REDACTED

REMEDIAL DESIGN WORK PLAN

CTS OF ASHEVILLE, INC. SUPERFUND SITE

235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared for:

CTS Corporation
2375 Cabot Drive
Lisle, Illinois 60532

Prepared by:

Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806

Amec Foster Wheeler Project 6252-16-2012

April 19, 2017

April 19, 2017

Mr. Craig Zeller, P.E.
Superfund Remedial and Site Evaluation Branch
U.S. Environmental Protection Agency
61 Forsyth Street, S.W.
Atlanta, Georgia 30303-8960
zeller.craig@epa.gov

Subject: **Remedial Design Work Plan**
CTS of Asheville, Inc. Superfund Site
235 Mills Gap Road, Asheville, Buncombe County, North Carolina
Amec Foster Wheeler Project 6252-16-2012
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Dear Mr. Zeller:

Please find attached the Remedial Design Work Plan (RDWP) for the above-referenced Site. Amec Foster Wheeler Environment & Infrastructure, Inc. prepared this RDWP on behalf of CTS Corporation to comply with the Consent Decree for Interim Remedial Design/Remedial Action at the CTS of Asheville, Inc. Superfund Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation (entered on March 7, 2017).

If you have questions regarding this RDWP, please contact us at (828) 252-8130.

Sincerely,

Amec Foster Wheeler Environment & Infrastructure, Inc.

Susan E. Kelly, P.E., L.G.
Senior Engineer

Matthew E. Wallace, P.E.
Principal Engineer

SEAL
24933
4/19/17

SEK/MEW:sek

cc: Franklin Hill, USEPA Region 4 Superfund Division Direction
Beth Hartzell, NCDEQ
George Lytwynyshyn, CTS Corporation
William Clarke, Roberts & Stevens, P.A.
Robert Ariatti, Northrop Grumman Systems Corporation
Jane Story, Jones Day

Correspondence:
Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806
Tel 828.252.8130
License Number: NC Corporate Engineering F-0653

TABLE OF CONTENTS

FIGURES

APPENDICES

ACRONYMS

bgs	below ground surface
CD	Consent Decree
DPT	direct-push technology
ECD	electron capture device
ERH	electrical resistivity heating
FSAP	Field Sampling and Analysis Plan
HASP	Health and Safety Plan
IRA	Interim Remedial Action
IROD	Interim Record of Decision
ISCO	in-situ chemical oxidation
MIP	membrane interface probe
NCDEQ	North Carolina Department of Environmental Quality
PDI	Pre-Design Investigation
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAO	remedial action objective
RD	Remedial Design
SOW	Statement of Work
TCE	trichloroethene (also, trichloroethylene)
TS	Treatability Study
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

DOCUMENT REVISION LOG

Revision	Date	Description
0	4/19/2017	Initial Issuance

1.0 INTRODUCTION

Pursuant to Paragraph 3.1 of the Statement of Work (SOW), this document presents the Remedial Design Work Plan (RDWP) for the CTS of Asheville, Inc. Superfund Site (Site) located at 235 Mills Gap Road in Asheville, Buncombe County, North Carolina (Figure 1). The activities described in this RDWP will be performed to comply with the Consent Decree for Interim Remedial Design/Remedial Action (CD) at the Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation.

1.1 SITE DESCRIPTION

The approximate center of the Site is located at north latitude 35°29’36” and west longitude 82°30’25”. The Site formerly contained an approximate 95,000-square foot, single-story brick and metal structure on the southern portion of the Site. The building was demolished in December 2011 and the concrete building pad remains intact. The northeastern portion of the Site contains an asphalt-paved parking area, and asphalt-paved driveways are located parallel to the north (front) of the building pad and southeast (rear) of the building pad. A six-foot high chain-link fence surrounds the Site and a locked gate at the north end of the Site controls access to the Site from Mills Gap Road. The Site is unoccupied. The Site and adjacent property boundaries are illustrated on Figure 2.

1.2 REMEDIAL DESIGN WORK PLAN PURPOSE AND OBJECTIVES

The purpose of this RDWP is to present the strategy, organization, and proposed data collection activities associated with developing the Remedial Design (RD) for the Interim Remedial Action (IRA) at the Site. The selected IRA includes two approaches that will be implemented, as follows:

- Reduction of trichloroethene (TCE) in an approximate 1.2-acre source area in the vicinity of the former facility at the Site using electrical resistivity heating (ERH).
- Reduction of TCE in an approximate 1.9-acre Northern Area portion of the Site using in-situ chemical oxidation (ISCO) via emplaced potassium permanganate.

The two remediation areas are shown in Figure 3.

This RDWP contains the general approach to design, construction, operation, maintenance and monitoring of the IRA, as well as:

- The responsibility and authority of organizations and key personnel involved with implementation of the remedial design.
- Identification of data gaps associated with implementing the ISCO IRA and description of proposed Pre-design Investigation (PDI) and Treatability Study (TS) activities.
- A description of the plan to obtain access for implementation of the IRA Work.
- An anticipated schedule for remedial design activities.

This RDWP describes the process and strategy for preparing the design for the IRA, but it does not contain specific design details such as design calculations, assumptions, technical specifications, etc. These details will be developed during the actual design process and will be included in the design/bid submittals. The RD approach and process may change or evolve as the design phase progresses due to the intricate and multi-phased nature of the Site and the IRA.

1.3 REMEDIAL ACTION OBJECTIVE

The overall remedial action objective (RAO) of the IRA is a 95 percent reduction of TCE concentrations in subsurface media in the two identified remediation areas of the Site.

ERH will be implemented in an approximate 1.2-acre portion of the Site. This area is generally considered the source area and, in addition to TCE, contains light non-aqueous phase liquid (LNAPL) from weathered fuel oil. In this area, TCE exists in three states: dissolved in groundwater, sorbed to soil, and partitioned in the petroleum LNAPL. The RAO of a 95 percent reduction of TCE will be applied to soil, groundwater and LNAPL samples in this 1.2-acre source area.

ISCO will be implemented in an approximate 1.9-acre acre area in the northern portion of the Site where a dissolved-phase TCE plume is present. The majority of TCE is present dissolved in groundwater; therefore, the RAO of a 95 percent reduction of TCE will be applied to groundwater samples only in this Northern Area.

2.0 PROJECT DELIVERY AND IMPLEMENTATION PLAN

Overall, the project delivery strategy is to deliver the RD efficiently, cost effectively, safely and in a manner that satisfies the requirements described in the CD. Because there are two remedial approaches for the IRA, the design of each will be developed separately, and the implementation of each will be performed separately; however, the phasing of the two remedial approaches will be merged in the overall RD/RA schedule. Refer to Section 8.0 for a proposed near-term schedule of RD activities, including the ISCO PDI and TS.

Implementation of the ERH IRA will be a design-build project delivery with performance-based specifications (the RAO). A bid document will be prepared and submitted to pre-qualified ERH contractors. The bid document will include Site-specific contaminant and hydrogeologic information and assumptions for the ERH contractors to use in developing remedial approaches and bids. ERH contractors have patents protecting their specific ERH implementation methods, so they will prepare remedial approaches and bids based on their unique ERH methodology to meet the RAO. The bid document will contain general specifications for the delivery of the project. The selected ERH contractor will be tasked with providing preliminary, and then detailed, design documents prior to implementation. The bid document will require that contractors provide a Statement of Qualification describing their ERH experience, proposed personnel, safety ratings, etc. The selection of the ERH contractor will, among other things, be based on a determination that the contractor will be able to implement ERH to meet the RAO, meet the schedule set forth in the SOW and this RDWP, and cost.

The selected ERH contractor will perform construction, operation, maintenance, and partial monitoring of the IRA. Amec Foster Wheeler will provide additional monitoring during, and after, implementation of the IRA.

Implementation of the ISCO IRA will be a design-bid-build project delivery with performance-based specifications. It is anticipated that Amec Foster Wheeler will design the ISCO IRA in consultation with an emplacement contractor and an ISCO consulting contractor. Additional data will be collected to gain additional information regarding the distribution of contamination in the Northern Area of the Site and to collect samples for characterization of the permanganate natural oxidant demand of the subsurface material.

A TS will then be conducted to evaluate subsequent reaction chemistry and the distribution of the emplaced potassium permanganate. Based on the additional data collected and the TS, the ISCO IRA will then be designed. The design document will be used to obtain bids from qualified ISCO contractors. The bid document will require that contractors provide a Statement of Qualification describing their ISCO experience, proposed personnel, safety ratings, etc. The selection of the ISCO contractor will, among other things, be based on a determination that the contractor will be able to implement ISCO to meet the RAO, meet the schedule set forth in the SOW, and cost.

The selected ISCO contractor will perform construction, operation, and maintenance during implementation of the IRA. Amec Foster Wheeler will provide monitoring during, and after, implementation of the IRA.

3.0 ROLES AND RESPONSIBILITIES

The roles and responsibilities of organizations involved in the remedial design are described in the following sections.

3.1 REGULATORY AGENCIES

The United States Environmental Protection Agency (USEPA) is the lead agency overseeing design and implementation of the IRA. The USEPA will review/approve plans and reports related to design and implementation of the IRA. The USEPA Remedial Project Manager is Mr. Craig Zeller, P.E.

The North Carolina Department of Environmental Quality (NCDEQ) will consult with USEPA during design and implementation of the IRA. NCDEQ will review submittals and provide comments to USEPA.

3.2 SETTLING DEFENDANTS

The Settling Defendants are designated in the CD as CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation. George Lytwynyshyn of CTS Corporation is the Settling Defendants' Project Coordinator, as defined in the CD, and will provide overall responsibility for procuring contractors/consultants, budgeting and assuring the requirements of the Interim RD/RA are achieved. Mills Gap Road Associates is the owner of the property located at 235 Mills Gap Road, and will provide access to the Site. Northrop Grumman Systems Corporation will provide additional review of project documents.

3.3 SUPERVISING CONTRACTOR

Amec Foster Wheeler is the Supervising Contractor procured by CTS Corporation to direct and supervise the technical aspects of designing and implementing the IRA. The Amec Foster Wheeler Project Manager is Mr. Matthew Wallace, P.E.

3.4 DRILLING CONTRACTORS

As described herein, a PDI will be conducted to address data gaps for the design of ISCO implementation at the Site. The PDI will include drilling/sampling and direct sensing activities. Cascade Drilling, LP is anticipated to be contracted to perform these activities.

A drilling contractor, to be determined, will also be contracted to install the injection points for the TS.

3.5 LABORATORY

Groundwater samples will be collected during the PDI. Pace Analytical Services, LLC will be contracted to perform the laboratory analyses.

3.6 ERH CONTRACTOR

An ERH contractor will be selected for design and implementation of the ERH IRA. The ERH contractor will have a team of managers, engineers, technicians and safety personnel.

3.7 ISCO CONTRACTORS

Two subcontractors are anticipated to be utilized for the ISCO TS. Geo-Cleanse International, Inc. (Geo-Cleanse) will provide consulting services for planning and implementing the TS. Soil samples collected during the PDI will be submitted to Geo-Cleanse for analysis of permanganate natural oxidant demand. Frx, Inc. will provide personnel, equipment and materials for emplacement of the solid potassium permanganate during the TS.

After design of the ISCO IRA, an ISCO contractor will be selected. The ISCO contractor will have a team of managers, engineers, technicians and safety personnel.

4.0 DATA GAP ANALYSIS AND PRE-DESIGN INVESTIGATION

An evaluation of the available data for the source area does not indicate that additional information is needed to proceed with the ERH RD. If, during the preparation of the preliminary ERH RD, it is determined that collection of additional data is required, USEPA will be notified of such needs/activities.

Data gaps and needed clarifications have been identified related to the ISCO RD for the Northern Area. Therefore, a PDI, and a TS, will be performed.

The overall objective of the PDI is to gain an understanding of the distribution of volatile organic compounds (VOCs), primarily trichloroethene (TCE), and permanganate natural oxidant demand (NOD) in overburden in the approximate 1.9-acre Northern Area of the Site so that the ISCO TS and the full-scale ISCO RD can be completed.

In general, the PDI will involve advancing borings and collecting qualitative and quantitative data in and around the perimeter of the Northern Area. Figure 3 presents the proposed boring locations. Additional information related to the scope of the PDI is contained in the PDI Work Plan (dated April 19, 2017, under separate cover), the RDWP Field Sampling and Analysis Plan (FSAP), and the RDWP Quality Assurance Project Plan (QAPP). The FSAP and QAPP are included in this RDWP as Appendices A and B, respectively.

Following the PDI, a PDI Evaluation Report summarizing field activities, results, conclusions and recommendations, will be prepared.

5.0 TREATABILITY STUDY

A TS will be conducted for the ISCO IRA to provide information for the final ISCO RD. The TS is intended to determine the radius of influence of the emplaced potassium permanganate slurry, determine the amount of oxidant required, and evaluate contaminant reductions in nearby monitoring wells. Additional preliminary information related to the scope of the TS is contained in the FSAP and the QAPP.

After completion of the PDI, and before conducting the TS, a TS Work Plan will be prepared and submitted to USEPA. After completion of the TS, a TS Evaluation Report will be prepared and submitted to USEPA. Recommendations for ISCO RD parameters will be provided in the TS Evaluation Report.

6.0 PERMITTING AND OTHER REGULATORY REQUIREMENTS

Per USEPA policy and guidance for performing on-Site CERCLA actions, permits are not required. However, the substantive provisions of the normally-applicable permit requirements are to be followed/addressed. Permitting and other regulatory requirements for performing the PDI and TS are described below.

Air or water discharge permits, erosion and sedimentation control permits, or construction/building permits are not applicable to the proposed PDI and TS. Permits are not required for the PDI sampling activities. North Carolina regulatory requirements related to permitting underground/groundwater injections, such as the potassium permanganate emplacement, will be followed for the TS. Such regulatory requirements include recording the treatment area, volume/concentration of injected material, duration of injections, injection well details, development of monitoring plan, etc. Potassium permanganate is on the NCDEQ-approved list of injected materials/additives in North Carolina. A groundwater monitoring plan will be provided in the TS Work Plan which will comply with typical NCDEQ Underground Injection Control permit requirements.

Regulatory requirements for handling and storage of the estimated necessary volume/mass of potassium permanganate for the TS will be evaluated and described in the TS Work Plan. Regulatory requirements for storage, transport, and disposal of non-hazardous and hazardous investigation derived waste will be followed.

Appropriately licensed and trained personnel will implement the remedial design activities. The PDI activities, TS, and remedial designs will be managed and overseen by geologists and engineers licensed in the state of North Carolina. A North Carolina-licensed well driller will oversee the drilling operations performed at the Site. Personnel with OSHA HAZWOPER training will perform field activities.

As required by the CD, an Emergency Response Plan (ERP) is provided in Appendix C. The ERP supplements the HASP for the Site, and includes procedures to be used in the event of an accident or emergency at the Site. The ERP currently addresses the proposed Remedial Design activities, and will be updated when contractors are selected for the IRA, as there will be additional input needed for addressing their respective ERH and ISCO activities.

7.0 ACCESS CONSIDERATIONS

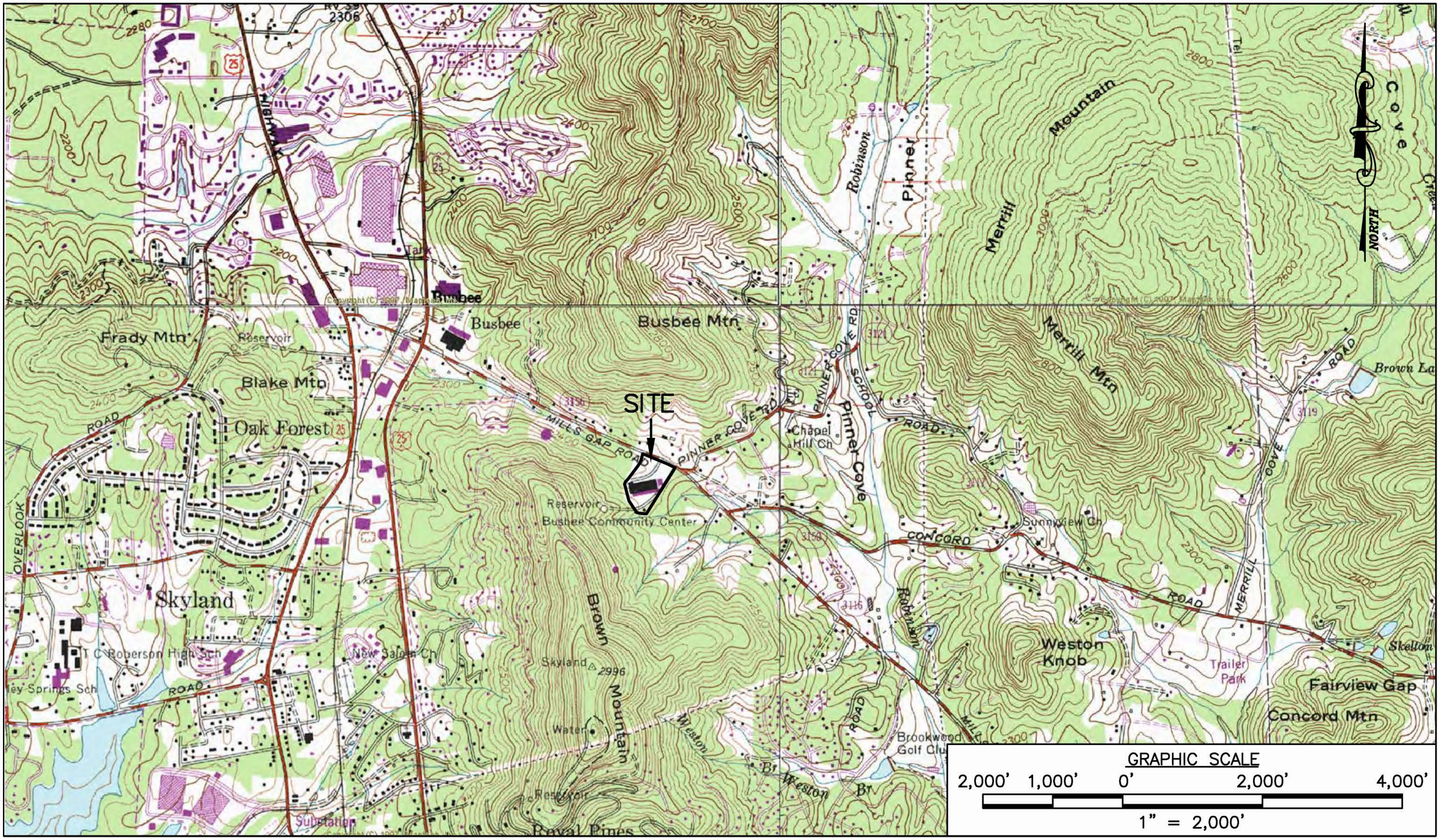
The proposed PDI, TS and ERH RD activities will be conducted on the approximate 8.7-acre former plant property. This property is owned by Mills Gap Road Associates, which has provided access to the property as a CD Settling Defendant.

The proposed ERH IRA activities will be conducted primarily on the former plant property owned by Mills Gap Road Associates. However, a portion of the ERH IRA activities will be conducted on the parcel to the east (Buncombe County tax parcel 9655-62-7448, with an address of (b) (6)). USEPA will obtain an access agreement for CTS and USEPA representatives to access this property to perform the ERH IRA activities on this portion of the property, which includes fencing a security/safety perimeter zone around the ERH IRA activities. Property acquisition or a lease is not anticipated.

8.0 SCHEDULE

The proposed schedule for the implementation of the RDWP is contained in Appendix D. The schedule may change as the RD progresses.

FIGURES



TOPOGRAPHIC SITE MAP
CTS OF ASHEVILLE, INC. SUPERFUND SITE
ASHEVILLE, NORTH CAROLINA

amec foster wheeler

DRAWN: SEK	ENG CHECK: --	DATE: APRIL 2017	PROJECT: 6252162012
DFT CHECK: MEW	APPROVAL: MEW	SCALE: 1" = 2,000'	FIGURE: 1

REFERENCE: USGS QUADRANGLES: ASHEVILLE (1961), OTEEN (1962), FRUITLAND (1978) AND SKYLAND (1978)

Prepared/Date: BRP 11/08/16
Checked/Date: SEK 11/08/16

Legend

⊙ Spring	Fence
	Property Line

N

0 50 100 Feet

amec foster wheeler

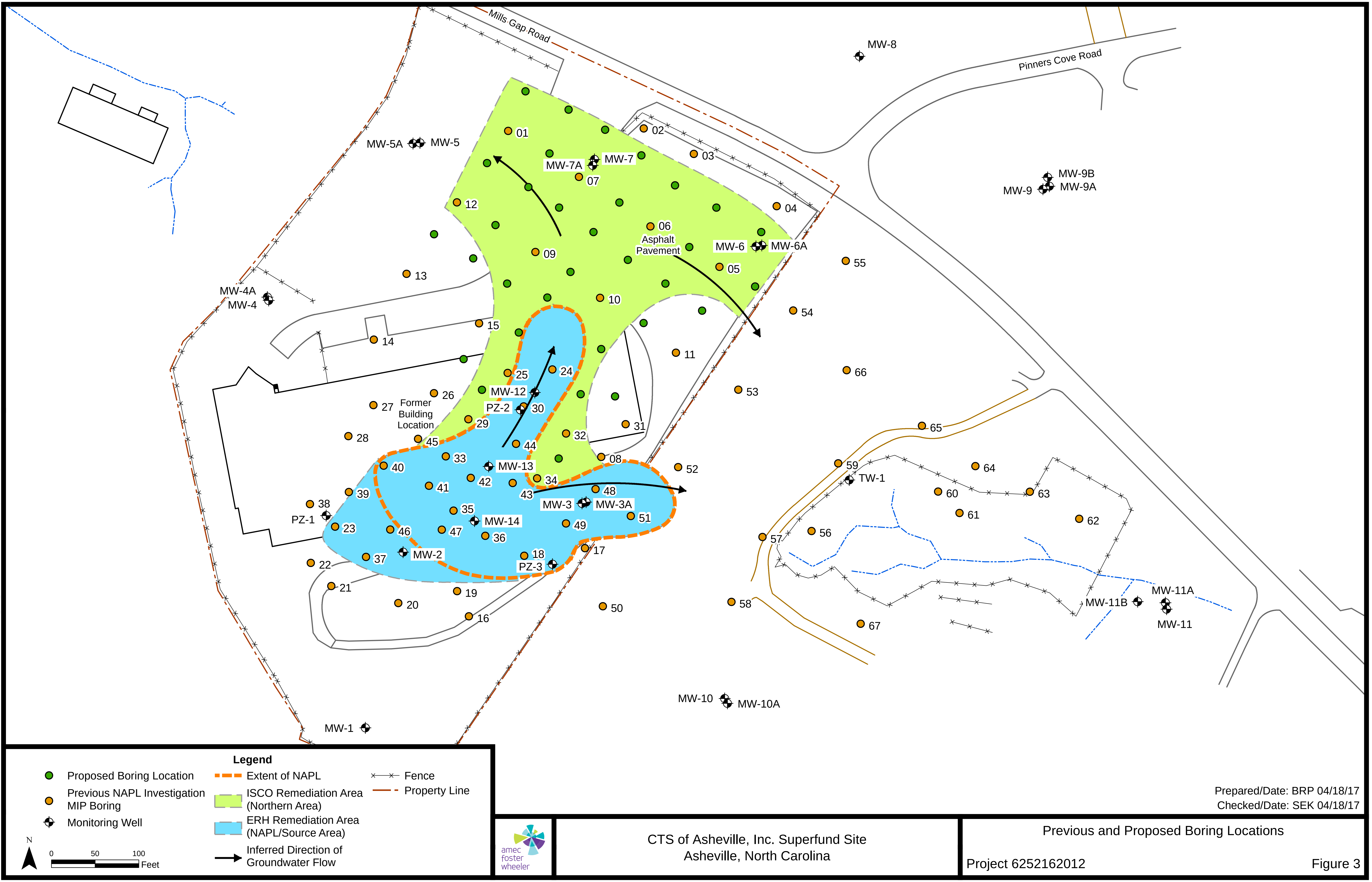
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina

Site Map

Project 6252162012

Figure 2

Document: P:\Projects\CTS Corporation\4.0 Project Deliverables\4.5 Databases\GIS\MapDocuments\Sep 2016\Sep2016_11x17LS.mxd PDF: P:\Projects\CTS Corporation\4.0 Project Deliverables\4.5 Databases\GIS\Figures\Sep 2016\Figure 2 - Site Map.pdf 11/08/2016 7:54 AM brian.peters



Prepared/Date: BRP 04/18/17
Checked/Date: SEK 04/18/17

amec foster wheeler

CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina

Previous and Proposed Boring Locations

Project 6252162012

Figure 3

APPENDIX A

FIELD SAMPLING AND ANALYSIS PLAN

REMEDIAL DESIGN WORK PLAN:
FIELD SAMPLING AND ANALYSIS PLAN

CTS OF ASHEVILLE, INC. SUPERFUND SITE

235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared for:

CTS Corporation
2375 Cabot Drive
Lisle, Illinois 60532

Prepared by:

Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806

Amec Foster Wheeler Project 6252-16-2012

April 19, 2017

TABLE OF CONTENTS

Page

APPENDIX

ACRONYMS

CD	Consent Decree
DOT	Department of Transportation
DPT	direct-push technology
DO	dissolved oxygen
ECD	electron capture detector
ERH	electrical resistivity heating
FID	flame ionization detector
FDR	field data record
FOL	Field Operations Leader
FSAP	Field Sampling and Analysis Plan
GPS	Global Positioning System
IDW	investigation derived waste
ISCO	in-situ chemical oxidation
MIP	membrane interface probe
NAPL	non-aqueous phase liquid
NOD	natural oxidant demand
ORP	oxidation-reduction potential
PDI	Pre-design Investigation
PID	photoionization detector
PPE	personal protective equipment
QAPP	Quality Assurance Project Plan
RDWP	Remedial Design Work Plan
SESD	USEPA Science and Ecosystem Support Division
TCE	trichloroethene
TS	Treatability Study
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

DOCUMENT REVISION LOG

Revision	Date	Description
0	4/19/2017	Initial Issuance

1.0 INTRODUCTION

Pursuant to Paragraph 6.7(c) of the Statement of Work, on behalf of CTS Corporation (CTS), Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) has prepared this Field Sampling and Analysis Plan (FSAP) for the CTS of Asheville, Inc. Superfund Site (Site) located in Asheville, Buncombe County, North Carolina. The activities described in this FSAP will be performed to comply with the Consent Decree for Interim Remedial Design/Remedial Action (CD) at the Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation. The CD was entered on March 7, 2017.

The interim remedial activities will be conducted in two phases: electrical resistivity heating (ERH) in the approximate 1.2-acre source area, and in-situ chemical oxidation (ISCO) in an approximate 1.9-acre downgradient dissolved-phase plume designated the Northern Area of the Site. At this time, the ERH remedial design does not require any field activities upon which data will be evaluated. If data gaps are identified and it is determined that collection of additional data is required for the ERH remedial design, this FSAP will be updated to include such activities. Therefore, this FSAP focuses on data to be collected for development of the ISCO remedial design in which data gaps have been identified.

The ISCO remedial design will be conducted in two phases: a Pre-design Investigation (PDI) and a Treatability Study (TS). This FSAP presents the details associated with the proposed ISCO PDI. This FSAP, in conjunction with the Quality Assurance Project Plan (QAPP), are included in the Remedial Design Work Plan (RDWP) and provide the framework upon which the PDI will be conducted. The design for the TS will be based on data collected during the PDI and data from previous investigations. This FSAP is focused on activities to be conducted during the PDI; however, if additional sampling activities are proposed for the TS, this FSAP will be updated prior to implementation of the TS, if necessary.

2.0 SAMPLING OBJECTIVES

The overall objective of the PDI is to gain an understanding of the distribution of volatile organic compounds (VOCs), primarily trichloroethene (TCE), and permanganate natural oxidant demand (NOD) in overburden in the approximate 1.9-acre Northern Area of the Site so that the ISCO TS and the full-scale ISCO Remedial Design can be completed. Specific objectives of the PDI are as follows:

- Determine the horizontal and vertical distribution of VOCs in soil and groundwater in the approximate 1.9-acre Northern Area, so that efforts can be made to focus remediation in the areas of highest contamination.
- Determine the permanganate NOD of the subsurface materials, which will influence the amount of permanganate required to effectively reduce TCE concentrations.

3.0 SAMPLE LOCATION AND FREQUENCY

The PDI involves collecting qualitative data to gain a relatively rapid, real-time, understanding of the VOC contaminant distribution in groundwater in the unconsolidated formation (i.e., above bedrock) in the Northern Area. Based on the qualitative data, a subset of quantitative groundwater data will be collected and analyzed to compare to the qualitative data. The interpretation/correlation of the associated qualitative/quantitative data will be expanded to the rest of the qualitative data. Data will also be collected to characterize the permanganate NOD of the subsurface materials in the area of the proposed remediation, which will influence the amount of permanganate required to effectively reduce TCE concentrations. Direct sensing data was collected in the Northern Area during the Non-aqueous Phase Liquid (NAPL) Investigation in 2013 and 2014 (Amec Foster Wheeler, 2014), and this data will also be evaluated with respect to the PDI data collected.

