From:	Love, Erica <Erica.Love@tetratech.com>
Sent:	Monday, November 4, 2019 8:26 PM
To:	Sasnow, Zachary
Cc:	Amadi, Eric A - DNR; Carey, Angela J - DNR; Overmyer, Jody; Chojnacki, Jim; Mendt, Richard S; Manthey, Mark; 'Bill Stanhope (william.stanhope@aptim.com)'
Subject:	PPG Industries, Inc. Oak Creek, Wisconsin Facility - Quality Assurance Project Plan
Attachments:	Transmittal Letter_PPG Oak Creek - QAPP-2019-11-04.pdf; PPG Industries Oak Creek-QAPP-2019-11-04.pdf

Zach –
PPG Industries, Inc.'s Quality Assurance Project Plan (QAPP) for the Delineation of LNAPL-Related Contamination in the RAX Building and TFA for the PPG Oak Creek, Wisconsin Facility is attached for your review and approval. Per WDNR's request, a hardcopy will follow, please let me know if you would like a hard copy or have any issue with the attached PDF files.

WDNR has comments on the Work Plan, and I will be incorporating upon receipt. I am planning on holding the work plan until all comments are received on the QAPP, to incorporate any related comments.

Best Regards,

Erica I. Love, PG | Project Manager
Direct **+1 (412) 921-4052** | Business **+1 (412) 921-7090** | Mobile **+1 (412) 512-7978** | Fax **+1 (412) 921-4040** | erica.love@tetratech.com

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TETRA TECH

PITT-11-19-003

November 4, 2019

Zachary Sasnow
Remediation and Reuse Branch
US EPA Region 5
77 W Jackson Blvd
Chicago, IL 60604

via email: sasnow.zachary@epa.gov

Subject: **Quality Assurance Project Plan**
PPG Industries, Inc. Oak Creek, Wisconsin Facility

Dear Mr. Sasnow:

On behalf of PPG Industries, Inc. (PPG), Tetra Tech, Inc. (Tetra Tech) is submitting for review and approval the enclosed *Quality Assurance Project Plan (QAPP)* for the PPG Oak Creek Wisconsin Facility located at 10800 South 13th Street, Oak Creek, Wisconsin. This QAPP is intended to provide the United States Environmental Protection Agency (USEPA) Region 5 with the quality procedures and quality control activities that will be completed during the planned investigation to ensure the data quality objectives are achieved.

Please contact me at 412.921.4052 if you have any questions on this submittal or require additional information.

Sincerely,

Erica L. Love

Erica Love, PG
Project Manager
Tetra Tech, Inc

EIL/stc

ec: Eric Amadi – WDNR, RR Program (hardcopy)
Angela Cary – WDNR, RR Program
Jody Overmyer – PPG EHS, Monroeville
Jim Chojnacki – PPG EHS, Oak Creek
Shawn Mendt – PPG EHS, Oak Creek
Alan Herberger – PPG EHS, Oak Creek
Mark Manthey – Tetra Tech, Inc.
William Stanhope – APTIM

TETRA TECH

QUALITY ASSURANCE PROJECT PLAN

PPG Oak Creek Facility
Oak Creek, Wisconsin

PPG Industries, Inc.
Pittsburgh, PA

November 2019

complex world

CLEAR SOLUTIONS™

QUALITY ASSURANCE PROJECT PLAN

PPG Industries, Inc.
Oak Creek Facility
Oak Creek, Wisconsin

Revision 0

November 2019

PRESENTED FOR

PPG Industries, Inc.
Monroeville, Pennsylvania

PRESENTED BY

Tetra Tech
661 Anderson Drive
Foster Plaza 7
Pittsburgh, PA 15220

TETRA TECH

TABLE OF CONTENTS

1.0 APPROVAL SIGNATURE PAGE 1
2.0 QUALITY ASSURANCE PLAN DISTRIBUTION LIST 2
3.0 PROBLEM DEFINITION 3
4.0 TASK DESCRIPTION 4
5.0 PROJECT ORGANIZATION 5
6.0 QUALITY OBJECTIVES AND CRITERIA 6
6.1 Data Quality Objectives 6
6.2 Data Quality Indicators 8
7.0 SPECIAL TRAINING/CERTIFICATION 10
8.0 DOCUMENTATION AND RECORDS 11
9.0 SAMPLING PROCESS DESIGN 12
10.0 SAMPLING METHODS 13
11.0 SAMPLING HANDLING AND CUSTODY 14
12.0 ANALYTICAL METHODS 15
13.0 QUALITY CONTROL 16
13.1 FIELD QUALITY CONTROL SAMPLES 16
13.2 Laboratory Quality Control Samples 16
14.0 INSTRUMENT TESTING, INSPECTION, AND MAINTENANCE 18
15.0 INSTRUMENT CALIBRATION AND FREQUENCY 19
16.0 INSPECTION OF SUPPLIES AND CONSUMABLES 20
17.0 NON-DIRECT MEASUREMENTS 21
18.0 DATA MANAGEMENT 22
19.0 ASSESSMENTS AND RESPONSE ACTIONS 23
20.0 REPORTS TO MANAGEMENT 24
21.0 DATA REVIEW, VERIFICATION, AND VALIDATION 25
21.1 Data Review and Verification 25
21.2 Data Validation 25
22.0 RECONCILLIATION WITH USER REQUIREMENTS 26
23.0 REFERENCES 28

TABLES

A-1 VOC Detection Limits, LCS Criteria, MS/MSD Criteria, Surrogate Criteria
A-2 Dissolved Metals Detection Limits, LCS Criteria, MS/MSD Criteria
2-1 Quality Assurance Distribution List
6-1 Target Cleanup Goals
11-1 Sample Handling SOPs
11-2 Sample Containers and Hold Time
12-1 Laboratory SOPs
13-1 Field Quality Control Samples
13-2 Lab Quality Control Samples

FIGURES

1 Site Location Map
2 Site Layout Map
3 Project Organization Chart

APPENDICES

A Tetra Tech Standard Operating Procedures
B Field Forms

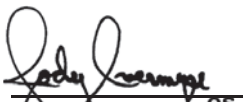
ACRONYMS

BETX	Benzene, Ethylbenzene, Toluene, And Xylene
Ca	Analytical Completeness
CLP	Contract Laboratory Program
COC	Contaminants of Concern
Cs	Completeness for sampling
ICAL	Internal Calibration
ICS	Interference Check Standard
IDL	Instrument Detection Limit
LCS	Laboratory Control Sample
LNAPL	Light Non-Aqueous Phase Liquid
MDL	Method Detection Limit
ml	Milliliter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
PACE	PACE Analytical Services, Inc.
PID	Photoionization Detector
PPG	PPG Industries, Inc.
PQL	Practical Quantitation Limit
QAPP	Quality Assurance Project Plan
QC	Quality Control
%R	Percent Recoveries
RCRA	Resource Conservation Recovery Act
RFI	RCRA Facility Investigation
RPD	Relative Percent Difference
Shaw	Shaw Environmental & Infrastructure, Inc.
SOP	Standard Operating Procedure
SWMU	Solid Waste Management Unit
TCGs	Target Cleanup Goals
TFA	Tank Farm Area
Tt	Tetra Tech, Inc.
USEPA	U.S. Environmental Protection Agency

UST	Underground Storage Tank
VOC	Volatile Organic Compound
WDNR	Wisconsin Department of Natural Resources

1.0 APPROVAL SIGNATURE PAGE

Title: Quality Assurance Project Plan, PPG Industries, Inc., Oak Creek Facility.



Jody Overmyer
PPG Project Manager

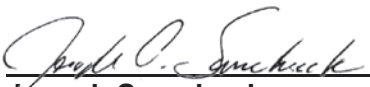
11/4/2019
Date Reviewed

Zachary Sasnow
USEPA Project Manager

Date Reviewed

Erica Love
Tetra Tech Project Manager

11/4/2019
Date Reviewed



Joseph Samchuck
Tetra Tech Project Chemist

11/4/2019
Date Reviewed

2.0 QUALITY ASSURANCE PLAN DISTRIBUTION LIST

Copies of the Quality Assurance Project Plan (QAPP) will be distributed to each individual listed below. Revisions to the QAPP will be likewise distributed, to include the revision number and date in the footer. Older versions of the QAPP should be destroyed when a newer revision is received.

Table 2-1

Quality Assurance Distribution List

PPG Industries, Inc. (PPG)		
Jody Overmyer, Project Manager	overmyer@ppg.com	(724) 325-5070
Jim Chojnacki, PPG Oak Creek Plant Contact	jchojnacki@ppg.com	(414) 574-7588
U.S. Environmental Protection Agency (USEPA)		
Zachary Sasnow, Project Manager	Sasnow.Zachary@epa.gov	(312) 886-0258
Tetra Tech, Inc. (Tt)		
Erica Love, Project Manager	Erica.Love@tetratech.com	(412) 921-4052
Mark Manthey, Project Technical Lead	Mark.Manthey@tetratech.com	(262) 792-1282
Joseph Samchuck, Project Chemist	Joseph.Samchuck@tetratech.com	(412) 921-8510
Field Team Jason Drews Connor Lauzon Todd Thomson	Jason.Drews@tetratech.com Connor.Lauzon@tetratech.com Todd.Thomson@tetratech.com	(262) 792-1282
PACE Analytical Services (PACE)		
Brian Basten, Account Executive	Brian.Basten@pacelabs.com	(920) 321-9411

3.0 PROBLEM DEFINITION

A detailed description of the problem definition is provided in the Work Plan for the Delineation of Light Non-Aqueous Phase Liquid (LNAPL)-Related Contamination at the RAX Building and Former Tank Farm Area (TFA) (Work Plan) at the PPG Oak Creek, Wisconsin Facility (Site). The Site is located at 10800 South 13th Street, Oak Creek, Wisconsin (Figure 1). The Work Plan was previously submitted under separate cover.

In general, the results of the May 14, 2019 synoptic groundwater level measurement event, which was the first to include wells from both the RAX Building and TFA, indicated that the extent of groundwater contamination may not be fully delineated (Figure 2). Further delineation was requested by the USEPA for two areas. The two areas include the area south of the RAX Building, related to a February 12, 2002 xylene and naptha spill at the Site, and the area west of the TFA, where contaminants of concern (COCs) may have migrated via the utility corridor preferential pathways.

4.0 TASK DESCRIPTION

Details of the tasks to be accomplished are provided in the Work Plan.

In general, the scope of work for this investigation will include supplemental assessment of soil and groundwater conditions to delineate the extent of volatile organic compounds (VOCs) in groundwater contamination (associated with the 2002 spill) to the south of the RAX Building; and determine if LNAPL is present in utility corridors between the RAX Building and TFA.

The field investigation will include the following activities:

- Utility clearance at each drilling location via a private utility locate company
- Installation and screening of soil borings for VOCs
- Installation of temporary monitoring wells for groundwater sampling
- Backfill screening in the fire suppression corridors
- Screening of the storm sewer utility outfall
- Collect a synoptic round of groundwater levels from the RAX Building and TFA areas
- Survey of the location of all borings, backfill screening locations, and temporary monitoring wells

5.0 PROJECT ORGANIZATION

The project organization is shown on Figure 3. Project responsibilities are as follows:

PPG Project Manager: The PPG Project Manager is responsible for all aspects of the project, including budget, schedule, contractor oversight, and agency communications.

Tt Project Manager: The Tt Project Manager oversees the activities of all Tt personnel, ensures compliance with the Work Plan, assigns duties to project staff, evaluates training needs for the project staff, and provides budget and schedule control. They oversee generation, distribution, and compliance with the Work Plan and controls project consistency.

USEPA Project Manager: The USEPA Project Manager reviews and approves project plans and reports, including the Work Plan and the QAPP, for both completeness and technical adequacy. They provide consultation regarding the execution and completion of the planned sampling efforts. They coordinate directly with other USEPA and PPG staff (as needed) to ensure that project goals are met.

Tt Project Technical Lead: The Tt Project Technical Lead is the primary point of contact for project field activities. They provide senior review for the generation and compliance with the Work Plan and project deliverables. Additional responsibilities include oversight of all field activities and report generation, ensuring that project deliverables are reviewed for accuracy and completeness before release, and ensuring that QAPP requirements are satisfied.

Tt Project Chemist: The Tt Project Chemist will generate the QAPP, transmit the QAPP to the field staff and laboratory, work with the PACE Account Executive to schedule bottle and sample shipments, identify and resolve analytical issues, assist in identifying and resolving sample collection issues, and review/validate all data based on data quality indicators.

Tt Field Team Lead: The Tt Field Team Lead is responsible for implementing the field aspects of the Work Plan and QAPP, including preparation for field activities, sample collection, and documentation. They work directly with the Project Technical Lead to ensure sample collection, documentation, packaging, and shipping are performed using the procedures specified in the QAPP.

PACE Account Executive: The PACE Account Executive is the primary point of contact between Tt and PACE. They coordinate sample receipt, processing, analysis, and data reporting with members of the laboratory technical staff.

6.0 QUALITY OBJECTIVES AND CRITERIA

6.1 DATA QUALITY OBJECTIVES

State the Problem

The USEPA's Final Decision and Response to Comments Groundwater Monitoring and Institutional Controls Remedy (Final Decision; USEPA, 2019) required further delineation of Site COCs in groundwater in two areas; south of the RAX Building and between the RAX Building and the former TFA.

Identify the Goal of the Study

The goals of this investigation are to determine whether impacts from well TF-3 in the TFA or from the 2002 RAX building spill have impacted groundwater in the area between the RAX building and TFA.

Through the results of this investigation USEPA will decide if permanent monitoring wells should be installed in this area and incorporated into the groundwater monitoring program selected as the final remedy for the Site. In addition, if the results of the investigation suggest that impacts remain below the foundation of the RAX building, soil gas samples will be collected to confirm whether soil gas concentrations are above appropriate risk levels.

Identify Informational Inputs

Soil borings and utility corridor backfill borings will be installed and examined for visual or olfactory signs of contamination with a photoionization detector (PID) to screen soil borings and utility corridor backfill for the presence of LNAPL.

Groundwater concentrations of COCs for this sampling event will include benzene, ethylbenzene, toluene, and xylene (BETX) and Resource Conservation and dissolved Recovery Act (RCRA) 8 metals (arsenic, barium, cadmium, chromium, mercury, selenium, and silver). Groundwater samples will be collected using low-flow techniques, as detailed in the Sampling Methods section of this QAPP. The samples will be analyzed using SW846 methods, as detailed in the Analytical Methods section of this QAPP.

The Corrective Measures Implementation Report (Shaw Environmental & Infrastructure, Inc. [Shaw], 2006) established the following Target Cleanup Goals (TCGs) for organic groundwater COCs conservatively based on the National Primary Drinking Water Standard Maximum Contaminant Levels (MCLs) for organic constituents. To be consistent, the MCLs for the RCRA metals (secondary MCL for silver) are included in Table 6-1.

Table 6-1

Target Cleanup Goals

Constituent	Cleanup Goal (milligrams per liter)
Benzene	0.005
Ethylbenzene	0.7
Toluene	1.0
Xylene	10.0
Arsenic	0.010
Barium	2
Cadmium	0.005
Chromium	0.1
Lead	0.015
Mercury	0.002
Selenium	0.05
Silver	0.1

Water levels will be measured using an electronic water level indicator, to the nearest 0.01 foot.

Define the Boundaries of the Study

Soil boings will extend to a maximum of 20 feet based on the depth of fill material in the TFA. In addition, shallow groundwater at the facility is typically found at a depth of 5 to 10 feet below ground surface and the COCs are related to LNAPL and contamination is not expected to be found at depth.

Groundwater samples must be collected at the former TFA and RAX Building that are representative of current site conditions. Samples will be collected from temporary monitoring wells screened across the potentiometric surface that are located downgradient of the RAX Building and between the former TFA and the RAX Building. The locations of the proposed temporary wells are presented on Figure 1 of the Work Plan. The subsequent analytical results will provide a picture of current conditions in both areas.

A synoptic round of water levels will be collected from all existing monitoring wells and temporary monitoring wells within both the RAX Building area and the former TFA.

Develop the Analytical Approach

The results of the investigation will document the condition of these previously uncharacterized areas with respect to the final remedy outlined in the Final Decision document and will assist with determining what additional actions, if any, are required for the facility.

Specify Performance or Acceptance Criteria

Overall precision and accuracy Data Quality Indicators (detailed below) have been established for this project based on the laboratory's previous experience and on analytical method guidance. Laboratory data will be reviewed on an ongoing basis. All data reported by the laboratory will undergo an internal review process by the analyst, a peer or supervisor review, and a project management review before undergoing data validation.

