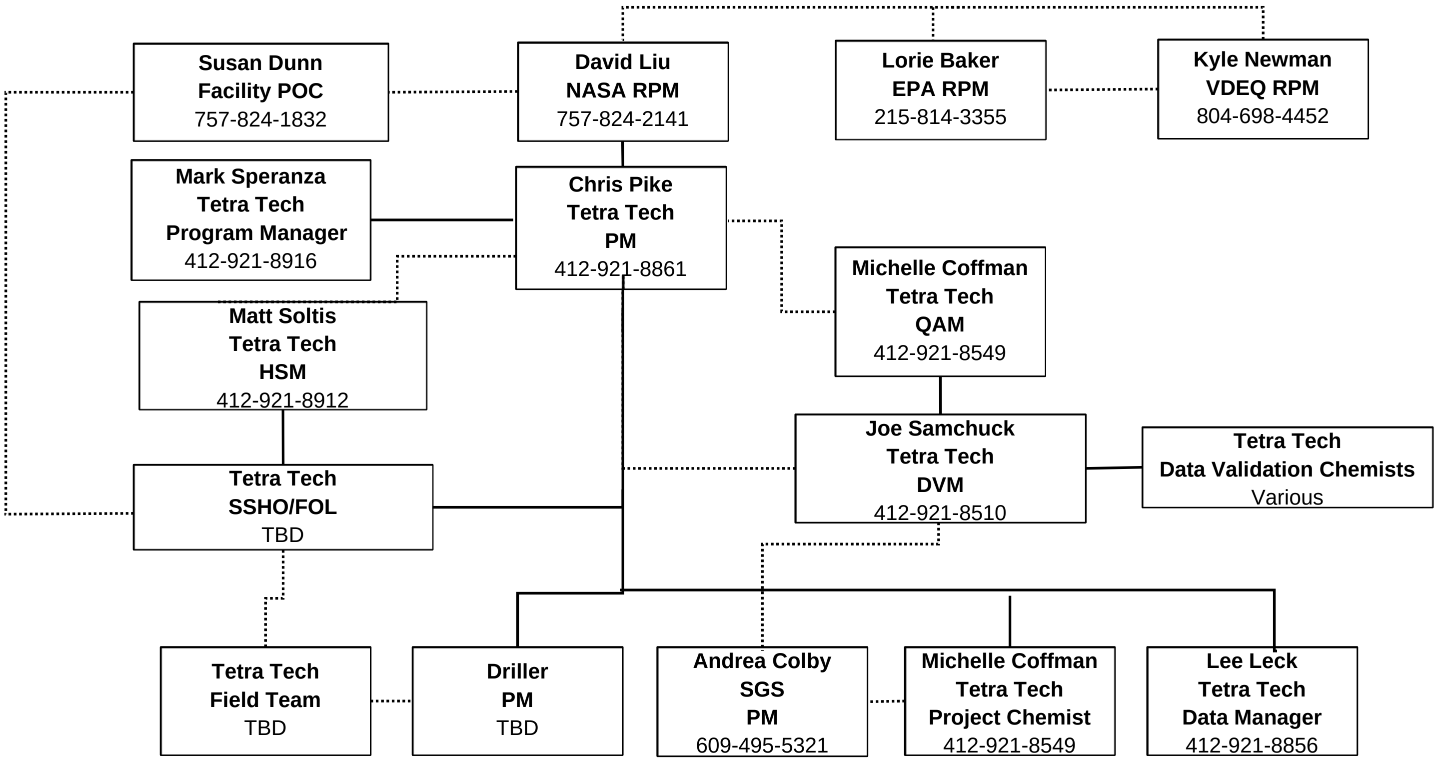
Footnote:

1 - Persons listed on this worksheet will be responsible for distributing the SAP to the appropriate people within their organization.

## SAP Worksheet #4 Project Organizational Chart

(UFP-QAPP Manual Section 2.4.1- Worksheet #5)

Lines of Authority ———————— Lines of Communication - - - - - - - - - - - - - -



## SAP Worksheet #5 Communication Pathways

(UFP-QAPP Manual Section 2.4.2-Worksheet #6)

| Communication Drivers | Responsible Entity | Name | Phone Number | Procedure (Timing, Pathway To/From, etc.) |
|---|---|---|---|---|
| Draft SAP Review/Revisions | Tetra Tech PM<br>NASA RPM | Chris Pike<br>David Liu | 412-921-8861<br>757-824-2141 | Within two days of completing the draft SAP, the SAP will be submitted to NASA by the Tetra Tech PM. NASA comments will be resolved to the satisfaction of the NASA RPM and the SAP will be submitted to NASA for signature. |
| Regulatory Agency Interface | NASA RPM | David Liu | 757-824-2141 | When due according to the project schedule, the draft SAP will be submitted to the regulatory agency by the NASA RPM or designee. |
| Field Progress Reports | Tetra Tech FOL | TBD | TBD | The Tetra Tech FOL will provide email or verbal reports to the Tetra Tech PM on a schedule arranged by the PM. |
| Stop Work Due to Safety Issues | Tetra Tech FOL<br>Tetra Tech PM<br>NASA RPM<br>Facility POC | TBD<br>Chris Pike<br>David Liu<br>Susan Dunn | TBD<br>412-921-8861<br>757-824-2141<br>757-824-1832 | If Tetra Tech is the responsible party for a stop work command, the Tetra Tech FOL will inform on-site personnel, subcontractor(s), and Facility POC, and the identified team members within 1 hour (verbally or by email).<br>If a subcontractor is the responsible party, the subcontractor must inform the Tetra Tech FOL within 15 minutes, and the Tetra Tech FOL will then follow the procedure described above. |
| SAP Changes Prior to Field/Laboratory Work | Tetra Tech FOL<br>Tetra Tech PM<br>NASA RPM<br>Facility POC | TBD<br>Chris Pike<br>David Liu<br>Susan Dunn | TBD<br>412-921-8861<br>757-824-2141<br>757-824-1832 | The Tetra Tech PM will document the required change via a Field Task Modification Request (FTMR) form within 5 days and send it to the NASA RPM. If necessary, the Tetra Tech PM will discuss out of scope items with the NASA RPM.<br>SAP amendments will be submitted by the Tetra Tech PM to the NASA RPM for review and approval. |
| SAP Changes in the Field | Tetra Tech FOL<br>Tetra Tech PM | TBD<br>Chris Pike | TBD<br>412-921-8861 | The Tetra Tech FOL will verbally inform the Tetra Tech PM within 24 hours of realizing the need for a change.<br>The Tetra Tech PM will document the change via an FTMR form within 5 days and send it to the NASA RPM. |
| Field Corrective Actions | Tetra Tech FOL<br>Tetra Tech PM | TBD<br>Chris Pike | TBD<br>412-921-8861 | The Tetra Tech FOL will initiate corrective actions and will notify the Tetra Tech PM verbally within 1 business day of taking action. |

| Communication Drivers | Responsible Entity | Name | Phone Number | Procedure (Timing, Pathway To/From, etc.) |
|---|---|---|---|---|
| Sample Receipt Variances | Laboratory PM<br>Tetra Tech FOL<br>Tetra Tech PM | Andrea Colby<br>TBD<br>Chris Pike | 609-495-5321<br>TBD<br>412-921-8861 | The Laboratory PM will report variances to the Tetra Tech FOL or PM within 24 hours of identifying a variance and those individuals will attempt to resolve the variance with the laboratory. If the variance cannot be resolved, the Tetra Tech PM will notify the NASA RPM within 1 business day of the variances being brought to his or her attention. If necessary, the NASA RPM will take corrective action commensurate with the deficiency. |
| Laboratory Quality Variances | Laboratory PM<br>Tetra Tech QAM/Project Chemist<br>Tetra Tech PM | Andrea Colby<br>Michelle Coffman<br>Chris Pike | 609-495-5321<br>412-921-8549<br>412-921-8861 | The Laboratory PM will notify (verbally or via email) the Tetra Tech QAM/Project Chemist within 1 business day of when an issue related to laboratory data is discovered.<br>The Tetra Tech QAM/Project Chemist will notify (verbally or via email) the data validation (DV) staff and the Tetra Tech PM within 1 business day.<br>The Laboratory PM will ensure that all quality variances are presented in the Case Narrative of the Analytical Laboratory Report. |
| Analytical Corrective Actions | Laboratory PM<br>Tetra Tech FOL<br>Tetra Tech QAM/Project Chemist<br>Tetra Tech PM<br>NASA RPM | Andrea Colby<br>TBD<br>Michelle Coffman<br>Chris Pike<br>David Liu | 609-495-5321<br>TBD<br>412-921-8549<br>412-921-8861<br>757-824-2141 | If the impact of an identified deficiency is limited to this project, it will be resolved between the Laboratory PM and Tetra Tech PM and support staff and 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 NASA RPM within 24 hours of notification from the QAM/Project Chemist. The NASA RPM and Tetra Tech PM will work together to determine the appropriate corrective action for the identified deficiency. Corrective actions may include a consult with the Tetra Tech QAM/Project Chemist and coordination with the laboratory. |
| Reporting Data Validation Issues | Tetra Tech DVM<br>Tetra Tech DV Chemist<br>Tetra Tech PM | Joe Samchuck<br>Various<br>Chris Pike | 412-921-8510<br>Various<br>412-921-8861 | Tetra Tech DV Chemist will document data qualifications in the data validation report and database. For serious deficiencies the DVM will notify Tetra Tech 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. |
| Data Validation Corrective Action | Tetra Tech DVM<br>Tetra Tech DV Chemist<br>Tetra Tech PM | Joe Samchuck<br>Various<br>Chris Pike | 412-921-8510<br>Various<br>412-921-8861 | If a data validation issue cannot be resolved between the Tetra Tech DV Chemist and DVM and the laboratory or the issue appears to be systemic, the Tetra Tech PM will verbally advise the NASA RPM within 24 hours of notification from the DV Chemist. The NASA RPM and Tetra Tech PM will work together to determine the appropriate corrective action for the identified deficiency. This may include a consult with the Tetra Tech QAM/Project Chemist. |

| Communication Drivers | Responsible Entity | Name | Phone Number | Procedure (Timing, Pathway To/From, etc.) |
|---|---|---|---|---|
| Project Report Review | Tetra Tech PM<br>Tetra Tech support staff<br>NASA RPM | Chris Pike<br>Various<br>David Liu | 412-921-8861<br>Various<br>757-824-2141 | Internal reviews will be conducted by the Tetra Tech PM and support staff. Comments will be resolved internally to the satisfaction of the Tetra Tech PM. When satisfied with resolution of all comments, the report will be submitted by the Tetra Tech PM or designee to the NASA RPM in accordance with the project scope of work requirements. Upon resolution of NASA comments, the report will be submitted to the NASA RPM for transmittal to the regulators for review. Comments will be resolved to the satisfaction of the NASA RPM, revisions will be made, and the report will be finalized for final distribution and submittal. |

## SAP Worksheet #6 Personnel Responsibilities and Qualifications Table

(UFP-QAPP Manual Section 2.4.3- Worksheet #7)

| Name | Title | Organizational Affiliation | Responsibilities | Education and Experience Qualifications |
|---|---|---|---|---|
| David Liu | RPM | NASA | Oversees implementation of the NASA Wallops Flight Facility (WFF) restoration program and AAOC. | To be provided upon request |
| Lorie Baker | RPM | EPA Region 3 | Participates in scoping, data review, evaluation, and approves the SAP. | To be provided upon request |
| Kyle Newman | RPM | VDEQ | Participates in scoping, data review, evaluation, and approves the SAP | To be provided upon request |
| Susan Dunn | Facility POC | NASA-Bluestone Environmental Group, Inc | Point of contact for NASA WFF and related information pertaining to this investigation. Field work coordination. | To be provided upon request |
| Chris Pike | PM | Tetra Tech | Daily project management and administration. Ensures that health and safety requirements are implemented. Oversees project, financial, schedule, and technical day to day management of the project. Oversees project implementation, including scoping, data review, and evaluation for this project. Coordinates and oversees review of Tetra Tech project deliverables. | Bachelor of Science, Chemical Engineering; over 30 years of professional experience in environmental industry. |
| Matt Soltis | HSM | Tetra Tech | Ensures that health and safety aspects of the Tetra Tech Health and Safety Program are implemented. Oversees review of health and safety documents and approves health and safety documents. | Bachelor of Science; Industrial Safety Sciences; over 30 years of professional experience in occupational safety and industrial hygiene. |
| TBD | FOL | Tetra Tech | Supervises, coordinates, and performs field sampling activities. Ensures that health and safety requirements are implemented during field work. Functions as the on-site communications link between field staff members, the facility POC, and the Tetra Tech PM. Oversees mobilization and demobilization of all field equipment and subcontractors. Ensures proper maintenance of site logbooks, field logbooks, and field recordkeeping. Identifies and resolves problems in the field, resolving difficulties via consultation with the Facility POC and NASA RPM, implementing and documenting corrective action procedures, and facilitating communication between the field team and project management. | TBD |

| Name | Title | Organizational Affiliation | Responsibilities | Education and Experience Qualifications |
|---|---|---|---|---|
| TBD | SSHO | Tetra Tech | Responsible for on-site project-specific health and safety training and monitoring site conditions. Details of health and safety responsibilities are presented in the Health and Safety Plan (HASP). | TBD |
| Michelle Coffman | QAM/<br>Project Chemist | Tetra Tech | Coordinates analyses with laboratory chemists, ensures that the laboratory scope or work is followed, and that QA has been performed for QA data packages, and communicates with Tetra Tech staff. Ensures that the project meets objectives from the standpoint of laboratory performance. Provides technical advice to the Tetra Tech team on project chemistry matters. Functions as the primary interface with the subcontracted laboratory and the Tetra Tech PM. | Bachelor of Science; Chemistry, Master of Science; Chemistry; 18 years of professional experience in environmental industry. |
| Joe Samchuck | DVM | Tetra Tech | Manages data validation activities within Tetra Tech, including ensuring QA of data validation deliverables, providing technical advice on data usability, and coordinating and maintaining the data validation review schedule. | Bachelor of Science; Chemistry, 28 years of professional experience in environmental industry specializing in data validation. |
| Lee Leck | Data Manager | Tetra Tech | Coordinates data receipt and upload to Tetra Tech and NASA databases; manages and controls flow of data to ensure data are secure. | 29 years of professional experience managing and maintaining information in project relational databases. |
| Andrea Colby | Laboratory PM | SGS | Coordinates analyses with laboratory chemists, ensures that the laboratory scope of work is followed, performs QA of data packages, and communicates with Tetra Tech staff. | To be provided upon request |

## SAP Worksheet #7 Special Personnel Training Requirements Table

(UFP-QAPP Manual Section 2.4.4- Worksheet #8)

Project-specific safety and training requirements are addressed in detail in the HASP.

## SAP Worksheet #8 Project Scoping Session Participants Sheet

(UFP-QAPP Manual Section 2.5.1- Worksheet #9)

Scoping sessions that apply to the Operable Unit (OU) 2 - Former Fire Training Area (FFTA) Long-Term Monitoring (LTM) Program will be held with regulators and stakeholders periodically and on an as-needed basis. These meetings will include project-specific meetings, teleconference calls, and RPM meetings. RPM meeting scoping sessions will be documented in meeting minutes prepared for each meeting or the template below will be used to document the scoping session. Meeting minutes will be reviewed and approved by attendees and captured in the NASA WFF Administrative Record.

| | | | | |
|---|---|---|---|---|
| **Project Name:** | FFTA LTM Program | **Site Name:** | FFTA | |
| **Projected Date(s) of Sampling:** | TBD | **Site Location:** | WFF | |
| **Project Manager:** | Chris Pike (Tetra Tech); David Liu (NASA) | | | |
| **Date of Session:** | TBD | | | |
| **Scoping Session Purpose:** | Project kick-off call | | | |
| **Name** | **Title** | **Affiliation** | **Phone #** | **Email Address** |
| David Liu | NASA RPM | NASA | 757-824-2141 | David.Liu-1@nasa.gov |
| Susan Dunn | Facility POC and Fieldwork Coordination | Bluestone Environmental Group Inc | 757-824-1832 | Susan.K.Dunn@nasa.gov |
| Chris Pike | Tetra Tech Facility Coordinator and PM | Tetra Tech | 412-921-8861 | Chris.Pike@tetratech.com |
| TBD | TBD | TBD | TBD | TBD |

Comments/Decisions: TBD

Action Items: TBD

# SAP Worksheet #9 Problem Definition

(UFP-QAPP Manual Section 2.5.2- Worksheet #9)

This SAP is an update to the FFTA LTM Plan. This SAP focuses on the collection of environmental data that will support the FFTA LTM Program at NASA WFF. This worksheet presents an overview of information for WFF and the FFTA (**Sections 9.1 through 9.4**).

## 9.1 PHYSICAL SETTING

NASA WFF is located in Accomack County, Virginia, and consists of three land parcels—Main Base, Mainland, and Wallops Island (**Figure 9-1**). The Main Base parcel is composed of approximately 2,000 acres and is located near the intersection of Virginia Routes 798 and 175. The Mainland parcel is located 6 miles to the south of the Main Base on Virginia Route 679 and consists of 1,207 acres containing about 100 acres of usable land (the remaining acres are marshland). The Mainland parcel is connected to the Wallops Island parcel by a causeway that was constructed in 1960. The 3,395 acre Wallops Island parcel is a 7-mile-long barrier island located immediately east of the Mainland. The Town of Chincoteague, Virginia, is located 5 miles east of the Main Base.

The Main Base is relatively flat with a maximum elevation of about 40 feet above mean sea level (msl) (Occu-Health Inc., 1999). The runway complex covers a large portion of the Main Base and forms a flat plateau-like feature that covers the majority of the higher elevations. The Main Base is bordered by extensive marshland and creeks.

The FFTA is situated in the northern portion of the Main Base (**Figure 9-2)**. NASA used the FFTA for fire-fighting training exercises from 1965 through 1987. The area is currently an open grass field that gently slopes to the north and northeast. The surface elevation of the site ranges from approximately 27 to 32 feet above msl. Areas of higher elevation surround the FFTA. There are no surface water bodies at the FFTA, but Outfall 003 Drainage Channel (drains to Little Mosquito Creek) is present east of the FFTA. Surface runoff at the FFTA flows to low-lying areas at the site, where it either infiltrates to the subsurface or evaporates.

## 9.2 FACILITY HISTORY

NASA and its predecessor, the National Advisory Committee for Aeronautics (NACA), have had a presence at WFF since 1945. NACA established a rocket launch site on the southern portion of Wallops Island (Wallops Station) in 1945 under the direction of the Langley Research Center and launched its first rocket in that year. NACA constructed launch and radar support and experimental facilities in 1946. Access to Wallops Island at that time was by water vessel only. Operations by NACA at WFF were limited to these test facilities until 1959 (Occu-Health, 1999). NASA absorbed the Langley Research Center and other NACA field centers and facilities when it was created by the U.S. government in 1958. NASA expanded its presence at WFF with the acquisition of the Main Base and Mainland parcels in 1959. The Wallops Station was named Wallops Flight Center in 1974, and the name was changed to WFF in 1981, when it became part Goddard Space Flight Center (GSFC), Greenbelt, Maryland (Wallace, 1997).

The Navy operated the Chincoteague Naval Auxiliary Air Station at the Main Base from 1942 until the transfer to NASA in 1959. During that time, the Navy constructed runways, buildings, and other support facilities for naval aviation and aviation ordnance testing and training (Occu-Health, 1999). NASA continues to maintain the runways and occupies many of the structures and buildings that were present at the time of the property transfer from the Navy. In addition, NASA has expanded and constructed additional buildings to support their mission and provides support to other tenant organizations. The Navy used the north end of Wallops Island as a training area and maintained a series of ranges that were used to develop ordnance and ordnance delivery systems, but few permanent structures were built.

The mission of WFF has undergone several changes since it was established in 1959, but the main focus has been and continues to be rocket research, the management of suborbital projects, suborbital and orbital tracking, aeronautical research, and space technology research. NASA does not manufacture rockets or rocket fuels/propellants at WFF. Rocket motors are transported to WFF from other facilities.

## 9.3 GEOLOGIC AND HYDROGEOLOGIC SETTING

NASA WFF is located on the Eastern Shore of Virginia within the Atlantic Coastal Plain physiographic province. The geology of the Eastern Shore of Virginia can be characterized as a series of layered, unconsolidated sediments that comprise an eastward-thickening wedge that dips to the northeast towards the Atlantic Ocean. Approximately 7,000 feet of sediment lies atop crystalline basement rock at NASA WFF. The two stratigraphic groups encountered at NASA WFF are the Chesapeake Group and the overlying Columbia Group.

The Chesapeake Group is characterized by marine deposits consisting mainly of shelly clays, silts, and sandy clays with some localized sand lenses. The Chesapeake Group is subdivided into the St. Mary's, Eastover, and Yorktown Formations (Mixon, 1985).

The Accomack Member of the Columbia Group overlies the Yorktown Formation. The Accomack Member can be described as a sequence of interbedded sand, gravel, silt, peat, and clay.

The hydrogeology of the Eastern Shore of Virginia consists of four aquifers: the upper, middle, and lower Yorktown-Eastover aquifers, and the surficial Columbia aquifer. This hydrogeologic framework is derived from *Hydrogeology and Analysis of the Ground-Water-Flow System of the Eastern Shore, Virginia* (Richardson, 1994). The uppermost aquifer, the Columbia aquifer, consists of sediments of the Columbia Group. The Columbia aquifer is an unconfined aquifer with the upper Yorktown-Eastover confining unit acting as its lower boundary. Below the Columbia aquifer is the Yorktown-Eastover aquifer system, a freshwater multi-aquifer unit consisting of a series of sandy layers separated by finer grained silt and clay layers of the Yorktown and Eastover Formations. The Yorktown-Eastover aquifers are typically subdivided into the upper, the middle, and the lower Yorktown-Eastover aquifers, each of which exist under confined or semi-confined conditions. Below the lower Yorktown-Eastover aquifer is the St. Mary's confining unit. The St. Mary's confining unit is predominantly clay with varying amounts of silt, sand, and shells.

In general, most of the local freshwater recharge on the Eastern Shore of Virginia occurs in the central upland (Sanford, Pope, and Nelms, 2009). From the central upland, groundwater typically flows horizontally with a small fraction infiltrating vertically downward through the upper Yorktown-Eastover confining unit into the upper Yorktown-Eastover aquifer. Generally, vertical migration through the confining units occurs very slowly.

The geology and hydrogeology of NASA WFF does not significantly differ from the known regional geology and hydrogeology.

The geology immediately underlying the FFTA consists of the sediments of the Columbia Group. This lithologic unit is approximately 50 feet thick and consists of fine- to medium-grained sand with lesser amounts of silt and clay. A silty clay layer (interstitial clay), approximately 3 to 5 feet thick, bisects the Columbia Group around 30 feet bgs. Underlying the Columbia Group is the fine-grained sediments (silty clay) of the Yorktown Formation. **Figure 9-3** presents a lithologic cross-section across the FFTA.

**Figure 9-4** presents the potentiometric surface contour map for the unconfined portion of the Columbia aquifer at the FFTA from the June 2021 LTM event. The contour lines were plotted based on calculations using information from nearby wells and topography. Groundwater flow at the FFTA is to the east and northeast. As the groundwater migrates northeast towards the Outfall 003 Drainage Channel, the gradient increases and flows in a more eastward direction. The Outfall 003 Drainage Channel then discharges into the Little Mosquito Creek.

A potentiometric surface map for the deeper, semi-confined portion of the Columbia aquifer and underlying upper Yorktown-Eastover aquifer were not generated. For the semi-confined portion of the Columbia aquifer, a localized interstitial clay layer is present that limits the downward migration of groundwater at the FFTA. Bisecting the Columbia and upper Yorktown-Eastover aquifers is the upper Yorktown-Eastover confining unit that effectively prevents vertical groundwater migration.

## 9.4 HYDROLOGICAL SETTING

Surface drainage at the Main Base occurs through a series of natural and man-made drainage structures. Drainage within the industrialized portions is controlled and diverted by stormwater collection and conveyance systems to permitted outfalls. The natural drainage patterns for the western and northern portions of the Main Base are towards Little Mosquito Creek and its tributaries. The eastern and southern portions of the Main Base drain to a series of marshlands and tributaries associated with Jenneys Gut and Simoneaston Bay.

## 9.5 SITE HISTORY

NASA used the FFTA twice a week for firefighting training exercises from 1965 until 1987. It was reported that flammable liquids were dispersed onto the ground, into a shallow pit, onto a discarded airplane fuselage, and/or into a tank and ignited for these exercises. There are no records identifying the type of materials used during these training exercises (NASA, 2007).

Environmental investigations at the FFTA began in 1986 when an inspection identified an unlined pit with substances thought to be jet fuel and crankcase oil. NASA removed approximately 120 cubic yards of contaminated soil in November 1986. Several investigations/reports followed including:

- 1989-1990 - Preliminary Assessment (PA) and Site Inspection (SI) (Ebasco, 1990)
- 1993-1994 – Remedial Investigation (RI) (Metcalf and Eddy, 1996)
- 2000 – Supplemental Groundwater Investigation
- 2003 – Supplemental RI (NASA, 2004)
- 2005 – Feasibility Study (FS) (NASA, 2005)
- 2007 – Proposed Remedial Action Plan (PRAP) (NASA, 2007a) and Record of Decision (ROD) (NASA, 2007b)

- 2008-2009 – Pilot Study (NASA, 2009)
- 2009-Present – LTM and associated reports

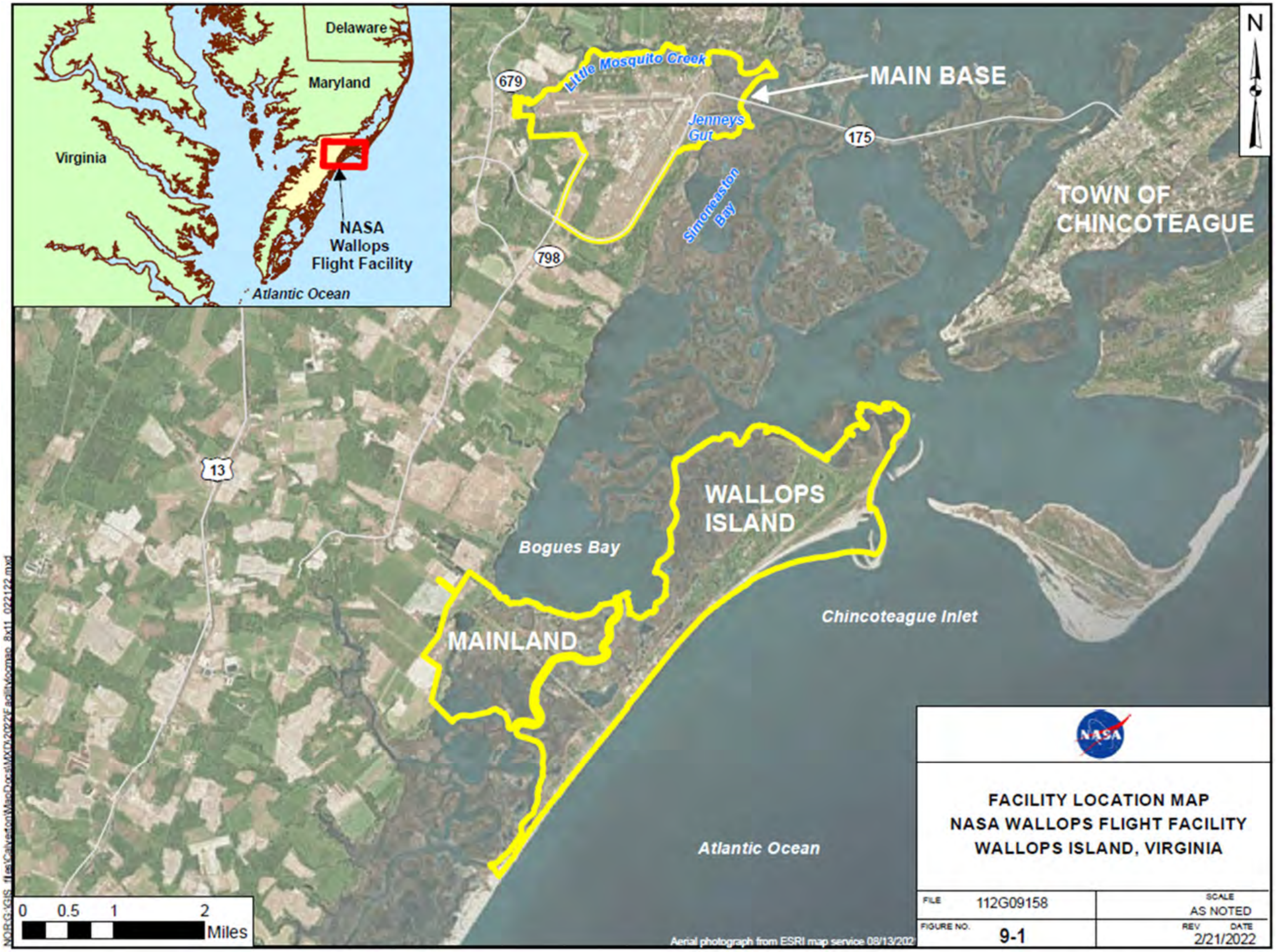
The ROD established cleanup goals for the seven constituents of concern (COCs) based on analytical data, risk drivers from the human health and ecological risk assessments, and exceedances of regulatory standards and criteria. Four of these COCs have been removed from the FFTA LTM program because they achieved their respective cleanup goals. The COCs, cleanup goals, and whether they continue to be monitored or have been removed from the FFTA LTM Program (and associated date) are provided below:

- benzene - 5 micrograms per liter (µg/L)
    - cleanup goal achieved and removed from monitoring starting in December 2018
- cis-1,2-dichloroethene - 70 µg/L
    - cleanup goal achieved and removed from monitoring starting in September 2013
- vinyl chloride - 2 µg/L
    - cleanup goal achieved and removed from monitoring starting in September 2013
- 4-methylphenol - 27 µg/L
    - cleanup goal achieved and removed from monitoring starting in June 2021
- naphthalene - 16 µg/L
    - continued monitoring
- arsenic - 10 µg/L
    - continued monitoring
- manganese - 124 µg/L
    - continued monitoring

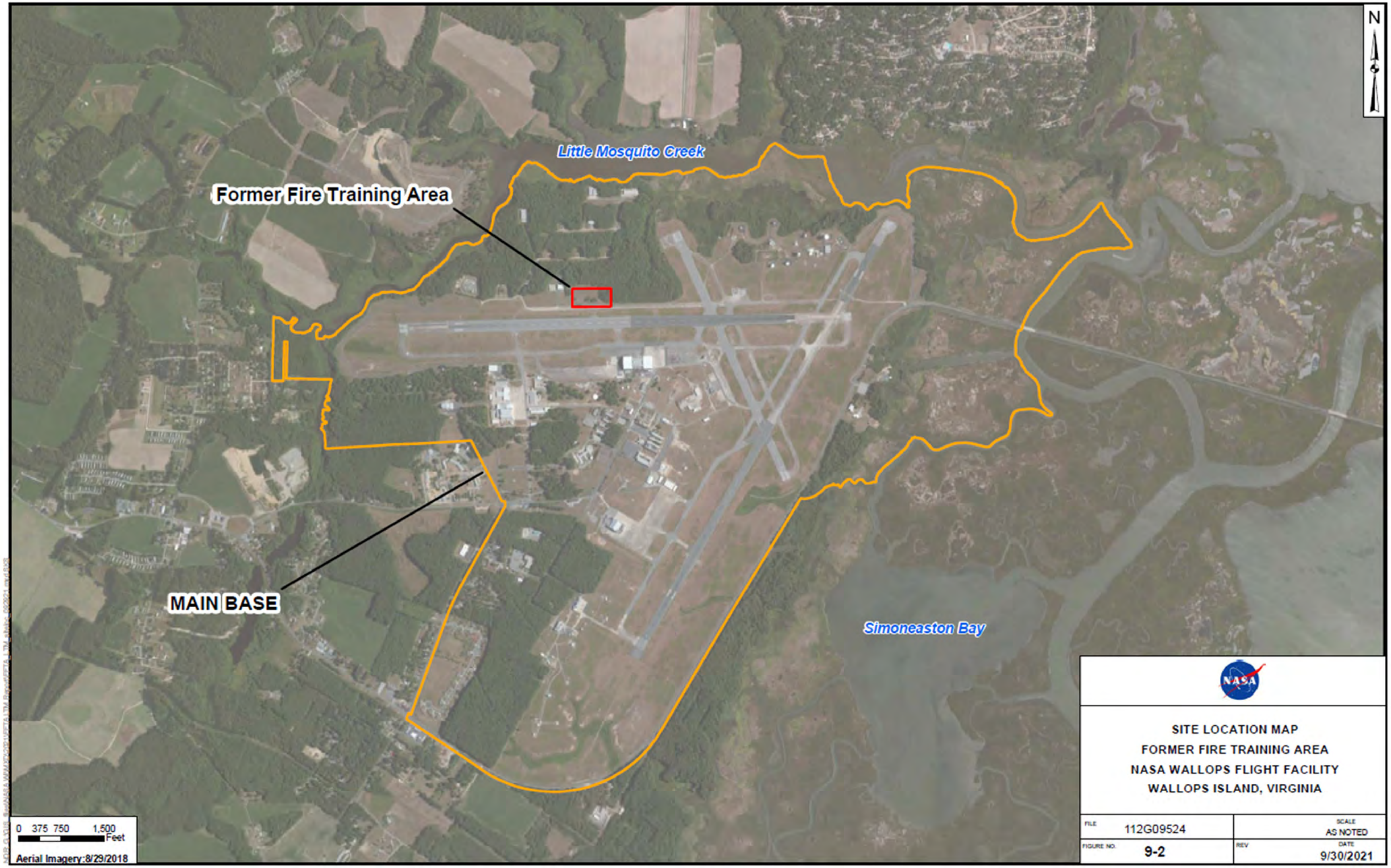
The sampling frequency of the FFTA LTM Program was reduced from every 9 months to every 15 months after the December 2018 event (NASA, 2019).

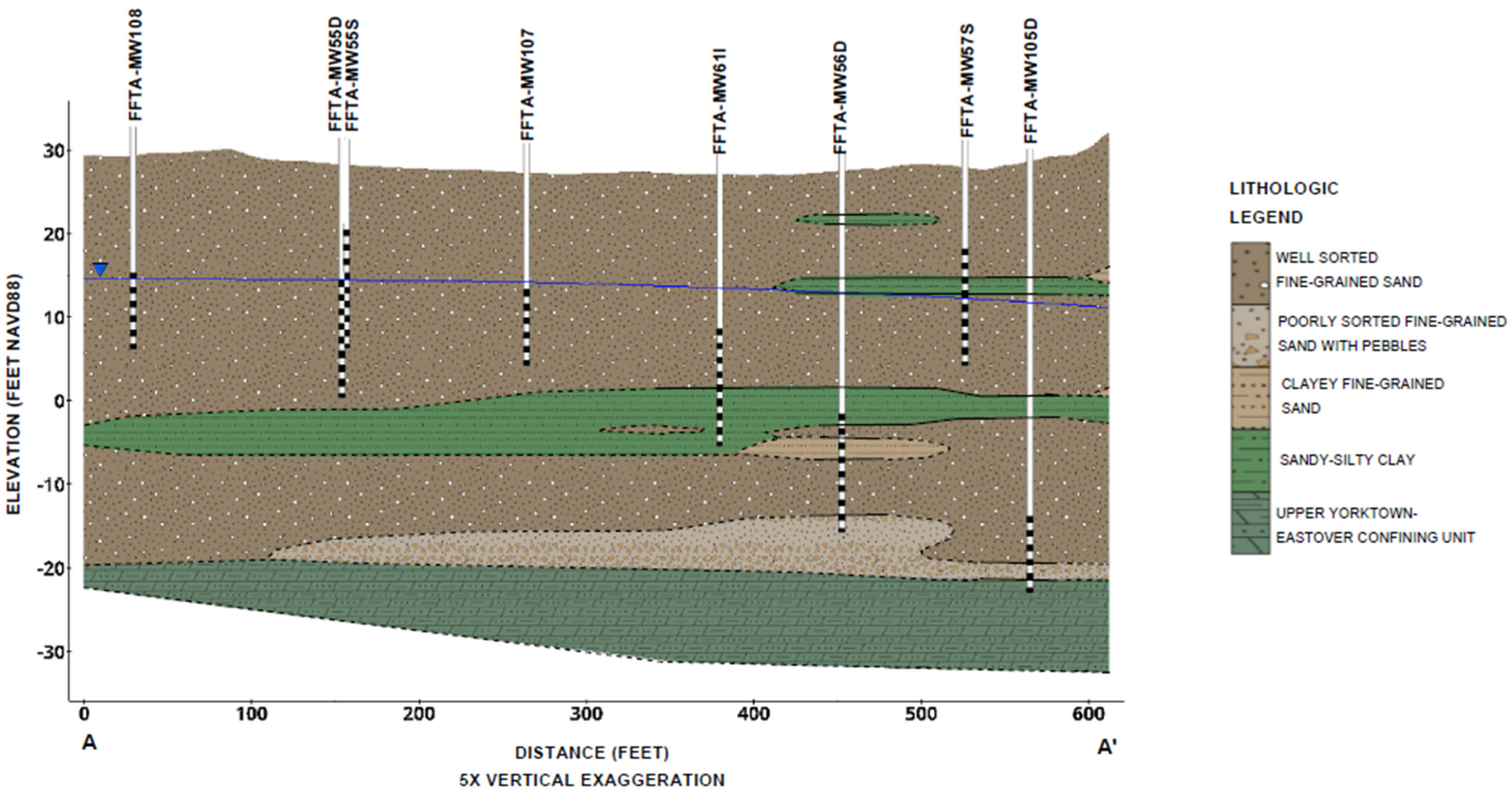
During the June 2021 groundwater monitoring event, samples were collected from 11 monitoring wells and analyzed for the three COCs – naphthalene, arsenic, and manganese (NASA, 2021a). Concentrations exceeded the cleanup goal for naphthalene in one well, arsenic in four wells, and manganese in six wells (**Figure 9-5**). In total, samples from seven monitoring wells had concentrations that exceeded at least one COC. The results were generally consistent with the results from previous monitoring events. The data indicate that concentrations have generally decreased and appear to have reached or are nearing stabilization, with one exception. Total arsenic concentrations detected in samples from FFTA-MW107 are trending up (less than 10 µg/L in 2010 and around 40 µg/L in June 2021).

Four wells (FFTA-MW102D, FFTA-MW105D, FFTA-MW106, and FFTA-MW108) were recommended to be removed from the FFTA LTM Program starting in September 2022 (NASA, 2021a). This recommendation was subsequently approved by the USEPA and VDEQ.