Qualitative data will be collected via direct-push technology (DPT) equipment. A membrane interface probe (MIP) will be advanced at boring locations depicted in Figure 3 of the RDWP for the collection of real-time, direct sensing data. The borings will be advanced in a general grid pattern. The area of the proposed MIP borings is based on the area to be remediated by ISCO, as described in the Final NAPL Area Focused Feasibility Study Addendum (Amec Foster Wheeler, 2015). Up to 35 borings are proposed. The boring locations have been established with consideration given to the location of known access barriers. Proposed boring locations have been established for 32 locations and three borings will be advanced at the end of the investigation to collect additional data where it is determined necessary.

Soil and groundwater samples will be collected at selected locations/depths using the DPT equipment. Up to ten groundwater samples and 30 soil samples will be collected. Groundwater samples will also be collected from four existing monitoring wells located in the Northern Area.

4.0 SAMPLE DESIGNATION, HANDLING, AND ANALYSIS

Procedures for sample designation, handling and analysis are included in the RDWP QAPP.

5.0 SAMPLING EQUIPMENT AND PROCEDURES

The following data collection or sampling methods are proposed for the PDI:

- Measurement of depth to groundwater in monitoring wells
- Collection of direct sensing data using a MIP
- Screening of volatile organic compounds via a photoionization detector (PID)
- Collection of soil and groundwater samples for analysis
- Chemical analyses for soil and groundwater for quantitative determination of constituent concentrations (described in the RDWP QAPP)
- Surveying boring locations

5.1 DEPTH TO GROUNDWATER MEASUREMENT

Depth to groundwater measurements will be performed at four of the Site overburden monitoring wells at the start of the PDI to gather information on the depth/elevation of the water table and potentiometric surface of the deeper partially weathered rock monitoring wells. The depth to groundwater measurement procedures have been developed in accordance with the United States Environmental Protection Agency (USEPA) Science and Ecosystem Support Division’s (SESD’s) Operating Procedure “Groundwater Level and Well Depth Measurement,” effective January 29, 2013 (Appendix A).

Depth to groundwater measurements will be made relative to the north side of the top of the monitoring well/piezometer casings. A water level meter with a measuring tape length of at least 50 feet and measurement accuracy of at least 0.01 feet will be used to measure the depth to groundwater. Depth to groundwater measurements will be recorded to the 0.01 foot on a field data record (FDR), such as the one included in Appendix C of the QAPP (“Depth to Water Measurement Record”).

5.2 DIRECT SENSING MEASUREMENTS

A MIP tool will be used to collect qualitative data regarding the presence of VOCs in the overburden. DPT equipment will be used to advance the MIP in the unconsolidated formation until refusal of the DPT equipment is encountered. Cascade Drilling will mobilize direct sensing equipment, which is mounted on a “data acquisition vehicle” and contains a computer, detectors/probes, power, compressed gases, redundant equipment in case of equipment malfunction/damage, and other ancillary tools required for the MIP investigation.

Cascade will advance the MIP until refusal with the DPT equipment is encountered. The MIP is a percussion tolerant VOC sensor that can continuously log volatile organics that diffuse through a semi-permeable membrane. Using a carrier gas, the VOCs are brought to the surface through tubing, which is connected to a laboratory grade PID, flame ionization detector (FID), and electron capture detector (ECD) for immediate screening. These three detectors are mounted in a Hewlett Packard 5890 Series II Gas Chromatograph cabinet.

As the operator advances the MIP sensor into the subsurface, a log of the detector data is displayed in real-time on the field computer. This log provides information about total volatiles relative concentrations using either the PID, ECD and FID. The real-time log also provides a depth/speed graph, electrical conductivity log of the formation, and temperature log of the heated sensor. The data will be imported into interpolation software to allow construction of cross sections from the MIP data.

Response tests will be performed at the beginning and end of each MIP logging location. A response test standard will be used that will measure the MIP response to a known concentration of chlorinated VOC. A trip time test will be performed at the beginning of each day to determine the time differential from MIP sensor to detector. The operator’s field notes will include daily setup notes as well as notes specific to each logging event.

5.3 PID SCREEING

Soil borings advanced during the PDI via the DPT macro-core sampler will be scanned at a minimum one-foot interval with a PID (PID “scan”). The soil core will be “pried” open and the tip of the PID will be placed within the freshly opened soil. A gloved hand will be “cupped” around the probe and atop the soil core to minimize volatilization. PID scan readings will be documented on a soil boring log, as described in the RDWP QAPP.

5.4 COLLECTION OF SOIL SAMPLES

Soil samples retrieved from the boring via the DPT macro-core sampler will be described in the field by a geologist. Information regarding moisture content, color, grain size, odor, PID measurement, etc. will be recorded on a soil boring log. Photographs of the soil core will be taken. Identification of the boring location and depth will be indicated in the photograph.

Soil samples will be collected in areas/zones where differing soil types are anticipated. Up to 20 samples will be collected and submitted for analysis of permanganate NOD according to ASTM D 7262-07 as described in the RDWP QAPP. Also, up to ten soil samples will be collected and analyzed for VOCs to determine the portion of VOC contamination that is sorbed to the soil. The soil samples will be collected in accordance with the SESD Operating Procedure “Soil Sampling,” effective August 21, 2014 (Appendix A).

Soil samples will be collected from the desired interval of a select macro-core liner using a decontaminated stainless steel spoon, or similar device. The sample will be placed in the sample container, labeled with sample information and the lid securely closed. Soil samples will be placed on ice following collection.

Clean, non-powdered, disposable gloves (e.g., nitrile) will be worn when collecting soil samples. A new pair of gloves will be donned immediately prior to collecting a soil sample that will be submitted for analysis. Sample information (e.g., sample designation, depth, etc.) will be recorded on the soil boring log and sample summary log, as described in the RDWP QAPP.

5.5 COLLECTION OF GROUNDWATER SAMPLES

Groundwater samples will be collected using the DPT equipment and from four monitoring wells. Groundwater samples will be collected in accordance with the SESD Operating Procedure “Groundwater Sampling,” effective March 6, 2013 (Appendix A).

Groundwater samples will be collected adjacent to the MIP borings, primarily where VOC contamination is anticipated based on the MIP data. DPT drilling equipment will advance a boring to the target depth of the groundwater sample. A stainless steel screen point sampler well screen will be utilized to collect a groundwater sample from the boring. At the selected groundwater sample depth/interval, the drill rods will be retracted one to two feet, exposing the screen point sampler well screen. Groundwater will be purged via a peristaltic pump and new, disposable polyethylene tubing. Where the depth to the water table is not within the operating depth of a peristaltic pump, a check valve inserted at the bottom of the tubing will be utilized to bring the groundwater to the surface for collection. Groundwater will be purged from the well screen in an effort to reduce turbidity and provide a representative groundwater sample. If turbidity is not reduced after removing several tubing volumes, a groundwater sample will be collected and turbidity will be noted. The following groundwater quality parameters will be measured prior to sample collection using a calibrated water quality meter: pH, temperature, conductivity, dissolved oxygen, and oxidation reduction potential. Up to 10 groundwater samples will be collected/submitted via the screen-point sampler method. The procedure for measuring water quality parameters is described in Section 5.6 herein.

Groundwater samples will also be collected from four monitoring wells during the PDI. Based on historical water level information, groundwater samples will be collected from monitoring wells MW-7 and MW-7A using a peristaltic pump, as described above. The intake of the tubing will be set to the approximate middle of the monitoring well screened interval. However, the historical depth to groundwater in MW-6 and MW-6A has been greater than 25 feet below ground surface, which is generally the maximum depth in which a peristaltic pump can be used. Therefore, a variable-speed submersible pump will be used to collect groundwater samples from MW-7 and MW-7A. The pump intake will be set to the approximate middle of the monitoring well screened interval and new, disposable polyethylene tubing will be used.

Groundwater will be purged from the monitoring wells using low-flow purging techniques, in which groundwater drawdown is minimized. A flow-through cell will be utilized and water quality parameters (pH, temperature, conductivity, dissolved oxygen, and oxidation reduction potential) will be continuously monitored. Measurements will be recorded approximately every three minutes. Turbidity will be monitored using a turbidity meter. Groundwater samples will be collected after water quality parameters have stabilized, as described in SESD Operating Procedure “Groundwater Sampling,” effective March 6, 2013 (Appendix A).

Because the groundwater samples are expected to contain elevated concentrations of VOCs and samples are not being submitted for trace VOC analysis, samples will be collected from the tubing (including the silicone pump head tubing) used to purge the groundwater, as the relative VOC loss via agitation at the pump head is expected to be minimal. New silicone pump head tubing and polyethylene tubing will be used for each sample location. Groundwater samples collected for analysis of VOCs will be placed in laboratory-prepared 40 milliliter volatile organic analysis sample containers preserved with hydrochloric acid. The samples will be collected with minimal agitation and the container should contain zero head space (e.g. no bubbles). Following collection of the groundwater samples using the DPT equipment, the screen point sampler and drill rods will be removed and the borings will be abandoned, as described in Section 5.7 herein.

Groundwater samples will be placed on ice following collection. Groundwater samples will be packaged and shipped/delivered to the laboratory with appropriate chain-of-custody as described in the RDWP QAPP. Clean, non-powdered, disposable gloves (e.g., nitrile) will be worn when collecting groundwater samples. A new pair of gloves will be donned immediately prior to sampling. Information regarding the collected sample (e.g., sample designation, depth, etc.) will be recorded on the sample summary log.

5.6 MEASUREMENT OF WATER QUALITY PARAMETERS

Water quality parameters will be collected during purging of groundwater for sample collection. The following water quality parameters will be measured:

- pH
- Temperature
- Conductivity
- Dissolved oxygen (DO)
- Oxidation-reduction potential (ORP)
- Turbidity

A multi-parameter water quality meter that measures pH, temperature, conductivity, DO, and ORP will be used. A separate turbidity meter will be used to measure turbidity. The equipment will be calibrated each day prior to sample collection in accordance with the manufacturer's specifications. Calibration data will be recorded on a Field Instrument Calibration Record FDR found in Appendix C of the RDWP QAPP. If drifting or erroneous readings occur during operation, the equipment will be checked for calibration, and re-calibrated if necessary. If the equipment cannot be re-calibrated, the Field Operations Leader (FOL) will be notified, and operable equipment will be identified/procured for use.

Water quality parameters will be measured in accordance with the most recent version of the following SESD Operating Procedures found in Appendix A:

- "Field pH Measurement," effective January 29, 2013
- "Field Specific Conductance," effective July 13, 2016
- "Field Temperature Measurement," effective October 23 2014
- "Field Measurement of Oxidation-Reduction Potential," effective January 29, 2013
- "Field Measurement of Dissolved Oxygen," effective January 8, 2014 (luminescent probe)
- "Field Turbidity Measurement," effective January 29, 2013

5.7 BOREHOLE ABANDOMENT

After completion of a DPT borehole, the borehole will be abandoned using a bentonite-cement grout. The grout mixture will consist of approximately 5.5 to 6 gallons of water (obtained from a fire hydrant located on Mills Gap Road north of the Site or another potable water source) per 94-pound bag of Type I cement. Powdered bentonite (approximately 3 to 6 percent by volume) will be added to reduce shrinkage of the cement grout. The grout will be injected from the bottom of the borehole to the top of the borehole using the DPT rods. If the grout settles after placement, the grout will be "topped off" as needed to match the surrounding ground surface.

5.8 SURVEYING

Boring locations will be surveyed using a Trimble® Global Positioning System (GPS) or similar instrument. As specified in SESD Operating Procedure "Global Positioning System," effective date June 23, 2015 (Appendix A), sample locations will be located with three-meter accuracy. If a boring is in an area where a GPS signal cannot be received (e.g. areas with tree canopy), the GPS locations will be located from the nearest point where a signal is received and deviations will be noted in the field book.

6.0 DECONTAMINATION PROCEDURES

The objective of this section is to provide procedures to ensure the removal of contaminants from sampling, drilling, and other field equipment to concentrations that do not adversely impact the investigation objectives. The decontamination procedures have been developed in accordance with the SESD Operating Procedure “Field Equipment Cleaning and Decontamination,” effective December 18, 2015 (Appendix A). Deviations from these procedures will be communicated to the FOL and documented in the field log book.

6.1 CLEANING SOLUTIONS

Specifications for standard cleaning materials referred to in this section are as follows:

- Water will be obtained from a municipal water fire hydrant located between the Site fence and Mills Gap Road. A hydrant meter will be procured from the City of Asheville for use during implementation of the project. “Hydrant” water can be kept in plastic/polyethylene tanks, buckets, spray/squeeze bottles. Although the water is considered potable, the water transfer lines/hoses and containers might not be sufficiently clean to containerize water for consumption; therefore, tanks/containers that contain hydrant water will be labeled as “non-potable.”
- Potable water will be obtained from an off-Site drinking water tap and containerized in a clean plastic bucket or plastic spray/squeeze bottle. The container will be labeled as “potable water.”
- Distilled water can be used in place of potable water, if necessary, and will be labeled as “distilled water.”
- Soap will be a standard brand of phosphate-free laboratory detergent such as Alconox® or Liquinox®. Soap will be kept in a plastic or glass container until use, and dispensed directly from the container. The soap container will be labeled with its contents.
- Organic-free water will be stored in glass or plastic containers that can be closed between uses. The organic-free water container will be labeled as such.
- De-ionized water will be obtained from the laboratory and stored in glass or plastic containers that can be closed between uses. The de-ionized water container will be labeled as such.

6.2 EQUIPMENT DECONTAMINATION

During implementation of the direct sensing methods, a DPT rig equipped with a dual core sampler will be utilized. The direct sensing probe/equipment will be decontaminated between borings, as follows:

- As each DPT rod is removed from the borehole, it will be placed in a bucket that is placed on plastic sheeting and will be washed with hydrant or potable water and soap. A brush will be used to remove particulate matter and surface films.
- Decontamination fluid in the bucket will be transferred to a 55-gallon drum upon completion of the decontamination activities.
- Clean equipment will be placed on clean plastic sheeting or on a rack until needed.

The back of the drill/DPT rig and associated tools and equipment will be decontaminated at the end of the project before leaving the Site.

6.3 SAMPLING EQUIPMENT DECONTAMINATION

The following procedures will be used to decontaminate non-dedicated, non-disposable field sampling equipment (e.g., spoons, submersible pump, water level meter):

- Equipment will be cleaned prior to sampling, between sampling locations, and at the end of the project before equipment is removed from the Site.
- Equipment will be washed with potable water and soap, and rinsed with potable water.
- If samples are collected for trace organic compounds, the sampling equipment used during collection will be decontaminated as described above and then rinsed with isopropanol and then organic-free water. The equipment will be placed on aluminum foil to dry and then wrapped in aluminum foil.
- The wetted portion of a water level meter tape/probe and interface probe will be decontaminated using soap and potable water, and then rinsed with deionized water, before use and between measurements.
- The submersible pump will be disassembled to the extent possible and cleaned with potable water and soap, and rinsed with potable water and then organic-free water. The cable and reel will be cleaned in the same manner. Upon reassembly and reeling the cable, a final rinse over and through the pump with organic-free water will be conducted.
- Decontamination liquids will be contained in a bucket and transferred to a 55-gallon drum upon completion of the decontamination activities.

6.4 SAFETY PROCEDURES FOR FIELD CLEANING OPERATIONS

Field personnel will exercise caution and follow applicable safety procedures contained in the Site Health and Safety Plan when handling cleaning materials. At a minimum, the following precautions will be taken in the field during cleaning operations:

- Safety glasses and nitrile gloves will be worn during decontamination of sampling equipment.

- Eating, smoking, drinking, or any hand to mouth contact will not be permitted during the cleaning operations.

6.5 HANDLING OF CLEANED EQUIPMENT

After field cleaning, personnel wearing clean gloves will handle equipment to prevent re-contamination. In addition, equipment cleaned at the decontamination pad will be moved away from the cleaning area to prevent re-contamination. If the equipment is not to be immediately re-used it will be covered with plastic sheeting and stored in an area away from potential contaminants.

7.0 MANAGEMENT OF INVESTIGATION DERIVED WASTE

The procedures associated with the management of investigation derived waste (IDW) have been developed in accordance with the SESD Operating Procedure “Management of Investigation Derived Waste,” effective July 3, 2014 (Appendix A). IDW that will be generated during implementation of the PDI include:

- Soil cuttings
- Groundwater (purge water)
- Decontamination fluids
- Acetate liners from soil sample collection via the DPT rig
- Tubing from groundwater sampling
- Decontamination pad materials
- Personal protective equipment (PPE)

Soil, purged water, and decontamination fluids will be stored in Department of Transportation (DOT)-approved 55-gallon drums. Liquid IDW will be accumulated separately from soil IDW and each drum will be labeled as to the drum’s contents. Disposable items, including PPE and acetate liners, are not considered hazardous and will be placed in trash bags and disposed of in a municipal solid waste dumpster. If the disposable items are heavily soiled and cannot be cleaned via the decontamination procedures described in Section 6.0, the items will be transferred to a DOT-approved 55-gallon drum and appropriately labeled pending disposal.

The drums will be transported off the Site for disposal at an approved disposal facility based on the laboratory analytical results of the submitted soil and groundwater samples. Waste characterization samples will be collected if required by the disposal facility. The IDW is not a listed hazardous waste. The proposed analyses will determine if the waste is hazardous by characterization. A drum management log will be completed by the FOL to track IDW generated during the PDI.

8.0 REFERENCES

Amec Foster Wheeler, 2014. NAPL Investigation Report, CTS of Asheville, Inc. Superfund Site, EPA ID: NCD003149556, May 5, 2014.

Amec Foster Wheeler, 2015. Final NAPL Area Focused Feasibility Study Addendum, CTS of Asheville, Inc. Superfund Site, EPA ID: NCD003149556, November 25, 2015.

USEPA, 2013. Field Measurement of Oxidation-Reduction Potential, Science and Ecosystem Support Division, Athens, GA; SESDPROC-113-R1, January 29, 2013.

USEPA, 2013. Field pH Measurement, Science and Ecosystem Support Division, Athens, GA; SESDPROC-100-R3, January 29, 2013.

USEPA, 2013. Groundwater Level and Well Depth Measurement, Science and Ecosystem Support Division, Athens, GA; SESDPROC-105-R2, January 29, 2013.

USEPA, 2013. Field Turbidity Measurement. Science and Ecosystem Support Division, Athens, GA; SESDPROC-103-R3, January 29, 2013.

USEPA, 2013. Groundwater Sampling, Science and Ecosystem Support Division, Athens, GA; SESDPROC-301-R3, March 6, 2013.

USEPA, 2014. Field Measurement of Dissolved Oxygen, Science and Ecosystem Support Division, Athens, GA; SESDPROC-106-R3, January 8, 2014.

USEPA, 2014. Management of Investigation Derived Waste, Science and Ecosystem Support Division, Athens, GA; SESDPROC-202-R3, July 3, 2014.

USEPA, 2014. Soil Sampling, Science and Ecosystem Support Division, Athens, GA; SESDPROC-300-R3, August 21, 2014.

USEPA, 2014. Field Temperature Measurement, Science and Ecosystem Support Division, Athens, GA; SESDPROC-102-R4, October 23, 2014.

USEPA, 2015. Global Positioning System, Science and Ecosystem Support Division, Athens, GA; SESDPROC-110-R4, June 23, 2015.

USEPA, 2015. Field Equipment Cleaning and Decontamination, Science and Ecosystem Support Division, Athens, GA; SESDPROC-205-R3, December 18, 2015.

USEPA, 2016. Field Specific Conductance Measurement, Science and Ecosystem Support Division, Athens, GA; SESDPROC-101-R6, July 13, 2016.

APPENDIX A

SESD OPERATING PROCEDURES

SESD PROCEDURE SESDPROC-105-R2:

GROUNDWATER LEVEL AND WELL DEPTH MEASUREMENT

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Groundwater Level and Well Depth Measurement**	
Effective Date: January 29, 2013	**Number:** SESDPROC-105-R2
Authors	
Name: Brian Striggow Title: Environmental Engineer Signature:	Date: 1-22-13
Approvals	
Name: Danny France Title: Chief, Enforcement and Investigations Branch Signature:	Date: 1-22-13
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature:	Date: 1/22/13

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-105-R2, *Groundwater Level and Well Depth Measurement*, replaces SESDPROC-105-R1 **General:** Corrected any typographical, grammatical, and/or editorial errors. **Title Page:** Changed the Author from Don Hunter to Brian Striggow Changed the EIB Chief from Antonio Quinones to Danny France. Changed the FQM from Laura Ackerman to Bobby Lewis. **Revision History:** In the 3rd sentence, changed Field Quality Manager to Document Control Coordinator. **Section 1.2:** Added the following statement: Mention of trade names or commercial products does not constitute endorsement or recommendation for use. **Section 1.3:** Omitted reference to the H: drive. Changed Field Quality Manager to Document Control Coordinator. **Section 1.4:** Updated references. **Section 2, 1st bullet:** Replaced references to "calibration" of groundwater level measuring devices to "verification" of such devices. In the 1st sentence, updated the language to reflect that devices used to measure groundwater levels will be verified annually against a NIST-traceable measuring tape instead of an Invar® steel surveyor's chain. In the 2nd sentence, added "…with an allowable error of 0.03 feet in the first 30 feet." Added the last sentence (reference to SESDFORM-043, *Well Sounder Function Check and Verification* form). **Section 3.1, 1st paragraph, last sentence:** Rewrote the sentence for clarity. Added the 4th paragraph regarding equilibration of water levels. **Added new Section 3.3,** *Special Considerations for Water Level Measurements at Low Groundwater Gradient.* Re-numbered following sub-sections. **Section 3.4:** Added the 5th sentence and the last sentence.	January 29, 2013

SESDPROC-105-R1, *Groundwater Level and Well Depth Measurement*, replaces SESDPROC-105-R0 **General** Updated referenced procedures due to changes in title names and/or to reflect most recent version. **Title Page** Changed title for Antonio Quinones from Environmental Investigations Branch to Enforcement and Investigations Branch. **Section 1.3** Updated information to reflect that procedure is located on the H: drive of the LAN. **Section 1.4** Alphabetized and revised the referencing style for consistency.	November 1, 2007
SESDPROC-105-R0, Groundwater Level and Well Depth Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when determining water levels and depths of wells.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators to measure water levels and depths of wells. On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for water level or depth determination, the variant procedure(s) will be documented in the field logbook and the subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network. The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when measuring water levels in wells and determining their depths. Refer to the SESD Safety, Health and

Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when measuring water levels and depths of wells:

- Special care must be taken to minimize the risk of cross-contamination between wells when conducting water level and depth measurements. This is accomplished primarily by decontaminating the sounders or other measuring devices between wells, according to SESD Operating Procedure for Field Equipment Cleaning and Decontamination, (SESDPROC-205) and maintaining the sounders in clean environment while in transit between wells.
- Water levels and well depths measured according to these procedures should be recorded in a bound logbook dedicated to the project as per SESD Operating Procedure for Logbooks (SESDPROC-010). Serial numbers, property numbers or other unique identification for the water level indicator or sounder must also be recorded.

2 Quality Control Issues

There are several specific quality control issues pertinent to conducting water level and depth measurements at wells. These are:

- Devices used to measure groundwater levels will be verified annually against a National Institute of Standards and Technology (NIST) traceable measuring tape.. These devices should check to within 0.01 feet per 10 feet of length with an allowable error of 0.03 feet in the first 30 feet. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage. All verification and maintenance data should be documented electronically or recorded in a logbook maintained at the Field Equipment Center (FEC) as per the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). The functional check and tape length verification should be performed according to the instructions included in SESDFORM-043, *Well Sounder Function Check and Verification,* which also includes the form for recording the required information.
- These devices should be decontaminated according to the procedures specified in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) prior to use at the next well.

3 Water Level and Depth Measurement Procedures

3.1 General

The measurement of the groundwater level in a well is frequently conducted in conjunction with ground water sampling to determine the "free" water surface. This potentiometric surface measurement can be used to establish ground water direction and gradients. Groundwater level and well depth measurements are needed to determine the volume of water or drawdown in the well casing for proper purging.

All groundwater level and well depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take both water level and depth measurements from the north side of the top of casing and note this procedure in the field logbook.

To be useful for establishing groundwater gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum. For an isolated group of wells, it is acceptable to use an arbitrary datum common to all wells in that group, if necessary.

Water levels should be allowed to equilibrate prior to measurement after removing sealing caps. There are no set guidelines and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology and topography, and project objectives.

3.2 Specific Groundwater Level Measurement Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods. Method accuracies are noted for each of the specific methods described below.

- Electronic Water Level Indicators – These types of instruments consist of a spool of dual conductor wire, a probe attached to the end and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or audible buzzer attached to the spool will signal contact. Penlight or 9-volt batteries are normally used as a power source. Measurements should be made and recorded to the nearest 0.01 foot.

- Other Methods – There are other types of water level indicators and recorders available on the market, such as weighted steel tape, chalked tape, sliding float method, air line pressure method and automatic recording methods. These methods are primarily used for closed systems or permanent monitoring wells.

Acoustic water level indicators are also available which measure water levels based on the measured return of an emitted acoustical impulse. Accuracies for these methods vary and should be evaluated before selection. Any method not capable of providing measurements to within 0.1 foot should not be used.

3.3 Special Considerations for Water Level Measurements at Sites with Shallow Groundwater Gradient

Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to allow the water level to equilibrate after removing sealing caps and the same sounder should be used for all measurements, if possible. The sounding activity should be coordinated to allow all wells to be sounded within the minimum possible time. This is particularly important in areas with potential tidal influences.

3.4 Total Well Depth Measurement Techniques

The well sounder, weighted tape or electronic water level indicators can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well and sediment in the bottom of the well can also make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements. The operator may find it easier to allow the weight to touch bottom and then detect the ‘tug’ on the tape while lifting the weight off the well bottom. All total depth measurements must be made and recorded to the nearest 0.1 foot. As a cautionary note, when measuring well depths with the electronic water level indicators, the person performing the measurement must measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth. This is necessary because the tape distance markings are referenced to the electrodes, rather than the end of the probe. For electronic sounders maintained at the SESD FEC, the sounder reel will be marked with the appropriate additional length identified as the ‘TD adder’.

3.5 Equipment Available

The following equipment is available for ground water level and total depth measurements:

- Weighted steel measuring tapes
- Electronic water level indicators

SESD PROCEDURE SESDPROC-300-R3:

SOIL SAMPLING

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Soil Sampling**

Effective Date: August 21, 2014

Number: SESDPROC-300-R3

Authors

Name: Kevin Simmons
Title: Environmental Scientist, Regional Expert
Signature:
Date: 8/18/2014

Approvals

Name: John Deatrick
Title: Acting Chief, Enforcement and Investigations Branch
Signature: John Deatrick
Date: 8/18/14

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: for Bobby Lewis
Date: 8/20/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-300-R3, *Soil Sampling*, replaces SESDPROC-300-R2. **General:** Corrected any typographical, grammatical and/or editorial errors. **Title Page:** Updated the author from Fred Sloan to Kevin Simmons. Updated the Enforcement and Investigations Branch Chief from Archie Lee to Acting Chief, John Deatrick. Section 1.5.1: Added "The reader should" to last sentence of the paragraph. Section 1.5.2: Omitted "When sampling in landscaped areas," from first sentence of eighth bullet. Section 3.2.4: In the first paragraph, first sentence, added "(rapidly form bubbles)." Omitted "(rapidly form bubbles)" from second paragraph, second sentence. Any reference to "Percent Moisture and Preservation Compatibility (MOICA)" or "Percent Moisture" was changed to "Percent Solids", both in the text and in Table 1.	August 21, 2014
SESDPROC-300-R2, *Soil Sampling*, replaces SESDPROC-300-R1.	December 20, 2011
SESDPROC-300-R1, *Soil Sampling*, replaces SESDPROC-300-R0.	November 1, 2007
SESDPROC-300-R0, Soil Sampling, Original Issue	February 05, 2007

TABLE OF CONTENTS

TABLES

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting soil samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling soil samples in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain a soil sample, the variant procedure will be documented in the field logbook and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN, and for maintaining records of review conducted prior to its issuance.

1.4 References

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field X-Ray Fluorescence (XRF) Measurement, SESDPROC-107, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

Title 49 Code of Federal Regulations, Pts. 171 to 179, Most Recent Version

US EPA Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Most Recent Version (Method 5035)

US EPA. Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting soil samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The reader should address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting soil samples:

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Collected samples are in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association

(IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader in the project files.
- Sampling in landscaped areas: Cuttings should be placed on plastic sheeting and returned to the borehole upon completion of the sample collection. Any 'turf plug' generated during the sampling process should be returned to the borehole.
- Sampling in non-landscaped areas: Return any unused sample material back to the auger, drill or push hole from which the sample was collected.

2 Special Sampling Considerations

2.1 Special Precautions for Trace Contaminant Soil Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different sample is collected and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers with samples suspected of containing high concentrations of contaminants shall be handled and stored separately.
- All background samples shall be segregated from obvious high-concentration or waste samples. Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area. Samples of waste or highly-contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other member(s) collect the samples.
- Samplers must use new, verified/certified-clean disposable or non-disposable equipment cleaned according to procedures contained in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205), for collection of samples for trace metals or organic compound analyses.

2.2 Sample Homogenization

1. If sub-sampling of the primary sample is to be performed in the laboratory, transfer the entire primary sample directly into an appropriate, labeled sample container(s). Proceed to step 4.

2. If sub-sampling the primary sample in the field or compositing multiple primary samples in the field, place the sample into a glass or stainless steel homogenization container and mix thoroughly. Each aliquot of a composite sample should be of the same approximate volume.