Develop the Plan for Obtaining Data

The Work Plan provides details as to which former TFA and RAX Building temporary monitoring wells will be sampled, sample collection methods, and the analyses to be performed.

6.2 DATA QUALITY INDICATORS

The usability of the data generated during this project directly affects whether project objectives are achieved. Precision, accuracy, representativeness, comparability, completeness, and sensitivity parameters will be evaluated at a minimum, and the results of these evaluations will be included in the project report. These indicators are described below.

Precision

Precision refers to the reproducibility of measurements and is defined as the measurement of mutual agreement among individual measurements of the same property, usually under "prescribed similar conditions." Precision is expressed in terms of the relative percent difference (RPD) between duplicate determinations. Field duplicates will have an RPD goal of ≤ 50%, while laboratory duplicates will have a goal of ≤ 25%.

The Tt Project Chemist, will determine whether precision goals for field duplicates and laboratory duplicates were met following the approach in Section 22 below.

Accuracy

Accuracy is a measure of the bias in a system or the degree of agreement of a measurement against an accepted reference or true value. It is typically expressed as a percent recovery. Analytical accuracy will be assessed through the analysis of spikes including surrogates, matrix spike/matrix spike duplicates (MS/MSDs), laboratory control samples (LCS), and calibration check samples with the goal of all recoveries falling with historical laboratory acceptance ranges.

The Tt Project Chemist will determine whether the accuracy/bias goals were met for project data following the approach in Section 22 below.

Representativeness

Representativeness is a qualitative parameter that expresses the degree to which sample data actually represent the matrix conditions. Requirements and procedures for sample collection and handling have been designed to maximize sample representativeness. A Tt Project Scientist will

determine whether the data are adequately representative of intended populations by following the approach in Section 22 below.

Completeness

Data completeness represents the percentage of valid data collected from a sampling/analytical program or measurement system compared to the amount expected to be obtained under optimal conditions. The completeness goals are > 95% for sample collection and > 90% for valid sample data. If deviations from the scheduled sample collection or analyses are identified, the Tt PM will determine whether the deviations compromise the ability to meet project objectives by following the approach in Section 22 below.

Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Comparability for sampling and analysis tasks will be achieved by:

- Specifying well-recognized techniques and accepted standard methods for sampling and analysis using well-trained sampling and analysis technicians to execute the prescribed methods consistently
- Requiring that all involved sampling and analysis personnel produce adequate documentation to record how the prescribed methods were actually executed, noting nonconformances and corrective measures taken

The Tt Project Chemist will determine whether the data generated under this project are sufficiently comparable to historical site data by following the approach in Section 22 below.

Sensitivity

Sensitivity is a qualitative parameter that addresses the ability of the instrumentation to differentiate between varying responses. Sensitivity is important as it affects the ability to detect the target analytes at the levels of interest so that project-specific goals are met. Sensitivity is achieved by establishing various limits, including instrument detection limits (IDLs), method detection limits (MDLs), and practical quantitation limits (PQLs). Both IDLs and MDLs are based on interference-free matrices which do not take into account the matrix effects of environmental samples. PQLs are the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. If sensitivity goals are not achieved, the limitations on the data will be described in the project report.

The Tt Project Chemist will determine whether project sensitivity goals were achieved by following the approach in Section 22 below.

7.0 SPECIAL TRAINING/CERTIFICATION

No special training or certifications are required for the RAX building and former TFA groundwater sampling and analysis.

8.0 DOCUMENTATION AND RECORDS

Work Plan Distribution: The Work Plan for the delineation investigation at PPG's former Oak Creek Facility will be distributed by Tt's Project Manager. The distribution list for the Work Plan is that same as the that of the QAPP and is detailed in Section 2 above. Revisions to the Work Plan will likewise be distributed by Tt's Project Manager.

Field Records: Soil boring logs, well development and well purging/sampling information, and equipment calibration logs will be recorded on appropriate log sheets (Appendix B). The log sheets will be compiled by the field team lead and shipped to the project manager for use and eventual storage in the central files.

Laboratory Records: Analytical data will be reported using PACE's standard reporting package format. The data will be provided electronically, in a format to be agreed upon by Tt and PACE data managers. The analytical data will be validated, compiled, interpreted, and reported and eventually stored in the Tt central files.

9.0 SAMPLING PROCESS DESIGN

The Work Plan details the design for the former TFA and RAX Building data collection effort.

10.0 SAMPLING METHODS

Soil samples will not be collected for fixed-based laboratory analysis. However, all soil borings will be continuously logged using the Unified Soil Classification System and described as detailed in the attached Soil Description Standard Operating Procedure (SOP) (Appendix A). In addition, all soils will be screened with a PID as detailed in the Soil Screening Using a PID SOP (Appendix A).

Groundwater samples will be collected using low-flow methods as detailed in attached Low-Flow (Minimum Drawdown) Groundwater Sampling SOP (Appendix A). However, to be consistent with existing sampling methods used in the TFA, a peristaltic pump will be used to complete sampling in this investigation. Appendix B contains field documentation forms that will be completed during site activities.

11.0 SAMPLING HANDLING AND CUSTODY

Sample documentation, custody, and shipping will be performed in accordance with the following SOPs (which are attached).

Table 11-1

Sample Handling SOPs

Standard Operating Procedure	Title
SOP 5	Sample Identification
SOP 8	Chain of Custody Procedures

Table 11-2

Sample Containers and Holding Times

Parameter	Container	Preservative	Holding time (days)		
			Collection to extraction	Extraction to analysis	Collection to analysis
VOCs	3 x 40 milliliter (ml) vials with Teflon™-lined septum cap	HCl to pH < 2, cool 4 °C	NA	NA	14
Dissolved Metals except mercury	1 x 1-liter plastic	HNO_3 to pH <2	NA	NA	180
Mercury	1 x 1-liter plastic	HNO_3 to pH <2	NA	NA	28

12.0 ANALYTICAL METHODS

Groundwater samples collected from the temporary monitoring wells will be analyzed for VOCs (BETX only) and the eight RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). PACE will perform the sample analyses in their Green Bay, Wisconsin, laboratory. PACE has developed SOPs for each analysis, based on the following USEPA SW846 analytical methods:

Volatile Organics:	Method 8260B
Dissolved Metals (except mercury):	Method 6010C
Mercury:	Method 7470A

MDLs and PQLs for each parameter are shown on Tables A-1 and A-2. Uncontrolled copies of the SOPs are available for review upon request.

Table 12-1

Laboratory SOPs

Standard Operating Procedure	Title
ENV-SOP-GBAY-0057-Rev.00	Aqueous Sample Preparation by 5030B
ENV-SOP-GBAY-0017-Rev.00	Acid Digestion of Aqueous Samples by EPA 3010A, 200.7, 200.8
ENV-SOP-GBAY-0093-Rev.01	Determination of Volatile Organics by GCMS 8260
ENV-SOP-GBAY-0009-Rev.00	Determination of Metals by ICP Spectroscopy by 6010B-C and 200.7
ENV-SOP-GBAY-0013-Rev.01	Determination of Mercury by Cold Vapor Atomic Absorption Spectroscopy by 7470A, 7471B, 245.1

13.0 QUALITY CONTROL

13.1 FIELD QUALITY CONTROL SAMPLES

Field quality control (QC) samples will be collected at the following frequency:

Table 13-1

Field Quality Control Samples

QC Sample	Frequency	Criteria
Trip blank	1 per cooler containing VOC aliquots	< reporting limit
Equipment blank	1 per 20 samples	< reporting limit
Field duplicate	1 per 10 samples	RPD < 50%
MS/MSD	1 per 20 samples	Historical lab criteria

Equipment blanks will be collected by pumping analyte-free water through the sample tubing and collecting it in the sample bottles, then analyzed for the same parameters as the field samples.

13.2 LABORATORY QUALITY CONTROL SAMPLES

The PACE analytical SOPs used for former TFA groundwater analyses are based on the SW846 analytical method, which include the following routine QC samples at the frequency shown.

Table 13-2

Lab Quality Control Samples

Methods 8260

QC Sample	Frequency	Criteria
Method blank	1 per prep batch	< reporting limit
LCS	1 per prep batch	Within historical limits, see Tables A-1 and A-2
MS/MSD	1 per prep batch	Within historical limits, see Tables A-1 and A-2
Internal standards	All field & QC samples	Retention time ± 30 seconds of Internal Calibration (ICAL) midpoint; response of -50% to +100% of ICAL midpoint.
Surrogate spikes	All field & QC samples	Within method defined limits, see Tables A-1 and A-2

Table 13-2

Lab Quality Control Samples

Methods 6010 and 7470

QC Sample	Frequency	Criteria
Calibration blank	1 per 10 samples, plus beginning and end of run	< reporting limit
Method blank	1 per prep batch	< reporting limit
LCS	1 per prep batch	Within historical limits, see Table A-2
MS/MSD	1 per prep batch	Within historical limits, see Table A-2
Interference check standard (ICS-A, ICS-AB) (Method 6010 Only)	Beginning of run, every 12 hours	ICS AB ± 20% of true
Serial dilution	1 per prep batch	5x dilution with ± 10% for analytes > 50x IDL

14.0 INSTRUMENT TESTING, INSPECTION, AND MAINTENANCE

Field: Various groundwater indicator parameters will be monitored during low-flow purging of the monitoring wells, including dissolved oxygen, oxidation-reduction potential, specific conductance, pH, temperature, and turbidity. The instrumentation used to monitor for these parameters will rented from a commercial vendor. Tt will request the most recent calibration records for each instrument to verify that each instrument has been maintained and calibrated per manufacturer specifications.

Laboratory: PACE has developed an SOP that addresses preventative, routine, and non-routine maintenance. The SOP defines the types and frequencies of maintenance for each piece of analytical instrumentation, as well as the required documentation. An uncontrolled copy of the SOP is available upon request.

15.0 INSTRUMENT CALIBRATION AND FREQUENCY

Field: Should a pH meter be used, it will be calibrated at the beginning of each day. The other indicator parameter instrumentation will be checked at the beginning of each day to determine if it is working properly. If not reading properly, the instrumentation will be calibrated (if possible) or replaced (if not possible). Field calibration logs will be maintained by the Field Team Lead for inclusion in the site files.

Laboratory: Each of the analytical SOPs used for groundwater analysis specifies the frequency of initial and ongoing calibrations, as well as the criteria that must be met by the calibration. The methods also specify corrective actions to be taken when calibrations fail and when recalibration is required. An uncontrolled copy of the analytical SOPs is available upon request.

16.0 INSPECTION OF SUPPLIES AND CONSUMABLES

There are no critical supplies or consumables that require inspection during the former TFA and RAX Building groundwater sampling project.

17.0 NON-DIRECT MEASUREMENTS

The PPG Oak Creek facility is subject to the regulations promulgated under RCRA. On March 31, 1992, the USEPA issued a RCRA permit to the Oak Creek facility. This permit contained a requirement for conducting a RCRA Facility Investigation (RFI) at 10 solid waste management units (SWMUs). With USEPA's approval of the RFI Report, corrective action requirements were met for 8 of the 10 SWMUs. The 2 remaining SWMUs represent the former TFA and were the focus of a presumptive remedy implementation.

The former TFA was also subject to federal and state regulations regarding underground storage tanks (USTs). In order to meet the UST regulations, PPG elected to take the USTs out of service and either remove or close them in place. This work was completed in the spring of 1999. The facility RCRA permit was closed on June 30, 2004.

Numerous investigations were performed at the facility between 1981 and 1997, a summary of which can be found in the 1997 RFI Report (ICF Kaiser Engineers, Inc., 1997). Subsequently, PPG voluntarily monitored groundwater quality semiannually from 2004 through September 2011. The groundwater monitoring program was temporarily discontinued after the September 2011 sampling event, pending approval of the Statement of Basis. In the spring of 2016, USEPA requested PPG conduct a single groundwater monitoring event to confirm groundwater conditions at the TFA, and that none of the COCs identified in the RFI had re-appeared because of the under-drain system being deactivated. See the 2016 report Groundwater Sampling in Support of the Statement of Basis included in the Administrative Record for more information.

All of the TFA investigations and groundwater sampling events were performed following USEPA-approved work plans using USEPA analytical methods. The data generated during these events will be used as the historical basis for comparison with the former TFA data generated during the present investigation.

In February 2002, a 550-gallon weigh tank located along the eastern exterior wall of the RAX building had a computer malfunction which resulted in an overflow of the reserve tank. PPG conducted initial removal actions that involved excavation of impacted soil, performed a subsurface investigation to delineate the extent of the spill impact, and began a semi-annual groundwater monitoring program around the perimeter of the RAX building. PPG conducted semi-annual groundwater monitoring from 2002 through 2019 under Wisconsin Department of Natural Resources (WDNR) supervision and results are summarized in semi-annual reports.

18.0 DATA MANAGEMENT

Field: Field logbooks, well development, and well purge/sample logs will be used to document observations, sampling information, and other pertinent information during groundwater sampling. They are considered legal documents and will be returned to the project office and maintained as part of the project file.

Chain of Custody forms are used to document the sample custody process from collection through shipment to receipt at the laboratory. The field copy of the form will also be returned to the project office and maintained as part of the project file. In addition, the analytical data package will contain a copy of the chain of custody showing receipt by the laboratory.

Laboratory: Laboratory reports will be received from PACE in electronic format. In addition, the analytical data will also be received as an Electronic Data Deliverable. Both deliverables will be stored at the Tt project office on a local server, with daily backup, from which it will be available to project staff for use and analysis.

Reports: The field and laboratory data will be used to generate tables and figures for the final report. In addition, the data may be used to determine human and ecological risk, characterize concentration trends, and perform a comparison with cleanup criteria. The data used to generate tables and figures and perform data comparisons will be accessed from the local server. The output of such data massage will likewise be stored on the local server. Project personnel may download the data to their computer for use but should save their work daily to the server so that appropriate backup precautions can be implemented. Draft and final versions of the report will be stored on a local Tt server with daily backup.

Hard copy reports will be stored in the project files, under the control of the Project Manager and Project Technical Lead, who will distribute copies as appropriate.

19.0 ASSESSMENTS AND RESPONSE ACTIONS

Field: Field logbooks, well development, well purge/sample logs, and sample custody forms will be reviewed by the Project Technical Lead at the end of field operations to verify consistency with Work Plan requirements. Data discrepancies will be identified and promptly resolved with the Field Team Lead.

Laboratory: PACE is certified by the WDNR to perform volatile organics and metals analysis of non-potable water samples. The certification lasts for one year—from August 26, 2019 to August 31, 2020. PACE was audited prior to their initial WDNR certification and has been audited every three years since. A copy of their most recent audit report is available upon request. In addition, all laboratories are required to complete proficiency testing analyses during their annual accreditation renewal process.

20.0 REPORTS TO MANAGEMENT

Results of the field record review will be verbally reported to the Project Manager once all issues have been resolved. The final project report will contain a section summarizing data quality information, including field data review, data validation results, and data usability. Corrective actions will be included in the report.

Laboratory audit and proficiency testing sample results are addressed by the PACE Quality Assurance Manager and Lab Manager as they become available.

21.0 DATA REVIEW, VERIFICATION, AND VALIDATION

21.1 DATA REVIEW AND VERIFICATION

Field Records:

- Chain of custody forms and shipping documentation will be reviewed by the laboratory upon receipt of samples for verification that all planned samples have been received and the appropriate analysis has been requested. The chain of custody forms will be signed by all parties that had custody of samples, with the exception of commercial carriers.
- All field records, including chain of custody forms, field log books, and well purge forms will be reviewed by the Project Technical Lead and verified for completeness.

Laboratory Analytical Data:

- All laboratory data packages will be verified internally by PACE laboratory management for completeness and technical accuracy prior to submittal.
- All laboratory data packages will be verified by the Tt Project Chemist for content upon receipt.
- A cross check of the electronic verses the hard copy data will be performed by the Tt Project Chemist to verify consistency.

Project Data:

- Data validation qualifiers will be entered into the project database. The qualifiers will be verified by the Tt Project Chemist prior to use by project staff.
- A data completeness summary will be prepared by the Tt Project Technical Lead to verify that completeness goals have been met.