FACILITY LOCATION MAP
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

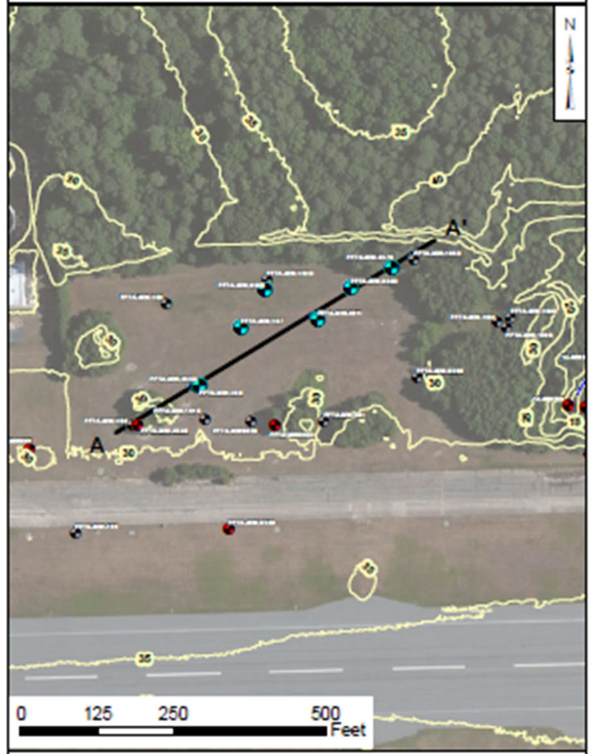

N
Little Mosquito Creek
Former Fire Training Area
MAIN BASE
Simoneaston Bay
NASA
SITE LOCATION MAP
FORMER FIRE TRAINING AREA
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
FILE
112G09524
SCALE
AS NOTED
FIGURE NO.
9-2
REV
DATE
9/30/2021
0 375 750 1,500
Feet
Aerial Imagery:8/29/2018



**Legend**

- Monitoring Well - included in the LTM Program
- Monitoring Well - not included in the LTM Program
- Monitoring Well - abandoned
- Cross-Section Transect
- Potentiometric Surface
- 2010 Lidar Contours

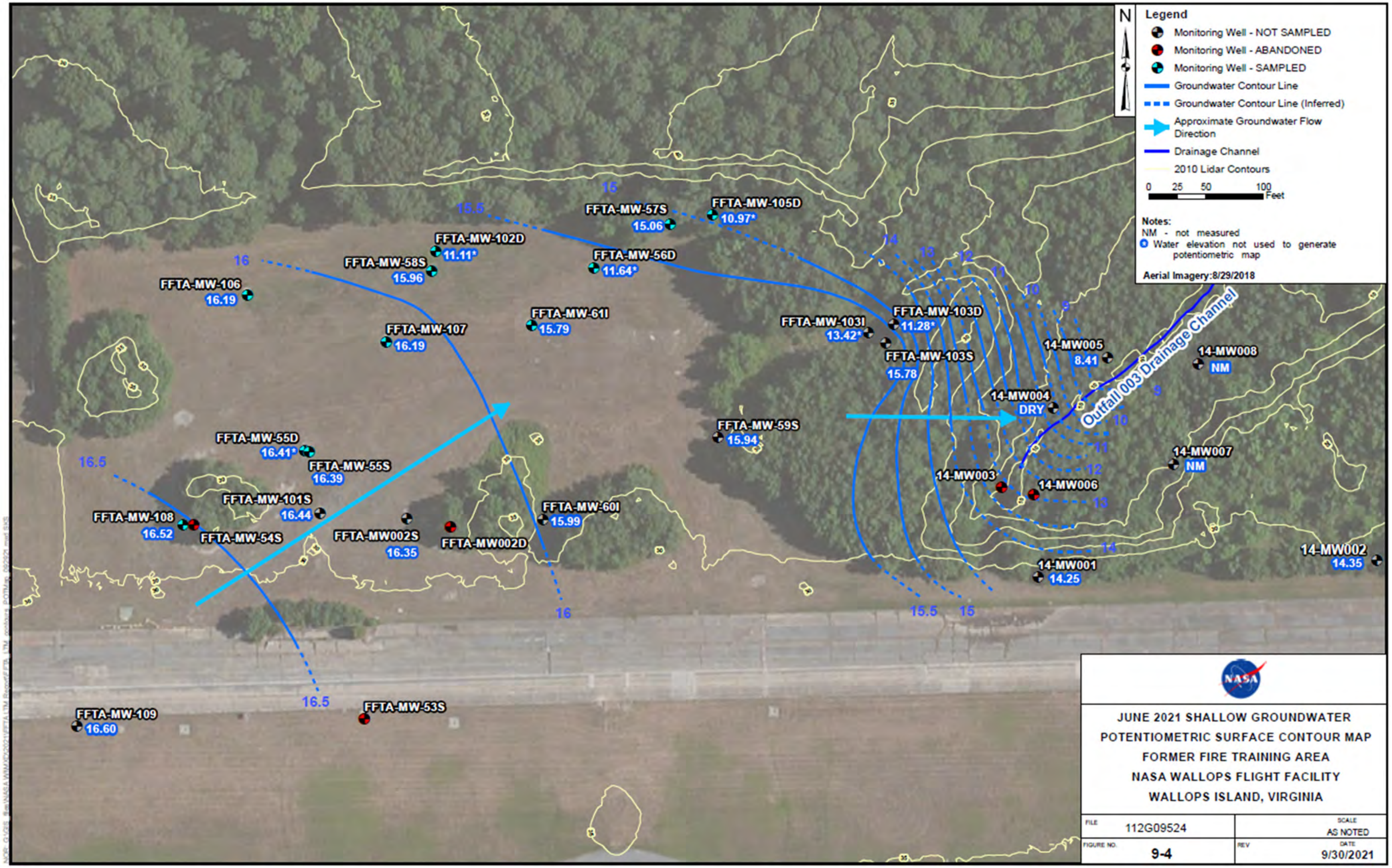
Aerial Imagery:8/29/2018

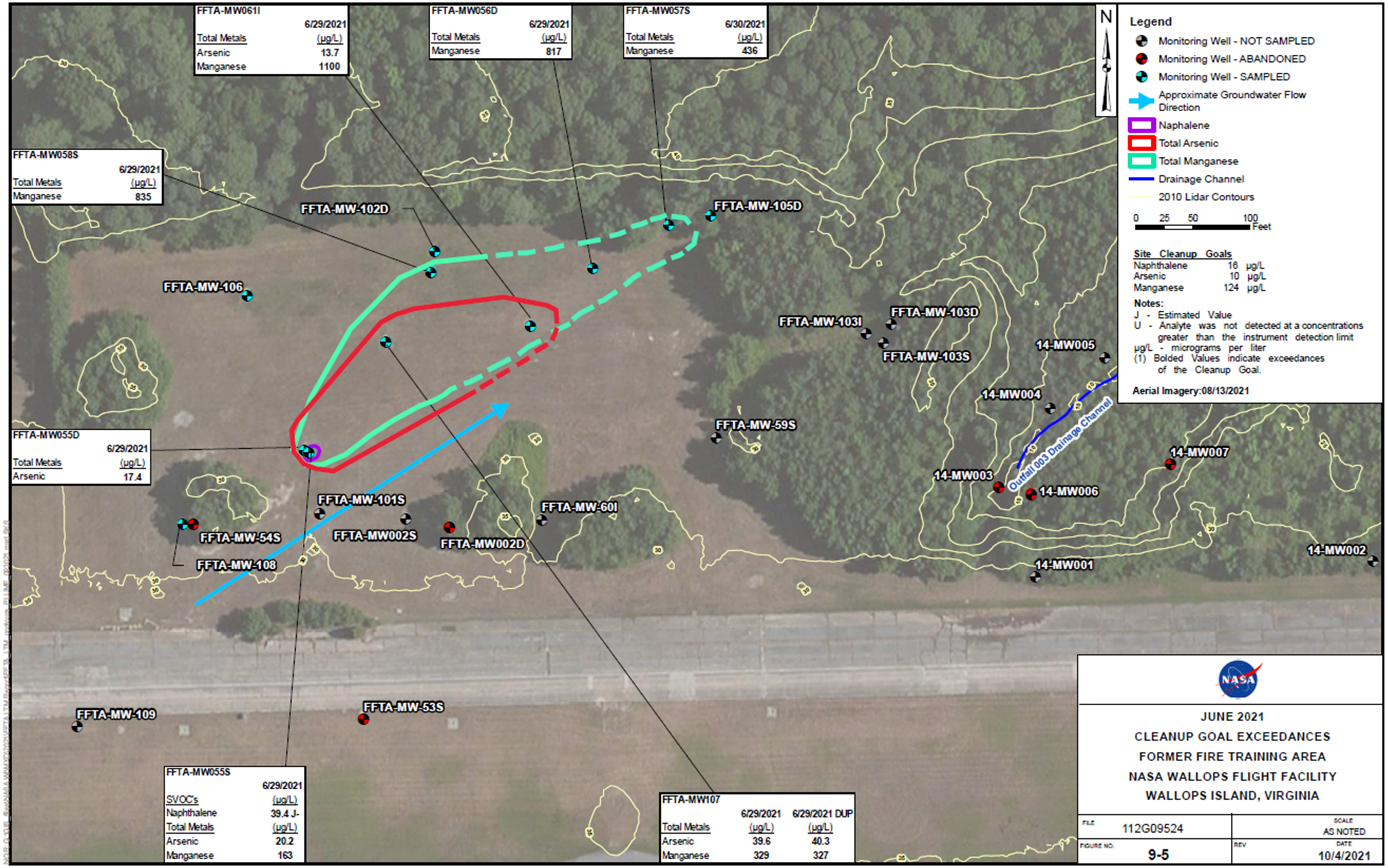


LITHOLOGIC CROSS-SECTION
FORMER FIRE TRAINING AREA
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

| | |
|---|---|
| FILE 112G09524 | SCALE AS NOTED |
| FIGURE NO. 9-3 | REV |
| | DATE 5/13/2022 |

NOR G:\GIS_files\NASA WWMXD\2022\FFTA LTM SAP\FFTA_Cross_section_A-A_051322.mxd SKS


N
Legend
Monitoring Well - NOT SAMPLED
Monitoring Well - ABANDONED
Monitoring Well - SAMPLED
Groundwater Contour Line
Groundwater Contour Line (Inferred)
Approximate Groundwater Flow Direction
Drainage Channel
2010 Lidar Contours
0 25 50 100 Feet
Notes:
NM - not measured
Water elevation not used to generate potentiometric map
Aerial Imagery:8/29/2018
FFTA-MW-106
16.19
FFTA-MW-58S
15.96
FFTA-MW-102D
11.11*
FFTA-MW-57S
15.06
FFTA-MW-105D
10.97*
FFTA-MW-56D
11.64*
FFTA-MW-107
16.19
FFTA-MW-61I
15.79
FFTA-MW-103I
13.42*
FFTA-MW-103D
11.28*
FFTA-MW-103S
15.78
14-MW005
8.41
14-MW008
NM
14-MW004
DRY
Outfall 003 Drainage Channel
FFTA-MW-59S
15.94
FFTA-MW-55D
16.41*
FFTA-MW-55S
16.39
FFTA-MW-101S
16.44
FFTA-MW-108
16.52
FFTA-MW-54S
FFTA-MW002S
16.35
FFTA-MW002D
FFTA-MW-60I
15.99
14-MW003
14-MW006
14-MW007
NM
14-MW001
14.25
14-MW002
14.35
FFTA-MW-109
16.60
FFTA-MW-53S
15.5
15
16
16.5
14
13
12
11
10
9
JUNE 2021 SHALLOW GROUNDWATER
POTENTIOMETRIC SURFACE CONTOUR MAP
FORMER FIRE TRAINING AREA
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA
FILE 112G09524
SCALE AS NOTED
FIGURE NO. 9-4
REV
DATE 9/30/2021



**FFTA-MW061I**

| Total Metals | 6/29/2021 (µg/L) |
|---|---|
| Arsenic | 13.7 |
| Manganese | 1100 |

**FFTA-MW056D**

| Total Metals | 6/29/2021 (µg/L) |
|---|---|
| Manganese | 817 |

**FFTA-MW057S**

| Total Metals | 6/30/2021 (µg/L) |
|---|---|
| Manganese | 436 |

**FFTA-MW058S**

| Total Metals | 6/29/2021 (µg/L) |
|---|---|
| Manganese | 835 |

**FFTA-MW055D**

| Total Metals | 6/29/2021 (µg/L) |
|---|---|
| Arsenic | 17.4 |

**FFTA-MW055S**

| | 6/29/2021 |
|---|---|
| SVOC's | (µg/L) |
| Naphthalene | 39.4 J- |
| Total Metals | (µg/L) |
| Arsenic | 20.2 |
| Manganese | 163 |

**FFTA-MW107**

| Total Metals | 6/29/2021 (µg/L) | 6/29/2021 DUP (µg/L) |
|---|---|---|
| Arsenic | 39.6 | 40.3 |
| Manganese | 329 | 327 |

**Legend**

- ● Monitoring Well - NOT SAMPLED
- ● Monitoring Well - ABANDONED
- ● Monitoring Well - SAMPLED
- ➔ Approximate Groundwater Flow Direction
- ▭ Naphalene
- ▭ Total Arsenic
- ▭ Total Manganese
- ― Drainage Channel
- ― 2010 Lidar Contours

**Site Cleanup Goals**

| | | |
|---|---|---|
| Naphthalene | 16 | µg/L |
| Arsenic | 10 | µg/L |
| Manganese | 124 | µg/L |

**Notes:**

J - Estimated Value
U - Analyte was not detected at a concentrations greater than the instrument detection limit
µg/L - micrograms per liter
(1) Bolded Values indicate exceedances of the Cleanup Goal.

**Aerial Imagery:08/13/2021**

JUNE 2021
CLEANUP GOAL EXCEEDANCES
FORMER FIRE TRAINING AREA
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

| | |
|---|---|
| FILE 112G09524 | SCALE AS NOTED |
| FIGURE NO. 9-5 | REV DATE 10/4/2021 |

# SAP Worksheet #10 Project Quality Objectives/Systematic Planning Process Statements

(UFP-QAPP Manual Section 2.6.1- Worksheet #10)

## 10.1 PROBLEM STATEMENT

Before the LTM program was implemented, a groundwater contaminant plume (primarily defined by the presence of volatile organic compounds [VOCs]) was identified at the FFTA. The plume was essentially confined to the upper flow unit of the Columbia aquifer with the presence of a silty clay lens (interstitial clay) controlling contaminant migration and groundwater flow.

A summary of the site history is provided in **Section 9.5**. The groundwater COCs currently included in the FFTA LTM program are naphthalene, arsenic, and manganese (NASA, 2021a).

This LTM Plan - Rev. 4 details the activities required to document the reduction of COC concentrations and to determine when the cleanup goals identified in the ROD are met.

Per-and polyfluoroalkyl substances (PFAS) are present in soil and groundwater at the FFTA but are being investigated under separate ongoing projects and, therefore, are not included in FFTA LTM Plan – Rev. 4. A UFP-Quality Assurance Project Plan (QAPP) for PFAS at NASA WFF (NASA, 2021b) and several other reports document the details of these investigations.

## 10.2 INFORMATION INPUTS

To address the problem statement, the information described in the following subsections is required.

### *10.2.1 Screening Levels*

Groundwater

The groundwater cleanup goals established in the ROD serve as the Project Action Limits (PAL) for the FFTA LTM Program.

- Naphthalene - 16 µg/L (noncancer risk based on target organ hazard index [HI] of 0.5)
- Arsenic - 10 µg/L (EPA Maximum Contaminant Level [MCL])
- Manganese - 124 µg/L (noncancer risk based on target organ HI of 0.5)

### *10.2.2 Depths to Groundwater*

Water level measurements will be collected using a water level meter to a precision of 0.01 foot at existing well locations at the FFTA (**Section 12.2.6**). These data measurements will be used to evaluate changes in groundwater elevation, flow direction, migration of COCs, and whether any modifications to the FFTA LTM program are needed.

### *10.2.3 Field Measurements*

Measurements of field parameters (temperature, dissolved oxygen [DO], pH, specific conductance, oxidation-reduction potential [ORP], and turbidity) will be recorded at each groundwater sampling location to determine when low-flow groundwater purge stabilization has been completed and the well water is representative of the surrounding groundwater. These measurements will be collected using a water quality multimeter, an independent turbidity meter, and a field test kit for DO (to confirm final DO readings) (**Section 12.2.5**).

### *10.2.4 Analytical Data*

Analytical methods and parameters are referenced in **Worksheet #13** and **Worksheet #16**. Currently, only three COCs remain a part of the FFTA LTM Program – naphthalene, arsenic, and manganese (**Section 9.5)**.

## 10.3 STUDY BOUNDARIES

The following paragraphs provide a description of the general study area boundaries. These boundaries may change based on conditions encountered in the field or based on the results of continued monitoring or other ongoing investigations. Deviations will be documented with a FTMR form.

Currently, groundwater is the only media included in the FFTA LTM Program. Soil was previously addressed. Surface water and sediment are not present at the FFTA. The Outfall 003 Drainage Channel, east of the FFTA has not been affected by COCs that are present in shallow groundwater.

The groundwater population of primary interest is shallow groundwater located at or downgradient of the FFTA. Groundwater wells screened in the shallow, unconfined Columbia aquifer (i.e., above the interstitial clay layer [26-29 feet bgs]) will be included in the FFTA LTM Program based on their location and previous chemical data. **Figure 9-4** shows the FFTA boundaries, monitoring well locations, and an interpretation of groundwater flow. **Figure 9-5** presents the cleanup goal exceedances for groundwater during the June 2021 LTM event.

## 10.4 ANALYTIC APPROACH

The following decision rules were developed to guide decision making for the FFTA LTM Program. The Project Team will evaluate the data and develop a path forward that is protective of human health and the environment.

- **Decision Rule 1**: Continue monitoring groundwater concentrations in the seven monitoring wells as recommended in the *Data Summary Report, June 2021 Groundwater Monitoring* (NASA, 2021a) on a 15-month schedule as long as concentrations exceed the PALs for arsenic, manganese, or naphthalene.
- **Decision Rule 2:** If concentrations of arsenic, manganese, and naphthalene are detected below their respective PALs in groundwater samples collected from a monitoring well for four consecutive monitoring events; then NASA will recommend the well be removed from the FFTA LTM Program but not be abandoned due to ongoing PFAS investigations at the FFTA.
- **Decision Rule 3:** If a specific COC (arsenic, manganese, or naphthalene) are detected at concentrations below their respective PALs in samples from each monitoring well for four consecutive events, then NASA will recommend the specific COC be removed from the FFTA LTM Program.

- **Decision Rule 4:** If groundwater concentrations at the FFTA are stable or decreasing per Mann Kendall analysis, then NASA will convene with the EPA and VDEQ to determine whether the 15-month monitoring schedule should be modified.
- **Decision Rule 5:** If groundwater concentrations at the FFTA are below each COC's PAL (drinking water standards or risk-based cleanup goals) for four consecutive events, then NASA will convene with the EPA and VDEQ to determine whether the sampling program can be discontinued.
- **Decision Rule 6**: If concentrations of any COC at a monitoring well on the perimeter of the network substantially increase over two consecutive sampling events, NASA will convene the EPA and VDEQ to evaluate the increased concentrations and determine if changes to the sampling protocol are recommended. Possible out-of-cycle resampling may be conducted on a case-by-case basis.

## 10.5 PERFORMANCE CRITERIA

The Project Team will use the results of this investigation to determine whether the quantity and quality of data collected are sufficient to support the attainment of project objectives and to determine if further monitoring is required. Sensitivity criteria for laboratory-generated data are the analysis specific laboratory method detection limits (MDL) for target analytes listed in **Worksheet #16**.

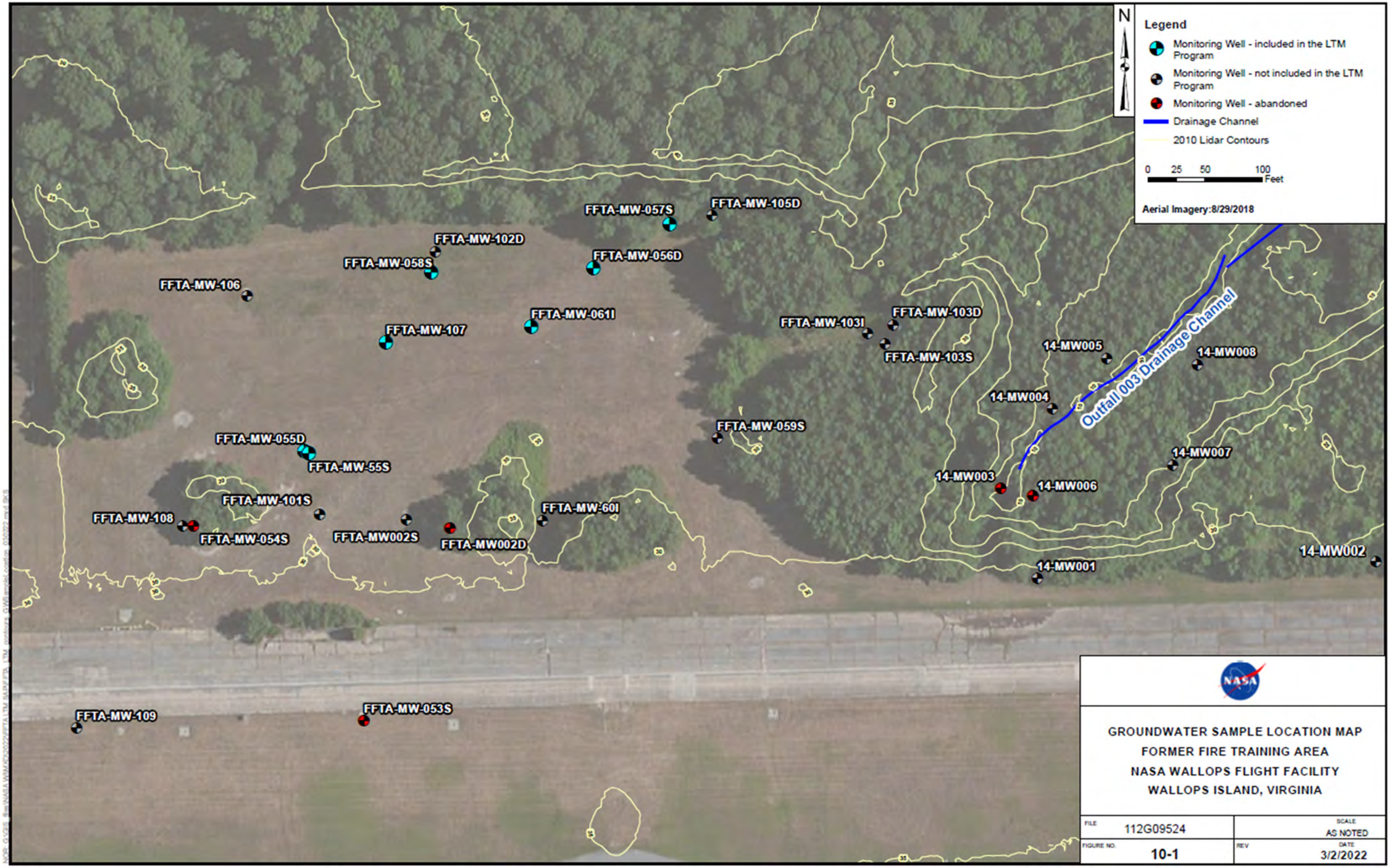
The data quality will be reviewed to ensure that performance criteria have been met and that the data are sufficient for decision-making purposes. If all data are collected as planned and no data points are missing or rejected for quality reasons, then the investigation completeness will be satisfactory. If any data gaps are identified, including missing or rejected data, the Project Team will assess whether a claim of having achieved project objectives is reasonable based on the quantity and types of data gaps. Project Team members will be involved in rendering the conclusion by consensus regarding adequacy of the data.

To limit uncertainty in the field and laboratory data, performance criteria for field collection and laboratory analysis will be measured. Performance criteria are described in **Worksheets #11, 16, and 18.** In addition, standardized procedures for sampling and analysis will be used. Use of these standardized protocols and adherence to this SAP are designed to minimize uncertainties in decision making.

## 10.6 SAMPLING DESIGN

The general data collection plan is included in **Worksheet #13** and is detailed in this SAP.

The proposed groundwater sampling locations (**Figure 10-1**) were selected based on available chemical and physical (geologic and hydrogeologic) data. The current approach will be modified based on the decision rules presented in **Section 10.4.**



GROUNDWATER SAMPLE LOCATION MAP
FORMER FIRE TRAINING AREA
NASA WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

| | |
|---|---|
| FILE 112G09524 | SCALE AS NOTED |
| FIGURE NO. 10-1 | REV DATE 3/2/2022 |

## SAP Worksheet #11 Field Quality Control Samples

(UFP-QAPP Manual Section 2.6.2-Worksheet #12)

| Quality Control (QC) Sample | Analytical Group | Frequency | Data Quality Indicators (DQIs) | Measurement Performance Criteria (MPC) |
|---|---|---|---|---|
| Field Duplicates | Naphthalene<br>Arsenic and Manganese (Total and Dissolved) | 1 per 10 field samples | Precision | If both the original and duplicate results are ≥ 2x reporting limit, Relative Percentage Difference (RPD) must be ≤ 30% for aqueous samples.<br>If either the original or duplicate result is < 2x reporting limit (±30%), use professional judgment. |
| Cooler Temperature Indicator | Naphthalene<br>Arsenic and Manganese (Total and Dissolved) | 1 per cooler | Representativeness | Temperature must be between 0 and 6 degrees Celsius (°C), but samples must not be frozen. |
| Matrix Spike (MS) | Naphthalene<br>Arsenic and Manganese (Total and Dissolved) | 1 per 20 discrete field samples collected | Accuracy/Bias | See **Worksheet #18**. |
| Matrix Spike Duplicate (MSD) | Naphthalene<br>Arsenic and Manganese (Total and Dissolved) | 1 per 20 discrete field samples collected | Accuracy/Bias and precision | See **Worksheet #18.** |

## SAP Worksheet #12 Summary of Project Tasks

(UFP-QAPP Manual Section 2.8.1-Worksheet #14)

### 12.1 LONG TERM MONITORING TASK PLAN

The following is a list of field tasks that will be performed for LTM Task. A short description of each task is provided under **Section 12.2.**

- Mobilization/Demobilization and Safety Training
- Equipment Calibration
- Groundwater Sample Collection
- Water Level Measurements
- Field Decontamination Procedures
- Investigation-Derived Waste (IDW) Management
- Field Documentation Procedures

The following is a list of additional project-related analytical and reporting tasks that will be completed as part of this investigation. A short description of each task is provided under **Section 12.3**.

- Analytical Tasks
- Data Handling and Management
- Data Tracking
- Data Storage, Archiving, and Retrieval
- Data Security
- Electronic Data
- Data Review and Validation
- Project Reports

Tetra Tech Standard Operating Procedures (SOPs) and field forms for field tasks referenced in this section are identified by title in **Worksheet #14**, and copies of applicable SOPs are provided in **Appendix A**. Field activities will be conducted in accordance with Tetra Tech SOPs. Field sampling equipment, including water level indicators, submersible pumps, and other nondedicated equipment used at each sample location will be decontaminated between uses.

### 12.2 FIELD TASKS

A summary of each field task is provided in the following sections.

### *12.2.1 Mobilization/Demobilization and Safety Training*

Mobilization will consist of the delivery of equipment, materials, and supplies to the site, the complete assembly in satisfactory working order of such equipment at the site, and the satisfactory storage at the site of such materials and supplies.

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

- Documents, field forms, logbooks, log sheets, labels, custody seals, air bills, and other paperwork required by the SAP and HASP.
- Vehicles for personnel, equipment, and sample transport.
- Personnel, supplies, and equipment (e.g., bottleware and personal protective equipment [PPE]) required by the SAP and HASP.
- Required sample containers.
- Equipment and supplies for sample custody, preservation, and packaging.
- Other miscellaneous office and field supplies.

Project-specific health and safety training for all Tetra Tech field staff and subcontractors, as applicable, will be provided as part of site mobilization and included in the HASP. During the required training and orientation, field team members will review the SAP and will be given any project-specific health and safety training based on the HASP. Field personnel must review and sign the HASP. The SSHO will be responsible for reviewing the HASP with field team members.

The Tetra Tech FOL or designee will coordinate with the Facility POC, Ms. Susan Dunn, verbally or via email at least one week prior to commencement of field work to arrange for access to the site and to identify appropriate locations for the temporary storage of equipment and supplies.

Demobilization will consist of the prompt and timely removal of all equipment, materials, and supplies from the site following completion of the work. Demobilization includes the cleanup and removal of IDW generated during each sampling event. Upon demobilization, field documentation will be filed and docketed in the project file.

### *12.2.2 Equipment Calibration*

Field equipment will be calibrated at the beginning of each day, unless otherwise stated by the equipment manufacturer or if problems are noted in the field. These procedures are described in **Worksheet #15**.

### *12.2.3 Well Inspection*

Field inspections will be performed on the monitoring wells included in the FFTA LTM Program (**Figure 10-1** and **Worksheet #13**) to identify any well integrity issues that could prevent the collection of representative groundwater samples. Before going into the field, well construction records and other relevant information (e.g., groundwater sample logs showing high turbidity or suspended particulates) will be reviewed. In the field, the condition of each well be assessed including (but not limited to) the protective casing, concrete pad, riser pipe, compression cap, and lock. Each well will be gauged to determine its total depth and water level. If these depths are significantly different than what was originally or previously measured, it may indicate that the screen, riser, and/or sump were compromised, which could allow formation material or other debris to enter the well. Well development may be needed to clear out the accumulated fines, or if the well has deteriorated enough, the well may need to be abandoned and replaced with a new well during a subsequent event. Coordination with the USEPA and VDEQ will be conducted before any existing well is abandoned or any new well is installed and included in the sampling plan.

Well inspection procedures are detailed in Tetra Tech SOP GH-1.2 (**Appendix A**).

### *12.2.4 Well Development*

The purpose of well development is to remove silt, clay, and other fine sediments from the well and ensure representative aquifer connectivity. If a well shows signs of being silted in, elevated turbidities, or the presence of particulates; well development may recondition the well so a representative groundwater sample can be collected. It is possible that a well is in such poor condition that well development may not be enough and well replacement may need to be evaluated during a subsequent event. Coordination with the USEPA and VDEQ will be conducted before any existing well is abandoned because PFAS investigations are ongoing at the FFTA.

If required, development will consist of using a small diameter submersible pump and/or a check valve/surge block assembly to surge and pump out groundwater from the well. Disposable high-density polyethylene (HDPE) tubing will be used during development activities. Total well depth and water level measurements will be collected before and after well development. Water quality parameters, total volume purged, visual observations, and other pertinent observations will be recorded during development activities. Development will be considered complete once water quality parameters stabilize and the target turbidity of 10 nephelometric turbidity units (NTU) is achieved, or after two hours if parameters do not stabilize. The monitoring wells will be allowed to stabilize a minimum of one day after development before groundwater sampling can occur. Well development activities will be conducted in accordance with Tetra Tech SOP GH-2.8 (**Appendix A**).

Development water will be containerized and managed as IDW (**Section 12.2.8**).

A Monitoring Well Development Record form will be used to document well development activities, as mentioned in SOP SA-6.3 (**Appendix A**).

### *12.2.5 Groundwater Sample Collection*

For the September 2022 FFTA LTM sampling event, groundwater samples will be collected from seven monitoring wells (**Worksheet #13** and **Figure 10-1**). During subsequent sampling events, the number of monitoring wells included in the FFTA LTM Program may change depending on the analytical results and the decision rules outlined in **Section 10.4**. A sample log sheet will be created to document the details of each sample. Groundwater sampling activities will be conducted in accordance with Tetra Tech SOP SA-1.1 (**Appendix A**).

Groundwater samples will be analyzed for naphthalene and arsenic and manganese (total and dissolved), see **Worksheet #13** for the specific methods. PALs are provided in **Worksheet #16**.

Prior to sampling, if tubing is present in an existing monitoring well it may be removed (depending on its material type and condition) and replaced with new HDPE and silicone tubing. The wells will be purged and sampled with a peristaltic or submersible (i.e., monsoon) pump using low-flow purging techniques. Water quality parameters and water level measurements will be monitored and recorded on field log forms during sampling activities. Sampling may be conducted once three consecutive readings, taken at 5 to 10-minute intervals, are within the following limits:

- pH ±0.2 standard units
- Specific conductance ±10%
- Temperature ±10%
- Turbidity less than 10 NTUs
- DO ±10%
- ORP ±10%

If the above conditions are not met after two hours, purging will be considered complete and sampling may begin.

IDW that is generated during sampling will be containerized and managed (**Section 12.2.8**).

### *12.2.6 Water Level Measurements*

Water level measurements will be collected from approximately 22 monitoring wells at the FFTA. The exact number of wells may change if additional wells are installed or existing wells are abandoned. Water level measurements will be measured following the procedures outlined in Tetra Tech SOP GH-1.2 (**Appendix A**). Groundwater elevation data will be used to generate potentiometric surface maps to determine groundwater flow patterns and gradients, the procedures for which are detailed in Tetra Tech SOP GH-2.5 (**Appendix A)**. Water level measurements will be completed within the shortest time possible on the same day, and no sooner than 24 hours after a significant precipitation event to minimize the effects of precipitation on the data. Water level measurements will be recorded to the nearest 0.01 foot and referenced to a top of casing notch or north side of the well casing. The water level meter will be decontaminated prior to conducting the measurement and between wells.

### *12.2.7 Decontamination*

Decontamination will be required for all reusable sampling/measuring equipment to prevent transferring potential contaminants to other locations or samples. Equipment will be decontaminated with a non-phosphate detergent scrub followed by a water rinse. The water used to decontaminate the tooling and equipment will be NASA potable water and all fluids generated during decontamination will be contained and managed as IDW (**Section 12.2.8**).

Decontamination procedures are detailed in Tetra Tech SOP SA-7.1 (**Appendix A**).

### *12.2.8 Investigation Derived Waste Management*

IDW will consist of decontamination water, development water, and purge water. IDW will be containerized in 55-gallon drums or a bulk storage container, properly labeled, sampled, and characterized. Building B-29 will serve as the temporary IDW storage location for the Main Base, until it is treated onsite or transported and disposed of at an approved offsite facility. The specific IDW analytical requirements for waste characterization will be dependent on the actual disposal facility requirements and NASA policies. IDW disposal will be coordinated by NASA.

Due to high PFAS concentrations detected in groundwater samples collected at the FFTA, the aqueous IDW will be treated with the portable onsite granular activated carbon (GAC) treatment system to remove PFAS. Confirmation samples will be collected to confirm whether the water was effectively treated before it is discharged to the WFF wastewater system. The discharge of treated water will be performed in a controlled manner to prevent negatively impacting the wastewater treatment plant (WWTP) operations. The treatment of aqueous IDW will be coordinated by Tetra Tech. Details on the operation of the onsite portable GAC treatment system and collection of confirmation samples are included in Section 4.9 of the UFP-QAPP for PFAS investigations at WFF (NASA, 2021b).

Used PPE (i.e., nitrile gloves), tubing, and general refuse will be bagged and disposed of as general trash.

### *12.2.9 Documentation*

Sample log sheets will be maintained for each sample collected. In addition, sample collection information will be recorded in bound field notebooks or on specific field forms. Samples will be packaged and shipped according to Tetra Tech SOP SA 6.1 (**Appendix A**).

A summary of field activities will be properly recorded in a bound logbook with consecutively numbered pages. Logbooks will be assigned to field personnel and stored in a secured area when not in use. Logbooks will be maintained in accordance with Tetra Tech SOP SA-6.3 (**Appendix A**).

Entries will be written in ink. No erasures will be made. If an incorrect entry is made, striking a single line through the incorrect information will mark the correction. The person making the correction will then initial, date, and provide the corrected entry. Sampling forms and other field forms will also be used to document field activities.

## 12.3 ANALYTICAL AND REPORTING TASKS

The following is a list of analytical and data management/reporting tasks**.**

### *12.3.1 Analytical Tasks*

Chemical analyses will be performed by SGS in Orlando, Florida. SGS has been accredited to conduct the analyses required by this SAP by the Commonwealth of Virginia. A copy of SGS's accreditation is provided in **Appendix B**. Analyses for naphthalene and arsenic and manganese (total and dissolved) will be performed in accordance with the analytical methods specified in **Worksheet #13**. The laboratory will perform chemical analysis following laboratory-specific SOPs (**Worksheet #17**) based on the analytical methods listed in **Worksheet #13**. Laboratory data will be delivered to Tetra Tech in the form of an Electronic Data Deliverable (EDD) and portable document format (PDF) data package. This information will be captured in the project database that will be uploaded upon completion of the report.

### *12.3.2 Data Handling and Management*

After each sampling event is completed, the field sampling log sheets will be organized by date and medium and filed in the project files. The field logbooks for this project will be used only for this facility and will also be categorized and maintained in the project files after completion of the field program. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity. Prior to placement in the project files, the logbook pages will be scanned electronically. The data handling procedures to be followed by the laboratory will meet the requirements of the laboratory technical specification. The electronic data will be automatically downloaded into the Tetra Tech database in accordance with proprietary Tetra Tech processes.

### *12.3.3 Data Tracking*

Data will be tracked from generation to archiving in the project-specific files. The Tetra Tech QAM/Project Chemist (or designee) is responsible for tracking the samples collected and shipped to the contracted analytical laboratory. Upon receipt of the data packages from the analytical laboratory, the project chemist will coordinate the data validation effort, which includes verifying that the data packages are complete and that results for all samples have been delivered by the analytical laboratory.

### *12.3.4 Data Storage, Archiving, and Retrieval*

After the data are validated, the data packages are entered into the Tetra Tech file system and archived in secure files. The field records including field logbooks, sample log sheets, and chain-of-custody records will be submitted by the Tetra Tech FOL to be entered into the Tetra Tech file system prior to archiving in secure project files. As documents are finalized, all relevant data and records will be uploaded electronically to the project database and retained there indefinitely.

### *12.3.5 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.

### *12.3.6 Electronic Data*

One hundred percent (100%) of the laboratory data (electronic and PDF report) will be validated in accordance with specifications in **Worksheet #19**, and qualifiers will be manually added to the database. Data will then be compiled and loaded into the project database. This process includes a QA review of the data to ensure that the content and format of the data satisfy Tetra Tech requirements.

### *12.3.7 Data Review and Validation*

Data verification, validation, and usability assessment processes are described on **Worksheet #19**.

### *12.3.8 Project Reporting*

After completion of the data review and resolution of any anomalies (should they occur), project-specific reports will be prepared to present the results of the investigations and satisfy data quality objectives, as identified in **Worksheet #10**. The draft reports will be submitted to the NASA RPM for initial review, and NASA comments will be addressed. After NASA approves the edits, the reports will be submitted to the EPA and VDEQ for review and comment. If the EPA or VDEQ provide comments, a response-to-comments table and a redline version of the text will detail the proposed changes. Once these changes are approved, a final report will be generated and sent to the EPA and VDEQ.

## SAP Worksheet #13 Sample Details Table

(UFP-QAPP Manual Section 2.8.1-Worksheets #18,19,20 and 30)

| | | |
|---|---|---|
| **FFTA**<br>**Wallops Flight Facility,**<br>**Wallops Island, Virginia**<br>**(Tentative Sampling Dates – September 2022 and then on a 15-month schedule)** | **Analysis Group** | Naphthalene, Arsenic (total and dissolved), Manganese (total and dissolved) |
| | **Preparation and Analytical Method** | Naphthalene: SW-846 3510C, 8270E<br>Arsenic and Manganese: SW-846 3010A, 6010D |
| | **Analytical Laboratory/ Analytical SOP Reference** | SGS Orlando / OP006.12, MS006.18, MET103.18, MET108.05 |
| | **Data Package Turnaround Time** | 21 Calendar Days |
| **SGS North America Inc. - Orlando**<br>**4405 Vineland Road, Suite C-15**<br>**Orlando, FL 32811**<br>Project Manager: Andrea Colby<br>Direct Dial: 609-495-5321<br>Email: andrea.colby@sgs.com | **Container Type/ Volume Required** (if different than container volume) | Naphthalene: 2x1-Liter amber bottles<br>Arsenic and Manganese: 1-250 milliliter (mL) polyethylene bottle |
| | **Preservative** | Naphthalene: Cool to 4±2 °C<br>Arsenic and Manganese: Nitric acid to pH<2 (Dissolved samples must be field-filtered through a 0.45-micron pore diameter membrane prior to preservation) |
| | **Holding Time (Preparation/Analysis)** | Naphthalene: 7 days to extraction, 40 days after extraction<br>Arsenic and Manganese: 6 months to analysis |

| Site | Matrix | Sample Location[1] | Sample ID[2] | QC |
|---|---|---|---|---|
| **Proposed Groundwater Samples** | | | | |
| FFTA | Groundwater | FFTA-MW055S | FFTA-MW055D-YYYYMMDD | Naphthalene, Arsenic and Manganese (total and dissolved) |
| FFTA | Groundwater | FFTA-MW055D | FFTA-MW055D-YYYYMMDD | Naphthalene, Arsenic and Manganese (total and dissolved) |
| FFTA | Groundwater | FFTA-MW056D | FFTA-MW056D-YYYYMMDD | Naphthalene, Arsenic and Manganese (total and dissolved) |
| FFTA | Groundwater | FFTA-MW057S | FFTA-MW057S-YYYYMMDD | Naphthalene, Arsenic and Manganese (total and dissolved) |
| FFTA | Groundwater | FFTA-MW058S | FFTA-MW058S-YYYYMMDD | Naphthalene, Arsenic and Manganese (total and dissolved) |
| FFTA | Groundwater | FFTA-MW061I | FFTA-MW061I-YYYYMMDD | Naphthalene, Arsenic and Manganese (total and dissolved) |
| FFTA | Groundwater | FFTA-MW107 | FFTA-MW107-YYYYMMDD | Naphthalene, Arsenic and Manganese (total and dissolved) |

| **Field QC Samples** | | | |
|---|---|---|---|
| QC | Field duplicate | FFTA-DUP01-YYYYMMDD | Tentative sampling locations will be selected by the FOL in field. |
| QC | MS | For groundwater, these are noted on the sample and chain of custody form as "MS/MSD". | |
| QC | MSD | | |

**Frequency of QA/QC sample collection:**
Duplicates – 1 per 10 samples,
MS/MSD – 1 per 20 samples,

1 Sample locations are presented on **Figure 10-1**.

2 YYYYMMDD stands for the year, month, and date the sample is collected. For example, if a groundwater sample is collected from FFTA-MW055S on September 25, 2022, the sample ID would be FFTA-MW055S-20220925.

## SAP Worksheet #14 Project Sampling SOP References Table

(UFP-QAPP Manual Section 3.1.2-Worksheet #21)

| Reference Number | Title, Revision Date and / or Number | Originating Organization | Equipment Type | Modified for Project Work? (Y/N) | Comments |
|---|---|---|---|---|---|
| SA-1.1 | Groundwater Sample Acquisition and Onsite Water Quality Testing, 7/17/2020, Revision 11 | Tetra Tech | Pump and water quality meter | N | Contained in Appendix A |
| SA-6.1 | Non-Radiological Sample Handling, 4/30/2020, Revision 6 | Tetra Tech | Sample bottleware, packaging material, shipping materials | N | Contained in Appendix A |
| SA-6.3 | Field Documentation, 8/26/2021, Revision 8 | Tetra Tech | Field logbook, field sample forms, boring logs | N | Contained in Appendix A |
| SA-7.1 | Decontamination of Field Equipment and Management of Investigation Derived Waste, 4/30/2020, Revision 9 | Tetra Tech | Pumps, reusable sample scoops, drill rods, and screens | N | Contained in Appendix A |
| GH-1.2 | Evaluation of Existing Monitoring Wells and Water Level Measurement, 4/30/2020, Revision 5 | Tetra Tech | Water level meter | N | Contained in Appendix A |
| GH-2.5 | Groundwater Contour Maps and Flow Determinations, 08/10/2020, Revision 4 | Tetra Tech | Water level meter | N | Contained in Appendix A |
| GH-2.8 | Groundwater Monitoring Well Installation, 06/19/2020, Revision 5 | Tetra Tech | Submersible pump, water level meter, water quality meter, and check valve/surge block | N | Contained in Appendix A |

## SAP Worksheet #15 Field Equipment Calibration, Maintenance, Testing, and Inspection Table

(UFP-QAPP Manual Section 3.1.2.4- Worksheet #22)

| Field Equipment | Calibration Activity | Maintenance Activity | Testing Activity | Inspection Activity | Frequency | Acceptance Criteria | Corrective Action | Responsible Person | SOP Reference |
|---|---|---|---|---|---|---|---|---|---|
| Water Level Meter -<br>Solinst 101 (or equivalent); keep spare batteries in carrying case. | Not applicable (N/A) | N/A | N/A | Visual Inspection | Daily before use. | No signs of stretching or twisting, damaged legibility of marking, or permanent stains. | Replace meter. | FOL or Designee | Manufacturer's Guidance |
| Multi-parameter Water Quality Meter – Horiba U-52 (or equivalent) | Calibration in accordance with manufacturer's instructions.<br>Calibration verification with second source standard; use calibration check standard in middle of calibration range.<br>Keep spare batteries and calibration solutions in carrying case. | N/A | N/A | Visual Inspection | Calibration prior to use on each day of use.<br>Calibration verification immediately after calibration and at end of day of use | Calibration in accordance with manufacturer's instructions. Calibration Check values should fall within these tolerances of the true value:<br>Temperature: Calibrated by instrument supplier; verify calibration is valid during use.<br>pH: ± 0.2<br>Specific Conductance: ± 5.0%<br>DO: ±0.3 mg/L. | Adjust calibration. If unable to calibrate, replace meter. | FOL or Designee | Manufacturer's Guidance |
| Turbidity Meter - LaMotte 2020 (or equivalent); keep spare batteries in carrying case. | Same as multi-parameter meter calibrations and calibration checks.<br>Acceptance limits do not apply to turbidity–free water sold as a standard by a vendor (i.e., a blank), but water must meet the vendor's stated value (typically < 0.1 NTU). This water may be used to set the zero point according to the instrument | N/A | N/A | N/A | Same as multi-parameter meter calibrations and calibration checks | Calibration in accordance with manufacturer's instructions. Calibration Check value should fall within these tolerances of the true value:<br>0.1-10 NTUs: ±10%<br>11-40 NTUs: ±8%<br>41-100 NTUs ±6.5%<br>>100 NTUs: ±5% | Reattempt calibration. If it does not calibrate, replace meter. | FOL or Designee | Manufacturer's Guidance. |

| Field Equipment | Calibration Activity | Maintenance Activity | Testing Activity | Inspection Activity | Frequency | Acceptance Criteria | Corrective Action | Responsible Person | SOP Reference |
|---|---|---|---|---|---|---|---|---|---|
| Peristaltic Pump - GeoTech Series II (or equivalent) | N/A | N/A | N/A | Visual inspection for functionality | Daily before use | Pump is operational and flow rate appears to be constant and is sufficiently low to not draw down the water level too quickly | Replace pump. | FOL or Designee | Manufacturer’s Guidance. |
| Photoionization Detector (PID) – MiniRAE 3000 (or equivalent) | Calibration in accordance with manufacturer’s instructions. | N/A | N/A | N/A | Daily before use | Calibration in accordance with manufacturer’s instructions. | Replace | FOL or Designee | Manufacturer’s Guidance. |

Note:
Use the Default Calibration Criteria for Multimeters and Turbidity.

## SAP Worksheet #16 Reference Limits and Evaluation Tables

(UFP-QAPP Manual Section 2.8.1 – Worksheet #15)

**Matrix: Groundwater**
**Analytical Group: Semivolatile Organic Compounds (SVOCs) (Naphthalene), Metals (Arsenic, Manganese)**

| Analyte | Chemical Abstracts Service Registry Number (CASRN) | PAL | PAL Reference [1] | Project Quantitation Limit Goal (PQLG) [2,3] | Laboratory Reference Limits | |
|---|---|---|---|---|---|---|
| | | | | | Reporting Limit | MDL |
| **SVOCs (µg/L)** | | | | | | |
| Naphthalene | 91-20-3 | 16 | Risk-based cleanup goal | 5.3 | 5.0 | 0.50 |
| **Metals (µg/L)** | | | | | | |
| Arsenic | 7440-38-2 | 10 | EPA MCL | 3.3 | 10 | 1.3 |
| Manganese | 7439-96-5 | 124 | Risk-based cleanup goal | 41.3 | 15 | 1.0 |

1 PALs determined from the EPA MCL for arsenic and risk-based cleanup goals for naphthalene and manganese (outlined in the ROD).
2 The PQLG is approximately one-third of the PAL.
3 The reporting limit for arsenic is greater than the PQLG but is less than the PAL and is therefore acceptable to meet project goals.

## SAP Worksheet #17 Analytical SOP References Table

(UFP-QAPP Manual Section 3.2.1 – Worksheet #23)

SGS North America Inc. - Orlando
4405 Vineland Road, Suite C-15
Orlando, FL 32811
Project Manager: Andrea Colby
Direct Dial: 609-495-5321
Email: andrea.colby@sgs.com

| Lab SOP Number | Title, Revision Date, and/or Number | Definitive or Screening Data | Matrix and Analytical Group | Instrument | Organization Performing Analysis | Modified for Project Work? (Y/N) |
|---|---|---|---|---|---|---|
| SGS Orlando SOP<br>MS006.18 | Analysis of Semivolatile Organics by GC/MS, Rev. 10/20 | Definitive | Groundwater<br>Naphthalene | Gas Chromatograph / Mass Spectrometry (GC/MS) | SGS | N |
| SGS Orlando SOP<br>OP006.12 | Standard Operating Procedure for the Extraction of Base-Neutral and Acid (BNAs) Extractables From Water Samples, Rev. 04/20 | Definitive | Preparation, Groundwater<br>Naphthalene | NA | SGS | N |
| SGS Orlando SOP<br>MET108.05 | Metals by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES), Rev. 12/20 | Definitive | Groundwater<br>Metals | Inductively Coupled Plasma -Atomic Emission Spectroscopy | SGS | N |
| SGS Orlando SOP<br>MET103.18 | Digestion of Water Samples for ICP/ICPMS Analysis, Rev. 04/22 | Definitive | Preparation, Groundwater<br>Metals | NA | SGS | N |

Laboratory SOPs are available directly from the laboratory upon request.