3. All soil samples must be thoroughly mixed to ensure that the sample is as representative as possible of the sample media. ***Samples for VOC analysis are not homogenized.*** The most common method of mixing is referred to as quartering. The quartering procedure should be performed as follows:

- The material in the sample pan should be divided into quarters and each quarter should be mixed individually.
- Two quarters should then be mixed to form halves.
- The two halves should be mixed to form a homogenous matrix.

  This procedure should be repeated several times until the sample is adequately mixed. If round bowls are used for sample mixing, adequate mixing is achieved by stirring the material in a circular fashion, reversing direction, and occasionally turning the material over.

4. Place the sample into an appropriate, labeled container(s) by using the alternate shoveling method and secure the cap(s) tightly. The alternate shoveling method involves placing a spoonful of soil in each container in sequence and repeating until the containers are full or the sample volume has been exhausted. Threads on the container and lid should be cleaned to ensure a tight seal when closed.

2.3 Dressing Soil Surfaces

Any time a vertical or near vertical surface is sampled, such as achieved when shovels or similar devices are used for subsurface sampling, the surface should be dressed (scraped) to remove smeared soil. This is necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels.

2.4 Quality Control

If possible, a control sample should be collected from an area not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same soil type. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by sampling tools. SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) contains other procedures that may be applicable to soil sampling investigations.

2.5 Records

Field notes, recorded in a bound field logbook, as well as chain-of-custody documentation will be generated as described in the SESD Operating Procedure for Logbooks (SESDPROC-010) and the SESD Operating Procedure for Sample and Evidence Management (SESDPROC-005).

3 Method 5035

The procedures outlined here are summarized from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Method 5035.*

3.1 Soil Samples for Volatile Organic Compounds (VOC) Analysis

If samples are to be analyzed for VOCs, they should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with an auger bucket, the sample for VOC analysis should be collected directly from the auger bucket (preferred) or from minimally disturbed material immediately after an auger bucket is emptied into the pan. The sample shall be containerized by filling an En Core® Sampler or other Method 5035 compatible container. ***Samples for VOC analysis are not homogenized.*** Preservatives may be required for some samples with certain variations of Method 5035. Consult the method or the principal analytical chemist to determine if preservatives are necessary.

3.2 Soil Sampling (Method 5035)

The following sampling protocol is recommended for site investigators assessing the extent of VOCs in soils at a project site. Because of the large number of options available, careful coordination between field and laboratory personnel is needed. The specific sampling containers and sampling tools required will depend upon the detection levels and intended data use. Once this information has been established, selection of the appropriate sampling procedure and preservation method best applicable to the investigation can be made.

3.2.1 Equipment

Soil for VOC analyses may be retrieved using any of the SESD soil sampling methods described in Sections 4 through 8 of this procedure. Once the soil has been obtained, the En Core® Sampler, syringes, stainless steel spatula, standard 2-oz. soil VOC container, or pre-prepared 40 mL vials may be used/required for sub-sampling. The specific sample containers and the sampling tools required will depend upon the data quality objectives established for the site or sampling investigation. The various sub-sampling methods are described below.

3.2.2 Sampling Methodology - Low Concentrations (<200 µg/kg)

When the total VOC concentration in the soil is expected to be less than 200 µg/kg, the samples may be collected directly with the En Core® Sampler or syringe. If using the syringes, the sample must be placed in the sample container (40 mL pre-prepared vial) immediately to reduce volatilization losses. The 40 mL vials should contain 10 mL of organic-free water for an un-preserved sample or approximately

10 mL of organic-free water and a preservative. It is recommended that the 40 mL vials be prepared and weighed by the laboratory (commercial sources are available which supply preserved and tared vials). When sampling directly with the En Core® Sampler, the vial must be immediately capped and locked.

A soil sample for VOC analysis may also be collected with conventional sampling equipment. A sample collected in this fashion must either be placed in the final sample container (En Core® Sampler or 40 mL pre-prepared vial) immediately or the sample may be immediately placed into an intermediate sample container with no head space. If an intermediate container (usually 2-oz. soil jar) is used, the sample must be transferred to the final sample container (En Core® Sampler or 40 mL pre-prepared vial) as soon as possible, not to exceed 30 minutes.

NOTE: After collection of the sample into either the En Core® Sampler or other container, the sample must immediately be stored in an ice chest and cooled.

Soil samples may be prepared for shipping and analysis as follows:

En Core® Sampler - the sample shall be capped, locked, and secured in the original foil bag. All foil bags containing En Core® samplers are then placed in a plastic bag and sealed with custody tape, if required.

Syringe - Add about 3.7 cc (approximately 5 grams) of sample material to 40-mL pre-prepared containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag. Note: When using the syringes, it is important that no air is allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.

Stainless Steel Laboratory Spatulas - Add between 4.5 and 5.5 grams (approximate) of sample material to 40 mL containers. Secure the containers in a plastic bag. Do not use a custody seal on the container; place the custody seal on the plastic bag.

3.2.3 Sampling Methodology - High Concentrations (>200 µg/kg)

Based upon the data quality objectives and the detection level requirements, this high level method may also be used. Specifically, the sample may be packed into a single 2-oz. glass container with a screw cap and septum seal. The sample container must be filled quickly and completely to eliminate head space. Soils\sediments containing high total VOC concentrations may also be collected as described in Section 3.2.2, Sampling Methodology - Low Concentrations, and preserved using 10 mL methanol.

3.2.4 Special Techniques and Considerations for Method 5035

Effervescence

If low concentration samples effervesce (rapidly form bubbles) from contact with the acid preservative, then either a test for effervescence must be performed prior to sampling, or the investigators must be prepared to collect each sample both preserved or un-preserved, as needed, or all samples must be collected unpreserved.

To check for effervescence, collect a test sample and add to a pre-preserved vial. If preservation (acidification) of the sample results in effervescence then preservation by acidification is not acceptable, and the sample must be collected un-preserved.

If effervescence occurs and only pre-preserved sample vials are available, the preservative solution may be placed into an appropriate hazardous waste container and the vials triple rinsed with organic free water. An appropriate amount of organic free water, equal to the amount of preservative solution, should be placed into the vial. The sample may then be collected as an un-preserved sample. Note: the amount of organic free water placed into the vials will have to be accurately measured.

Sample Size

While this method is an improvement over earlier ones, field investigators must be aware of an inherent limitation. Because of the extremely small sample size and the lack of sample mixing, sample representativeness for VOCs may be reduced compared to samples with larger volumes collected for other constituents. The sampling design and objectives of the investigation should take this into consideration.

Holding Times

Sample holding times are specified in the Analytical Support Branch *Laboratory Operations and Quality Assurance Manual* (ASBLOQAM), Most Recent Version. Field investigators should note that the holding time for an un-preserved VOC soil/sediment sample on ice is 48 hours. Arrangements should be made to ship the soil/sediment VOC samples to the laboratory by overnight delivery the day they are collected so the laboratory may preserve and/or analyze the sample within 48 hours of collection.

Percent Solids

Samplers must ensure that the laboratory has sufficient material to determine percent solids in the VOC soil/sediment sample to correct the analytical results to dry weight. If other analyses requiring percent solids determination are being performed upon the sample, these results may be used. If not, a separate sample (minimum of 2 oz.) for percent solids determination will be required. The sample collected for percent solids may also be used by the laboratory to check for preservative compatibility.

Safety

Methanol is a toxic and flammable liquid. Therefore, methanol must be handled with all required safety precautions related to toxic and flammable liquids. Inhalation of methanol vapors must be avoided. Vials should be opened and closed quickly during the sample preservation procedure. Methanol must be handled in a ventilated area. Use protective gloves when handling the methanol vials. Store methanol away from sources of ignition such as extreme heat or open flames. The vials of methanol should be stored in a cooler with ice at all times.

Shipping

Methanol and sodium bisulfate are considered dangerous goods, therefore shipment of samples preserved with these materials by common carrier is regulated by the U.S. Department of Transportation and the International Air Transport Association (IATA). The rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179) and the current edition of the IATA Dangerous Goods Regulations must be followed when shipping methanol and sodium bisulfate. Consult the above documents or the carrier for additional information. Shipment of the quantities of methanol and sodium bisulfate used for sample preservation falls under the exemption for small quantities.

The summary table on the following page lists the options available for compliance with SW846 Method 5035. The advantages and disadvantages are noted for each option. SESD's goal is to minimize the use of hazardous material (methanol and sodium bisulfate) and minimize the generation of hazardous waste during sample collection.

Table 1: Method 5035 Summary

OPTION	PROCEDURE	ADVANTAGES	DISADVANTAGES
1	Collect two 40 mL vials with ≈ 5 grams of sample, and one 2 oz. glass jar w/septum lid for screening, % moisture and preservative compatibility.	Screening conducted by lab.	Presently a 48-hour holding time for unpreserved samples. Sample containers must be tared.
2	Collect three En Core® samplers, and one 2 oz. glass jar w/septum lid for screening, % solids.	Lab conducts all preservation/preparation procedures.	Presently a 48- hour holding time for preparation of samples.
3	Collect two 40 mL vials with 5 grams of sample and preserve w/methanol or sodium bisulfate, and one 2-oz. glass jar w/septum lid for screening, % solids .	High level VOC samples may be composited. Longer holding time.	Hazardous materials used in the field. Sample containers must be tared.
4	Collect one 2-oz. glass jar w/septum lid for analysis, % solids (high level VOC only).	Lab conducts all preservation/preparation procedures.	May have significant VOC loss.

4 Manual Soil Sampling Methods

4.1 General

These methods are used primarily to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface. The most common interval is 0 to 6 inches; however, the data quality objectives of the investigation may dictate another interval, such as 0 to 3 inches for risk assessment purposes. The shallow subsurface interval may be considered to extend from approximately 12 inches below ground surface to a site-specific depth at which sample collection using manual collection methods becomes impractical.

If a thick, matted root zone, gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials.

When compositing, make sure that each composite location (aliquot) consist of equal volumes, i.e., same number of equal spoonfuls.

4.2 Spoons

Stainless steel spoons may be used for surface soil sampling to depths of approximately 6 inches below ground surface where conditions are generally soft and non-indurated, and there is no problematic vegetative layer to penetrate.

4.2.1 Special Considerations When Using Spoons

- When using stainless steel spoons, consideration must be given to the procedure used to collect the volatile organic compound sample. If the soil being sampled is cohesive and holds its in situ texture in the spoon, the En Core® Sampler or syringe used to collect the sub-sample for Method 5035 should be plugged directly from the spoon. If, however, the soil is not cohesive and crumbles when removed from the ground surface for sampling, consideration should be given to plugging the sample for Method 5035 directly from the ground surface at a depth appropriate for the investigation Data Quality Objectives.

4.3 Hand Augers

Hand augers may be used to advance boreholes and collect soil samples in the surface and shallow subsurface intervals. Typically, 4-inch stainless steel auger buckets with cutting heads are used. The bucket is advanced by simultaneously pushing and turning using an attached handle with extensions (if needed).

4.3.1 Surface Soil Sampling

When conducting surface soil sampling with hand augers, the auger buckets may be used with a handle alone or with a handle and extensions. The bucket is advanced to the appropriate depth and the contents are transferred to the homogenization container for processing. Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

4.3.2 Subsurface Soil Sampling

Hand augers are the most common equipment used to collect shallow subsurface soil samples. Auger holes are advanced one bucket at a time until the sample depth is achieved. When the sample depth is reached, the bucket used to advance the hole is removed and a clean bucket is attached. The clean auger bucket is then placed in the hole and filled with soil to make up the sample and removed.

The practical depth of investigation using a hand auger depends upon the soil properties and depth of investigation. In sand, augering is usually easily performed, but the depth of collection is limited to the depth at which the sand begins to flow or collapse. Hand augers may also be of limited use in tight clays or cemented sands. In these soil types, the greater the depth attempted, the more difficult it is to recover a sample due to increased friction and torqueing of the hand auger extensions. At some point these problems become so severe that power equipment must be used.

4.3.3 Special Considerations for Soil Sampling with the Hand Auger

- Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to placing the bucket contents in the homogenization container for processing.
- Observe precautions for volatile organic compound (VOC) sample collection found in Section 3, Method 5035. Collect the VOC sample directly from the auger bucket, if possible.
- Power augers, such as the Little Beaver® and drill rigs may be used to advance boreholes to depths for subsurface soil sampling with the hand auger. They may not be used for sample collection. When power augers are used to advance a borehole to depth for sampling, care must be taken that exhaust fumes, gasoline and/or oil do not contaminate the borehole or area in the immediate vicinity of sampling.
- When moving to a new sampling location, the entire hand auger assembly must be replaced with a properly decontaminated hand auger assembly.

5 Direct Push Soil Sampling Methods

5.1 General

These methods are used primarily to collect shallow and deep subsurface soil samples. Three samplers are available for use within the Division's direct push tooling inventory. All of the sampling tools involve the collection and retrieval of the soil sample within a thin-walled liner. The following sections describe each of the specific sampling methods that can be accomplished using direct push techniques, along with details specific to each method. While SESD currently uses the sample tooling described, tooling of similar design and materials is acceptable.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

5.2 Large Bore® Soil Sampler

The Large Bore® (LB) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of depth-discrete subsurface soil samples. The sample barrel is approximately 30-inches (762 mm) long and has a 1.5-inch (38 mm) outside diameter. The LB® sampler is capable of recovering a discrete sample core 22 inches x 1.0 inch (559 mm x 25 mm) contained inside a removable liner. The resultant sample volume is a maximum of 283 mL.

After the LB® sample barrel is equipped with the cutting shoe and liner, the piston-rod point assembly is inserted, along with the drive head and piston stop assembly. The assembled sampler is driven to the desired sampling depth, at which time the piston stop pin is removed, freeing the push point. The LB® sampler is then pushed into the soil a distance equal to the length of the LB® sample barrel. The probe rod string, with the LB® sampler attached, is then removed from the subsurface. After retrieval, the LB® sampler is then removed from the probe rod string. The drive head is then removed to allow removal of the liner and soil sample.

5.3 Macro-Core® Soil Sampler

The Macro-Core® (MC) sampler is a solid barrel direct push sampler equipped with a piston-rod point assembly used primarily for collection of either continuous or depth-discrete subsurface soil samples. Although other lengths are available, the standard MC® sampler has an assembled length of approximately 52 inches (1321 mm) with an outside diameter of 2.2 inches (56 mm). The MC® sampler is capable of recovering a discrete sample core 45 inches x 1.5 inches (1143 mm x 38 mm) contained inside a removable liner. The resultant sample volume is a maximum of 1300 mL. The MC® sampler may be used in either an open-tube or closed-point configuration. Although the MC® sampler can be used as an open-barrel sampler, in SESD usage, the piston point is always used to prevent the collection of slough from the borehole sides.

5.4 Dual Tube Soil Sampling System

The Dual Tube 21 soil sampling system is a direct push system for collecting continuous core samples of unconsolidated materials from within a sealed outer casing of 2.125-inch (54 mm) OD probe rod. The samples are collected within a liner that is threaded onto the leading end of a string of 1.0-inch diameter probe rod. Collected samples have a volume of up to 800 mL in the form of a 1.125-inch x 48-inch (29 mm x 1219 mm) core. Use of this method allows for collection of continuous core inside a cased hole, minimizing or preventing cross-contamination between different intervals during sample collection. The outer casing is advanced, one core length at a time, with only the inner probe rod and core being removed and replaced between samples. If the sampling zone of interest begins at some depth below ground surface, a solid drive tip must be used to drive the dual tube assembly and core to its initial sample depth.

5.5 Special Considerations When Using Direct Push Sampling Methods

- *Liner Use and Material Selection* – Direct Push Soil Samples are collected within a liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool, although overall, liners are available in brass, stainless steel, cellulose acetate butyrate (CAB), polyethylene terepthalate glycol (PETG), polyvinyl chloride (PVC) and Teflon®. For most SESD investigations, the standard polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or unusual contaminants of concern, the use of more inert liner materials such as Teflon® or stainless steel may be necessary.

- *Sample Orientation* – When the liners and associated sample are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.

- *Core Catchers* – Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In cases such as these, the use of core catchers on the leading end of the sampler may help retain the sample until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable.

- *Decontamination* – The cutting shoe and piston rod point are to be decontaminated between each sample, using the procedures specified for the collection of trace organic and inorganic compounds found in Field Equipment and Decontamination – SESDPROC-205, most recent version. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material, but must be cleaned between boreholes using the procedures specified for downhole drilling equipment in Field Equipment and Decontamination – SESDPROC-205, most recent version.

- *Decommissioning* – Boreholes must be decommissioned after the completion of sampling. Boreholes less than 10 feet deep that remain open and do not approach the water table may be decommissioned by pouring 30% solids bentonite grout from the surface or pouring bentonite pellets from the surface, hydrating the pellets in lifts. Boreholes deeper than 10 feet, or any borehole that intercepts groundwater, must be decommissioned by pressure grouting with 30% solids bentonite grout, either through a re-entry tool string or through tremie pipe introduced to within several feet of the borehole bottom.

- *VOC Sample Collection* – Observe precautions for volatile organic compound sample collection found in Section 3 of this procedure.

6 Split Spoon/Drill Rig Methods

6.1 General

Split spoon sampling methods are used primarily to collect shallow and deep subsurface soil samples. All split spoon samplers, regardless of size, are basically split cylindrical barrels that are threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe. The other end is held together with a threaded collar that serves as the sub used to attach the spoon to the string of drill rod. Two basic methods are available for use, including the smaller diameter standard split spoon, driven with the drill rig safety hammer, and the larger diameter continuous split spoon, advanced inside and slightly ahead of the lead auger during hollow stem auger drilling. The following sections describe each of the specific sampling methods, along with details specific to each method.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with these devices.

6.2 Standard Split Spoon

A drill rig is used to advance a borehole to the target depth. The drill string is then removed and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2.0-inches OD (1.5-inches ID) and 18-inches to 24-inches in length. Other diameters and lengths are common and may be used if constructed of the proper material. After the spoon is attached to the string of drill rod, it is lowered into the borehole. The safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample acquisition.

6.3 Continuous Split Spoon

The continuous split spoon is a large diameter split spoon that is advanced into the soil column inside a hollow stem auger. Continuous split spoons are typically 3 to 5 inches in diameter and either 5 feet or 10 feet in length, although the 5-foot long samplers are most common. After the auger string has been advanced into the soil column a distance equal to the length of the sampler being used it is returned to the surface. The sampler is removed from inside the hollow stem auger and the threaded collars are removed. The split spoon is then opened for sampling.

6.4 Special Considerations When Using Split Spoon Sampling Methods

- Always discard the top several inches of material in the spoon before removing any portion for sampling. This material normally consists of borehole wall material that has sloughed off of the borehole wall after removal of the drill string prior to and during inserting the split spoon.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

7 Shelby Tube/Thin-Walled Sampling Methods

7.1 General

Shelby tubes, also referred to generically as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses, such as hydraulic conductivity and permeability, to support hydrogeologic characterizations at hazardous waste and other sites.

If gravel, concrete, etc. is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with this device.

7.2 Shelby Tube Sampling Method

A typical Shelby tube is 30 inches in length and has a 3.0-inch OD (2.875-inch ID) and may be constructed of steel, stainless steel, galvanized steel, or brass. They also typically are attached to push heads that are constructed with a ball-check to aid in holding the contained sample during retrieval. If used for collecting samples for chemical analyses, it must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable.

To collect a sample, the tube is attached to a string of drill rod and is lowered into the borehole, where the sampler is then pressed into the undisturbed material by hydraulic force. After retrieval to the surface, the tube containing the sample is then removed from the sampler head. If samples for chemical analyses are needed, the soil contained inside the tube is then removed for sample acquisition. If the sample is collected for geotechnical parameters, the tube is typically capped, maintaining the sample in its relatively undisturbed state, and shipped to the appropriate geotechnical laboratory.

7.3 Special Considerations When Using Split Spoon Sampling Methods

Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

8 Backhoe Sampling Method

8.1 General

Backhoes may be used in the collection of surface and shallow subsurface soil samples. The trenches created by excavation with a backhoe offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. If possible, the sample should be collected without entering the trench. Samples may be obtained from the trench wall or they may be obtained directly from the bucket at the surface. The following sections describe various techniques for safely collecting representative soil samples with the aid of a backhoe.

The depth measurement for the sample begins at the top of the soil horizon.

8.2 Scoop-and-Bracket Method

If a sample interval is targeted from the surface, it can be sampled using a stainless steel scoop and bracket. First a scoop and bracket are affixed to a length of conduit and is lowered into the backhoe pit. The first step is to take the scoop and scrape away the soil comprising the surface of the excavated wall. This material likely represents soil that has been smeared by the backhoe bucket from adjacent material. After the smeared material has been scraped off, the original stainless steel scoop is removed and a clean stainless steel scoop is placed on the bracket. The clean scoop can then be used to remove sufficient volume of soil from the excavation wall to make up the required sample volume.

8.3 Direct-from-Bucket Method

It is also possible to collect soil samples directly from the backhoe bucket at the surface. Some precision with respect to actual depth or location may be lost with this method but if the soil to be sampled is uniquely distinguishable from the adjacent or nearby soils, it may be possible to characterize the material as to location and depth. In order to ensure representativeness, it is also advisable to dress the surface to be sampled by scraping off any smeared material that may cross-contaminate the sample.

8.4 Special Considerations When Sampling with a Backhoe

- Do not physically enter backhoe excavations to collect a sample. Use either procedure 8.2, Scoop-and-Bracket Method, or procedure 8.3, Direct-from-Bucket Method to obtain soil for sampling.
- Smearing is an important issue when sampling with a backhoe. Measures must be taken, such as dressing the surfaces to be sampled (see Section 2.3), to mitigate problems with smearing.

- Paint, grease and rust must be removed and the bucket decontaminated prior to sample collection.
- Observe precautions for volatile organic compound sample collection found in Section 3, Method 5035.

SESD PROCEDURE SESDPROC-301-R4:

GROUNDWATER SAMPLING

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Groundwater Sampling**

Effective Date: March 6, 2013

Number: SESDPROC-301-R3

Authors

Name: Jonathan Vail
Title: Environmental Scientist, Regional Expert
Signature:
Date: 3/4/2013

Approvals

Name: Danny France
Title: Chief, Enforcement and Investigations Branch
Signature:
Date: 3/4/13

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 3/4/13

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-301-R3, Groundwater Sampling, replaces SESDPROC-301-R2. **General:** Corrected any typographical, grammatical and/or editorial errors. **Title Page:** Changed author from Donald Hunter to Jonathan Vail. Changed Enforcement and Investigations Branch Chief from Archie Lee to Danny France. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 2.3**: Item 4 was revised to reflect practice of using individual single-use preservative vials instead of preservatives prepared by ASB.	**March 6, 2013**
SESDPROC-301-R2, Groundwater Sampling, replaces SESDPROC-301-R1.	**October 28, 2011**
SESDPROC-301-R1, Groundwater Sampling, replaces SESDPROC-301-R0.	**November 1, 2007**
SESDPROC-301-R0, Groundwater Sampling, Original Issue	**February 05, 2007**

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when collecting groundwater samples for field screening or laboratory analysis.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when collecting and handling groundwater samples in the field. On the occasion that SESD field personnel determine that any of the procedures described are either inappropriate, inadequate or impractical and that another procedure must be used to obtain a groundwater sample, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Columbia Analytical Services, Lab Science News, Passive Diffusion Devices & Polyethylene Diffusion Bag (PDB) Samplers.

International Air Transport Authority (IATA). Dangerous Goods Regulations, Most Recent Version

Puls, Robert W., and Michael J. Barcelona. 1989. Filtration of Ground Water Samples for Metals Analysis. Hazardous Waste and Hazardous Materials 6(4), pp.385-393.

Puls, Robert W., Don A. Clark, and Bert Bledsoe. 1992. Metals in Ground Water: Sampling Artifacts and Reproducibility. Hazardous Waste and Hazardous Materials 9(2), pp. 149-162.
SESD Guidance Document, Design and Installation of Monitoring Wells, SESDGUID-001, Most Recent Version

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version

SESD Operating Procedure for Sample and Evidence Management, SESDPROC-005, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Operating Procedure for Field Sampling Quality Control, SESDPROC-011, Most Recent Version

SESD Operating Procedure for Field pH Measurement, SESDPROC-100, Most Recent Version

SESD Operating Procedure for Field Specific Conductance Measurement, SESDPROC-101, Most Recent Version

SESD Operating Procedure for Field Temperature Measurement, SESDPROC-102, Most Recent Version

SESD Operating Procedure for Field Turbidity Measurement, SESDPROC-103, Most Recent Version

SESD Operating Procedure for Groundwater Level and Well Depth Measurement, SESDPROC-105, Most Recent Version

SESD Operating Procedure for Management of Investigation Derived Waste, SESDROC-202, Most Recent Version

SESD Operating Procedure for Pump Operation, SESDPROC-203, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

SESD Operating Procedure for Potable Water Supply Sampling, SESDPROC-305, Most Recent Version

The Interstate Technology & Regulatory Council, Technology Overview of Passive Sampler Technologies, Prepared by The Interstate Technology & Regulatory Council Diffusion Sampler Team, March 2006.

United States Environmental Protection Agency (US EPA). 1975. Handbook for Evaluating Water Bacteriological Laboratories. Office of Research and Development (ORD), Municipal Environmental Research Laboratory, Cincinnati, Ohio.

US EPA. 1977. Sampling for Organic Chemicals and Microorganisms in the Subsurface. EPA-600/2-77/176.

US EPA. 1978. Microbiological Methods for Monitoring the Environment, Water and Wastes. ORD, Municipal Environmental Research Laboratory, Cincinnati, Ohio.

US EPA. 1981. "Final Regulation Package for Compliance with DOT Regulations in the Shipment of Environmental Laboratory Samples," Memo from David Weitzman, Work Group Chairman, Office of Occupational Health and Safety (PM-273), April 13, 1981.

US EPA. 1995. Ground Water Sampling - A Workshop Summary. Proceedings from the Dallas, Texas November 30 – December 2, 1993 Workshop. ORD, Robert S. Kerr Environmental Research Laboratory. EPA/600/R-94/205, January 1995.

US EPA. Analytical Support Branch Laboratory Operations and Quality Assurance Manual. Region 4 SESD, Athens, GA, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when collecting groundwater samples. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when collecting groundwater samples.

- Special care must be taken not to contaminate samples. This includes storing samples in a secure location to preclude conditions which could alter the properties of the sample. Samples shall be custody sealed during long-term storage or shipment.
- Always sample from the anticipated cleanest, i.e., least contaminated location, to the most contaminated location. This minimizes the opportunity for cross-contamination to occur during sampling.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.

- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Shipped samples shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.
- Documentation of field sampling is done in a bound logbook.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- All shipping documents, such as air bills, bills of lading, etc., shall be retained by the project leader and placed in the project files.

2 Special Sampling Considerations

2.1 Volatile Organic Compounds (VOC) Analysis

Groundwater samples for VOC analysis must be collected in 40 ml glass vials with Teflon® septa. The vial may be either preserved with concentrated hydrochloric acid or they may be unpreserved. Preserved samples have a two-week holding time, whereas unpreserved samples have only a seven-day holding time. In the great majority of cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has a high amount of dissolved limestone, i.e., is highly calcareous, there will most likely be an effervescent reaction between the hydrochloric acid and the water, producing large numbers of fine bubbles. This will render the sample unacceptable. In this case, unpreserved vials should be used and arrangements must be confirmed with the laboratory to ensure that they can accept the unpreserved vials and meet the shorter sample holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and absolutely no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm of one hand to see if any undetected bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus. Care should be taken not to flush any preservative out of the vial during topping off. If, after topping off and capping the vial, bubbles are still present, a new vial should be obtained and the sample re-collected.

Samples for VOC analysis must be collected using either stainless steel or Teflon® equipment, such as:

- Bailers must be constructed of stainless steel or Teflon®
- RediFlo2® submersible pumps used for sampling should be equipped with Teflon® sample delivery tubing
- Peristaltic pump/vacuum jug assemblies should be outfitted with Teflon® tubing from the water column to the transfer cap, which should also be constructed of Teflon®

2.2 Special Precautions for Trace Contaminant Groundwater Sampling

- A clean pair of new, non-powdered, disposable gloves will be worn each time a different location is sampled and the gloves should be donned immediately prior to sampling. The gloves should not come in contact with the media being sampled and should be changed any time during sample collection when their cleanliness is compromised.
- Sample containers for samples suspected of containing high concentrations of contaminants shall be stored separately.

- Sample collection activities shall proceed progressively from the least suspected contaminated area to the most suspected contaminated area if sampling devices are to be reused. Samples of waste or highly contaminated media must not be placed in the same ice chest as environmental (i.e., containing low contaminant levels) or background samples.
- If possible, one member of the field sampling team should take all the notes and photographs, fill out tags, etc., while the other members collect the samples.
- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.
- Samplers must use new, verified certified-clean disposable or non-disposable equipment cleaned according to procedures contained in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) for collection of samples for trace metals or organic compound analyses.

2.3 Sample Handling and Preservation Requirements

1. Groundwater samples will typically be collected from the discharge line of a pump or from a bailer, either from the pour stream of an up-turned bailer or from the stream from a bottom-emptying device. Efforts should be made to reduce the flow from either the pump discharge line or the bailer during sample collection to minimize sample agitation.