21.2 DATA VALIDATION

Tt will validate the laboratory analytical data packages by reviewing the QC summary information against method and historically developed laboratory criteria. Data qualifiers will be applied as detailed in the following methods (as they are applicable to SW846 analytical procedures):

- National Functional Guidelines for Superfund Organic Methods Data Review, January 2017
- National Functional Guidelines for Superfund Inorganic Methods Data Review, January 2017

22.0 RECONCILLIATION WITH USER REQUIREMENTS

A review will be undertaken to determine whether Data Quality Objectives were met. Precision, accuracy, representativeness, comparability, completeness, and sensitivity parameters will be evaluated and compared with user requirements. The following characteristics will be evaluated at a minimum, and the results of these evaluations will be included in the project report.

Precision

Overall sampling and analysis precision will be assessed by evaluating the field duplicate RPD with the expectation that laboratory duplicate results will be no less precise than field duplicate results. The MS/MSD RPD will be used to assess laboratory precision. RPD is defined as the difference between two measurements divided by their mean and expressed as a percent as shown below. If the goals are not met, or if data have been flagged as estimated (J qualifier), limitations on the use of the data will be described in the project report. RPD will be computed as follows for original/duplicate pairs of results:

$$RPD = \frac{200 * |\text{Result}_A - Result_B|}{(\text{Result}_A + Result_B)}$$

Accuracy

Accuracy is a measure of the bias in a system and is measured as the degree of agreement between a measurement and an accepted reference or true value. It is typically expressed as a percent recovery.

By comparing percent recoveries (%R) of LCS, MS/MSD, and surrogate compounds to accuracy goals accuracy can be measured. This assessment will include an evaluation of field and laboratory contamination; instrument calibration variability; and analyte recoveries for surrogates, MSs, and LCSs. If the goals are not met, limitations on the use of the data will be described in the project report. Bias of the qualified results and a description of the impact of identified non-compliances on a specific data package or on the overall project data will also be described in the project report. Accuracy will be computed as follows for MS/MSD samples:

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

The %R calculation for LCSs and surrogate spikes will be as follows:

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

Representativeness

Representativeness is a qualitative parameter that expresses the degree to which sample data represent the matrix conditions. Requirements and procedures for sample collection and handling are designed to maximize sample representativeness.

A Tt Project Scientist will determine whether the data are adequately representative of intended populations, both spatially and temporally. This will be accomplished by verifying that samples

were collected and processed for analysis in accordance with the SOPS in Appendix A of the QAPP, by reviewing spatial and temporal data variations (as applicable), and by comparing these characteristics to expectations. The usability report will describe the representativeness of the data for each matrix and analytical fraction. This will not require quantitative comparisons unless professional judgment of the Project Scientist indicates that a quantitative analysis is required.

Completeness

Data completeness represents the percentage of valid data collected from a sampling/analytical program system compared to the amount expected to be obtained under optimal conditions, and will be calculated as follows:

Completeness for sampling (Cs) will be expressed as the percent of samples collected divided by samples planned for collection and analytical completeness (Ca) will be computed as the percent of valid data points divided by the planned number of data points as follows:

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

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

Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Comparability for sampling and analysis tasks is achieved by:

- Specifying standard methods for sampling and analysis
- Requiring adequate sampling and analysis documentation

Standard field and laboratory methods help ensure that the data generated for an event are comparable to past and future activities.

The Tt Project Chemist will determine whether the data generated under this project are sufficiently comparable to historical site data generated by different methods and for samples collected using different procedures and under different site conditions. This will be accomplished 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 Tt Project Chemist indicates that such quantitative analysis is required.

Sensitivity

Sensitivity is achieved by establishing IDLs, MDLs, and PQLs. PQLs are the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions. The Project Chemist will review the analytical data to verify that PQLs have been achieved in support of project cleanup goals.

23.0 REFERENCES

ICF Kaiser Engineers, Inc., 1997. *RCRA Facility Investigation Report*, PPG Oak Creek Facility, Oak Creek, Wisconsin, July.

Shaw Environmental & Infrastructure, Inc., 2006. Corrective Measures Implementation Report, PPG Oak Creek Facility, Oak Creek, Wisconsin, March.

Tetra Tech, 2019. Work Plan: Delineation of LNAPL-Related Contamination in the RAX Building and TFA, PPF Industries, Inc. Oak Creek Facility, Oak Creek, Wisconsin, September.

USEPA, 2019. *Final Decision and Response to Comments Groundwater Monitoring and Institutional Controls Remedy*, PPG Industries, 10800 South 13th Street, Oak Creek, Wisconsin, EPA ID: WID 059972935.

TABLES

Table A-1
VOC Detection Limits, LCS Criteria, MS/MSD Criteria, Surrogate Criteria
PPG Oak Creek QAPP

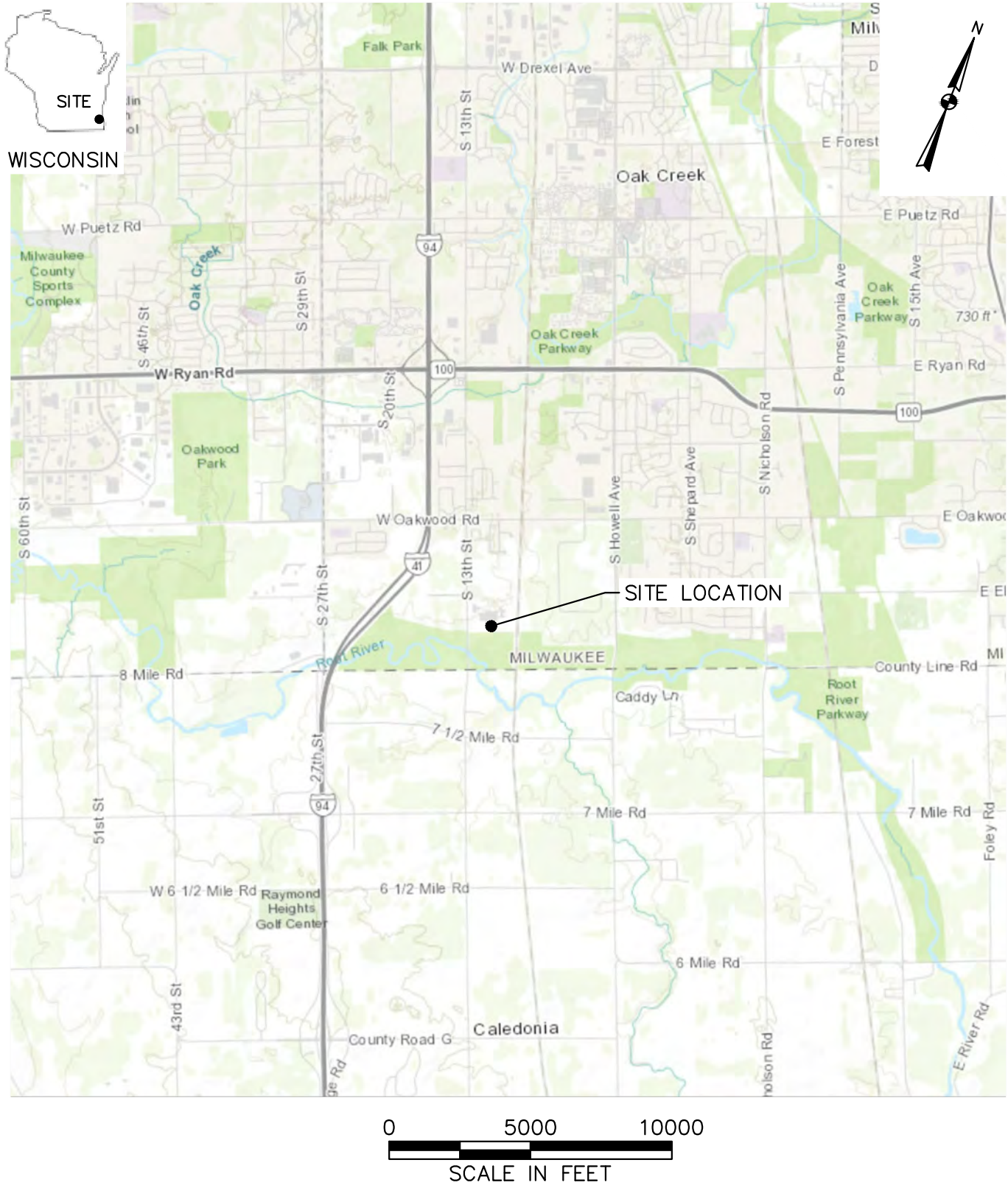
Analyte	Method Detection Limit (ug/L)	Practical Quantitation Limit (ug/L)	LCS/LCSD			MS/MSD		
			Lower Limit (%)	Upper Limit (%)	RPD	Lower Limit (%)	Upper Limit (%)	RPD
Benzene	0.25	1	70	130	20	70	130	20
Ethylbenzene	0.22	1	80	124	20	80	125	20
Toluene	0.17	5	80	126	20	80	131	20
Total Xylene	1.5	3	70	130	20	70	130	20

Surrogate	Surrogate	
	Lower Limit (%)	Upper Limit (%)
4-Bromofluorobenzene	70	130
Dibromofluoromethane	70	130
Toluene-d8	70	130

Table A-2
Metals Detection Limits, LCS Criteria, MS/MSD Criteria
PPG Oak Creek QAPP

Analyte	Method Detection Limit (ug/L)	Practical Quantitation Limit (ug/L)	LCS/LCSD			MS/MSD		
			Lower Limit (%)	Upper Limit (%)	RPD	Lower Limit (%)	Upper Limit (%)	RPD
Arsenic	8.345	25	80	120	20	75	125	20
Barium	1.5	5	80	120	20	75	125	20
Cadmium	1.33	5	80	120	20	75	125	20
Chromium	2.546	20	80	120	20	75	125	20
Lead	5.911	19.704	80	120	20	75	125	20
Mercury	0.179	0.597	85	115	20	85	115	20
Selenium	12.233	40.776	80	120	20	75	125	20
Silver	3.2	10.66	80	120	20	75	125	20

FIGURES



TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE - SUITE 200
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

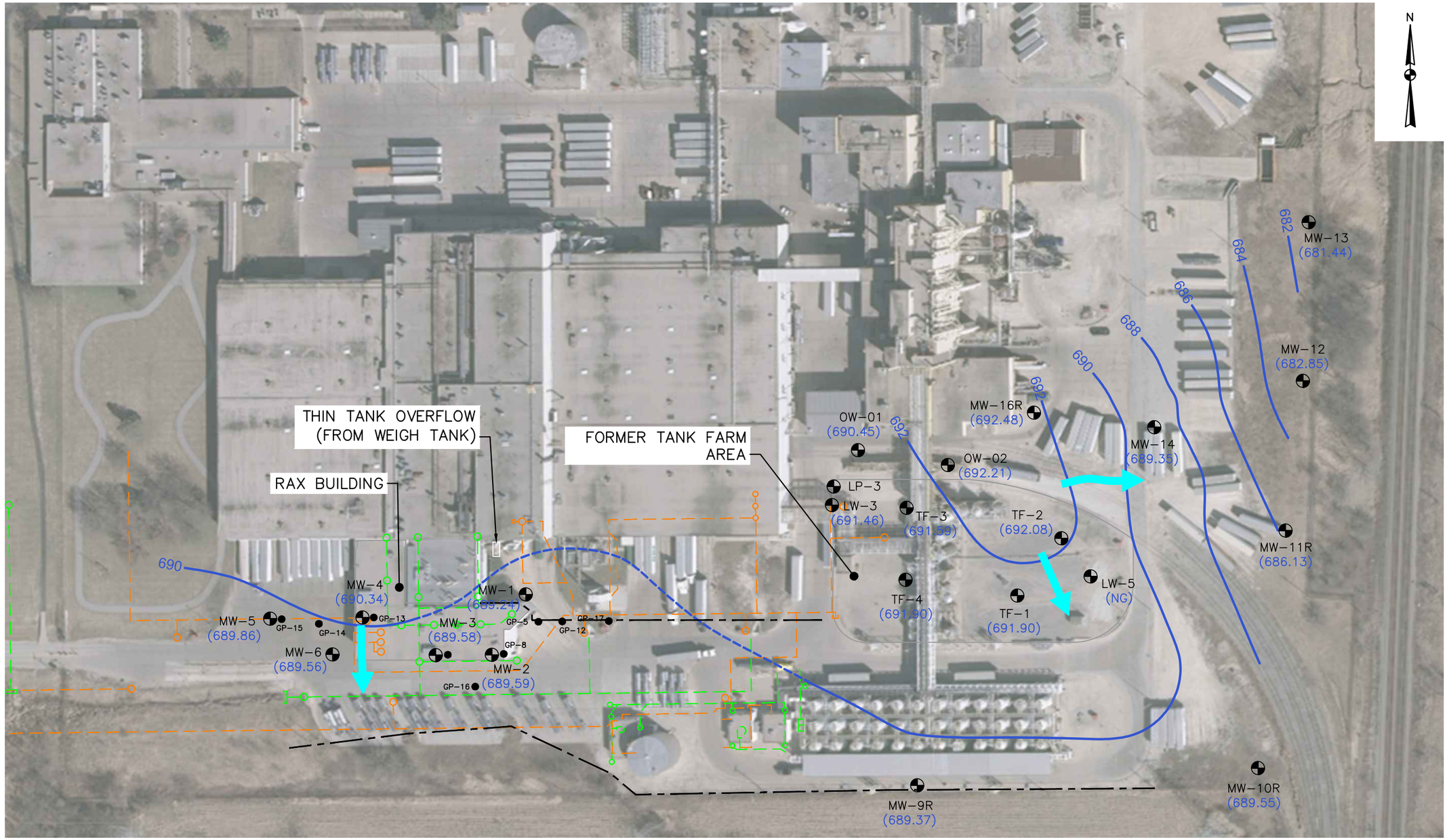
PPG
OAK CREEK, WISCONSIN

SITE LOCATION MAP

DATE:	11/01/19
PROJECT NO.:	112C09042
DESIGNED BY:	EL
DRAWN BY:	KL
CHECKED BY:	EL

FIGURE 1

SHEET 1 OF 1



LEGEND

LP-3	EXISTING MONITORING WELL LOCATION
OW-01	OBSERVATION WELL LOCATION
(690.45)	GROUNDWATER ELEVATION (MSL)
692	GROUNDWATER CONTOUR (DASHED WHERE INFERRED)
	DIRECTION OF GROUNDWATER FLOW
	PREVIOUS SOIL BORING - 2002 RAX BUILDING INVESTIGATION
	FIRE LINE (APPROX. LOCATION)
	SEWER LINE (APPROX. LOCATION)
	OVERHEAD ELECTRICAL LINE (APPROX. LOCATION)

NOTES

1. GROUNDWATER CONTORS CONSTRUCTED FROM WATER LEVELS COLLECTED ON MAY 14, 2019.
2. *LP-3 NOT USED FOR CONTOURING PURPOSES AS IT IS SCREENED AT A DIFFERENT INTERVAL.
3. NG = MONITORING WELL NOT GUAGED ON MAY 14, 2019.

TETRA TECH

DISCLAIMER

THE INFORMATION PROVIDED ON THIS DRAWING WAS PRODUCED USING BOTH TECHNICAL INFORMATION AND KNOW HOW. ANY ADAPTATION OR MODIFICATION OF THE INFORMATION OR DRAWING SHALL BE AT THE USER'S SOLE RISK AND WITHOUT LIABILITY OR LEGAL EXPOSURE TO THE ENGINEER.