## SAP Worksheet #18 Laboratory QC Samples Table

(UFP-QAPP Manual Section 3.4 – Worksheet #28)

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Naphthalene |
| **Analytical Method/ SOP Reference** | SW-846 8270E<br>MS006.18 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| Method Blank (MB) | One per preparatory batch of up to 20 samples. | No analytes detected > $^{1}/_{2}$ reporting limit or > 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.<br>Common contaminants must not be detected > reporting limit.<br>Results may not be reported without a valid MB. | Correct problem. If required, re-prepare and reanalyze MB and all QC samples and field samples processed with the contaminated blank.<br>If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative.<br>Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.<br>Flagging is only appropriate in cases where the samples cannot be reanalyzed. | Analyst, Supervisor | Accuracy/Bias/ Contamination | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Naphthalene |
| **Analytical Method/ SOP Reference** | SW-846 8270E<br>MS006.18 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| Laboratory Control Sample (LCS) | One per preparatory batch of up to 20 samples. | Use in-house limits (47-100%).<br>Must contain all surrogates and all analytes to be reported.<br>Results may not be reported without a valid LCS. | Correct problem, then reprepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available.<br>If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative.<br>Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch.<br>Flagging is only appropriate in cases where the samples cannot be reanalyzed. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Naphthalene |
| **Analytical Method/ SOP Reference** | SW-846 8270E<br>MS006.18 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| Internal Standards (IS) | Every field sample, standard, and QC sample. | Retention time within ± 10 seconds from retention time of the midpoint standard in the Initial Calibration (ICAL); Extracted Ion Current Profile (EICP) area within – 50% to +100% of ICAL midpoint standard.<br>On days when ICAL is not performed, the daily initial continuing calibration verification (CCV) can be used. | Inspect mass spectrometer and GC for malfunctions and correct problem.<br>Reanalysis of samples analyzed while system was malfunctioning is mandatory.<br>If corrective action fails in field samples, data must be qualified and explained in the Case Narrative.<br>Apply Q-flag to analytes associated with the noncompliant IS.<br>Flagging is not appropriate for failed standards. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Naphthalene |
| **Analytical Method/ SOP Reference** | SW-846 8270E<br>MS006.18 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| MS | One per preparatory batch of up to 20 samples. | Use in-house limits (47-100%).<br>Must contain all surrogates and all analytes to be reported. | Examine the project specific requirements. Contact the client as to additional measures to be taken.<br>For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.<br>For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference, i.e., matrix effect or analytical error. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Naphthalene |
| **Analytical Method/ SOP Reference** | SW-846 8270E<br>MS006.18 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| MSD or Matrix Duplicate (MD) | One per preparatory batch of up to 20 samples. | Use in-house limits (47-100%).<br>MSD or MD: RPD of all analytes ≤ 20% (between MS and MSD or sample and MD).<br>MSD: Must contain all surrogates and all analytes to be reported.<br>For Sample/MD: RPD criteria only apply to analytes whose concentration in the sample is greater than or equal to the reporting limit. | Examine the project-specific requirements. Contact the client as to additional measures to be taken.<br>For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.<br>The data shall be evaluated to determine the source of difference. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Naphthalene |
| **Analytical Method/ SOP Reference** | SW-846 8270E<br>MS006.18 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| Surrogate Spike | All field and QC samples.<br>Alternative surrogates are recommended when there is obvious chromatographic interference. | Use in-house limits.<br>Nitrobenzene-d5: 42-108<br>2-Fluorobiphenyl: 40-106<br>Terphenly-d14: 39-121 | Correct problem, then re-prepare and reanalyze all failed samples for all surrogates in the associated preparatory batch if sufficient sample material is available.<br>If obvious chromatographic interference is present, reanalysis may not be necessary, but the client must be notified prior to reporting data and the failures must be discussed in the Case Narrative.<br>Apply Q-flag to all associated analytes if acceptance criteria are not met and explain in the Case Narrative. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Metals (Arsenic and Manganese) |
| **Analytical Method/ SOP Reference** | SW-846 6010D/ MET108.05 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| MB | One per preparatory batch of up to 20 samples. | The absolute values of all analytes must be < $^1/_2$ reporting limit or < 1/10th the amount measured in any sample or 1/10th the regulatory limit, whichever is greater.<br>Results may not be reported without a valid MB.<br>Non-detects associated with positive blank infractions may be reported.<br>Sample results > 10X the reporting limit associated with negative blanks may be reported. | Correct problem. If required, re-prepare and reanalyze MB and all QC samples and field samples processed with the contaminated blank.<br>If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative.<br>Apply B-flag to all results for the specific analyte(s) in all samples in the associated preparatory batch.<br>Flagging is only appropriate in cases where the samples cannot be reanalyzed. | Analyst, Supervisor | Accuracy/Bias/ Contamination | Same as Method/SOP QC Acceptance Limits. |

| **Matrix** | Groundwater and Aqueous QC samples |
|---|---|
| **Analytical Group** | Metals (Arsenic and Manganese) |
| **Analytical Method/ SOP Reference** | SW-846 6010D/ MET108.05 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| LCS | One per preparatory batch of up to 20 samples. | Use in-house limits (80-120%).<br>Must contain all reported analytes. Results may not be reported without a valid LCS. | Correct problem, then re-prepare and reanalyze the LCS and all samples in the associated preparatory batch for failed analytes if sufficient sample material is available.<br>If reanalysis cannot be performed, data must be qualified and explained in the Case Narrative.<br>Apply Q-flag to specific analyte(s) in all samples in the associated preparatory batch.<br>Flagging is only appropriate in cases where the samples cannot be reanalyzed. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Metals (Arsenic and Manganese) |
| **Analytical Method/ SOP Reference** | SW-846 6010D/ MET108.05 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| MS | One per preparatory batch of up to 20 samples. | Use in-house limits (80-120%). | Examine the project- specific requirements. Contact the client as to additional measures to be taken.<br>For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative<br>.<br>For matrix evaluation only. If MS results are outside the limits, the data shall be evaluated to determine the source(s) of difference (i.e., matrix effect or analytical error). | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Metals (Arsenic and Manganese) |
| **Analytical Method/ SOP Reference** | SW-846 6010D/ MET108.05 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| MSD or MD | One per preparatory batch of up to 20 samples. | Use in-house limits (80-120%).<br>MSD or MD: RPD of all analytes ≤ 20% (between MS and MSD or sample and MD).<br>For Sample/MD: RPD criteria only apply to analytes whose concentration in the sample is greater than or equal to the reporting limit. | Examine the project- specific requirements. Contact the client as to additional measures to be taken.<br>For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative.<br>The data shall be evaluated to determine the source of difference. | Analyst, Supervisor | Precision/ Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |
| Dilution Test | One per preparatory batch of up to 20 samples if MS or MSD fails.<br>Only applicable for samples with concentrations > 50 X reporting limit (prior to dilution). Use along with MS/MSD or post digestion spike (PDS) data to confirm matrix effects. | Five-fold dilution must agree within ± 10% of the original measurement. | No specific corrective action unless required by the project.<br>For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

| | |
|---|---|
| **Matrix** | Groundwater and Aqueous QC samples |
| **Analytical Group** | Metals (Arsenic and Manganese) |
| **Analytical Method/ SOP Reference** | SW-846 6010D/ MET108.05 |

| QC Sample | Frequency/Number | Method/SOP QC Acceptance Limits | Corrective Action | Person(s) Responsible for Corrective Action | DQIs | MPCs |
|---|---|---|---|---|---|---|
| PDS Addition | One per preparatory batch if MS or MSD fails (using the same sample as used for the MS/MSD if possible).<br>Criteria apply for samples with concentrations < 50 X reporting limit prior to dilution. | Recovery within 80-120%. | No specific corrective action unless required by the project.<br>For the specific analyte(s) in the parent sample, apply J-flag if acceptance criteria are not met and explain in the Case Narrative. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |
| Method of Standard Additions (MSA) | When dilution or post digestion spike fails and if the required by project.<br>Document use of MSA in the Case Narrative. | NA. | Document use of MSA in the Case Narrative. | Analyst, Supervisor | Accuracy/Bias | Same as Method/SOP QC Acceptance Limits. |

## SAP Worksheet #19 Data Verification and Validation (Steps I and IIa/IIb) Process Table

(UFP-QAPP Manual Section 5.2.1, UFP-QAPP Manual Section 5.2.2, Figure 37 UFP-QAPP Manual, Table 9 UFP-QAPP Manual – Worksheets #34, 35, 36)

| Data Review Input | Description | Responsible for Verification (name, organization) | Step I/IIa/IIb [1] | Internal/ External |
|---|---|---|---|---|
| Sample log sheets, chain of custody forms, SAP, and laboratory sample login documentation | The FOL will verify that samples were correctly identified, chain of custody records are legible, data will be traceable to the corresponding samples, the samples listed in **Worksheets #11 and #13** were collected from intended locations, and the correct sampling and analytical methods/SOPs were assigned to samples listed on the chain of custody record. The PM will verify that the sampling plan was implemented and carried out as written and will make sure that any significant deviations are documented in the project report. | FOL and PM, Tetra Tech | I | Internal |
| Chain-of-custody forms | Verify that the chain-of-custody form is complete and accurate; and was signed and dated by the sampler relinquishing the samples and by the laboratory receiving the samples. Resolve discrepancies, if possible. Alert the Tetra Tech PM verbally or via email if discrepancies are unresolvable. | FOL, Tetra Tech | I | Internal |
| Chain-of-custody forms | Verify sample shipment completeness against the chain-of-custody record, verify proper sample preservation/integrity, sign to indicate receipt, note any discrepancies, and correct them as necessary. Notify the Tetra Tech FOL or PM of any deviations from sample shipping requirements such as damaged sample containers, or inappropriate temperature or pH. Note uncorrectable discrepancies in the data package case narrative. | Laboratory sample custodian, SGS | I | External |

| Data Review Input | Description | Responsible for Verification (name, organization) | Step I/IIa/IIb [1] | Internal/ External |
|---|---|---|---|---|
| Analytical calibration standards | Verify that standards are traceable and meet contract, method, and procedural requirements, as applicable, and include certificates of analysis in the laboratory data package to document the traceability. If discrepancies in traceability are found, bring the discrepancies to the laboratory PM attention for correction. | Laboratory analyst, SGS | I | Internal |
| SAP, analytical SOPs, and analytical data packages | Verify that the correct analytical methods/SOPs were applied. Establish that method QC samples were analyzed and in control as listed in the analytical SOPs. If method QC is not in control, the Laboratory PM will contact the Tetra Tech Project Chemist or PM verbally or via email for guidance prior to laboratory data package preparation. | Laboratory PM, SGS | I | Internal |
| Laboratory analytical data package | Verify the analytical data package for completeness and accuracy, including certificates of analysis for calibration and check standards. The laboratory QAM will sign the case narrative for each data package. | Laboratory QAM, SGS | I | Internal |
| Laboratory analytical data package | Review chain-of-custody records to ensure that the required analytical samples were collected, appropriate sample identifications were used, and correct analytical methods were applied to each sample. Verify the analytical data package for completeness and accuracy, including certificates of analysis for calibration and check standards. Obtain missing data package elements from the laboratory. Document unrecoverable elements, if any, in the data validation report submitted to the Tetra Tech PM and alert the project chemist or PM. | Data validator, Tetra Tech | I/IIa | External |

| Data Review Input | Description | Responsible for Verification (name, organization) | Step I/IIa/IIb [1] | Internal/ External |
|---|---|---|---|---|
| EDDs/Analytical data packages | Verify 100% of EDD results for accuracy and completeness against hard copy data package and chain of custody records at the start of validation. If required elements are missing, obtain missing elements form the laboratory before completing the validation. If any element cannot be obtained, document the omission in the DV report and identify the missing elements to the Tetra Tech project chemist or PM as early as possible. | Data validator, Tetra Tech | I/IIa | External |
| Sample shipment and storage conditions; and holding times for representativeness | Verify that sample shipping and storage conditions satisfy **Worksheet #13** requirements. Document deviations from requirements in the DV report and notify the Tetra Tech project chemist or PM if deviations from the SAP requirements are serious enough to warrant data rejection. Document findings in the DV report. | Data validator, Tetra Tech | I/IIa | External |
| QC samples/MPC compliance | Ensure that the scheduled laboratory and field QC samples were submitted for analysis and that the MPCs listed in SAP **Worksheets #11, #16, and #18** were met for all field samples and QC samples. Document findings in the DV report.<br>Evaluate sample results for laboratory contamination and qualify false detections using the laboratory method/preparation blank summaries. Qualify analyte concentrations between the MDL and the reporting limit as estimated ("*J*" qualifier). Replace laboratory flags with validation qualifiers on validated data in accordance with the laboratory data validation process described below and document findings in the data validation report. Retain laboratory flags in the database and provide them in the DV reports to document data as received from the laboratory. | Data validator, Tetra Tech | IIa/IIb | External |

| Data Review Input | Description | Responsible for Verification (name, organization) | Step I/IIa/IIb [1] | Internal/ External |
|---|---|---|---|---|
| Field and laboratory duplicate analyses for precision | Verify field sampling precision by checking RPDs for field duplicate samples. Verify laboratory precision by checking RPDs or %D values from calibrations, laboratory duplicates, MS/MSDs, and LCS/laboratory control sample duplicates (LCSDs). Ensure compliance with MPC accuracy and precision goals listed in **Worksheets #11 and #18**. Document findings in the DV report. | Data validator, Tetra Tech | I/IIb | External |
| SAP/Laboratory data packages/ EDDs | Conduct EPA Stage 4 data validation on 100% of the definitive laboratory data generated by the selected methods using QC criteria listed in this SAP. Apply validation qualifiers in accordance with logic provided in the National Functional Guidelines (NFG) for Inorganic Superfund (EPA, 2020a) or Organic Superfund (EPA, 2020b) data review (including EPA Region-specific requirements, if applicable). Document findings in the DV report. | Data validator, Tetra Tech | IIa/IIb | External |

## Usability Assessment

(UFP-QAPP Manual Section 2.6.2 and 5.2.3 Worksheet #37)

After data validation, the data and data quality will be reviewed to determine whether sufficient data of acceptable quality are available for decision making. The Tetra Tech PM and designees will be responsible for conducting this data usability assessment. Summary statistics for target analytes such as sampling completeness (Cs), analytical data completeness (Ca), maximum concentration, minimum concentration, number of samples with non-detected results, number of samples with detected results, and the proportion of samples with detected and non-detected results will be compiled at the discretion of the Tetra Tech PM. The project team will consider whether any missing or rejected data have reduced the Cs and Ca to less than the associated goals and will consider factors that affect sample integrity such as holding times, preservation, and storage conditions. The assessment findings will be presented to the NASA RPM, EPA, and VDEQ.

The goal for Cs is 90% and for Ca it is 90%. These values will be calculated as follows:

$$\%Cs = \frac{No.\,of\ Valid\ Samples}{No.\,of\ Planned\ Samples} x100\%$$

$$\%Ca = \frac{No.\,of\ Valid\ Analytical\ Results}{\mathrm{No.\,of\ Planned\ Analytical\ Results}} x100\%$$

Field and laboratory precision will be evaluated for each matrix, analytical fraction, and concentration level (as applicable), with the expectation that laboratory duplicate results which will be no less precise than field duplicate results.

Precision will be computed in terms of RPD as follows:

$$RPD = \frac{200 * |\mathrm{Result}_\mathrm{A} - Result_B|}{(\mathrm{Result}_\mathrm{A} + Result_B)}$$

Accuracy will be computed in terms of percent recovery (%R) as follows for MS/MSD samples:

$$\%\mathrm{R} = \frac{\textit{Amount in Spiked Sample} - \textit{Amount in Sample}}{\textit{Known Amount Added}} \ \mathrm{X}\ \ 100\%$$

The %R calculation for laboratory control samples and surrogate spikes will be as follows:

$$\%\mathrm{R} = \frac{Experimental\ Concentration}{Certified\ or\ Known\ Concentration} \ \mathrm{x}\ 100$$

Data comparability and representativeness will be evaluated by reviewing sample collection processes and associated documentation; and by comparing overall precision and bias among data sets for each matrix and analytical fraction. This will not require quantitative comparisons unless professional judgment of the Tetra Tech project chemist indicates that such quantitative analysis is required. If comparability or representativeness deficiencies are identified, limitations on the data will be described in the project report. If data gaps exist, they will be identified and, if appropriate, the project team will take them into consideration if additional work is required to meet project objectives.

Data validators apply “*X*” qualifiers to results that are seriously compromised and potentially unusable from a quality perspective. The project team will consider whether any missing or “*X*”-qualified data have compromised the ability to make decisions or to make decisions with the desired level of confidence. In these cases, “X”-qualified data will be qualified with an “*R*” qualifier if rejected. The data will be evaluated to determine whether available data can compensate for missing or rejected data.

The project report will identify and describe the data usability limitations and suggest resampling or other corrective actions, if necessary. If applicable, this will include a description of unacceptable levels of bias/contamination, non-representativeness of data, or poor data comparability that could affect the accuracy and usability of reported results. These discussions may be specific to a matrix, analytical fraction, or other logical grouping of results

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# APPENDIX A

# FIELD STANDARD OPERATING PROCEDURES

TETRA TECH

# STANDARD OPERATING PROCEDURE

| | |
|---|---|
| Number<br>GH-1.2 | Page<br>1 of 9 |
| Effective Date<br>04/30/2020 | Revision<br>5 |
| Applicability<br>EGS Operating Unit | |
| Prepared<br>Earth Sciences Department | |
| Approved<br>T. Johnston T.E. Johnston 04/30/2020 | |

Subject EVALUATION OF EXISTING MONITORING WELLS AND WATER LEVEL MEASUREMENT

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## ATTACHMENTS

## 1.0 PURPOSE

The purpose of this procedure is to provide reference information regarding the proper methods for evaluating the physical condition and project utility of existing monitoring wells and determining water levels.

## 2.0 SCOPE

The procedures described herein are applicable to all existing monitoring wells and, for the most part, are independent of construction materials and methods.

## 3.0 GLOSSARY

Hydraulic Head - The height to which water will rise in a well.

Water Table - A surface in an unconfined aquifer where groundwater pressure is equal to atmospheric pressure (i.e., the pressure head is zero).

## 4.0 RESPONSIBILITIES

Site Geologist/Hydrogeologist - Has overall responsibility for the evaluation of existing wells, obtaining water level measurements and developing groundwater contour maps. The site geologist/hydrogeologist (in concurrence with the Project Manager) shall specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing and if not otherwise designated, the north edge of the well casing), the number and location of data points which shall be used for constructing a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - Must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements or objectives.

## 5.0 PROCEDURES

Accurate, valid, and useful groundwater evaluation requires that four important conditions be met:

- Proper characterization of site hydrogeology.
- Proper design of the groundwater monitoring program, including adequate numbers of wells installed at appropriate locations and depths.
- Satisfactory methods of groundwater sampling and analysis to meet the project data quality objectives (DQOs).
- The assurance that specific monitoring well samples are representative of water quality conditions in the monitored interval.

To ensure that these conditions are met, adequate descriptions of subsurface geology, well construction methods and well testing results must be available. The following steps will help to ensure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples.

## 5.1 PRELIMINARY EVALUATION

A necessary first step in evaluating existing monitoring well data is the study and review of the original work plan for monitoring well installation (if available). This helps to familiarize the site geologist/hydrogeologist with site-specific condition, and will promote an understanding of the original purpose of the monitoring wells.

The next step of the evaluation should involve a review of all available information concerning borehole drilling and well construction. This will allow interpretation of groundwater flow conditions and area geology, and will help to establish consistency between hydraulic properties of the well and physical features of the well or formation. The physical features which should be identified and detailed, if available, include:

- The well identification number, permit number and location by referenced coordinates, the distance from prominent site features, or the location of the well on a map.

- The installation dates, drilling methods, well development methods, past sampling dates, and drilling contractors.

- The depth to bedrock -- where rock cores were not taken, auger refusal, drive casing refusal, or penetration test results (blow counts for split-barrel sampling) may be used to estimate bedrock interface.

- The soil profile and stratigraphy, often referred to as lithology or lithologic description.

- The borehole depth and diameter.

- The elevation of the top of the protective casing, the top of the well riser, and the ground surface.

- The total depth of the well.

- The type of well materials, screen type, slot size, and length, and the elevation/depths of the screen, interval, and/or monitored interval.

- The elevation/depths of the tops and bottom of the filter pack and well seals and the type and size.

## 5.2 FIELD INSPECTION

During the onsite inspection of existing monitoring wells, observe and record the following features and others as appropriate:

- The condition of the protective casing, cap and lock.
- The condition of the cement seal surrounding the protective casing.
- The presence of depressions or standing water around the casing.
- The presence of and condition of dedicated sampling equipment.
- The presence of a survey mark on the inner well casing.

If the protective casing, cap and lock have been damaged or the cement collar appears deteriorated, or if there are any depressions around the well casing capable of holding water, surface water may have infiltrated into the well. This may invalidate previous sampling results unless the time when leakage started can be precisely determined.

The routine physical inspection must be followed by a more detailed investigation to identify other potential routes of contamination or sampling equipment malfunction. Any of these occurrences may invalidate previously-collected water quality data. If the monitoring well is to be used in the future, considerations shown in the steps described above should be rectified to rehabilitate the well.

After disconnecting any wires, cables or electrical sources, remove the lock and open the cap. Check for the presence of organic vapors with a photoionization detector (PID) or flame-ionization detector (FID) to determine the appropriate worker safety level. The following information should be recorded (at a minimum):

- Cap function.
- Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space.
- Presence of grout between the riser and outer protective casing and the existence of drain holes in the protective casing.
- Presence of a riser cap, method of attachment to casing, and venting of the riser.
- Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition. (A licensed electrician may be required if the pump looks to be wired to an electrical source.)

The final step of the field inspection is to confirm previous hydraulic or physical property data and to obtain data not previously available. This includes the determination of static water levels, total well depth and potential well obstructions. This may be accomplished using a weighted tape measure which can also be used to check for sediment (the weight will advance slowly if sediment is present, and the presence of sediment on the weight upon removal should be noted). If sediment is present and/or the well has not been sampled in 12 or more months, it should be redeveloped before sampling.

Lastly, as a final step, the location, condition and expected water quality of the wells should be reviewed in light of their usefulness for the intended purpose of the investigation.

See Attachment A, Monitoring Well Inspection Sheet.

## 5.3 WATER LEVEL (HYDRAULIC HEAD) MEASUREMENTS

### 5.3.1 General

Groundwater level measurements can be made in monitoring wells, private or public water wells, piezometers, open boreholes, or test pits (after stabilization). Groundwater level measurements should generally not be made in boreholes with drilling rods or auger flights present. If groundwater sampling activities are to occur, groundwater level measurements shall take place prior to well purging or sampling.

Measure all groundwater levels to the nearest 0.01 foot, and record the levels in the site geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B), along with the date and time of the reading with the well identification.

If not already known, measure the total depth of the well and record this depth. Weather changes that occur over the period of time during which water levels are being taken, such as precipitation and barometric pressure changes, should be noted.

In measuring groundwater levels, ensure that there is a clearly-established reference point of known elevation, which is normally identified by a mark on the upper edge of the inner well casing. To be useful, the reference point should be tied in with an established USGS benchmark or other properly surveyed elevation datum. An arbitrary datum could be used for an isolated group of wells, if necessary.

Cascading water within a borehole or steel well casings can cause false readings with some types of sounding devices (chalked line, electrical). Oil layers may also cause problems in determining the true water level in a well. Special devices (interface probes) are available for measuring the thickness of oil layers and true depth to groundwater, if required.

Water level measurements should be taken regularly, as required by the site geologist/hydrogeologist. Monitoring wells or open-cased boreholes that are subject to tidal fluctuations should be measured in conjunction with a tidal chart (or preferably in conjunction with readings of a tide staff or tide level recorder installed in the adjacent water body); the frequency of such measurements should be established by the site hydrogeologist. All water level measurements at a site used to develop a groundwater contour map should be made in the shortest practical time to minimize affects due to weather changes.

### 5.3.2 Water Level Measuring Techniques

There are several methods for determining standing or changing water levels in boreholes and monitoring wells. Certain methods have particular advantages and disadvantages depending upon well conditions. A general description of these methods is presented, along with a listing of various advantages and disadvantages of each technique. An effective technique shall be selected for the particular site conditions by the site geologist/hydrogeologist.

In most instances, preparation of accurate potentiometric surface maps require that static water level measurements be obtained to a precision of 0.01 feet. To obtain such measurements in individual accessible wells, electrical water level indicator methods have been found to be best, and thus should be utilized. Other, less precise methods, such as the popper or bell sound, or bailer line methods, should be avoided. When a large number of (or continuous) readings are required, time-consuming individual readings are not usually feasible. In such cases, it is best to use a pressure transducer.

### 5.3.3 Methods

Water levels may be measured by several different techniques, but the same steps should be followed in each case. The proper sequence is as follows:

1. Check operation of recording equipment above ground. Prior to opening the well, don personal protective equipment, as required. Never remove an air-tight lock (such as a J-plug) with your face over the well. Pressure changes within the well may explosively force the cap off once loosened. Listen closely as the well plug is removed for air exiting or rushing into the well. If pressure or vacuum was evident, then it may take a while for the water level to reach equilibrium to atmospheric pressure for an accurate water level measurement.

2. Record all information specified below in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet (Attachment B):

   - Well number.
   - Water level (to the nearest 0.01 foot). Water levels shall be taken from the surveyed reference mark on the top edge of the inner well casing. If the J-plug was on the well very tightly, it may take several minutes for the water level to stabilize as mentioned above.
   - Time and day of the measurement.
   - Thickness of free product if present.

Water level measuring devices with permanently marked intervals shall be used. The devices shall be free of kinks or folds which will affect the ability of the equipment to hang straight in the well pipe.

### 5.3.4 Water Level Measuring Devices

#### Electric Water Level Indicators

These are the most commonly used devices and consist of a spool of small-diameter cable and a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool will signal the contact.

There are a number of commercial electric sounders available, none of which is entirely reliable under all conditions likely to occur in a contaminated monitoring well. In conditions where there is oil on the water, groundwater with high specific conductance, water cascading into the well, steel well casing, or a turbulent water surface in the well, measuring with an electric sounder may be difficult.

For accurate readings, lower the probe slowly into the well adjacent to the survey mark on the inner well casing. The electric tape is read (to the nearest 0.01 ft.) at the measuring point and recorded where contact with the water surface was indicated.

#### Popper or Bell Sounder

A bell- or cup-shaped weight that is hollow on the bottom is attached to a measuring tape and lowered into the well. A "plopping" or "popping" sound is made when the weight strikes the surface of the water. An accurate reading can be determined by lifting and lowering the weight in short strokes, and reading the tape when the weight strikes the water. This method is not sufficiently accurate to obtain water levels to 0.01 feet, and thus is more appropriate for obtaining only approximate water levels quickly.

#### Pressure Transducer

Pressure transducers can be lowered into a well or borehole to measure the pressure of water and therefore the water elevation above the transducer. If using a hardwired transducer, it will be connected to a recorder at the surface to record changes in water level with time. The recorder digitizes the information and can provide a printout or transfer the information to a computer for evaluation (using a well drawdown/recovery model). The pressure transducer should be initially calibrated with another water level measurement technique to ensure accuracy. This technique is very useful for hydraulic conductivity testing in highly permeable material where repeated, accurate water level measurements are required in a very short period of time. A sensitive transducer element is required to measure water levels to 0.01 foot accuracy.

#### Borehole Geophysics

Approximate water levels can be determined during geophysical logging of the borehole (although this is not the primary purpose for geophysical logging and such logging is not cost effective if used only for this purpose). Several logging techniques will indicate water level. Commonly used logs which will indicate saturated/unsaturated conditions and include the spontaneous potential (SP) log and the neutron log.

### 5.3.5 Data Recording

Record water level measurements, time, data, and weather conditions in the geologist/hydrogeologist's field notebook or on the Groundwater Level Measurement Sheet. All water level measurements should be measured from a known reference point (see Section 5.3.1). The reference point is generally a marked point on the upper edge of the inner well casing that has been surveyed for an elevation. The exact reference point should be marked with permanent ink on the casing since the top of the casing may not be entirely level. Alternatively, a small notch may be made in the PVC. It is important to note changes in weather conditions because changes in the barometric pressure may affect the water level within a well.

### 5.3.6 Specific Quality Control Procedures for Water Level Measuring Devices

All groundwater level measurement devices must be cleaned before and after each use to prevent cross contamination of wells. Manufacturer's instructions for cleaning the device should be strictly followed. Some devices used to measure groundwater levels may need to be calibrated. These devices should be calibrated to 0.01 foot accuracy and any adjustments/corrections should be recorded in the field logbook/notebook. After the corrections/adjustments are made to the measuring device and entered in the field logbook/notebook, the corrected readings should be entered onto the Groundwater Level Measurement Sheet (Attachment B). Elevations referenced to a known point will be entered on the sheet when they become available.

## 5.4 EQUIPMENT DECONTAMINATION

Equipment used for water level measurements provide a mechanism for potentially cross contaminating wells. Therefore, all portions of a device which project down the well casing must be decontaminated prior to advancing to the next well. Decontamination procedures vary based on the project objectives but must be defined prior to conducting any field activities including the collection of water level data. Consult the project planning documents and SA-7.1 Decontamination of Field Equipment.

## 5.5 HEALTH AND SAFETY CONSIDERATIONS

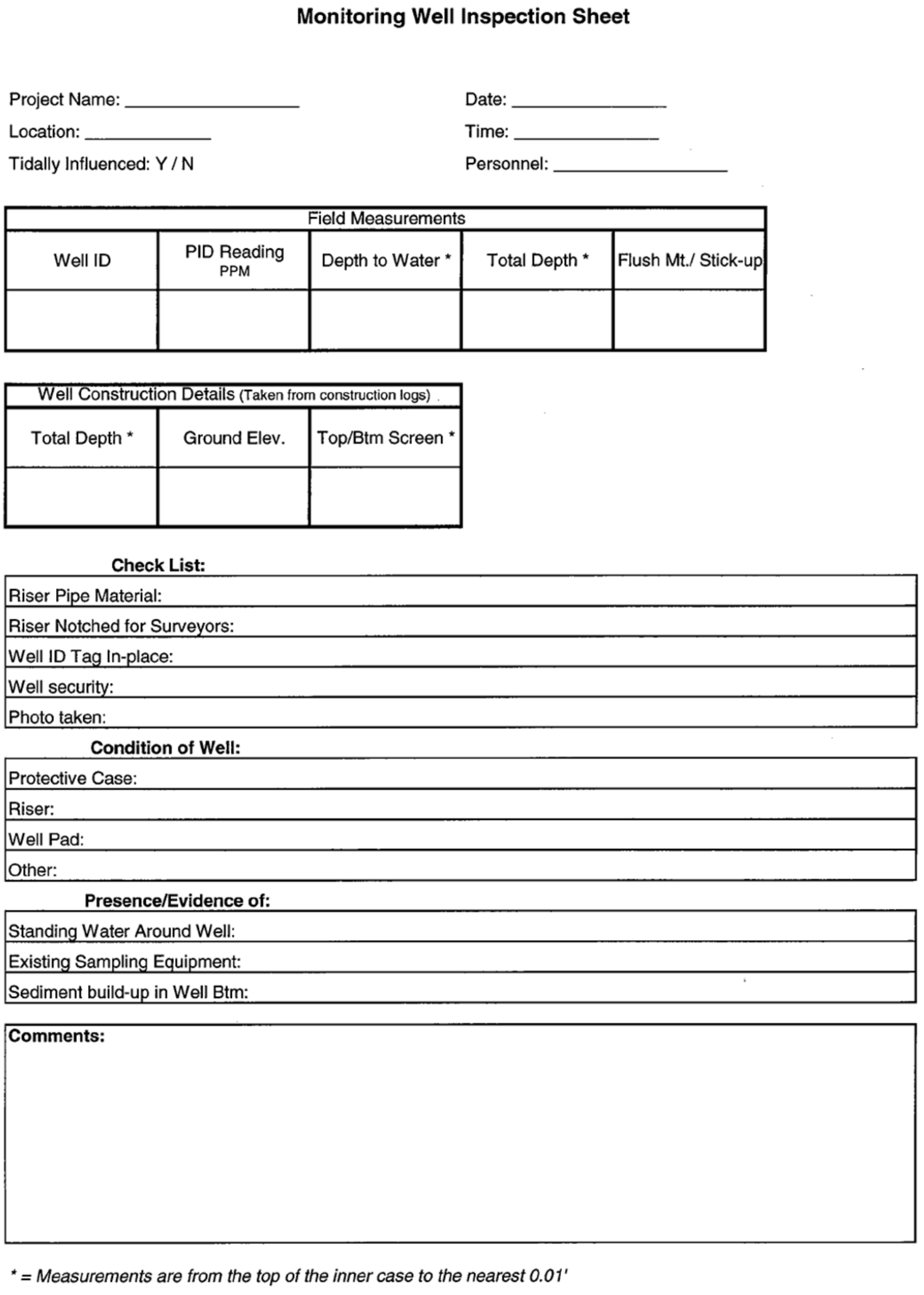
Groundwater contaminated by volatile organic compounds may release toxic vapors into the air space inside the well pipe. The release of this air when the well is initially opened is a health/safety hazard which must be considered. Under certain conditions, air-tight well caps may explosively fly off the well when the pressure is relieved. Never stand directly over a well when uncapping it.

Perform initial air monitoring of the well headspace and breathing zone concentrations using a PID or FID to determine required levels of protection.

# 6.0 RECORDS

Record all field procedures, tests and observations in the site logbook or designated field notebook. Entries in the log/notebook should include the individuals participating in the field effort, and the date and time. The use of annotated sketches may help to supplement the evaluation. If one person is measuring the water levels and a second person is recording, the second person should ensure the measurement is correct by repeating the measurement back to the person doing the measurement to confirm.

## ATTACHMENT A
## MONITORING WELL INSPECTION SHEET (EXAMPLE)



### Monitoring Well Inspection Sheet

Project Name: __________________

Date: ________________

Location: _____________

Time: _______________

Tidally Influenced: Y / N

Personnel: __________________

| Field Measurements | | | | |
|---|---|---|---|---|
| Well ID | PID Reading<br>PPM | Depth to Water * | Total Depth * | Flush Mt./ Stick-up |
| | | | | |

| Well Construction Details (Taken from construction logs) | | |
|---|---|---|
| Total Depth * | Ground Elev. | Top/Btm Screen * |
| | | |

**Check List:**

| |
|---|
| Riser Pipe Material: |
| Riser Notched for Surveyors: |
| Well ID Tag In-place: |
| Well security: |
| Photo taken: |

**Condition of Well:**

| |
|---|
| Protective Case: |
| Riser: |
| Well Pad: |
| Other: |

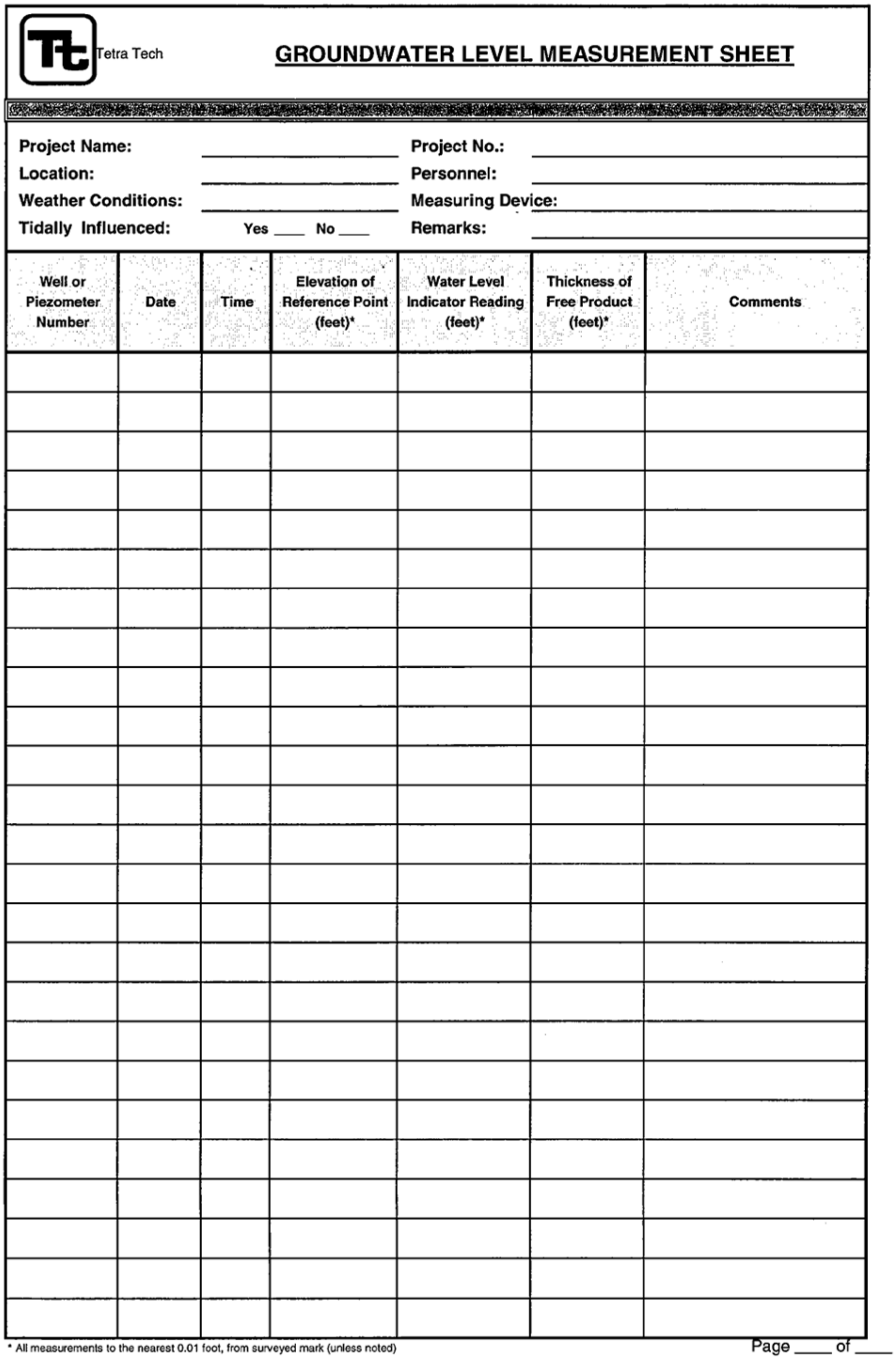
**Presence/Evidence of:**

| |
|---|
| Standing Water Around Well: |
| Existing Sampling Equipment: |
| Sediment build-up in Well Btm: |

**Comments:**

** = Measurements are from the top of the inner case to the nearest 0.01'*

## ATTACHMENT B
## GROUNDWATER LEVEL MEASUREMENT SHEET (EXAMPLE)



Tetra Tech

**GROUNDWATER LEVEL MEASUREMENT SHEET**

**Project Name:** ____________________
**Location:** ____________________
**Weather Conditions:** ____________________
**Tidally Influenced:** Yes ____ No ____
**Project No.:** ____________________
**Personnel:** ____________________
**Measuring Device:** ____________________
**Remarks:** ____________________

| Well or Piezometer Number | Date | Time | Elevation of Reference Point (feet)* | Water Level Indicator Reading (feet)* | Thickness of Free Product (feet)* | Comments |
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* All measurements to the nearest 0.01 foot, from surveyed mark (unless noted)

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| TETRA TECH | **STANDARD OPERATING PROCEDURE (GUIDANCE)** | Number<br>GH-2.5 | Page<br>1 of 10 |
| | | Effective Date<br>08/10/2020 | Revision<br>4 |
| | | Applicability<br>EGS Operating Unit | |
| | | Prepared<br>Earth Sciences Department | |
| Subject GROUNDWATER CONTOUR MAPS AND FLOW DETERMINATIONS | | Approved<br>T. Johnston T.E. Johnston | 8/10/2020 |

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## 1.0 PURPOSE

This guideline describes the process for developing groundwater contour maps and the approaches used to identify and quantify the direction and rate of groundwater flow and contaminant plume movement.

## 2.0 SCOPE

This document provides only a general overview of the field techniques, mathematical and physical relationships, and data handling procedures used for determining groundwater flow direction and rate. The references identified herein can provide a more complete explanation of particular methods and a more comprehensive discussion on the interpretation of hydrogeologic data.

## 3.0 GLOSSARY

Aquifer - A geologic formation capable of transmitting usable quantities of groundwater to a well or other discharge point.

Aquitard - A geologic formation that retards the flow of groundwater due to its low permeability.

Confined Aquifer - An aquifer that is overlain and underlain by zones of lower permeability (aquitards). If the aquifer is "artesian," the potentiometric head of the aquifer at a given point is higher than the top of the zone comprising the aquifer at that point.

Equipotential Line - A line connecting points of equal elevation of the water table or potentiometric surface. Equipotential lines are also called water level contours.

Flow Line - A flow line indicates the direction of groundwater movement within the saturated zone. Flow lines are drawn perpendicular to equipotential lines.

Flow Net - A diagram of groundwater flow showing flow lines and equipotential lines. Flow nets can be drawn in plan view or in vertical cross section.

Hydraulic Conductivity (K) - A quantitative measure of the ability of porous media to transmit water. This is defined mathematically as the volume of water that will flow through a unit cross-sectional area of porous media per unit time under a head pressure gradient. Hydraulic conductivity is dependent on properties of the medium and fluid.

Hydraulic Gradient (i) - The rate of change of hydraulic head per unit distance of flow at a given point and in the downgradient direction.

Hydraulic Head - The height to which water will rise inside a well casing; equal to the elevation head plus the pressure head. In a well screened across the water table, hydraulic head equals the elevation head because the pressure head equals zero. In wells screened below the water table in an unconfined aquifer or screened at any interval within a confined aquifer, the head is the sum of the elevation of the aquifer (elevation head) and the fluid pressure of the water confined in the aquifer (pressure head).

North American Vertical Datum of 1988 (NAVD 88) – The current national standard vertical control datum established in 1991, replacing the National Geodetic Vertical Datum of 1929 (NGVD 29).

Potentiometric Surface - A hypothetical surface that coincides with the static level of the water in an aquifer (i.e., the maximum elevation to which water will rise in a well or piezometer penetrating the aquifer). The term "potentiometric surface" is usually applied to confined aquifers, although the water table is the potentiometric surface of an unconfined aquifer.

Unconfined Aquifer - An aquifer in which the water table forms the upper boundary.

Water Table - The surface in the groundwater system at which the fluid pressure is equal to atmospheric pressure (i.e., the net pressure head is zero) and below which all geologic strata are saturated with water.

## 4.0 RESPONSIBILITIES AND PERSONNAL REQUIREMENTS

Project Hydrogeologist - The project hydrogeologist has overall responsibility for obtaining water level measurements and developing groundwater contour maps. The hydrogeologist will specify the reference point from which water levels are measured (usually a specific point on the upper edge of the inner well casing), the number of data points needed and which wells will be used for a contour map, and how many complete sets of water levels are required to adequately define groundwater flow directions (e.g., if there are seasonal variations).

Field Personnel - All supporting field personnel must have a basic familiarity with the equipment and procedures involved in obtaining water levels and must be aware of any project-specific requirements.

General personnel qualifications for contour map preparation include the following:

- Technical background in geosciences
- Familiarity with reading and interpreting boring logs and other geologic and hydrogeologic information
- Strong technical understanding of groundwater flow, influences on groundwater flow, and techniques for evaluation of groundwater flow data

## 5.0 PROCEDURES

### 5.1 POTENTIOMETRIC SURFACE MAPPING

Construction of a potentiometric surface map includes the following general steps:

- Selecting wells
- Obtaining water level measurements and calculating groundwater elevations
- Constructing equipotential lines
- Determining groundwater flow direction(s)

**Selecting Wells:**

- All wells used to construct a single potentiometric map must represent the same hydrogeologic unit. The recorded water levels, monitoring well construction data, site geology, and topographic setting must be reviewed to ascertain that the wells are completed in the same hydrogeologic unit and to determine whether strong vertical hydraulic gradients may be present. Strong vertical hydraulic gradients will be manifested by a pronounced correlation between well depth and water level or by differences in water levels between two wells located near each other but having different screened intervals or screen lengths. Professional judgment of the hydrogeologist is important in this determination. If vertical gradients are significant, the data to be used must be limited vertically, and only wells finished within a chosen vertical zone of the hydrogeologic unit can be used (unless a vertical flow net is being constructed).

- Data from at least three wells are needed to provide an estimation of the direction of groundwater flow, and the three wells should be distributed across the site in a configuration other than a straight line. Information from many more than three wells is generally needed to provide an accurate contour map.

In general, shallow groundwater flow systems require data from more wells than deep systems for accurate contour mapping.

- Accurate and useful potentiometric surface maps for shallow flow systems require water level measurements from nearby surface water bodies, especially at sites where groundwater/surface water interactions are, or may be, important. Acquisition of these measurements should be incorporated into the field investigation planning process.

**Obtaining Water Level Measurements and Calculating Groundwater Elevations**

After selecting wells, the next step is to obtain water level measurements from the selected points. In addition, measurements from any other readily available wells/surface water bodies should be collected to ensure that sufficient data are available for interpretation purposes. To calculate groundwater elevations from water level measurements, survey data for all monitoring wells must be available and referenced to the same vertical datum. In addition, elevations of points and areas of groundwater discharge or recharge such as springs, seeps, streams, rivers, and lakes need to be determined, typically through staff gauge measurements.

***REMINDER*:**

***All water level measurements to be used to generate potentiometric surface maps must be collected on the same day,*** preferably within 2 to 3 hours. This is especially important when working in an area where groundwater levels are tidally influenced or influenced by pumping.

Calculate groundwater elevations using water level measurements and elevation (survey) data as follows:

- Compile measurements of depth to water in the wells and surface water points to be used for mapping. Water level measurements in monitoring wells or piezometers are generally taken from the tops of the well casings. Consult Standard Operating Procedure (SOP) GH-1.2. It is important that the measurement points at all wells are documented (e.g., location of notch at top of PVC casing) so that the points at which measurements are taken can be surveyed. The procedure for surface water depth-to-water measurements depends on the location and nature of the point being used. For example, if a surface water measurement is required in an area with an accessible permanent feature that can be used for reference (e.g., a bridge or culvert), a measurement can be taken from a fixed point on the bridge/culvert, and the elevation of that point can later be surveyed.

- Compile surveyed elevations for the wells and surface water points, making sure that all elevations are referenced to the same vertical datum. If the difference in elevations across a site appears to be greater that the total change in elevation across the site, recheck the vertical datum. The North American Vertical Datum of 1988 (NAVD 88) is the current national standard vertical datum, but site-specific datums can also be used.