2. During sample collection, make sure that the pump discharge line or the bailer does not contact the sample container.

3. Place the sample into appropriate, labeled containers. Samples collected for VOC, acidity and alkalinity analysis must not have any headspace. All other sample containers must be filled with an allowance for ullage.

4. All samples requiring preservation must be preserved as soon as practically possible, ideally immediately at the time of sample collection. If preserved VOC vials are used, these will be preserved with concentrated hydrochloric acid by ASB personnel prior to departure for the field investigation. For all other chemical preservatives, SESD will use the appropriate chemical preservative generally stored in an individual single-use vial as described in the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011). The adequacy of sample preservation will be checked after the addition of the preservative for all samples except for the samples collected for VOC analysis. If additional preservative is needed, it should be added to achieve adequate preservation. Preservation requirements for groundwater samples are found in the USEPA Region 4 Analytical Support Branch Laboratory Operations and Quality Assurance Manual (ASBLOQAM).

2.4 Quality Control

If possible, a control sample should be collected from a location not affected by the possible contaminants of concern and submitted with the other samples. This control sample should be collected as close to the sampled area as possible and from the same water-bearing formation. Equipment blanks should be collected if equipment is field cleaned and re-used on-site or if necessary to document that low-level contaminants were not introduced by pumps, bailers or other sampling equipment.

2.5 Records

Information generated or obtained by SESD personnel will be organized and accounted for in accordance with SESD records management procedures found in SESD Operating Procedure for Control of Records, SESDPROC-002. Field notes, recorded in a bound field logbook, will be generated, as well as chain-of-custody documentation in accordance with SESD Operating Procedure for Logbooks, SESDPROC-010 and SESD Procedure for Sample and Evidence Management, SESDPROC-005.

3 Groundwater Sampling Methods – Purging

3.1 General

Purging is the process of removing stagnant water from a well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation that is representative of actual aquifer conditions. In order to determine when a well has been adequately purged, field investigators should monitor, at a minimum, the pH, specific conductance and turbidity of the groundwater removed during purging and, in the case of permanent monitoring wells, observe and record the volume of water removed.

There are several purging strategies that may be used, depending on specific conditions encountered for given well sampling situations. When a specific well is characterized, based on the field investigators experience and knowledge, as having fairly typical water levels, depths and purge volumes, as determined according to the procedures in Section 3.2.1, below, SESD will normally use the multiple volume purging procedures and equipment described in Sections 3.2.1 and 3.3 of this procedure for purging the well.

When the traditional multiple volume purge method is considered and it is determined that excessive quantities of IDW would be generated using this method, it may be appropriate, under very limited and specific circumstances, to use an alternate method that reduces the time and amount of purge water to be removed prior to sampling the well. The field project leader will select the alternate method only after careful consideration of the conditions presented by the well and the impact these conditions have on all aspects of the sampling event (time required to sample, quantities of IDW requiring management, etc.).

The alternate purge procedures or sampling strategies available are the "Tubing-in-Screened Interval" method and the MicroPurge or No-Purge methods. These are described and discussed in Sections 3.2.2 and 4.5 of this operating procedure, respectively.

3.2 Purging Methods and Strategies

3.2.1 Traditional Multiple Volume Purge

3.2.1.1 Purging and Purge Adequacy

3.2.1.1.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined, if possible. To do this, the diameter of the well should be determined and the water level and total depth of the well should be measured and recorded. Specific methodology for obtaining these measurements is found in SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105).

Once this information is obtained, the volume of water to be purged can be determined using one of several methods. One is the equation:

$V = 0.041\ d^2h$

Where: h = depth of water in feet
d = diameter of well in inches
V = volume of water in gallons

Alternatively, the volume of standing water in the well and the volume of three water columns may be determined using a casing volume per foot factor for the appropriate diameter well, similar to that in Table 3.2.1. The water level is subtracted from the total depth, providing the length of the water column. This length is multiplied by the appropriate factor in the Table 3.2.1, corresponding to either the single well volume or the triple well volume, to determine both the single well volume and triple well volumes, in gallons, for the well in question. Other acceptable methods include the use of nomographs or other equations or formulae.

TABLE 3.2.1: WELL CASING DIAMETER VOLUME FACTORS

Casing Diameter (inches)	Gallons/ft, One Water Column	Gallons/ft, Three Water Columns
1	0.04	0.12
2	0.16	0.48
3	0.37	1.11
4	0.65	1.98
5	1.02	3.06
6	1.47	4.41
7	1.99	5.97
8	2.61	7.83
9	3.30	9.90
10	4.08	12.24
11	4.93	14.79
12	5.87	17.61

With respect to volume, an adequate purge is normally achieved when three to five well volumes have been removed. The field notes should reflect the single well volume calculations or determinations, according to one of the above methods, and a reference to the appropriate multiplication of that volume, i.e., a minimum three well volumes, clearly identified as a purge volume goal.

3.2.1.1.2 Chemical Parameter Stabilization Criteria

With respect to the ground water chemistry, an adequate purge is achieved when the pH and specific conductance of the ground water have stabilized and the turbidity has either stabilized or is below 10 Nephelometric Turbidity Units (NTUs) (twice the Primary Drinking Water Standard of 5 NTUs). Although 10 NTUs is normally considered the minimum goal for most ground water sampling objectives, lower turbidity has been shown to be easily achievable in most situations and reasonable attempts should be made to achieve these lower levels. (Note: Because groundwater temperature is subject to rapid changes when collected for parameter measurement, its usefulness is subject to question for the purpose of determining parameter stability. As such, it has been removed from the list of parameters used for stability determination. Even though temperature is not used to determine stability during well purging, it is still advisable to record the sample temperature, along with the other groundwater chemistry parameters during well purging, as it may be needed to interpret other chemical parameter results in some situations.)

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.1 Standard Unit (SU) and specific conductance varies no more than approximately 5 percent. Other parameters, such as dissolved oxygen (DO), may also be used as a purge adequacy parameter. Normal goals for DO are 0.2 mg/L or 10% saturation, whichever is greater. DO measurements must be conducted using either a flow-through cell or an over-topping cell to minimize or reduce any oxygenation of the sample during measurement. Oxidation Reduction Potential (ORP) should not be used as a purge stabilization parameter but may be measured during purging to obtain the measurement of record for ORP for the sampling event.

There are no set criteria for establishing how many total sets of measurements are adequate to document stability of parameters. If the calculated purge volume is small, the measurements should be taken frequently enough to provide a sufficient number of measurements to evaluate stability. If the purge volume is large, measurements taken every 15 minutes, for example, may be sufficient. See the SESD Operating Procedures for Field pH Measurement (SESDPROC-100), Field Specific Conductance Measurement (SESDPROC-101), Field Temperature Measurement (SESDPROC-102), Field Turbidity Measurement (SESDPROC-103), Field Measurement of Dissolved Oxygen (SESDPROC-106) and Field Measurement of Oxidation-Reduction Potential (SESDPROC-113) for procedures for conducting these measurements.

If, after three well volumes have been removed, the chemical parameters have not stabilized according to the above criteria, additional well volumes (up to five well volumes), should be removed. If the parameters have not stabilized within five volumes, it is at the discretion of the project leader whether or not to collect a sample or to continue purging. If, after five well volumes, pH and conductivity have stabilized and the turbidity is still decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible, with respect to turbidity. The conditions of sampling should be noted in the field log.

3.2.1.1.3 Purge Adequacy Considerations

In some situations, even with slow purge rates, a well may be pumped or bailed dry (evacuated). In these situations, this generally constitutes an adequate purge and the well can be sampled following sufficient recovery (enough volume to allow filling of all sample containers). ***It is not necessary that the well be evacuated three times before it is sampled***. The pH, specific conductance, temperature, and turbidity should be measured and recorded, during collection of the sample from the recovered volume, as the measurements of record for the sampling event.

For wells with slow recovery, attempts should be made to avoid purging them to dryness. This can be accomplished, for example, by slowing the purge rate. As water enters a well that has been purged to dryness, it may cascade down the sand pack and/or the well screen, stripping volatile organic constituents that may be present and/or introducing soil fines into the water column.

It is particularly important that wells be sampled as soon as possible after purging. If adequate volume is available immediately upon completion of purging, the well must be sampled immediately. If not, sampling should occur as soon as adequate volume has recovered. If possible, sampling of wells which have a slow recovery should be scheduled so that they can be purged and sampled in the same day, after adequate volume has recovered. Wells of this type should, unless it is unavoidable, not be purged at the end of one day and sampled the following day.

3.2.2 "Tubing-in-Screened-Interval" Method

The "Tubing-in-Screen" method, sometimes referred to as the "Low Flow" method, is used primarily when calculated purge volumes for the traditional purging method are excessive and present issues related to timely completion of the project and/or management of investigation derived waste.

3.2.2.1 Purge Criteria

3.2.2.1.1 Placement of Pump Tubing or Intake

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well. By definition, this method cannot be applied for purging with a bailer.

3.2.2.1.2 Conditions of Pumping

Prior to initiation of pumping, a properly decontaminated well sounder should be lowered into the well being sampled to monitor the static water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. If this condition cannot be met, then one of the other methods should be employed.

3.2.2.1.3 Stability of Chemical Parameters

As with the traditional purging method described in Section 3.2.1, it is important that all chemical parameters be stable as defined in Section 3.2.1.1 prior to sampling.

3.3 Equipment Considerations for Purging

Monitoring well purging is accomplished by using in-place plumbing and dedicated pumps or by using portable pumps/equipment when dedicated systems are not present. The equipment utilized by Branch personnel will usually consist of peristaltic pumps and variable speed electric submersible pumps, but may also include bladder pumps or inertial pumps. The pump of choice is usually a function of the well diameter, the depth to water, the depth of the well and the amount of water that is to be removed during purging. Whenever the head difference between the sampling location and the water level is less than the limit of suction and the volume to be removed is reasonably small, a peristaltic pump should be used for purging. For wells where the water level is below the limit of suction (approximately 25’ to 30’, and/or where there is a large volume of water to be purged), the variable speed electric submersible pump would be the pump of choice. SESD Operating Procedure for Pump Operation (SESDPROC-203) contains the use and operating instructions for all pumps commonly used during SESD ground water investigations.

Bailers may also be used for purging in appropriate situations, however, their use is discouraged. Bailers tend to disturb any sediment that may be present in the well, creating or increasing sample turbidity. Bailers, if improperly used, may also strip volatile organic compounds from the water column being sampled. If a bailer is used, it should be a closed-top Teflon® bailer.

3.3.1 Wells Without Plumbing or In-Place Pumps

For permanent monitoring wells, the depth to water (water level) and depth of the well (total depth) should be determined before purging. Caution should be exercised during this procedure to prevent cross-contamination between wells. This is a critical concern when samples for trace organic compounds or metals analyses are collected. See SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) for cleaning procedures for well sounders. After cleaning, the well sounding device should be protected to keep it clean until its next use.

3.3.1.1 Purging with Pumps

3.3.1.1.1 Peristaltic Pumps

The following step-by-step procedures describe the process of purging with a peristaltic pump:

1. Cut a length of standard-cleaned (SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206)) Teflon® tubing, equal to the well depth plus an additional five to ten feet. Enough tubing is needed to run from the ground surface up to the top of the well casing and back down to the bottom of the well. This will allow for operation of the pump at all possible water level conditions in the well.

2. Place one end of the tubing into the vacuum side of the peristaltic pump head. Proper sizing of the Teflon® and Silastic® or Tygon® tubing should allow for a snug fit of the Teflon® tubing inside the flexible tubing mounted in the pump head.

3. Run a short section of tubing (does not have to be Teflon®) from the discharge side of the pump head to a graduated bucket.

4. Place the free end of the Teflon® tubing into the well until the end of the tubing is just below the surface of the water column.

5. Secure the Teflon® tubing to the well casing or other secure object using electrician's tape or other suitable means. This will prevent the tubing from being lost in the well should the tubing detach from the pump head.

6. Turn on the pump to produce a vacuum on the well side of the pump head and begin the purge. Observe pump direction to ensure that a vacuum is being applied to the purge line. If the purge line is being pressurized, either switch the tubing at the pump head or reverse the polarity of the cables on the pump or on the battery.

7. If the pumping rate exceeds the recovery rate of the well, continue to lower the tubing into the well, as needed, until the drawdown stabilizes or the well is evacuated to dryness. If the pump is a variable speed peristaltic pump, and the water level in the well is being drawn down, reduce the speed of the pump in an attempt to stabilize the drawdown. If the well can be purged without evacuating the well to dryness, a sample with greater integrity can be obtained.

8. For wells which are not evacuated to dryness, particularly those with recovery rates equal to or very nearly equal to the purge rate, there may not be a complete exchange and removal of stagnant water in that portion of the water column above the tubing intake. For this reason, it is important that the tubing intake be placed in the very uppermost portion of the water column while purging. Standard field measurements should frequently be taken during this process to verify adequacy of the purge and readiness for sampling, as described in Section 3.

3.3.1.1.2 Submersible Pumps

When a submersible pump is used for well purging, the pump itself is lowered into the water column. The pump must be cleaned as specified in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

The pump/hose assembly used in purging should be lowered into the top of the standing water column and not deep into the column. This is done so that the purging will "pull" water from the formation into the screened area of the well and up through the casing so that the entire static volume can be removed. If the pump is placed deep into the water column, the water above the pump may not be removed, and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. It is recommended that the pump not be lowered more than three to five feet into the water column. If the recovery rate of the well is faster than the pump rate and no observable draw down occurs, the pump should be raised until the intake is within one foot of the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump will have to be lowered, as needed, to accommodate the drawdown. After the pump is removed from the well, the hose and the pump should be cleaned as outlined in SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

3.3.1.2 Purging with Bailers

Standard-cleaned (SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206)), closed top Teflon® bailers with Teflon® coated stainless steel leaders and new nylon rope are lowered into the top of the water column, allowed to fill, and removed. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging, to minimize turbidity and disturbance of volatile organic constituents. The use of bailers for purging and sampling is discouraged because the correct technique is highly operator dependent and improper use may result in an unrepresentative sample.

3.3.2 Wells With In-Place Plumbing

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, etc. Many permanent monitoring wells at active facilities are also equipped with dedicated, in-place pumps. The objective of purging wells with in-place pumps is the same as with monitoring wells without in-place pumps, i.e., to ultimately collect a ground water sample representative of aquifer conditions. Among the types of wells identified in this section, two different approaches are necessary.

A permanent monitoring well with an in-place pump should, in all respects, be treated like a monitoring well without a pump. One limitation is that in most cases the in-place pump is “hard” mounted, that is, the pump is suspended in the well at a pre-selected depth and cannot be moved up or down during purging and sampling. In these cases, well volumes are calculated, parameters are measured and the well is sampled from the pump discharge, after volume removal and parameter conditions have been met.

In the case of the other types of wells, i.e., municipal, industrial and residential supply wells, however, not enough is generally known about the construction aspects of the wells to apply the same criteria as used for monitoring wells, i.e., 3 to 5 well volumes. The volume to be purged in these situations, therefore, depends on several factors: whether the pumps are running continuously or intermittently and whether or not any storage/pressure tanks are located between the sampling point and the pump. The following considerations and procedures should be followed when purging wells with in-place plumbing under the conditions described.

3.3.2.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for a few minutes) is necessary. If a storage tank is present, a spigot, valve or other sampling point should be located between the pump and the storage tank. If not, locate the valve closest to the tank. Measurements of pH, specific conductance, temperature, and turbidity are recorded at the time of sampling.

3.3.2.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Generally, under these conditions, 15 to 30 minutes will be adequate. Measurements of pH, specific conductance, temperature and turbidity should be made and recorded at intervals during the purge and the final measurements made at the time of sampling should be considered the measurements of record for the event.

3.3.3 Temporary Monitoring Wells

3.3.3.1 General Considerations

Procedures used to purge temporary ground water monitoring wells differ from permanent wells because temporary wells are installed for immediate sample acquisition. Wells of this type may include standard well screen and riser placed in boreholes created by hand augering, power augering, or by drilling. They may also consist of a rigid rod and screen that is pushed, driven, or hammered into place to the desired sampling interval, such as a direct push Wellpoint®, a Geoprobe® Screen Point 15/16 sampler or a Hydropunch® sampler. As such, the efforts to remove several volumes of water to replace stagnant water do not necessarily apply because stagnant water is not present. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply, to the extent possible, standard permanent monitoring well purging criteria to it to re-achieve aquifer conditions.

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, resulting primarily in increased turbidity. Therefore, the goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure. Low turbidity conditions in these types of wells that are completed within the limit of suction are typically and routinely achieved by the use of low-flow/low stress purging techniques using variable speed peristaltic pumps.

3.3.3.2 Purging When Water Level Is Within Limit of Suction

In situations where the elevation of the top of the water column is within the limit of suction (no greater than about 25 feet head difference between the pump and the water level), a variable speed peristaltic pump may be used to purge temporary wells. Enough tubing is deployed to reach the bottom of the temporary well screen. At the onset of purging, the tubing is slowly lowered to the bottom of the screen and is used to remove any formation material which may have entered the well screen during installation. This is critical to ensuring rapid achievement of low turbidity conditions. After the formation material is removed from the bottom of the screen, the tubing is slowly raised through the water column to near the top of the column. The tubing can be held at this level to determine if the pump rate is drawing down the water level in the well. If the water level remains the same, secure the tubing at the surface to maintain this pumping level.

If drawdown is observed on initiation of pumping, reduce the pump speed and attempt to match the drawdown of the well. Sustained pumping at these slow rates will usually result in a relatively clear, low turbidity sample. If the drawdown stabilizes, maintain that level, however, if it continues to lower, "chase" the water column until the well is evacuated. In this case, the recovered water column may be relatively free of turbidity and can be sampled. It may take several episodes of recovery to provide enough volume for a complete sample.

3.3.3.3 Purging When Water Level Is Greater Than Limit of Suction

In situations where the elevation of the water table is greater than the limit of suction, peristaltic pumps cannot be used to purge temporary wells. If the temporary well is a ScreenPoint15® sampler with small diameter probe rod riser, the only practical choices for water removal are a small diameter bailer, a small diameter bladder pump or an inertial pump. If the well is to be used strictly for VOC screening, it may be acceptable to use the bailer to bail as much sediment from the well as possible prior to sampling. If metals are the analytes of concern, the bladder pump is the best choice for lowering the turbidity of the water column prior to sampling, followed next by the inertial pump. For larger diameter temporary wells, two-inch diameter or greater, bailers and the Grundfos® RediFlo2 may be used although excessive silt or other “fines” may present problems with the operation of the pump.

3.3.3.4 Considerations for Direct Push Groundwater Sampling

With many of the direct push sampling techniques, purging is either not practical or possible, therefore, no purging is conducted. The sampling device is simply pushed or driven to the desired depth and opened and the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses, i.e., the subject procedure may yield a turbid sample that is not appropriate for metals analyses.

3.4 Field Care of Purging Equipment

New plastic sheeting should be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. It is preferable that hoses used in purging that come into contact with the ground water be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible pumps to purge wells which are excessively contaminated with oily compounds, because it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative purging methods, such as bailers, should be considered.

3.5 Investigation Derived Waste

Purging generates quantities of purge water or investigation derived waste (IDW), the disposition of which must be considered. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for guidance on management or disposal of this waste.

4 Groundwater Sampling Methods – Sampling

4.1 General

Sampling is the process of obtaining, containerizing, and preserving (if required) a ground water sample after the purging process is complete. Non-dedicated pumps for sample collection generally should not be used. Many pumps are made of materials such as brass, plastic, rubber, or other elastomeric products which may cause chemical interferences with the sample. Their principle of operation may also render them unacceptable as a sample collection device. It is recognized that there are situations, such as industrial or municipal supply wells or private residential wells, where a well may be equipped with a dedicated pump from which a sample would not normally be collected. Discretion should always be used in obtaining a sample.

4.2 Sampling Wells With In-Place Plumbing

Samples should be collected following purging from a valve or cold water tap as near to the well as possible, preferably prior to any storage/pressure tanks or physical/chemical treatment system that might be present. Remove any hose that may be present before sample collection and reduce the flow to a low level to minimize sample disturbance, particularly with respect to volatile organic constituents. Samples should be collected directly into the appropriate containers as specified in the ASBLOQAM. It may be necessary to use a secondary container, such as a clean 8 oz. or similar size sample jar or a stainless steel scoop, to obtain and transfer samples from spigots with low ground clearance. Also, refer to the discussion in the SESD Operating Procedure for Potable Water Supply Sampling (SESDPROC-305), Sec. 4.2, Potable Water Samples Collected from Wells with In-Place Plumbing**.** Potable well measurements for pH, specific conductance and turbidity and possibly temperature, if warranted, should be recorded at the time of sample collection.

4.3 Sampling Wells Without Plumbing, Within the Limit of Suction

4.3.1 Equipment Available

The pump of choice for sampling ground water within the limit of suction is the variable-speed peristaltic pump. Its use is described in the following sections. Other acceptable alternatives that may be used under these conditions are the RediFlo2® electric submersible pump (with Teflon® tubing) and a closed-top Teflon® bailer.

4.3.1.1 Peristaltic Pump, Direct from Pump Head Tubing

Samples for some constituents, primarily inorganic analytes such as metals and cyanide, may be collected directly from the pump head tubing. This method is acceptable under the following conditions:

- The pump head tubing must be changed between sampling locations;

- The pump head tubing must be either be certified clean according to SESD's internal quality control program described in Section 3.2 of the SESD Operating Procedure for Field Sampling Quality Control (SESDPROC-011) or
- An equipment rinsate blank is collected by pumping de-ionized water through a piece of the tubing.

4.3.1.2 Peristaltic Pump/Vacuum jug

It is not acceptable to collect samples for organic compound analyses through the flexible tubing used in the pump head. When collecting samples for organic compound analyses it is necessary to use a vacuum container, placed between the pump and the well for sample collection. The following step-by-step procedures describe the process of sampling with a peristaltic pump and vacuum jug (see note following these procedures for collection of VOC samples):

1. Disconnect the purge tubing from the pump. Make sure the tubing is securely attached to the protective casing or other secure object.

2. Insert the tubing into one of the ferrule nut fittings of a Teflon® vacuum container transfer cap assembly.

3. Place a suitable length of Teflon® tubing between the remaining transfer cap assembly ferrule nut fitting and the vacuum side of the flexible tubing in the peristaltic pump head. Securely hand-tighten both fittings.

4. Turn the pump on. Water should begin to collect in the transfer container (typically a 1-liter sample container) within a few minutes. If water does not begin to flow into the container within several minutes, check the transfer cap fittings and make sure the assembly is tightly attached to the container. It may be necessary to tighten the ferrule nuts with a wrench or pliers to achieve a vacuum in the system, particularly when approaching the maximum head difference between the pump and water table (limit of suction).

5. When the transfer container is nearly full, turn off the pump, remove the transfer cap assembly, and pour the sample into the appropriate containers. Because the 1-liter containers used by the Branch are rinsed with nitric acid during cleaning, they cannot be used for collecting samples to be analyzed for nitrogen sensitive parameters.

6. If additional sample volume is needed, replace the transfer cap assembly, turn the pump on, and collect additional volume. The use of Teflon® valves or ball check devices to retain the water column in the sample delivery tubing during the transfer phase, when large volumes of sample are required, is acceptable. These devices, however, must be constructed so that they may be completely disassembled and cleaned according to the procedures in SESD

Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205).

7. When sampling is completed, all Teflon® tubing should be discarded.

   NOTE: Samples for volatile organic compound analyses cannot be collected using this method. If samples for VOC analyses are required, they must be collected with a Teflon® or stainless steel bailer or by other approved methods, such as the "soda straw" method. The "soda straw" method involves allowing the tubing to fill, by either lowering it into the water column (A) or by filling it via suction applied by the pump head (B). If method (A) is used, the tubing is removed from the well after filling and the captured sample is allowed to drain into the sample vial. If method (B) is used, after running the pump and filling the tubing with sample, the pump speed is reduced and the direction reversed to push the sample out of the tubing into the vials. Avoid completely emptying the tubing when filling the sample vials when using method (B) to prevent introducing water that was in contact with the flexible pump head tubing. Either method is repeated, as necessary, until all vials are filled.

4.3.1.3 RediFlo2® Electric Submersible Pump (with Teflon® Tubing)

After purging has been accomplished with RediFlo2® electric submersible pump, the sample may be obtained directly from the pump discharge, provided that Teflon® tubing was used for the sample delivery line. The discharge rate of the pump should be reduced during volatile organic compound sample collection to minimize sample disturbance. Note, if the RediFlo2® electric submersible pump is used for sampling, the pump must undergo a full external and internal cleaning. In addition, pump rinsate blanks must be collected, at the appropriate frequency, to demonstrate that the pump has been adequately cleaned between wells.

4.3.1.4 Bailers

New bailer rope should be attached to the bailer via a Teflon® coated stainless steel wire. (If a bailer was used to purge the well, it may also be used to sample the well and new bailer rope is not required between purging and sampling). The bailer should be gently immersed in the top of the water column until just filled. At this point, the bailer should be slowly removed and the contents emptied into the appropriate sample containers.

4.4 Sampling Wells without Plumbing, Exceeding the Limit of Suction

All methods described previously in Section 4.3.2.1.3, RediFlo2® Electric Submersible Pumps, and Section 4.3.2.1.4, Bailers, are suitable sample methods where the water table is too deep to consider the use of a peristaltic pump for sampling.

4.5 Micro-Purge or No Purge Sampling Procedures

The Micro-Purge or No Purge sampling procedures are usually employed when it necessary to keep purge volumes to an absolute minimum. Among the Micro-Purge or No Purge procedures that might be employed are:

- Low pump rate sampling with peristaltic or submersible pumps (typical Micro-Purge sampling),
- HydraSleeve^{TM} or
- Passive diffusion bag (PDB) sampling

The use of these procedures is acceptable only when the site hydrogeology is well understood, with respect to the hydraulic conductivity of geologic materials within the well screen interval. The underlying assumption, when employing these procedures, is that the formation in which the well is screened has a high hydraulic conductivity ($K>10^{-5}$ cm/sec, for example), resulting in a state of equilibrium existing between the water standing in the screened interval and the formation water in which the well is screened. In this situation, the well is considered to be in a perpetually "purged" state and purging is not required.

These procedures are generally impractical for SESD to implement because of the general lack of hydrogeologic information for the sampled wells and the real necessity, in some cases, that the pumps be pre-deployed to overcome issues related to turbidity resulting from pump placement prior to sampling.

4.5.1 Sampling with Pumps

The peristaltic pump tubing or intake point of the submersible pump is placed in the approximate mid-portion of the screened interval of the well or other interval selected by the field team leader. If turbidity and its impact on metals analyses are a concern, a period of time sufficient should be allowed to mitigate effects of pump or tubing placement. After it has been determined that sampling may proceed, the pump is turned on and operated at a rate that does not cause significant drawdown of the water column, as measured using a water level sounder. During sampling, sufficient water to supply enough volume for the analytes of concern and the purge parameters is pumped. Purging should continue until purge parameters stabilize, generally three consecutive stable sets of readings, before samples are collected.

4.5.2 HydraSleeves^{TM}

HydraSleeeves^{TM} are grab sampling devices that are deployed in a closed configuration then opened in the desired interval for sample collection. The following is a summary of its operation:

1. Sampler placement - Reusable weight is attached and the HydraSleeve^{TM} is lowered and placed at the desired position in the well screen. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. Well is allowed to return to equilibrium.

2. Sample collection - The reed valve opens to allow filling when the sampler is moved upward faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler up and down to sample a shorter interval. There is no change in water level, and only minimal agitation during collection.

3. Sample retrieval - When the flexible sleeve is full, the reed valve closes and the sampler can be recovered without entry of extraneous overlying fluids. Samples are removed by puncturing the sleeve with the pointed discharge tube and draining the contents into containers for sampling or field measurement.

4.5.3 Passive Diffusion Bags

Passive diffusion bag (PDB) samplers are bags comprised of low-density polyethylene (LDPE) plastic and containing analyte-free water, preferably with no headspace. The bags are deployed, with stainless steel weights, to the desired sample interval and are allowed to equilibrate with the water at the point of deployment in the well. A deployment period of a minimum of 14 days is recommended to ensure equilibration prior to removal.

After 14 days, the bags and opened with a puncture device or other cutting implement and the contents transferred to containers for sampling or field measurement.

4.5.4 General Considerations for Micro-Purge or No-Purge Sampling

When using the Micro-Purge method, it may be advisable to deploy the tubing or pump in advance of sample collection. Introducing the tubing or pump into the screened interval is likely to dislodge sediment and other fines that have settled or bridged on the well screen material and the gravel pack media behind the screen. If sampling is conducted immediately, turbidity issues may render this method impractical from a parameter stability standpoint.

HydraSleevesTM and PDBs must be evaluated for appropriateness for analytes of concern.

4.6 Sample Preservation

After sample collection, all samples requiring preservation must be preserved as soon as practical. Consult the ASBLOQAM for the correct preservative for the particular analytes of interest. All samples preserved using a pH adjustment (except VOCs) must be checked, using pH strips, to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip. Do not place the strip in the sample. Samples requiring reduced temperature storage should be placed on ice immediately.

4.7 Special Sample Collection Procedures

4.7.1 Trace Organic Compounds and Metals

Special sample handling procedures should be instituted when trace contaminant samples are being collected. All sampling equipment, including pumps, bailers, water level measurement equipment, etc., which comes into contact with the water in the well must be cleaned in accordance with the cleaning procedures described in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206). Pumps should not be used for sampling unless the interior and exterior portions of the pump and the discharge hoses are thoroughly cleaned. Blank samples should be collected to determine the adequacy of cleaning prior to collection of any sample using a pump other than a peristaltic pump.