REFERENCE

NO.	REVISIONS	BY	DATE
0	ISSUE FOR REVIEW	–	–

DESIGNED BY:	JRF
DRAWN BY:	KAL
CHECKED BY:	EL
APPROVED BY:	JGK
PCP/PC2:	MFG-STD
VIEW NAME:	
ORIGINATION DATE:	08/21/19
PLOT SCALE:	1:120
DATE:	NOVEMBER 2019

PPG – OAK CREEK

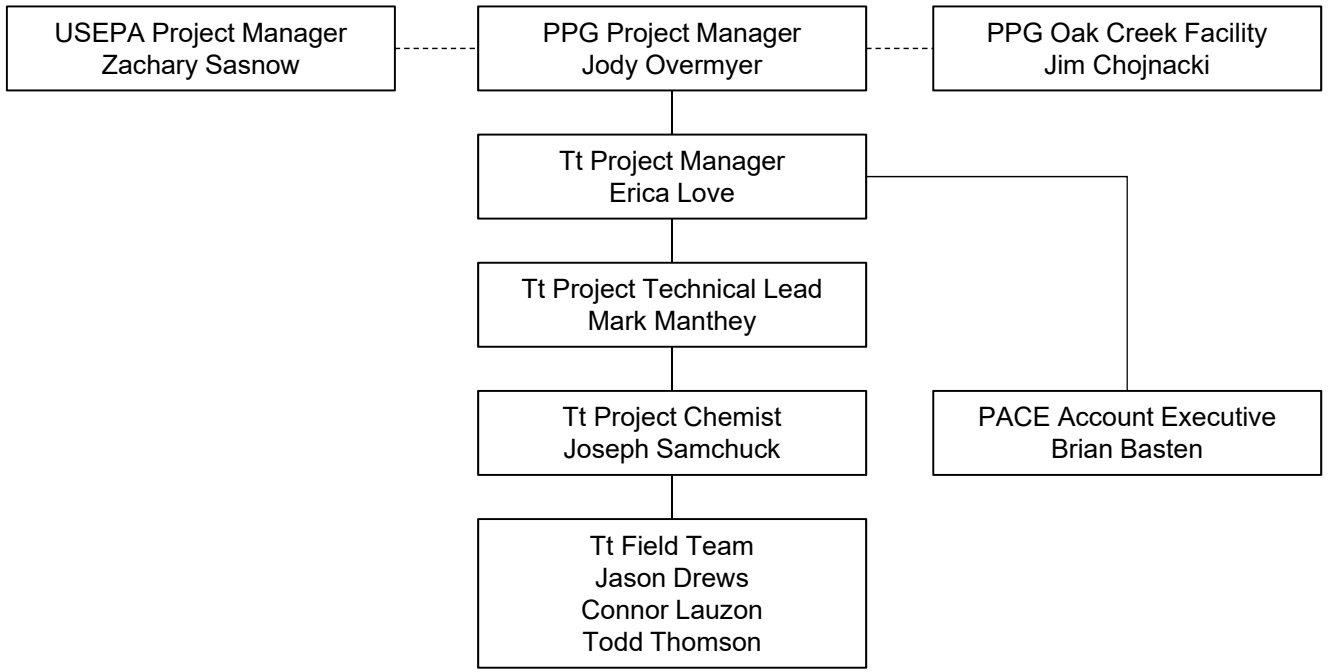
OAK CREEK, WISCONSIN

FIGURE 2
SITE LAYOUT MAP

G:\graphics\AutoCAD\ncs\120208-ppg oak creek\8629 - Synoptic\Civil\8629F002.dwg SAVED:11/1/19 PRINTED:11/1/19

Figure 3
Project Organization Chart

PPG Industries, Inc.
Oak Creek Facility
Oak Creek, Wisconsin



APPENDIX A

Tt Standard Operating Procedures

STANDARD OPERATING PROCEDURE

GEOPROBE® (DIRECT-PUSH) SAMPLING

1. PURPOSE

The purpose of this procedure is to obtain samples of saturated and unsaturated unconsolidated geologic materials from below grade. This procedure requires a weight-driven hydraulic rig to advance the Geoprobe® sampler to the required sampling depth.

2. PROCEDURE

2.1 FIELD PREPARATION

Call for utility clearance more than 72 hours in advance to arrange utility staking in any subsurface boring or exploration area.
Notify client, property owner, and Regulatory agency if required.

2.1.1 Forms

Soil boring and Monitoring Well Logs
Daily Report Sheets
Tailgate Health and Safety
Field Service Request

2.1.2 Equipment

- 1-inch diameter by 1-foot length or 2-inch diameter by 4 or 5 foot length Geoprobe® macrosamplers and 4-foot long clear acetate liners (provided by probe contractor).
- Hooked razor knife for cutting sample tube liners into sections.
- Latex or nitrile sampling gloves - sufficient quantity to provide one change for each sample collection interval.
- Pens and extra-fine or ultra-fine tip permanent markers.
- A stainless steel (must be decontaminated between samples), disposable plastic, or wooden spatulas for cutting soil samples and transferring them to containers.
- Pint (sandwich size) or quart size “zip-lock” plastic bags for soil sample field screening.
- 1- or 2-gallon size zip lock bags for storage of filled sample bottles, chain-of-custody documents, and for separation of ice.
- Large plastic trash bags.
- Laboratory containers, labels, tamper protection security seals, and chain of custody sheets for appropriate type and number of samples.
- Personal protective equipment as described within the Site Health and Safety Plan.
- Laboratory cleaned cooler, ice or refrigerant gel packs, packaging and padding material (bubble wrap or foam), shipping labels, and packing tape.

If needed:

- Photoionization detector(s) with 10.6 eV and/or 11.7 eV lamps.
- DOT approved sealable 55-gallon drums, roll-off boxes, or other appropriate containers for storage of soil cuttings and discarded samples.

- Field preservation (methanol or sodium bisulfate) and electronic scale

2.1.3 Documents
Health and Safety Plan
Work Plan
Maps
Notebook and/or field record sheet to record boring information and observations.

2.1.4 Other
Cellular telephone
First aid kit
Fire extinguisher
Personal comfort items
Decontamination items and tools

2.2 FIELD ACTIVITIES
GeoProbe® soil samples are generally retrieved from continuous intervals from the ground surface to the boring terminus using the 2-inch diameter by 4 or 5-foot long macrosampler, or at selected intervals using the 1-inch diameter by 1-foot long sampler. The sampling tool is hydraulically driven to collect continuous, relatively undisturbed soil samples in 4 or 5 foot long, clear, acetate liners. The 1-inch diameter by 1-foot length Geoprobe® sampling tool can be hydraulically driven to collect continuous or discreet, relatively undisturbed soil samples within 1" acetate liners. Geologic logs are typically completed for each Geoprobe® boring.

As each GeoProbe® sampler is retrieved and opened, the on-site geologist will conduct the following activities using the procedures described.

2.2.1 Sample Collection
Don a new pair of disposable latex or nitrile gloves prior to handling each new sample interval.

Upon opening the acetate liner (using a hooked razor knife), describe and characterize the soil per the "Geologic Descriptions" SOP, or another acceptable method described in the project work plan or field sampling plan. Record this description on the soil boring log sheet and/or field notes form.

If using the 4 or 5-foot sampler with the clear acetate liner, identify the portions of the sample tube that will be used for geotechnical analyses, analytical evaluation, and for later biological and special chemical analysis.

Using either a decontaminated stainless steel implement, or a disposable plastic or wooden implement, place a portion of the sample into a zip-lock plastic bag for later field screening if necessary (per SOP – PID Screening).

At the sample depth intervals designated for laboratory analysis, proceed as follows: distribute the portion of the sample remaining in the sampler to laboratory supplied containers, preserving

if necessary first. Place samples in the appropriate containers in order of decreasing volatility (ex. purgeable halocarbons, aromatic hydrocarbons, semi-volatile hydrocarbons, and lastly metals and inorganics). If there is insufficient sample volume to provide all sampling needs, the balance of the sample will be obtained from the same depth interval in an adjacent boring drilled for additional sample volume.

Groundwater samples may be collected from saturated intervals using a temporary 1" well or using expendable point screens and a peristaltic pump.

2.2.2 Laboratory Sample Handling

To the extent possible, complete labels for laboratory containers (using permanent ink) in advance of sample collection. Place the appropriate label on the laboratory containers prior to filling with the sample. Add the sample to the container as described above, tightly cap the container, and place the tamper protection seal (if applicable) over the container cap. Then record the date, time of collection, and any other missing information, onto the label and chain of custody.

Wrap all glass laboratory containers in bubble wrap or foam, then place into large 1-2 gallon zip-lock bags, label the outside of the bag, and place into the coolers. Periodically add crushed ice to the coolers to maintain all collected samples under chilled conditions (refrigerant gel packs are an acceptable alternative). Ice should first be placed into separate large zip-lock bags to further isolate melt water from the samples. Ice should be distributed evenly through out the cooler.

Complete the sample Chain of Custody documentation, seal in a water tight zip-lock bag, and attach to the underside of the cooler lid with packaging tape. Ship coolers or arrange delivery to the laboratory as soon as practical and before the sample holding time limit expires.

Ensure the ground surface has been restored to acceptable conditions and all Geoprobe® borings have been properly abandoned.

2.2.3 Decontamination and Clean Up

Decontaminate all sampling equipment and tools that will be reused between samples as follows: 1) Between samples within the same boring - Rinse with clean water, wash and scrub in an Alconox solution, rinse again with clean water, and allow to air dry. 2) Between borings - spray wash all sample tools and drilling rods, bits, and augers using a high pressure steam cleaner.

Drill cuttings, acetate liners, gloves, and other disposable sampling waste generated during the field investigation will be containerized using Department of Transportation- (DOT) approved 55-gallon drums if necessary. Removal and proper off-site disposal of the drill cuttings follow characterization analyses of the containerized soil.

3. QUALITY ASSURANCE

1. A field blank should be provided by the laboratory and kept with all soils collected from the site to insure sample integrity.
2. All data must be documented on field data sheets or within site logbooks.
3. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

STANDARD OPERATING PROCEDURE

SOIL DESCRIPTIONS

1. PURPOSE

The purpose of this procedure is to describe and classify soil samples in the field during soil boring advancement.

2. PROCEDURE

2.1 FIELD PREPARATION

Call for utility clearance at least 72 hours in advance to arrange utility staking in any subsurface boring or exploration area.
Notify client, property owner, and Regulatory agency if necessary.

2.1.1 Forms

Soil Boring and Monitoring Well Logs
Tailgate Health and Safety
Daily Report Sheets

2.1.2 Equipment

Knife or spatula.
Ruler, tape measure, or scale.
Latex or nitrile gloves.
Sand gauge and geotechnical gauge, if necessary.
Pens, pencils and permanent markers.
Paper towels.
Small bottle of water.
Garbage bags.

2.1.3 Documents

Health and Safety Plan
Workplan
Maps
Site access agreements

2.1.4 Other

Cellular telephone
First aid kit
Personal comfort items

2.2 FIELD ACTIVITIES

The following sections provide guidance for how proper field visual descriptions of soils and rock samples should be conducted. These methods may not be applicable to every soil or rock sample found, but should provide enough guidance to allow accurate and defensible descriptions by a variety of field geologists.

The following section provides a description of the procedures that should be used when describing soils.

2.2.1 General Considerations for Description of Soils

The most popular soil classification method that is based on grain size and other properties, is the Unified Soil Classification System (USCS). This system was initially developed by A. Casagrande in 1948 and was then called the Airfield Classification System. It was adopted with minor modifications by the U.S. Bureau of Reclamation and the U.S. Corps of Engineers in 1952. In 1969, the American Society for Testing and Materials (ASTM) adopted the system. This system is designated currently by ASTM as D-2488-90 and will be used as a guideline for classifying and describing lithology. It requires certain information (e.g. liquid limit, plastic limit moisture content and plasticity index) about the soil which can only be obtained in a laboratory.

The USCS is based on grain size and response to physical manipulation at various water contents. This system is often used for classifying soils encountered in boreholes, test pits, and surface sampling. The following properties form the basis of USCS soil classification:

- Percentage of gravel, sand, and fines;
- Shape of the grain size distribution curve; and
- Plasticity and compressibility characteristics.

Four soil fractions are recognized. They are cobbles, gravel, sand, and fines (silt or clay). The soils are divided as coarse grained soils, fine grained soils, and highly organic soils. The coarse grained soils contain 50 percent of grains coarser than a number 200 sieve (approximately 0.08 mm). Fine grained soils contain more than 50 percent of material smaller than the number 200 sieve. Organic soils contain particles of leaves, roots, peat, etc.

2.2.2 Soil Description Procedures

The following will be used as a guideline for logging lithology from subsurface activities (i.e. borehole drilling, trenching, etc.).

The USCS recognizes 15 soil groups and uses names and letter symbols to distinguish between these groups. The coarse grained soils are subdivided into gravels (G) and sands (S). Both the gravel and sand groups are divided into four secondary groups. Fine grained soils are subdivided into silts (M) and clays (C).

Soils are also classified according to their plasticity and grading. Plastic soils are able to change shape under the influence of applied stress and to retain the shape once the stress is removed. Soils are referred to either low (L) or high (H) plasticity. The grading of a soil sample refers to the particle size distribution of the sample. A well graded (W) sand or gravel has a wide range of particle sizes and substantial amounts of particles sized between the coarsest and finest grains. A poorly graded (P) sand o gravel consists predominately of one size or has a wide range of sizes with some intermediate sizes missing.

Soils which have characteristics of two groups are given boundary classifications using the names that most nearly describe the soil. The two groups are separated by a slash. The same is true when a soil could be well or poorly graded. Again the two groups are separated by a slash.

Soil description should be concise and stress major constituents and characteristics for fine-grained, organic, or coarse-grained soils. Tables 1 and 2 are checklists for descriptions of fine-

grained, organic soils, and coarse-grained soils, respectively. Field descriptions should include as a minimum:

- Soil name: The basic name of the predominant constituent and a single-word modifier indicating the major subordinate constituent.

- Particle Size Distribution: An estimate of the percentage and grain-size range of each of the soil's subordinate constituents with emphasis on clay-particle constituents. This description may also include a description of angularity. This parameter is critical for assessing hydrogeology of the site and should be carefully and fully documented.

Criteria for grain size (Wentworth Scale):

Particle Size (mm)	Individual Particle Term
>256	Boulder Gravel
64 - 256	Cobble Gravel
32 - 64	Very Coarse Pebble Gravel
16 - 32	Coarse Pebble Gravel
8 - 16	Medium Pebble Gravel
4 - 8	Fine Pebble Gravel
2 - 4	Granule Gravel
1 - 2	Very Coarse Sand
0.5 - 1	Coarse Sand
0.25 - 0.5	Medium Sand
0.125 - 0.25	Fine Sand
0.0625 - 0.125	Very Fine Sand
0.004 - 0.0625	Silt
<0.004	Clay

Criteria for Amounts

Term	%
Trace	0 – 5
Few	5 - 10
Little	10 - 20
Some	20 - 35
With	35 - 50
And	50 i.e. equal parts

- Gradation or Plasticity. For granular soil (sands or gravels) that should be described as wellgraded, poorly graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soil (silts or clays) should be described as non-plastic, low plastic, medium plastic, or highly plastic.

Criteria for Describing Plasticity

Descriptive item	Criteria
Nonplastic	A 1/8 inch (3 mm) thread cannot be rolled at any moisture content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times close to the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

- Dry Strength. Dry strength describes the crushing characteristics of a dry soil crumb about ¼ inch (5 mm) in diameter. If a crumb of dry soil is not available, after removing particles larger than No. 40 sieve size, mold at least three balls of soil about ¼ inch (5 mm) in diameter to the consistency of putty, adding water if necessary. Allow the balls to dry completely by oven, sun, or air drying, and then test their strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

Criteria for Describing Dry Strength

Descriptive item	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces and crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very high	The dry specimen cannot be broken between the thumb and a hard surface.

- Dilatancy. Dilatancy describes the soils reaction to shaking. After removing particles larger than No. 40 sieve size, prepare a ball of moist soil about ½ inch (15 mm) in diameter. Add enough water, if necessary, to make the soil soft but not sticky. Place the ball in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the ball which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the ball stiffens, and finally cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Criteria for Describing Dilatancy

Descriptive item	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear, or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

- Toughness. Toughness is the consistency of the soil near the plastic limit. After removing particles larger than the No. 40 sieve size, mold a ball of soil about ½ inch (15 mm) in diameter to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. The specimen is then rolled out by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. The thread is folded and rerolled repeatedly. During this manipulation, the moisture content is gradually reduced and the specimen stiffens, finally loses it plasticity, and crumbles when the plastic limit is reached.

Criteria for Describing Toughness

Descriptive item	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near the plastic limit. The lump and thread have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

- Color. The basic color of the soil (refer to Munsell soil color charts).

Criteria for Mottling:

Contrast Term	Description
Faint	indistinct
Distinct	easily seen
Prominent	outstanding

- Odor. Odor is described from a warm, moist sample. The odor should only be described if it is organic or unusual. An organic odor will have distinctive decaying vegetation smell. Unusual odors, petroleum product, chemical, and the like should be described.

- Soil Texture and Structure. Description of particle size distribution, arrangement of particles into aggregates, and their structure. This description includes joints, fissures, slicked sides, bedding, veins, root holes, debris, organic content, and residual or relict structure, as well as other characteristics that may influence the movement or retention of water or contaminants.