- Subtract the depth-to-water measurement at each well (generally in feet below top of casing) from the corresponding top-of-casing elevation (generally in feet above mean sea level referenced to NAVD 88) to calculate the groundwater (potentiometric surface) elevation at each well. For surface water elevations, subtract the depth-to-water measurement to the surface water body from the elevation of the reference point at which the measurement was taken.

## Constructing Equipotential Lines:

- Plot water level elevations on a site map. Other hydrogeologic features associated with the zone of interest, such as seeps, wetlands, and surface water bodies, should also be plotted along with their elevations. Topographic contours are also important to consider in interpreting groundwater flow and should be included on the site map.

- Contour the data using mathematically valid and generally accepted techniques. Linear interpolation is the most commonly used technique, however other techniques of trend-surface analysis or data smoothing are also acceptable. Computer-generated contour maps may be useful for rough mapping of large data sets; however, final detailed mapping must ***always*** be performed by hand by an experienced hydrogeologist. Draw all equipotential contours as smooth, continuous lines that never cross one another. Where data is sparse and contouring has significant uncertainty associated with it, dashed contours should be used instead of continuous lines.

- Inspect the contour map, noting known features such as pumping wells, surface water bodies, and site topography, and adjust the contour lines using professional judgment in accordance with these features. Closed contours should be avoided unless a known groundwater sink (i.e., pumping well) or mound exists. Groundwater mounding is common under landfills and lagoons; if the data imply this, the feature must be evident in the contour plot.

- If the hydrogeologic system consists of a water table aquifer and one or more confined aquifers, prepare separate contour maps for each aquifer. Develop water table maps using water level measurements from monitoring wells screened at or near the unsaturated-saturated interface. Contour water level measurements from monitoring wells screened in deeper portions of an unconfined aquifer as a separate potentiometric surface map(s). Tie surface water discharge or recharge features into the water table groundwater flow system.

- If constructing a vertical flow net, use a cross section aligned parallel to the direction of groundwater flow, and plot all water level measurements along this cross section, both deep and shallow, to develop equipotential lines and flow lines.

## Determining Groundwater Flow Direction:

- ***Draw flow lines so that they are perpendicular to equipotential lines***. Flow lines will begin at high head elevations and end at low head elevations. Closed highs (mounding) will be the source of additional flow lines. Closed depressions (i.e., pumping wells) will be the termination of some flow lines. Care must be used in areas with significant vertical gradients to avoid erroneous conclusions concerning gradients and flow directions.

- Include a flow arrow(s) drawn parallel to the direction(s) of flow (and perpendicular to equipotential lines) on each potentiometric surface contour map. The number of arrows required depends on the complexity of the flow system, but only major changes should have separate arrows. Again, professional judgment is required.

***REMINDER*:**

***Have the completed cross section reviewed by the project hydrogeologist or another qualified geoscientist with significant groundwater flow contouring experience.***

## 5.2 GROUNDWATER FLOW CONSIDERATIONS

Groundwater movement is an integral part of the hydrologic cycle. Recharge to the shallow groundwater environment generally occurs by infiltration of precipitation through an upper unsaturated soil zone. Movement is downward under the force of gravity until the water reaches the saturated zone of the water table aquifer. After water has become part of the water table aquifer, movement is controlled by differences in hydraulic head, with movement from areas of high head to areas of low head. Areas of low head include natural discharge areas such as springs, lakes, rivers, and, ultimately, oceans. These features can be considered as outcrops of the water table. Points of low head also are created by pumping wells.

Local head differences and consequent vertical flow patterns within an aquifer can be detected by well clusters. A well cluster consists of several adjacent wells, generally installed within a few feet of each other, and screened at different depths. Variations in water levels in these closely spaced wells indicate the vertical component of groundwater flow within an aquifer, provided that the wells are all screened within the same aquifer.

The number, location, and extent of geologic units and their properties with regard to aquifer or aquitard characteristics must be understood to properly interpret water level data gathered from the monitoring system. This firm understanding of the hydrogeologic system must be developed through a program of borings, wells, and interpretation of subsurface geology. The adequacy of the positions and depths of borings/wells used to define relevant subsurface hydrogeologic conditions must also be assessed. The location of surface water discharge or recharge points must be considered. Surface water features influence the system because flow is most likely toward them (if they are discharge points) or away from them (if they are recharge points). Man-made discharge or recharge features such as pumping or injection wells, ditches, and trenches can also affect the flow of groundwater.

## 5.3 DETERMINATION OF FLOW RATE

Darcy's Law states that the quantity of water flowing through a geologic material is dependent on the permeability of the material, hydraulic gradient, and cross-sectional area through which the water flows. This relation is expressed in the equation:

$$Q = KiA$$

where:

Q = volume of water flowing through the cross sectional area of the formation ($L^3/T$)
K = hydraulic conductivity (L/T)
i = hydraulic gradient (L/L, i.e., dimensionless)
A = cross sectional area of formation being considered ($L^2$)
L = length (or distance)
T = time

The relation is similar to one used in stream flow measurements where:

$$Q = VA$$

where:

Q = discharge from the cross sectional area of a stream or pipe ($L^3/T$)
V = average velocity of flowing water (L/T)
A = cross sectional area through which water flows ($L^2$)
L = length (or distance)

T = time

To determine the velocity of water movement within a geologic formation, which depends on the specific formation properties and the head differences across the formation, use the following equation:

$$V = \frac{Ki}{n}$$

where:

V = average linear velocity of groundwater through the formation (L/T)
K = hydraulic conductivity (L/T)
i = hydraulic gradient (dimensionless)
n = porosity (expressed as a fraction)
L = length (or distance)
T = time

Hydraulic conductivity, K, can be determined using slug tests (see SOP GH-2.4) packer tests (see SOP GH-2.2), pumping tests (see SOP GH-2.3), or geotechnical laboratory analysis of undisturbed soil samples (see SOP SA-1.3). Hydraulic conductivity is related to the permeability of the formation and depends on the size and interconnection of the pore spaces. In isotropic and homogeneous formations, the hydraulic conductivity will be the same vertically and horizontally. In anisotropic formations, horizontal and vertical conductivity can be markedly different, and the vertical hydraulic conductivity can be up to several orders of magnitude lower than the horizontal hydraulic conductivity. Typically, most formations are anisotropic with horizontal hydraulic conductivities at least several times greater than vertical hydraulic conductivities. Generally, hydraulic conductivities are high for sands, gravels, and limestone containing large solution cavities and low for silts, clays, and tightly fractured rock (see Attachment A).

General values of porosity, n, for several geologic materials are provided in Attachment A. More accurate and specific values of porosity can be obtained by laboratory analysis of site-specific formation samples or evaluation of unconfined aquifer pumping test results. Results from field testing usually provide greater (and more representative) hydraulic conductivities than laboratory testing because full-scale field testing includes the effects of the formational macrostructure (i.e., secondary permeability due to jointing or fractures), which is not reflected in the testing of a small sample in the laboratory.

Hydraulic gradient, i, is defined as the rate of change in hydraulic head (dh) per unit distance of flow (dl) determined from field measurements of hydraulic head, as follows:

- Using the potentiometric surface map generated as described above, measure the horizontal distance (generally in feet) between two equipotential lines (dl) that represent a significant portion of the site. If equipotential lines are spaced significantly differently in different areas of the site (e.g., closely spaced in the northern portion and widely separated in the southern portion), consider calculating separate gradients for the different sections of the site in addition to a site-wide gradient. The longer the distance over which the head change is measured, the more representative the gradient is of overall conditions. However, averaging gradients across large areas may not accurately represent the distribution of different gradients across the area.

- Do ***not*** measure from well to well; measure along a flow line drawn extending (and running perpendicular) from the beginning to ending equipotential lines that are drawn based on well (and other) hydraulic head data.

- Determine the change in head (dh) (generally in feet and in [or converted to] the same units as dl) between the equipotential lines described above (i.e., the difference in elevation between the lines). For example, if lines used in the horizontal distance measurement above represented 100 and 105 feet above mean sea level, the dh would be: 105 feet -100 feet = 5 feet.

- Using the values of dl and dh (in the same units) as determined above, calculate the hydraulic gradient by dividing the change in head by the length of the flow line using the following formula:

$$i = \frac{dh}{dl}$$

where:

dh = change in head (L)
dl = distance between equipotential lines (L)

- Because the distance and head differences (change in head) are in the same units, hydraulic gradients are dimensionless.

## 5.4 CONTAMINANT TRANSPORT

When chemical solutes are traveling in groundwater, as in cases of groundwater contamination, the calculated groundwater velocity may predict migration rates in excess of those actually observed. The difference in chemical versus water velocities may be due to attenuation or biodegradation of the chemical species in the aquifer. Attenuation is most often caused by adsorption of the chemical contaminant onto the formation grains or matrix. The result is that the chemical does not appear at the downgradient sampling point as quickly as the velocity calculation predicts. An equation to correct for this attenuation is:

$$V_c = V_w / (1 + K_d P_b / n)$$

where:

$V_c$ = velocity of the chemical solute flow (L/T)
$V_w$ = velocity of groundwater flow (L/T)
$P_b$ = formation mass bulk density ($M/L^3$)
n = formation porosity (expressed as a fraction)
$K_d$ = distribution coefficient = ($L^3/M$)

The $K_d$ is equal to the mass of solute per unit mass of solid phase divided by the concentration of solute in a solution that is in equilibrium with the solid phase. The term in the denominator is known as the retardation factor.

Density and/or viscosity differences between water and contaminants can also cause velocity determination errors. Light hydrocarbons such as gasoline are less dense than water and consequently float on the water table. These contaminants can migrate along the water table surface at rates different than the rate of groundwater movement, depending on specific conditions, and may also volatilize into unsaturated soil pore spaces. Oils are more viscous than water and will typically migrate more slowly due to the viscosity difference. Contaminants denser than water such as heavy hydrocarbons (e.g., coal tar) or chlorinated compounds (e.g., TCE, PCE) tend to sink if present in concentrations exceeding their solubility limit (these chemicals are often referred to as dense, nonaqueous phase liquids, or DNAPLs if present as a separate-phase liquid), then pool along the surface of a low permeability layer encountered. Here, the separate-phase contamination may move at faster or slower rates than the overlying groundwater and may actually move in a direction opposite to that of the groundwater, depending on the dip of the surface that the DNAPL pools on.

Other factors involving the physicochemical interaction between the chemical and the groundwater, such as dilution (mixing of contaminated water with uncontaminated or less-contaminated groundwater) and dispersion (molecular diffusion of the chemical throughout the groundwater regime), can also affect the observed rates of contaminant transport in groundwater.

## 6.0 REFERENCES

Cedergren, H. R., 1997. Seepage, Drainage and Flow Nets (Third edition). John Wiley and Sons, New York.

Fetter, C. W., 2018. Applied Hydrogeology (Fourth edition). Waveland Press, Long Grove, IL.

Davis, S. N. and R. J. DeWiest, 1966. Hydrogeology. John Wiley and Sons, New York.

Freeze, R. A. and J. A. Cherry, 1979. Ground Water. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Johnson Division, UOP, Inc., 1975. Ground Water and Wells. Johnson Division, UOP, Inc., Saint Paul, Minnesota.

## ATTACHMENT A (EXAMPLE)

## GENERALIZED POROSITY AND HYDRAULIC CONDUCTIVITY VALUES FOR GEOLOGIC MATERIALS

| Material | Porosity Range (%) | Hydraulic Conductivity Range | |
|---|---|---|---|
| | | cm/sec | ft/day |
| Gravel | 30-40 | $10^{-1}$ to $10^{-2}$ | 280 to 2.8 x $10^{5}$ |
| Coarse sand (clean) | 30-40 | $10^{-1}$ to 1 | 280 to 2,800 |
| Medium sand (clean) | 35-45 | $10^{-2}$ to $10^{-1}$ | 28 to 280 |
| Fine sand (clean) | 40-50 | 5 x $10^{-4}$ to $10^{-2}$ | 1.4 to 28 |
| Silty sand | 25-40 | $10^{-5}$ to $10^{-2}$ | 0.03 to 280 |
| Glacial Till | Variable | $10^{-10}$ to $10^{-4}$ | 3 x $10^{-7}$ to 0.3 |
| Unweathered Clay/Shale | 45-55 (clay) | $10^{-7}$ to $10^{-4}$ | 3 x $10^{-4}$ to 0.3 (horizontal) |
| | | $10^{-10}$ to $10^{-6}$ | 3 x $10^{-7}$ to 3 x $10^{-3}$ (vertical) |
| Karst Limestone | --- | $10^{-4}$ to $10^{-1}$ | 0.3 to 2,800 |
| Fractured Igneous/Metamorphic Rocks | --- | $10^{-6}$ to $10^{-1}$ | 3 x $10^{-3}$ to 280 |
| Sandstone | 5-30 | $10^{-8}$ to $10^{-4}$ | 3 x $10^{-5}$ to 0.3 |

Sources: Cedergren, 1977 and Fetter, 1980.

| | | | |
|---|---|---|---|
| **TETRA TECH** | **STANDARD OPERATING PROCEDURES** | Number<br>GH-2.8 | Page<br>1 of 12 |
| | | Effective Date<br>06/19/2020 | Revision<br>5 |
| | | Applicability<br>EGS Operating Unit | |
| | | Prepared<br>Earth Sciences Department | |
| Subject<br>GROUNDWATER MONITORING WELL INSTALLATION | | Approved<br>T. Johnston T.E. Johnston 06/19/2020 | |

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## 1.0 PURPOSE

This procedure provides general guidance and information pertaining to proper monitoring well design, installation, and development.

## 2.0 SCOPE

This procedure is applicable to the construction of monitoring wells. The methods described herein may be modified by project-specific requirements for monitoring well construction. In addition, many regulatory agencies have specific regulations pertaining to monitoring well construction and permitting. These requirements must be determined during the project planning phases of the investigation, and any required permits must be obtained before field work begins. Innovative monitoring well installation techniques, which typically are not used, will be discussed only generally in this procedure.

## 3.0 GLOSSARY

Monitoring Well - A well which is screened, cased, and sealed which is capable of providing a groundwater level and groundwater sample representative of the zone being monitored. Some monitoring wells may be constructed as open boreholes.

Piezometer - A pipe or tube inserted into the water bearing zone, typically open to water flow at the bottom and to the atmosphere at the top, and used to measure water level elevations. Piezometers may range in size from 1/2-inch-diameter plastic tubes to well points or monitoring wells.

Potentiometric Surface - The surface representative of the level to which water will rise in a well cased to the screened aquifer.

Well Point (Drive Point) - A screened or perforated tube (Typically 1-1/4 or 2 inches in diameter) with a solid, conical, hardened point at one end, which is attached to a riser pipe and driven into the ground with a sledge hammer, drop weight, or mechanical vibrator. Well points may be used for groundwater injection and recovery, as piezometers (i.e., to measure water levels) or to provide groundwater samples for water quality data.

## 4.0 RESPONSIBILITIES

Driller - The driller provides adequate and operable equipment, sufficient quantities of materials, and an experienced and efficient labor force capable of performing all phases of proper monitoring well installation and construction. The driller may also be responsible for obtaining, in advance, any required permits for monitoring well installation and construction.

Field Geologist - The field geologist supervises and documents well installation and construction performed by the driller, and insures that well construction is adequate to provide representative groundwater data from the monitored interval. Geotechnical engineers, field technicians, or other suitable trained and experienced personnel may also serve in this capacity.

## 5.0 PROCEDURES

### 5.1 EQUIPMENT/ITEMS NEEDED

Below is a list of items that may be needed when installing a monitoring well or piezometer:

- Health and safety equipment (hard hats, safety glasses, etc.) as required by the Site Safety Officer.

- Well drilling and installation equipment with associated materials (typically supplied by the driller).

- Hydrogeologic equipment (weighted engineer's tape, water level indicator, retractable engineers rule, electronic calculator, clipboard, mirror and flashlight - for observing downhole activities, paint and ink marker for marking monitoring wells, sample jars, well installation forms, and a field notebook).

- Drive point installation tools (sledge hammer, drop hammer, or mechanical vibrator; tripod, pipe wrenches, drive points, riser pipe, and end caps).

### 5.2 WELL DESIGN

The objectives and intended use for each monitoring well must be clearly defined before the monitoring system is designed. Within the monitoring system, different monitoring wells may serve different purposes and, therefore, require different types of construction. During all phases of the well design, attention must be given to clearly documenting the basis for design decisions, the details of well construction, and the materials used. The objectives for installing the monitoring wells may include:

- Determining groundwater flow directions and velocities.
- Sampling or monitoring for contaminants in groundwater.
- Determining aquifer characteristics (e.g., hydraulic conductivity).

Siting of monitoring wells shall be performed after a preliminary estimation of the groundwater flow direction. In most cases, groundwater flow directions and potential well locations can be determined by an experienced hydrogeologist through the review of geologic data and the site terrain. In addition, data from production wells or other monitoring wells in the area may be used to determine the groundwater flow direction. If these methods cannot be used, piezometers, which are relatively inexpensive to install, may have to be installed in a preliminary investigative phase to determine groundwater flow direction.

#### 5.2.1 Well Depth, Diameter, and Monitored Interval

The well depth, diameter, and monitored interval must be tailored to the specific monitoring needs of each investigation. Specification of these items generally depends on the purpose of the monitoring system and the characteristics of the hydrogeologic system being monitored. Wells of different depth, diameter, and monitored interval can be employed in the same groundwater monitoring system. For instance, varying the monitored interval in several wells, at the same location (cluster wells) can help to determine the vertical gradient and the depths at which contaminants are present. Conversely, a fully penetrating well is usually not used to quantify or vertically locate a contaminant plume, since groundwater samples collected in wells that are screened over the full thickness of the water-bearing zone will be representative of average conditions across the entire monitored interval. However, fully penetrating wells can be used to establish the existence of contamination in the water-bearing zone. The well diameter desired depends upon the hydraulic characteristics of the water-bearing zone, sampling requirements, drilling method and cost.

The decision concerning the monitored interval and well depth is based on the following (and possibly other) information:

- The vertical location of the contaminant source in relation to the water-bearing zone.
- The depth, thickness and uniformity of the water-bearing zone.
- The anticipated depth, thickness, and characteristics (e.g., density relative to water) of the contaminant plume.
- Fluctuation in groundwater levels (due to pumping, tidal influences, or natural recharge/discharge events).
- The presence and location of contaminants encountered during drilling.
- Whether the purpose of the installation is for determining existence or non-existence of contamination or if a particular stratigraphic zone is being investigated.
- The analysis of borehole geophysical logs.

In most situations where groundwater flow lines are horizontal, depending on the purpose of the well and the site conditions, monitored intervals are 20 feet or less. Shorter screen lengths (5 feet or less) are usually required where flow lines are not horizontal, (i.e., if the wells are to be used for accurate measurement of the potentiometric head at a specific point).

Many factors influence the diameter of a monitoring well. The diameter of the monitoring well depends on the application. In determining well diameter, the following needs must be considered:

- Adequate water volume for sampling.
- Drilling methodology.
- Type of sampling device to be used.
- Costs.

Standard monitoring well diameters are 2, 4, 6, or 8 inches. Drive points are typically 1-1/4 or 2 inches in diameter. For monitoring programs which require screened monitoring wells, either a 2-inch or 4-inch-diameter well is preferred. Typically, well diameters greater than 4 inches are used in monitoring programs in which open-hole bedrock monitoring wells are used. With smaller diameter wells, the volume of stagnant water in the well is minimized, and well construction costs are reduced; however, the sampling devices that can be used are limited.

In specifying well diameter, sampling requirements must be considered (up to a total of 4 gallons of water may be required for a single sample to account for full organic and inorganic analyses, and split samples), particularly if the monitored formation is known to be a low-yielding formation. The unit volume of water contained within a monitoring well is dependent on the well diameter as follows:

| Casing Inside Diameter (Inch) | Standing Water Length to Obtain 1 Gallon Water (Feet) |
|---|---|
| 2 | 6.13 |
| 4 | 1.53 |
| 6 | 0.68 |

If a well recharges quickly after purging, then well diameter may not be an important factor regarding sample volume requirements.

Pumping tests for determining aquifer characteristics may require larger diameter wells (for installation of high capacity pumps); however, in small-diameter wells in-situ permeability tests can be performed during drilling or after well installation is completed.

### 5.2.2 Riser Pipe and Screen Materials

Well materials are specified by diameter, type of material, and thickness of pipe. Well screens require an additional specification of slot size. Thickness of pipe is referred to as "Schedule" for polyvinyl chloride (PVC) casing and is usually Schedule 40 (thinner wall) or 80 (thicker wall). Steel pipe thickness is often referred to as "Strength". Standard Strength is usually adequate for monitoring well purposes. With larger diameter pipe, the wall thickness must be greater to maintain adequate strength. The required thickness is also dependent on the method of installation; risers for drive points require greater strength than wells installed inside drilled borings.

The selection of well screen and riser materials depends on the method of drilling, the type of subsurface materials the well penetrates, the type of contamination expected, and natural water quality and depth. Cost and the level of accuracy required are also important. The materials generally available are Teflon, stainless steel, PVC, galvanized steel, and carbon steel. Each has advantages and limitations (see Attachment A of this guideline for an extensive presentation on this topic). The two most commonly used materials are PVC and stainless steel. Properties of these two materials are compared in Attachment B. Stainless steel is a good choice where trace metals or organic sampling is required; however, costs are high. Teflon materials are extremely expensive, but are relatively inert and provide the least opportunity for water contamination due to well materials. PVC has many advantages, including low cost, excellent availability, light weight, ease of manipulation, and widespread acceptance. The crushing strength of PVC may limit the depth of installation, but the use of Schedule 80 materials may overcome some of the problems associated with depth. However, the smaller inside diameter of Schedule 80 pipe may be an important factor when considering the size of bailers or pumps required for sampling or testing. Due to this problem, the minimum well pipe size recommended for Schedule 80 wells is 4-inch I.D.

Screens and risers may have to be decontaminated before use because oil-based preservatives and oil used during thread cutting and screen manufacturing may contaminate samples. Metal pipe may corrode and release metal ions or chemically react with organic constituents, but this is considered a minor issue. Galvanized steel is not recommended where samples may be collected for metals analyses, as zinc and cadmium levels in groundwater samples may become elevated from leaching of the zinc coating.

Threaded, flush-joint casing is most often preferred for monitoring well applications. PVC, Teflon, and steel can all be obtained with threaded joints. Welded-joint steel casing is also acceptable. Glued PVC may release organic contaminants into the well, and therefore, should not be used if the well is to be sampled for organic constituents.

When the water-bearing zone is in consolidated bedrock, such as limestone or fractured granite, a well screen is often not necessary (the well is simply an open hole in bedrock). Unconsolidated materials, such as sands, clay, and silts require a screen. A screen slot size of 0.010 or 0.020 inch is generally used when a screen is necessary, and the annular borehole space around the screened interval is artificially packed with an appropriately sized sand, selected based on formation grain size. The slot size controls the quantity of water entering the well and prevents entry of natural materials or sand pack. The screen shall pass no more than 10 percent of the pack material, or in-situ aquifer material. The site geologist shall specify the combination of screen slot size and sand pack which will be compatible with the water-bearing zone, to maximize groundwater inflow and minimize head losses and movement of fines into the wells. For example, as a standard procedure, a Morie No. 1 or No. 10 to No. 20 U.S. Standard Sieve size filter pack is typically appropriate for a 0.020-inch slot screen; however, a No. 20 to No. 40 U.S. Standard Sieve size filter pack is typically appropriate for a 0.010-inch slot screen.

### 5.2.3 Annular Materials

Materials placed in the annular space between the borehole and riser pipe and screen include a sand pack when necessary, a bentonite seal, and cement-bentonite grout. The sand pack is usually a medium-to coarse-grained poorly graded, silica sand and should relate to the grain size of the aquifer sediments. The quantity of sand placed in the annular space is dependent upon the length of the screened interval, but should always extend at least 1 foot above the top of the screen. At least 1 to 3 feet of bentonite pellets or equivalent shall be placed above the sand pack. Cement-bentonite grout (or equivalent) is then placed to extent from the top of the bentonite pellets to the ground surface.

On occasion, and with the concurrence of the involved regulatory agencies, monitoring wells may be packed naturally (i.e., no artificial sand pack installed). In this case, the natural formation material is allowed to collapse around the well screen after the well is installed. This method has been used where the formation material itself is a relatively uniform grain size, or when artificial sand packing is not possible due to borehole collapse.

Bentonite expands by absorbing water and provides a seal between the screened interval and the overlying portion of the annular space and formation. Cement-bentonite grout is placed on top of the bentonite pellets, extending to the surface. The grout effectively seals the remaining borehole annulus and eliminates the possibility for surface infiltration reaching the screened interval. Grouting also replaces material removed during drilling and prevents hole collapse and subsidence around the well. A tremie pipe should be used to introduce grout from the bottom upward, to prevent bridging, and to provide a better seal. In shallow boreholes that don't collapse, it may be more practical to pour the grout from the surface without a tremie pipe.

Grout is a general term which has several different connotations. For all practical purposes within the monitoring well installation industry, grout refers to the solidified material which is installed and occupies the annular space above the bentonite pellet seal. Grout, most of the time, is made up of one or two assemblages of material, (e.g., cement and/or bentonite). A cement-bentonite grout, which is the most common type of grout used in monitoring well completions, normally is a mixture of cement, bentonite, and water at a ratio of one 90-pound bag of Portland Type I cement, plus 3 to 5 pounds of granular or flake-type bentonite, and 6-7 gallons of water. A neat cement consists of one ninety-pound bag of Portland Type I cement and 6-7 gallons of water. A bentonite slurry (bentonite and water mixed to a thick but pumpable mixture) is sometimes used instead of grout for deep well installations where placement of bentonite pellets is difficult. Bentonite chips are also occasionally used for annular backfill in place of grout.

In certain cases, the borehole may be drilled to a depth greater than the anticipated well installation depth. For these cases, the well shall be backfilled to the desired depth with bentonite pellets/chips or sand. A short (1- to 2-foot) section of capped riser pipe sump is sometimes installed immediately below the screen, as a silt reservoir, when significant post-development silting is anticipated. This will ensure that the entire screen surface remains unobstructed.

### 5.2.4 Protective Casing

When the well is completed and grouted to the surface, a protective steel casing is typically placed over the top of the well. This casing generally has a hinged cap and can be locked to prevent vandalism. The protective casing has a larger diameter than the well and is set into the wet cement grout over the well upon completion. In addition, one hole is drilled just above the cement collar through the protective casing which acts as a weep hole for the flow of water which may enter the annulus during well development, purging, or sampling.

A protective casing which is level with the ground surface (flush-mounted) is used in roadway or parking lot applications where the top of a monitoring well must be below the pavement. The top of the riser pipe is placed 4 to 5 inches below the pavement, and a locking protective casing is cemented in place to 3 inches below the pavement. A large diameter, manhole-type protective collar is set into the wet cement around the well with the top set level with or slightly above the pavement. An appropriately-sized lid, typically 8-inch diameter, is placed over the protective sleeve. The cement should be slightly mounded to direct pooled water away from the well head.

## 5.3 MONITORING WELL INSTALLATION

Pertinent data regarding monitoring well installation shall be recorded on log sheets as depicted and discussed in SOP SA-6.3. Attachments to this referenced SOP illustrate terms and physical construction of various types of monitoring wells.

### 5.3.1 Monitoring Wells in Unconsolidated Sediments

After the borehole is drilled to the desired depth, well installation can begin. The procedure for well installation will partially be dictated by the stability of the formation in which the well is being placed. If the borehole collapses immediately after the drilling tools are withdrawn, then a temporary casing must be installed and well installation will proceed through the center of the temporary casing, and continue as the temporary casing is withdrawn from the borehole. In the case of hollow-stem auger drilling, the augers will act to stabilize the borehole during well installation.

Before the screen and riser pipe are lowered into the borehole, all pipe and screen sections should be measured with an engineer's rule to verify screen and riser pipe lengths for proper depth placement. When measuring sections, the threads on one end of the pipe or screen must be excluded while measuring, since the pipe and screen sections are screwed flush together.

After the screen and riser pipe are lowered through the temporary casing, the sand pack can be installed. A weighted tape measure must be used during the installation procedure to carefully monitor installation progress. The sand is slowly poured into the annulus between the riser pipe and temporary casing, as the temporary casing is withdrawn. Sand should always be kept within the temporary casing during withdrawal in order to ensure an adequate sand pack. However, if too much sand is within the temporary casing (greater than 1 foot above the bottom of the casing) bridging between the temporary casing and riser pipe may occur. Centralizers may be used at the geologist's discretion, one above and one below the screen, to assure enough annular space for sand pack placement.

After the sand pack is installed to the desired depth (at least 1 foot above the top of the screen), then the bentonite pellet seal (or equivalent), can be installed in the same manner as the sand pack. At least 1 to 3 feet of bentonite pellets should be installed above the sand pack. Pellets should be added slowly, and their fall monitored closely to ensure that bridging does not occur. Bentonite pellets require hydration to provide the desired sealing properties and generally require a minimum time for hydration dependent on the regulatory requirements or on manufacturers specifications.

The cement-bentonite grout is then mixed and tremied into the annulus as the temporary casing or augers are withdrawn. Finally, the protective casing can be installed as detailed in Section 5.2.4.

### 5.3.2 Confining Layer Monitoring Wells

When drilling and installing a well in a confined aquifer, proper well installation techniques must be applied to avoid cross contamination between aquifers. Under most conditions, this can be accomplished by installing double-cased wells. This is accomplished by drilling a large-diameter boring through the upper aquifer, 1 to 5 feet into the underlying confining layer, and setting and pressure grouting or tremie grouting a large-diameter casing into the confining layer. The grout material must fill the space between the native material and the outer casing. A smaller diameter boring is then continued through the confining layer for installation of the monitoring well as detailed for overburden monitoring wells. Sufficient time (determined by the field geologist), must be allowed for curing of the grout prior to drilling through the confined layer.

### 5.3.3 Bedrock Monitoring Wells

When installing bedrock monitoring wells, a large diameter boring is drilled through the overburden and approximately 5 –10 feet into bedrock. A casing (typically steel) is installed and either pressure grouted or tremie grouted in place. After the grout has cured, a smaller diameter boring is continued into bedrock to the desired depth. If the boring does not collapse, the well can be left open, and a screen is not necessary. If the boring collapses, then a screen is required and can be installed as detailed for overburden monitoring wells. If a screen is to be used, then the casing which is installed through the overburden and into the bedrock does not require grouting and can be removed when the final well installation is completed with the full annular seal.

### 5.3.4 Drive Points

Drive points can be installed with either a sledge hammer, drop hammer, or a mechanical vibrator. The screen section is threaded and tightened onto the riser pipe with pipe wrenches. The drive point is simply pounded into the subsurface to the desired depth. If a heavy drop hammer is used, then a tripod and pulley setup is required to lift the hammer. Drive points typically cannot be manually driven to depths exceeding 10 feet.

Direct push sampling/monitoring point installation methods, using a direct push rig or drilling rig, are described in SOP SA-2.5.

### 5.3.5 Innovative Monitoring Well Installation Techniques

Certain innovative sampling devices have proven advantageous. These devices are essentially screened samplers installed in a borehole with only small-diameter tubes extending to the surface. This reduces drilling costs, decreases the volume of stagnant water, and provides a sampling system that minimizes cross-contamination from sampling equipment. Four manufacturers of these samplers include Timco Manufacturing Company, Inc., of Prairie du Sac, Wisconsin, BARCAD Systems, Inc., of Concord, Massachusetts, Westbay Instruments Ltd. of Vancouver, British Columbia, Canada and the University of Waterloo at Waterloo, Ontario, Canada.. Each manufacturer offers various construction materials, installation procedures, and sampling techniques.

## 5.4 WELL DEVELOPMENT METHODS

The purpose of well development is to stabilize and increase the permeability of the gravel pack around the well screen, and to restore the permeability of the formation which may have been reduced by drilling operations. Wells are typically developed until all fine material and drilling water is removed from the well. If water is used during drilling, the driller should be aware of amount of water gained or lost into the formation. Sequential measurements of pH, conductivity, turbidity, and temperature taken during development should provide information (stabilized values) regarding whether sufficient development has been performed. The selection of the well development method shall be made by the field geologist and is based on the drilling methods, well construction and installation details, and the characteristics of the formation that the well is screened in. The primary methods of well development are summarized below. A more detailed discussion may be found in Driscoll (1986).

### 5.4.1 Overpumping and Backwashing

Wells may be developed by alternatively drawing the water level down at a high rate (by pumping or bailing) and then reversing the flow direction (backwashing) so that water is passing from the well into the formation. This back and forth movement of water through the well screen and gravel pack serves to remove fines from the formation immediately adjacent to the well, while preventing bridging (wedging) of sand grains. Backwashing can be accomplished by several methods, including pouring water into the well and then bailing, starting and stopping a pump intermittently to change water levels, or forcing water into the well under pressure through a water-tight fitting ("rawhiding"). Care should be taken when backwashing not to apply too much pressure, which could damage or destroy the well screen or the sand pack.

### 5.4.2 Surging with a Surge Plunger

A surge plunger (also called a surge block) is approximately the same diameter as the well casing and is aggressively moved up and down within the well to agitate the water, causing it to move in and out of the screens. This movement of water pulls fine materials into the well, where they may be removed by any of several methods, and prevents bridging of sand particles in the gravel pack. There are two basic types of surge plungers; solid and valved surge plungers. In formations with low yields, a valved surge plunger may be preferred, as solid plungers tend to force water out of the well at a greater rate than it will flow back in. Valved plungers are designed to produce a greater inflow than outflow of water during surging.

### 5.4.3 Compressed Air

Compressed air can be used to develop a well by either of two methods: backwashing or surging. Backwashing is done by forcing water out through the screens, using increasing air pressure inside a sealed well, then releasing the pressurized air to allow the water to flow back into the well. Care should be taken when using this method so that the water level does not drop below the top of the screen, thus introducing air into the formation and reducing well yield. Surging, or the "open well" method, consists of alternately releasing large volumes of air suddenly into an open well below the water level to produce a strong surge by virtue of the resistance of water head, friction, and inertia. Pumping of the well is subsequently done using the air lift method. Compressor must have a compressed air trap to capture water and oil from the compression process.

### 5.4.4 High Velocity Jetting

In the high velocity jetting method, water is forced at high velocities from a plunger-type device and through the well screen to loosen fine particles from the sand pack and surrounding formation. The jetting tool is slowly rotated and raised and lowered along the length of the well screen to develop the entire screened area. Jetting using a hose lowered into the well may also be effective. The fines washed into the screen during this process can then be bailed or pumped from the well.

## 6.0 RECORDS

A critical part of monitoring well installation is recording of all significant details and events in the site logbook or field notebook. The geologist must record the exact depths of significant hydrogeological features, screen placement, gravel pack placement, and bentonite placement.

A Monitoring Well Sheet (see Attachments to SOP SA-6.3) shall be completed, ensuring the uniform recording of data for each installation and rapid identification of missing information. Well depth, length, materials of construction, length and openings of screen, length and type of riser, and depth and type of all backfill materials shall be recorded. Additional information shall include location, installation date, problems encountered, water levels before and after well installation, cross-reference to the geologic boring log, and methods used during the installation and development process. Documentation is very important to prevent problems involving questionable sample validity. Somewhat different information will need to be recorded, depending on whether the well is completed in overburden (single- or double-cased), as a cased well in bedrock, or as an open hole in bedrock.

The quantities of sand, bentonite, and grout placed in the well are also important. The geologist shall calculate the annular space volume and have an idea of the quantity of material needed to fill the annular space. Volumes of backfill significantly higher than the calculated volume may indicate a problem such as a large cavity, while a smaller backfill volume may indicate a cave-in or bridging of the backfill materials. Any problems with rig operation or down-time shall be recorded and may affect the driller's final fee.

## 7.0 REFERENCES

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Barcelona, M. J., P. P. Gibb and R. A. Miller, 1983. A Guide to the selection of Materials for Monitoring Well Construction and Groundwater Sampling. ISWS Contract Report 327, Illinois State Water Survey, Champaign, Illinois.

U.S. EPA, 1980. Procedures Manual for Groundwater Monitoring of Solid Waste Disposal Facilities. Publication SW-611, Office of Solid Waste, U.S. EPA, Washington, D.C.

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## ATTACHMENT A

### RELATIVE COMPATIBILITY OF RIGID WELL CASING MATERIAL (PERCENT)

| Potentially-Deteriorating Substance | Type of Casing Material | | | | | | |
|---|---|---|---|---|---|---|---|
| | PVC 1 | Galvanized Steel | Carbon Steel | Lo-carbon Steel | Stainless Steel 304 | Stainless Steel 316 | Teflon* |
| Buffered Weak Acid | 100 | 56 | 51 | 59 | 97 | 100 | 100 |
| Weak Acid | 98 | 59 | 43 | 47 | 96 | 100 | 100 |
| Mineral Acid/ High Solids Content | 100 | 48 | 57 | 60 | 80 | 82 | 100 |
| Aqueous/Organic Mixtures | 64 | 69 | 73 | 73 | 98 | 100 | 100 |
| Percent Overall Rating | 91 | 58 | 56 | 59 | 93 | 96 | 100 |

<u>Preliminary Ranking of Rigid Materials</u>:

1 Teflon[7]
2 Stainless Steel 316
3. Stainless Steel 304
4 PVC 1
5 Lo-Carbon Steel
6 Galvanized Steel
7 Carbon Steel

* Trademark of DuPont

### RELATIVE COMPATIBILITY OF SEMI-RIGID OR ELASTOMERIC MATERIALS (PERCENT)

| Potentially-Deteriorating Substance | Type of Casing Material | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | PVC Flexible | PP | PE Conv. | PE Linear | PMM | Viton[7]* | Silicone | Neoprene | Teflon[7]* |
| Buffered Weak Acid | 97 | 97 | 100 | 97 | 90 | 92 | 87 | 85 | 100 |
| Weak Acid | 92 | 90 | 94 | 96 | 78 | 78 | 75 | 75 | 100 |
| Mineral Acid/ High Solids Content | 100 | 100 | 100 | 100 | 95 | 100 | 78 | 82 | 100 |
| Aqueous/Organic Mixtures | 62 | 71 | 40 | 60 | 49 | 78 | 49 | 44 | 100 |
| Percent Overall Rating | 88 | 90 | 84 | 88 | 78 | 87 | 72 | 72 | 100 |

<u>Preliminary Ranking of Semi-Rigid or Elastomeric Materials</u>:

1 Teflon[7]
2 Polypropylene (PP)
3. PVC Flexible/PE Linear
4 Viton[7]
5 PE Conventional
6 Plexiglas/Lucite (PMM)
7 Silicone/Neoprene

* Trademark of DuPont

Source: Barcelona et al., 1983

## ATTACHMENT B

## COMPARISON OF STAINLESS STEEL AND PVC FOR MONITORING WELL CONSTRUCTION

| Characteristic | Stainless Steel | PVC |
|---|---|---|
| Strength | Use in deep wells to prevent compression and closing of screen/riser. | Use when shear and compressive strength are not critical. |
| Weight | Relatively heavier. | Light-weight; floats in water. |
| Cost | Relatively expensive. | Relatively inexpensive. |
| Corrosivity | Deteriorates more rapidly in corrosive water. | Non-corrosive -- may deteriorate in presence of ketones, aromatics, alkyl sulfides, or some chlorinated hydrocarbons. |
| Ease of Use | Difficult to adjust size or length in the field. | Easy to handle and work with in the field. |
| Preparation for Use | Should be steam cleaned if organics will be subsequently sampled. | Never use glue fittings -- pipes should be threaded or pressure fitted. Should be steam cleaned when used for monitoring wells. |
| Interaction with Contaminants* | May sorb organic or inorganic substances when oxidized. | May sorb or release organic substances. |

* See also Attachment A.

| | | | |
|---|---|---|---|
| TETRA TECH | **STANDARD OPERATING PROCEDURE** | Number<br>SA-1.1 | Page<br>1 of 27 |
| | | Effective Date<br>07/17/2020 | Revision<br>11 |
| | | Applicability<br>EGS Operating Unit | |
| | | Prepared<br>Earth Sciences Department | |
| Subject<br>GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING FROM MONITORING WELLS | | Approved<br>T. Johnston T.E. Johnston 07/17/2020 | |

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**ATTACHMENTS**

## 1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the processes to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters. Governing project specific work plans, quality assurance project plans (QAPPs), sampling and analysis plans (SAPs), and comparable documents take precedence if this SOP conflicts with them.

## 2.0 SCOPE AND APPLICABILITY

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

**WARNING**

Sample containers can be contaminated during storage, especially by volatile substances that infiltrate the surrounding air and migrate into the containers. This can occur even when containers are capped. Therefore, containers that have been stored onsite for longer than 6 months should not be used. For DoD per- and polyfluoroalkyl substances (PFAS) projects, PFAS containers may not be stored longer than 3 weeks before use.

## 3.0 GLOSSARY

Dissolved Oxygen (DO) – Oxygen, e.g., from the atmosphere, dissolves in water without reacting chemically with the water. The resulting DO concentrations reflect the degree of physical, chemical, and biochemical activities in the water. Analysis of DO is a key test in water pollution and wastewater treatment process control that can provide an indication of the level of biological activity. Accurate measurement requires exclusion of air from samples during DO measurements. Results are typically reported in milligrams/Liter (mg/L).

Groundwater Sample – A quantity of water removed from the ground, usually via a monitoring well (temporary or permanent) that may or may not be lined with a well casing, and typically in a manner that is designed to represent the in-situ characteristics of the groundwater.

Oxidation-Reduction Potential (ORP) – A measure of the chemical activity ratio of oxidizing and reducing species in water. This ratio is proportional to the electromotive force developed in water by a noble metal electrode, as compared to a reference electrode. Positive values represent a net oxidizing tendency and negative values represent a net reducing tendency of the water. ORP can provide evidence of the likelihood of anaerobic degradation of biodegradable organic compounds. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of approximately 210 millivolts (mV) from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset voltage depends on the temperature and the reference electrode and can be found in documents other than this SOP.

pH – A unitless number equal to the negative logarithm (base 10) of the hydrogen ion activity expressed in moles per liter. The hydrogen ion activity is related to the hydrogen ion concentration, and for all practical purposes, pH reflects the hydrogen ion concentration. The pH decreases with increasing hydrogen ion concentration. The standard pH scale ranges from 0 to 14. Aqueous solutions at 25°C with a pH less than 7 are acidic, whereas those with a pH greater than 7 are basic or alkaline (sometimes referred to as caustic). Measurement of pH is one of the most important and frequently used tests in water chemistry, therefore accurate pH measurement is typically required. The most accurate measurements are obtained using an electronic pH meter with two separate electrodes or one combined electrode connected to the meter.

**NOTE:** Although pH measurements are unitless, some references and data management systems may indicate that pH is measured in “standard units” (S.U.s).

pH Paper – Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer provides an indication of the solution's pH. Indicator paper is used when only an approximation of the pH is required, e.g., to verify pH meter readings.

Representativeness – A qualitative description of the degree to which a sample accurately mimics characteristics of a larger population (i.e., a larger area, volume, or mass of material). Selection of sampling locations and proper sample collection and handling are important to ensure that representative samples are collected.

Salinity – A measure of the mass of dissolved salts in a given mass of solution. Many field meters determine salinity automatically and indirectly from specific conductivity and temperature. The value will be displayed in either parts per thousand (ppt, or $^0/_{00}$) or percent (e.g., 35 ppt equals 3.5 percent). The parts per thousand symbol ($^0/_{00}$) is different than the percent symbol (%) and the two symbols must not be confused.

Specific Conductivity – Specific conductivity is the electrical conductivity of a solution across an electrical cell of specified geometry. It can be used to identify the direction and extent of migration of contaminants in groundwater or surface water, as well as subsurface biodegradation or to indicate the presence of contamination sources. The electrical current is carried by charged atoms or molecules in solution (i.e., ions) and can be affected by exposure to the atmosphere. Measurements are commonly made at, or normalized to, a standard temperature of 25 degrees Celsius (°C). Temperature normalizations commonly are automated by the instruments used to make these measurements. This type of compensation, however, adjusts only for temperature-induced changes in electronic instrument response; it does not compensate for temperature-induced changes in ion mobility that also affect the measurement. For comparability to literature references, measurements are commonly made at the standard temperature of 25°C. To minimize atmospheric alteration of the sample’s conductivity, these measurements are made within a closed flow-through cell. Most conductivity meters in use today display specific conductivity in units of mS/cm normalized to a temperature of 25°C, but other units (e.g., µS/cm) also are used.

Temperature – Temperature is a measure of the average kinetic energy of the atoms or molecules in a material expressed in units of degrees on a standard scale. The scale most commonly used for scientific work is the Celsius scale. A constant temperature during well purging is an indicator which, with other parameters, helps to establish when sampling conditions are stable enough for collecting a representative sample. Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers, or combination meters equipped with an in-line sample chamber and electronic temperature probe (e.g., YSI 600 series and Horiba U-52). Temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater

Turbidity – Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water, measured in nephelometric turbidity units (NTUs) is caused by suspended matter such as clay, silt, and other fine organic and inorganic matter. It is important to obtain a turbidity reading immediately after collecting a sample because irreversible changes in turbidity may occur if the sample is stored too long.