4.7.2 Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, an adequate purge, with respect to turbidity, is often difficult to achieve. Removal and insertion of equipment after the purge and prior to actual sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to collect the aliquot for metals first. Therefore, the preferred order of sampling is metals first, followed by other inorganic analytes, extractable organic compounds and volatile organic compounds.

4.7.3 Filtering

As a standard practice, ground water samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter and used for flow system analysis and for the purpose of geochemical speciation modeling. Filtration is not allowed to correct for improperly designed or constructed monitoring wells, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered. Prior to filtration of the ground water sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis:

1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with the SESD Guidance Document, Design and Installation of Monitoring Wells (SESDGUID-001).

2. The ground water samples were collected using sampling techniques in accordance with this section, and the ground water samples were analyzed in accordance with USEPA approved methods.

3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of the following:

   - Redevelopment or re-installation of permanent ground water monitoring wells.
   - Implementation of low flow/low stress purging and sampling techniques.

4. Turbidity measurements should be taken during purging and sampling to demonstrate stabilization or lack thereof. These measurements should be documented in the field notes. If the ground water sample appears to have either a chemically-induced elevated turbidity, such as would occur with precipitate formation, or a naturally elevated colloid or fine, particulate-related turbidity, filtration will not be allowed.

If filtration is necessary for purposes of geochemical modeling or other **pre-approved** cases, the following procedures are suggested:

1. Accomplish in-line filtration through the use of disposable, high capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high capacity, barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 mm is suggested.

2. Use a 5 µm pore-size filter for the purpose of determining the colloidal constituent concentrations. A 0.1 µm pore-size filter should be used to remove most non-dissolved particles.

3. Rinse the cartridge or barrel-type filter with 500 milliliters of the solute (groundwater to be sampled) prior to collection of sample. If a membrane filter is used, rinse with 100 milliliters of solute prior to sample collection.

Potential differences could result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter "dissolved" trace element concentrations; these include filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidally-associated trace elements, and concentration of organic matter. Therefore, consistency is critical in the comparison of short-term and long-term results. Further guidance on filtration may be obtained from the following: 1) Metals in Ground Water: Sampling Artifacts and Reproducibility; 2) Filtration of Ground Water Samples for Metals Analysis; and 3) Ground Water Sampling - A Workshop Summary. See Section 1.4, References, for complete citation for these documents.

Bacterial Sampling

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well. Further information regarding bacteriological sampling is available in the following: 1) Sampling for Organic Chemicals and Microorganisms in the Subsurface; 2) Handbook for Evaluating Water Bacteriological Laboratories; and 3) Microbiological Methods for Monitoring the Environment, Water and Wastes. See Section 1.4, References, for complete citation for these documents.

4.8 Specific Sampling Equipment Quality Assurance Techniques

All equipment used to collect ground water samples shall be cleaned as outlined in the SESD Operating Procedure for Field Equipment Cleaning and Decontamination (SESDPROC-205) or SESD Operating Procedure for Field Equipment Cleaning and Decontamination at the FEC (SESDPROC-206) and repaired, if necessary, before being stored at the conclusion of field studies. Cleaning procedures utilized in the field or field repairs shall be thoroughly documented in field records.

4.9 Auxiliary Data Collection

During ground water sample collection, it is important to record a variety of ground water related data. Included in the category of auxiliary data are water levels measured according to the SESD Operating Procedure for Groundwater Level and Well Depth Measurement (SESDPROC-105), well volume determinations (Section 3.1.1, P urging and Purge Adequacy), pumping rates during purging (see below), and occasionally, drillers or boring logs. This information should be documented in the field records.

4.9.1 Well Pumping Rate – Bucket/Stop Watch Method

The pumping rate for a pump can be determined by collecting the discharge from the pump in a bucket of known volume and timing how long it takes to fill the bucket. The pumping rate should be in gallons per minute. This method shall be used primarily with pumps with a constant pump rate, such as gasoline-powered or electric submersible pumps. Care should be taken when using this method with some battery-powered pumps. As the batteries' charge decreases, the pump rate also decreases so that pumping rate calculations using initial, high pump rates may be erroneously high. If this method is used with battery-powered pumps, the rate should be re-checked frequently to ensure accuracy of the pumping rate calculations.

SESD PROCEDURE SESDPROC-100-R3:

FIELD PH MEASUREMENT

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field pH Measurement**

Effective Date: January 29, 2013

Number: SESDPROC-100-R3

Author

Name: Timothy Simpson
Title: Environmental Scientist
Signature: Timothy Simpson Date: 01/23/2013

Approvals

Name: Danny France
Title: Chief, Enforcement and Investigations Branch
Signature: Date: 1/23/13

Name: John Deatrick
Title: Chief, Ecological Assessment Branch
Signature: John Deatrick Date: 1/23/13

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 1/23/13

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-100-R3, *Field pH Measurement,* replaces SESDPROC-100-R2 **General:** Corrected any typographical, grammatical and/or editorial errors. **Cover Page:** The Author was changed from Ron Phelps to Timothy Simpson. The EIB Branch Chief was changed from Antonio Quinones to Danny France. The EAB Branch Chief was changed from Bill Cosgrove to John Deatrick. The Field Quality Manager was changed from Laura Ackerman to Bobby Lewis. **Section 1.2:** Added the following statement: Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use. **Section 1.3, last sentence:** Added "and for maintaining records of review conducted prior to its issuance." **Section 1.4:** Added reference to the SHEMP Manual. **Section 1.5.1:** Updated the SHEMP Manual reference to reflect that the most recent version of the Manual will be used. **Section 2:** In the first paragraph, replaced "and" in the second sentence with "or". **Section 3.2:** Replaced the first paragraph with the following language for clarification purposes: "Many brands of instruments are commercially available for the measurement of pH incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. At a minimum, a two-point calibration should be conducted to ensure the accuracy of the meter. The following are basic guidelines for calibration/verification and are provided as an example: In Item #4, the first sentence, replaced "original buffer" to "appropriate buffer".	January 29, 2013

Item #5 was replaced with the following: "Once the meter has been properly calibrated and verified (steps 1-4 above), it is ready for use. Rinse the probe with de-ionized water and store it according to manufacturer's recommendations. Certain instruments may require being left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against a known calibration buffers if used for extended periods (> 4 hrs). **Section 3.4:** Revised the language to clarify procedures associated with operational checks. Item # 2 was converted to paragraphs 2.	
SESDPROC-100-R2, *Field pH Measurement,* replaces SESDPROC-100-R1 **Cover Page:** Author was changed from Marty Allen to Ron Phelps. **Revision History** Changed Field Quality Manager to Document Control Coordinator. **Section 1.3** Changed Field Quality Manager to Document Control Coordinator. **Section 2** Added requirements for unattended deployment of in-situ monitoring equipment. **Section 3.1 and 3.2, 4** Clarified requirements for routine and NPDES compliance monitoring. **Section 3.2, 2 and 5** Added first sentence for clarification.	June 13, 2008

SESDPROC-100-R1, *Field pH Measurement*, replaces SESDPROC-100-R0 **General** Deleted all references to SOSA. Updated referenced procedures due to changes in title names and/or to reflect most recent version. Replaced “shall” with “will”. **Title Page** Changed title for Antonio Quinones from Environmental Investigations Branch to Enforcement and Investigations Branch. C hanged Bill Cosgrove’s title from Acting Chief to Chief. **Section 1.3** Updated information to reflect that procedure is located on the H: drive of the LAN. **Section 1.4** Alphabetized and revised the referencing style for consistency. **Section 2** Added last paragraph regarding stopping measurements due to environmental conditions. **Section 3.4** Re-phrased procedure #2 for clarity.	November 1, 2007
SESDPROC-100-R0, Field pH Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field pH measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring the pH of aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain pH measurements of the media being sampled, and that another method must be used to obtain said measurements, the variant instrument and/or measurement procedure will be documented in the field logbook and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on SESD's local area network (LAN). The Document Control Coordinator is responsible for ensuring that the most recent version of the procedure is placed on SESD's LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

USEPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version.

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when conducting field pH measurements. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field pH measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010) and the SESD Operating Procedure for Equipment Inventory and Management, (SESDPROC-108).

Care should be taken not to contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to the manufacturer's specifications.

2 Quality Control

All pH meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter is taken to the field, it will be properly calibrated or verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for *in-situ* measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in-situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field pH Measurement Procedures

3.1 General

pH is defined as the negative logarithm of the effective hydrogen-ion concentration. For routine work, a pH meter accurate and reproducible to within 0.2 Standard Unit (S.U.) is suitable. For NPDES compliance monitoring, the pH meter should be accurate and reproducible to within 0.1 S.U. Both meters should have a range of 0 to 14 S.U.s and be equipped with a temperature-compensation adjustment.

3.2 Instrument Calibration

Many brands of instruments are commercially available for the measurement of pH incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. At a minimum, a two-point calibration should be conducted to ensure the accuracy of the meter. The following are basic guidelines for calibration/verification and are provided as an example:

1. Verify the meter's internal temperature sensor (thermistor) against a National Institute of Standards and Technology (NIST) traceable thermometer and note any differences between the thermistor and the NIST-traceable thermometer in the logbook. If the temperatures do not agree within ± 4°C, the unit or probe must be repaired or replaced. Alternatively, if the meter can be used in a manual temperature compensation mode, the NIST-traceable thermometer may be used for temperature readings and the necessary corrections applied. Check and record the temperatures of the standards and the samples.

2. If the pH range of the sample is not known, the pH of the sample to be tested should be estimated either from historical data or by using a four-color pH indicator paper or equivalent. Using this information, calibrate the pH meter with the buffers that bracket the expected pH range. Buffer solutions are commonly pH 4, 7 and 10. It may be possible to configure the pH meter so that it can be standardized with buffers other than those in the default configuration.

3. Immerse the probe in the first buffer solution and calibrate the meter to read the correct pH. After the initial buffer calibration, calibrate the meter using other buffer solutions, as appropriate. Rinse the probe with de-ionized water and blot dry or otherwise remove excess rinse water between the different buffer solutions. Record the buffer values and temperatures used to calibrate the meter.

4. Rinse the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate buffer and read as a sample. If the meter reads within ± 0.2 S.U. of the known value of the buffer (for general applications such as ecological studies) or ± 0.1 S.U. (for regulatory applications such as NPDES or drinking Water programs), record the value indicated by the meter. If the meter is outside of the acceptable accuracy range, it should be recalibrated. If it is still outside of the acceptable accuracy range after the second calibration, the electrode and/or meter should be replaced.

5. Once the meter has been properly calibrated and verified (steps 1-4 above), it is ready for use. Rinse the probe with de-ionized water and store it according to manufacturer's recommendations. Certain instruments may require being left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against a known calibration buffers if used for extended periods (> 4 hrs).

6. Unless the manufacturer indicates that the meter maintains its calibration after being turned off, meters must be re-calibrated if they are turned off during their period of use.

3.3 Sample Measurement Procedures

These procedures should be followed when conducting field pH measurements of grab samples:

1. Collect a sample. If the meter's thermistor is to be used for the temperature of record for the measurement activity, the temperature should be read as soon as the reading stabilizes and prior to measuring the pH.

   Note 1: When the pH meter response is slow, unstable, or non-reproducible, it may be necessary to check the conductivity. If the conductivity is lower than 20 to 30 µmhos/cm, it is permissible to add 1 ml of 1M potassium chloride solution per 100 ml of sample to improve response time for the probe. Recheck the pH and record.

   Note 2: If the pH measurements are to be used for RCRA regulatory purposes and when the pH approaches the alkaline end (pH $\geq$ 11.0) of the scale, the pH measurements should be made by a qualified analyst using laboratory quality equipment to control the sample at 25°C ± 1°C.

2. Immerse the probe in the sample keeping it away from the sides and

bottom of the sample container. Allow ample time for the probe to equilibrate with the sample.

3. While suspending the probe away from the sides and bottom of the sample container, record the pH.

4. Rinse the probe with de-ionized water and store it in the manufacturer's recommended storage solution until the next sample is ready.

These procedures should be followed when conducting in-situ field pH measurements:

1. Place the probe into the media to be measured and allow the pH and temperature readings to stabilize. Once the readings have stabilized, record the measurements in the logbook.

2. When deploying meters for extended periods of time, insure the measurement location is representative of average media conditions.

3.4 Operational Check

Even though it is not necessary to re-calibrate pH meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter's performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

1. While in use, periodically check the pH by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate buffer solution. If the measured pH differs by ≥ 0.2 S.U. or 0.1 S.U. (depending on the application) from the buffer solution, the meter must be re-calibrated.

A post-operation instrument verification check will be performed using the appropriate buffer(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

SESD PROCEDURE SESDPROC-101-R6:

FIELD SPECIFIC CONDUCTANCE MEASUREMENT

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Specific Conductance Measurement**

Effective Date: July 13, 2016

Number: SESDPROC-101-R6

Authors

Name: Timothy Simpson
Title: Environmental Scientist
Signature:
Date: 07/07/2016

Approvals

Name: John Deatrick
Title: Chief, Ecological Assessment Branch
Signature: John Deatrick
Date: 7/7/16

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 7/7/16

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-101-R6, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R5 **General:** Corrected any typographical, grammatical, and/or editorial errors. Throughout the document mention of quality system or SESD quality system was replaced with Field Branches Quality System or FBQS. **Cover Page:** Omitted Hunter Johnson as an author. Updated cover page to represent SESD reorganization. John Deatrick was not listed as the Chief of the Field Services Branch.	July 13, 2016
SESDPROC-101-R5, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R4	August 30, 2012
SESDPROC-101-R4, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R3	January 13, 2012
SESDPROC-101-R3, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R2	August 12, 2011
SESDPROC-101-R2, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R1	June 13, 2008
SESDPROC-101-R1, *Field Specific Conductance Measurement*, replaces SESDPROC-101-R0	November 1, 2007
SESDPROC-101-R0, *Field Specific Conductance Measurement*, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field specific conductance measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field investigators when measuring the specific conductance of aqueous phase environmental media in the field. On the occasion that SESD field investigators determine that any of the procedures described in this section cannot be used to obtain specific conductance measurements of the media being sampled, and that another method must be used to obtain said measurements, the variant instrument and/or measurement procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when conducting field specific conductance measurements. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field specific conductance measurements pertinent to the sampling event, including a unique, traceable identifier for the instrument, such as a property number or serial number, should be recorded in the field logbook for the event. All records should be entered according to the procedures outlined in the SESD Operating Procedure Logbooks (SESDPROC-010, most recent version).

Care should be taken to not contaminate standards and samples and verify the expiration date of all standards prior to use. All meters should be calibrated, operated and maintained according to the manufacturer's specifications.

2 Quality Control

All specific conductance meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108, most recent version). Before a meter is taken to the field, it will be properly calibrated or verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to ensure the instrument is operated within the manufacturer's specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in-situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

If at any time during a field investigation it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Specific Conductance Measurement Procedures

3.1 General

Specific conductance is a measure of the ability of an aqueous solution to conduct an electric current and is customarily reported in microsiemens per centimeter (µS/cm) or micromhos per centimeter (µmhos/cm) at 25°C. It is important to note that if the specific conductance measurements are for NPDES reporting purposes, the meter and conductivity cell should be verified by comparing against a laboratory meter with a platinum-electrode type conductivity cell.

3.2 Instrument Calibration and Verification

Many brands of instruments are commercially available for the measurement of specific conductance incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate.

Conductivity is affected by temperature; therefore, for instruments that do not automatically compensate for temperature, the user should document temperature first so that appropriate adjustments can be made in accordance with the manufacturer's instructions and/or method. The following are basic guidelines for calibration/verification and are provided as an example:

1. Verify the meter's internal temperature sensor (thermistor) against a National Institute of Standards and Technology (NIST) traceable thermometer and note any differences between the thermistor and the NIST-traceable thermometer in the logbook. If the temperatures do not agree within ± 4°C, the unit must be repaired or replaced. Alternatively, if the meter can be used in a manual temperature compensation mode, the NIST-traceable thermometer may be used for temperature readings and the necessary corrections applied. Check and record the temperatures of the standards and the samples.

2. Rinse the probe with de-ionized water and blot dry before conducting the following calibration and verification checks.

3. Immerse the probe in the first standard solution and calibrate or verify the meter against that solution. Fresh standards should be used for each calibration. After the initial standard, calibrate and/or verify the meter using additional standards, as appropriate. Rinse the probe with de-ionized water and blot dry or otherwise remove excess rinse water between the different standards. Record the standard values/temperatures used to calibrate or verify the meter.

Note: Some instruments require that calibration standards reflect the anticipated specific conductance of the media being measured.

4. Some meters will auto-recognize standards during calibration. For example, the Orion Star Series meter will auto-recognize standards 1413 µS/cm, 100 µS/cm and 12.9 mS/cm. If the meter is calibrated in a manner where it does not auto-recognize the standard, and the meter is not accurate to within ± 10 % of the standard solution(s) known values, the meter or probe should be repaired or replaced. If this condition can be corrected by adjusting the cell constant of the probe, refer to the instruction manual and make the adjustment.

5. After calibration is complete, place the probe back into the calibration standard used and record a post-calibration reading. Record a post calibration reading for each standard used. If the meter is not accurate to within ± 10 % of the standard solution(s) known values, it should be recalibrated. If it is still outside of the acceptable accuracy range after the second calibration, the probe and/or meter should be replaced.

6. Once the meter has been properly calibrated and verified (steps 1-5 above), it is ready for use. Rinse the probe with de-ionized water and store it in the manufacturer's recommended storage solution. Certain meters may require that the instrument be left on until all sample measurements are performed and the results are recorded. When collecting measurements from grab samples, certain instrument manufacturers recommend that an intermediate check(s) be performed by periodically checking the meter against the known calibration standards if used for extended periods (> 4 hrs).

3.3 Sample Measurement Procedures

The following procedures should be followed when conducting field specific conductance measurements of grab samples:

1. Collect the sample, check and record its temperature.

2. Correct the instrument's temperature adjustment to the temperature of the sample (if required).

3. Immerse the probe in the sample keeping it away from the sides and bottom of the container. It is important that the center portion of the probe be wetted by the sample.

4. Allow meter to stabilize. Record the results in a logbook.

5. Rinse probe with de-ionized water.

The following procedures should be followed when conducting in-situ field specific conductivity measurements:

1. Place the probe into the media to be measured and allow the specific conductivity and temperature readings to stabilize. Once the readings have stabilized, record the measurements in the logbook.

2. When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.4 Operational Checks

Even though it is not necessary to re-calibrate conductivity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an extreme temperature change, have impacted the meter's performance. If an operational check is warranted, the following procedures should be followed to ensure that the performance of the meter has not changed.

Check the conductivity meter with fresh conductivity standard. Rinse the conductivity probe with deionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate conductivity standard. If the measured conductivity value is not with ± 10% of the standard, the probe should be re-calibrated. If the probe is still not within ± 10% of the standard, the probe should be repaired or replaced. These measurements must be recorded in the field logbook.

A post-operation instrument verification check should be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

SESD PROCEDURE SESDPROC-102-R4:

FIELD TEMPERATURE MEASUREMENT

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Temperature Measurement**

Effective Date: October 23, 2014

Number: SESDPROC-102-R4

Authors

Name: Hunter Johnson
Title: Environmental Engineer
Signature:
Date: 10/21/14

Approvals

Name: John Deatrick
Title: Chief, Enforcement and Investigations Branch
Signature: MBaxter for
Date: 10/22/14

Name: Laura Ackerman
Title: Acting Chief, Ecological Assessment Branch
Signature: Laura Acke
Date: 10/21/14

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 10/21/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-102-R4, *Field Temperature Measurement*, replaces SESDPROC-102-R3 **Cover Page:** The Enforcement and Investigations Branch Chief was changed from Archie Lee to John Deatrick. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Laura Ackerman. The FQM was changed from Liza Montalvo to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 2:** Omitted the following: "Data Sonde thermistors will be verified on a monthly basis to ensure accuracy. These verification checks are documented in the instrument's tracking logbook."	October 23, 2014
SESDPROC-102-R3, *Field Temperature Measurement*, replaces SESDPROC-102-R2	February 4, 2011
SESDPROC-102-R2, *Field Temperature Measurement*, Replaces SESDPROC-102-R1	June 13, 2008
SESDPROC-102-R1, *Field Temperature Measurement*, Replaces SESDPROC-102-R0	November 1, 2007
SESDPROC-102-R0, Field Temperature Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when measuring the temperature of aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring the temperature of aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain temperature measurements of the media being sampled, and that another method or measurement instrument must be used to obtain said measurements, the variant instrument and measurement procedure will be documented in the field log book and subsequent investigation report, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). Most Recent Version. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when conducting temperature measurements in the field. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. The field investigators will address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

2 Quality Control

All thermometers should be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Temperature measurement devices such as pH, conductivity and dissolved oxygen (DO) meter thermistors will be verified against a National Institute of Standards and Technology (NIST)-traceable thermometer before each use as described in Section 3.2.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Temperature Measurement Procedures

3.1 General

Field temperature measurements may be made with a field thermometer, equipment thermistor, or NIST-traceable thermometer. At a minimum, the temperature measurement device should be capable of measuring in 0.1°C increments.

3.2 Instrument Verification

3.2.1 Field thermometers and thermistors

Temperature measurement devices such as field thermometers and equipment thermistors will be verified against a NIST-traceable thermometer prior to use and should agree within ± 4.0°C. Corrections may be applied for measurements up to ± 4.0°C depending on investigation objectives, but the instrument must be repaired or replaced beyond that range.

3.2.2 NIST-traceable thermometer

Verification of the NIST-traceable thermometers that are used to verify temperature measuring devices is accomplished by comparing temperature readings from the NIST-traceable thermometer to a thermometer that has an independent certification of accuracy traceable to the National Institute of Standards and Testing. Current certified thermometers are maintained by the SESD Analytical Support Branch and are called reference thermometers.

Each NIST-traceable thermometer is verified by comparing at least annually against a reference thermometer. If corrections need to be applied, they will be noted in the NIST-traceable thermometer. Depending on investigation objectives, project leaders may decide to apply the correction factor as necessary.

3.3 Inspections

All temperature measurement devices should be inspected for leaks, cracks, and/or function prior to each use.

3.4 Sample measurement procedures for thermometers/thermistors

(Make measurements in-situ when possible)

1. Clean the probe end with de-ionized water and immerse into sample.

2. If not measuring in-situ, swirl the instrument in the sample for mixing and

equilibration.

3. Allow the instrument to equilibrate with the sample for at least one minute.

4. Suspend the instrument away from the sides and bottom, if not in-situ, to observe the temperature reading.

5. Record the reading in the log book. For most applications, report temperature readings to the nearest 0.5°C or to the nearest 0.1°C depending on need.

   Note: Always clean the thermometer with de-ionized water or a detergent solution, if appropriate, prior to storage and/or use.

3.5 Units

Degrees Celsius (°C) or Degrees Fahrenheit (°F)

Conversion Formulas:

°F = (9/5 °C) + 32 or °C = 5/9 (°F - 32)

SESD PROCEDURE SESDPROC-113-R1:

FIELD MEASUREMENT OF OXIDATION-REDUCTION POTENTIAL

U.S. Environmental Protection Agency
Region 4, Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Measurement of Oxidation-Reduction Potential (ORP)**	
Effective Date: January 29, 2013	**Number:** SESDPROC-113-R1
Author	
Name: Brian Striggow Title: Environmental Engineer Signature:	Date: 1-23-13
Approval	
Name: Danny France Title: Chief, Enforcement and Investigations Branch Signature:	Date: 1/23/13
Name: Bobby Lewis Title: Field Quality Manager, Science and Ecosystem Support Division Signature:	Date: 1/23/13

Revision History

This Table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-113-R1, *Field Measurement of Oxidation-Reduction Potential (ORP)*, replaces SESDPROC-013-R0 **General:** Corrected any typographical, grammatical, and/or editorial errors. **Title Page:** Changed the EIB Chief from Archie Lee to Danny France, and the Field Quality Manager from Laura Ackerman to Bobby Lewis. **Section 1.2:** Added the following statement: Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use. **Section 2.2:** Added new paragraph #7 and new Figure 4. Renumbered subsequent Figures. In paragraph #8, deleted the following sentence: "In multi parameter sondes, the reference electrode is typically shared by the ORP and pH measuring systems." In paragraph #10, 2nd sentence, updated the reference from Figure 3 to Table 1. In addition, updated numbers in the "example" equation. In paragraph #11, 1st sentence, replaced +560 mV with +544 mV. Added new paragraph #12 and new Figure 6. **Section 3.2:** Added new paragraph #5 describing operational checks in the event of potential disturbances. In paragraph #8, added the following at the end of the 1st sentence: "or handled as directed by the SHEMP."	January 29, 2013
SESDPROC-113-R0, *Field Measurement of Oxidation-Reduction Potential (ORP)*, Original Issue	August 7, 2009

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes procedures, methods and considerations to be used and observed when conducting field Oxidation-Reduction Potential (ORP) measurements in aqueous environmental media, including groundwater, surface water and certain wastewater. The measurement of soil ORP is a non-standard measurement and procedures should be developed on a project-specific basis.

1.2 Scope/Application

This document describes procedures generic to all ORP measurement methods to be used by Science and Ecosystem Support Division (SESD) field personnel when collecting and handling samples in the field. On the occasion SESD personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to obtain an ORP measurement, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the SESD LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Faulkner, S.P., W.H. Patrick, Jr., and R.P. Gambrell. 1989. Field techniques for measuring wetland soil parameters. Soil Sci. Soc. Am. J. 53:883-890.

Megonigal, J.P., W.H. Patrick, Jr., and S.P. Faulkner. 1993. Wetland identification in seasonally flooded forest soils: soil morphology and redox dynamics. Soil Sci. Soc. Am. J. 57:140-149.

D.K. Nordstrom and F.D. Wilde. 2005. National Field Manual, Chapter A6, Section 6.5: Reduction Oxidation Potential (Electrode Method). USGS.

Pankow, J.E. 1991. Aquatic chemistry concepts. Lewis Publishers, Inc. Cheleas, Michigan. USA.

Pruitt, B.A. 2001. Hydrologic and soil conditions across hydrogeomorphic settings. Dissertation. The University of Georgia, Athens, GA. USA.

Soil Survey Staff. 1998. Keys to soil taxonomy, 8th Edition. United States Department of Agriculture, Natural Resources Conservation Service, Washington, DC. USA.

Standard Methods. 1992. Standard Methods for the Examination of Water and Wastewater, 18th Edition. Prepared and published jointly by: American Public Health Association, American Water Works Association, Water Environment Federation. American Public Health Association, Washington, DC. USA.

Stumm, W. and J.J. Morgan. 1981. Aquatic chemistry: an introduction emphasizing chemical equilibra in natural waters, 2nd Ed. John Wiley & Sons, New York. USA.

USEPA. 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division, Athens, GA.

USEPA. 2007. Safety, Health and Environmental Management Program Procedures and Policy Manual. Science and Ecosystem Support Division, Region 4, Athens, GA.

Wikipedia entry. Reduction Potential. http://en.wikipedia.org/wiki/Reduction_potential. Retrieved April 2, 2009.

1.5 General Considerations

1.5.1 Safety

Proper safety precautions must be observed when verifying or calibrating instruments for measurement of Oxidation-Reduction Potential. Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual (most recent version) and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines should be used to complement the judgment of an experienced professional.

Reagents commonly used in the preparation of ORP calibration standards are toxic and require care when handling. When using this procedure, avoid exposure to these materials through the use of protective clothing, eye wear and gloves. Safety precautions when handling and preparing verification solutions should include gloves and eyewear to prevent dermal and eye contact, and a mask to avoid inhaling dust particles when handling dry materials. Vigorous flushing should be used if the reagents or solutions come in contact with skin or eyes. Following is specific information on commonly used solutions. The application of the solutions is described in detail in Section 3.1, Standard Solutions, of this procedure.

- Quinhydrone (CAS# 106-34-3) is a skin and respiratory irritant and is poisonous if ingested. Safety precautions when handling quinhydrone should include gloves to prevent dermal contact and a mask to avoid inhaling dust particles when mixing dry material to prepare calibration standards. Vigorous flushing should be used if concentrated material comes in contact with skin or eyes.

- Zobell's solution is also an irritant and toxic if ingested. The same handling precautions apply when mixing and using Zobell's solution as when using quinhydrone. Zobell's reacts with acid to form harmful byproducts, including hydrocyanide gas.

- Light's solution contains ferro- and ferric-cyanide compounds in sulfuric acid. The components are toxic and burns are possible from contact with this solution.

- Potassium iodide solutions have lower toxicity than most calibration solution options. General ingestion, skin contact, and eye contact precautions apply.

Unused quinhydrone, Zobell's, Light's or other calibration reagents and solutions should be returned to SESD for disposal in accordance with the SESD Safety, Health, and Environmental Management Plan (SHEMP).

1.5.2 Records

Documentation of field activities is done in a bound logbook. All records, including a unique, traceable identifier for the instrument, should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010, most recent version) and the SESD Operating Procedure for Equipment Inventory and Management, (SESDPROC-108, most recent version).

All field ORP measurements pertinent to the sampling event should be recorded in the field logbook for the event as outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010, most recent version), or managed electronically with appropriate backups as described in SESD Operating Procedure for Control of Records (SESDPROC-002, most recent version).