Structure (for description of soils only)

Descriptive item	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm (1/4 inch) thick; note thickness
Laminated	Alternating layers of varying material or color with layers less than 6 mm (1/ 4 inch) thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated (parallel grooves or scratches)
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

Additional descriptors for bedding or laminations

Term	Thickness (feet/meters)
Very Thickly Bedded	> 3.3’ (1 m)
Thickly Bedded	1’- 3.3’ (30 - 100 cm)
Medium Bedded	4” - 1’ (10 - 30 cm)
Thinly Bedded	1” - 4” (3 - 10 cm)
Very Thinly Bedded	0.4” - 1” (1 - 3 cm)
Thickly Laminated	0.12” - 0.4” (0.1 - 1 cm)
Thinly Laminated	<0.12” (<0.3 cm)

- Moisture Content. The amount of soil moisture described as dry, moist, or wet/saturated.

Criteria for Describing Moisture

Descriptive item	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet/saturated	Visible free water, usually soil is below water table.

- Relative Density or Consistency. An estimate of density of a fine-grained soil or consistency of a cohesive soil, usually based on standard penetration tests.

Criteria for Describing Consistency

Descriptive item	Criteria
Very soft	Thumb penetrates soil more than 1 inch
Soft	Thumb penetrates about 1 inch
Firm	Thumb indentation up to ¼ inch
Hard	No indentation with thumb, readily indented with thumbnail
Very Hard	Not indented with thumbnail

Density, based upon blow counts:

Sand or Gravel	Blows per foot	Silt or Clay	Blows per foot	Thumb Penetration
Very loose	0 - 4	Very soft	0 - 2	Very easily
Loose	4 - 10	Soft	2 - 4	Easily
Medium dense	10 - 30	Medium stiff	4 - 8	Moderate effort
Dense	30 - 50	Stiff	8 - 15	Indented easily
Very dense	>50	Very stiff	15 - 30	Indented by nail
		Hard	>30	Difficult by nail

- Cementation. An estimate of cementation of a coarse-grained soil.

Criteria for Describing Cementation

Descriptive item	Criteria
Weak	Crumbles or breaks with handling or little finger pressure.
Moderate	Crumbles or breaks with considerable finger pressure.
Strong	Will not crumble or break with finger pressure.

- Relative Permeability. An estimate of the permeability based on visual examination of materials (e.g., high permeability for course sand and gravel verses low permeability for silty clay). The estimate should address presence and condition of fractures (open, iron-stand, calcite-filled, open but claylined, etc.), as well as fracture density and orientation;

- Local Geologic Name. Any specific local name or generic name (i.e., alluvium, loess).

- Group Symbol. USCS of symbols.

The soil logs should also include a complete description of any tests run in the borehole; placement and construction details of piezometers, wells, and other monitoring equipment; abandonment records; geophysical logging techniques used; and notes on readings obtained by air monitoring instruments.

Examples of soil descriptions:
Fine to coarse **SAND**, and medium to coarse **GRAVEL**
Fine **GRAVEL**, some fine to coarse Sand, little Silt, trace Clay
Medium to coarse **SAND**, trace fine Gravel, trace fine Sand
Gray, wet, medium dense, fine to coarse **SAND**, some fine Gravel
Brown with distinct gray mottling, moist, soft, interbedded **SILT** and **CLAY**, trace fine Sand, very thinly bedded.

Notes:
-Always use capital letters for primary constituents, or both primary constituents if you use "and". The first letter of each subsequent component of soil content is capitalized.
-Describe grain size small to large (ex. fine to coarse Gravel).
-Within one percentage category, list in decreasing grain-size (ex. trace fine Gravel, trace fine Sand).

STANDARD OPERATING PROCEDURE

SOIL SCREENING USING A PID

1. PURPOSE

The purpose of this procedure is to screen soil samples while in the field for the presence of volatile organic vapors using a photoionization detector (PID).

2. PROCEDURE

2.1 FIELD PREPARATION

Charge and calibrate the instrument.

2.1.1 Forms

Daily Report Sheets
Tailgate Health and Safety
Field PID Screening Data Form

2.1.2 Equipment

PID with 10.6 eV lamp for lighter (molar mass) organic compounds, and an 11.7 eV lamp for heavier organic compounds.
Either a stainless steel (must be decontaminated between samples) or a disposable plastic or wooden spatula for cutting soil samples and transferring them to containers.
Latex or nitrile sampling gloves - sufficient quantity to change for each sample collection event.
Self-locking plastic bags for field screening
Watch or clock.
Permanent fine point markers.
DOT-approved sealed drums for storage of excess soil (if required).
Personal protective equipment as described within the Site Health and Safety Plan.

2.1.3 Documents

Health and Safety Plan
Workplan
Maps

2.1.4 Other

Cellular telephone
First aid kit
Personal comfort items
Bubble wrap for samples
Distilled water
Paper towels

2.2 FIELD ACTIVITIES

Select and install the lamp with the appropriate ionization energy for the objective of the field screening. See the PID instruction manual for proper lamp selection for various compounds.

2.2.1 Calibration

Calibrate the PID by following the calibration procedure described in the PID instruction manual. Be sure to use the appropriate calibration gas as identified within the manual.

2.2.2 Sample collection

After retrieving a soil sample from the sample location, segregate the portion of the sample identified for screening either a decontaminated stainless steel implement, or a disposable plastic or wooden implement. Place the soil sample into the zip-lock plastic bag and seal the bag. Set the plastic bag and sample aside for later PID screening. A new pair of disposable latex or nitrile gloves must be worn for each soil screening event.

After being placed into the self-locking plastic bag, the sample will be clearly labeled using permanent ink, and allowed to equilibrate with ambient air temperature (minimum wait of 15 minutes). If the ambient temperature is below 32 degrees Fahrenheit (0 degress Celsius), the sample should be placed in a heated vehicle or a building for 15 minutes prior to analysis.

Note and record the background PID response on the field PID data form, then slightly open the seal on the self-locking plastic bag, insert the PID probe tip, and observe and record the response. Do not allow the probe tip to come into contact with the soil sample to prevent the uptake of soil particles into the PID. If the vapor concentrations rise quickly and then subside, record the maximum reading indicated. If the vapor readings increase slowly, observe the readings and record the concentration response after one minute.

Record the observed vapor concentrations on the field PID data form, *and* the rate of response, as this provides useful information about the relative volatility of the vapor-emitting compounds. Record descriptions of the soil type and relative moisture content and note any visual or olfactory impacts.

Allow the monitoring equipment to return to zero before initiating the next sample screening.

3. QUALITY ASSURANCE

Always calibrate the instrument prior to use. Telephone the project manager prior to leaving the site at the completion of each day.

STANDARD OPERATING PROCEDURE

LOW-FLOW (MINIMUM DRAWDOWN) GROUNDWATER SAMPLING

1. PURPOSE

This standard operating procedure (SOP) provides a general framework for collecting ground water samples that are indicative of mobile organic and inorganic loads at ambient flow conditions (both the dissolved fraction and the fraction associated with mobile particulates). The SOP emphasizes the need to minimize stress by low water-level drawdowns, and low pumping rates (usually less than 1 liter/min) in order to collect samples with minimal alterations to water chemistry. This SOP is aimed primarily at sampling monitoring wells that can accept a submersible pump and have a screen, or open interval length of 10 feet or less (this is the most common situation). However, this procedure is flexible and can be used in a variety of well construction and ground-water yield situations. Samples thus obtained are suitable for analyses of ground water contaminants (volatile and semi-volatile organic analytes, pesticides, PCBs, metals and other inorganics), or other naturally occurring analytes.

This procedure does not address the collection of samples from wells containing light or dense non-aqueous phase liquids (LNAPLs and DNAPLs). For this the reader may wish to check: Cohen, R.M. and J.W. Mercer, 1993, DNAPL Site Evaluation; C.K. Smoley (CRC Press), Boca Raton, Florida and U.S. Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance; Washington, DC (EPA/530-R-93-001).

The screen, or open interval of the monitoring well should be optimally located (both laterally and vertically) to intercept existing contaminant plume(s) or along flowpaths of potential contaminant releases. It is presumed that the analytes of interest move (or potentially move) primarily through the more permeable zones within the screen, or open interval.

Proper well construction and development cannot be overemphasized, since the use of installation techniques that are appropriate to the hydrogeologic setting often prevents "problem well" situations from occurring. It is also recommended that as part of development or redevelopment the well should be tested to determine the appropriate pumping rate to obtain stabilization of field indicator parameters with minimal drawdown in shortest amount of time. With this information field crews can then conduct purging and sampling in a more expeditious manner.

The mid-point of the saturated screen length (which should not exceed 10 feet) is used by convention as the location of the pump intake. However, significant chemical or permeability contrast(s) within the screen may require additional field work to determine the optimum vertical location(s) for the intake, and appropriate pumping rate(s) for purging and sampling more localized target zone(s). Primary flow zones (high(er) permealability and/or high(er) chemical concentrations) should be identified in wells with screen lengths longer than 10 feet, or in wells with open boreholes in bedrock. Targeting these zones for water sampling will help insure that the low stress procedure will not underestimate contaminant concentrations. The Sampling and

Analysis Plan must provide clear instructions on how the pump intake depth(s) will be selected, and reason(s) for the depth(s) selected.

Stabilization of indicator field parameters is used to indicate that conditions are suitable for sampling to begin. Achievement of turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet, while desirable, are not mandatory. Sample collection may still take place provided the remaining criteria in this procedure are met. If after 4 hours of purging indicator field parameters have not stabilized, one of 3 optional courses of action may be taken: a) continue purging until stabilization is achieved, b) discontinue purging, do not collect any samples, and record in log book that stabilization could not be achieved (documentation must describe attempts to achieve stabilization) c) discontinue purging, collect samples and provide full explanation of attempts to achieve stabilization (note: there is a risk that the analytical data obtained, especially metals and strongly hydrophobic organic analytes, may not meet the sampling objectives).

2. PROCEDURE

2.1 FIELD PREPARATION

Notify client, property owner, and Regulatory agency as necessary.

2.1.1 Forms

- Water Level Data Sheet
- Daily Report Sheets
- Chain of Custodies
- Water Quality Data Sheet
- Field Service Request
- Tailgate Health and Safety
- Well Construction Log
- Well location map/site map
- Work Plan
- Health and Safety Plan
- Signed site access agreement

2.1.2 Equipment

- Extraction device - Adjustable rate, submersible pumps are preferred (for example, centrifugal or bladder pump constructed of stainless steel or Teflon). Adjustable rate, peristaltic pumps (suction) may be used with caution. Note that EPA guidance states: "Suction pumps are not recommended because they may cause degassing, pH modification, and loss of volatile compounds" (EPA/540/P-87/001, 1987, page 8.5-11). The use of inertial pumps is discouraged. These devices frequently cause greater disturbance during purging and sampling and are less easily controlled than the pumps listed above. This can lead to sampling results that are adversely affected by purging and sampling operations, and a higher degree of data variability.

- Tubing - Teflon or Teflon lined polyethylene tubing are preferred when sampling is to include VOCs, SVOCs, pesticides, PCBs and inorganics. PVC, polypropylene or polyethylene tubing may be used when collecting samples for inorganics analyses. However, these materials should be used with caution when sampling for organics. If these materials are used, the equipment blank (which includes the tubing) data must show that these materials do not add contaminants to the sample. Stainless steel tubing may be used when sampling for VOCs, SVOCs, pesticides, and PCBs. However, it should be used with caution when sampling for metals. The use of 1/4 inch or 3/8 inch (inner diameter) tubing is preferred. This will help ensure the tubing remains liquid filled when operating at very low pumping rates. Pharmaceutical grade (Pharmed) tubing should be used for the section around the rotor head of a peristaltic pump, to minimize gaseous diffusion.
- Water level measuring device(s), capable of measuring to 0.01 foot accuracy (electronic "tape", pressure transducer). Recording pressure transducers, mounted above the pump, are especially helpful in tracking water levels during pumping operations, but their use must include check measurements with a water level "tape" at the start and end of each record.
- Flow measurement supplies (e.g., graduated cylinder and stop watch).
- Interface probe, if needed.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at least 30 feet from the well so that the exhaust fumes do not contaminate the samples.
- Indicator field parameter monitoring instruments - pH, Eh, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Use of a flow-through-cell is required when measuring all listed parameters, except turbidity. Standards to perform field calibration of instruments. Analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW-846. For Eh measurements, follow manufacturer's instructions.
- Decontamination equipment including deionized or distilled water, Alconox, graduated cylinders, and paper towel
- Logbook(s), and other forms (for example, well purging forms).
- Laboratory provided containers and labels
- Laboratory-cleaned cooler
- Ice to keep the samples cold
- Well construction data, location map, field data from last sampling event.
- Well keys.
- Site specific Sample and Analysis Plan/Quality Assurance Project Plan.
- PID or FID instrument (if appropriate) to detect VOCs for health and safety purposes, and provide qualitative field evaluations.
- Calculator
- Latex or nitrile gloves
- Tools to access wells
- Knife, or scissors
- Garbage bags
- Two graduated 5-gallon pails to collect purge water

- Cellular phone
- Replacement locks
- Writing implements and an indelible marker

If needed:

- DOT-approved sealed drums for storage of purged well water, or a suitable location to disperse of liquid (i.e., on-site treatment system)
- Quantab ™ and Hach™ Titration kits
- Bubble wrap if required to protect samples during shipment to the laboratory.
- Machete or other vegetation-clearing tool

2.2 FIELD ACTIVITIES

2.2.1 Preliminary Site Activities

Check well for security damage or evidence of tampering, record pertinent observations.

Lay out sheet of clean polyethylene for monitoring and sampling equipment.

Remove well cap and immediately measure VOCs at the rim of the well with a PID or FID instrument and record the reading in the field logbook.

If the well casing does not have a reference point (usually a V-cut or indelible mark in the well casing), make one. Describe its location and record the date of the mark in the logbook.

A synoptic water level measurement round should be performed (in the shortest possible time) before any purging and sampling activities begin. It is recommended that water level depth (to 0.01 ft.) and total well depth (to 0.1 ft.) be measured the day before, in order to allow for re-settlement of any particulates in the water column. If measurement of total well depth is not made the day before, it should not be measured until after sampling of the well is complete. All measurements must be taken from the established referenced point. Care should be taken to minimize water column disturbance.

Check newly constructed wells for the presence of LNAPLs or DNAPLs before the initial sampling round. If none are encountered, subsequent check measurements with an interface probe are usually not needed unless analytical data or field head space information signal a worsening situation. Note: procedures for collection of LNAPL and DNAPL samples are not addressed in this SOP.

2.2.2 Well Purging and Sampling Procedure

Sampling wells in order of increasing chemical concentrations (known or anticipated) is preferred.

1. Install Pump – Lower pump, safety cable, tubing and electrical lines slowly (to minimize disturbance) into the well to the midpoint of the zone to be sampled. The Sampling and Analysis Plan should specify the sampling depth, or provide criteria for selection of intake depth for each well (see Section I). If possible keep the pump intake at least two feet above the bottom of the well, to minimize mobilization of particulates present in the bottom of the well. Collection of turbid free water samples may be especially difficult if there is two feet or less of standing water in the well.
2. Measure Water Level – Before starting pump, measure water level. If recording pressure transducer is used-initialize starting condition.
3. Purge Well
    a. Initial Low Stress Sampling Event – Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Check water level. Adjust pump speed until there is little or no water level drawdown (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue purging until indicator field parameters stabilize.

        Monitor and record water level and pumping rate every three to five minutes (or as appropriate) during purging. Record any pumping rate adjustments (both time and flow rate). Pumping rates should, as needed, be reduced to the minimum capabilities of the pump (for example, 0.1 - 0.4 l/min) to ensure stabilization of indicator parameters. Adjustments are best made in the first fifteen minutes of pumping in order to help minimize purging time. During pump start-up, drawdown may exceed the 0.3 feet target and then "recover" as pump flow adjustments are made. Purge volume calculations should utilize stabilized drawdown value, not the initial drawdown. Do not allow the water level to fall to the intake level (if the static water level is above the well screen, avoid lowering the water level into the screen). The final purge volume must be greater than the stabilized drawdown volume plus the extraction tubing volume.

        Wells with low recharge rates may require the use of special pumps capable of attaining very low pumping rates (bladder, peristaltic), and/or the use of dedicated equipment. If the recharge rate of the well is lower than extraction rate capabilities of currently manufactured pumps and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples (ideally the intake should not be moved during this recovery period). Samples may then be collected even though the indicator field parameters have not stabilized.