## 4.0 PERSONEL RESPONSIBILITIES, QUALIFICATIONS, AND TRAINING

**NOTE:** The composition of a project team may not include all of the positions listed below and may include others that are not listed. Training is provided to these individual according to applicable corporate protocols.

Project Manager – Responsible for overall project direction and execution in coordination with the client and project team. Responsible for identifying key staff needs and resulting makeup of the project support staff. The project manager 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 project manager 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-specific work plan.

Site Safety & Health Officer (SSHO) – The SSHO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP) or equivalent. This includes but is not limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSHO or SSHO designee may also be required to advise the Field Operations Leader (FOL) on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Hydrogeologist – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project-specific work plan. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

Field Operations Leader (FOL) – The FOL is responsible for overall coordination and execution of the field program in accordance with project-specific work plan and for communication from the field to the project manager and other key staff. 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 sample collection protocols. 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 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. This person shall have significant hands-on experience with sample collection, handling, and documentation under the circumstances required for the current project.

Field Support Personnel – Responsible for the proper acquisition of samples in accordance with this SOP and governing work plans or similar project-specific documents. In addition, this individual is 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.

Minimum 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 (Hazardous Waste Operations and Emergency Response [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 the project-specific work plan and this SOP.

## 5.0 SAFETY PRECAUTIONS

Specific safety and health hazards are identified throughout the project-specific HASP or Accident Prevention Plan/Site Safety and Health Plan (APP/SSHP), specifically the Activity Hazard Analysis (AHA). Common health and safety concerns that may arise during implementation of this SOP are identified below:

- Knee injuries from kneeling on hard surfaces.
- Slips, trips, and falls.
- Cuts and lacerations.
- Traffic hazards associated with sampling in parking areas and roadways and along highways and railways.
- Biological hazards including insects; spiders; snakes and other reptiles, as well as, poisonous fauna.
- Physical hazards directly associated with the groundwater sampling equipment.

General methods of avoiding these hazards include:

- Maintaining situational awareness, e.g., surveilling the area to identify hazards, such as:
    - Vehicular traffic within industrial areas.
    - Remote locations requiring traverse through heavy vegetation or over steep terrain.
    - Time of the year potentially resulting in heat and/or cold stress.
    - Potential for insect or snake bites or contact with poisonous plants such as poison ivy
    - Rushing/fatigue/frustration/complacency (reference: Safe Start Program based on four states that can lead critical errors).
- Hierarchy of Control
  1st: Engineering controls – If a hazard can be eliminated or avoided by using shielding against it, then avoidance or use of shielding is the preferred action.
  2nd: Administrative Work Practices – Altering work practices to avoid the hazard is another option to limit exposure potential and minimize potential hazards.
  3rd: Personal Protective Equipment (PPE) – This is the least preferred option though it may not be required if other options cannot be readily implemented.

## 6.0 PROCEDURES

### 6.1 GENERAL

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular water zone being sampled. The physical, chemical, and microbiological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters after collection to a minimum. Fresh, certified-clean sample containers should be used. Use of previously stored containers should be avoided, if possible (see Section 2.0 warning). If containers that had been previously stored on site must be used, this should be noted in the field log to support identification of cross-contamination sources, if necessary. Obtaining a representative sample of groundwater requires avoiding collection of stagnant (standing) water in a well and avoiding physical or chemical alteration of the water sample.

In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. This stagnant water is not representative of the surrounding geologic formation. Concentration gradients, layers of different geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase contaminant concentrations in the collected sample compared to what is representative of the natural water column, resulting in collection of a non-representative sample.

## 6.2 PURGING, SAMPLING, AND MONITORING EQUIPMENT

The following equipment, supplies, and/or documents may be required (depending on the chosen sampling technique) when sampling groundwater wells:

- Pumps
    - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.
    - Deep-well pumps: Submersible pumps and electrical power-generating units, or bladder pumps where applicable.
- Power source (electrical generator, nitrogen tank, 12 volt battery, etc.). If a gasoline powered generator is used, it must be located downwind and at a safe distance from the well to avoid unnecessary exposures to exhaust and so that the exhaust fumes do not contaminate samples.
- Tubing – Teflon, Teflon-lined polyethylene, polyethylene, PVC, Tygon, or stainless steel tubing may be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements. When collecting samples for per- and polyfluoroalky substances (PFAS) analysis, avoid using materials containing Teflon and other fluoropolymers.
- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).
- Photoionization detector (PID) or flame ionization detector (FID) for measuring volatile organic vapors per the HASP (or equivalent).
- Interface probe if separate-phase product is suspected.
- Water quality meters – pH, turbidity, specific conductivity, and temperature. Optional indicators - ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required for low-flow sampling.
- Chemical Standards to perform field calibrations.
- Other sampling equipment – Disposable clear bottom-filling bailers to be used to check for and obtain samples of light non-aqueous phase liquid (LNAPL) or dense non-aqueous phase liquid (DNAPL), graduated cylinder, stopwatch, and inert line (cord).

- Clean paper or cotton towels for cleaning equipment.
- Buckets with lids for collecting purge water.
- Decontamination solutions – Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.
- Well construction data, location map, field data from the previous sampling event (if available).
- Field Sampling Plan, field logbooks, field forms, camera (if appropriate), and well keys.
- Sample packaging and shipping equipment – Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.

Ideally, water sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use (in the case of reusable items), able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection. Additional information regarding the selection of purging equipment can be found in Attachment A.

## 6.3 CALCULATION OF WELL VOLUME

To ensure that a proper volume of water is removed from a well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method.

1. Obtain all available information on well construction (location, casing material and thickness, screen configuration, etc.).
2. Determine well or inner casing diameter.
3. Measure and record static water level (depth below ground level or top of casing reference point).
4. Sound the well depth using a clean, decontaminated, weighted tape measure or water level indicator.
5. Calculate and record the number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).
6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

where: V = Static volume of well in gallons.
T = Linear feet of water in the well.
r = Inside radius of well casing in inches.
0.163 = Conversion factor (compensates for conversion of casing radius from inches to feet; cubic feet to gallons; and Pi (π)).

**NOTE:** Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see Attachment C).

## 6.4 EVACUATION OF STATIC WATER – PURGING

### 6.4.1 General

The volume of water to be purged from each well will be determined prior to sample collection. This volume will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long purge periods to obtain a sample that is representative of a large volume of the aquifer. The purged volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be purged until parameters such as temperature, specific conductivity, pH, and turbidity (as applicable) have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

### 6.4.2 Evacuation Devices

The following list of evacuation devices is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for particular sampling situations. All of these techniques involve equipment that is portable and readily available.

**Bailers**

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check-valve at the bottom and are lowered and raised using a length of inert, non-absorbent rope (polyethylene) or cable. Bailers are typically comprised of stainless steel, high density polyethylene (HDPE) or polyvinyl chloride (PVC) plastic or Teflon. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. These devices come in weighted and non-weighted configurations. As the bailer is lowered into the water column, the ball is pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.

**Bladder Pumps**

Bladder pumps are low-flow pneumatic devices used mainly for fluid sampling applications. These pumps typically have low flow rates making them ideal for collecting very low turbidity samples (<5 NTUs). They are also designed to minimize the potential for sample contamination. These characteristics are especially important for groundwater analysis, which requires representative, reproducible sampling data to obtain accurate results. Bladder pumps are EPA-accepted for low-flow sampling.

Bladder pumps are available in a range of sizes, materials, and models. These include models for deep wells, narrow or obstructed casings, and small-volume pumps for low-yield wells. When low-flow pumping rates are used, these pumps consistently collect high quality, uniform samples.

**Suction Pumps**

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump (“peri” pump) is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive them. The advantage of the peristaltic pump is that it can operate from either a built in power source or a portable battery source. Safety measures associated with these pumps are provided below.

**Air-Lift and Gas-Lift Samplers**

This group of pump samplers uses gas pressure (ether air or nitrogen) either in the annulus of the well or in a Venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive.

**CAUTION**

Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause loss of volatile organics and pH changes with subsequent loss of trace metals via precipitation.

**Submersible Pumps**

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet) when connected in stages. Limitations of this class of pumps include the following:

- They may have low delivery rates.
- Many models are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding of the impellers with some of these
- pumps.
- Decontamination of internal components can be difficult and time consuming.

### 6.4.3 Safety Precautions Associated with Evacuation Devices

**Compressed Gases**

Compressed gases are provided in metal cylinders at pressures of approximately 2,000 pounds per square inch (psi) for some gases. If damaged, these cylinders can become dangerous projectiles. Sudden release of a cylinder's contents can involve considerable force that could cause significant damage to eyes and/or skin. Protective measures include the following:

- Always wear safety impact glasses when handling compressed gases.
- Always administer compressed gases through appropriate dual stage pressure-reducing regulators.
- Keep valve protection caps on gas cylinders when not in use.
- When using a gas cylinder, restrain it or lay it on its side to avoid the risk of knocking the valve off, which could cause the cylinder to become a missile.
- DO NOT use compressed gas to clean clothing or to spray off skin. Pressurized gas can enter cuts in the protective layer of the skin, presenting the potential danger of an embolism.

See the project-specific HASP (or equivalent) for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.

**Electrical Shock**

Even when using portable batteries and vehicle batteries, the potential for damaging electrical shock exists. This risk increases whenever water is present near the batteries. The risk also increases in (prohibited) situations involving jury-rigging of electrical connections To control these hazards:

- If unfamiliar with electrical devices, do not experiment. Get help, and get the proper equipment.

- Use proper portable power inverters for vehicle cigarette lighter connections to minimize the need to access the battery under the hood of a vehicle.

To minimize or eliminate electrical generator hazards:

- Wear hearing protection when working near generators and stay alert .

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.

- Fuel the generator before purging and sampling to avoid loss of power during sampling.

- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.

**Lifting Hazards**

These hazard may be experienced when moving containers of purge water, equipment, cylinders, as well as generators and compressors. To control these potential hazards:

- Do not fill purge buckets to more than 80 percent of their capacity.

- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. K-size cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.

- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).

- Use proper lifting techniques as described in project-specific work plan, specifically the AHAs for additional hazards concerning heavy lifting and recommended control measures to minimize such hazards.

## 6.5 ONSITE WATER QUALITY TESTING

The following field parameters are often measured during groundwater well purging prior to sample collection:

- pH
- Specific Conductivity
- Temperature

- DO
- ORP
- Turbidity
- Salinity

Refer to the Glossary for descriptions of these parameters and descriptions of their importance.

The measurement of water quality is typically performed using multi-parameter water quality instruments from manufacturers such as a Horiba or YSI. Turbidity is often measured independently using a LaMotte 2020. The procedures and equipment described below are applicable to groundwater samples and are not, in general, subject to interferences from color, turbidity, colloidal material or other suspended matter in samples.

Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require daily calibration and should be done so according to the manufacturer’s calibration requirements. Refer to Attachment C for an example equipment calibration log.

Safety Data Sheets (SDSs) for all chemicals such as buffer solutions and calibration solutions per 29 CFR 1910.1200 (Hazard Communication, 2012) must be obtained from the chemical supplier and maintained onsite (see Section DCN 02-01 of the Tetra Tech Health and Safety Manual regarding the Hazard Communication Program).

**NOTE:** If conditions that may interfere with water quality measurements are observed, such as high turbidity or oily material that could foul electrodes, note them and avoid them as much as possible.

### 6.5.1 Use of Electronic Instruments to Measure pH, Specific Conductivity, Temperature, DO, ORP, Salinity, and Turbidity

1. Before going to the field
    a) Check batteries of field instruments to ensure sufficient charge is available to make all required measurements.
    b) Condition DO probes in water for as long a period as practical before use in the field. Intermittent periods of dry storage may result in inaccurate readings.
    c) Check the expiration dates of solutions used for calibration and replace them if they are expired.

2. Standardize (pH) or calibrate (non-pH) the instruments in accordance with manufacturer’s instructions and steps presented below.

3. Ensure that solutions used for field standardization/calibration will not be used after their expiration dates.

**NOTE:** pH buffer solutions need to be changed often as a result of degradation from exposure to the atmosphere.

4. If applicable, make sure all electrolyte solutions within electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

5. For temperature, follow these calibration instructions:

    a) Prior to use, verify whether calibration of the thermometer or temperature probe is required (as indicated in the governing work plan or directed by the FOL).

b) If calibration is not required, use the device as received, record in the field notes that it was not calibrated prior to use, and skip the remaining calibration steps.

c) If the thermometer comes with a calibration sticker or certificate and the date of use is within the valid calibration date range, it may be used as received. In this case skip the remaining calibration steps.

d) If calibration is required but invalid or undocumented, take one of the following actions, otherwise proceed to Step e):
   - Calibrate the thermometer or temperature probe in accordance with the manufacturer's instructions.
   - Return the thermometer or temperature probe to the supplier for calibration.

e) Record calibration data on a calibration log (see Attachment C).

6. Except for temperature, calibrate the meter and electrode(s)/probe(s) on a daily use basis in accordance with manufacturer's instructions and requirements of the governing work plan. Record calibration data on a water quality meter calibration log sheet (see Attachment C).

**NOTE:** Ensure DO probes have sufficient flow of water around them during measurement, especially if readings appear to be unstable.

7. For all water quality parameters except turbidity, direct groundwater to be measured through the flow-through cell or immerse the electrode(s) in the sample(e.g., for surface water). Stabilization may take several seconds to minutes.
   a. If the measurement continues to drift, the sample temperature may not be stable, a physical or chemical reaction (e.g., degassing or absorption of $CO_2$) may be taking place, or the meter or electrode(s) may be malfunctioning. Additional time should be allowed for stabilization but if it does not appear that the measurements will stabilize within a reasonable timeframe, and the instrument is functioning properly, proceed with recording the measurements and clearly note in the logbook or equivalent electronic form the failure of measurements to stabilize.

   b. If the instrument appears to be malfunctioning, follow troubleshooting corrective measures or contact the instrument supplier for assistance, then repeat the calibration and measurement steps above, as applicable, to make the required measurements. Verification of proper pH measurement may be possible using pH paper (see Section 6.5.2).

8. For turbidity, direct water flow (e.g., through a "T" fitting upstream of the flow through cell) into the appropriate clean sample cup, then:
   a. When using the YSI 600 and/or Horiba U-52, rinse the electrode with one or more portions of the sample to be tested or with deionized water.

   b. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off the glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter, aligning the arrow on the cap of the test cell to the arrow on the meter, and close the lid.

   c. Immerse the probe in the sample and measure the turbidity immediately to prevent changes in turbidity from settling particulates.

9. Read and record all water quality measurements using the following guide (or as directed in the governing work plan):

a. pH: Nearest 0.01.
b. Specific Conductivity: Nearest 0.001 to 0.1 mS/cm (range dependent)
c. Temperature: Nearest 0.02 degree Fahrenheit or 0.01 degree Celsius, or less
d. Dissolved Oxygen: Nearest 0.01 mg/L
e. Oxidation-Reduction Potential (ORP): Nearest 0.1 mV
f. Turbidity: Nearest 0.1 NTU
g. Salinity: Nearest 0.01 parts per thousand ($^{0}/_{00}$)

**NOTE:** For greatest accuracy on instruments that allow selection of different scales, choose scales that result in measured values at least 10 percent of full scale.

10. Record the sample temperature along with other water quality measurements.

11. When finished using water quality meters, rinse their electrode(s)/probe(s) with deionized water and store them in accordance with the manufacturer's instructions. Some probes require that they be stored in a protective cup or other device that ensures they remain in contact with an aqueous liquid.

### 6.5.2 Use of pH Paper to Measure pH

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH = 0 to 14), mid-range (approximately pH = 0 to 6, 6 to 9, or 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units and a pH resolution of 0.5 or less). The appropriate range of pH paper must be selected. If the pH is unknown, then measurements should start with wide-range paper followed by narrower range paper until the sample pH is determined to the desired degree of precision. To measure the pH:

1. Collect a small portion of sample in a clean container separate from the main sample container.

2. Dip the pH paper into this small portion of sample.

3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.

4. If desired, continue to narrow the pH range for a more specific reading.

5. Record the final pH value from the chart on the sample log sheet.

6. Discard the used pH paper as trash.

7. Discard the small volume of sample that was used for the pH measurement with the other investigative-derived waste.

## 6.6 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling typically is performed using conventional methods or via low-flow (minimal drawdown) methods. The following sections provide guidance on the procedures to be followed when performing groundwater sampling using each of these methods. It should be noted that EPA regional protocols may supersede the procedures outlined below (consult the governing work plan).

**NOTE:** If using a generator that requires liquid fuels, place the generator and any fuel source at least 50 feet downwind from the sampling point to prevent human exposure to fuel vapors and prevent the vapors from contaminating samples.

### 6.6.1 Conventional Sampling Methods (Not Low-Flow Sampling)

The collection of a groundwater sample consists of the following steps:

1. Open the well cover at arm's length, then step away and allow the well to vent. In situations where volatile organic compounds (VOCs) are the primary contaminants of concern, air monitoring of the sampler's breathing zone may be required by the HASP or equivalent (typically with a PID or FID).

2. Measure the water level prior to placing the pump or tubing in the well and record the water level on the Groundwater Sample Log Sheet (see Attachment B) or equivalent electronic form immediately prior to placing the pump or tubing into the well.

3. Calculate volume of well water to be removed as described in Section 6.3.

4. Select the appropriate purging equipment (see Attachment A) or as designated within the governing work plan. If an electric submersible pump with packer is chosen, go to Step 10.

5. Lower the purging equipment or intake into the well to a short distance below the water level or mid-screen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are denser than water and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.6.2) or as directed in the governing project-specific documents. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water as indicated in the governing work plan. Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.

6. Estimate the approximate rate of discharge frequently and record it on the Groundwater Sample Log Sheet (see Attachment B). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.

7. If using a peristaltic pump, observe the pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics. I must be replaced.

8. Purge a minimum of three to five well casing volumes before sampling (or as directed by the project-specific work plan). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.

9. Measure and record water quality parameters every 5 to 15 minutes or as otherwise specified in the governing work plan throughout the purging process. At a minimum, pH, specific conductivity and turbidity should be measured during purging. If parameters have stabilized after evacuating three casing volumes, then sampling may commence.

10. If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in uncased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

11. For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the

screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, collect the largest quantity available and record this occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.

13. Fill sample containers, and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.

14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.

15. Prepare samples for shipping as described in SOP SA-6.1.

16. Decontaminate equipment as described in SOP SA-7.1.

### 6.6.2 Low-Flow Purging and Sampling

Low-flow purging and sampling techniques are often implemented for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (VOCs and semivolatile organic compounds [SVOCs], pesticides, polychlorinated biphenyls [PCBs], metals, and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing LNAPL or DNAPL.

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

1. Open the monitoring well and prepare purging equipment. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP or equivalent (typically with a PID or FID).

2 Measure the water level prior to placing the pump or tubing in the well and record the water level on the Groundwater Sample Log Sheet (see Attachment B) or equivalent electronic form immediately prior to placing the pump or tubing into the well.

3. Lower the measuring device further into the well to collect the total depth measurement, if necessary. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.

4. Record the total well depth on the Groundwater Sample Log Sheet (see Attachment B) or equivalent electronic form immediately prior to placing the pump or tubing into the well.

5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.

6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rate as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate should be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease, and allowed to recover to 75 percent of the initial water level above the screen. Otherwise, the well shall be pumped to dryness and then allowed to recover before sampling. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.

7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Groundwater Sample Log Sheet (see Attachment B) or equivalent electronic form.

8. Record on the Groundwater Sample Log Sheet every 5 to 10 minutes the water quality parameters (pH, specific conductivity, temperature, turbidity, ORP, DO, and salinity or as specified by the approved project specific work plan) measured by the water quality meter with flow-through cell and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Groundwater Sample Log Sheet or equivalent electronic form.

9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.

10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loosen connections and tighten, repair, or replace them as necessary to achieve a tight connection.

11. Purge the well at a constant nominal rate of 100 mL/min (minimum rate) to 300 mL/min (maximum rate if there is no drawdown) until stabilization is achieved. Stabilization is achieved when the last three consecutive readings taken at 5- to 10-minute intervals are within the following limits, or a minimum of three saturated screen volumes have been removed:

    - **pH:** ±0.1 unit
    - **Specific conductivity:** 3%
    - **DO:** 10% for values greater than 0.5 mg/L, if three DO values are less than 0.5 mg/L, consider the values as stabilized.
    - **Turbidity:** 10% for values greater than 5 NTUs; if three Turbidity values are less than 5 NTUs, consider the values as stabilized**.**
    - **Temperature:** 3**%**
    - **ORP:** ±10 mV

12. If the above conditions have not been met after the well has been purged for 2 hours, consider purging to be complete and begin sampling (unless otherwise directed by the project manager). Record the final well stabilization parameters on the Groundwater Sample Log Sheet or equivalent electronic form.

13. Once well purging is complete, redirect water flow through the upstream “T” fitting (if installed) or disconnect the pump tubing from the flow-through cell, and collect samples directly from the tubing.

    **NOTE:** VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

14. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, collect samples for non-VOC analyses first, then use one of the following procedures to collect VOC samples:

    - Increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.

    - Reduce the diameter of the tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.

    - Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.

15. Prepare samples for shipping as described in SOP SA-6.1.

16. Decontaminate equipment as described in SOP SA-7.1.

### 6.6.3 Groundwater Sampling Using Drive Points

Conduct drive point sampling of groundwater as follows:

1. Stand by as a third party:
    a. Advances the direct push technology (DPT) dual tube and discrete point sampler to the desired depth in accordance with standard DPT protocols.
    b. Removes the drive rods and discrete point sampler and inserts internal rods and well screen.
    c. Retracts the outer casing approximately 18-24 inches to expose the well screen.
2. After being granted access to the well by the third party, insert a polyethylene purging/sampling tube into the well to mid-screen.
3. Connect the other end of this tubing to the peristaltic pump using a short length of silicone tubing for the drive section of the pump and polyethylene tubing on the discharge.
4. Pump groundwater from the drive point tube using a rate of 100mL/minute for 20 minutes, collecting groundwater quality measurements as described in Section 6.6.2, Steps 5 through 12.

**NOTE:** If turbidity is not reduced to less than 10 NTUs after 20 minutes or pumping, introduce the tubing at the top of the water column and slowly lower it while pumping. This will clear some turbidity within the water column above the screen interval.

5. Collect the sample(s), document operations, and decontaminant equipment in accordance with Section 6.6.2, Steps 13 through 16.

### 6.6.4 Groundwater Sampling Using Temporary Wells

Temporary pre-packed monitoring wells can be installed into a DPT dual tube system from 1- to 2-inch pre-packed wells as follows:

1. A third party will:
   a. Advance tooling to pre-determined levels based on data collected during soil boring or previously acquired information.
   b. Introduce a pre-packed well screen into the outside casing, held in place as the outer casing is extracted.
2. After being granted access to the well by the third party, insert purging/sampling tubing into the well to mid-screen.
3. Connect the other end of this tubing to the peristaltic pump using a short length of silicone tubing for the drive section of the pump and polyethylene tubing on the discharge end.
4. Pump groundwater from the temporary well at a rate of 100mL/min, while monitoring drawdown. If there is no drawdown, the pumping rate maybe incrementally increased up to 300mL/minute.
5. Pump groundwater from the drive point tube using a rate of 100mL/minute for 20 minutes, collecting groundwater quality measurements as described in Section 6.6.2, Steps 5 through 12.

**NOTE:** If turbidity is not reduced to less than 10 NTUs after 20 minutes or pumping, introduce the tubing at the top of the water column and slowly lower it while pumping. This will clear some turbidity within the water column above the screen interval.

6. Collect the sample(s), document operations, and decontaminant equipment in accordance with 6.6.2, Steps 13 through 16.

### 6.6.5 Passive Diffusion Bag Sampling

Passive diffusion bags (PDBs) are closed-ended, cylindrical, semipermeable membranes filled with laboratory pure water. They are deployed in a well by hanging them within the well's screened interval for several days to weeks. Groundwater contaminants diffuse across the semipermeable membrane from outside the PDB to its interior. Only contaminants in the column of water contacting the PDB can diffuse across the membrane, and this diffusion occurs over a longer time period than a low-flow sampling period. Given enough time (e.g., more than a week), the contaminant concentrations inside and outside the PDB equilibrate. Diffusion and equilibration reduce short-term data variations.

1. Prior to the deployment of the PDB samplers, contact the laboratory subcontractor (i.e., the PDB provider) and provide details regarding total depth and screen intervals for each monitoring well to be sampled

**NOTE:** The PDB provider will construct a PDB sampler for each monitoring well according to the specifications provided in Step 1 and will include various lengths of line to allow each PDB sampler to hang at the prescribed depth within the monitoring well. Additionally, the PDB provider will furnish hangers and stainless steel weights to secure each PDB sampler in place. PDB samplers will be prefilled by the PDB provider with laboratory-grade deionized water. After construction at the laboratory, the PDB samplers will be packaged and shipped to the site for deployment.

**NOTE:** Each PDB sampler will be properly identified and individually packaged by the PDB provider so the field crew will be able to match each PDB sampler with the corresponding monitoring well.

2. Upon arrival at a monitoring well designated for PDB sampler deployment, remove the PDB sampler from its packaging.

3. Carefully lower the PDB sampler into the monitoring well, and secure it using the hanger provided.

4. Record the date and time of deployment on a sample log sheet, field notebook, or equivalent.

5. Secure the monitoring well with a lock or other means until such time that the PDB sampler is recovered.

6. After the prescribed soak time detailed in the work plan has elapsed, recover the PDB sampler from the well by carefully lifting the hanger and line from the well to remove the PDB sampler. Care must be taken to minimize agitation of the sampler during retrieval.

7. Document on a sample log sheet, field notebook, or equivalent any evidence of growths such as algae or iron bacteria, or other substances on the sampler.

8. If there is evidence of any tears in the PDB sampler discard that sampler's contents in accordance with IDW management practices prescribed in the project-specific work plan, as the PDB sample is considered to be non-representative of conditions in the well. The empty PDB bag may be discarded as municipal trash.

9. Detach the PDB sampler from the line and wipe away any excess water from the outside of the sampler in a manner that prevents cross-contamination of the sample when later transferring the water sample to sample vials.

10. Cut open the top end of the PDB sampler using decontaminated scissors.

11. In a manner that minimizes water agitation transfer the water inside the PDB sampler to pre-preserved 40-mL VOC vials to obtain a convex meniscus at the vial opening.

12. Screw the cap with septum onto the vial in a manner that prevents bubbles from forming inside the vial.

13. Following placement of the cap, invert the vial and gently tap the side of the vial to ensure no bubbles are visible. If bubbles are visible, remove the cap, add additional sample water from the PDB sampler to re-establish the convex meniscus at the vial opening, and replace the cap. Re-check the vial for bubbles.

14. After each vial has been filled and capped, label it and immediately place it on ice in a laboratory-provided cooler. The samples must be maintained between 0 and 6 °C until delivery to laboratory.

15. Package the sample vials and ship them via courier (e.g., Federal Express) to the analytical laboratory in accordance with Tetra Tech SOP No. SA-6.1.

16. Containerize any remaining water from the PDB sampling and manage it in accordance with IDW according to the project-specific work plan.

17. Dispose of the PDB bag as municipal trash with the disposable personal protective equipment (nitrile gloves, etc.) and decontamination supplies (paper towels, etc.).

18. After a sample has been collected, place the hanger and weighted line assembly in a Ziploc bag and labeled with the associated monitoring well number so that it can be reused at a later date.

## 7.0 REFERENCES

USGS National Field Manual for the Collection of Water Quality Data (NFM), Feb 2019.

U.S. EPA, Region 1, 2017. Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells, Revision 4, Dated 30 July 1996, Revised 20 Sept 2017.

U.S. EPA, Region 4, 2017. Groundwater Sampling. U.S. Environmental Protection Agency, Region 4 Number SESDPROC-301-R4, April.

Department of Defense Environmental Field Sampling Handbook, Revision 1, Chapter 8, Groundwater Sampling, April 2013

## ATTACHMENT A

## PURGING EQUIPMENT SELECTION (EXAMPLE)

| Diameter Casing | | Bailer | Peristaltic Pump | Vacuum Pump | Air-lift | Diaphragm "Trash" Pump | Submersible Diaphragm Pump | Submersible Electric Pump | Submersible Electric Pump w/Packer |
|---|---|---|---|---|---|---|---|---|---|
| 1.25-Inch | Water level <25 feet | X | X | X | X | X | | | |
| | Water Level >25 feet | X | | | X | | | | |
| 2-Inch | Water level <25 feet | X | X | X | X | X | X | | |
| | Water Level >25 feet | X | | | X | | X | | |
| 4-Inch | Water level <25 feet | X | X | X | X | X | X | X | X |
| | Water Level >25 feet | X | | | X | | X | X | X |
| 6-Inch | Water level <25 feet | | | | X | X | | X | X |
| | Water Level >25 feet | | | | X | | | X | X |
| 8-Inch | Water level <25 feet | | | | X | X | | X | X |
| | Water Level >25 feet | | | | X | | | X | X |

**ATTACHMENT A**
**Purging and Sampling Equipment Selection (Updated July 2016)**

| Manufacturer | Model Name/ Number | Principle of Operation | I/E[1] | Maximum Outer Diameter (OD)/ Length (L)[2] | Construction Materials[3] (with Lines and Tubing) | Lift Range (Feet) | Delivery Rates or Volumes[4] | Main Source(s) of Information[5] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| **Commonly Used Purging/Sampling Equipment** | | | | | | | | | |
| GeoTech Environmental Equipment, Inc. | Geopump (Series I or II) | Portable; peristaltic vacuum (suction) or pressure - reversible pump | E | 3.5" x 8" x 8" | Not applicable (NA) | 0 - 27 | 0 - 1,000 mL/min | Mfg./Pine | Variable speed; operate with 12 volt (V) direct current (DC) or 120V alternating current (AC) power source. |
| Grundfos Pumps Corporation | Redi-Flo2 | Portable; submersible pump | I | 1.8" OD x 11" L | SS; PTFE (i.e., Teflon®) | 0 - 250 | 100 mL/min to 9 gpm | Pine/PNNL | Variable speed (adjustable flow rate); ideal for purging or sampling. |
| QED Environmental Systems | Sample Pro | Portable; bladder pump (positive displacement) | I | 1.75" OD x 12" L | SS: PTFE or PE disposable bladder | 0 - 250 | 0 - 800 mL/min | Mfg. | First pump developed specifically to bring the advantages of low-flow sampling to sites with non-dedicated pumps. |
| QED Environmental Systems | Well Wizard | Dedicated; bladder pump (positive displacement) | I | 1.66" OD x 41" L | SS; PTFE bladder, HDPE, PP | 0 - 1,000 | 0 - 2,000 mL/min | Pine/PNNL | Ideal for deep well applications and long-term monitoring. Available in a variety of sizes and materials. |
| **Less Commonly Used Purging/Sampling Equipment** | | | | | | | | | |
| Bennett Sample Pumps, Inc. | Bennett 1800-8 | Portable; piston pump (positive displacement) | I | 1.8" OD x 23.625" L | SS: PTFE, PP, Nylon | 0 - 1,000 | 100 mL/min to 2.6 gpm | Mfg./PNNL | Variable speed (adjustable flow rate); ideal for purging or sampling. Discharge rates are difficult to control. |
| Cole-Parmer Inst. Co. | Masterflex 7571-00 | Portable; peristaltic vacuum (suction) or pressure - reversible pump | E | 16" x 10.25" x 11" | NA | 0 - 27 | 0.06 - 680 mL/min | Mfg./Pine | Peristaltic pumps are not recommended for sampling volatile organic compounds (VOCs). |
| Fultz Pumps, Inc. | Fultz SP300 | Portable; gear driven pump (positive displacement) | I | 1.75" OD x 9.16" L | SS; PTFE gears, Viton® | 0 - 200 | 100 mL/min to 2.4 gpm | Mfg./PNNL | Variable speed (adjustable flow rate); ideal for purging or sampling. Low extraction rates are difficult to control. |
| GeoTech Environmental Equipment, Inc. | Keck SP12 | Portable; progressive cavity pump (positive displacement) | I | 1.75" OD x 25" L | SS; EPDM stator, PE | 0 - 150 | 100 mL/min to 1.2 gpm | Mfg./PNNL | Variable speed (adjustable flow rate); ideal for purging or sampling. Low extraction rates are difficult to control. |
| GeoTech Environmental Equipment, Inc. | SS Geosub | Portable; single speed submersible purge pump | I | 1.75" OD x 13.2" L | SS; PTFE, Viton® | 0 - 200 | low flow to 10 mL/min | Mfg./Pine | Only 12V SS pump with Teflon® cable according to GeoTech brochure. |
| GeoTech Environmental Equipment, Inc. | NA | Portable; centrifugal purge pump | | NA | NA | 0 - 55 | 2.5 gpm max. | Mfg. | Not recommended for sampling. |
| GeoTech Environmental Equipment, Inc. | Various | Portable; bladder pump (positive displacement) | I | 0.675-1.66" OD | SS or PVC; PTFE or PE bladder; FEP or PE tubing | 0 - 200 SS;<br>0 - 250 PVC | NA | Mfg. | Various sizes are available. Pump is also available in PVC instead of SS. |
| GeoTech Environmental Equipment, Inc. | Bailer | Portable; grab (positive displacement) | I | Various sizes | Various materials - HDPE, PVC, SS, or fluoropolymer | No limit | NA | Mfg. | Low cost, easy operation; potential churning could increase turbidity. Typically a last-resort option. |
| Grundfos Pumps Corporation | Redi-Flo3 | Portable; submersible pump | I | 2.9" OD | SS; PVDF, Viton®, Tefzel® | 0 - 360 | 8 gpm max. | Pine/PNNL | Not designed for low flow use. |
| Grundfos Pumps Corporation | Redi-Flo4 | Portable; submersible pump | I | 3.8" OD | SS; PTFE | 0 - 600 | 100 mL/min to 10 gpm | Pine/PNNL | Variable speed (adjustable flow rate); ideal for purging or sampling. |
| KYB | HydroStar™ | Portable; single-action piston pump (positive displacement) | I | 1.66" OD | SS; PTFE | 0 - 400 | 100 mL/min to 5 gpm | Mfg./PNNL | Variable speed (adjustable flow rate); ideal for purging or sampling. Discharge rates are difficult to control. |

**ATTACHMENT A**
**Purging and Sampling Equipment Selection (Updated July 2016)**

| Manufacturer | Model Name/ Number | Principle of Operation | I/E[1] | Maximum Outer Diameter (OD)/ Length (L)[2] | Construction Materials[3] (with Lines and Tubing) | Lift Range (Feet) | Delivery Rates or Volumes[4] | Main Source(s) of Information[5] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| Landtec North America | Nu-Matic 4 | Dedicated; pneumatic displacement pump | I | 3.5" OD x 43.25" L | SS | 0 - 275 | 10 gpm max. | Pine | Float activated, fully automatic; ideal for the harsh environment of landfill conditions. |
| ProActive Environmental Products | SS Monsoon (and others) | Portable; Low Flow pumps available in a variety of sizes | I | 1.82" OD x 7.5" L | SS; PE | 0 - 120 | 10 mL/min to 3.5 gpm | Pine/GeoTech | 12V DC - designed for continuous purging and low flow sampling. |
| QED Environmental Systems | Eliminator | Portable; bladder pump (positive displacement) | I | 3" OD x 40" L | SS; PTFE or elastomer bladder, Q-Tal®, Viton® | 0 - 230 | 6 gpm max. | Pine | High capacity; designed for light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) removal in 4" wells. |
| QED Environmental Systems | Pulse Pump | Portable; pneumatic displacement pump | I | 1.66" OD x 20" L | SS; PTFE | 0 - 230 | 2 gpm max. | Pine | Especially suited for DNAPL recovery. Requires compressed air, external timer. |
| Solinst Canada Ltd. | 404 WaTerra | Portable; inertial reciprocating pump (positive displacement) | I | Various sizes | SS or Delrin® footvalve; HDPE tubing | 0 - 200 | 2 gpm max. | Pine | Low cost, easy operation; potential churning could increase turbidity. Simple alternative to a bailer. |
| Solinst Canada Ltd. | 407 Integra | Portable; bladder pump | I | 1" or 1.66" OD | SS or PVC; FEP bladder (disposable PE available) | SS - 0 - 500<br>PVC - 0-100 | 3.3 L/min at 150' | Pine | Regular or low flow applications. |
| Solinst Canada Ltd. | 408 DVP | Portable; pneumatic drive pump | I | 1.66" OD x 24" L | SS or PVC; FEP bladder | SS - 0 - 500<br>PVC - 0-100 | 3.3 L/min at 150' | Pine | Regular or low flow applications - can deliver high flow rates. |
| Solinst Canada Ltd. | 408M DVP | Portable; micro pneumatic drive pump | I | 0.375" OD | FEP tubing | 0 - 240 | 20 - 150 mL/min | Pine | Uses coaxial FEP tubing, easy to transport and install; ideal for low flow and narrow down-hole applications. |
| Solinst Canada Ltd. | 410 | Portable; peristaltic (negative pressure) pump | E | 13" x 5" x 6" | NA | 0 - 27 | 120 - 3,500 mL/min | Pine | Ideal for vapor sampling, water from shallow wells, or surface water. |
| TIMCO Mfg. Co., Inc. | Bailer | Portable; grab (positive displacement) | I | Various sizes | PVC, PP, others | No limit | 250 mL/foot of bailer | Old SOP | Other sizes, materials, models available; optional bottom-emptying device available, no solvents used. |
| **No-Purge Sampling Equipment (Available Options on Some Projects)** | | | | | | | | | |
| Amplified Geochemical Imaging (AGI), LLC | AGI Universal Sampler (formerly Gore-Sorber™ Module) | Passive container; diffusion-type sampler | I | 0.25" OD x 8" L | Waterproof, vapor-permeable GORE-TEX™ polymer membrane of expanded PTFE | 0 - 32 | NA | ITRC PSC-5 | Demonstrated to be applicable to a variety of (but not all) VOCs, semivolatile organic compounds (SVOCs), and polycyclic aromatic hydrocarbons (PAHs); not designed for inorganics. |
| GeoInsight, Inc. | HydraSleeve™ | Passive container; grab-type sampler | I | 1.5-2.6" OD x 30" L | PE tubing with PE reed-valve | No limit | 650 - 1,250 mL | ITRC PSC-5 | Demonstrated to be applicable to a variety of VOCs and inorganics. |
| Mutiple Manufacturers | RPPS | Rigid Porous Polyethylene Sampler (RPPS); diffusion-type sampler | I | 1.5" OD x 5" L | Rigid PE tube - thin sheets of foamlike porous PE with a Delrin® plug | No limit | 80 - 100 mL | ITRC PSC-5 | Developed by Don Vroblesky (USGS). Demonstrated to be applicable to a variety of water-soluble organics and inorganics. |
| Mutiple Manufacturers | PDB | Passive Diffusion Bag (PDB) Sampler; diffusion-type sampler | I | 1.2-2" OD, 18-24" L | LDPE with HDPE cap; some vendors use other materials and sizes | No limit | 75 - 350 mL | ITRC PSC-3 | Developed by Don Vroblesky (USGS) and Thomas Hyde (GE). Demonstrated to be applicable to a variety of (but not all) VOCs; not for inorganics. |

**ATTACHMENT A**
**Purging and Sampling Equipment Selection (Updated July 2016)**

| Manufacturer | Model Name/ Number | Principle of Operation | I/E[1] | Maximum Outer Diameter (OD)/ Length (L)[2] | Construction Materials[3] (with Lines and Tubing) | Lift Range (Feet) | Delivery Rates or Volumes[4] | Main Source(s) of Information[5] | Comments |
|---|---|---|---|---|---|---|---|---|---|
| ProHydro, Inc. | Snap Sampler™ | Pneumatic actuator; grab-type sampler | I | 1.7-3.4" OD x 19-22+" L | Acetal with PFA-coated SS spring; optional SS weight; 40 mL glass vials or 125-350 mL PP bottles | 0 - 2,500 | 40 - 1,400 mL | ITRC PSC-5 | Demonstrated to be applicable to a variety of VOCs and inorganics. Up to 4 bottles may be employed together. |
| **Multi-Level Groundwater Monitoring System (MLS) (Used on Some Projects based on Stakeholder Agreement)** | | | | | | | | | |
| FLUT, Ltd. Co. | Water FLUTe™ | Dedicated; gas drive sampling, liner seals entire borehole wall. | I | Various sizes | NA | NA | NA | Mfg. | Practical to collect large volumes; can use low flow method; minimizes investigation-derived waste (IDW); proven technology. |
| Solinst Canada Ltd. | Continuous Multichannel Tubing (CMT) | Dedicated; 3 or 7-channel tubing designed to isolate and monitor depth discrete zones. | I | Up to 7 ports | NA | NA | NA | Mfg. | Low cost and easy to install; ideal for shallow applications; single tube for effective sealing. |
| Solinst Canada Ltd. | Waterloo | Dedicated; double valve or bladder pump sampling; packers separate ports at multiple depths. | I | Various sizes | NA | NA | NA | Mfg. | Practical to collect large volumes; can use low flow method; minimizes IDW; proven technology. |
| Schlumberger | Westbay | Dedicated; packers separate ports at multiple depths. | I | Various sizes | NA | NA | NA | Mfg. | Transducer and sampler are on a wire line; minimizes IDW; proven technology. Low long-time maintenance costs. |

**Footnotes:**

1 - I/E - Internal (I) or external (E) to the well.

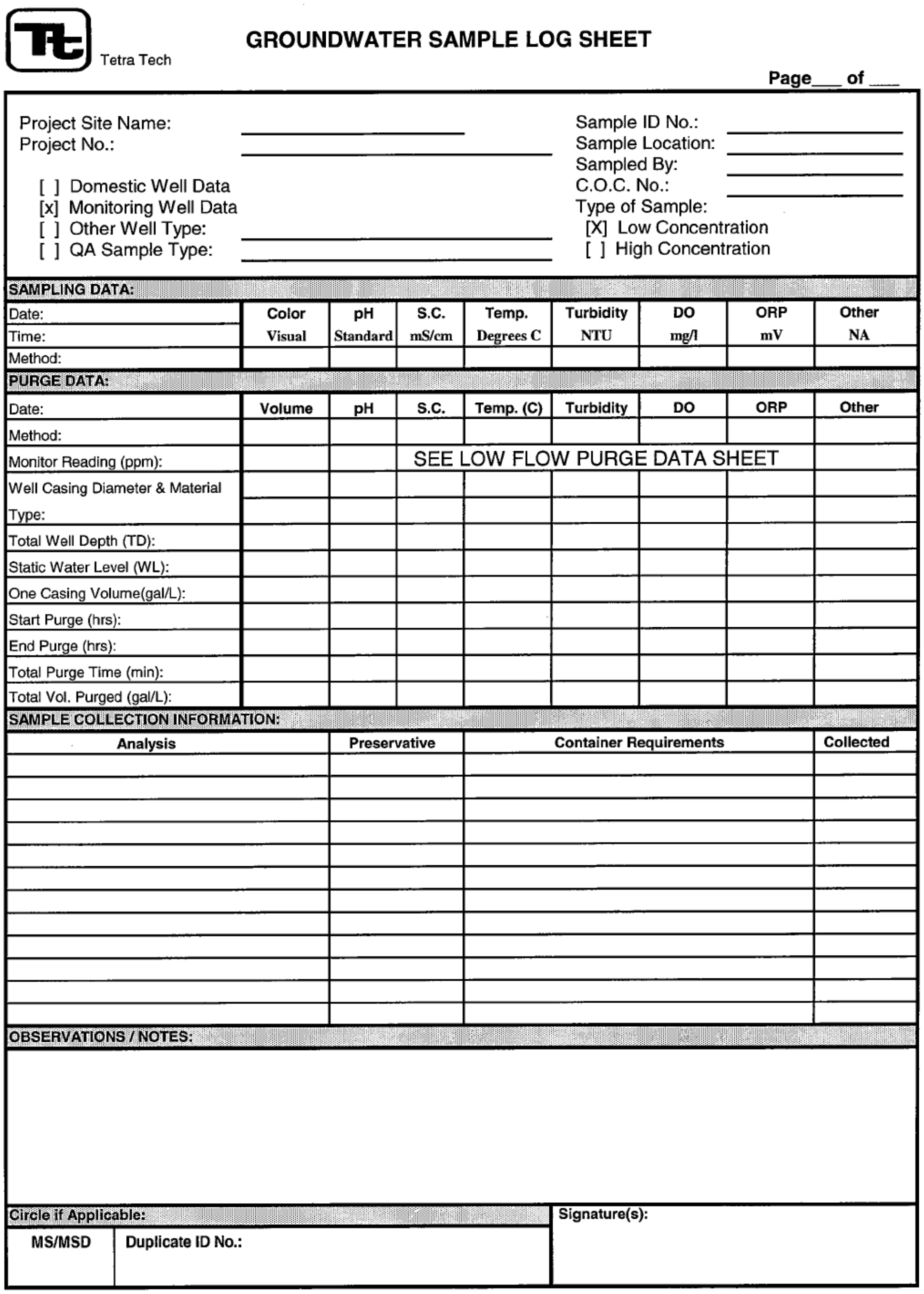
2 - For external pumps, the size is given in three dimensions (i.e. length, width, height); for internal pumps, the size is given in outside diameter (OD) and length (L) (in inches).