1.5.3 Shipping

Shipped material shall conform to all U.S. Department of Transportation (DOT) rules of shipment found in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and/or International Air Transportation Association (IATA) hazardous materials shipping requirements found in the current edition of IATA's Dangerous Goods Regulations.

All shipping documents, such as bills of lading, will be retained by the project leader and stored in a secure place.

2 Background

2.1 General

Oxidation is the process of liberating electrons or gaining oxygen. Examples of oxidation include conversion of elemental iron to rust, elemental sulfur to sulfate, and elemental hydrogen to water (Pankow 1991). Reduction is the process of gaining electrons resulting in the charge on some atomic unit in the species to be reduced. Oxidation-reduction potential (ORP) or redox potential (hereafter, referred to as redox) is a measure of the intensity or activity of an aqueous environment or soil to mediate reactions of important elements in biological systems (e.g., O, N, Mn, Fe, S, and C) and other metallic elements.

Considerable confusion arises on the use of the terms oxidation and reduction as they apply to the media under study. The following introduction reproduced from an online ‘Wikipedia’ article on the topic lucidly explains their relationship in ORP measurement:

> **Reduction potential** (also known as **redox potential**, **oxidation / reduction potential** or **ORP**) is the tendency of a chemical species to acquire electrons and thereby be reduced. Each species has its own intrinsic reduction potential; the more positive the potential, the greater the species' affinity for electrons and tendency to be reduced.
>
> In aqueous solutions, the reduction potential is the tendency of the solution to either gain or lose electrons when it is subject to change by introduction of a new species. A solution with a higher (more positive) reduction potential than the new species will have a tendency to gain electrons from the new species (i.e. to be reduced by oxidizing the new species) and a solution with a lower (more negative) reduction potential will have a tendency to lose electrons to the new species (i.e. to be oxidized by reducing the new species). Just as the transfer of hydrogen ions between chemical species determines the pH of an aqueous solution, the transfer of electrons between chemical species determines the reduction potential of an aqueous solution. Like pH, the reduction potential represents an intensity factor. It does not characterize the capacity of the system for oxidation or reduction, in much the same way that pH does not characterize the buffering capacity.

In short, a numerically positive redox potential or ORP represents an environment conducive to the oxidation of an introduced substance by reduction of the original media.

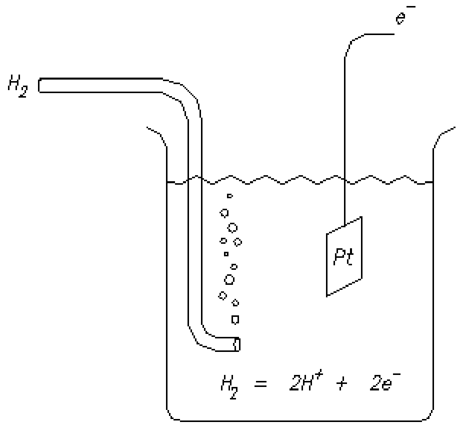
2.2 Instrumentation

ORP measurement systems are a practical implementation of electrochemical cells, which use metal electrodes in a solution to generate an electric current or voltage. If a platinum electrode is immersed in water with hydrogen bubbled into the solution, the H^2 is oxidized as follows:

$$H^2 = 2H^+ + 2e^-$$

In the electrochemical half-cell illustrated below in Fig.1, hydrogen gas oxidizes to hydrogen ions and free electrons, comprising an oxidation-reduction couple. This couple reaches an equilibrium state that maintains the reference potential of the electrode. The electric potential develops on the wire connected to the platinum electrode, but is difficult to measure in practice in the isolated half-cell. However, when used in a complete electrochemical cell, the cell illustrated is used as a reference to measure other half-cells against, and is called a Standard Hydrogen Electrode (SHE).

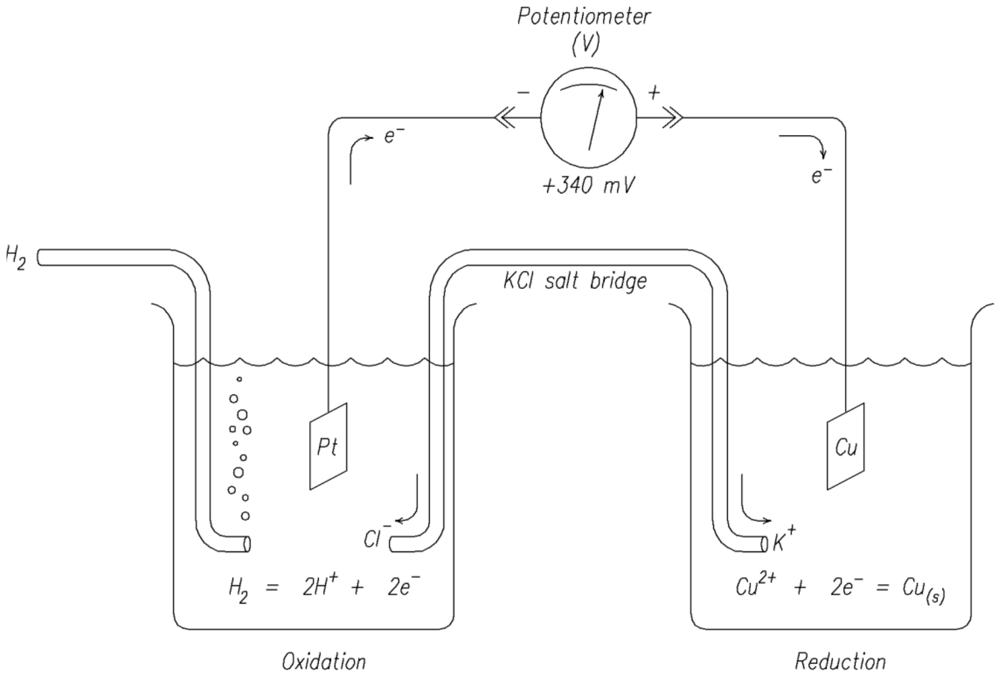
Figure 1



Hydrogen Half–Cell

If, as shown in Figure 2, a SHE is connected with a salt bridge to a second half-cell in which a reduction reaction is taking place, the electric potential between the two cells can be measured. In the case shown, the potential of the right cell will be +0.34 Volts in reference to the standard hydrogen electrode on the left. This would be represented as an Oxidation Reduction Potential (ORP) of +340mV on the hydrogen scale, or simply as Eh = +340mV.

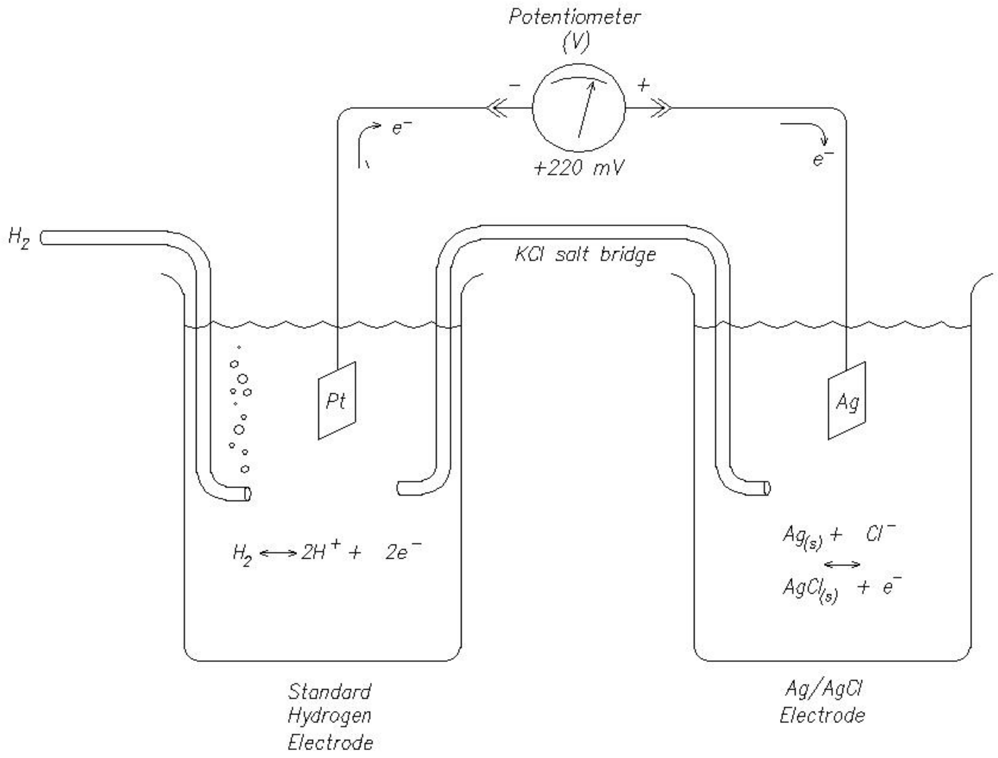
Figure 2



In field practice, the hydrogen electrode is difficult to reproduce. To conduct field measurements, a reference electrode is needed that is simple to maintain and will generate a potential that can be referenced to the standard hydrogen electrode. These requirements are met by the Saturated Calomel Electrode (SCE) and the Silver/Silver Chloride Electrode (SSCE - the SSCE is also commonly identified as an Ag/AgCl electrode). The SCE contains a small amount of elemental mercury, and while useful for certain applications, would rarely be used at SESD. The SSCE or Ag/AgCl electrode is generally used as the reference cell in SESD instrumentation.

In Figure 3 below, a SHE is connected to an Ag/AgCl electrode. In this example of an electrochemical cell, both cells reach an equilibrium potential. At that equilibrium state, the potential of the Ag/AgCl cell is 220mV more positive than the standard hydrogen electrode.

Figure 3



This half-cell potential of the Ag/AgCl electrode in reference to the SHE is used to convert measurements taken with an Ag/AgCl reference back to the hydrogen scale. While the laboratory Ag/AgCl half-cell shown has a potential of +220mV, practical reference cells have varying potentials based on temperature and filling solutions as shown in Table 1 below.

Table 1

Half-cell Potential of Ag/AgCl reference electrode

derived from USGS NFM, Table 6.5.2 (9/2005)

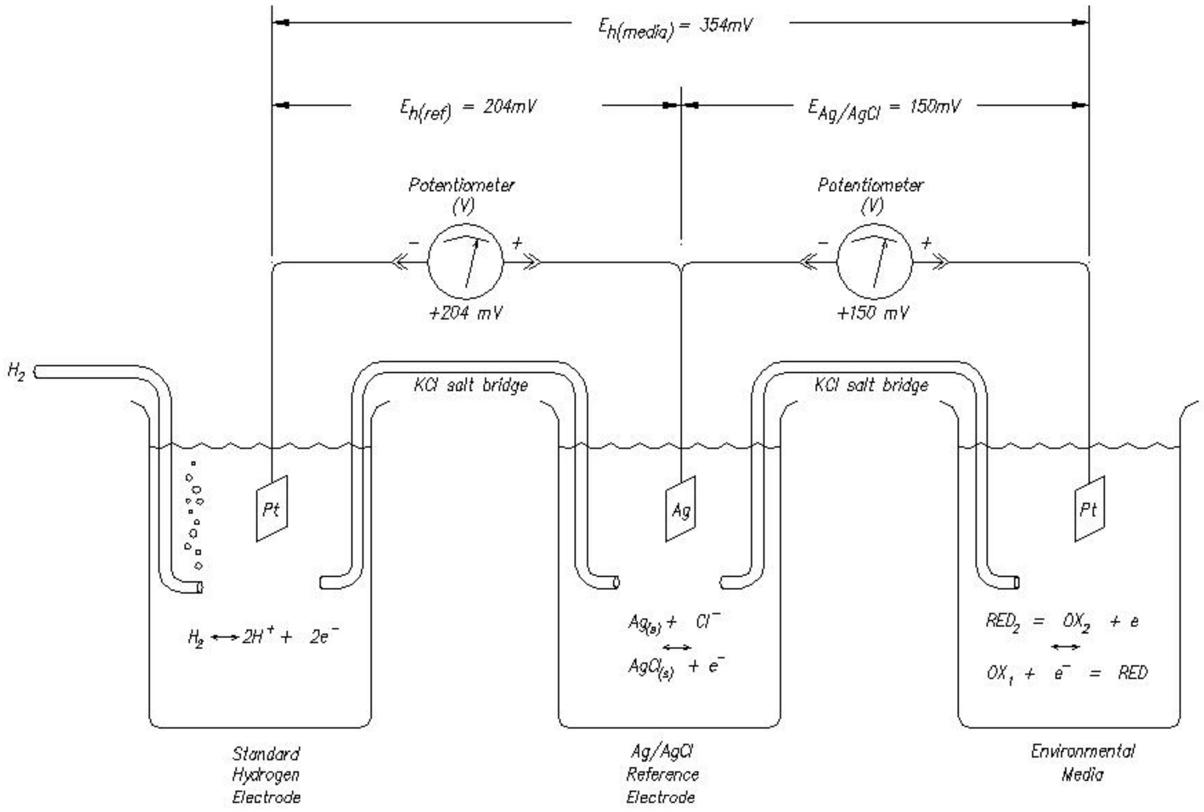
	Molarity of KCl filling solution			
T(°C)	3M	3.3M*	3.5M	Sat/4M
10	220	217	215	214
15	216	214	212	209
20	213	210	208	204
25	209	207	205	199
30	205	203	201	194
35	202	199	197	189
40	198	195	193	184

*interpolated value

Note: YSI sondes and Thermo electrodes typically use 4M KCl filling solutions. Eureka sondes typically use 3.3M KCl filling solutions.

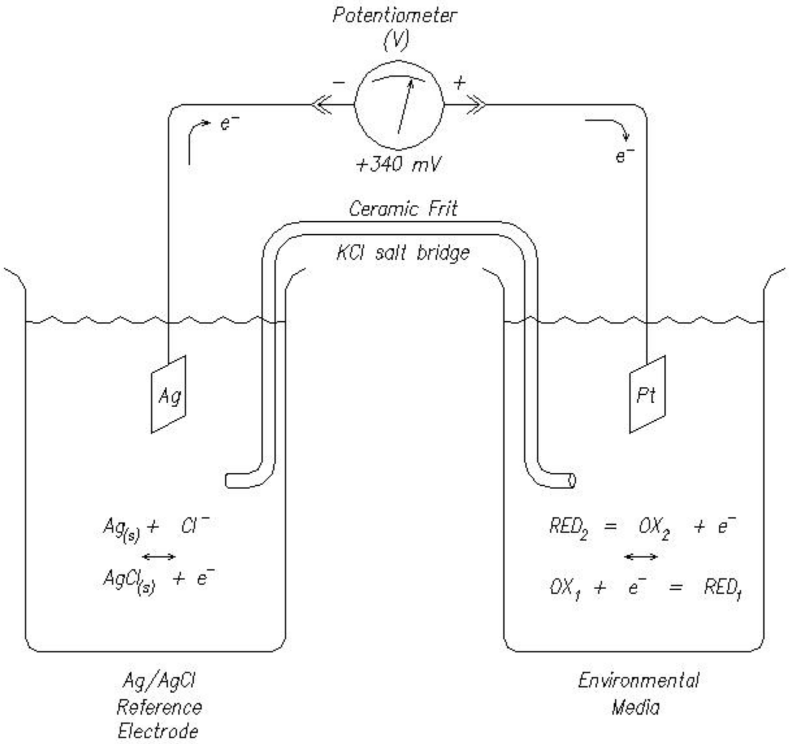
In Figure 4, below, the relationship between a hydrogen electrode, a reference electrode, and a platinum sensing electrode in an arbitrary media is shown. In this case, the ORP of the media in reference to the silver/silver chloride electrode is 150mV. To obtain Eh, the potential of the reference electrode in relation to a hydrogen electrode is added to the potential of the sensing electrode in relation to the reference electrode. In practice, the potential of the reference electrode in relation to a hydrogen electrode is not measured, but obtained from Table 1 above.

Figure 4



In Figure 5 below, a field instrument is represented as separate electrochemical cells. The Ag/AgCl reference electrode uses a ceramic frit or other means to provide the essential salt bridge to the environmental media. The platinum sensing electrode is immersed in the environmental media and connected internally in the instrument to measure the potential (voltage) between the two electrodes.

Figure 5



In this illustration, the ORP is measured as 340 mV. This measurement is made in reference to the Ag/AgCl reference electrode and would be reported as such, or as $E_{Ag/AgCl}$ = 340mV.

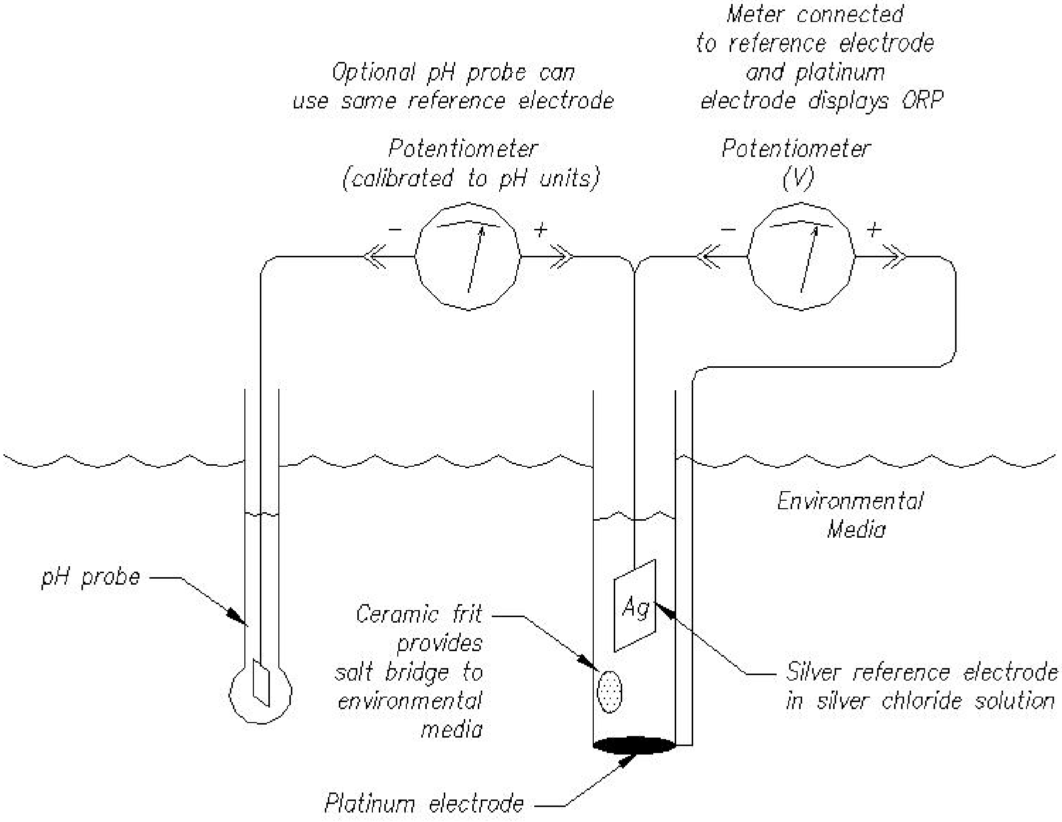
In some cases it will be desirable to report the reading on the hydrogen scale, or Eh. To do so, the potential of the reference electrode against the SHE, obtained from Table 1, is added to $E_{Ag/AgCl}$. For our example:

	340 mv	Measured ORP ($E_{Ag/AgCl}$) of sample
+	<u>204 mV</u>	Eh of Ag/AgCl electrode (ORP of Ag/AgCl electrode referenced to SHE)
	544 mV	Eh of sample

Both the +340 mV field reading and the corrected +544 mV Eh can properly be referred to as ORP results. It is only through specifying the reference scale that the ambiguity can be eliminated.

In Figure 6, below, the theoretical cells shown above have been configured as a practical field instrument. The salt bridge is commonly provided by a ceramic frit connecting the environmental media to the reference electrode. In multi-parameter sondes, the pH probe commonly uses the same reference electrode as the ORP probe.

Figure 6



2.3 Redox Chemistry

In acid-base chemistry, the pH of a system is defined as the negative logarithm of the hydrogen ion activity (simplified in practice to the hydrogen ion concentration):

$$pH = -\log \{H^+\}$$

Similarly, Pankow (1991) described the negative logarithm of the electron activity (pe) as the master variable for describing the equilibrium position for all redox couples in a given system:

$$pe \ / \ -\log \{e^-\}$$

It can be shown (Pankow) that pe is related to Eh by

$$Eh = pe*(2.303*R*T)/F$$

Where:

R = gas constant = 8.314 J K^{-1} mol^{-1}
T = temperature, ^{o}K
F = Faraday constant = $96.485*10^{3}$ C mol^{-1}

At 25°C (298°K) this simplifies to

$$E_H = pe * 0.05916$$

And

$$pe = E_H / 0.05916$$

According to Faulkner et al. (1989) redox is a quantitative measure of electron availability and is indicative of the intensity of oxidation or reduction in both chemical and biological systems. When based on a hydrogen scale, redox (E_H) is derived from the Nernst Equation (Stumm and Morgan 1981):

$$E_H = E_H^{o} + 2.3 \ H \ (R \ H \ T)/nF \ H \log (J_i \{ox\}^{ni} / J_j \{red\}^{nj})$$

Where:

E_H^{o} = potential of reference, mV
R = gas constant = 81.987 cal deg^{-1} $mole^{-1}$
T = temperature, ^{o}K
n = number of moles of electrons transferred
F = Faraday constant = 23.061 cal/mole-mv
{ox} and {red} = activity of the oxidants and reductants, respectively

2.4 Applications

When interpreted properly, redox combined with other conventional water quality parameters is useful in developing a more complete understanding of water chemistry. Several applications of redox are identified below:

1. Redox could be viewed as an extension of the oxygen scale. In this model, the DO probe spans the aerobic scale and the redox probe extends that scale to measure anaerobic conditions. Inferences to geochemistry and chemical speciation can be made from the oxidative state of the system. Application to metal sequestration, metal-iron, -sulfide, -methane complexation, and the subsequent bioaccumulation potential is possible.
2. Redox can be used to identify anaerobiosis at or near the water column and sediment interface in streams, lakes, and estuaries.
3. Redox may be useful in determination of stream jurisdiction and wetland delineation in that it can indicate conditions of soil saturation.

4. Based on redox, a pe (or EH) vs. pH stability diagram can be developed to aid in nutrient exchange studies including the timing, release, and partitioning of important water and sediment quality pollutants such as nitrogen and phosphorus species. Most importantly, redox can be used to address error associated with chamber-effect during closed chamber measurements of the water-sediment interface. Redox probes placed inside the contact chamber and inserted approximately ten centimeters into the underlying sediment can be used to monitor changes in sediment redox caused by the chamber, and steps can be taken to reduce chamber-effect.
5. Redox may be useful in establishing water and sediment quality standards applicable to wetlands.
6. Redox is used to assess the potential of a groundwater system to support various in situ reactions with contaminants, such as reductive dechlorination of chlorinated solvents.
7. Redox can provide a useful indicator of conditions that might compromise the performance of Clark-type dissolved oxygen (DO) probes. In general, anaerobic conditions occur at a redox range of +150 mV to +300 mV (pH-dependent and adjusted to hydrogen reference electrode). When redox drops below this level, DO measurements as determined with a Clarke-type probe are highly suspect as the semi-permeable membrane does not discriminate between partial O_2 and sulfides. Consequently, the meter may be reading sulfides.

2.5 Limitations

In most environmental media, redox reactions will not reach equilibrium due to low concentrations or multiple redox species. Consequently, redox measurements can generally be considered semi-quantitative in environmental media, unless certain conditions exist.

The USGS in the Interferences and Limitations Section 6.5.3A of their National Field Manual succinctly describe some of the issues encountered in the application of ORP measurements. This section is reproduced here, unedited:

> 6.5.3.A INTERFERENCES AND LIMITATIONS
>
> *Measurements should not be carried out without an awareness of the interferences and limitations inherent in the method.*
>
> - *Organic matter and sulfide may cause contamination of the electrode surface, salt bridge, or internal electrolyte, which can cause drift or erratic performance when reference electrodes are used (American Public Health Association and others, 2001).*
> - *Hydrogen sulfide can produce a coating on the platinum electrode that interferes with the measurement if the electrode is left in sulfide-rich water for several hours (Whitfield, 1974; Sato, 1960).*
> - *The platinum single and combination redox electrodes may yield unstable readings in solutions containing chromium, uranium, vanadium, or titanium ions and other ions that*

are stronger reducing agents than hydrogen or platinum (Orion Research Instruction Manual, written commun., 1991).

- *Do not insert redox electrodes into iron-rich waters directly after the electrode(s) contact ZoBell's. An insoluble blue precipitate coats the electrode surface because of an immediate reaction between ferro- and ferricyanide ions in ZoBell's with ferrous and ferric ions in the sample water, causing erratic readings.*

Many elements with more than one oxidation state do not exhibit reversible behavior at the platinum electrode surface and some systems will give mixed potentials, depending on the presence of several different couples (Barcelona and others, 1989; Bricker, 1982, p. 59–65; Stumm and Morgan, 1981, p. 490–495; Bricker, 1965, p. 65). Methane, bicarbonate, nitrogen gas, sulfate, and dissolved oxygen generally are not in equilibrium with platinum electrodes (Berner, 1981).

TECHNICAL NOTE:

Misconceptions regarding the analogy between Eh (pe) and pH as master variables and limitations on the interpretation of Eh measurements are explained in Hostettler (1984), Lindberg and Runnells (1984), Thorstenson (1984), and Berner (1981). To summarize:

(1) Hydrated electrons do not exist in meaningful concentrations in most aqueous systems—in contrast, pH represents real activities of hydrated protons. Eh may be expressed as pe (the negative logarithm of the electron activity), but conversion to pe offers no advantage when dealing with measured potentials.

(2) Do not assume that redox species coexist in equilibrium. Many situations have been documented in which dissolved oxygen coexists with hydrogen sulfide, methane, and ferrous iron.

- *The practicality of Eh measurements is limited to iron in acidic mine waters and sulfide in waters undergoing sulfate reduction.*

- *Other redox species are not sufficiently electroactive to establish an equilibrium potential at the surface of the conducting electrode.*

(3) A single redox potential cannot be assigned to a disequilibrium system, nor can it be assigned to a water sample without specifying the particular redox species to which it refers. Different redox elements (iron, manganese, sulfur, selenium, arsenic) tend not to reach overall equilibrium in most natural water systems; therefore, a single Eh measurement generally does not represent the system.

3 Methodology

3.1 Standard Solutions

Care should be taken not to contaminate standards and samples and to verify the expiration date of all standards prior to use. All meters should be verified or calibrated according to the manufacturer's procedures.

Standard solutions for calibration and verification should be selected to meet project requirements. SESD generally maintains a stock of Zobell's solution suitable for most projects. The characteristics and use of the common standard solutions are described below.

- Zobell's solution contains potassium ferri- and ferro- cyanide compounds. The solution is available as prepared solutions or premeasured reagents for mixing by the user. Zobell's has moderate toxicity but will react with acid to form harmful byproducts, including hydrocyanide gas. It has a shelf life ranging from several days to several months depending on the manufacturer. Stock and working solutions of Zobell's should be stored in dark bottles due to its light sensitivity.

- Quinhydrone solutions are mixed at the time of use by adding quinhydrone to pH 4 or pH 7 buffers. At 25°C, the E_h of quinhydrone pH 4 and pH 7 verification solutions are 462mV and 285mV respectively. An advantage of quinhydrone solutions is that they offer a span of calibration points that may be appropriate for particular applications. Quinhydrone is a lightly 'poised' solution in that it offers less driving force towards the calibration point: a compromised instrument is more likely to be revealed in a quinhydrone calibration. A quinhydrone calibration/verification solution is created by adding 10g of quinhydrone to 1L of pH 4 or pH 7 buffer solution (ASTM D1498). The solutions are mixed on a magnetic mixing plate for a minimum of 15 minutes to create a saturated solution with undissolved crystals remaining. Quinhydrone solutions are usable for 8 hrs from the time of mixing.

- Light's solution consists of ferrous and ferric ammonium sulphate in sulphuric acid. The solution would rarely be used at SESD due to its high acidity and associated handling difficulty. Spent solutions with a pH<2 would be regulated as a hazardous waste. Light's is a highly poised solution that may allow a marginally functioning electrode to pass calibration.

- A prepared potassium iodide solution is available which has low toxicity and a long shelf life. The solution may stain clothing or surfaces if spilled.

3.2 Verification and Calibration

ORP instruments may be **verified** or **calibrated**, depending on the application. The approach chosen should be selected based on project needs and information presented in Section 2.4., Limitations. Standard laboratory practice in making ORP measurements is to **verify** the accuracy of the instrument prior to use, and this practice should be followed when true quantitative results are required. In a **verification,** the instrument in its direct-reading mode is checked against a standard solution in a pass/no-pass test, and no corrections are applied to subsequent measurements. In most applications, the ORP information is used semi-quantitatively and for these applications, the instruments may be **calibrated** to the standard solutions. In an instrument **calibration**, the instrument probe is placed in the standard solution and the difference between the standard measurement and the known ORP value of the standard is used by the instrument to make adjustments to the subsequent measurements.

In **verification** of an ORP instrument, the instrument is set to absolute mV reading mode or the internal calibration offset is zeroed out. The instrument probe should then be placed in the standard solution and the reading verified to fall within +/-10mV of the predicted reading for the standard. Instruments with single-purpose electrodes are most suitable for this approach. If the instrument fails the verification, standard solution quality should be considered and instrument maintenance performed per the manufacturer's procedures.