        NOTE: If well goes dry before at least 3 well volumes can be purged from the well, allow groundwater to recharge, then collect sample.

    b. Subsequent Low Stress Sampling Events – After synoptic water level measurement round, check intake depth and drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the intake

depth and extraction rate (use final pump dial setting information) from previous event(s). Perform purging operations as above.

4. Monitor Indicator Field Parameters – During well purging, monitor indicator field parameters (turbidity, temperature, specific conductance, pH, Eh, DO) every three to five minutes (or less frequently, if appropriate). Note: during the early phase of purging emphasis should be put on minimizing and stabilizing pumping stress, and recording those adjustments. Purging is considered complete and sampling may begin when all the above indicator field parameters have stabilized. Stabilization is considered to be achieved when three consecutive readings, taken at three (3) to five (5) minute intervals, are within the following limits:
   - turbidity (10% for values greater than 1 NTU),
   - DO (10%), specific conductance (3%),
   - temperature (3%),
   - pH (± 0.1 unit),
   - ORP/Eh (± 10 millivolts).

   All measurements, except turbidity, must be obtained using a flow-through-cell. Transparent flow-through-cells are preferred, because they allow field personnel to watch for particulate build-up within the cell. This build-up may affect indicator field parameter values measured within the cell and may also cause an underestimation of turbidity values measured after the cell. If the cell needs to be cleaned during purging operations, continue pumping and disconnect cell for cleaning, then reconnect after cleaning and continue monitoring activities.

   The flow-through-cell must be designed in a way that prevents air bubble entrapment in the cell. When the pump is turned off or cycling on/off (when using a bladder pump), water in the cell must not drain out. Monitoring probes must be submerged in water at all times. If two flow-through-cells are used in series, the one containing the dissolved oxygen probe should come first (this parameter is most susceptible to error if air leaks into the system).

5. Collect Water Samples – Water samples for laboratory analyses must be collected before water has passed through the flow-through-cell (use a by-pass assembly or disconnect cell to obtain sample).

   VOC samples should be collected first and 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.

   During purging and sampling, the tubing should remain filled with water so as to minimize possible changes in water chemistry upon contact with the atmosphere. It is recommended that 1/4 inch or 3/8 inch (inside diameter) tubing be used to help insure that the sample tubing remains water filled. If the pump tubing is not completely filled to the sampling point, use one of the following procedures to collect samples:

- add clamp, connector (Teflon or stainless steel) or valve to constrict sampling end of tubing;
- insert small diameter Teflon tubing into water filled portion of pump tubing allowing the end to protrude beyond the end of the pump tubing, collect sample from small diameter tubing;
- collect non-VOC samples first, then increase flow rate slightly until the water completely fills the tubing, collect sample and record new drawdown, flow rate and new indicator field parameter values.

Add preservative, as required by analytical methods, to samples immediately after they are collected if the sample containers are not pre-preserved. Check analytical methods (e.g. EPA SW-846, water supply, etc.) for additional information on preservation. Check pH for all samples requiring pH adjustment to assure proper pH value. For VOC samples, this will require that a test sample be collected during purging to determine the amount of preservative that needs to be added to the sample containers prior to sampling.

If determination of filtered metal concentrations is a sampling objective, collect filtered water samples using the same low flow procedures. The use of an in-line filter is required, and the filter size (0.45 um is commonly used) should be based on the sampling objective. Pre-rinse the filter with approximately 25 - 50 ml of ground water prior to sample collection. Preserve filtered water sample immediately. Note: filtered water samples are not an acceptable substitute for unfiltered samples when the monitoring objective is to obtain chemical concentrations of total mobile contaminants in ground water for human health risk calculations.

Label each sample as collected. Samples requiring cooling (volatile organics, cyanide, etc.) will be placed into a cooler with ice or refrigerant for delivery to the laboratory. Metal samples after acidification to a pH less than 2 do not need to be cooled.

6. Post Sampling Activities – If recording pressure transducer is used, remeasure water level with tape.

   After collection of the samples, the pump tubing may either be dedicated to the well for resampling (by hanging the tubing inside the well), decontaminated, or properly discarded.

   Before securing the well, measure and record the well depth (to 0.1 ft.), if not measured the day before purging began. Note: measurement of total well depth is optional after the initial low stress sampling event. However, it is recommended if the well has a “silting” problem or if confirmation of well identity is needed.

   Secure the well.

2.2.3 Decontamination

Decontaminate sampling equipment prior to use in the first well and following sampling of each subsequent well. Pumps will not be removed between purging and sampling operations. The pump and tubing (including support cable and electrical wires which are in contact with the well) will be decontaminated by one of the procedures listed below.

Procedure 1
The decontaminating solutions can be pumped from either buckets or short PVC casing sections through the pump or the pump can be disassembled and flushed with the decontaminating solutions. It is recommended that detergent and isopropyl alcohol be used sparingly in the decontamination process and water flushing steps be extended to ensure that any sediment trapped in the pump is removed. The pump exterior and electrical wires must be rinsed with the decontaminating solutions, as well. The procedure is as follows:

- Flush the equipment/pump with potable water.
- Flush with non-phosphate detergent solution. If the solution is recycled, the solution must be changed periodically.
- Flush with potable or distilled/deionized water to remove all of the detergent solution. If the water is recycled, the water must be changed periodically.
- Flush with isopropyl alcohol (pesticide grade). If equipment blank data from the previous sampling event show that the level of contaminants is insignificant, then this step may be skipped.
- Flush with distilled/deionized water. The final water rinse must not be recycled.

Procedure 2
Steam clean the outside of the submersible pump. Pump hot potable water from the steam cleaner through the inside of the pump. This can be accomplished by placing the pump inside a three or four inch diameter PVC pipe with end cap. Hot water from the steam cleaner jet will be directed inside the PVC pipe and the pump exterior will be cleaned. The hot water from the steam cleaner will then be pumped from the PVC pipe through the pump and collected into another container. Note: additives or solutions should not be added to the steam cleaner.

Pump non-phosphate detergent solution through the inside of the pump. If the solution is recycled, the solution must be changed periodically.

Pump potable water through the inside of the pump to remove all of the detergent solution. If the solution is recycled, the solution must be changed periodically.

Pump distilled/deionized water through the pump. The final water rinse must not be recycled.

2.2.4 Disposal

Dispose of all gloves, bailers, rope/string, tubing, and filters used to collect the sample prior to accessing the next well. Empty purge water onto the ground, away from the well, or in the event containerizing is required, transfer purged water from the pail into the appropriate storage container for storage until disposal/treatment is arranged.

3. QUALITY ASSURANCE

Quality control samples are required to verify that the sample collection and handling process has not compromised the quality of the ground water samples. All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples shall be collected for each batch of samples (a batch may not exceed 20 samples). Trip blanks are required for the VOC samples at a frequency of one set per VOC sample cooler.

- Field duplicate.
- Matrix spike.
- Matrix spike duplicate.
- Equipment blank.
- Trip blank (VOCs).
- Temperature blank (one per sample cooler).

Equipment blank shall include the pump and the pump's tubing. If tubing is dedicated to the well, the equipment blank will only include the pump in subsequent sampling rounds.

Collect samples in order from wells with lowest contaminant concentration to highest concentration. Collect equipment blanks after sampling from contaminated wells and not after background wells.

Field duplicates are collected to determine precision of sampling procedure. For this procedure, collect duplicate for each analyte group in consecutive order (VOC original, VOC duplicate, SVOC original, SVOC duplicate, etc.).

If split samples are to be collected, collect split for each analyte group in consecutive order (VOC original, VOC split, etc.). Split sample should be as identical as possible to original sample.

All monitoring instrumentation shall be operated in accordance with EPA analytical methods and manufacturer's operating instructions. EPA analytical methods are listed in 40 CFR 136, 40 CFR 141, and SW- 846 with exception of Eh, for which the manufacturer's instructions are to be followed. Instruments shall be calibrated at the beginning of each day. If a measurement falls outside the calibration range, the instrument should be re-calibrated so that all measurements fall within the calibration range. At the end of each day, check calibration to verify that instruments remained in calibration. Temperature measuring equipment, thermometers and thermistors, need not be calibrated to the above frequency. They should be checked for accuracy prior to field use according to EPA Methods and the manufacturer's instructions.

Avoid cross-contamination of wells with the water level indicator, and sampling equipment by conducting proper decontamination procedures described above. Take care in labeling the samples, and the corresponding *Chain-of-Custody* with the correct sample date, time and well identification. All labeling must be consistent between sample labels and the *Chain of Custody*. Keep samples on ice following collection, and be conscience of "hold-times" for the samples. It is imperative that samples are submitted to the laboratory prior to the exceedence of hold times.

4. FIELD LOG BOOK

A field log shall be kept to document all ground water field monitoring activities (see attached example matrix), and record all of the following:

- Well identification.
- Well depth, and measurement technique.
- Static water level depth, date, time and measurement technique.
- Presence and thickness of immiscible liquid (NAPL) layers and detection method.
- Pumping rate, drawdown, indicator parameters values, and clock time, at the appropriate time intervals; calculated or measured total volume pumped.
- Well sampling sequence and time of each sample collection.
- Types of sample bottles used and sample identification numbers.
- Preservatives used.
- Parameters requested for analysis.
- Field observations during sampling event.
- Name of sample collector(s).
- Weather conditions.
- QA/QC data for field instruments.
- Any problems encountered should be highlighted.
- Description of all sampling equipment used, including trade names, model number, diameters, material composition, etc.

STANDARD OPERATING PROCEDURE

SAMPLE IDENTIFICATION

1.0 PURPOSE

Locations for collection of samples are affixed alpha-numeric codes which are used to track affixed laboratory results and enable presentation of data on maps and drawings. Each plan view location where a sample is collected is issued a unique numeric code (number) which corresponds to a specific map location at a site. An alpha-code (letter) is used to describe the type of sampling activity performed at the specific numeric location. The date of sample collection will be listed and used to delineate sampling events.

The alpha-numeric codes used to identify existing wells and sample locations will be used to identify samples collected from existing wells or sample locations. The following alpha codes will be used to identify new sample locations:

B:	Borehole (no monitoring well installed)
EW or EX:	Extraction well for remediation of groundwater
MW:	Water table monitor well
P:	Piezometer well
PW:	Private residential well or Public water supply well
TP:	Test pit
SS:	Surface soil
SW:	Surface water sampling station
A:	Air sampling station
SD:	Sediment

Each number used at a site should correspond to one, and only one, location. A typical series of alpha numeric codes for a site might include test pit locations T-1 through T-12; borings B-13, B-14, B-15; monitor wells MW-16, MW-17, MW-18, etc. A borehole drilled with the intent of installing a monitor well or piezometer will be identified as MW or P. There should not be a borehole log B-1 for monitor well MW-1.

If previous work has been performed at a site, the alpha-numeric code should continue with previous successive numbers. If there is any potential for conflict with identified sample number identifiers, the proposed sample number should begin with series 101, 10001, or other appropriate system.

2.0 CONTAINER LABELING

Each sample container, tag, and/or label will contain the following information:

- Project number and/or project name
- Sample type identification code and number
- Date and time of collection
- Sampler's initials
- Preservative

The sample identification code will be an alpha-numeric code used to specify the material type, location, and sampling interval (i.e., depth), where appropriate, for each sample. For example: SB110-3 to 5 refers to a soil sample from borehole location 110 over the 3 to 5-foot depth interval, and MW-203 refers to a groundwater sample from monitor well location 203. The date of sample collection will be listed and used to delineate sampling events.

Listed below are the standard codes to identify the type of material to be sampled. To an extent, these codes also identify the sampling location.

SB: Sample from a soil borehole

WB: Water sample from a borehole with no monitor well

MW: Water table monitor well (soils and groundwater)

P: Piezometer well (soils and groundwater)

PW: Private residential well water samples

ST: Trench or test pit (soil)

WT: Trench or test pit (water)

SS: Surficial soil

SW: Surface water

SD: Sediment

A: Air

If a sample is a composite, the letter "C" should follow the depth intervals over which the composite was collected. An appropriate description of the sample should be recorded on the chain-of-custody record and field notebook.

3.0 SAMPLE INDENTIFICATION – MULTI SITE PROJECTS

For project situations where a number of sites are being investigated concurrently for an individual client, each site should be assigned a series of numbers for use in identifying sampling locations. An example is given below:

Site	Environmental Samples	QA Samples
# 1	101 to 119	11 to 19
# 2	201 to 299	21 to 29
# 3	301 to 399	31 to 39
# 4	401 to 499	41 to 49
# 5	501 to 599	51 to 59

# 6	601 to 699	61 to 69
# 7	701 to 799	71 to 79
# 8	801 to 899	81 to 89

For example; SD301 refers to a sediment sample collected at sampling location 301 at the number 3 site; and MW-21 refers to a QA (trip blank, field blank, duplicate) groundwater sample from a monitoring well at the number 2 site.

Samples collected for matrix spike and matrix spike duplicates analysis will be identified with the code MSD (e.g., MW-21-MSD).

STANDARD OPERATING PROCEDURE

GROUNDWATER ELEVATIONS

1. PURPOSE

The purpose of this procedure is to obtain groundwater level measurements from wells and piezometers to assist in defining site hydrogeologic conditions.

2. PROCEDURE

2.1 FIELD PREPARATION

Notify client, property owner, and regulatory angency as necessary.

2.1.1 Forms

Water Level Data Sheet
Daily Report Sheets
Tailgate Health and Safety
Field Service Request

2.1.2 Equipment

Well keys
Electronic water level indicator
Calculator
Latex or nitrile gloves
Tools to access wells
Metal detector, turkey baster or plastic cup
Pens and permanent markers.
Decontamination equipment including deionized or distilled water, Alconox, and paper towels.
Garbage bags.

2.1.3 Documents

Well Construction Log, or total well depth and previous water level measurements
Well location map/site map
Work Plan
Health and Safety Plan
Signed site access agreement, as applicable

2.1.4 Other

Cellular phone
Replacement locks
Writing implements and an indelible marker
First aid kit
Personal comfort items
Machete or other vegetation-clearing tool

2.2 FIELD ACTIVITIES

Don a new pair of latex or nitrile gloves and open the well with a socket set if it is a flush grade manhole cover or a key if it is an above grade cover.

Beware of insects (particularly wasps and bees) that may be nesting within the protective casing. Bail out any standing water with a turkey baster or cup in flush-grade manholes. Note on presence and appearance of standing water, insects, and well condition.

Unlock, loosen, and carefully remove locking expandable well cap.

Well may be under pressure. Always face away from well when removing well cover. Allow groundwater elevation to stabilize for a minimum of five minutes prior to measuring depth to groundwater. When working on smaller sites, it may be appropriate to open all of the wells first, and then gauge them.

2.2.1 Identify the Monitoring Point for the Well

The well monitoring point may be the north side of the riser casing and marked with an indelible marker, or on the highest side of the top of casing. The top of an above-grade protector or flush-grade manhole should never be used as a reference point due to frost heave and settling. Note the reference point used on the *Water Level Data Sheet.*

2.2.2 Obtain the Water Level Measurement

Water levels will be measured from suspected cleanest (up-gradient) well to the suspected most contaminated (down-gradient or near source) well.

Use a consistent sensitivity setting for all wells.

Lower the decontaminated probe into the well until a "beep" sound is heard. The probe should be raised and lowered to confirm the exact water level. NOTE: condensation inside the well casing can result in a premature sounding and contaminants can result in incorrect confirmatory measurements. Refer to previous depths to groundwater recorded on the *Field Groundwater Sample Form* to verify measurement, if available. When a false reading is suspected, gently shake the tape of the electronic water level indicator until the audible sound stops. Then proceed to lower the probe to confirm.

Read the tape at the monitoring point and recorded the measurement to the nearest 0.01-foot on the *Water Level Data* Sheet.

Lower probe to bottom of well and record total depth on *Field Groundwater Sample Form,* if necessary.

Complete all information on the *Water Level Data* Sheet.

2.2.4 Decontamination

The measuring device shall be decontaminated immediately after each use. The decontamination procedure should be initiated while reeling in the tape and probe: wipe tape with clean paper towel soaked with deionized or distilled water and Alconox solution, rinse probe with deionized or distilled water and Alconox solution, rinse tape and probe with deionized or distilled water, and dry probe with clean paper towel. Apply decontamination fluids with a labeled spray bottle.