3 - Construction materials for pumps and associated equipment include: SS = stainless steel; PTFE = polytetrafluoroethylene; HDPE = high density polyethylene; PP = polypropylene; PE = polyethylene; PVC = polyvinyl chloride; FEP = fluorinated ethylene propylene; PVDF = polyvinylidene difluoride; EPDM = ethylene-propylene-diene elastomr; LDPE = low density polyethylene; PFA = perfluoroalkoxy.

4 - Rate or volume abbreviations: mL/min = milliliters per minute; gpm = gallons per minute; L/min = liters per minute; max. = maximum; mL = milliliters.

5 - Sources of information include specification sheets from the manufacturer (i.e., "Mfg."); equipment rental company websites - Pine Environmental (www.pine-environmental.com); GeoTech (www.geoenvtech.com); and guidance documents from Pacific Northwest National Laboratory (PNNL) (i.e., PNNL-13690) and Interstate Technology & Regulatory Council (ITRC) (i.e., PSC-3 and PSC-5 available at www.itrcweb.org).

## ATTACHMENT B
## GROUNDWATER SAMPLE LOG SHEET (EXAMPLE)



Tetra Tech

### GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: ____________________
Project No.: ____________________________

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: ____________________________
[ ] QA Sample Type: ____________________________

Sample ID No.: ________________
Sample Location: ________________
Sampled By: ________________
C.O.C. No.: ________________
Type of Sample:
[X] Low Concentration
[ ] High Concentration

**SAMPLING DATA:**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Date: | **Color** | **pH** | **S.C.** | **Temp.** | **Turbidity** | **DO** | **ORP** | **Other** |
| Time: | Visual | Standard | mS/cm | Degrees C | NTU | mg/l | mV | NA |
| Method: | | | | | | | | |

**PURGE DATA:**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Date: | **Volume** | **pH** | **S.C.** | **Temp. (C)** | **Turbidity** | **DO** | **ORP** | **Other** |
| Method: | | | | | | | | |
| Monitor Reading (ppm): | | | SEE LOW FLOW PURGE DATA SHEET | | | | | |
| Well Casing Diameter & Material Type: | | | | | | | | |
| | | | | | | | | |
| Total Well Depth (TD): | | | | | | | | |
| Static Water Level (WL): | | | | | | | | |
| One Casing Volume(gal/L): | | | | | | | | |
| Start Purge (hrs): | | | | | | | | |
| End Purge (hrs): | | | | | | | | |
| Total Purge Time (min): | | | | | | | | |
| Total Vol. Purged (gal/L): | | | | | | | | |

**SAMPLE COLLECTION INFORMATION:**

| Analysis | Preservative | Container Requirements | Collected |
|---|---|---|---|
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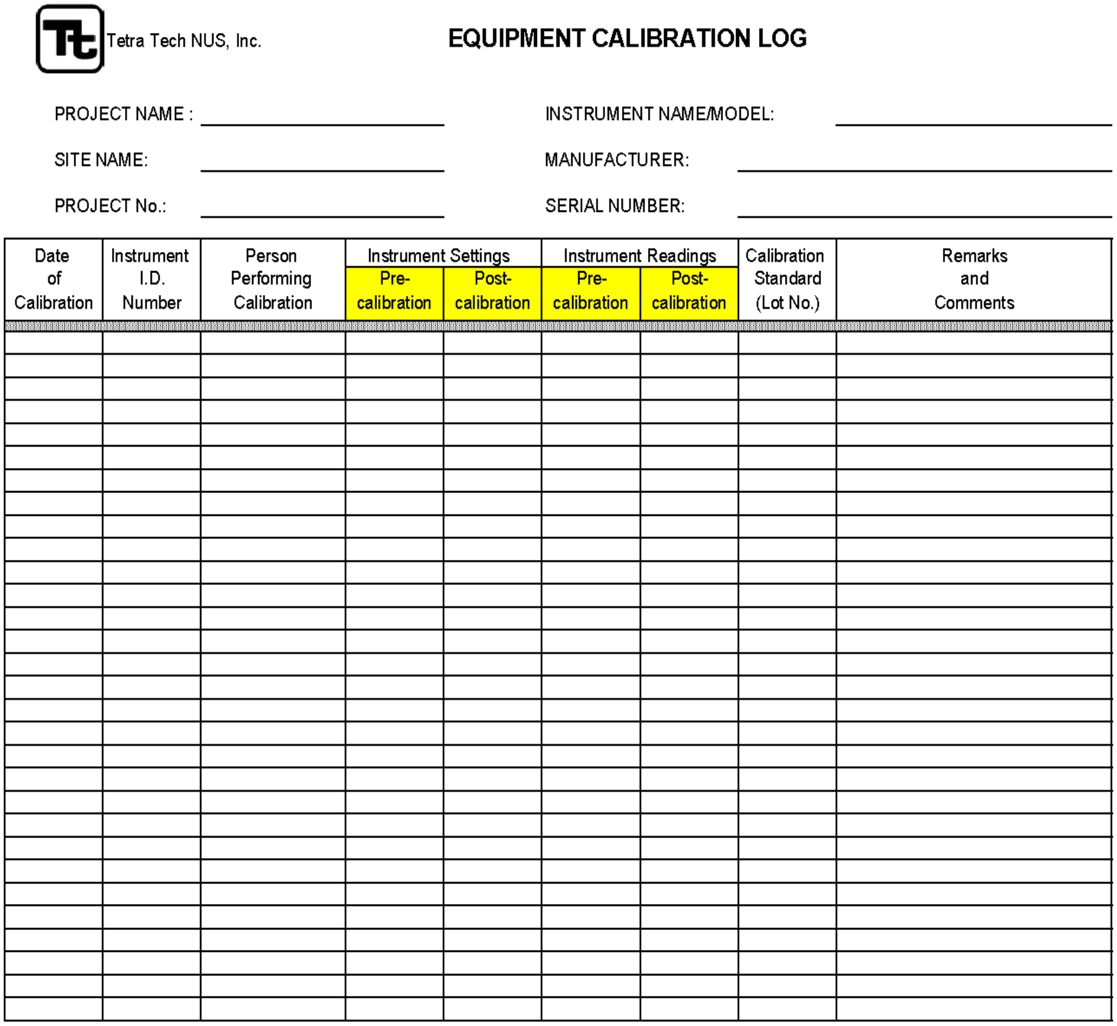
**OBSERVATIONS / NOTES:**

**Circle if Applicable:**

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

**Signature(s):**

# ATTACHMENT C
# FIELD CALIBRATION LOG SHEET (EXAMPLE)



Tetra Tech NUS, Inc.

## EQUIPMENT CALIBRATION LOG

PROJECT NAME : ______________________

SITE NAME: ______________________

PROJECT No.: ______________________

INSTRUMENT NAME/MODEL: ______________________

MANUFACTURER: ______________________

SERIAL NUMBER: ______________________

| Date of Calibration | Instrument I.D. Number | Person Performing Calibration | Instrument Settings | | Instrument Readings | | Calibration Standard (Lot No.) | Remarks and Comments |
|---|---|---|---|---|---|---|---|---|
| | | | Pre-calibration | Post-calibration | Pre-calibration | Post-calibration | | |
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## ATTACHMENT D
## LOW FLOW PURGE DATA SHEET (EXAMPLE)

### LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: ____________________
PROJECT NUMBER: ____________________

WELL ID.: ____________________
DATE: ____________________

| Time (Hrs.) | Water Level (Ft. below TOC) | Flow (mL/Min.) | pH (S.U.) | S. Cond. (mS/cm) | Turb. (NTU) | DO (mg/L) | Temp. (Celcius) | ORP mV | Salinity % or ppt | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
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| | | Effective Date<br>04/30//2020 | Revision<br>6 |
| | | Applicability<br>EGS Operating Unit | |
| | | Prepared<br>Earth Sciences Department | |
| Subject<br>NON-RADIOLOGICAL SAMPLE HANDLING | | Approved<br>T. Johnston T.E. Johnston 04/30/2020 | |

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**SECTION** **PAGE**

## 1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

## 2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

## 3.0 GLOSSARY

Hazardous Material – A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of §172.101 and §172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, International Air Transport Association (IATA) has adopted Department of Transportation (DOT) "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste – Any substance listed in 40 CFR, Subpart D (§261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (§261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking – A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i – Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s – Not otherwise specified.

Packaging – A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard – Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - $H_2SO_4$
- Nitric Acid - $HNO_3$
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

Normality (N) – Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) – For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR §172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample – A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

## 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 sample handling.

Field Operations Leader – Responsible for implementing field activities as detailed in approved project plans for the specific site. Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Support Personnel – Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

## 5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

### 5.1 SAMPLE CONTAINERS

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Proper sample containers, sample volumes, preservation methods such as chemical preservatives/cooling requirements, and holding times should be provided in the project-specific work plan. Some of these requirements may be laboratory-specific and should be arranged during the laboratory procurement phase of a project. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted.

The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. These containers shall be pre-cleaned to meet or exceed requirements of the latest U.S. Environmental Protection Agency (EPA) "Specifications and Guidance for Contaminant-Free Sample Containers." I-Chem 200 and 300 Series containers meet these requirements; other certifications may be available that also meet these requirements. Each case of 300 Series containers comes with a "Certificate of Analysis," and every container bears a similar bar-coded label for traceability. I-Chem Series 200 containers do not come with a Certificate of Analysis, but a certificate may be accessed upon request to the supplier. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Upon being opened, the container must be used at once for collection/storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

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 should not be stored on site but if on site storage is necessary, sample containers that have been stored on site for longer than 6 months should not be used.

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

## 5.2 SAMPLE PRESERVATION

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

### 5.2.1 Overview

Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation and field preservation of samples is discouraged for reasons of potential cross-contamination of samples and worker safety. Most samples require cooling to <6$^{o}$C and the project-specific planning documents should be consulted for detailed preservation and storage requirements.

The following subsections describe the procedures for preparing and adding chemical preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site. Furthermore, the FOL must ensure that a corresponding Safety Data Sheet (SDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate SDS for substances they will work with. The Chemical Inventory and the SDSs must be maintained at each work site in a location and manner where they are readily accessible to all personnel.

### 5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

| Acid/Base | Dilution | Concentration | Estimated Amount Required for Preservation |
|---|---|---|---|
| Hydrochloric Acid (HCl) | 1 part concentrated HCI: 1 part double-distilled, deionized water | 6N | 5 to 10 mL |

| Acid/Base | Dilution | Concentration | Estimated Amount Required for Preservation |
|---|---|---|---|
| Sulfuric Acid ($H_2SO_4$) | 1 part concentrated $H_2SO_4$: 1 part double-distilled, deionized water | 18N | 2 to 5 mL |
| Nitric Acid ($HNO_3$) | Undiluted concentrated $HNO_3$ | 16N | 2 to 5 mL |
| Sodium Hydroxide (NaOH) | 400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution | 10N | 2 mL |

**NOTE:** Pre diluted preservatives are available as ampules or in dropper bottles and are preferred as opposed to handling concentrated acids and bases.

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5 to 10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents (e.g., chlorine, permanganate or persulfate) present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 mL of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine, use a field test kit specially made for this purpose.

If residual chlorine is present (e.g., in municipal water systems), add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.
Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

## 5.3 FIELD FILTRATION

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing) or hand pump.

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicone tubing (note flow direction arrow); attach the unfiltered aqueous sample source to the intake end of the silicone tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 mL of sample through the filter and discard prior to sample collection of the filtered sample.

- Continue by preserving the filtrate, as applicable and generally described above.

## 5.4 SAMPLE PACKAGING AND SHIPPING

The Department of Transportation requires that persons who are required to transport or ship hazardous substances be specially trained. Only employees who have successfully completed the corporate “Shipping Hazardous Materials” training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)

- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

### 5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified and labeled sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking. Glass bottles should be individually wrapped in bubble wrap.

- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed and dated custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

## 6.0 REFERENCES

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

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

U.S. Department of Transportation (latest issue). Hazardous Materials Regulations, 49 CFR 171-177.

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

US EPA (U.S. Environmental Protection Agency), 2015. Test Methods for Evaluating Solid Waste (SW-846, Third Edition), Physical/Chemical Methods, as amended by Updates I, II, IIA, IIB, III, IIIA, IIIB, IVA, IVB, and VII, August.

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| | | Effective Date<br>08/26/2021 | Revision<br>8 |
| | | Applicability<br>EGS Operating Unit | |
| | | Prepared<br>Earth Sciences Department | |
| Subject<br>FIELD DOCUMENTATION | | Approved<br>T. Chuhay | 08/26/2021 |

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## 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

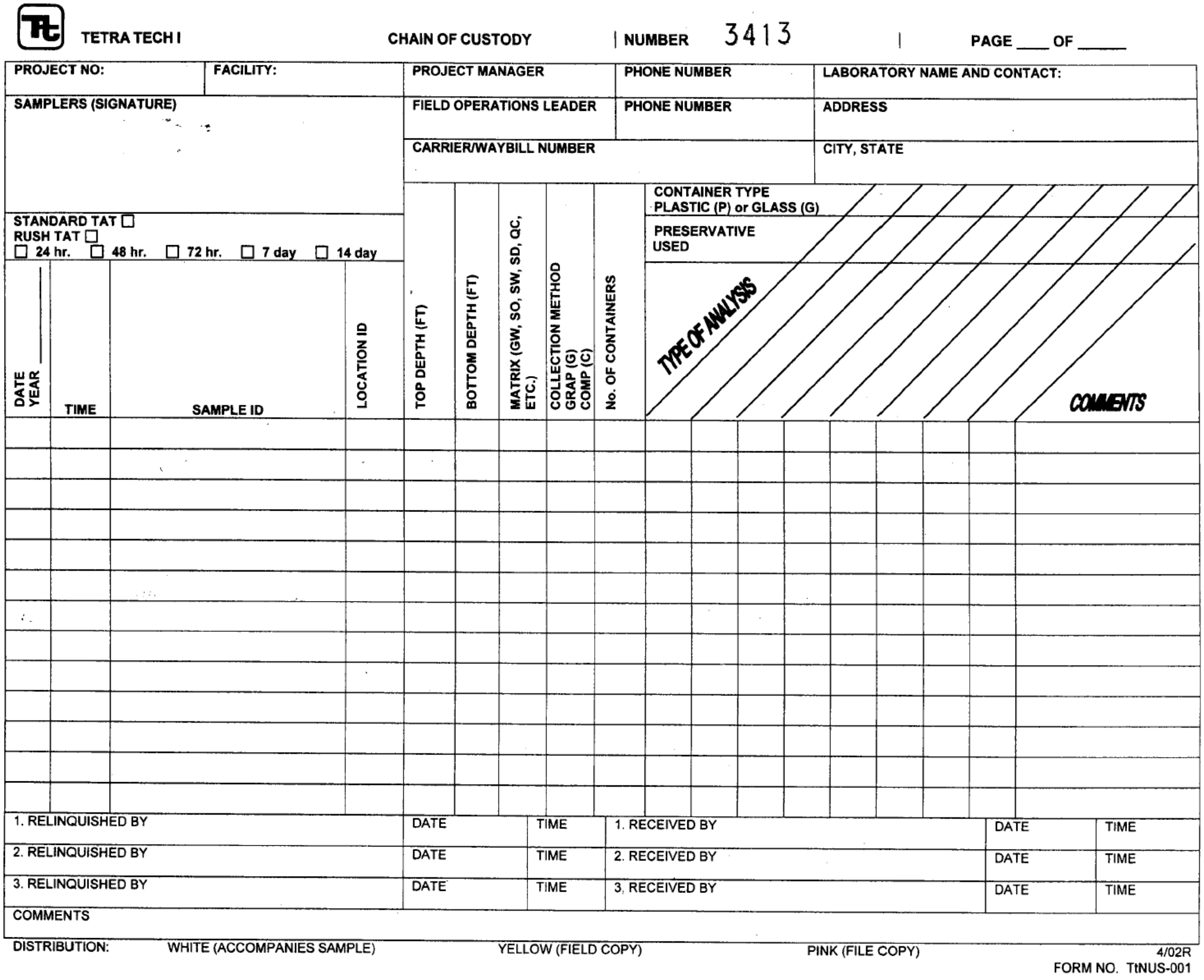
## ATTACHMENT B

## SAMPLE LABEL (EXAMPLE)

| | | | | |
|---|---|---|---|---|
| **TETRA TECH** | Tetra Tech EGS<br>661 Andersen Drive<br>Pittsburgh, 15220<br>(412)921-7090 | **Project:**<br>**Site:**<br>**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
TYPE OF ANALYSIS

| 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 | | | | | | | | | COMMENTS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | |
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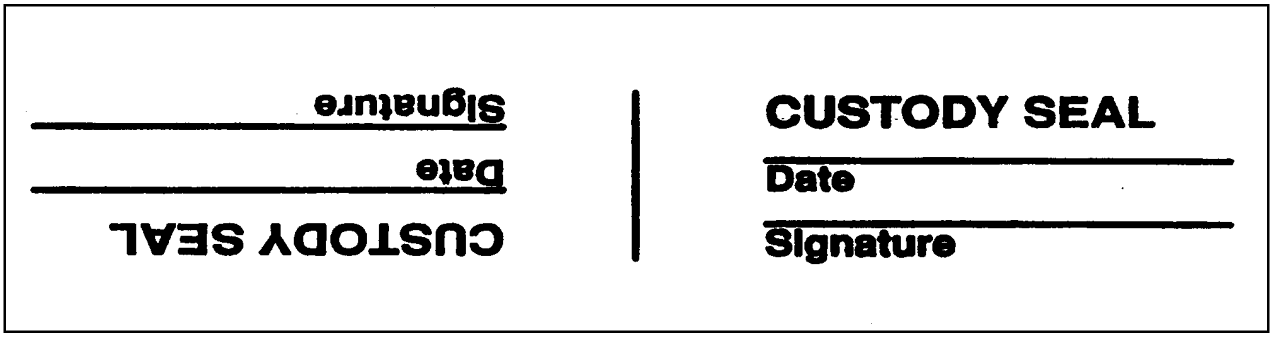
|---|---|---|---|---|---|
| 1. RELINQUISHED BY | DATE | TIME | 1. RECEIVED BY | DATE | TIME |
| 2. RELINQUISHED BY | DATE | TIME | 2. RECEIVED BY | DATE | TIME |
| 3. RELINQUISHED BY | DATE | TIME | 3, RECEIVED BY | DATE | TIME |
| COMMENTS | | | | | |

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

## ATTACHMENT D

## CHAIN-OF-CUSTODY SEAL (EXAMPLE)



| TETRA TECH | STANDARD OPERATING PROCEDURE | Number<br>SA-7.1 | Page<br>1 of 17 |
|---|---|---|---|
| | | Effective Date<br>04/30/2020 | Revision<br>9 |
| | | Applicability<br>Tetra Tech, Inc., EGS Operating Unit | |
| | | Prepared<br>Earth Sciences Department | |
| Subject<br>DECONTAMINATION OF FIELD EQUIPMENT AND MANAGEMENT OF INVESTIGATION DERIVED WASTE | | Approved<br>T. Johnston<br>T.E. Johnston 04/30/2020 | |

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## 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.

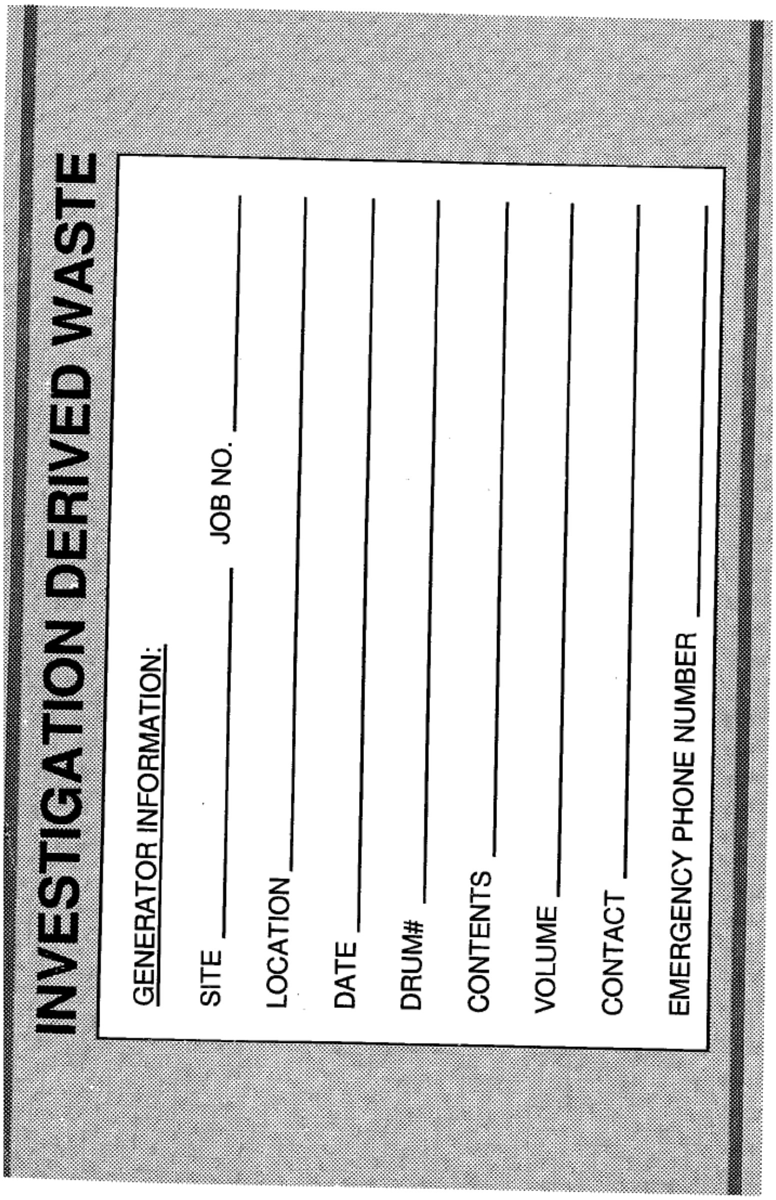
Equipment rinsate blank sample collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional equipment rinsate blank samples due to the obvious challenges to the decontamination process. 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: ____________

# APPENDIX B

# LABORATORY ACCREDITATION

## Commonwealth of Virginia

Department of General Services
Division of Consolidated Laboratory Services

## Scope of Accreditation

VELAP Certificate No.: 11525

**SGS - Orlando**
4405 Vineland Rd, Ste. C-15
Orlando, FL 32811

**Virginia Laboratory ID: 460177**
Effective Date: September 15, 2021
Expiration Date: September 14, 2022

### DRINKING WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 504.1 REV 1.1 | 1,2-DIBROMO-3-CHLOROPROPANE (DBCP) | FL | EPA 504.1 REV 1.1 | 1,2-DIBROMOETHANE (EDB, ETHYLENE DIBROMIDE) | FL |

### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 1010 | FLASHPOINT | FL | EPA 120.1 | CONDUCTIVITY | FL |
| EPA 1664 A | OIL AND GREASE (AS N-HEXANE EXTRACTABLE MATERIAL (HEM)) | FL | EPA 180.1 REV 2 | TURBIDITY | FL |
| EPA 200.7 REV 4.4 | ALUMINUM | FL | EPA 200.7 REV 4.4 | ANTIMONY | FL |
| EPA 200.7 REV 4.4 | ARSENIC | FL | EPA 200.7 REV 4.4 | BARIUM | FL |
| EPA 200.7 REV 4.4 | BERYLLIUM | FL | EPA 200.7 REV 4.4 | CADMIUM | FL |
| EPA 200.7 REV 4.4 | CALCIUM | FL | EPA 200.7 REV 4.4 | CHROMIUM | FL |
| EPA 200.7 REV 4.4 | COBALT | FL | EPA 200.7 REV 4.4 | COPPER | FL |
| EPA 200.7 REV 4.4 | IRON | FL | EPA 200.7 REV 4.4 | LEAD | FL |
| EPA 200.7 REV 4.4 | MAGNESIUM | FL | EPA 200.7 REV 4.4 | MANGANESE | FL |
| EPA 200.7 REV 4.4 | MOLYBDENUM | FL | EPA 200.7 REV 4.4 | NICKEL | FL |
| EPA 200.7 REV 4.4 | POTASSIUM | FL | EPA 200.7 REV 4.4 | SELENIUM | FL |
| EPA 200.7 REV 4.4 | SILVER | FL | EPA 200.7 REV 4.4 | SODIUM | FL |
| EPA 200.7 REV 4.4 | THALLIUM | FL | EPA 200.7 REV 4.4 | TIN | FL |
| EPA 200.7 REV 4.4 | TITANIUM | FL | EPA 200.7 REV 4.4 | VANADIUM | FL |
| EPA 200.7 REV 4.4 | ZINC | FL | EPA 200.8 REV 5.4 | ALUMINUM | FL |
| EPA 200.8 REV 5.4 | ANTIMONY | FL | EPA 200.8 REV 5.4 | ARSENIC | FL |
| EPA 200.8 REV 5.4 | BARIUM | FL | EPA 200.8 REV 5.4 | BERYLLIUM | FL |
| EPA 200.8 REV 5.4 | CADMIUM | FL | EPA 200.8 REV 5.4 | CHROMIUM | FL |
| EPA 200.8 REV 5.4 | COBALT | FL | EPA 200.8 REV 5.4 | COPPER | FL |
| EPA 200.8 REV 5.4 | LEAD | FL | EPA 200.8 REV 5.4 | MANGANESE | FL |
| EPA 200.8 REV 5.4 | MOLYBDENUM | FL | EPA 200.8 REV 5.4 | NICKEL | FL |
| EPA 200.8 REV 5.4 | SELENIUM | FL | EPA 200.8 REV 5.4 | SILVER | FL |
| EPA 200.8 REV 5.4 | THALLIUM | FL | EPA 200.8 REV 5.4 | VANADIUM | FL |
| EPA 200.8 REV 5.4 | ZINC | FL | EPA 200.8 REV 5.4 - EXTENDED | CALCIUM | FL |
| EPA 200.8 REV 5.4 - EXTENDED | IRON | FL | EPA 200.8 REV 5.4 - EXTENDED | MAGNESIUM | FL |
| EPA 200.8 REV 5.4 - EXTENDED | POTASSIUM | FL | EPA 200.8 REV 5.4 - EXTENDED | SODIUM | FL |
| EPA 200.8 REV 5.4 - EXTENDED | TIN | FL | EPA 200.8 REV 5.4 - EXTENDED | TITANIUM | FL |
| EPA 245.1 REV 3 | MERCURY | FL | EPA 300.0 REV 2.1 | BROMIDE | FL |
| EPA 300.0 REV 2.1 | CHLORIDE | FL | EPA 300.0 REV 2.1 | FLUORIDE | FL |
| EPA 300.0 REV 2.1 | NITRATE AS N | FL | EPA 300.0 REV 2.1 | NITRATE/NITRITE | FL |
| EPA 300.0 REV 2.1 | NITRITE AS N | FL | EPA 300.0 REV 2.1 | SULFATE | FL |

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### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 335.4 REV 1.0 | CYANIDE | FL | EPA 350.1 REV 2 | AMMONIA AS N | FL |
| EPA 351.2 REV 2 | KJELDAHL NITROGEN - TOTAL (TKN) | FL | EPA 365.3 | ORTHOPHOSPHATE AS P | FL |
| EPA 365.3 | PHOSPHORUS, TOTAL | FL | EPA 420.4 REV 1 | TOTAL PHENOLICS | FL |
| EPA 6010 C | ALUMINUM | FL | EPA 6010 C | ANTIMONY | FL |
| EPA 6010 C | ARSENIC | FL | EPA 6010 C | BARIUM | FL |
| EPA 6010 C | BERYLLIUM | FL | EPA 6010 C | CADMIUM | FL |
| EPA 6010 C | CALCIUM | FL | EPA 6010 C | CHROMIUM | FL |
| EPA 6010 C | COBALT | FL | EPA 6010 C | COPPER | FL |
| EPA 6010 C | IRON | FL | EPA 6010 C | LEAD | FL |
| EPA 6010 C | MAGNESIUM | FL | EPA 6010 C | MANGANESE | FL |
| EPA 6010 C | MOLYBDENUM | FL | EPA 6010 C | NICKEL | FL |
| EPA 6010 C | POTASSIUM | FL | EPA 6010 C | SELENIUM | FL |
| EPA 6010 C | SILVER | FL | EPA 6010 C | SODIUM | FL |
| EPA 6010 C | STRONTIUM | FL | EPA 6010 C | THALLIUM | FL |
| EPA 6010 C | TIN | FL | EPA 6010 C | TITANIUM | FL |
| EPA 6010 C | VANADIUM | FL | EPA 6010 C | ZINC | FL |
| EPA 6010 D | ALUMINUM | FL | EPA 6010 D | ANTIMONY | FL |
| EPA 6010 D | ARSENIC | FL | EPA 6010 D | BARIUM | FL |
| EPA 6010 D | BERYLLIUM | FL | EPA 6010 D | CADMIUM | FL |
| EPA 6010 D | CALCIUM | FL | EPA 6010 D | CHROMIUM | FL |
| EPA 6010 D | COBALT | FL | EPA 6010 D | COPPER | FL |
| EPA 6010 D | IRON | FL | EPA 6010 D | LEAD | FL |
| EPA 6010 D | MAGNESIUM | FL | EPA 6010 D | MANGANESE | FL |
| EPA 6010 D | MOLYBDENUM | FL | EPA 6010 D | NICKEL | FL |
| EPA 6010 D | POTASSIUM | FL | EPA 6010 D | SELENIUM | FL |
| EPA 6010 D | SILVER | FL | EPA 6010 D | SODIUM | FL |
| EPA 6010 D | STRONTIUM | FL | EPA 6010 D | THALLIUM | FL |
| EPA 6010 D | TIN | FL | EPA 6010 D | TITANIUM | FL |
| EPA 6010 D | VANADIUM | FL | EPA 6010 D | ZINC | FL |
| EPA 6020 A | ALUMINUM | FL | EPA 6020 A | ANTIMONY | FL |
| EPA 6020 A | ARSENIC | FL | EPA 6020 A | BARIUM | FL |
| EPA 6020 A | BERYLLIUM | FL | EPA 6020 A | CADMIUM | FL |
| EPA 6020 A | CALCIUM | FL | EPA 6020 A | CHROMIUM | FL |
| EPA 6020 A | COBALT | FL | EPA 6020 A | COPPER | FL |
| EPA 6020 A | IRON | FL | EPA 6020 A | LEAD | FL |
| EPA 6020 A | MAGNESIUM | FL | EPA 6020 A | MANGANESE | FL |
| EPA 6020 A | NICKEL | FL | EPA 6020 A | POTASSIUM | FL |
| EPA 6020 A | SELENIUM | FL | EPA 6020 A | SILVER | FL |
| EPA 6020 A | SODIUM | FL | EPA 6020 A | THALLIUM | FL |

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## NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 6020 A | VANADIUM | FL | EPA 6020 A | ZINC | FL |
| EPA 6020 A - EXTENDED | MOLYBDENUM | FL | EPA 6020 A - EXTENDED | TIN | FL |
| EPA 6020 A - EXTENDED | TITANIUM | FL | EPA 6020 B | ALUMINUM | FL |
| EPA 6020 B | ANTIMONY | FL | EPA 6020 B | ARSENIC | FL |
| EPA 6020 B | BARIUM | FL | EPA 6020 B | BERYLLIUM | FL |
| EPA 6020 B | CADMIUM | FL | EPA 6020 B | CALCIUM | FL |
| EPA 6020 B | CHROMIUM | FL | EPA 6020 B | COBALT | FL |
| EPA 6020 B | COPPER | FL | EPA 6020 B | IRON | FL |
| EPA 6020 B | LEAD | FL | EPA 6020 B | MAGNESIUM | FL |
| EPA 6020 B | MANGANESE | FL | EPA 6020 B | MOLYBDENUM | FL |
| EPA 6020 B | NICKEL | FL | EPA 6020 B | POTASSIUM | FL |
| EPA 6020 B | SELENIUM | FL | EPA 6020 B | SILVER | FL |
| EPA 6020 B | SODIUM | FL | EPA 6020 B | THALLIUM | FL |
| EPA 6020 B | TIN | FL | EPA 6020 B | VANADIUM | FL |
| EPA 6020 B | ZINC | FL | EPA 6020 B - EXTENDED | STRONTIUM | FL |
| EPA 6020 B - EXTENDED | TITANIUM | FL | EPA 608.3 | 4,4'-DDD | FL |
| EPA 608.3 | 4,4'-DDE | FL | EPA 608.3 | 4,4'-DDT | FL |
| EPA 608.3 | ALDRIN | FL | EPA 608.3 | ALPHA-BHC (ALPHA-HEXACHLOROCYCLOHEXANE) | FL |
| EPA 608.3 | AROCLOR-1016 (PCB-1016) | FL | EPA 608.3 | AROCLOR-1221 (PCB-1221) | FL |
| EPA 608.3 | AROCLOR-1232 (PCB-1232) | FL | EPA 608.3 | AROCLOR-1242 (PCB-1242) | FL |
| EPA 608.3 | AROCLOR-1248 (PCB-1248) | FL | EPA 608.3 | AROCLOR-1254 (PCB-1254) | FL |
| EPA 608.3 | AROCLOR-1260 (PCB-1260) | FL | EPA 608.3 | BETA-BHC (BETA-HEXACHLOROCYCLOHEXANE) | FL |
| EPA 608.3 | CHLORDANE, TOTAL | FL | EPA 608.3 | DELTA-BHC | FL |
| EPA 608.3 | DIELDRIN | FL | EPA 608.3 | ENDOSULFAN I | FL |
| EPA 608.3 | ENDOSULFAN II | FL | EPA 608.3 | ENDOSULFAN SULFATE | FL |
| EPA 608.3 | ENDRIN | FL | EPA 608.3 | ENDRIN ALDEHYDE | FL |
| EPA 608.3 | GAMMA-BHC (LINDANE, GAMMA-HEXACHLOROCYCLOHEXANE) | FL | EPA 608.3 | HEPTACHLOR | FL |
| EPA 608.3 | HEPTACHLOR EPOXIDE | FL | EPA 608.3 | TOXAPHENE (CHLORINATED CAMPHENE) | FL |
| EPA 624.1 | 1,1,1-TRICHLOROETHANE | FL | EPA 624.1 | 1,1,2,2-TETRACHLOROETHANE | FL |
| EPA 624.1 | 1,1,2-TRICHLOROETHANE | FL | EPA 624.1 | 1,1-DICHLOROETHANE | FL |
| EPA 624.1 | 1,1-DICHLOROETHYLENE | FL | EPA 624.1 | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL |
| EPA 624.1 | 1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE) | FL | EPA 624.1 | 1,2-DICHLOROPROPANE | FL |
| EPA 624.1 | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL | EPA 624.1 | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL |
| EPA 624.1 | 2-CHLOROETHYL VINYL ETHER | FL | | | |

# Commonwealth of Virginia

Department of General Services
Division of Consolidated Laboratory Services

## Scope of Accreditation

VELAP Certificate No.: 11525

**SGS - Orlando**
4405 Vineland Rd, Ste. C-15
Orlando, FL 32811

**Virginia Laboratory ID: 460177**
Effective Date: September 15, 2021
Expiration Date: September 14, 2022

### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 624.1 | ACROLEIN (PROPENAL) | FL | EPA 624.1 | ACRYLONITRILE | FL |
| EPA 624.1 | BENZENE | FL | EPA 624.1 | BROMODICHLOROMETHANE | FL |
| EPA 624.1 | BROMOFORM | FL | EPA 624.1 | CARBON TETRACHLORIDE | FL |
| EPA 624.1 | CHLOROBENZENE | FL | EPA 624.1 | CHLORODIBROMOMETHANE | FL |
| EPA 624.1 | CHLOROETHANE (ETHYL CHLORIDE) | FL | EPA 624.1 | CHLOROFORM | FL |
| EPA 624.1 | CIS-1,3-DICHLOROPROPENE | FL | EPA 624.1 | ETHYLBENZENE | FL |
| EPA 624.1 | METHYL BROMIDE (BROMOMETHANE) | FL | EPA 624.1 | METHYL CHLORIDE (CHLOROMETHANE) | FL |
| EPA 624.1 | METHYL TERT-BUTYL ETHER (MTBE) | FL | EPA 624.1 | METHYLENE CHLORIDE (DICHLOROMETHANE) | FL |
| EPA 624.1 | TETRACHLOROETHENE (PERCHLOROETHENE) | FL | EPA 624.1 | TOLUENE | FL |
| EPA 624.1 | TRANS-1,2-DICHLOROETHENE | FL | EPA 624.1 | TRANS-1,3-DICHLOROPROPENE (TRANS-1,3-DICHLOROPROPYLENE) | FL |
| EPA 624.1 | TRICHLOROETHENE (TRICHLOROETHYLENE) | FL | EPA 624.1 | TRICHLOROFLUOROMETHANE (FLUOROTRICHLOROMETHANE, FREON 11) | FL |
| EPA 624.1 | VINYL CHLORIDE (CHLOROETHENE) | FL | EPA 624.1 | XYLENE (TOTAL) | FL |
| EPA 625.1 | 1,2,4-TRICHLOROBENZENE | FL | EPA 625.1 | 2,2'-OXYBIS(1-CHLOROPROPANE) | FL |
| EPA 625.1 | 2,4,6-TRICHLOROPHENOL | FL | EPA 625.1 | 2,4-DICHLOROPHENOL | FL |
| EPA 625.1 | 2,4-DIMETHYLPHENOL | FL | EPA 625.1 | 2,4-DINITROPHENOL | FL |
| EPA 625.1 | 2,4-DINITROTOLUENE (2,4-DNT) | FL | EPA 625.1 | 2,6-DINITROTOLUENE (2,6-DNT) | FL |
| EPA 625.1 | 2-CHLORONAPHTHALENE | FL | EPA 625.1 | 2-CHLOROPHENOL | FL |
| EPA 625.1 | 2-METHYL-4,6-DINITROPHENOL (4,6-DINITRO-2-METHYLPHENOL) | FL | EPA 625.1 | 2-NITROPHENOL | FL |
| EPA 625.1 | 3,3'-DICHLOROBENZIDINE | FL | EPA 625.1 | 4-BROMOPHENYL PHENYL ETHER (BDE-3) | FL |
| EPA 625.1 | 4-CHLORO-3-METHYLPHENOL | FL | EPA 625.1 | 4-CHLOROPHENYL PHENYLETHER | FL |
| EPA 625.1 | 4-NITROPHENOL | FL | EPA 625.1 | ACENAPHTHENE | FL |
| EPA 625.1 | ACENAPHTHYLENE | FL | EPA 625.1 | ANTHRACENE | FL |
| EPA 625.1 | BENZIDINE | FL | EPA 625.1 | BENZO(A)ANTHRACENE | FL |
| EPA 625.1 | BENZO(A)PYRENE | FL | EPA 625.1 | BENZO(B)FLUORANTHENE | FL |
| EPA 625.1 | BENZO(G,H,I)PERYLENE | FL | EPA 625.1 | BENZO(K)FLUORANTHENE | FL |
| EPA 625.1 | BIS(2-CHLOROETHOXY)METHANE | FL | EPA 625.1 | BIS(2-CHLOROETHYL) ETHER | FL |
| EPA 625.1 | BIS(2-ETHYLHEXYL) PHTHALATE (DI(2-ETHYLHEXYL)PHTHALATE), (DEHP) | FL | EPA 625.1 | BUTYL BENZYL PHTHALATE | FL |
| EPA 625.1 | CHRYSENE | FL | EPA 625.1 | DI-N-BUTYL PHTHALATE | FL |
| EPA 625.1 | DI-N-OCTYL PHTHALATE | FL | EPA 625.1 | DIBENZO(A,H) ANTHRACENE | FL |
| EPA 625.1 | DIETHYL PHTHALATE | FL | EPA 625.1 | DIMETHYL PHTHALATE | FL |
| EPA 625.1 | FLUORANTHENE | FL | EPA 625.1 | FLUORENE | FL |
| EPA 625.1 | HEXACHLOROBENZENE | FL | EPA 625.1 | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL |

# Commonwealth of Virginia

Department of General Services
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## Scope of Accreditation

VELAP Certificate No.: 11525

**SGS - Orlando**
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**Virginia Laboratory ID: 460177**
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### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 625.1 | HEXACHLOROCYCLOPENTADIENE | FL | EPA 625.1 | HEXACHLOROETHANE | FL |
| EPA 625.1 | INDENO(1,2,3-CD) PYRENE | FL | EPA 625.1 | ISOPHORONE | FL |
| EPA 625.1 | N-NITROSODI-N-PROPYLAMINE | FL | EPA 625.1 | N-NITROSODIMETHYLAMINE | FL |
| EPA 625.1 | N-NITROSODIPHENYLAMINE | FL | EPA 625.1 | NAPHTHALENE | FL |
| EPA 625.1 | NITROBENZENE | FL | EPA 625.1 | PENTACHLOROPHENOL | FL |
| EPA 625.1 | PHENANTHRENE | FL | EPA 625.1 | PHENOL | FL |
| EPA 625.1 | PYRENE | FL | EPA 6850 | PERCHLORATE | FL |
| EPA 7196 A | CHROMIUM VI | FL | EPA 7470 A | MERCURY | FL |
| EPA 8011 | 1,2-DIBROMO-3-CHLOROPROPANE (DBCP) | FL | EPA 8011 | 1,2-DIBROMOETHANE (EDB, ETHYLENE DIBROMIDE) | FL |
| EPA 8015 B | 1-BUTANOL (N-BUTANOL, N-BUTYL ALCOHOL) | FL | EPA 8015 C | DIESEL RANGE ORGANICS (DRO) | FL |
| EPA 8015 C | ETHANOL | FL | EPA 8015 C | GASOLINE RANGE ORGANICS (GRO) | FL |
| EPA 8015 C | ISOBUTYL ALCOHOL (2-METHYL-1-PROPANOL) | FL | EPA 8015 C | ISOPROPYL ALCOHOL (2-PROPANOL, ISOPROPANOL) | FL |
| EPA 8015 C | METHANOL | FL | EPA 8015 C | N-PROPANOL (1-PROPANOL) | FL |
| EPA 8015 D | DIESEL RANGE ORGANICS (DRO) | FL | EPA 8015 D | ETHANOL | FL |
| EPA 8015 D | GASOLINE RANGE ORGANICS (GRO) | FL | EPA 8015 D | ISOPROPYL ALCOHOL (2-PROPANOL, ISOPROPANOL) | FL |
| EPA 8015 D | METHANOL | FL | EPA 8015 D | N-PROPANOL (1-PROPANOL) | FL |
| EPA 8081 B | 4,4'-DDD | FL | EPA 8081 B | 4,4'-DDE | FL |
| EPA 8081 B | 4,4'-DDT | FL | EPA 8081 B | ALDRIN | FL |
| EPA 8081 B | ALPHA-BHC (ALPHA-HEXACHLOROCYCLOHEXANE) | FL | EPA 8081 B | ALPHA-CHLORDANE (CIS-CHLORDANE) | FL |
| EPA 8081 B | BETA-BHC (BETA-HEXACHLOROCYCLOHEXANE) | FL | EPA 8081 B | CHLORDANE, TOTAL | FL |
| EPA 8081 B | DELTA-BHC | FL | EPA 8081 B | DIELDRIN | FL |
| EPA 8081 B | ENDOSULFAN I | FL | EPA 8081 B | ENDOSULFAN II | FL |
| EPA 8081 B | ENDOSULFAN SULFATE | FL | EPA 8081 B | ENDRIN | FL |
| EPA 8081 B | ENDRIN ALDEHYDE | FL | EPA 8081 B | ENDRIN KETONE | FL |
| EPA 8081 B | GAMMA-BHC (LINDANE, GAMMA-HEXACHLOROCYCLOHEXANE) | FL | EPA 8081 B | GAMMA-CHLORDANE (BETA-CHLORDANE, TRANS-CHLORDANE) | FL |
| EPA 8081 B | HEPTACHLOR | FL | EPA 8081 B | HEPTACHLOR EPOXIDE | FL |
| EPA 8081 B | METHOXYCHLOR | FL | EPA 8081 B | TOXAPHENE (CHLORINATED CAMPHENE) | FL |
| EPA 8082 A | AROCLOR-1016 (PCB-1016) | FL | EPA 8082 A | AROCLOR-1221 (PCB-1221) | FL |
| EPA 8082 A | AROCLOR-1232 (PCB-1232) | FL | EPA 8082 A | AROCLOR-1242 (PCB-1242) | FL |
| EPA 8082 A | AROCLOR-1248 (PCB-1248) | FL | EPA 8082 A | AROCLOR-1254 (PCB-1254) | FL |
| EPA 8082 A | AROCLOR-1260 (PCB-1260) | FL | EPA 8141 B | AZINPHOS-METHYL (GUTHION) | FL |
| EPA 8141 B | BOLSTAR (SULPROFOS) | FL | EPA 8141 B | CARBOPHENOTHION | FL |