In most SESD field practice, the end data use is semi-quantitative. In this case, the instruments can be **calibrated** to standard solutions appropriate for the project using the manufacturer's recommended procedure. One minute after the calibration, the instrument should display a stable reading within +/-10mV of the predicted reading. An instrument failing this test should be recalibrated to determine if the problem is inadequate equilibration time. In the event of continued instrument failure, aging or contamination of the standard solution should be considered. Subsequently the electrode should be serviced according to the manufacturer's procedures. Common service procedures include cleaning the platinum electrode with mild abrasives or acids and refilling or replacing the reference electrode.

Prior to a mobilization, all ORP instruments will be checked for proper operation and verified or calibrated against standard solutions. During the field mobilization, each instrument will be calibrated or verified prior to, and verified after, each day's use or deployment.

Even though it is not necessary to re-calibrate ORP instrument at regular intervals during the day, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an extreme temperature change or submersion of a filling solution port have impacted the instrument's performance. If an operational check is warranted, the field operator should follow the appropriate verification/calibration steps as described above.

The predicted ORP values of standard solutions will be obtained from the manufacturer of prepared solutions, literature, or appropriate values listed in this procedure. Care is in order, as the predicted ORP value is specific for the type of reference electrode used by the probe (either Ag/AgCl or calomel) and the molarity of the filling solution in the reference electrode. To use the solution with another electrode or filling solution, the expected ORP readings for the solution should be converted to Eh for the probes intended for the solution as per the Reporting section of this procedure. Then a table can be compiled for the electrode in use by subtracting the $E_{h,ref}$ for the electrode and filling solution in use. This will be done at the Field Equipment Center (FEC) for the solutions stocked.

Verification solutions should be managed per the manufacturer's directions regarding storage and handling. After instrument verification or calibration, the solution cannot be returned to the stock solution container, although a separate container of working solution can be maintained.

Spent solutions and working solutions should be returned from the field to the SESD laboratory for proper disposal by the SHEMP, or handled as directed by the SHEMP. Properly handled stock solutions may be returned to the FEC for use at that facility.

3.3 Measurement

ORP measurements should be conducted in a fashion that prevents the addition or loss of any potential oxidants or reductants. Results could be compromised by exposing the sample to air or allowing H_2S to off-gas from anoxic samples. Like dissolved oxygen measurements, ORP measurements should be conducted in situ or by using a flow-through cell evacuated of air (see the SESD Operating Procedure for Field Measurement of Dissolved Oxygen (SESDPROC-106, most recent version).

When using multi-parameter probes for ORP measurements, the general guidelines for probe deployment described in the SESD Operating Procedure for Field Measurement of Dissolved Oxygen (SESDPROC-106, most recent version) and the SESD Operating Procedure for In situ Water Quality Monitoring (SESDPROC-111, most recent version) apply.

ORP probes must be operated and maintained in accordance with the manufacturer's instructions. Reference electrodes in multi-parameter probes may require regular filling or replacement. Single parameter ORP electrodes may require regular filling and operation in an upright position to assure that proper salt bridge flow is maintained. Platinum electrode surfaces are easily contaminated and polishing or cleaning of the electrodes should be performed as recommended by the manufacturer.

Measurements in field logbooks should be recorded to the nearest mV. The type of reference electrode in use and its filling solution should be recorded in at least one logbook as part of the field project records.

ORP is a temperature sensitive measurement, but ORP instruments are not temperature compensated. Consequently, the media temperature should always be recorded at the same time as the ORP is recorded. Likewise, as ORP is often pH dependent, pH should also be recorded at the time of ORP measurement.

3.4 Reporting

In the absence of a specified reference scale, ORP data has no meaning. Therefore, the reference scale used should always be specified in reporting or discussing the ORP data. ORP measurements converted to a hydrogen scale can be reported as "E_h". Data reported as the direct field measurement without correction might be described as "ORP referenced to Ag/AgCl electrode" or "$E_{Ag/AgCl}$". The expectations of the data user should be ascertained or the measurements should be reported in both systems.

To apply corrections to obtain E_h from the direct field measurement, the known half-cell potential of the reference electrode is added to the recorded field ORP value:

$$E_{h,sample} = ORP_{sample} + \text{half-cell potential of reference electrode}$$

The following table, reproduced from Section 2.2, presents the half-cell potential of a silver/silver chloride reference electrode at various temperatures and with various molarities of KCl filling solutions.

Table 1

Half-cell Potential of Ag/AgCl reference electrode

derived from USGS NFM, Table 6.5.2 (9/2005)

	Molarity of KCl filling solution			
T(°C)	3M	3.3M*	3.5M	Sat/4M
10	220	217	215	214
15	216	214	212	209
20	213	210	208	204
25	209	207	205	199
30	205	203	201	194
35	202	199	197	189
40	198	195	193	184

*interpolated value

Note: YSI sondes and Thermo electrodes typically use 4M KCl filling solutions. Eureka sondes typically use 3.3M KCl filling solutions

Example:

A multi-parameter probe with a silver/silver chloride reference electrode and 4M KCl filling solution is used to record a stream ORP measurement of 146mV. The stream temperature is recorded as 15°C.

From the above table, the half-cell potential of an Ag/AgCl reference electrode filled with 4M KCl is 209mV at 15°C. Then:

$$E_{h,sample} = ORP_{Ag/AgCl,sample} + \text{half-cell potential of Ag/AgCl reference electrode}$$

$$E_{h,sample} = 146mV + 209mV$$

$$E_{h,sample} = 355mV$$

As noted in Section 3.3, Measurement, ORP measurements are sensitive to temperature, and may be sensitive to pH. As the instruments do not compensate for these parameters, ORP data should always be reported with the temperature and pH of the media at the time of measurement.

Final reporting values of Eh or ORP should be rounded to the nearest 10mV. The following spreadsheet formula can perform the rounding of an interim result located in spreadsheet cell 'A1':

```
=INT(A1/10+0.5)*10
```

SESD PROCEDURE SESDPROC-106-R3:

FIELD MEASUREMENT OF DISSOLVED OXYGEN

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Measurement of Dissolved Oxygen**

Effective Date: January 8, 2014	**Number:** SESDPROC-106-R3

Author

Name: Hunter Johnson
Title: Environmental Engineer
Signature: Date: 1/6/14

Approvals

Name: Danny France
Title: Chief, Enforcement and Investigations Branch
Signature: Date: 1/6/14

Name: John Deatrick
Title: Chief, Ecological Assessment Branch
Signature: Date: 1/6/14

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 1/6/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-106-R3, *Field Measurement of Dissolved Oxygen*, replaces SESDPROC-106-R2 **General** Corrected any typographical, grammatical, and/or editorial errors. **Title Page** Changed Chief, Enforcement and Investigations Branch from Archie Lee to Danny France. Changed Chief, Ecological Assessment Branch from Bill Cosgrove to John Deatrick. Changed Field Quality Manager from Liza Montalvo to Bobby Lewis. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 1.1**: In the last sentence, replaced "diffusion" with "reaeration." **Section 1.2:** Added the following statement: "Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use." **Section 2:** First Paragraph, Second Sentence: The phrase "taken to the field" was replaced with "utilized in the field". Third Paragraph: This paragraph, which discussed a 24 hour burn in period for Clarke Cell probes, was omitted. Fourth Paragraph: This paragraph, which discussed Winkler Titration, was omitted. **Section 3.1:** Converted part of the first paragraph into bulleted items. Omitted all language that referred to Winkler Titration. **Section 3.2:** Omitted all language that referred to Winkler Titration.	January 8, 2014
SESDPROC-106-R2, *Field Measurement of Dissolved Oxygen*, replaces SESDPROC-106-R1	February 12, 2010

SESDPROC-106-R1, *Field Measurement of Dissolved Oxygen*, replaces SESDPROC-106-R0	November 1, 2007
SESDPROC-106-R0, *Field Measurement of Dissolved Oxygen*, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes methods and considerations to be used and observed when conducting field measurements of dissolved oxygen in surface water, treated wastewater and in gas media for specific applications (e.g., reaeration measurement).

1.2 Scope/Application

On the occasion that SESD field investigators determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another method must be used to obtain a measurement of dissolved oxygen, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

SESD Field Branches Quality Management Plan, SESDPLAN-001, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Refer to the SESD Safety, Health and Environmental Management Program Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

Appropriate precautions should be observed when working in and around bodies of water and on boats. Be aware of fast flowing waters, waterway obstructions such as dams, and other vessels on the water.

2 Quality Control

All dissolved oxygen meters will be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter is utilized in the field, it will be calibrated and verified, according to Section 3.2 of this procedure, to ensure it is operating properly. These calibration and verification checks will be documented and maintained in a logbook.

For in-situ measurements, an instrument warm-up period appropriate for that instrument should be provided. Consult manufacturer’s documentation for appropriate warm-up time.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer’s specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

Following instrument use, an end check should be performed using one of the techniques described in Section 3.2 to quantify potential instrument drift during use.

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Measurement of Dissolved Oxygen

3.1 General

Dissolved oxygen can be defined as the volume of oxygen contained in a volume of water. The solubility of oxygen in water is dependant on the water temperature, salinity and pressure.

- As the temperature of the water decreases, the solubility of oxygen increases.
- As salinity increases, the solubility of oxygen decreases.
- As the pressure decreases (altitude increases), the solubility of oxygen decreases.

Several methods for measurement of dissolved oxygen in water are available utilizing a variety of technologies.. When measuring dissolved oxygen for compliance with the National Pollutant Discharge Elimination System (NPDES) Program, only approved methods will be used. Approved methods can be found in the Code of Federal Regulations (CFR) 40 CFR Part 136.

3.1.1 Clark Cell Probes

Clark cell probes utilize an oxygen permeable membrane that covers an electrolytic cell which consists of a cathode and an anode. The anode acts as a reference electrode. After passing through the permeable membrane, the oxygen is reduced by an applied potential voltage that is referenced to the anode. The reduction current at the cathode is directly proportional to the partial pressure of oxygen in liquid, expressed as %-air saturation. The concentration of oxygen, in mg/l, is calculated based on the %-air saturation reading and the solubility of oxygen in water at the sample temperature.

In general, sample collection using a DO probe requires only lowering the probe into the sample media and recording or logging the results. The probe should be lowered gently to prevent damage to the membrane and gently turned when initially lowered to remove any attached air bubbles. If the instrument requires the use of a stirrer, the stirrer should be turned on before recording any readings. Prior to use, the instrument should be calibrated and any manufacturer specified warm-up period should be observed.

3.1.2 Luminescent Probes

Luminescent dissolved oxygen probes employ a light emitting diode (LED) to provide incident light, which excites the oxygen-sensitive luminescent-dye molecule substrate of the sensor. After dissipation of the excitation energy, longer-wavelength light is emitted (luminescence). The magnitude of steady-state luminescence (intensity) is measured by the sensor and is inversely proportional to the dissolved oxygen concentration.

Sample collection with this type of probe should follow the sample procedures described in the second paragraph of Section 3.1.2 for Clark Cell probes.

3.2 Calibration

Many brands of instruments are commercially available for *in-situ* measurement of dissolved oxygen using Clark cell probes and luminescent probes. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate.

In general, calibrations should be conducted at temperatures and pressures as close as possible to those of the sample media for the most accurate measurements. Due to the sensitivity of dissolved oxygen measurements to changes in temperature, the temperature probe or thermistor should be verified using a NIST traceable thermometer prior to each calibration. Most dissolved oxygen meters utilize a one-point calibration which is generally performed using either water saturated air or air-saturated water. When using the water-saturated air method, the probes should be placed in a 100% relative humidity environment and the temperature and dissolved oxygen readings should be allowed to equilibrate. After equilibration, the meter should be set to read the appropriate dissolved oxygen concentration based on the temperature and barometric pressure.

When using air-saturated water for calibration, an aeration device such as an aquarium pump with a diffusion stone should be placed in a vessel containing tap water. The water in the vessel should be aerated for a minimum of one hour at a constant temperature. Saturation should be verified by placing the dissolved oxygen probe in the vessel and monitoring the temperature and dissolved oxygen readings for stabilization. Avoid placing the probe in the direct stream of air bubbles. Bubbles can accumulate on the probe surface and cause erroneous readings. Once the water is saturated, the temperature of the water and the barometric pressure can be used to determine the dissolved oxygen value. The meter can then be set to read that value.

3.3 Maintenance

Maintenance procedures vary depending on the technology utilized by each instrument and the manufacturer. The manufacturer's instruction manual should be consulted for instrument specific procedures. Following are some general guidelines for maintaining dissolved oxygen meters:

- Inspect probes for damage prior to use.

- For Clark cell probes, membranes and electrolyte solution should be changed prior to each study, when feasible.
- Battery voltages should be checked. For meters that will be deployed unattended, new or fully charged batteries should be used for each study.
- All calibration and maintenance procedures performed should be thoroughly documented.

3.4 Conducting Field Measurement of Dissolved Oxygen

Following are guidelines for conducting field measurements of dissolved oxygen:

- Except as described in specific operating procedures, dissolved oxygen measurements should if possible be conducted *in-situ*.
- When measuring DO at distinct points in the water column, the probe should be allowed to equilibrate at each location prior to recording the measurement.
- In water bodies with a great deal of flow, a weight may be attached to the probe guard or support cable to insure the probe is maintained at the proper depth.
- Insure that the measurement location is representative of conditions within the water body or reach. Avoid measurements directly below turbulent sections or still water unless these conditions represent most of the water body or reach.
- If DO measurements are conducted in saline water, the DO meter should either be capable of correcting for salinity or a separate instrument should be used to measure salinity so that the final DO measurements can be corrected.

3.5 Operational Check

A post-operation instrument verification check will be performed using one of the techniques described in Section 3.2 to quantify potential instrument drift during use. A verification check will be performed at the end of all measurements for a day or at the end of a deployment. The verification DO concentration will be measured and recorded in the field logbook prior to any instrument adjustment.

It may be appropriate to check the calibration of a DO meter periodically during the course of a day's measurements when conducting individual measurements rather than deploying an instrument. When this is done, it should be noted in the field logbook. The calibration of meters checked throughout the day maybe adjusted if drift is occurring.

SESD PROCEDURE SESDPROC-103-R3:

FIELD TURBIDITY MEASUREMENT

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Turbidity Measurement**

Effective Date: January 29, 2013

Number: SESDPROC-103-R3

Authors

Name: Timothy Simpson
Title: Environmental Scientist
Signature: Timothy Simpson
Date: 01/23/2013

Approvals

Name: Danny France
Title: Chief, Enforcement and Investigations Branch
Signature:
Date: 1/23/13

Name: John Deatrick
Title: Chief, Ecological Assessment Branch
Signature: John Deatrick
Date: 1/23/13

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 1/23/13

Revision History

This table shows changes to this controlled document over time. The most recent version is presented in the top row of the table. Previous versions of the document are maintained by the SESD Document Control Coordinator.

History	Effective Date
SESDPROC-103-R3, *Field Turbidity Measurement*, replaces SESDPROC-103-R2 **General:** Corrected any typographical, grammatical and/or editorial errors. **Cover Page:** The Author was changed from Ron Phelps to Timothy Simpson. The Enforcement and Investigations Branch Chief was changed from Antonio Quinones to Danny France. The FQM was changed from Laura Ackerman to Bobby Lewis. **Section 1.2:** Added the following statement: Mention of trade names or commercial products does not constitute endorsement or recommendation for use. **Section 1.3:** Omitted the reference to the H: drive of the LAN. **Section 1.5.1:** Updated the SHEMP Manual reference to reflect that the most recent version of the Manual will be used. **Section 2:** In the first paragraph, replaced "and" in the second sentence with "or". **Section 3.2:** Replaced "Meter" with "Instrument" in section title. Replaced the first paragraph with the following language: "Many brands of instruments are commercially available for the measurement of turbidity incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. Depending on the instrument, the verification and calibration can differ slightly. If the instrument readings do not agree within ± 10 % of the calibration standards, the unit must be recalibrated, repaired or replaced. The following are basic guidelines for calibration/verification of meters and are provided as an example:" Removed section on calibration and verification of the HACH 2100P Turbidimeter. Added Section 3.2.1, Meter Calibration and Verification, that includes information on the calibration and verification of the 2100Q Turbidimeter. Replaced Section 3.3, Probe Calibration and Verification, with Section 3.2.1, Probe Calibration and Verification.	January 29, 2013

Section 3.3: Added “Depending on the meter, the sample measurement procedure can differ slightly.” Converted Section 3.3 into Section 3.3.1, Grab Sample Measurement, and Section 3.3.2, *In-Situ* Measurement. **Section 3.3.1:** In Item #3 replaced “Press I/O and the instrument will turn on.” with “Turn instrument on.” In Item #5 and #6 added “If appropriate”. In Item #8 added “or rinse out with sample water prior to the next reading”. **Section 3.5:** Replaced the section with the following language: “Even though it is not necessary to re-calibrate turbidity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter’s performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed. While in use, periodically check the turbidity by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate calibration standard. If the measured turbidity differs by ± 10 % (depending on the application) from the calibration standard, the meter must be re-calibrated. A post-operation instrument verification check will be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.”	
SESDPROC-103-R2, *Field Turbidity Measurement*, replaces SESDPROC-103-R1 **Cover Page:** Author was changed from Marty Allen to Ron Phelps. **Revision History:** Changed Field Quality Manager to Document Control Coordinator. **Section 1.3:** Changed Field Quality Manager to Document Control Coordinator.	June 13, 2008

SESDPROC-103-R1, *Field Turbidity Measurement*, replaces SESDPROC-103-R0 **General** Deleted all references to SOSA. Updated referenced procedures due to changes in title names and/or to reflect most recent version. **Title Page** Changed title for Antonio Quinones from Environmental Investigations Branch to Enforcement and Investigations Branch. Changed Bill Cosgrove's title from Acting Chief to Chief. **Section 1.3** Updated information to reflect that procedure is located on the H: drive of the LAN. **Section 1.4** Alphabetized and revised the referencing style for consistency. **Section 2** Added last paragraph regarding stopping measurements due to environmental conditions. **Section 3.5** Re-phrased operational check 2 for clarity.	November 1, 2007
SESDPROC-103-R0, Field Turbidity Measurement, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when conducting field turbidity measurements in aqueous phase environmental media, including groundwater, surface water and certain wastewaters.

1.2 Scope/Application

The procedures contained in this document are to be used by field personnel when measuring turbidity of various, aqueous phase environmental media in the field. On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain turbidity measurements of the media being sampled, and that another method or turbidity measurement instrument must be used to obtain said measurements, the variant instrument and measurement procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Equipment Inventory and Management, SESDPROC-108, Most Recent Version

SESD Operating Procedure for Logbooks, SESDPROC-010, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when conducting field turbidity measurements. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Manual (Most Recent Version) and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. When using this procedure, minimize exposure to potential health hazards through the use of protective clothing, eye wear and gloves. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

All field turbidity measurements pertinent to the sampling event should be recorded in the field logbook for the event. All records should be entered according to the procedures outlined in the SESD Operating Procedure for Logbooks (SESDPROC-010).

2 Quality Control

All turbidity meters and probes shall be maintained and operated in accordance with the manufacturer's instructions and the SESD Operating Procedure for Equipment Inventory and Management (SESDPROC-108). Before a meter or probe is taken to the field, it shall be properly calibrated or verified, according to Sections 3.2 and 3.3 of this procedure, to ensure it is operating properly. These calibration and verification checks shall be documented and maintained in a logbook.

The ambient temperature in the immediate vicinity of the meter should be measured and recorded in the field logbook to insure the instrument is operated within the manufacturer’s specified range of operating temperatures. For instruments that are deployed for in-situ measurements, the temperature of the medium being monitored should be measured and recorded in the logbook prior to deployment. *In-situ monitoring equipment may be utilized in unattended deployments where autonomous logging may preclude temperature measurement prior to deployment. Because in situ instrumentation generally has a wide range of operating temperature, the field investigator may utilize professional judgment in determining if the operating environment is suitable for unattended deployment.*

If at any time during a field investigation, it appears that the environmental conditions could jeopardize the quality of the measurement results, the measurements will be stopped. This will be documented in the field logbook.

3 Field Turbidity Measurement Procedures

3.1 General

Turbidity is caused by suspended and colloidal matter such as clay, silt, organic and inorganic matter and microscopic organisms. Many methods are available for the measurement of turbidity including turbidimeters and optical probes. Turbidity is measured by determining the amount of scatter when a light is passed through a sample.

3.2 Instrument Calibration and Verification

Many brands of instruments are commercially available for the measurement of turbidity incorporating a wide variety of technologies. The manufacturer's instruction manual should be consulted for specific procedures regarding their calibration, maintenance and use. Calibration of any measurement instrument must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. Depending on the instrument, the verification and calibration can differ slightly. If the instrument readings do not agree within ± 10 % of the calibration standards, the unit must be recalibrated, repaired or replaced. The following are basic guidelines for calibration/verification of meters and are provided as an example:

3.2.1 Meter Calibration and Verification

HACH 2100Q Turbidimeter:

Portable turbidimeters are calibrated with Formazin Primary Standards. The manufacturer recommends calibration with a primary standard such as StablCal® Stabilized Standards or with formazin standards every three months.

Generally only a calibration verification measurement is required in the field; however, if a calibration is needed, record a post calibration reading for each calibration standard used.

Meter Verification:

1. Push **Verify Cal** to enter the Verify menu.
2. Gently invert the liquid standard several times prior to insertion into meter. Insert the 10.0 NTU (or other defined value) Verification Standard and close the Lid.
3. Push **Read**. The display shows "Stabilizing" and then shows the result and tolerance range.

4. Push **Done** to return to the reading display. Repeat the calibration verification if the verification failed. If a meter is unable to pass verification, then that meter will need to be calibrated.

Meter Calibration:

1. Push the **CALIBRATION** key to enter the Calibration mode. Follow the instructions on the display. **Note:** Gently invert each standard several times before inserting the standard and use a non-abrasive, lint-free paper or cloth to wipe off the standards.

2. Insert the 20 NTU StablCal Standard and close the lid. Push **Read**. The display shows "Stabilizing" and then shows the result. Record the result.

3. Repeat Step 2 with the 100 NTU and 800 NTU StablCal Standard. Record both results.

4. Push **Done** to review the calibration details.

5. Push **Store** to save the results. After a calibration is complete, the meter automatically goes into the Verify Cal mode.

3.2.2 Probe Calibration and Verification

The manufacturer's instruction manual should be consulted for specific procedures regarding probe's calibration, maintenance and use. Their calibration must be conducted and/or verified prior to each use or on a daily basis, whichever is most appropriate. The following are basic guidelines for calibration/verification of probes and are provided as an example:

1. Turn the meter "ON" and allow it to stabilize

2. Immerse the probe in the first standard solution and calibrate the probe against the solution.

3. Rinse the probe with de-ionized water, remove excess rinse water and calibrate the probe using additional standards as appropriate.

4. Record the standard values used to calibrate the meter.

3.3 Sample Measurement Procedures

Depending on the meter, the sample measurement procedure can differ slightly.

3.3.1 Grab Sample Measurement

These procedures should be followed when conducting turbidity measurements of grab samples:

1. Collect a representative sample and pour off enough to fill the cell to the fill line (about 15 mL) and replace the cap on the cell.
2. Wipe off excess water and any streaks with a soft, lint-free cloth (lens paper).
3. Turn instrument on. Place the meter on a flat, sturdy surface. Do not hold the instrument while making measurements.
4. Insert the sample cell in the instrument so the diamond or orientation mark aligns with the raised orientation mark in the front of the cell compartment. Close the lid.
5. If appropriate, select manual or automatic range selection by pressing the range key.
6. If appropriate, select signal averaging mode by pressing the Signal Average key. Use signal average mode if the sample causes a noisy signal (display changes constantly).
7. Press Read. T he display will show ---- NTU. Then the turbidity is displayed in NTU. Record the result after the lamp symbol turns off.
8. Rinse the cell with de-ionized water or rinse out with sample water prior to the next reading.

3.3.2 In-Situ Measurement

These procedures should be followed when conducting in-situ turbidity measurements:

1. Place the probe into the media to be measured and allow the turbidity reading to stabilize. Once the reading has stabilized, record the measurement in the logbook.

2. When deploying meters for extended periods of time, ensure the measurement location is representative of average media conditions.

3.5 Operational check

Even though it is not necessary to re-calibrate turbidity meters at regular intervals during the day, depending on the instrument, it may be appropriate to occasionally perform operational checks to determine if site conditions, such as an increase in temperature, have impacted the meter's performance. If an operational check is warranted, the following procedure should be followed to ensure that the performance of the meter has not changed.

While in use, periodically check the turbidity by rinsing the probe with de-ionized water, blot dry or otherwise remove excess rinse water and immerse it into the appropriate calibration standard. If the measured turbidity differs by ± 10 % (depending on the application) from the calibration standard, the meter must be re-calibrated.

A post-operation instrument verification check will be performed using the appropriate standard(s) at the end of the day or after all measurements have been taken for a particular period of operation. These measurements must be recorded in the field logbook.

3.6 Units

Turbidity measurements are reported in nephelometric turbidity units (NTUs). It is important to note that if the turbidity measurements are for NPDES reporting purposes, all values above 40 NTU must be diluted with turbidity free-water and calculated by multiplying by a dilution factor.

SESD PROCEDURE SESDPROC-110-R4:

GLOBAL POSITIONING SYSTEM

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Global Positioning System**

Effective Date: June 23, 2015

Number: SESDPROC-110-R4

Authors

Name: Jonathan Vail
Title: Environmental Scientist, Regional Expert
Signature: J Vail
Date: 6/18/2015

Name: Mel Parsons
Title: Life Scientist
Signature: Mel Parsons
Date: 6/18/15

Name: Brian Striggow
Title: Environmental Engineer
Signature:
Date: 6/18/15

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch
Signature: John Deatrick
Date: 6/18/15

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 6/18/15

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-110-R4, *Global Positioning System*, replaces SESDPROC-110-R3 **Cover Page:** SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Liza Montalvo to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **Section 2.1.1**: Changes were added to elaborate on the description and purpose of GPS systems. **Section 2.1.3**: Changes made to reflect the abilities of different differential GPS systems. Sentence added to reflect the preferences to certain differential GPS systems. **Section 2.2.1**: Added to explain that the GPS measurement estimate will be based on a certain number of standard deviations. **Section 2.2.2**: Changes were made to reflect a name change. **Section 2.4.1**: Changes were made to reflect the current procedures. **Section 2.4.2**: Changes were added to reflect the changes in current procedure practices. Conversion process removed and revised in a later section. **Section 4.X**: Conversion procedure updated and revised to reflect the current practices. Paragraph added to reflect the standard format for navigational purposes. **Section 2.5**: Removed the DOP where it includes accuracy requirements for what the output should include to reflect the changes in the operating procedures	June 23, 2015

SESDPROC-110-R3, *Global Positioning System*, replaces SESDPROC-110-R2	April 20, 2011
SESDPROC-110-R2, *Global Positioning System*, replaces SESDPROC-110-R01	November 1, 2007
SESDPROC-110-R1, *Global Positioning System*, replaces SESDPROC-110-R0	October 1, 2007
SESDPROC-110-R0, Global Positioning System, Original Issue	March 22, 2007

TABLE OF CONTENTS

Contents

1 General Information

1.1 Purpose

This document describes the Global Positioning System (GPS) and procedures, methods and considerations to be used and observed when using GPS to record location data in the field. Guidance is provided on accuracy requirements for various uses of location data and potential means to obtain the requisite accuracy. This document contains direction developed solely to provide internal guidance to SESD employees.

1.2 Scope/Application

The procedures contained in this document are to be used by SESD field investigators when using the Global Positioning System to obtain the geographical coordinates of sampling locations and/or measurements during field investigations. In SESD investigations, GPS is the preferred means of collecting horizontal location information. In most cases the accuracy of GPS is unsuitable for collection of elevation data.

On the occasion that SESD field personnel determine that any of the procedures described in this section cannot be used to obtain the required coordinate information and alternate procedures are employed, the alternate procedure will be documented in the field log book, along with a description of the circumstances requiring its use. GPS users must be currently qualified as proficient in the operation of the specific GPS equipment to be used. The manufacturer's operation manuals should be used for detailed information on the use of specific GPS equipment. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD local area network (LAN). The Document Control Coordinator is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

Rand Corporation, The Global Positioning System, Assessing National Policies, Appendix B, GPS History, Chronology, and Budgets, 1995.

SESD Operating Procedure for Control of Records, SESDPROC-002, Most Recent Version.

Trimble® Navigation Limited, Mapping Systems General Reference, Revision B, 1996.

USEPA, Global Position Systems – Technical Implementation Guidance, Office of Environmental Information (EPA/250/R-03/001), 2003.

USEPA, GIS Technical Memorandum 3. Global Positioning Systems – Technology and It's Application in Environmental Programs, Research and Development (PM-225). EPA/600/R-92/036, 1992.

USEPA, Locational Data Policy, Office of Information Resources Management, IRM Policy Manual 2100 Chapter 13, 1991.