3. QUALITY ASSURANCE

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures. However, the following QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

STANDARD OPERATING PROCEDURE

MONITORING WELL DEVELOPMENT

1. PURPOSE

This procedure describes development procedures for wells and piezometers in unconsolidated and consolidated (rock) materials. Adherence to this procedure will ensure that wells and piezometers installed as part of a groundwater impact investigation will be adequate for the collection of groundwater quality samples and water level measurements. Wells or piezometers may be installed to determine one or more of the following: 1) water table or piezometric elevations and their fluctuation over time; 2) the presence or absence of light non-aqueous phase liquids (LNAPLs) on the water surface, or dense non-aqueous phase liquids (DNAPLs) at depth; and 3) the presence or absence of specific contaminant compounds in the groundwater.

2. PROCEDURE

2.1 FIELD PREPARATION

Call for utility clearance more than 72 hours in advance of field activity commencement to identify buried utilities in the area of subsurface activity.
Notify the client, property owner, and Regulatory agency as necessary.

2.1.1 Forms

Field notebook
Field well development forms
Tailgate Health and Safety form
Daily Report Sheets

2.1.2 Equipment

Extra well caps (expanding, locking) to replace missing or damaged caps.
Extra locks (keyed alike) to replace missing or broken well locks.
Well keys
Bailers (disposable or dedicated) and/or submersible pump, discharge hose and generator.
Graduated bucket.
Tools to open flush-mount wells.
Latex or nitrile gloves.
Pens, pencils and permanent markers.
Water quality meter (temperature-pH-conductivity)

2.1.3 Documents

Site Access Agreements (if necessary)
Site maps
Workplan
Health and Safety Plan

2.1.4 Other

Cellular telephone
First aid kit
Personal comfort items
Drum(s) or polyethylene tank(s) if groundwater needs to be contained.

2.2 Well Development

Wells and monitor wells will be developed using either a pump or a bailer or a combination of the two to remove the effects of drilling and installation operations. If a monitor well can be purged dry, development will consist of slowly purging the well dry to limit agitation. Development is complete when ten well volumes have been removed, or sediment-free water is produced. If a monitor well cannot be purged dry, it will be developed by alternately surging and purging the well for a minimum of 30 minutes and then pumping or bailing until ten well volumes are removed or until sediment free water is produced.

The well casing volume is determined as follows:

- Using the electronic water level indicator, determine the depth to the top of the water table surface (H_1).
- Determine the depth to the bottom of the well (H_2) using the *Well Construction Log* if verified, or by using the water level indicator. Measure the total well depth during your first visit to a site.
- Calculate the height of the column of water (H) as the difference between the two measurements ($H = H_2 - H_1$).
- Calculate the volume of water occupying the well casing using the formula to calculate the volume of a cylinder:

$$\mathbf{V = \pi r^2 H}$$

where:
V = volume of water in the casing, in gallons
π = the constant "Pi", approximately equal to 3.14
r = radius of the well casing, in feet
H = height of the initial column of water in the casing, in feet

It is imperative that all units are compatible; i.e., do not use inches for **r**, meters for **H**, and gallons for **V.**
A simplified version of this formula is provided using the well casing diameter in inches:

Well Casing Diameter (inches)	Equation
1	V= H (0.0408)
2	V= H (0.1632)
4	V=H (0.6528)
6	V=H (1.4688)

where:
V = volume of water in the casing, in gallons
H = height of the initial column of water in the casing, in feet

Multiply the casing volume by three or five to determine the minimum volume of water that should be purged from the well prior to collecting a water sample.

Periodic measurements and observations of field parameters including temperature, specific conductance, pH, visual appearance and odor will be made and recorded on well development/purge summary form as each well is developed. In addition, time expended in development, volume of water removed, and any sedimentation present in the bottom of each well before and after development will be noted. Water level measurements will be obtained prior to and following development, and following water level stabilization.

3. QUALITY ASSURANCE

There are no specific quality assurance (QA) activities which apply to the implementation of these procedures. However, the following QA procedures apply:

1. All data must be documented on field data sheets or within site logbooks/notebooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation, and they must be documented.

STANDARD OPERATING PROCEDURE

CHAIN-OF-CUSTODY PROCEDURES

1.0 PURPOSE

Chain-of-custody procedures are established to provide sample integrity. Sample custody protocols will be based on procedures as described in "NEIC Policies and Procedures", EPA-330/9-78-DD1-R, Revised June, 1985. This custody is in two parts: sample collection and laboratory analysis. A sample is under a person's custody if it meets the following requirements:

- It is in the person's possession;
- It is in the person's view, after being in the person's possession;
- It was in the person's possession and it was placed in a secured location; or
- It is in a designated secure area.

2.0 FIELD SPECIFIC CUSTODY PROCEDURES

The sample packaging and shipment procedures summarized below will assure that the samples will arrive at the laboratory with the chain-of-custody intact.

Field procedures are as follows:

(a) The field sampler is personally responsible for the care and custody of the samples until they are transferred or properly dispatched. As few people as possible should handle the samples.

(b) All bottles should be tagged with sample numbers and locations.

(c) Sample tags should be filled out using waterproof ink for each sample.

(d) The Project Manager should review all field activities to determine whether proper custody procedures were followed during the field work and decide if additional samples are required.

Transfer of Custody and Shipment Procedures are as follows:

(a) Samples should be accompanied by a properly completed chain-of-custody form (Attachment A). The sample numbers and locations will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage area.

(b) Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis with a separate signed custody record enclosed in each sample

box or cooler. Shipping containers will be locked and secured with strapping tape in at least two locations for shipment to the laboratory. Custody seals will be used for samples shipped to laboratories. When custody seals are used, two printed, numbered custody seals will be placed on each cooler and the numbers will also appear on the chain-of-custody forms, or two signed and dated seals will be placed on the cooler. Clear tape will be placed over the seals.

(c) Whenever samples are split with a source or government agency, a separate Sample Receipt is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the facility or agency should request the representative's signature acknowledging sample receipt. If the representative is unavailable or refuses, this is noted in the "Received By" space.

(d) If the samples are sent by common carrier, a bill of lading should be used. Receipts of bills of lading will be retained as part of the permanent documentation. If sent by mail, the package will be registered with return receipt requested. Commercial carriers are not required to sign off on the custody form as long as the custody forms are sealed inside the sample cooler. Air bill information will be recorded on chain-of-custody forms.

STANDARD OPERATING PROCEDURE

CALIBRATION OF FIELD INSTRUMENTS

Note: Taken from "Standard Operating Procedure Calibration of Field Instruments" (U.S. EPA January 19, 2010, Revision Number 2).

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for groundwater and surface water. Water quality parameters include temperature, pH, dissolved oxygen, specific conductance, oxidation/reduction potential [ORP], and turbidity.

This SOP is written for instruments that measure temperature, pH, dissolved oxygen, specific conductance, turbidity, and/or oxidation/reduction potential [ORP] and the probe readings for pH, dissolved oxygen, and specific conductance are automatically corrected for temperature.

For groundwater monitoring, the instrument must be equipped with a flow-through-cell. Turbidity is measured using a separate instrument. It must not be measured in a flow-through-cell because the flow-through-cell acts as a sediment trap.

2.0 HEALTH AND SAFETY WARNINGS

Read all labels on the standards and note any warnings on the labels. Wear appropriate personal protection equipment (e.g., gloves, eye shields, etc.) when handling the standards. If necessary, consult the Material Safety Data Sheets (MSDS) for additional safety information on the chemicals in the standards.

3.0 GENERAL

All monitoring instruments must be calibrated before they are used to measure environmental samples. For instrument probes that rely on the temperature sensor (pH, dissolved oxygen, specific conductance, and oxidation/reduction potential [ORP]), each temperature sensor needs to be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST). Before any instrument is calibrated or used to perform environmental measurements, the instrument must stabilize (warm-up) according to manufacturer's instructions and must have no air bubbles lodged between the probe and probe guard.

Most projects will require at least two standards to bracket the expected measurement range. This means that one standard is less than the expected value and one is higher. When an environmental sample measurement falls outside the calibration range, the instrument must be recalibrated to bracket the new range before continuing measurements. Otherwise, the measurements that are outside the calibration range will need to be qualified.

The manufacturer's instruction manual (including the instrument specifications) must accompany the instrument into the field.

4.0 FREQUENCY OF CALIBRATION

At a minimum, the instrument is calibrated prior to use on the day the measurements are to be performed. A post calibration check at the end of the day is performed to determine if the instrument drifted out of calibration. Some projects may require more frequent calibration checks throughout the day in addition to the check at the end of the day. For these checks, the instrument can be recalibrated during the day if the instrument drifted out of calibration and only the data measured prior to the check would need to be qualified. The calibration/post calibration data information should be recorded in the field notebook and/or on an equipment calibration form.

Instruments (e.g., sonde) that monitor continuously over a period of time are calibrated before deployment. When these instruments are recovered, the calibration is checked to determine if any of them drifted out of calibration.

Some instruments lose their calibration criteria when they are turned off. Those instruments can either be left on all day (battery dependent) or calibrated at each sampling location. If they are calibrated at each sampling location, a post calibration check is not needed.

Ideally, the temperature of the standards should be close to the temperature of the ambient water that is being measured.

5.0 CALIBRATION PROCEDURES

Prior to calibration, all instrument probes and cable connections must be cleaned and the battery checked according to the manufacturer's instructions. Failure to perform these steps (proper maintenance) can lead to erratic measurements.

If a multi-probe instrument is to be used, program the instrument to display the parameters to be measured (e.g., temperature, pH, percent dissolved oxygen, mg/L dissolved oxygen, specific conductance, and ORP).

The volume of the calibration solutions must be sufficient to cover both the probe and temperature sensor (see manufacturer's instructions for the volume to be used). Check the expiration date of the standards. Do not use expired standards. All standards are stored according to manufacturer instructions.

5.1 TEMPERATURE

Most instrument manuals state there is no calibration of the temperature sensor, but the temperature sensor must be checked to determine its accuracy. This accuracy check is performed at least once per year and the accuracy check dat/ information is kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was over a year, the temperature sensor accuracy needs to be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor must be checked. This procedure is not normally performed in the field. If the instrument is obtained from a rental company, the rental company should have performed the calibration check and should include with the instrument documentation that it was performed.

Verification Procedure

1. Fill a container with water and adjust the water temperature to below the water body's temperature to be measured. Use ice or warm water to adjust the temperature.

2. Place a thermometer that is traceable to the National Institute of Standards and Technology (NIST) and the instrument's temperature sensor into the water. Wait for both temperature readings to stabilize.

3. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (e.g., ±O.2°C). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.

4. Adjust the water temperature to a temperature higher than the water body to be measured.

5. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (e.g., ± 0.20 C). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.

5.2 pH (electro metric)

The pH of a sample is determined electrometrically using a glass electrode. Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. If the water body's pH is unknown, then three standards are needed for the calibration: one c1ose to seven, one at least two pH units below seven, and the other at least two pH units above seven. Instruments that will not accept three standards will need to be re-calibrated if the water sample's pH is outside the initial calibration range described by the two standards.

Calibration Procedure

1. Allow the buffered standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the buffered standards so each standard will cover the pH probe and temperature sensor.

3. Remove probe from its storage container, rinse with deionized water, and remove excess water.

4. Select measurement mode. Immerse probe into the initial standard (e.g., pH 7).

5. Wait until the readings stabilize. If the reading does not change within 30 seconds, select calibration mode and then select "pH". Enter the buffered standard value into instrument.

6. Remove probe from the initial standard, rinse with deionized water, and remove excess water.

7. Immerse probe into the second standard (e.g., pH 4). Repeat step 5.

8. Remove probe from the second standard, rinse with deionized water, and remove excess water. If instrument only accepts two standards, the calibration is complete. Go to step 'II. Otherwise continue.

9. Immerse probe in third buffered standard (e.g., pH 10) and repeat step 5.

10. Remove probe from the third standard, rinse with deionized water, and remove excess water.

11. Select measurement mode, if not already selected. To ensure that the initial calibration standard (e.g., pH 7) has not changed, immerse the probe into the initial standard. Wait for the readings to stabilize. The reading should read the initial standard value within the manufacturer's specifications. If not, re-calibrate the instrument. If re-calibration does not help, the calibration range may be too great. Reduce calibration range by using standards that are closer together.

12. The calibration is complete. Rinse the probe with deionized water and store the probe according to manufacturer's instructions.

13. Record the calibration information in the field notebook and/or on an equipment calibration form.

5.3 DISSOLVED OXYGEN

Dissolved oxygen (DO) content in water is measured using a membrane electrode. To insure proper operation, the DO probe's membrane and electrolyte should be replaced prior to calibration for the sampling event. The new membrane may need to be conditioned before it is used; consult manufacturer's manual on how the conditioning is to be performed. Failure to perform this step may lead to erratic measurements. Before performing the calibration/measurements, inspect the membrane for air bubbles and nicks.

Note: some manufacturers require an altitude correction instead of a barometric correction. In that case, enter the altitude correction according to the manufacturer's directions in Step 5 and then proceed to Step 6.

Note: some instruments have a built-in barometer. Follow the manufacturer's instructions for entering the barometric value in step 5.

Calibration Procedure

1. Gently dry the temperature sensor and remove any water droplets from the DO probe's sensor membrane according to manufacturer's instructions. Note that the evaporation of moisture on the temperature sensor or DO probe may influence the readings during calibration.

2. Create a 100 percent water-saturated air environment by placing a wet sponge or a wet paper towel on the bottom of the DO calibration container. Place the DO probe into the calibration container. The probe is loosely fitted into the calibration container to prevent the escape of moisture evaporating from the sponge or paper towel while maintaining ambient pressure (see manufacturer's instructions). Note that the probe and the temperature sensor must not come in contact with these wet items.

3. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 10 to 15 minutes). During this time, turn on the instrument to allow the DO probe to warm-up. Select the measurement mode. Check the temperature readings. Readings must stabilize before continuing to the next step.

4. Select calibration mode; then select "DO %".

5. Enter the local barometric pressure (usually in mm of mercury) for the sampling location into the instrument. This measurement must be determined from an on-site barometer. Do not use barometric pressure obtained from the local weather services unless the pressure is corrected for the elevation of the sampling location. [Note: inches of mercury times 25.4 mm/inch equals mm of mercury or consult Oxygen Solubility at Indicated Pressure chart attached to the SOP for conversion at selected pressures].

6. The instrument should indicate that the calibration is in progress. After calibration, the instrument should display percent saturated DO.

7. Select measurement mode and set the display to read DO mg/L and temperature. Compare the DO mg/L reading to the Oxygen Solubility at Indicated Pressure chart attached to the SOP. The numbers should agree. If they do not agree within the accuracy of the instrument (usually ± 0.2 mg/L), repeat calibration. If this does not work, change the membrane and electrolyte solution.

8. Remove the probe from the container and place it into a 0.0 mglL DO solution (see footnote). Check temperature readings. They must stabilize before continuing.

9. Wait until the "mg/L DO" readings have stabilized. The instrument should read less than 0.5 mg/L (assuming an accuracy of ± 0.2 mg/L). If the instrument reads above 0.5 mg/L or reads negative, it will be necessary to clean the probe, and change the membrane and electrolyte solution. If this does not work, try a new 0.0 mg/L DO solution. If these changes do not work, contact the manufacturer. Note: some projects and instruments may have different accuracy requirements. The 0.5 mg/L value may need to be adjusted based on the accuracy requirements of the project or instrument.

10. After the calibration has been completed, rinse the probe with tap or deionized water and store the probe according to manufacturer's instructions. It is important that all of the 0.0 mg/L DO solution be rinsed off the probe so as not to effect the measurement of environmental samples.

11. Record calibration information in the field notebook and/or on an equipment calibration form.

Note: You can either purchase the 0.0 mg/L DO solution from a vendor or prepare the solution yourself. To prepare a 0.0 mg/L DO solution, follow the procedure stated in Standard Methods (Method 4500-0 G). The method basically states to add excess sodium sulfite (until no more dissolves) and a trace amount of cobalt chloride (read warning on the label before use) to water.

This solution is prepared prior to the sampling event. Note: this solution can be made without cobalt chloride, but the probe will take longer to respond to the low DO concentration.

5.4 SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to carry an electrical current. Specific conductance is the conductivity value corrected to 25°C.

Most instruments are calibrated against a single standard which is near the specific conductance of the environmental samples. The standard can be either below or above the specific conductance of the environmental samples. A second standard is used to check the linearity of the instrument in the range of measurements. When performing specific conductance measurement on groundwater or surface water and the measurement is outside the initial calibration range defined by the two standards, the instrument will need to be re-calibrated using the appropriate standards.