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### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8141 B | CHLORPYRIFOS | FL | EPA 8141 B | COUMAPHOS | FL |
| EPA 8141 B | DEMETON-O | FL | EPA 8141 B | DEMETON-S | FL |
| EPA 8141 B | DIAZINON | FL | EPA 8141 B | DICHLOROVOS (DDVP, DICHLORVOS) | FL |
| EPA 8141 B | DIMETHOATE | FL | EPA 8141 B | DISULFOTON | FL |
| EPA 8141 B | EPN (PHOSPHONOTHIOIC ACID, PHENYL-, O-ETHYL O-(P-NITROPHENYL) ESTER) | FL | EPA 8141 B | ETHION | FL |
| EPA 8141 B | ETHOPROP | FL | EPA 8141 B | FAMPHUR | FL |
| EPA 8141 B | FENSULFOTHION | FL | EPA 8141 B | FENTHION | FL |
| EPA 8141 B | MALATHION | FL | EPA 8141 B | MERPHOS | FL |
| EPA 8141 B | METHYL PARATHION (PARATHION, METHYL) | FL | EPA 8141 B | MEVINPHOS | FL |
| EPA 8141 B | MONOCROTOPHOS | FL | EPA 8141 B | NALED | FL |
| EPA 8141 B | PARATHION (PARATHION - ETHYL) | FL | EPA 8141 B | PHORATE | FL |
| EPA 8141 B | RONNEL | FL | EPA 8141 B | SULFOTEPP (TETRAETHYL DITHIOPYROPHOSPHATE) | FL |
| EPA 8141 B | TETRACHLORVINPHOS (STIROPHOS, GARDONA) Z-ISOMER | FL | EPA 8141 B | TETRAETHYL PYROPHOSPHATE (TEPP) | FL |
| EPA 8141 B | THIONAZIN (ZINOPHOS, DIETHYL-O-2-PYRAZINYL PHOSPHOROTHIONATE) | FL | EPA 8141 B | TOKUTHION (PROTHIOPHOS) | FL |
| EPA 8141 B | TRICHLORONATE | FL | EPA 8151 A | 2,4,5-T | FL |
| EPA 8151 A | 2,4-D | FL | EPA 8151 A | 2,4-DB | FL |
| EPA 8151 A | DALAPON | FL | EPA 8151 A | DICAMBA | FL |
| EPA 8151 A | DICHLOROPROP (DICHLORPROP) | FL | EPA 8151 A | DINOSEB (2-SEC-BUTYL-4,6-DINITROPHENOL, DNBP) | FL |
| EPA 8151 A | MCPA | FL | EPA 8151 A | MCPP | FL |
| EPA 8151 A | PENTACHLOROPHENOL | FL | EPA 8151 A | SILVEX (2,4,5-TP) | FL |
| EPA 8260 C | 1,1,1,2-TETRACHLOROETHANE | FL | EPA 8260 C | 1,1,1-TRICHLOROETHANE | FL |
| EPA 8260 C | 1,1,2,2-TETRACHLOROETHANE | FL | EPA 8260 C | 1,1,2-TRICHLOROETHANE | FL |
| EPA 8260 C | 1,1-DICHLOROETHANE | FL | EPA 8260 C | 1,1-DICHLOROETHYLENE | FL |
| EPA 8260 C | 1,1-DICHLOROPROPENE | FL | EPA 8260 C | 1,2,3-TRICHLOROBENZENE | FL |
| EPA 8260 C | 1,2,3-TRICHLOROPROPANE | FL | EPA 8260 C | 1,2,4-TRICHLOROBENZENE | FL |
| EPA 8260 C | 1,2,4-TRIMETHYLBENZENE | FL | EPA 8260 C | 1,2-DIBROMO-3-CHLOROPROPANE (DBCP) | FL |
| EPA 8260 C | 1,2-DIBROMOETHANE (EDB, ETHYLENE DIBROMIDE) | FL | EPA 8260 C | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL |
| EPA 8260 C | 1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE) | FL | EPA 8260 C | 1,2-DICHLOROPROPANE | FL |
| EPA 8260 C | 1,3,5-TRIMETHYLBENZENE | FL | EPA 8260 C | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL |
| EPA 8260 C | 1,3-DICHLOROPROPANE | FL | EPA 8260 C | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL |

## Scope of Accreditation

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### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8260 C | 1,4-DIOXANE (P-DIOXANE /1,4-DIETHYLENEOXIDE) | FL | EPA 8260 C | 1-CHLOROHEXANE | FL |
| EPA 8260 C | 2,2-DICHLOROPROPANE | FL | EPA 8260 C | 2-BUTANONE (METHYL ETHYL KETONE, MEK) | FL |
| EPA 8260 C | 2-CHLOROETHYL VINYL ETHER | FL | EPA 8260 C | 2-CHLOROTOLUENE | FL |
| EPA 8260 C | 2-HEXANONE | FL | EPA 8260 C | 2-NITROPROPANE | FL |
| EPA 8260 C | 4-CHLOROTOLUENE | FL | EPA 8260 C | 4-ISOPROPYLTOLUENE (P-CYMENE, P-ISOPROPYLTOLUENE) | FL |
| EPA 8260 C | 4-METHYL-2-PENTANONE (METHYL ISOBUTYL KETONE, MIBK) | FL | EPA 8260 C | ACETONE | FL |
| EPA 8260 C | ACETONITRILE | FL | EPA 8260 C | ACROLEIN (PROPENAL) | FL |
| EPA 8260 C | ACRYLONITRILE | FL | EPA 8260 C | ALLYL CHLORIDE (3-CHLOROPROPENE) | FL |
| EPA 8260 C | BENZENE | FL | EPA 8260 C | BROMOBENZENE | FL |
| EPA 8260 C | BROMOCHLOROMETHANE | FL | EPA 8260 C | BROMODICHLOROMETHANE | FL |
| EPA 8260 C | BROMOFORM | FL | EPA 8260 C | CARBON DISULFIDE | FL |
| EPA 8260 C | CARBON TETRACHLORIDE | FL | EPA 8260 C | CHLOROBENZENE | FL |
| EPA 8260 C | CHLORODIBROMOMETHANE | FL | EPA 8260 C | CHLOROETHANE (ETHYL CHLORIDE) | FL |
| EPA 8260 C | CHLOROFORM | FL | EPA 8260 C | CHLOROPRENE (2-CHLORO-1,3-BUTADIENE) | FL |
| EPA 8260 C | CIS-1,2-DICHLOROETHYLENE | FL | EPA 8260 C | CIS-1,3-DICHLOROPROPENE | FL |
| EPA 8260 C | CIS-1,4-DICHLORO-2-BUTENE | FL | EPA 8260 C | DIBROMOMETHANE (METHYLENE BROMIDE) | FL |
| EPA 8260 C | DICHLORODIFLUOROMETHANE (FREON-12) | FL | EPA 8260 C | DIETHYL ETHER | FL |
| EPA 8260 C | ETHANOL | FL | EPA 8260 C | ETHYL ACETATE | FL |
| EPA 8260 C | ETHYL METHACRYLATE | FL | EPA 8260 C | ETHYL-T-BUTYLETHER (2-ETHOXY-2-METHYLPROPANE, ETBE) | FL |
| EPA 8260 C | ETHYLBENZENE | FL | EPA 8260 C | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL |
| EPA 8260 C | IODOMETHANE (METHYL IODIDE) | FL | EPA 8260 C | ISOBUTYL ALCOHOL (2-METHYL-1-PROPANOL) | FL |
| EPA 8260 C | ISOPROPYLBENZENE | FL | EPA 8260 C | METHACRYLONITRILE | FL |
| EPA 8260 C | METHYL BROMIDE (BROMOMETHANE) | FL | EPA 8260 C | METHYL CHLORIDE (CHLOROMETHANE) | FL |
| EPA 8260 C | METHYL METHACRYLATE | FL | EPA 8260 C | METHYL TERT-BUTYL ETHER (MTBE) | FL |
| EPA 8260 C | METHYLENE CHLORIDE (DICHLOROMETHANE) | FL | EPA 8260 C | N-BUTYLBENZENE | FL |
| EPA 8260 C | N-PROPYLBENZENE | FL | EPA 8260 C | NAPHTHALENE | FL |
| EPA 8260 C | PENTACHLOROETHANE | FL | EPA 8260 C | PROPIONITRILE (ETHYL CYANIDE) | FL |
| EPA 8260 C | SEC-BUTYLBENZENE | FL | EPA 8260 C | STYRENE | FL |
| EPA 8260 C | T-AMYLMETHYLETHER (TAME) | FL | EPA 8260 C | TERT-BUTYL ALCOHOL (2-METHYL-2-PROPANOL) | FL |

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## NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY |
|---|---|---|
| EPA 8260 C | TERT-BUTYLBENZENE | FL |
| EPA 8260 C | TOLUENE | FL |
| EPA 8260 C | TRANS-1,3-DICHLOROPROPENE (TRANS-1,3-DICHLOROPROPYLENE) | FL |
| EPA 8260 C | TRICHLOROETHENE (TRICHLOROETHYLENE) | FL |
| EPA 8260 C | VINYL ACETATE | FL |
| EPA 8260 C | XYLENE (TOTAL) | FL |
| EPA 8260 C - EXTENDED | DI-ISOPROPYLETHER (DIPE, ISOPROPYL ETHER) | FL |
| EPA 8260 D | 1,1,1-TRICHLOROETHANE | FL |
| EPA 8260 D | 1,1,2-TRICHLORO-1,2,2-TRIFLUORO ETHANE (FREON 113) | FL |
| EPA 8260 D | 1,1-DICHLOROETHANE | FL |
| EPA 8260 D | 1,1-DICHLOROPROPENE | FL |
| EPA 8260 D | 1,2,3-TRICHLOROPROPANE | FL |
| EPA 8260 D | 1,2,4-TRICHLOROBENZENE | FL |
| EPA 8260 D | 1,2-DIBROMO-3-CHLOROPROPANE (DBCP) | FL |
| EPA 8260 D | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL |
| EPA 8260 D | 1,2-DICHLOROPROPANE | FL |
| EPA 8260 D | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL |
| EPA 8260 D | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL |
| EPA 8260 D | 1-BUTANOL (N-BUTANOL, N-BUTYL ALCOHOL) | FL |
| EPA 8260 D | 2,2-DICHLOROPROPANE | FL |
| EPA 8260 D | 2-CHLOROETHYL VINYL ETHER | FL |
| EPA 8260 D | 2-HEXANONE | FL |
| EPA 8260 D | 4-CHLOROTOLUENE | FL |
| EPA 8260 D | 4-METHYL-2-PENTANONE (METHYL ISOBUTYL KETONE, MIBK) | FL |
| EPA 8260 D | ACETONITRILE | FL |
| EPA 8260 D | ACRYLONITRILE | FL |
| EPA 8260 D | BENZENE | FL |
| EPA 8260 D | BROMOCHLOROMETHANE | FL |
| EPA 8260 D | CARBON DISULFIDE | FL |
| EPA 8260 C | TETRACHLOROETHENE (PERCHLOROETHENE) | FL |
| EPA 8260 C | TRANS-1,2-DICHLOROETHENE | FL |
| EPA 8260 C | TRANS-1,4-DICHLORO-2-BUTENE | FL |
| EPA 8260 C | TRICHLOROFLUOROMETHANE (FLUOROTRICHLOROMETHANE, FREON 11) | FL |
| EPA 8260 C | VINYL CHLORIDE (CHLOROETHENE) | FL |
| EPA 8260 C - EXTENDED | 1,1,2-TRICHLORO-1,2,2-TRIFLUORO ETHANE (FREON 113) | FL |
| EPA 8260 D | 1,1,1,2-TETRACHLOROETHANE | FL |
| EPA 8260 D | 1,1,2,2-TETRACHLOROETHANE | FL |
| EPA 8260 D | 1,1,2-TRICHLOROETHANE | FL |
| EPA 8260 D | 1,1-DICHLOROETHYLENE | FL |
| EPA 8260 D | 1,2,3-TRICHLOROBENZENE | FL |
| EPA 8260 D | 1,2,3-TRIMETHYLBENZENE | FL |
| EPA 8260 D | 1,2,4-TRIMETHYLBENZENE | FL |
| EPA 8260 D | 1,2-DIBROMOETHANE (EDB, ETHYLENE DIBROMIDE) | FL |
| EPA 8260 D | 1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE) | FL |
| EPA 8260 D | 1,3,5-TRIMETHYLBENZENE | FL |
| EPA 8260 D | 1,3-DICHLOROPROPANE | FL |
| EPA 8260 D | 1,4-DIOXANE (P-DIOXANE /1,4-DIETHYLENEOXIDE) | FL |
| EPA 8260 D | 1-CHLOROHEXANE | FL |
| EPA 8260 D | 2-BUTANONE (METHYL ETHYL KETONE, MEK) | FL |
| EPA 8260 D | 2-CHLOROTOLUENE | FL |
| EPA 8260 D | 2-NITROPROPANE | FL |
| EPA 8260 D | 4-ISOPROPYLTOLUENE (P-CYMENE, P-ISOPROPYLTOLUENE) | FL |
| EPA 8260 D | ACETONE | FL |
| EPA 8260 D | ACROLEIN (PROPENAL) | FL |
| EPA 8260 D | ALLYL CHLORIDE (3-CHLOROPROPENE) | FL |
| EPA 8260 D | BROMOBENZENE | FL |
| EPA 8260 D | BROMODICHLOROMETHANE | FL |
| EPA 8260 D | CARBON TETRACHLORIDE | FL |

## Scope of Accreditation

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### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8260 D | CHLOROBENZENE | FL | EPA 8260 D | CHLORODIBROMOMETHANE | FL |
| EPA 8260 D | CHLOROETHANE (ETHYL CHLORIDE) | FL | EPA 8260 D | CHLOROFORM | FL |
| EPA 8260 D | CHLOROPRENE (2-CHLORO-1,3-BUTADIENE) | FL | EPA 8260 D | CIS-1,2-DICHLOROETHYLENE | FL |
| EPA 8260 D | CIS-1,3-DICHLOROPROPENE | FL | EPA 8260 D | CIS-1,4-DICHLORO-2-BUTENE | FL |
| EPA 8260 D | DI-ISOPROPYLETHER (DIPE, ISOPROPYL ETHER) | FL | EPA 8260 D | DIBROMOMETHANE (METHYLENE BROMIDE) | FL |
| EPA 8260 D | DICHLORODIFLUOROMETHANE (FREON-12) | FL | EPA 8260 D | DIETHYL ETHER | FL |
| EPA 8260 D | ETHANOL | FL | EPA 8260 D | ETHYL ACETATE | FL |
| EPA 8260 D | ETHYL METHACRYLATE | FL | EPA 8260 D | ETHYL-T-BUTYLETHER (2-ETHOXY-2-METHYLPROPANE, ETBE) | FL |
| EPA 8260 D | ETHYLBENZENE | FL | EPA 8260 D | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL |
| EPA 8260 D | IODOMETHANE (METHYL IODIDE) | FL | EPA 8260 D | ISOBUTYL ALCOHOL (2-METHYL-1-PROPANOL) | FL |
| EPA 8260 D | ISOPROPYL ALCOHOL (2-PROPANOL, ISOPROPANOL) | FL | EPA 8260 D | ISOPROPYLBENZENE | FL |
| EPA 8260 D | METHACRYLONITRILE | FL | EPA 8260 D | METHYL BROMIDE (BROMOMETHANE) | FL |
| EPA 8260 D | METHYL CHLORIDE (CHLOROMETHANE) | FL | EPA 8260 D | METHYL METHACRYLATE | FL |
| EPA 8260 D | METHYL TERT-BUTYL ETHER (MTBE) | FL | EPA 8260 D | METHYLENE CHLORIDE (DICHLOROMETHANE) | FL |
| EPA 8260 D | N-BUTYLBENZENE | FL | EPA 8260 D | N-PROPYLBENZENE | FL |
| EPA 8260 D | NAPHTHALENE | FL | EPA 8260 D | PENTACHLOROETHANE | FL |
| EPA 8260 D | PROPIONITRILE (ETHYL CYANIDE) | FL | EPA 8260 D | SEC-BUTYLBENZENE | FL |
| EPA 8260 D | STYRENE | FL | EPA 8260 D | T-AMYLMETHYLETHER (TAME) | FL |
| EPA 8260 D | TERT-BUTYL ALCOHOL (2-METHYL-2-PROPANOL) | FL | EPA 8260 D | TERT-BUTYLBENZENE | FL |
| EPA 8260 D | TETRACHLOROETHENE (PERCHLOROETHENE) | FL | EPA 8260 D | TOLUENE | FL |
| EPA 8260 D | TRANS-1,2-DICHLOROETHENE | FL | EPA 8260 D | TRANS-1,3-DICHLOROPROPENE (TRANS-1,3-DICHLOROPROPYLENE) | FL |
| EPA 8260 D | TRANS-1,4-DICHLORO-2-BUTENE | FL | EPA 8260 D | TRICHLOROETHENE (TRICHLOROETHYLENE) | FL |
| EPA 8260 D | TRICHLOROFLUOROMETHANE (FLUOROTRICHLOROMETHANE, FREON 11) | FL | EPA 8260 D | VINYL ACETATE | FL |
| EPA 8260 D | VINYL CHLORIDE (CHLOROETHENE) | FL | EPA 8260 D | XYLENE (TOTAL) | FL |
| EPA 8270 C | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL | EPA 8270 C - EXTENDED | 1,4-DIOXANE (P-DIOXANE /1,4-DIETHYLENEOXIDE) | FL |
| EPA 8270 D | 1,2,4,5-TETRACHLOROBENZENE | FL | EPA 8270 D | 1,2,4-TRICHLOROBENZENE | FL |
| EPA 8270 D | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL | EPA 8270 D | 1,2-DIPHENYLHYDRAZINE | FL |

## Scope of Accreditation

VELAP Certificate No.: 11525

**SGS - Orlando**
4405 Vineland Rd, Ste. C-15
Orlando, FL 32811

**Virginia Laboratory ID: 460177**
Effective Date: September 15, 2021
Expiration Date: September 14, 2022

### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8270 D | 1,3,5-TRINITROBENZENE (1,3,5-TNB) | FL | EPA 8270 D | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL |
| EPA 8270 D | 1,3-DINITROBENZENE (1,3-DNB) | FL | EPA 8270 D | 1,4-NAPHTHOQUINONE | FL |
| EPA 8270 D | 1,4-PHENYLENEDIAMINE | FL | EPA 8270 D | 1-CHLORONAPHTHALENE | FL |
| EPA 8270 D | 1-NAPHTHYLAMINE | FL | EPA 8270 D | 2,2'-OXYBIS(1-CHLOROPROPANE) | FL |
| EPA 8270 D | 2,3,4,6-TETRACHLOROPHENOL | FL | EPA 8270 D | 2,4,5-TRICHLOROPHENOL | FL |
| EPA 8270 D | 2,4,6-TRICHLOROPHENOL | FL | EPA 8270 D | 2,4-DICHLOROPHENOL | FL |
| EPA 8270 D | 2,4-DIMETHYLPHENOL | FL | EPA 8270 D | 2,4-DINITROPHENOL | FL |
| EPA 8270 D | 2,4-DINITROTOLUENE (2,4-DNT) | FL | EPA 8270 D | 2,6-DICHLOROPHENOL | FL |
| EPA 8270 D | 2,6-DINITROTOLUENE (2,6-DNT) | FL | EPA 8270 D | 2-ACETYLAMINOFLUORENE | FL |
| EPA 8270 D | 2-CHLORONAPHTHALENE | FL | EPA 8270 D | 2-CHLOROPHENOL | FL |
| EPA 8270 D | 2-METHYL-4,6-DINITROPHENOL (4,6-DINITRO-2-METHYLPHENOL) | FL | EPA 8270 D | 2-METHYLNAPHTHALENE | FL |
| EPA 8270 D | 2-METHYLPHENOL (O-CRESOL) | FL | EPA 8270 D | 2-NAPHTHYLAMINE | FL |
| EPA 8270 D | 2-NITROANILINE | FL | EPA 8270 D | 2-NITROPHENOL | FL |
| EPA 8270 D | 2-PICOLINE (2-METHYLPYRIDINE) | FL | EPA 8270 D | 3,3'-DICHLOROBENZIDINE | FL |
| EPA 8270 D | 3,3'-DIMETHYLBENZIDINE | FL | EPA 8270 D | 3-METHYLCHOLANTHRENE | FL |
| EPA 8270 D | 3-METHYLPHENOL (M-CRESOL) | FL | EPA 8270 D | 3-NITROANILINE | FL |
| EPA 8270 D | 4-AMINOBIPHENYL | FL | EPA 8270 D | 4-BROMOPHENYL PHENYL ETHER (BDE-3) | FL |
| EPA 8270 D | 4-CHLORO-3-METHYLPHENOL | FL | EPA 8270 D | 4-CHLOROANILINE | FL |
| EPA 8270 D | 4-CHLOROPHENYL PHENYLETHER | FL | EPA 8270 D | 4-DIMETHYL AMINOAZOBENZENE | FL |
| EPA 8270 D | 4-METHYLPHENOL (P-CRESOL) | FL | EPA 8270 D | 4-NITROANILINE | FL |
| EPA 8270 D | 4-NITROPHENOL | FL | EPA 8270 D | 4-NITROQUINOLINE-1-OXIDE | FL |
| EPA 8270 D | 5-NITRO-O-TOLUIDINE | FL | EPA 8270 D | 7,12-DIMETHYLBENZ(A) ANTHRACENE | FL |
| EPA 8270 D | A-A-DIMETHYLPHENETHYLAMINE | FL | EPA 8270 D | ACENAPHTHENE | FL |
| EPA 8270 D | ACENAPHTHYLENE | FL | EPA 8270 D | ACETOPHENONE | FL |
| EPA 8270 D | ANILINE | FL | EPA 8270 D | ANTHRACENE | FL |
| EPA 8270 D | ARAMITE | FL | EPA 8270 D | BENZIDINE | FL |
| EPA 8270 D | BENZO(A)ANTHRACENE | FL | EPA 8270 D | BENZO(A)PYRENE | FL |
| EPA 8270 D | BENZO(B)FLUORANTHENE | FL | EPA 8270 D | BENZO(G,H,I)PERYLENE | FL |
| EPA 8270 D | BENZO(K)FLUORANTHENE | FL | EPA 8270 D | BENZOIC ACID | FL |
| EPA 8270 D | BENZYL ALCOHOL | FL | EPA 8270 D | BIS(2-CHLOROETHOXY)METHANE | FL |
| EPA 8270 D | BIS(2-CHLOROETHYL) ETHER | FL | EPA 8270 D | BIS(2-ETHYLHEXYL) PHTHALATE (DI(2-ETHYLHEXYL)PHTHALATE), (DEHP) | FL |
| EPA 8270 D | BUTYL BENZYL PHTHALATE | FL | EPA 8270 D | CHLOROBENZILATE | FL |
| EPA 8270 D | CHRYSENE | FL | EPA 8270 D | DI-N-BUTYL PHTHALATE | FL |
| EPA 8270 D | DI-N-OCTYL PHTHALATE | FL | EPA 8270 D | DIALLATE | FL |
| EPA 8270 D | DIBENZ(A, J) ACRIDINE | FL | EPA 8270 D | DIBENZO(A,H) ANTHRACENE | FL |
| EPA 8270 D | DIBENZOFURAN | FL | EPA 8270 D | DIETHYL PHTHALATE | FL |

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### NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8270 D | DIMETHOATE | FL | EPA 8270 D | DIMETHYL PHTHALATE | FL |
| EPA 8270 D | DISULFOTON | FL | EPA 8270 D | ETHYL METHANESULFONATE | FL |
| EPA 8270 D | FAMPHUR | FL | EPA 8270 D | FLUORANTHENE | FL |
| EPA 8270 D | FLUORENE | FL | EPA 8270 D | HEXACHLOROBENZENE | FL |
| EPA 8270 D | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL | EPA 8270 D | HEXACHLOROCYCLOPENTADIENE | FL |
| EPA 8270 D | HEXACHLOROETHANE | FL | EPA 8270 D | HEXACHLOROPHENE | FL |
| EPA 8270 D | HEXACHLOROPROPENE | FL | EPA 8270 D | INDENO(1,2,3-CD) PYRENE | FL |
| EPA 8270 D | ISODRIN | FL | EPA 8270 D | ISOPHORONE | FL |
| EPA 8270 D | ISOSAFROLE | FL | EPA 8270 D | KEPONE | FL |
| EPA 8270 D | METHAPYRILENE | FL | EPA 8270 D | METHYL METHANESULFONATE | FL |
| EPA 8270 D | METHYL PARATHION (PARATHION, METHYL) | FL | EPA 8270 D | N-NITROSO-DI-N-BUTYLAMINE | FL |
| EPA 8270 D | N-NITROSODI-N-PROPYLAMINE | FL | EPA 8270 D | N-NITROSODIETHYLAMINE | FL |
| EPA 8270 D | N-NITROSODIMETHYLAMINE | FL | EPA 8270 D | N-NITROSODIPHENYLAMINE | FL |
| EPA 8270 D | N-NITROSOMETHYLETHYLAMINE | FL | EPA 8270 D | N-NITROSOMORPHOLINE | FL |
| EPA 8270 D | N-NITROSOPIPERIDINE | FL | EPA 8270 D | N-NITROSOPYRROLIDINE | FL |
| EPA 8270 D | NAPHTHALENE | FL | EPA 8270 D | NITROBENZENE | FL |
| EPA 8270 D | O,O,O-TRIETHYL PHOSPHOROTHIOATE | FL | EPA 8270 D | O-TOLUIDINE (2-METHYLANILINE) | FL |
| EPA 8270 D | PARATHION (PARATHION - ETHYL) | FL | EPA 8270 D | PENTACHLOROBENZENE | FL |
| EPA 8270 D | PENTACHLORONITROBENZENE | FL | EPA 8270 D | PENTACHLOROPHENOL | FL |
| EPA 8270 D | PHENACETIN | FL | EPA 8270 D | PHENANTHRENE | FL |
| EPA 8270 D | PHENOL | FL | EPA 8270 D | PHORATE | FL |
| EPA 8270 D | PRONAMIDE (KERB) | FL | EPA 8270 D | PYRENE | FL |
| EPA 8270 D | SAFROLE | FL | EPA 8270 D | SULFOTEPP (TETRAETHYL DITHIOPYROPHOSPHATE) | FL |
| EPA 8270 D | THIONAZIN (ZINOPHOS, DIETHYL-O-2-PYRAZINYL PHOSPHOROTHIONATE) | FL | EPA 8270 D | THIOPHENOL (BENZENETHIOL) | FL |
| EPA 8270 D - EXTENDED | 1-METHYLNAPHTHALENE | FL | EPA 8270 D - EXTENDED | CARBAZOLE | FL |
| EPA 8270 D - EXTENDED | PYRIDINE | FL | EPA 8270 E | 1,1'-BIPHENYL (BZ-0) | FL |
| EPA 8270 E | 1,2,4,5-TETRACHLOROBENZENE | FL | EPA 8270 E | 1,2,4-TRICHLOROBENZENE | FL |
| EPA 8270 E | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL | EPA 8270 E | 1,2-DIPHENYLHYDRAZINE | FL |
| EPA 8270 E | 1,3,5-TRINITROBENZENE (1,3,5-TNB) | FL | EPA 8270 E | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL |
| EPA 8270 E | 1,3-DINITROBENZENE (1,3-DNB) | FL | EPA 8270 E | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL |
| EPA 8270 E | 1,4-DIOXANE (P-DIOXANE /1,4-DIETHYLENEOXIDE) | FL | EPA 8270 E | 1,4-NAPHTHOQUINONE | FL |
| EPA 8270 E | 1,4-PHENYLENEDIAMINE | FL | EPA 8270 E | 1-CHLORONAPHTHALENE | FL |
| EPA 8270 E | 1-METHYLNAPHTHALENE | FL | EPA 8270 E | 1-NAPHTHYLAMINE | FL |
| EPA 8270 E | 2,3,4,6-TETRACHLOROPHENOL | FL | EPA 8270 E | 2,4,5-TRICHLOROPHENOL | FL |

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## NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8270 E | 2,4,6-TRICHLOROPHENOL | FL | EPA 8270 E | 2,4-DICHLOROPHENOL | FL |
| EPA 8270 E | 2,4-DIMETHYLPHENOL | FL | EPA 8270 E | 2,4-DINITROPHENOL | FL |
| EPA 8270 E | 2,4-DINITROTOLUENE (2,4-DNT) | FL | EPA 8270 E | 2,6-DICHLOROPHENOL | FL |
| EPA 8270 E | 2,6-DINITROTOLUENE (2,6-DNT) | FL | EPA 8270 E | 2-ACETYLAMINOFLUORENE | FL |
| EPA 8270 E | 2-CHLORONAPHTHALENE | FL | EPA 8270 E | 2-CHLOROPHENOL | FL |
| EPA 8270 E | 2-METHYL-4,6-DINITROPHENOL (4,6-DINITRO-2-METHYLPHENOL) | FL | EPA 8270 E | 2-METHYLNAPHTHALENE | FL |
| EPA 8270 E | 2-METHYLPHENOL (O-CRESOL) | FL | EPA 8270 E | 2-NAPHTHYLAMINE | FL |
| EPA 8270 E | 2-NITROANILINE | FL | EPA 8270 E | 2-NITROPHENOL | FL |
| EPA 8270 E | 2-PICOLINE (2-METHYLPYRIDINE) | FL | EPA 8270 E | 3,3'-DICHLOROBENZIDINE | FL |
| EPA 8270 E | 3,3'-DIMETHYLBENZIDINE | FL | EPA 8270 E | 3-METHYLCHOLANTHRENE | FL |
| EPA 8270 E | 3-METHYLPHENOL (M-CRESOL) | FL | EPA 8270 E | 3-NITROANILINE | FL |
| EPA 8270 E | 4-AMINOBIPHENYL | FL | EPA 8270 E | 4-BROMOPHENYL PHENYL ETHER (BDE-3) | FL |
| EPA 8270 E | 4-CHLORO-3-METHYLPHENOL | FL | EPA 8270 E | 4-CHLOROANILINE | FL |
| EPA 8270 E | 4-CHLOROPHENYL PHENYLETHER | FL | EPA 8270 E | 4-METHYLPHENOL (P-CRESOL) | FL |
| EPA 8270 E | 4-NITROANILINE | FL | EPA 8270 E | 4-NITROPHENOL | FL |
| EPA 8270 E | 4-NITROQUINOLINE-1-OXIDE | FL | EPA 8270 E | 5-NITRO-O-TOLUIDINE | FL |
| EPA 8270 E | 7,12-DIMETHYLBENZ(A) ANTHRACENE | FL | EPA 8270 E | A-A-DIMETHYLPHENETHYLAMINE | FL |
| EPA 8270 E | ACENAPHTHENE | FL | EPA 8270 E | ACENAPHTHYLENE | FL |
| EPA 8270 E | ACETOPHENONE | FL | EPA 8270 E | ANILINE | FL |
| EPA 8270 E | ANTHRACENE | FL | EPA 8270 E | ARAMITE | FL |
| EPA 8270 E | ATRAZINE | FL | EPA 8270 E | BENZALDEHYDE | FL |
| EPA 8270 E | BENZIDINE | FL | EPA 8270 E | BENZO(A)ANTHRACENE | FL |
| EPA 8270 E | BENZO(A)PYRENE | FL | EPA 8270 E | BENZO(B)FLUORANTHENE | FL |
| EPA 8270 E | BENZO(G,H,I)PERYLENE | FL | EPA 8270 E | BENZO(K)FLUORANTHENE | FL |
| EPA 8270 E | BENZOIC ACID | FL | EPA 8270 E | BENZYL ALCOHOL | FL |
| EPA 8270 E | BIS(2-CHLOROETHOXY)METHANE | FL | EPA 8270 E | BIS(2-CHLOROETHYL) ETHER | FL |
| EPA 8270 E | BIS(2-ETHYLHEXYL) PHTHALATE (DI(2-ETHYLHEXYL)PHTHALATE), (DEHP) | FL | EPA 8270 E | BUTYL BENZYL PHTHALATE | FL |
| EPA 8270 E | CAPROLACTAM | FL | EPA 8270 E | CARBAZOLE | FL |
| EPA 8270 E | CHLOROBENZILATE | FL | EPA 8270 E | CHRYSENE | FL |
| EPA 8270 E | DI-N-BUTYL PHTHALATE | FL | EPA 8270 E | DI-N-OCTYL PHTHALATE | FL |
| EPA 8270 E | DIALLATE | FL | EPA 8270 E | DIBENZ(A, J) ACRIDINE | FL |
| EPA 8270 E | DIBENZO(A,H) ANTHRACENE | FL | EPA 8270 E | DIBENZOFURAN | FL |
| EPA 8270 E | DIETHYL PHTHALATE | FL | EPA 8270 E | DIMETHOATE | FL |
| EPA 8270 E | DIMETHYL PHTHALATE | FL | EPA 8270 E | DISULFOTON | FL |
| EPA 8270 E | ETHYL METHANESULFONATE | FL | EPA 8270 E | FAMPHUR | FL |
| EPA 8270 E | FLUORANTHENE | FL | EPA 8270 E | FLUORENE | FL |
| EPA 8270 E | HEXACHLOROBENZENE | FL | | | |

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## NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8270 E | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL | EPA 8270 E | HEXACHLOROCYCLOPENTADIENE | FL |
| EPA 8270 E | HEXACHLOROETHANE | FL | EPA 8270 E | HEXACHLOROPHENE | FL |
| EPA 8270 E | HEXACHLOROPROPENE | FL | EPA 8270 E | INDENO(1,2,3-CD) PYRENE | FL |
| EPA 8270 E | ISODRIN | FL | EPA 8270 E | ISOPHORONE | FL |
| EPA 8270 E | ISOSAFROLE | FL | EPA 8270 E | KEPONE | FL |
| EPA 8270 E | METHAPYRILENE | FL | EPA 8270 E | METHYL METHANESULFONATE | FL |
| EPA 8270 E | METHYL PARATHION (PARATHION, METHYL) | FL | EPA 8270 E | N-NITROSO-DI-N-BUTYLAMINE | FL |
| EPA 8270 E | N-NITROSODI-N-PROPYLAMINE | FL | EPA 8270 E | N-NITROSODIETHYLAMINE | FL |
| EPA 8270 E | N-NITROSODIMETHYLAMINE | FL | EPA 8270 E | N-NITROSODIPHENYLAMINE | FL |
| EPA 8270 E | N-NITROSOMETHYLETHYLAMINE | FL | EPA 8270 E | N-NITROSOMORPHOLINE | FL |
| EPA 8270 E | N-NITROSOPIPERIDINE | FL | EPA 8270 E | N-NITROSOPYRROLIDINE | FL |
| EPA 8270 E | NAPHTHALENE | FL | EPA 8270 E | NITROBENZENE | FL |
| EPA 8270 E | O,O,O-TRIETHYL PHOSPHOROTHIOATE | FL | EPA 8270 E | O-TOLUIDINE (2-METHYLANILINE) | FL |
| EPA 8270 E | PARATHION (PARATHION - ETHYL) | FL | EPA 8270 E | PENTACHLOROBENZENE | FL |
| EPA 8270 E | PENTACHLORONITROBENZENE | FL | EPA 8270 E | PENTACHLOROPHENOL | FL |
| EPA 8270 E | PHENACETIN | FL | EPA 8270 E | PHENANTHRENE | FL |
| EPA 8270 E | PHENOL | FL | EPA 8270 E | PHORATE | FL |
| EPA 8270 E | PRONAMIDE (KERB) | FL | EPA 8270 E | PYRENE | FL |
| EPA 8270 E | PYRIDINE | FL | EPA 8270 E | SAFROLE | FL |
| EPA 8270 E | SULFOTEPP (TETRAETHYL DITHIOPYROPHOSPHATE) | FL | EPA 8270 E | THIONAZIN (ZINOPHOS, DIETHYL-O-2-PYRAZINYL PHOSPHOROTHIONATE) | FL |
| EPA 8270 E | THIOPHENOL (BENZENETHIOL) | FL | EPA 8270 E - EXTENDED | 2,2'-OXYBIS(1-CHLOROPROPANE) | FL |
| EPA 8270 E - EXTENDED | 4-DIMETHYL AMINOAZOBENZENE | FL | EPA 8270 E - EXTENDED | 6-METHYLCHRYSENE | FL |
| EPA 8270 E - EXTENDED | DIPHENYL ETHER (DIPHENYL OXIDE) | FL | EPA 8270 E - EXTENDED | INDENE | FL |
| EPA 8270 E - EXTENDED | PENTACHLOROETHANE | FL | EPA 8270 E - EXTENDED | QUINOLINE | FL |
| EPA 8270 E - EXTENDED | SIMAZINE | FL | EPA 8330 A | 1,3,5-TRINITROBENZENE (1,3,5-TNB) | FL |
| EPA 8330 A | 1,3-DINITROBENZENE (1,3-DNB) | FL | EPA 8330 A | 2,4,6-TRINITROTOLUENE (2,4,6-TNT) | FL |
| EPA 8330 A | 2,4-DINITROTOLUENE (2,4-DNT) | FL | EPA 8330 A | 2,6-DINITROTOLUENE (2,6-DNT) | FL |
| EPA 8330 A | 2-AMINO-4,6-DINITROTOLUENE (2-AM-DNT) | FL | EPA 8330 A | 2-NITROTOLUENE | FL |
| EPA 8330 A | 3-NITROTOLUENE | FL | EPA 8330 A | 4-AMINO-2,6-DINITROTOLUENE (4-AM-DNT) | FL |
| EPA 8330 A | 4-NITROTOLUENE | FL | EPA 8330 A | METHYL-2,4,6-TRINITROPHENYLNITRAMINE (TETRYL) | FL |
| EPA 8330 A | NITROBENZENE | FL | EPA 8330 A | NITROGLYCERIN | FL |
| EPA 8330 A | OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZOCINE (HMX) | FL | EPA 8330 A | RDX (HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE) | FL |

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## NON-POTABLE WATER

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8330 B | 1,3,5-TRINITROBENZENE (1,3,5-TNB) | FL | EPA 8330 B | 1,3-DINITROBENZENE (1,3-DNB) | FL |
| EPA 8330 B | 2,4,6-TRINITROTOLUENE (2,4,6-TNT) | FL | EPA 8330 B | 2,4-DINITROTOLUENE (2,4-DNT) | FL |
| EPA 8330 B | 2,6-DINITROTOLUENE (2,6-DNT) | FL | EPA 8330 B | 2-AMINO-4,6-DINITROTOLUENE (2-AM-DNT) | FL |
| EPA 8330 B | 2-NITROTOLUENE | FL | EPA 8330 B | 3,5-DINITROANILINE | FL |
| EPA 8330 B | 3-NITROTOLUENE | FL | EPA 8330 B | 4-AMINO-2,6-DINITROTOLUENE (4-AM-DNT) | FL |
| EPA 8330 B | 4-NITROTOLUENE | FL | EPA 8330 B | METHYL-2,4,6-TRINITROPHENYLNIT RAMINE (TETRYL) | FL |
| EPA 8330 B | NITROBENZENE | FL | EPA 8330 B | NITROGLYCERIN | FL |
| EPA 8330 B | OCTAHYDRO-1,3,5,7-TETRANITRO-1 ,3,5,7-TETRAZOCINE (HMX) | FL | EPA 8330 B | PENTAERYTHRITOLTETRANITRATE (PETN) | FL |
| EPA 8330 B | RDX (HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE) | FL | EPA 9040 C | PH | FL |
| EPA 9056 A | BROMIDE | FL | EPA 9056 A | CHLORIDE | FL |
| EPA 9056 A | FLUORIDE | FL | EPA 9056 A | NITRATE AS N | FL |
| EPA 9056 A | NITRITE AS N | FL | EPA 9056 A | SULFATE | FL |
| RSK-175 | ETHANE | FL | RSK-175 | ETHENE (ETHYLENE) | FL |
| RSK-175 | METHANE | FL | SM 2120 B-2011 | COLOR | FL |
| SM 2320 B-2011 | ALKALINITY AS CACO3 | FL | SM 2340 B-2011 | TOTAL HARDNESS AS CACO3 | FL |
| SM 2540 B-2011 | RESIDUE-TOTAL (TS) | FL | SM 2540 C-2011 | RESIDUE-FILTERABLE (TDS) | FL |
| SM 2540 D-2011 | RESIDUE-NONFILTERABLE (TSS) | FL | SM 4500-S2$^-$ F-2011 | SULFIDE | FL |
| SM 5210 B-2011 | BIOCHEMICAL OXYGEN DEMAND (BOD) | FL | SM 5210 B-2011 | CARBONACEOUS BOD (CBOD) | FL |
| SM 5220 C-2011 | CHEMICAL OXYGEN DEMAND (COD) | FL | SM 5310 B-2011 | TOTAL ORGANIC CARBON (TOC) | FL |

## SOLID AND CHEMICAL MATERIALS

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 1010 A | FLASHPOINT | FL | EPA 1311 | PREP: TOXICITY CHARACTERISTIC LEACHING PROCEDURE | FL |
| EPA 1312 | PREP: SYNTHETIC PRECIPITATION LEACHING PROCEDURE | FL | EPA 350.1 REV 2 | AMMONIA AS N | FL |
| EPA 351.2 REV 2 | KJELDAHL NITROGEN - TOTAL (TKN) | FL | EPA 6010 C | ALUMINUM | FL |
| EPA 6010 C | ANTIMONY | FL | EPA 6010 C | ARSENIC | FL |
| EPA 6010 C | BARIUM | FL | EPA 6010 C | BERYLLIUM | FL |
| EPA 6010 C | CADMIUM | FL | EPA 6010 C | CALCIUM | FL |
| EPA 6010 C | CHROMIUM | FL | EPA 6010 C | COBALT | FL |
| EPA 6010 C | COPPER | FL | EPA 6010 C | IRON | FL |
| EPA 6010 C | LEAD | FL | EPA 6010 C | MAGNESIUM | FL |
| EPA 6010 C | MANGANESE | FL | EPA 6010 C | MOLYBDENUM | FL |
| EPA 6010 C | NICKEL | FL | EPA 6010 C | POTASSIUM | FL |

## Scope of Accreditation

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### SOLID AND CHEMICAL MATERIALS

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 6010 C | SELENIUM | FL | EPA 6010 C | SILVER | FL |
| EPA 6010 C | SODIUM | FL | EPA 6010 C | STRONTIUM | FL |
| EPA 6010 C | THALLIUM | FL | EPA 6010 C | TIN | FL |
| EPA 6010 C | TITANIUM | FL | EPA 6010 C | VANADIUM | FL |
| EPA 6010 C | ZINC | FL | EPA 6010 D | ALUMINUM | FL |
| EPA 6010 D | ANTIMONY | FL | EPA 6010 D | ARSENIC | FL |
| EPA 6010 D | BARIUM | FL | EPA 6010 D | BERYLLIUM | FL |
| EPA 6010 D | CADMIUM | FL | EPA 6010 D | CALCIUM | FL |
| EPA 6010 D | CHROMIUM | FL | EPA 6010 D | COBALT | FL |
| EPA 6010 D | COPPER | FL | EPA 6010 D | IRON | FL |
| EPA 6010 D | LEAD | FL | EPA 6010 D | MAGNESIUM | FL |
| EPA 6010 D | MANGANESE | FL | EPA 6010 D | MOLYBDENUM | FL |
| EPA 6010 D | NICKEL | FL | EPA 6010 D | POTASSIUM | FL |
| EPA 6010 D | SELENIUM | FL | EPA 6010 D | SILVER | FL |
| EPA 6010 D | SODIUM | FL | EPA 6010 D | STRONTIUM | FL |
| EPA 6010 D | THALLIUM | FL | EPA 6010 D | TIN | FL |
| EPA 6010 D | TITANIUM | FL | EPA 6010 D | VANADIUM | FL |
| EPA 6010 D | ZINC | FL | EPA 6020 A | ALUMINUM | FL |
| EPA 6020 A | ANTIMONY | FL | EPA 6020 A | ARSENIC | FL |
| EPA 6020 A | BARIUM | FL | EPA 6020 A | BERYLLIUM | FL |
| EPA 6020 A | CADMIUM | FL | EPA 6020 A | CALCIUM | FL |
| EPA 6020 A | CHROMIUM | FL | EPA 6020 A | COBALT | FL |
| EPA 6020 A | COPPER | FL | EPA 6020 A | IRON | FL |
| EPA 6020 A | LEAD | FL | EPA 6020 A | MAGNESIUM | FL |
| EPA 6020 A | MANGANESE | FL | EPA 6020 A | NICKEL | FL |
| EPA 6020 A | POTASSIUM | FL | EPA 6020 A | SELENIUM | FL |
| EPA 6020 A | SILVER | FL | EPA 6020 A | SODIUM | FL |
| EPA 6020 A | THALLIUM | FL | EPA 6020 A | VANADIUM | FL |
| EPA 6020 A | ZINC | FL | EPA 6020 A - EXTENDED | MOLYBDENUM | FL |
| EPA 6020 A - EXTENDED | STRONTIUM | FL | EPA 6020 A - EXTENDED | TIN | FL |
| EPA 6020 A - EXTENDED | TITANIUM | FL | EPA 6020 B | ALUMINUM | FL |
| EPA 6020 B | ANTIMONY | FL | EPA 6020 B | ARSENIC | FL |
| EPA 6020 B | BARIUM | FL | EPA 6020 B | BERYLLIUM | FL |
| EPA 6020 B | CADMIUM | FL | EPA 6020 B | CALCIUM | FL |
| EPA 6020 B | CHROMIUM | FL | EPA 6020 B | COBALT | FL |
| EPA 6020 B | COPPER | FL | EPA 6020 B | IRON | FL |
| EPA 6020 B | LEAD | FL | EPA 6020 B | MAGNESIUM | FL |
| EPA 6020 B | MANGANESE | FL | EPA 6020 B | MOLYBDENUM | FL |
| EPA 6020 B | NICKEL | FL | EPA 6020 B | POTASSIUM | FL |

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|---|---|---|---|---|---|
| EPA 6020 B | SELENIUM | FL | EPA 6020 B | SILVER | FL |
| EPA 6020 B | SODIUM | FL | EPA 6020 B | THALLIUM | FL |
| EPA 6020 B | TIN | FL | EPA 6020 B | VANADIUM | FL |
| EPA 6020 B | ZINC | FL | EPA 6020 B - EXTENDED | STRONTIUM | FL |
| EPA 6850 | PERCHLORATE | FL | EPA 7196 A | CHROMIUM VI | FL |
| EPA 7471 B | MERCURY | FL | EPA 8011 | 1,2-DIBROMO-3-CHLOROPROPANE (DBCP) | FL |
| EPA 8011 | 1,2-DIBROMOETHANE (EDB, ETHYLENE DIBROMIDE) | FL | EPA 8015 C | 1-BUTANOL (N-BUTANOL, N-BUTYL ALCOHOL) | FL |
| EPA 8015 C | DIESEL RANGE ORGANICS (DRO) | FL | EPA 8015 C | ETHANOL | FL |
| EPA 8015 C | GASOLINE RANGE ORGANICS (GRO) | FL | EPA 8015 C | ISOBUTYL ALCOHOL (2-METHYL-1-PROPANOL) | FL |
| EPA 8015 C | ISOPROPYL ALCOHOL (2-PROPANOL, ISOPROPANOL) | FL | EPA 8015 C | METHANOL | FL |
| EPA 8015 C | N-PROPANOL (1-PROPANOL) | FL | EPA 8015 D | DIESEL RANGE ORGANICS (DRO) | FL |
| EPA 8015 D | ETHANOL | FL | EPA 8015 D | GASOLINE RANGE ORGANICS (GRO) | FL |
| EPA 8015 D | ISOPROPYL ALCOHOL (2-PROPANOL, ISOPROPANOL) | FL | EPA 8015 D | METHANOL | FL |
| EPA 8015 D | N-PROPANOL (1-PROPANOL) | FL | EPA 8081 B | 4,4'-DDD | FL |
| EPA 8081 B | 4,4'-DDE | FL | EPA 8081 B | 4,4'-DDT | FL |
| EPA 8081 B | ALDRIN | FL | EPA 8081 B | ALPHA-BHC (ALPHA-HEXACHLOROCYCLOHEXANE) | FL |
| EPA 8081 B | ALPHA-CHLORDANE (CIS-CHLORDANE) | FL | EPA 8081 B | BETA-BHC (BETA-HEXACHLOROCYCLOHEXANE) | FL |
| EPA 8081 B | CHLORDANE, TOTAL | FL | EPA 8081 B | DELTA-BHC | FL |
| EPA 8081 B | DIELDRIN | FL | EPA 8081 B | ENDOSULFAN I | FL |
| EPA 8081 B | ENDOSULFAN II | FL | EPA 8081 B | ENDOSULFAN SULFATE | FL |
| EPA 8081 B | ENDRIN | FL | EPA 8081 B | ENDRIN ALDEHYDE | FL |
| EPA 8081 B | ENDRIN KETONE | FL | EPA 8081 B | GAMMA-BHC (LINDANE, GAMMA-HEXACHLOROCYCLOHEXANE) | FL |
| EPA 8081 B | GAMMA-CHLORDANE (BETA-CHLORDANE, TRANS-CHLORDANE) | FL | EPA 8081 B | HEPTACHLOR | FL |
| EPA 8081 B | HEPTACHLOR EPOXIDE | FL | EPA 8081 B | METHOXYCHLOR | FL |
| EPA 8081 B | TOXAPHENE (CHLORINATED CAMPHENE) | FL | EPA 8082 A | AROCLOR-1016 (PCB-1016) | FL |
| EPA 8082 A | AROCLOR-1221 (PCB-1221) | FL | EPA 8082 A | AROCLOR-1232 (PCB-1232) | FL |
| EPA 8082 A | AROCLOR-1242 (PCB-1242) | FL | EPA 8082 A | AROCLOR-1248 (PCB-1248) | FL |
| EPA 8082 A | AROCLOR-1254 (PCB-1254) | FL | EPA 8082 A | AROCLOR-1260 (PCB-1260) | FL |
| EPA 8141 B | AZINPHOS-METHYL (GUTHION) | FL | EPA 8141 B | BOLSTAR (SULPROFOS) | FL |
| EPA 8141 B | CARBOPHENOTHION | FL | EPA 8141 B | CHLORPYRIFOS | FL |
| EPA 8141 B | COUMAPHOS | FL | EPA 8141 B | DEMETON-O | FL |

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|---|---|---|---|---|---|
| EPA 8141 B | DEMETON-S | FL | EPA 8141 B | DIAZINON | FL |
| EPA 8141 B | DICHLOROVOS (DDVP, DICHLORVOS) | FL | EPA 8141 B | DIMETHOATE | FL |
| EPA 8141 B | DISULFOTON | FL | EPA 8141 B | EPN (PHOSPHONOTHIOIC ACID, PHENYL-, O-ETHYL O-(P-NITROPHENYL) ESTER) | FL |
| EPA 8141 B | ETHION | FL | EPA 8141 B | ETHOPROP | FL |
| EPA 8141 B | FAMPHUR | FL | EPA 8141 B | FENSULFOTHION | FL |
| EPA 8141 B | FENTHION | FL | EPA 8141 B | MALATHION | FL |
| EPA 8141 B | MERPHOS | FL | EPA 8141 B | METHYL PARATHION (PARATHION, METHYL) | FL |
| EPA 8141 B | MEVINPHOS | FL | EPA 8141 B | MONOCROTOPHOS | FL |
| EPA 8141 B | NALED | FL | EPA 8141 B | PARATHION (PARATHION - ETHYL) | FL |
| EPA 8141 B | PHORATE | FL | EPA 8141 B | RONNEL | FL |
| EPA 8141 B | SULFOTEPP (TETRAETHYL DITHIOPYROPHOSPHATE) | FL | EPA 8141 B | TETRACHLORVINPHOS (STIROPHOS, GARDONA) Z-ISOMER | FL |
| EPA 8141 B | TETRAETHYL PYROPHOSPHATE (TEPP) | FL | EPA 8141 B | THIONAZIN (ZINOPHOS, DIETHYL-O-2-PYRAZINYL PHOSPHOROTHIONATE) | FL |
| EPA 8141 B | TOKUTHION (PROTHIOPHOS) | FL | EPA 8141 B | TRICHLORONATE | FL |
| EPA 8151 A | 2,4,5-T | FL | EPA 8151 A | 2,4-D | FL |
| EPA 8151 A | 2,4-DB | FL | EPA 8151 A | DALAPON | FL |
| EPA 8151 A | DICAMBA | FL | EPA 8151 A | DICHLOROPROP (DICHLORPROP) | FL |
| EPA 8151 A | DINOSEB (2-SEC-BUTYL-4,6-DINITROPHENOL, DNBP) | FL | EPA 8151 A | MCPA | FL |
| EPA 8151 A | MCPP | FL | EPA 8151 A | PENTACHLOROPHENOL | FL |
| EPA 8151 A | SILVEX (2,4,5-TP) | FL | EPA 8260 C | 1,1,1,2-TETRACHLOROETHANE | FL |
| EPA 8260 C | 1,1,1-TRICHLOROETHANE | FL | EPA 8260 C | 1,1,2,2-TETRACHLOROETHANE | FL |
| EPA 8260 C | 1,1,2-TRICHLOROETHANE | FL | EPA 8260 C | 1,1-DICHLOROETHANE | FL |
| EPA 8260 C | 1,1-DICHLOROETHYLENE | FL | EPA 8260 C | 1,1-DICHLOROPROPENE | FL |
| EPA 8260 C | 1,2,3-TRICHLOROBENZENE | FL | EPA 8260 C | 1,2,3-TRICHLOROPROPANE | FL |
| EPA 8260 C | 1,2,4-TRICHLOROBENZENE | FL | EPA 8260 C | 1,2,4-TRIMETHYLBENZENE | FL |
| EPA 8260 C | 1,2-DIBROMO-3-CHLOROPROPANE (DBCP) | FL | EPA 8260 C | 1,2-DIBROMOETHANE (EDB, ETHYLENE DIBROMIDE) | FL |
| EPA 8260 C | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL | EPA 8260 C | 1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE) | FL |
| EPA 8260 C | 1,2-DICHLOROPROPANE | FL | EPA 8260 C | 1,3,5-TRIMETHYLBENZENE | FL |
| EPA 8260 C | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL | EPA 8260 C | 1,3-DICHLOROPROPANE | FL |
| EPA 8260 C | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL | EPA 8260 C | 1,4-DIOXANE (P-DIOXANE /1,4-DIETHYLENEOXIDE) | FL |
| EPA 8260 C | 1-CHLOROHEXANE | FL | EPA 8260 C | 2,2-DICHLOROPROPANE | FL |
| EPA 8260 C | 2-BUTANONE (METHYL ETHYL KETONE, MEK) | FL | EPA 8260 C | 2-CHLOROETHYL VINYL ETHER | FL |

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### SOLID AND CHEMICAL MATERIALS

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|---|---|---|---|---|---|
| EPA 8260 C | 2-CHLOROTOLUENE | FL | EPA 8260 C | 2-HEXANONE | FL |
| EPA 8260 C | 2-NITROPROPANE | FL | EPA 8260 C | 4-CHLOROTOLUENE | FL |
| EPA 8260 C | 4-ISOPROPYLTOLUENE (P-CYMENE, P-ISOPROPYLTOLUENE) | FL | EPA 8260 C | 4-METHYL-2-PENTANONE (METHYL ISOBUTYL KETONE, MIBK) | FL |
| EPA 8260 C | ACETONE | FL | EPA 8260 C | ACETONITRILE | FL |
| EPA 8260 C | ACROLEIN (PROPENAL) | FL | EPA 8260 C | ACRYLONITRILE | FL |
| EPA 8260 C | ALLYL CHLORIDE (3-CHLOROPROPENE) | FL | EPA 8260 C | BENZENE | FL |
| EPA 8260 C | BROMOBENZENE | FL | EPA 8260 C | BROMOCHLOROMETHANE | FL |
| EPA 8260 C | BROMODICHLOROMETHANE | FL | EPA 8260 C | BROMOFORM | FL |
| EPA 8260 C | CARBON DISULFIDE | FL | EPA 8260 C | CARBON TETRACHLORIDE | FL |
| EPA 8260 C | CHLOROBENZENE | FL | EPA 8260 C | CHLORODIBROMOMETHANE | FL |
| EPA 8260 C | CHLOROETHANE (ETHYL CHLORIDE) | FL | EPA 8260 C | CHLOROFORM | FL |
| EPA 8260 C | CHLOROPRENE (2-CHLORO-1,3-BUTADIENE) | FL | EPA 8260 C | CIS-1,2-DICHLOROETHYLENE | FL |
| EPA 8260 C | CIS-1,3-DICHLOROPROPENE | FL | EPA 8260 C | CIS-1,4-DICHLORO-2-BUTENE | FL |
| EPA 8260 C | DIBROMOMETHANE (METHYLENE BROMIDE) | FL | EPA 8260 C | DICHLORODIFLUOROMETHANE (FREON-12) | FL |
| EPA 8260 C | DIETHYL ETHER | FL | EPA 8260 C | ETHYL ACETATE | FL |
| EPA 8260 C | ETHYL METHACRYLATE | FL | EPA 8260 C | ETHYL-T-BUTYLETHER (2-ETHOXY-2-METHYLPROPANE, ETBE) | FL |
| EPA 8260 C | ETHYLBENZENE | FL | EPA 8260 C | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL |
| EPA 8260 C | IODOMETHANE (METHYL IODIDE) | FL | EPA 8260 C | ISOBUTYL ALCOHOL (2-METHYL-1-PROPANOL) | FL |
| EPA 8260 C | ISOPROPYLBENZENE | FL | EPA 8260 C | METHACRYLONITRILE | FL |
| EPA 8260 C | METHYL BROMIDE (BROMOMETHANE) | FL | EPA 8260 C | METHYL CHLORIDE (CHLOROMETHANE) | FL |
| EPA 8260 C | METHYL METHACRYLATE | FL | EPA 8260 C | METHYL TERT-BUTYL ETHER (MTBE) | FL |
| EPA 8260 C | METHYLENE CHLORIDE (DICHLOROMETHANE) | FL | EPA 8260 C | N-BUTYLBENZENE | FL |
| EPA 8260 C | N-PROPYLBENZENE | FL | EPA 8260 C | NAPHTHALENE | FL |
| EPA 8260 C | PENTACHLOROETHANE | FL | EPA 8260 C | PROPIONITRILE (ETHYL CYANIDE) | FL |
| EPA 8260 C | SEC-BUTYLBENZENE | FL | EPA 8260 C | STYRENE | FL |
| EPA 8260 C | T-AMYLMETHYLETHER (TAME) | FL | EPA 8260 C | TERT-BUTYL ALCOHOL (2-METHYL-2-PROPANOL) | FL |
| EPA 8260 C | TERT-BUTYLBENZENE | FL | EPA 8260 C | TETRACHLOROETHENE (PERCHLOROETHENE) | FL |
| EPA 8260 C | TOLUENE | FL | EPA 8260 C | TRANS-1,2-DICHLOROETHENE | FL |
| EPA 8260 C | TRANS-1,3-DICHLOROPROPENE (TRANS-1,3-DICHLOROPROPYLENE) | FL | EPA 8260 C | TRANS-1,4-DICHLORO-2-BUTENE | FL |
| EPA 8260 C | TRICHLOROETHENE (TRICHLOROETHYLENE) | FL | | | |

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|---|---|---|---|---|---|
| EPA 8260 C | TRICHLOROFLUOROMETHANE (FLUOROTRICHLOROMETHANE, FREON 11) | FL | EPA 8260 C | VINYL ACETATE | FL |
| EPA 8260 C | VINYL CHLORIDE (CHLOROETHENE) | FL | EPA 8260 C | XYLENE (TOTAL) | FL |
| EPA 8260 C - EXTENDED | 1,1,2-TRICHLORO-1,2,2-TRIFLUORO ETHANE (FREON 113) | FL | EPA 8260 C - EXTENDED | DI-ISOPROPYLETHER (DIPE, ISOPROPYL ETHER) | FL |
| EPA 8260 D | 1,1,1,2-TETRACHLOROETHANE | FL | EPA 8260 D | 1,1,1-TRICHLOROETHANE | FL |
| EPA 8260 D | 1,1,2,2-TETRACHLOROETHANE | FL | EPA 8260 D | 1,1,2-TRICHLORO-1,2,2-TRIFLUORO ETHANE (FREON 113) | FL |
| EPA 8260 D | 1,1,2-TRICHLOROETHANE | FL | EPA 8260 D | 1,1-DICHLOROETHANE | FL |
| EPA 8260 D | 1,1-DICHLOROETHYLENE | FL | EPA 8260 D | 1,1-DICHLOROPROPENE | FL |
| EPA 8260 D | 1,2,3-TRICHLOROBENZENE | FL | EPA 8260 D | 1,2,3-TRICHLOROPROPANE | FL |
| EPA 8260 D | 1,2,4-TRICHLOROBENZENE | FL | EPA 8260 D | 1,2,4-TRIMETHYLBENZENE | FL |
| EPA 8260 D | 1,2-DIBROMO-3-CHLOROPROPANE (DBCP) | FL | EPA 8260 D | 1,2-DIBROMOETHANE (EDB, ETHYLENE DIBROMIDE) | FL |
| EPA 8260 D | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL | EPA 8260 D | 1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE) | FL |
| EPA 8260 D | 1,2-DICHLOROPROPANE | FL | EPA 8260 D | 1,3,5-TRIMETHYLBENZENE | FL |
| EPA 8260 D | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL | EPA 8260 D | 1,3-DICHLOROPROPANE | FL |
| EPA 8260 D | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL | EPA 8260 D | 1,4-DIOXANE (P-DIOXANE /1,4-DIETHYLENEOXIDE) | FL |
| EPA 8260 D | 1-BUTANOL (N-BUTANOL, N-BUTYL ALCOHOL) | FL | EPA 8260 D | 1-CHLOROHEXANE | FL |
| EPA 8260 D | 2,2-DICHLOROPROPANE | FL | EPA 8260 D | 2-BUTANONE (METHYL ETHYL KETONE, MEK) | FL |
| EPA 8260 D | 2-CHLOROETHYL VINYL ETHER | FL | EPA 8260 D | 2-CHLOROTOLUENE | FL |
| EPA 8260 D | 2-HEXANONE | FL | EPA 8260 D | 2-NITROPROPANE | FL |
| EPA 8260 D | 4-CHLOROTOLUENE | FL | EPA 8260 D | 4-ISOPROPYLTOLUENE (P-CYMENE, P-ISOPROPYLTOLUENE) | FL |
| EPA 8260 D | 4-METHYL-2-PENTANONE (METHYL ISOBUTYL KETONE, MIBK) | FL | EPA 8260 D | ACETONE | FL |
| EPA 8260 D | ACETONITRILE | FL | EPA 8260 D | ACROLEIN (PROPENAL) | FL |
| EPA 8260 D | ACRYLONITRILE | FL | EPA 8260 D | ALLYL CHLORIDE (3-CHLOROPROPENE) | FL |
| EPA 8260 D | BENZENE | FL | EPA 8260 D | BROMOBENZENE | FL |
| EPA 8260 D | BROMOCHLOROMETHANE | FL | EPA 8260 D | BROMODICHLOROMETHANE | FL |
| EPA 8260 D | BROMOFORM | FL | EPA 8260 D | CARBON DISULFIDE | FL |
| EPA 8260 D | CARBON TETRACHLORIDE | FL | EPA 8260 D | CHLOROBENZENE | FL |
| EPA 8260 D | CHLORODIBROMOMETHANE | FL | EPA 8260 D | CHLOROETHANE (ETHYL CHLORIDE) | FL |
| EPA 8260 D | CHLOROFORM | FL | EPA 8260 D | CHLOROPRENE (2-CHLORO-1,3-BUTADIENE) | FL |
| EPA 8260 D | CIS-1,2-DICHLOROETHYLENE | FL | EPA 8260 D | CIS-1,3-DICHLOROPROPENE | FL |
| EPA 8260 D | CIS-1,4-DICHLORO-2-BUTENE | FL | | | |

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|---|---|---|---|---|---|
| EPA 8260 D | DI-ISOPROPYLETHER (DIPE, ISOPROPYL ETHER) | FL | EPA 8260 D | DIBROMOMETHANE (METHYLENE BROMIDE) | FL |
| EPA 8260 D | DICHLORODIFLUOROMETHANE (FREON-12) | FL | EPA 8260 D | DIETHYL ETHER | FL |
| EPA 8260 D | ETHYL ACETATE | FL | EPA 8260 D | ETHYL METHACRYLATE | FL |
| EPA 8260 D | ETHYL-T-BUTYLETHER (2-ETHOXY-2-METHYLPROPANE, ETBE) | FL | EPA 8260 D | ETHYLBENZENE | FL |
| EPA 8260 D | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL | EPA 8260 D | IODOMETHANE (METHYL IODIDE) | FL |
| EPA 8260 D | ISOBUTYL ALCOHOL (2-METHYL-1-PROPANOL) | FL | EPA 8260 D | ISOPROPYL ALCOHOL (2-PROPANOL, ISOPROPANOL) | FL |
| EPA 8260 D | ISOPROPYLBENZENE | FL | EPA 8260 D | METHACRYLONITRILE | FL |
| EPA 8260 D | METHYL BROMIDE (BROMOMETHANE) | FL | EPA 8260 D | METHYL CHLORIDE (CHLOROMETHANE) | FL |
| EPA 8260 D | METHYL METHACRYLATE | FL | EPA 8260 D | METHYL TERT-BUTYL ETHER (MTBE) | FL |
| EPA 8260 D | METHYLENE CHLORIDE (DICHLOROMETHANE) | FL | EPA 8260 D | N-BUTYLBENZENE | FL |
| EPA 8260 D | N-PROPYLBENZENE | FL | EPA 8260 D | NAPHTHALENE | FL |
| EPA 8260 D | PENTACHLOROETHANE | FL | EPA 8260 D | PROPIONITRILE (ETHYL CYANIDE) | FL |
| EPA 8260 D | SEC-BUTYLBENZENE | FL | EPA 8260 D | STYRENE | FL |
| EPA 8260 D | T-AMYLMETHYLETHER (TAME) | FL | EPA 8260 D | TERT-BUTYL ALCOHOL (2-METHYL-2-PROPANOL) | FL |
| EPA 8260 D | TERT-BUTYLBENZENE | FL | EPA 8260 D | TETRACHLOROETHENE (PERCHLOROETHENE) | FL |
| EPA 8260 D | TOLUENE | FL | EPA 8260 D | TRANS-1,2-DICHLOROETHENE | FL |
| EPA 8260 D | TRANS-1,3-DICHLOROPROPENE (TRANS-1,3-DICHLOROPROPYLENE) | FL | EPA 8260 D | TRANS-1,4-DICHLORO-2-BUTENE | FL |
| EPA 8260 D | TRICHLOROETHENE (TRICHLOROETHYLENE) | FL | EPA 8260 D | TRICHLOROFLUOROMETHANE (FLUOROTRICHLOROMETHANE, FREON 11) | FL |
| EPA 8260 D | VINYL ACETATE | FL | EPA 8260 D | VINYL CHLORIDE (CHLOROETHENE) | FL |
| EPA 8260 D | XYLENE (TOTAL) | FL | EPA 8270 D | 1,2,4,5-TETRACHLOROBENZENE | FL |
| EPA 8270 D | 1,2,4-TRICHLOROBENZENE | FL | EPA 8270 D | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL |
| EPA 8270 D | 1,2-DIPHENYLHYDRAZINE | FL | EPA 8270 D | 1,3,5-TRINITROBENZENE (1,3,5-TNB) | FL |
| EPA 8270 D | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL | EPA 8270 D | 1,3-DINITROBENZENE (1,3-DNB) | FL |
| EPA 8270 D | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL | EPA 8270 D | 1,4-NAPHTHOQUINONE | FL |
| EPA 8270 D | 1,4-PHENYLENEDIAMINE | FL | EPA 8270 D | 1-CHLORONAPHTHALENE | FL |
| EPA 8270 D | 1-NAPHTHYLAMINE | FL | EPA 8270 D | 2,2'-OXYBIS(1-CHLOROPROPANE) | FL |
| EPA 8270 D | 2,3,4,6-TETRACHLOROPHENOL | FL | EPA 8270 D | 2,4,5-TRICHLOROPHENOL | FL |
| EPA 8270 D | 2,4,6-TRICHLOROPHENOL | FL | EPA 8270 D | 2,4-DICHLOROPHENOL | FL |
| EPA 8270 D | 2,4-DIMETHYLPHENOL | FL | EPA 8270 D | 2,4-DINITROPHENOL | FL |

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**Virginia Laboratory ID: 460177**
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## SOLID AND CHEMICAL MATERIALS

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8270 D | 2,4-DINITROTOLUENE (2,4-DNT) | FL | EPA 8270 D | 2,6-DICHLOROPHENOL | FL |
| EPA 8270 D | 2,6-DINITROTOLUENE (2,6-DNT) | FL | EPA 8270 D | 2-ACETYLAMINOFLUORENE | FL |
| EPA 8270 D | 2-CHLORONAPHTHALENE | FL | EPA 8270 D | 2-CHLOROPHENOL | FL |
| EPA 8270 D | 2-METHYL-4,6-DINITROPHENOL (4,6-DINITRO-2-METHYLPHENOL) | FL | EPA 8270 D | 2-METHYLNAPHTHALENE | FL |
| EPA 8270 D | 2-METHYLPHENOL (O-CRESOL) | FL | EPA 8270 D | 2-NAPHTHYLAMINE | FL |
| EPA 8270 D | 2-NITROANILINE | FL | EPA 8270 D | 2-NITROPHENOL | FL |
| EPA 8270 D | 2-PICOLINE (2-METHYLPYRIDINE) | FL | EPA 8270 D | 3,3'-DICHLOROBENZIDINE | FL |
| EPA 8270 D | 3,3'-DIMETHYLBENZIDINE | FL | EPA 8270 D | 3-METHYLCHOLANTHRENE | FL |
| EPA 8270 D | 3-METHYLPHENOL (M-CRESOL) | FL | EPA 8270 D | 3-NITROANILINE | FL |
| EPA 8270 D | 4-AMINOBIPHENYL | FL | EPA 8270 D | 4-BROMOPHENYL PHENYL ETHER (BDE-3) | FL |
| EPA 8270 D | 4-CHLORO-3-METHYLPHENOL | FL | EPA 8270 D | 4-CHLOROANILINE | FL |
| EPA 8270 D | 4-CHLOROPHENYL PHENYLETHER | FL | EPA 8270 D | 4-DIMETHYL AMINOAZOBENZENE | FL |
| EPA 8270 D | 4-METHYLPHENOL (P-CRESOL) | FL | EPA 8270 D | 4-NITROANILINE | FL |
| EPA 8270 D | 4-NITROPHENOL | FL | EPA 8270 D | 4-NITROQUINOLINE-1-OXIDE | FL |
| EPA 8270 D | 5-NITRO-O-TOLUIDINE | FL | EPA 8270 D | 7,12-DIMETHYLBENZ(A) ANTHRACENE | FL |
| EPA 8270 D | A-A-DIMETHYLPHENETHYLAMINE | FL | EPA 8270 D | ACENAPHTHENE | FL |
| EPA 8270 D | ACENAPHTHYLENE | FL | EPA 8270 D | ACETOPHENONE | FL |
| EPA 8270 D | ANILINE | FL | EPA 8270 D | ANTHRACENE | FL |
| EPA 8270 D | ARAMITE | FL | EPA 8270 D | BENZIDINE | FL |
| EPA 8270 D | BENZO(A)ANTHRACENE | FL | EPA 8270 D | BENZO(A)PYRENE | FL |
| EPA 8270 D | BENZO(B)FLUORANTHENE | FL | EPA 8270 D | BENZO(G,H,I)PERYLENE | FL |
| EPA 8270 D | BENZO(K)FLUORANTHENE | FL | EPA 8270 D | BENZOIC ACID | FL |
| EPA 8270 D | BENZYL ALCOHOL | FL | EPA 8270 D | BIS(2-CHLOROETHOXY)METHANE | FL |
| EPA 8270 D | BIS(2-CHLOROETHYL) ETHER | FL | EPA 8270 D | BIS(2-ETHYLHEXYL) PHTHALATE (DI(2-ETHYLHEXYL)PHTHALATE), (DEHP) | FL |
| EPA 8270 D | BUTYL BENZYL PHTHALATE | FL | EPA 8270 D | CHLOROBENZILATE | FL |
| EPA 8270 D | CHRYSENE | FL | EPA 8270 D | DI-N-BUTYL PHTHALATE | FL |
| EPA 8270 D | DI-N-OCTYL PHTHALATE | FL | EPA 8270 D | DIALLATE | FL |
| EPA 8270 D | DIBENZ(A, J) ACRIDINE | FL | EPA 8270 D | DIBENZO(A,H) ANTHRACENE | FL |
| EPA 8270 D | DIBENZOFURAN | FL | EPA 8270 D | DIETHYL PHTHALATE | FL |
| EPA 8270 D | DIMETHOATE | FL | EPA 8270 D | DIMETHYL PHTHALATE | FL |
| EPA 8270 D | DISULFOTON | FL | EPA 8270 D | ETHYL METHANESULFONATE | FL |
| EPA 8270 D | FAMPHUR | FL | EPA 8270 D | FLUORANTHENE | FL |
| EPA 8270 D | FLUORENE | FL | EPA 8270 D | HEXACHLOROBENZENE | FL |
| EPA 8270 D | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL | EPA 8270 D | HEXACHLOROCYCLOPENTADIENE | FL |
| EPA 8270 D | HEXACHLOROETHANE | FL | EPA 8270 D | HEXACHLOROPHENE | FL |
| EPA 8270 D | HEXACHLOROPROPENE | FL | EPA 8270 D | INDENO(1,2,3-CD) PYRENE | FL |

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## SOLID AND CHEMICAL MATERIALS

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8270 D | ISODRIN | FL | EPA 8270 D | ISOPHORONE | FL |
| EPA 8270 D | ISOSAFROLE | FL | EPA 8270 D | KEPONE | FL |
| EPA 8270 D | METHAPYRILENE | FL | EPA 8270 D | METHYL METHANESULFONATE | FL |
| EPA 8270 D | METHYL PARATHION (PARATHION, METHYL) | FL | EPA 8270 D | N-NITROSO-DI-N-BUTYLAMINE | FL |
| EPA 8270 D | N-NITROSODI-N-PROPYLAMINE | FL | EPA 8270 D | N-NITROSODIETHYLAMINE | FL |
| EPA 8270 D | N-NITROSODIMETHYLAMINE | FL | EPA 8270 D | N-NITROSODIPHENYLAMINE | FL |
| EPA 8270 D | N-NITROSOMETHYLETHYLAMINE | FL | EPA 8270 D | N-NITROSOMORPHOLINE | FL |
| EPA 8270 D | N-NITROSOPIPERIDINE | FL | EPA 8270 D | N-NITROSOPYRROLIDINE | FL |
| EPA 8270 D | NAPHTHALENE | FL | EPA 8270 D | NITROBENZENE | FL |
| EPA 8270 D | O,O,O-TRIETHYL PHOSPHOROTHIOATE | FL | EPA 8270 D | O-TOLUIDINE (2-METHYLANILINE) | FL |
| EPA 8270 D | PARATHION (PARATHION - ETHYL) | FL | EPA 8270 D | PENTACHLOROBENZENE | FL |
| EPA 8270 D | PENTACHLORONITROBENZENE | FL | EPA 8270 D | PENTACHLOROPHENOL | FL |
| EPA 8270 D | PHENACETIN | FL | EPA 8270 D | PHENANTHRENE | FL |
| EPA 8270 D | PHENOL | FL | EPA 8270 D | PHORATE | FL |
| EPA 8270 D | PRONAMIDE (KERB) | FL | EPA 8270 D | PYRENE | FL |
| EPA 8270 D | SAFROLE | FL | EPA 8270 D | SULFOTEPP (TETRAETHYL DITHIOPYROPHOSPHATE) | FL |
| EPA 8270 D | THIONAZIN (ZINOPHOS, DIETHYL-O-2-PYRAZINYL PHOSPHOROTHIONATE) | FL | EPA 8270 D | THIOPHENOL (BENZENETHIOL) | FL |
| EPA 8270 D - EXTENDED | 1-METHYLNAPHTHALENE | FL | EPA 8270 D - EXTENDED | CARBAZOLE | FL |
| EPA 8270 D - EXTENDED | PYRIDINE | FL | EPA 8270 E | 1,1'-BIPHENYL (BZ-0) | FL |
| EPA 8270 E | 1,2,4,5-TETRACHLOROBENZENE | FL | EPA 8270 E | 1,2,4-TRICHLOROBENZENE | FL |
| EPA 8270 E | 1,2-DICHLOROBENZENE (O-DICHLOROBENZENE) | FL | EPA 8270 E | 1,2-DIPHENYLHYDRAZINE | FL |
| EPA 8270 E | 1,3,5-TRINITROBENZENE (1,3,5-TNB) | FL | EPA 8270 E | 1,3-DICHLOROBENZENE (M-DICHLOROBENZENE) | FL |
| EPA 8270 E | 1,3-DINITROBENZENE (1,3-DNB) | FL | EPA 8270 E | 1,4-DICHLOROBENZENE (P-DICHLOROBENZENE) | FL |
| EPA 8270 E | 1,4-DIOXANE (P-DIOXANE /1,4-DIETHYLENEOXIDE) | FL | EPA 8270 E | 1,4-NAPHTHOQUINONE | FL |
| EPA 8270 E | 1,4-PHENYLENEDIAMINE | FL | EPA 8270 E | 1-CHLORONAPHTHALENE | FL |
| EPA 8270 E | 1-METHYLNAPHTHALENE | FL | EPA 8270 E | 1-NAPHTHYLAMINE | FL |
| EPA 8270 E | 2,3,4,6-TETRACHLOROPHENOL | FL | EPA 8270 E | 2,4,5-TRICHLOROPHENOL | FL |
| EPA 8270 E | 2,4,6-TRICHLOROPHENOL | FL | EPA 8270 E | 2,4-DICHLOROPHENOL | FL |
| EPA 8270 E | 2,4-DIMETHYLPHENOL | FL | EPA 8270 E | 2,4-DINITROPHENOL | FL |
| EPA 8270 E | 2,4-DINITROTOLUENE (2,4-DNT) | FL | EPA 8270 E | 2,6-DICHLOROPHENOL | FL |
| EPA 8270 E | 2,6-DINITROTOLUENE (2,6-DNT) | FL | EPA 8270 E | 2-ACETYLAMINOFLUORENE | FL |
| EPA 8270 E | 2-CHLOROANILINE | FL | EPA 8270 E | 2-CHLORONAPHTHALENE | FL |
| EPA 8270 E | 2-CHLOROPHENOL | FL | EPA 8270 E | 2-METHYL-4,6-DINITROPHENOL (4,6-DINITRO-2-METHYLPHENOL) | FL |
| EPA 8270 E | 2-METHYLNAPHTHALENE | FL | EPA 8270 E | 2-METHYLPHENOL (O-CRESOL) | FL |

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## SOLID AND CHEMICAL MATERIALS

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8270 E | 2-NAPHTHYLAMINE | FL | EPA 8270 E | 2-NITROANILINE | FL |
| EPA 8270 E | 2-NITROPHENOL | FL | EPA 8270 E | 2-PICOLINE (2-METHYLPYRIDINE) | FL |
| EPA 8270 E | 3,3'-DICHLOROBENZIDINE | FL | EPA 8270 E | 3,3'-DIMETHYLBENZIDINE | FL |
| EPA 8270 E | 3-METHYLCHOLANTHRENE | FL | EPA 8270 E | 3-METHYLPHENOL (M-CRESOL) | FL |
| EPA 8270 E | 3-NITROANILINE | FL | EPA 8270 E | 4-AMINOBIPHENYL | FL |
| EPA 8270 E | 4-BROMOPHENYL PHENYL ETHER (BDE-3) | FL | EPA 8270 E | 4-CHLORO-3-METHYLPHENOL | FL |
| EPA 8270 E | 4-CHLOROANILINE | FL | EPA 8270 E | 4-CHLOROPHENYL PHENYLETHER | FL |
| EPA 8270 E | 4-METHYLPHENOL (P-CRESOL) | FL | EPA 8270 E | 4-NITROANILINE | FL |
| EPA 8270 E | 4-NITROPHENOL | FL | EPA 8270 E | 4-NITROQUINOLINE-1-OXIDE | FL |
| EPA 8270 E | 5-NITRO-O-TOLUIDINE | FL | EPA 8270 E | 7,12-DIMETHYLBENZ(A) ANTHRACENE | FL |
| EPA 8270 E | A-A-DIMETHYLPHENETHYLAMINE | FL | EPA 8270 E | ACENAPHTHENE | FL |
| EPA 8270 E | ACENAPHTHYLENE | FL | EPA 8270 E | ACETOPHENONE | FL |
| EPA 8270 E | ANILINE | FL | EPA 8270 E | ANTHRACENE | FL |
| EPA 8270 E | ARAMITE | FL | EPA 8270 E | ATRAZINE | FL |
| EPA 8270 E | BENZALDEHYDE | FL | EPA 8270 E | BENZIDINE | FL |
| EPA 8270 E | BENZO(A)ANTHRACENE | FL | EPA 8270 E | BENZO(A)PYRENE | FL |
| EPA 8270 E | BENZO(B)FLUORANTHENE | FL | EPA 8270 E | BENZO(G,H,I)PERYLENE | FL |
| EPA 8270 E | BENZO(K)FLUORANTHENE | FL | EPA 8270 E | BENZOIC ACID | FL |
| EPA 8270 E | BENZYL ALCOHOL | FL | EPA 8270 E | BIS(2-CHLOROETHOXY)METHANE | FL |
| EPA 8270 E | BIS(2-CHLOROETHYL) ETHER | FL | EPA 8270 E | BIS(2-ETHYLHEXYL) PHTHALATE (DI(2-ETHYLHEXYL)PHTHALATE), (DEHP) | FL |
| EPA 8270 E | BUTYL BENZYL PHTHALATE | FL | EPA 8270 E | CAPROLACTAM | FL |
| EPA 8270 E | CARBAZOLE | FL | EPA 8270 E | CHLOROBENZILATE | FL |
| EPA 8270 E | CHRYSENE | FL | EPA 8270 E | DI-N-BUTYL PHTHALATE | FL |
| EPA 8270 E | DI-N-OCTYL PHTHALATE | FL | EPA 8270 E | DIALLATE | FL |
| EPA 8270 E | DIBENZ(A, J) ACRIDINE | FL | EPA 8270 E | DIBENZO(A,H) ANTHRACENE | FL |
| EPA 8270 E | DIBENZOFURAN | FL | EPA 8270 E | DIETHYL PHTHALATE | FL |
| EPA 8270 E | DIMETHOATE | FL | EPA 8270 E | DIMETHYL PHTHALATE | FL |
| EPA 8270 E | DISULFOTON | FL | EPA 8270 E | ETHYL METHANESULFONATE | FL |
| EPA 8270 E | FAMPHUR | FL | EPA 8270 E | FLUORANTHENE | FL |
| EPA 8270 E | FLUORENE | FL | EPA 8270 E | HEXACHLOROBENZENE | FL |
| EPA 8270 E | HEXACHLOROBUTADIENE (1,3-HEXACHLOROBUTADIENE) | FL | EPA 8270 E | HEXACHLOROCYCLOPENTADIENE | FL |
| EPA 8270 E | HEXACHLOROETHANE | FL | EPA 8270 E | HEXACHLOROPHENE | FL |
| EPA 8270 E | HEXACHLOROPROPENE | FL | EPA 8270 E | INDENO(1,2,3-CD) PYRENE | FL |
| EPA 8270 E | ISODRIN | FL | EPA 8270 E | ISOPHORONE | FL |
| EPA 8270 E | ISOSAFROLE | FL | EPA 8270 E | KEPONE | FL |
| EPA 8270 E | METHAPYRILENE | FL | EPA 8270 E | METHYL METHANESULFONATE | FL |

## Commonwealth of Virginia

Department of General Services
Division of Consolidated Laboratory Services

## Scope of Accreditation

VELAP Certificate No.: 11525

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### SOLID AND CHEMICAL MATERIALS

| METHOD | ANALYTE | PRIMARY | METHOD | ANALYTE | PRIMARY |
|---|---|---|---|---|---|
| EPA 8270 E | METHYL PARATHION (PARATHION, METHYL) | FL | EPA 8270 E | N-NITROSO-DI-N-BUTYLAMINE | FL |
| EPA 8270 E | N-NITROSODI-N-PROPYLAMINE | FL | EPA 8270 E | N-NITROSODIETHYLAMINE | FL |
| EPA 8270 E | N-NITROSODIMETHYLAMINE | FL | EPA 8270 E | N-NITROSODIPHENYLAMINE | FL |
| EPA 8270 E | N-NITROSOMETHYLETHYLAMINE | FL | EPA 8270 E | N-NITROSOMORPHOLINE | FL |
| EPA 8270 E | N-NITROSOPIPERIDINE | FL | EPA 8270 E | N-NITROSOPYRROLIDINE | FL |
| EPA 8270 E | NAPHTHALENE | FL | EPA 8270 E | NITROBENZENE | FL |
| EPA 8270 E | O,O,O-TRIETHYL PHOSPHOROTHIOATE | FL | EPA 8270 E | O-TOLUIDINE (2-METHYLANILINE) | FL |
| EPA 8270 E | PARATHION (PARATHION - ETHYL) | FL | EPA 8270 E | PENTACHLOROBENZENE | FL |
| EPA 8270 E | PENTACHLORONITROBENZENE | FL | EPA 8270 E | PENTACHLOROPHENOL | FL |
| EPA 8270 E | PHENACETIN | FL | EPA 8270 E | PHENANTHRENE | FL |
| EPA 8270 E | PHENOL | FL | EPA 8270 E | PHORATE | FL |
| EPA 8270 E | PRONAMIDE (KERB) | FL | EPA 8270 E | PYRENE | FL |
| EPA 8270 E | PYRIDINE | FL | EPA 8270 E | SAFROLE | FL |
| EPA 8270 E | SULFOTEPP (TETRAETHYL DITHIOPYROPHOSPHATE) | FL | EPA 8270 E | THIONAZIN (ZINOPHOS, DIETHYL-O-2-PYRAZINYL PHOSPHOROTHIONATE) | FL |
| EPA 8270 E | THIOPHENOL (BENZENETHIOL) | FL | EPA 8270 E - EXTENDED | 2,2'-OXYBIS(1-CHLOROPROPANE) | FL |
| EPA 8270 E - EXTENDED | 4-DIMETHYL AMINOAZOBENZENE | FL | EPA 8270 E - EXTENDED | 6-METHYLCHRYSENE | FL |
| EPA 8270 E - EXTENDED | DIBENZ(A,H) ACRIDINE | FL | EPA 8270 E - EXTENDED | DIPHENYL ETHER (DIPHENYL OXIDE) | FL |
| EPA 8270 E - EXTENDED | INDENE | FL | EPA 8270 E - EXTENDED | N-NITROSODIPHENYLAMINE/DIPHENYLAMINE (ANALYTE PAIR) | FL |
| EPA 8270 E - EXTENDED | PENTACHLOROETHANE | FL | EPA 8270 E - EXTENDED | QUINOLINE | FL |
| EPA 8270 E - EXTENDED | SIMAZINE | FL | EPA 8330 A | 1,3,5-TRINITROBENZENE (1,3,5-TNB) | FL |
| EPA 8330 A | 1,3-DINITROBENZENE (1,3-DNB) | FL | EPA 8330 A | 2,4,6-TRINITROTOLUENE (2,4,6-TNT) | FL |
| EPA 8330 A | 2,4-DINITROTOLUENE (2,4-DNT) | FL | EPA 8330 A | 2,6-DINITROTOLUENE (2,6-DNT) | FL |
| EPA 8330 A | 2-AMINO-4,6-DINITROTOLUENE (2-AM-DNT) | FL | EPA 8330 A | 2-NITROTOLUENE | FL |
| EPA 8330 A | 3-NITROTOLUENE | FL | EPA 8330 A | 4-AMINO-2,6-DINITROTOLUENE (4-AM-DNT) | FL |
| EPA 8330 A | 4-NITROTOLUENE | FL | EPA 8330 A | METHYL-2,4,6-TRINITROPHENYLNITRAMINE (TETRYL) | FL |
| EPA 8330 A | NITROBENZENE | FL | EPA 8330 A | NITROGLYCERIN | FL |
| EPA 8330 A | OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZOCINE (HMX) | FL | EPA 8330 A | RDX (HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE) | FL |
| EPA 8330 B | 1,3,5-TRINITROBENZENE (1,3,5-TNB) | FL | EPA 8330 B | 1,3-DINITROBENZENE (1,3-DNB) | FL |
| EPA 8330 B | 2,4,6-TRINITROTOLUENE (2,4,6-TNT) | FL | EPA 8330 B | 2,4-DINITROTOLUENE (2,4-DNT) | FL |
| EPA 8330 B | 2,6-DINITROTOLUENE (2,6-DNT) | FL | EPA 8330 B | 2-AMINO-4,6-DINITROTOLUENE (2-AM-DNT) | FL |
| EPA 8330 B | 2-NITROTOLUENE | FL | EPA 8330 B | 3,5-DINITROANILINE | FL |
| EPA 8330 B | 3-NITROTOLUENE | FL | | | |

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## SOLID AND CHEMICAL MATERIALS

| METHOD | ANALYTE | PRIMARY |
|---|---|---|
| EPA 8330 B | 4-AMINO-2,6-DINITROTOLUENE (4-AM-DNT) | FL |
| EPA 8330 B | METHYL-2,4,6-TRINITROPHENYLNITRAMINE (TETRYL) | FL |
| EPA 8330 B | NITROGLYCERIN | FL |
| EPA 8330 B | PENTAERYTHRITOLTETRANITRATE (PETN) | FL |
| EPA 9012 B | TOTAL CYANIDE | FL |
| EPA 9056 A | BROMIDE | FL |
| EPA 9056 A | FLUORIDE | FL |
| EPA 9056 A | NITRITE AS N | FL |
| EPA 9060 A | TOTAL ORGANIC CARBON (TOC) | FL |

| METHOD | ANALYTE | PRIMARY |
|---|---|---|
| EPA 8330 B | 4-NITROTOLUENE | FL |
| EPA 8330 B | NITROBENZENE | FL |
| EPA 8330 B | OCTAHYDRO-1,3,5,7-TETRANITRO-1,3,5,7-TETRAZOCINE (HMX) | FL |
| EPA 8330 B | RDX (HEXAHYDRO-1,3,5-TRINITRO-1,3,5-TRIAZINE) | FL |
| EPA 9045 D | PH | FL |
| EPA 9056 A | CHLORIDE | FL |
| EPA 9056 A | NITRATE AS N | FL |
| EPA 9056 A | SULFATE | FL |