Specific Conductance Calibration Procedure

1. Allow the calibration standards to equilibrate to the ambient temperature.

2. Fill calibration containers with the standards so each standard will cover the probe and temperature sensor. Remove probe from its storage container, rinse the probe with deionized water or a small amount of the standard (discard the rinsate), and place the probe into the standard.

3. Select measurement mode. Wait until the probe temperature stabilizes.

4. Select calibration mode, then specific conductance. Enter the specific conductance standard. Value. Make sure the units on the standard are the same as the units used by the instrument. If the units are different, convert the units on the standard to the units used by the instrument.

5. Select measurement mode. The reading should remain within the manufacturer's specifications. If it does not, re-calibrate. If readings continue to change after re-calibration, consult the manufacturer's instruction manual or replace the calibration solution.

6. Remove probe from the standard, rinse the probe with deionized water or a small amount of the second standard (discard the rinsate), and place the probe into the second standard. The second standard will serve to verify the linearity of the instrument. Read the specific conductance value from the instrument and compare the value to the specific conductance on the standard. The two values should agree within the specifications of the instrument. If they do not agree, re-calibrate. If readings do not compare, then the second standard may be outside the linear range of the instrument. Use a standard that is closer to the first standard and repeat the verification. If values still do not compare, try cleaning the probe or consult the manufacturer.

7. After the calibration has been completed, rinse the probe with deionized water and store the probe according to manufacturer's instructions.

8. Record the calibration information in the field notebook and/or on an equipment calibration form.

Note: for projects where specific conductance is not a critical measurement it may be possible to calibrate with one standard in the range of the expected measurement.

5.5 OXIDATIONIREDUCTION POTENTIAL (ORP)

The oxidation/reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode. The electrometric difference is measured in millivolts and is temperature dependent.

Calibration or Verification Procedure

1. Allow the calibration standard (a Zobell solution: read the warning on the label before use) to equilibrate to ambient temperature.

2. Remove the probe from its storage container and place it into the standard.

3. Select measurement mode.

4. Wait for the probe temperature to stabilize, and then read the temperature.

5. If the instrument is to be calibrated, do Steps 6 and 7. If the instrument calibration is to be verified, then go to Step 8.

6. Look up the millivolt (mv) value at this temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. You may need to interpolate millivolt value between temperatures. Select "calibration mode", then "ORP". Enter the temperature-corrected ORP value into the instrument.

7. Select measurement mode. The readings should remain unchanged within manufacturer's specifications. If they change, re-calibrate. If readings continue to change after re-calibration, try a new Zobell solution or consult the manufacturer. Go to Step 9.

8. If the instrument instruction manual states that the instrument is factory calibrated, then verify the factory calibration against the Zobell solution. If they do not agree within the specifications of the instrument, try a new Zobell solution. If it does not agree, the instrument will need to be re-calibrated by the manufacturer.

9. After the calibration has been completed, rinse the probe with deionized water and store the probe according to manufacturer's instructions.

10. Record the calibration information in the field notebook and/or an equipment calibration form.

5.6 TURBIDITY

The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidity meter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed ninety degrees to the path of the light source. Note: the below calibration procedure is for a turbidimeter which the sample is placed into a cuvette.

Some instruments will only accept one standard. For those instruments, the second, third, etc., standards will serve as check points.

Calibration Procedures

1. Allow the calibration standards to equilibrate at the ambient temperature. The use of commercially available polymer primary standards (AMCO-AEPA-l) is preferred; however, the standards can be prepared using Formazin (read the warning on the label before use) according to the EPA analytical Method 180.1. Other standards may be used if they can be shown that they are equivalent to the previously mentioned standards.

2. If the standard cuvette is not sealed, rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe dry the inside of the cuvette because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.

3. Before performing the calibration procedure, make sure the cuvettes are not scratched and the outside surfaces are dry and free from fingerprints and dust. If the cuvette is scratched or dirty, discard or clean the cuvette respectively. Note: some manufacturers require the cuvette to be orientated in the instrument in a particular direction for accurate reading.

4. Select a low value standard such as a zero or 0.02 NTU and calibrate according to manufacturer's instructions. Note: a zero standard (approximately 0 NTU) can be prepared by passing distilled water through a 0.45 micron pore size membrane filter.

5. Select a high standard and calibrate according to manufacturer's instructions or verify the calibration if instrument will not accept a second standard. In verifying, the instrument should read the standard value to within the specifications of the instrument. If the instrument has range of scales, check each range that will be used during the sampling event with a standard that falls within that range.

6. Record the calibration information in the field notebook and/or on an equipment calibration form.

6.0 POST CALIBRATION CHECK

After the initial calibration is performed, the instrument's calibration may drift during the measurement period. As a result, you need to detennine the amount of drift that occurred after collecting the measurements. This is performed by placing the instrument in measurement mode (not calibration mode) and placing the probe in one or more of the standards used during the initial calibration; for turbidity place the standard in a cuvette and then into the turbidimeter. Wait for the instrument to stabilize and record the measurement in the field notebook and/or on a

field water quality form. Compare the measurement value to the initial calibration value. This difference in value is then compared to the drift criteria or post calibration criteria described in the quality assurance project plan or the sampling and analysis plan for the project. If the check value is outside the criteria, then the measurement data will need to be qualified.

For the dissolved oxygen calibration check, follow the calibration instructions steps one through three while the instrument is in measurement mode. Record dissolved oxygen value (mg/L), temperature, and barometric pressure. Compare the measurement value to the Oxygen Solubility at Indicated Pressure chart attached to this SOP. The value should be within the criteria specified for the project. If measurement value drifted outside the criteria, the data will need to be qualified.

If the quality assurance project plan or the sampling and analysis plan do not list the drift criteria or the post-calibration criteria, use the criteria below.

Measurement	**Post Calibration Criteria**
Dissolved Oxygen	± 0.5 mg/L of sat. value* < 0.5 mg/L for the 0 mg/L solution, but not a negative value
Specific Conductance	±5% of standard or ± 10 uS/cm (whichever is greater)
pH	± 0.3 pH unit with pH 7 buffer*
Turbidity	± 5% of standard
ORP	± 10 mv*

Note: * Table 8.1, USEPA Region 1 *YSI6-Series Sondes and Data Logger SOP,* January 30, 2007, revision 9.

7.0 DATA MANAGEMENT AND RECORDS MANAGEMENT

All calibration records must be documented in the project's field notebook or on an equipment calibration form. At a minimum, include the instrument manufacturer, model number, instrument identification number (when more than one instrument of the same model is used), the standards used to calibrate the instruments (including source), the calibration date, the instrument readings, the post calibration check, and the name of the person(s) who performed the calibration.

8.0 REFERENCES

Standard Methods for the Examination of Water and Wastewater, 20th edition, 1998.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

Turbidity - Methods for the Determination of Inorganic Substances in Environmental Samples, EP A/600/R-93/l00, August 1993.

U.S. EPA Region 1 Quality Assurance Unit, Standard Operating Procedure Calibration of Field Instruments, January 19, 2010, Revision Number 2.

U.S. EPA Region 1 YSI 6-Series Sondes and Data Logger SOP, January 30, 2007, Revision 9.

USGS Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Station Operation, Record Computation, and Data Reporting, Techniques and Methods 1-D3.

Oxygen Solubility at Indicated Pressure

	Pressure (Hg)							
Temp.	760	755	750	745	740	735	730	mm
°C	29.92	29.72	29.53	29.33	29.13	28.94	28.74	in
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/L
1	14.17	14.08	13.98	13.89	13.79	13.70	13.61	mg/L
2	13.79	13.70	13.61	13.52	13.42	13.33	13.24	mg/L
3	13.43	13.34	13.25	13.16	13.07	12.98	12.90	mg/L
4	13.08	12.99	12.91	12.82	12.73	12.65	12.56	mg/L
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	mg/L
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	mg/L
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	mg/L
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	mg/L
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	mg/L
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	mg/L
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	mg/L
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	mg/L
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	mg/L
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	mg/L
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	mg/L
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	mg/L
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	mg/L
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	mg/L
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	mg/L
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	mg/L
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	mg/L
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	mg/L
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	mg/L
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	mg/L
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	mg/L
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	mg/L
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	mg/L
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	mg/L
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	mg/L
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	mg/L
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	mg/L
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	mg/L
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	mg/L
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	mg/L
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	mg/L
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	mg/L
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	mg/L
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	mg/L
39	6.52	6.47	6.43	6.38	6.35	6.29	6.24	mg/L
40	6.42	6.37	6.33	6.28	6.24	6.19	6.15	mg/L
41	6.32	6.27	6.23	6.18	6.14	6.09	6.05	mg/L
42	6.22	6.18	6.13	6.09	6.04	6.00	5.95	mg/L
43	6.13	6.09	6.04	6.00	5.95	5.91	5.87	mg/L
44	6.03	5.99	5.94	5.90	5.86	5.81	5.77	mg/L
45	5.94	5.90	5.85	5.81	5.77	5.72	5.68	mg/L

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

Oxygen Solubility at Indicated Pressure (continued)

	Pressure (Hg)								
Temp.	725	720	715	710	705	700	695	690	mm
°C	28.54	28.35	28.15	27.95	27.76	27.6	27.36	27.17	in
0	13.89	13.8	13.7	13.61	13.51	13.4	13.32	13.22	mg/L
1	13.51	13.42	13.33	13.23	13.14	13	12.95	12.86	mg/L
2	13.15	13.06	12.07	12.88	12.79	12.7	12.6	12.51	mg/L
3	12.81	12.72	12.63	12.54	12.45	12.4	12.27	12.18	mg/L
4	12.47	12.39	12.3	12.21	12.13	12	11.95	11.87	mg/L
5	12.15	12.06	11.98	11.89	11.81	11.7	11.64	11.56	mg/L
6	11.84	11.73	11.68	11.6	11.51	11.4	11.35	11.27	mg/L
7	11.55	11.47	11.39	11.31	11.22	11.1	11.06	10.98	mg/L
8	11.26	11.18	11.1	11.02	10.95	10.9	10.79	10.71	mg/L
9	10.99	10.92	10.84	10.76	10.69	10.6	10.53	10.46	mg/L
10	10.74	10.66	10.59	10.51	10.44	10.4	10.29	10.21	mg/L
11	10.48	10.4	10.33	10.28	10.18	10.1	10.04	9.96	mg/L
12	10.24	10.17	10.1	10.02	9.95	9.88	9.81	9.46	mg/L
13	10.01	9.94	9.87	9.8	9.73	9.66	9.59	9.52	mg/L
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	mg/L
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	mg/L
16	9.37	9.3	9.24	9.17	9.11	9.04	8.97	8.91	mg/L
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	mg/L
18	8.99	8.92	8.86	8.8	8.73	8.67	8.61	8.54	mg/L
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	mg/L
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	mg/L
21	8.46	8.4	8.34	8.28	8.22	8.16	8.1	8.04	mg/L
22	8.3	8.24	8.18	8.12	8.06	8	7.95	7.89	mg/L
23	8.15	8.09	8.03	7.97	7.91	7.86	7.8	7.74	mg/L
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	mg/L
25	7.85	7.79	7.74	7.68	7.6	7.57	7.51	7.46	mg/L
26	7.7	7.65	7.59	7.54	7.48	7.43	7.37	7.32	mg/L
27	7.57	7.52	7.46	7.41	7.35	7.3	7.25	7.19	mg/L
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	mg/L
29	7.31	7.26	7.21	7.15	7.1	7.05	7	6.94	mg/L
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	mg/L
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.7	mg/L
32	6.95	6.9	6.85	6.8	6.7	6.7	6.64	6.59	mg/L
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	mg/L
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	mg/L
35	6.61	6.56	6.51	6.47	6.42	6.37	6.36	6.27	mg/L
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	mg/L
37	6.4	6.35	6.31	6.26	6.21	6.16	6.12	6.07	mg/L
38	6.3	6.26	6.21	6.16	6.12	6.07	6.02	5.98	mg/L
39	6.26	6.15	6.11	6.06	6.01	5.97	5.92	5.87	mg/L
40	6.1	6.06	6.01	5.96	5.92	5.86	5.83	5.78	mg/L
41	6	5.96	5.91	5.87	5.82	5.78	5.73	5.69	mg/L
42	5.91	5.86	5.82	5.77	5.73	5.69	5.64	5.6	mg/L
43	5.82	5.78	5.73	5.69	5.65	5.6	5.56	5.51	mg/L
44	5.72	5.68	5.64	5.59	5.55	5.51	5.46	5.42	mg/L
45	5.64	5.59	5.55	5.51	5.47	5.42	5.38	5.34	mg/L

Source: Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989.

APPENDIX B

Field Forms

TETRA TECH EQUIPMENT CALIBRATION FORM

Equipment Make	
Equipment Model	
Instrument Identification	

DATE	TIME	CALIBRATION MEDIA	RESULTS	COMMENTS

TETRA TECH

TETRA TECH FIELD DIRECT PUSH SOIL BORING LOG

Drilled By (Company): Stearns Drilling	Drilling Method: Direct Push	Borehole Number: GP-
Drilled By (Crew Chief):	Sampling Method: Macro Sampler	Project Number: 117-2202039
Type of Drill Rig: Geoprobe		Project Name: Former McGraw-Edison Facility
Date:	Page 1 of 3	Final Borehole Diameter: 2.0 inches
		Logged By: Todd M Thomson

Sample #	Depth Interval (ft bgs)	Sample Recovery Time & Length (24 hr & ft)	Particle Size Distr. (Est. to nearest 5%)				Size			Angularity		Silt and Clay Soil Identification Criteria				Munsell Color		Odor	Moisture Content	USCS Symbol
			Cbbls Bldrs	Grvl	Sand	Silt & Clay	Max (in)	Grvl	Sand	Grvl	Sand	Plas-ticity	Dry Strngth	Dila-tancy	Tough-ness	Number	Name			
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	
								F C	F M C	A SA SR R	A SA SR R	None L M H	N L M H VH	None S R	Low Med Hi				Dry Moist Wet	

Notes:

TETRA TECH FIELD PID DATA FORM

Project Number:	Date(s):
Project Name	Personnel:
Site Location:	Meter Identification:
	Probe eV:

Sample Number	Location	Depth (feet)	Sample Media (1)	Moisture (2)	Time Sample Collected	Time Sample Analyzed	Volatilization Period Air Temp. (^{O}C)	PID Readings (Instrument Units)			Comments
								Background	Peak Response	After 15 sec.	

(1) SO - Soil SD - Sediment GW - Ground Water SW - Surface Water WS - Waste (Solid) WL - Waste (Liquid) SG – Soil Gas

(2) D - Dry M - Moist W - Wet

TETRA TECH

TETRA TECH LOW-FLOW METHOD FIELD WATER QUALITY SAMPLING AND ANALYSIS FORM FOR SAMPLEPRO AND PERISTALTIC PUMPS

PROJECT INFORMATION		INSTRUMENTS	
PROJECT		Temp., pH,	
PROJECT NO.		Conductivity	
LOCATION		ORP	
PERSONNEL		DO	

MONITOR WELL ID									
WATER TYPE	Groundwater			Groundwater			Groundwater		
DATE (month/day/year)									
STATIC WATER LEVEL (ft)*/TIME									
WELL DEPTH (feet)*									
PUMP INLET DEPTH (feet)*									
ENDING WATER LEVEL (ft)*/TIME									
START PURGE TIME (Military)									
END PURGE TIME (Military)									
PURGE VOLUME (gallons)									
SAMPLE TIME (Military)									
STABILIZED INDICATOR PARAMETERS	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
TIME (minutes)									
TEMPERATURE (° C)									
pH									
ELEC. COND. at 25° C (uS/cm)									
ORP (mV)									
DISSOLVED OXYGEN (ppm)									
DISSOLVED OXYGEN (% Sat.)									
TURBIDIDTY (NTU)									
COLOR									
ODOR									
CLARITY									
SAMPLING PARAMETERS	# OF CONTAINERS & VOLUME; CONTAINER TYPE (A=AMBER; G=GLASS; P=PLASTIC); PRESERVATIVE TYPE (L=LAB ADDED; F=FIELD ADDED) OR NEUTRAL; FILTERED (YES or NO)								
NAME OF LABORATORY									
DATE SENT TO LAB									
SAMPLER ' S NAME									

*Measured from top of well casing.

TETRA TECH

TETRA TECH FIELD WATER LEVEL DATA SHEET

Project Number_____ Project Name:_____

Location: _____ Instrument:_____

Personnel: _____

Monitor Well/ Sample Port Identification	Date	Time	Depth to Groundwater (feet below top of casing)	Comments

TETRA TECH