2 Methodology

2.1 General

2.1.1 GPS Description

The Navigation Satellite Time and Ranging (NAVSTAR) Global Positioning System (GPS) is a worldwide radio-navigation system created by the U. S. Department of Defense (DOD) to provide navigation, location, and timing information for military operations. System testing using a limited number of satellites began in 1978 with the system being declared fully operational in 1995. The system was declared available for civilian uses in the 1980s and has seen burgeoning civilian application for navigation and mapping. GPS is the U.S. implementation of a Global Navigation Satellite System (GNSS). Increasingly, GPS receivers have the capability to utilize signals from other GNSS such as the Russian GLONASS or European Galileo systems. SESD has no limitations on the use of signals from other GNSS.

The GPS system consists of three basic elements: the space segment, control segment, and user segment. The space segment consists of the constellation of up to 24 active NAVSTAR satellites in six orbital tracks. The satellites are not in geo-synchronous orbit and are in constant motion relative to a ground user. The control segment consists of several ground stations that serve as uplinks to the satellites and that make adjustments to satellite orbits and clocks when necessary. The user segment consists of the GPS receiver which will typically consist of an antenna, multi-channel receiver, and processing unit.

For the purposes of this document, the user segment GPS receivers may be loosely grouped into Recreational and Navigational receivers (henceforth referred to as General-Use receivers), Mapping Grade receivers, and Survey Grade receivers.

- Most General-Use grade receivers are available on the retail market to consumers for a variety of applications including boating, hiking, and automotive navigation. They display an instantaneous reading of position and are generally not optimized for data collection. Waypoints containing instantaneous position fixes can often be stored and downloaded. The accuracy of these receivers is adequate for many environmental applications.

- Mapping Grade receivers are used for applications such as resource management and Geographical Information System (GIS) feature collection. The receivers are capable of averaging multiple position fixes for greater accuracy and then data-logging the results with sufficient information to post-correct the positions as described below. The accuracy that can be achieved may be better than one meter.

- Survey Grade receivers can provide accuracy at the centimeter level by using long occupation times and special techniques for receiver use and data processing. Survey Grade receivers are not currently used by SESD in field investigations.

GPS receivers derive positions by simultaneously measuring the distance (range) to several satellites in precisely known orbits, and using trilateration of the ranges to calculate a unique position for the receiver. The range to each satellite is determined by precisely measuring the transit time of radio signals broadcast from the satellites.

2.1.2 GPS Accuracy Factors

The accuracy of the basic GPS system is approximately 15m. GPS accuracy can be affected by a number of factors including the Selective Availability feature, atmospheric delays, satellite clock and orbit errors, multipath signals, signal strength, and satellite geometry relative to the user.

In the early GPS implementation, the DOD used a feature known as Selective Availability (SA) to degrade the quality and subsequent accuracy of the GPS signals to non-DOD users. With Selective Availability enabled, accuracy of position fixes could be as poor as 100m without the use of differential correction techniques described below. Currently there is no SA limitation in accuracy in place with a stated Executive Branch intention to not return to the use of the SA signal degradation.

As satellites move in their orbits and some signals are blocked by obstructions, the geometry of the available satellite signals relative to the user will constantly change. When the satellites with available signals are clustered closely together in the sky, small errors in range will result in large errors in reported position. Conversely, when the satellites are distributed more broadly across the sky, the resultant position errors will be at their minimum. The general measure of this phenomenon is Dilution of Precision (DOP), which may be represented as Position Dilution of Precision (PDOP), or more specifically for geographical coordinate collection, Horizontal Dilution of Precision (HDOP). Mapping and Survey Grade receivers generally can calculate and display DOP and allow the user to limit logging to times when the higher potential accuracy conditions of low DOP prevail. General-Use receivers may display DOP and use DOP with other factors to estimate a general accuracy figure. DOP may range from approximately 2 to 50, with high quality work usually requiring a HDOP of less than 4-6.

Signal strength and multipath signals relate to the strength and quality of the signal reaching the receiver antenna. Signal attenuation by the atmosphere, buildings, and tree cover limit the accuracy of the ranges obtained. The measure of signal strength is Signal to Noise Ratio (SNR), generally measured in decibels (db). Most receivers of any grade will display the SNR of the satellite signals in a bar graph or table. Mapping Grade

Receivers generally allow the user to specify a minimum signal strength for the use of a satellite signal (commonly 2-15db). Poor signal strength can be resolved by waiting for satellite locations to change or moving the receiver location. Multipath signals result from portions of the satellite signal bouncing off terrain, structures, or atmospheric disturbances, resulting in a degraded total signal. Higher quality Mapping Grade receivers may be capable of rejecting the stray multipath signals, such as Trimble® receivers using Everest™ technology.

2.1.3 Differential GPS

Selective Availability, clock errors, and orbital errors affect all GPS users, and atmospheric delays affect all users over a relatively wide region. A second GPS receiver in the same general area as the user will experience the same errors from these sources as the user's receiver. Consequently, correction factors from a remote station at a known location can be applied to the user's receiver in a process known as Differential GPS (DGPS). DGPS can be applied in real-time using additional radio signals, or after the collection event by a method called post-correction.

Real-time DGPS uses established networks of base stations at precisely surveyed locations. The US Coast Guard operates a system of 80 base stations which became fully operational in 1999. The range corrections are broadcast on marine radiobeacon frequencies, with redundant coverage of most of the US coastline and the Mississippi River. There is near complete single beacon coverage of most of the internal US, but there are known gaps in coverage in both EPA Region 4 and the US as a whole. The system is sometimes referred to using the more general term DGPS or in nomenclature referring to the beacon-based nature of the system. Beacon-based DGPS is implemented primarily in Navigational and Mapping Grade receivers. Use of beacon based DGPS at SESD has become increasingly rare in favor of use of the Wide Area Augmentation System

Real-time DGPS can also be implemented with a Space Based Augmentation System (SBAS). The most common SBAS used in the United States is the Wide Area Augmentation System (WAAS), developed by the Federal Aviation Administration to meet the additional demands on GPS for aircraft navigation. The WAAS network of base stations collects information on satellite clock errors, orbital errors, and atmospheric conditions. The error information is transferred to satellites in geo-synchronous orbits and subsequently broadcast to suitably equipped GPS receivers on frequencies compatible with the GPS range signals. While the beacon-based DGPS passes specific satellite range corrections to the receivers, WAAS communicates a model for the errors which is usable over large areas. Current Mapping Grade receivers will likely use WAAS with or without the option of beacon-based DGPS. Modern General-Use receivers are generally equipped with WAAS differential correction capability.

Post-Corrected DGPS is accomplished by downloading the receiver survey files to a desktop or laptop computer and then retrieving correction files for the same time period (generally via the internet) from an established base station in the area of the survey. Post-processed accuracy improves with proximity of the base station to the surveyed locations and base station data should be used from a station within 300km of the site surveyed. The survey positions are processed by application software and a new set of positions is generated using the correction data. The capability for post-processed differential correction is limited to Mapping Grade and Survey Grade receivers.

Various factors limit GPS accuracy in the vertical plane to approximately half of that obtainable in the horizontal plane, i.e., if a location fix is accurate to 3 m in the horizontal plane, it may only be accurate to 6 m in the vertical plane. Since relatively high accuracy is usually required for the uses of elevation data, GPS is rarely used to obtain and report elevations.

2.2 Requirements for Locational Information

2.2.1 Data Uses

Locational information can serve many purposes in an environmental investigation, a few of which are listed below:

1. Providing an unambiguous means to identify facilities or sampling plats.
2. Providing locational information to key analytical data in a GIS based data archiving system to the original sampling locations.
3. Differentiating watersheds.
4. Providing information to calculate extents and volumes of contamination.
5. Providing a means to relocate the media represented by samples for removal or treatment.
6. Providing information to prepare presentation graphics of sampling locations.

Depending on the specific uses for the data and the type of work being performed, there will be different needs for the accuracy of the locational data. Studies where a sample represents a large area of relatively homogeneous material would not require the same accuracy as the location of a permanent monitoring well. Below are broad guidelines for the accuracy that might be required for different applications.

Desired Accuracy	**Application**
100 m	Open ocean work where sample is presumed to be representative of a large area
20 m	Open water work (lakes or estuaries) where sample is presumed to be representative of a large area
10 m	Stream and river work where samples are presumed to be broadly representative of a reach
5-3 m	Stream work where samples are representative of a specific narrowly defined section
10 m	Air Monitoring Stations
10 - 3 m	Microscale air monitoring
3 - 1 m	Permanent monitoring wells
1 m	Locations of 'Hot Spots' destined for removal of limited areal extent
3 - 1 m	Locations of Temporary groundwater wells in plumes requiring narrow delineation
3 m	Locations of Temporary groundwater wells in broad plumes
3 m	Locations of environmental samples with sample spacing >20 m
5 m	Locations of environmental samples with sample spacing >60 m
200 - 20 m	Coordinates describing a facility where mobile waste units are sampled
30 - 3 m	Locations of industrial process areas or NPDES permitted facilities where the sampling locations are described in field notes relative to the process or site features

Specific demands of a study may drive increased or decreased requirements for accuracy. The preferred means of locational data collection for most studies will be GPS, although alternate means are permissible if they meet accuracy requirements. The following table indicates the accuracy that may be expected from various means of establishing coordinates.

Accuracy	Description
200 - 50 m	Map Derived, coarse work
40 - 20 m	Map Derived, fine work or using GIS with digital imagery
15 m	General-UseGeneral-Use Grade GPS, w/o WAAS
5 m	General-Use Grade GPS, w/ WAAS or beacon corrections
10 m	Mapping Grade GPS, no corrections, averaged readings,
3 m	Mapping Grade GPS w/ differential correction, averaged readings
1 m	Mapping Grade GPS w/ differential correction, controlled DOP and SNR, averaged readings
<10 cm	Surveying Grade GPS or optical surveying (dependent on baseline length)

Accuracy is a term used to describe the degree of conformity of a measurement. In GPS, accuracy is usually specified as an estimate of the radius from the measured coordinates that is likely to include the actual coordinates. The estimate will be based on a percentage likelihood or a certain number of standard deviations that the accuracy estimate is met. As such, it is recognized that some measurements will fall outside of the specified accuracy. For the purposes of SESD GPS work, the nominal accuracy figures derived from manufacturer's literature for specific operating conditions, displayed by the receiver at the time of feature collection, or output from processing software will be taken at face value.

2.2.2 Datums and Data formats

In general, a datum is a reference from which other measurements are taken. In the development of surveying systems by civil entities, different datums were used as base references that will result in differing coordinates for the same location. A GPS receiver will generally display coordinates in a number of different user-selected datums. **Unless there are specific requirements on a project, all SESD work should be conducted using the WGS84 datum.** Alternatively, the nearly equivalent NAD83 datum may be used if WGS84 is unavailable as a receiver option. If an alternate coordinate system is used where coordinates are obtained and recorded in field logbooks, the use of the alternate coordinate system should also be noted in the logbook.

The Region 4 Equis database requires that coordinates for sample locations be entered in the WGS84 datum and dd.dddddd format. Unless specific project requirements dictate otherwise, all coordinates explicitly stated in reports will be in WGS84 format and in all cases the datum used will be specified.

There is no SESD policy on significant digits for GPS information, and accuracy should not be implied from the presence of significant digits in reported coordinates. However, good scientific practice should be followed in the presentation of locational information in order that useful information not be truncated or a higher degree of accuracy implied. The following table shows the incremental distance in latitude represented by the least significant digit for various coordinate formats:

dd.dddddd°	Approximately 4" or 10 cm
dd.ddddd°	Approximately 44" or 1.1 m
dd.dddd°	Approximately 36' or 11 m
dd°mm'ss"	Approximately 100' or 30 m
dd°mm'ss.x"	Approximately 10' or 3 m
dd°mm'ss.xx"	Approximately 1' or 30 cm
dd°mm.xxxx'	Approximately 7" or 18 cm
dd°mm.xxx'	Approximately 6' or 1.8 m
dd°mm.xx'	Approximately 60' or 18 m

2.3 Quality Control Procedures

By nature of its origin in the DOD and recent application to aircraft navigation, the GPS is designed for high reliability. GPS failures resulting in an incorrect reading beyond the bounds of known errors are so rare that the possibility can be ignored for most SESD studies. If a study requires the verification of receiver function, this can be accomplished by verifying that a receiver displays the correct position while occupying a known benchmark.

2.4 Special Considerations

The data quality objectives for the application, availability of receivers, and other factors will dictate the type of receiver used. There are several specific considerations for the use of the various GPS receivers available at SESD.

2.4.1 Special considerations for the use of Trimble® Geo7X Mapping Grade Receivers

Several important settings can be adjusted or checked under the 'Setup' toolbar.

Suggested settingsfor Trimble® Geo7X receivers are:

1. Settings>Coordinate System:

   System = Latitude/Longituude

   Datum = WGS 1984

   Altitude Reference = MSL

   Altitude Units – Feet

These settings would rarely need to be changed, but should be checked prior to collecting data.

2. Settings>Real-time Settings
   Set to:

   Choice 1 = Integrated SBAS

   Choice 2 = Wait for Real-time

   When 'Choice 2' is set to 'Wait for Real-time', the receiver will not log positions if a WAAS signal cannot be received. When this occurs, 'Choice 2' may need to be changed temporarily to 'Use uncorrected GNSS'. The location would then be logged with the reduced accuracy of uncorrected GPS, which should be noted in field logbooks. The accuracy of the position can be improved later by post-processing.

3. Settings>Logging Settings

   At the top of the logging settings dialog is the 'Accuracy Settings' label. Tap the 'wrench' box to the right of the first field to open the Accuracy Settings dialog box.

   Set the first box under 'Accuracy Value for Display/Logging' to 'Horizontal'

   The box below the Horizontal/Vertical selection chooses whether positions will be corrected in real time or by post-processing. Choose 'In the field' if Real-time WAAS corrections will be used, or 'Postprocessed' if positions will be post-corrected. This selection will affect the accuracy estimates displayed. If Real-time correction is used when this setting is set to 'Postprocessed', the estimated error reported will be erroneously low.

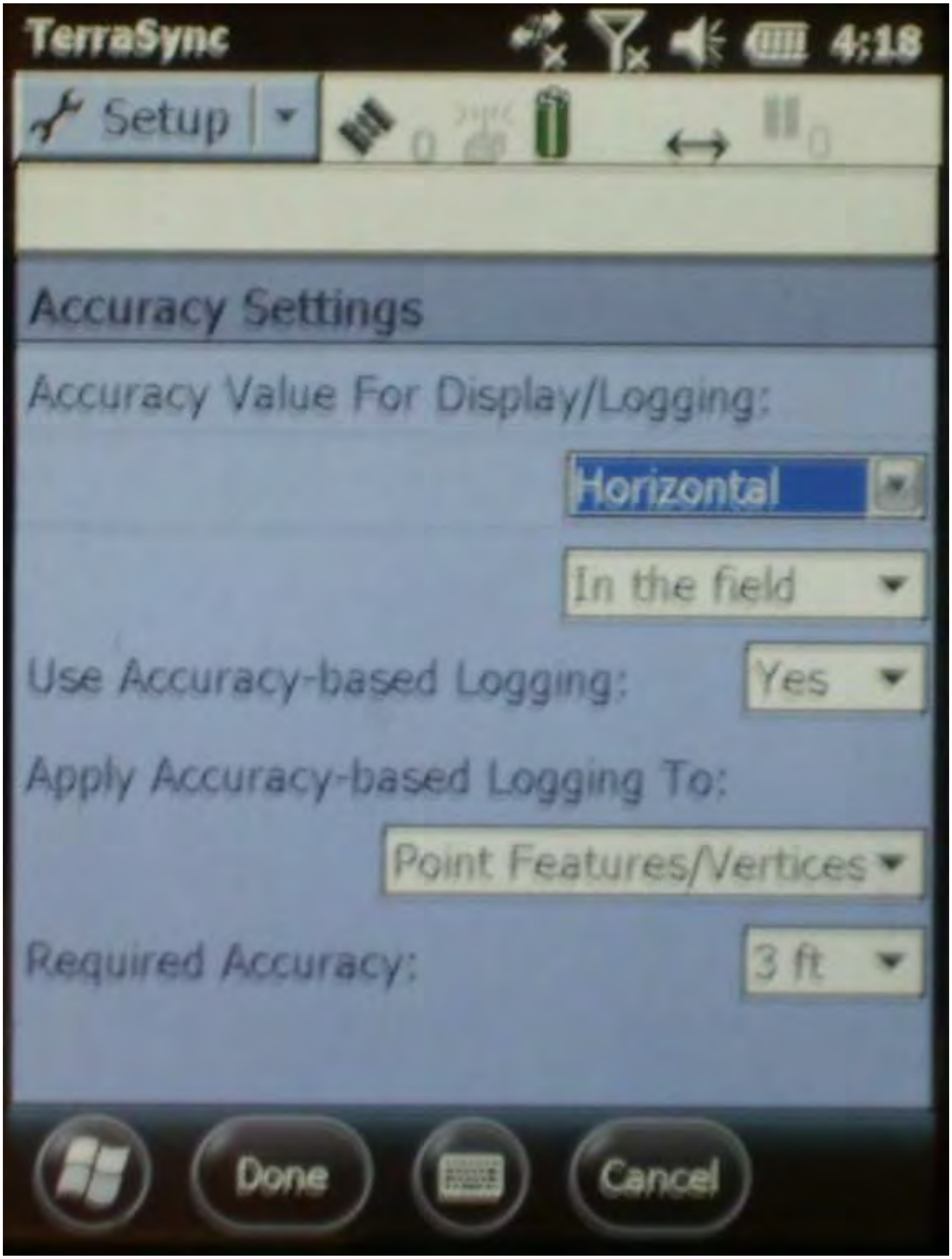
Select ‘Yes’ or ‘No’ for accuracy based logging. Selecting ‘Yes’ will prevent the receiver from logging until the desired accuracy can be achieved. This setting is recommended when a specific accuracy for locational data is required. Selecting ‘Yes’ enables the following choices:

The next box, ‘Apply Accuracy-based Logging to:’ can be set to point features or ‘All Features’. Set appropriately.

The ‘Required Accuracy’ field selects the accuracy threshold that will allow logging. If a position cannot be logged because the threshold cannot be met, several options are available:

1. Set the accuracy threshold to a higher but still acceptable value.
2. Plan to post-correct the coordinates and change the settings in this dialogs accordingly. Post-correction will generally allow more accurate correction than WAAS.
3. Return to the point at a later time when propagation or satellite geometry is more suitable.
4. Use the ‘Offset’ feature (see below) to log the positions from a more suitable location (e.g. less tree cover).

The screen shot below shows the Accuracy Settings Dialog Box:



Accuracy Settings

Accuracy Value For Display/Logging: Horizontal

In the field

Use Accuracy-based Logging: Yes

Apply Accuracy-based Logging To: Point Features/Vertices

Required Accuracy: 3 ft

If the point to be logged cannot be occupied, or signals cannot be received at the location, the ‘Offset’ feature of the receiver can be used. The SESD Geo7X receivers can employ a laser rangefinder and internal compass to calculate the offsets. To use the ‘Offset’ feature:

1. Begin logging from the offset location.
2. Pull down the ‘Options’ menu and select ‘Offset’, then ‘Distance – Bearing’
3. The Offset dialog will open where distances and bearings could be manually entered.
4. To use the laser rangefinder and compass to populate the dialog fields, press the physical ‘⌖□ button located on the receiver below the screen.
5. The laser rangefinder application will start and a red sighting laser will turn on. Point the laser at the desired point to survey and sight the object in the crosshairs on the screen. When sighted on the survey object, tap on the ‘⌖' icon on the screen to lock in the distance and bearing at the bottom of the screen. Press the ‘⌖' icon again to update the readings, or press the ‘✓□ icon to transfer the bearing and distance to the Offset dialog box.
6. If the numbers transferred to the Offset dialog box are appropriate, tap ‘Done’ to return to the feature logging screen.

There is no quality system calibration performed on the electronic compass and rangefinder. It is the responsibility of the user to assure that the bearings and ranges returned by the laser rangefinder system will result in accuracy consistent with the overall GPS work. A quick check for reasonableness can be performed by comparing the logged position on the Map screen with the current position shown.

Photos can also be taken with the unit and associated with the logged features. The user is referred to vendor documentation for instruction in the use of this feature.

Trimble® receivers at SESD contain a data dictionary that can facilitate the management of GIS data. If the COC_GIS dictionary is selected at the time of file creation, SESD standard media codes can be assigned to features at the time of logging that will accompany the data through the download process. The use of the COC_GIS data dictionary can simplify the management of the data when processed in a GIS system or when submitted to the Equis data archiving system.

The logging interval of the Trimble® Geo 7X receivers can be set to a 1 or 5 second interval as an option during feature collection. The setting may be set to 1 second to expedite feature collection. A point feature should have a minimum of 36 positions logged to obtain the additional accuracy afforded by the averaging of positions. After a minimum of 36 positions are logged and the feature is closed, the averaged coordinates for the location can be obtained by selecting the feature on the ‘Map’ screen. The averaged position should always be the one entered into field notebooks.

2.4.2 Special considerations for the use of Garmin® and other General-Use Grade Receivers

Several types of General-Use grade of receivers are in use at SESD, most from the Garmin® product line. Most of the Garmin® receivers operate with a similar interface to facilitate use of the various devices. The nautical receivers/depth sounders are suitable for recording location data within the limitations described for the General-Use grade receivers.

Some receivers will allow averaging of positions to improve accuracy. Use of this feature is recommended when possible.

Anecdotal experience at SESD suggests that GPS designed primarily for automobile navigation is unsuitable for obtaining locational data.

The older Garmin receivers would display on the status screen whether differential correction was in use by displaying small ‘D’ characters at the base of the signal strength bars. Newer receivers do not display this information directly and correction status can only be ascertained by the accuracy estimates or monitoring the status screen for acquisition of signals from the WAAS satellites.

2.4.3 Coordinate Conversion

Coordinates may be displayed in different formats on the various receivers, or coordinates obtained from outside SESD may be presented in a format other than that required. If the coordinates are in the correct datum, but recorded in the dd°mm’ss.sss” format they can be arithmetically converted to dd.dddddd format. Convert to decimal degrees as follows:

Converting to decimal degrees (dd.dddddd) from degrees°minutes’seconds” (dd°mm’ss.sss”):

dd.dddddd = dd + (mm/60) + (ss.sss/3600)

Example: Convert 33°28’45.241” to decimal degrees

33 + (28/60) + (45.241/3600) = 33.479236

The reverse conversion is accomplished as follows:

Converting to degrees°minutes’seconds” from decimal degrees

Starting with dd.dddddd

Multiply .dddddd by 60 to obtain mm.mmmm

Multiply .mmmm by 60 to obtain ss.sss

Then dd°mm’ss.sss” = dd & mm & ss.sss

Example: Convert 33.479236 to dd°mm’ss.sss” format

Multiply .479236 by 60 to obtain 28.7540 (mm.mmmm)

Multiply .7540 by 60 to obtain 45.241 (ss.sss)

Dd°mm’ss.sss” = 33° & 28’ & 45.241” = 33°28’45.241”

The standard format for navigational purposes is decimal minutes (dd°mm.mmm’). This format is utilized due to the fact that nautical navigation charts are set up in this format. However, location information must be converted to a decimal degree (dd.ddddd°) format in order for GIS software to properly interpret the information and for submission to the Region 4 Equis database. Assuming the coordinates have been recorded in the proper datum, the conversion can be accomplished by dividing the minutes portion of the coordinates by 60.

Converting to decimal degrees from decimal minutes:

dd.ddddd° = dd + (mm.mmm/60)

Example: Convert 81°49.386’ to decimal degrees

81 + (49.386/60) = 81.8231 degrees

The reverse conversion is accomplished as follows:

dd°mm.mmm’ = dd & (.ddddd*60)

Example: Convert 81.8231 degrees to decimal minutes (dd°mm.mmm')

Multiply .8231 by 60 to obtain 49.386 (mm.mmm)

81° & 49.386' = 81°49.386'

GPS users need to familiarize themselves with the differences between the formats, as they can appear similar. Spreadsheets can automate the conversion process.

2.5 Records

The GPS coordinates and the SESD equipment identification number of the GPS receiver should be recorded in field logbooks at the time of GPS coordinate collection. The data logging capability of receivers may be used in lieu of the requirement to record the coordinates in logbooks when the following conditions can be met:

1. The location can easily be found later if it needs to be resurveyed prior to demobilization. A permanent monitoring well can easily be resurveyed, while most open-water work would not afford this opportunity.

2. The data is downloaded and ascertained to meet the accuracy requirements for the project prior to demobilization from the site.

3. The data is stored in at least two separate locations for transport, such as a laptop hard drive and a flash drive or compact disc.

In all cases where positions are electronically recorded, the provisions of the Electronic Records section of the SESD Operating Procedure for Control of Records (SESDPROC-002) should be followed.

Where locational data is collected and processed electronically, but not reported explicitly in the final report, a copy of the coordinates in text format should be output and entered into the project file in paper or electronic form. The output should include:

1. Latitude, generally in dd.dddddd format.

2. Longitude, generally in dd.dddddd format.

3. Date of collection.

4. A note on the differential correction process used where it supports the accuracy requirements.

5. The datum used for the export.

Trimble® Pathfinder Office can create files with this information when exporting coordinates to a text file. The information will be contained in the .pos and .inf files.

SESD PROCEDURE SESDPROC-205-R3:

FIELD EQUIPMENT CLEANING AND DECONTAMINATION

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Field Equipment Cleaning and Decontamination**

Effective Date: December 18, 2015

Number: SESDPROC-205-R3

Authors

Name: Brian Striggow
Title: Environmental Engineer
Signature:
Date: 12-18-15

Approvals

Name: John Deatrick
Title: Chief, Field Services Branch
Signature:
Date: 12/18/15

Name: Hunter Johnson
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature:
Date: 12/18/15

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-205-R3, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R2. **Cover Page:** The author was changed to Brian Striggow. SESD's reorganization was reflected in the authorization section by making John Deatrick the Chief of the Field Services Branch. The FQM was changed from Bobby Lewis to Hunter Johnson. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history. **General:** Corrected any typographical, grammatical and/or editorial errors. **Section 1.4:** Differentiate between Liquinox® and Luminox® detergents. **Section 3.4:** Restore solvent rinse as alternative cleaning method. **Section 3.7:** Added section on cleaning of 12 Volt electric submersible pumps. **Section 3.8:** Added section on cleaning of bladder pumps. **Section 3.9:** Added language on cleaning and transport of SP15/16 screens **Section 3.10:** Added section on cleaning of rental pumps	December 18, 2015
SESDPROC-205-R2, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R1.	December 20, 2011
SESDPROC-205-R1, *Field Equipment Cleaning and Decontamination*, replaces SESDPROC-205-R0.	November 1, 2007
SESDPROC-205-R0, *Field Equipment Cleaning and Decontamination*, Original Issue	February 05, 2007

TABLE OF CONTENTS

1 General Information

1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when cleaning and decontaminating sampling equipment during the course of field investigations.

1.2 Scope/Application

The procedures contained in this document are to be followed when field cleaning sampling equipment, for both re-use in the field, as well as used equipment being returned to the Field Equipment Center (FEC). On the occasion that SESD field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that other procedures must be used to clean or decontaminate sampling equipment at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products in this operating procedure does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on LAN and for maintaining records of review conducted prior to its issuance.

1.4 Definitions

- Decontamination: The process of cleaning dirty sampling equipment to the degree to which it can be re-used, with appropriate QA/QC, in the field.

- Deionized water: Tap water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable heavy metals or other inorganic compounds (i.e., at or above analytical detection limits) as defined by a standard inductively coupled Argon Plasma Spectrophotometer (ICP) (or equivalent) scan. Deionized water obtained by other methods is acceptable, as long as it meets the above analytical criteria. Organic-free water may be substituted for deionized water.

- Detergent shall be a standard brand of phosphate-free laboratory detergent such as Liquinox® or Luminox®. Liquinox® is a traditional anionic laboratory detergent and is used for general cleaning and where there is concern for the stability of the cleaned items in harsher cleaners. Luminox® is a specialized detergent with the capability of removing oils and organic contamination. It is used in lieu of a solvent rinse step in cleaning of equipment for trace contaminant sampling. Where not specified in these procedures, either detergent is acceptable.

- Drilling Equipment: All power equipment used to collect surface and sub-surface soil samples or install wells. For purposes of this procedure, direct push is also included in this definition.

- Field Cleaning: The process of cleaning dirty sampling equipment such that it can be returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

- Organic-free water: Tap water that has been treated with activated carbon and deionizing units. At a minimum, the finished water must meet the analytical criteria of deionized water and it should contain no detectable pesticides, herbicides, or extractable organic compounds, and no volatile organic compounds above minimum detectable levels as determined by the Region 4 laboratory for a given set of analyses. Organic-free water obtained by other methods is acceptable, as long as it meets the above analytical criteria.

- Tap water: Water from any potable water supply. Deionized water or organic-free water may be substituted for tap water.

1.5 References

SESD Operating Procedure for Management of Investigation Derived Waste, SESDPROC-202, Most Recent Version

SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC, SESDPROC-206, Most Recent Version

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.6 General Precautions

1.6.1 Safety

Proper safety precautions must be observed when field cleaning or decontaminating dirty sampling equipment. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASPs) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate. At a minimum, the following precautions should be taken in the field during these cleaning operations:

- When conducting field cleaning or decontamination using laboratory detergent, safety glasses with splash shields or goggles, and latex gloves will be worn.

- No eating, smoking, drinking, chewing, or any hand to mouth contact should be permitted during cleaning operations.

1.6.2 Procedural Precaution

Prior to mobilization to a site, the expected types of contamination should be evaluated to determine if the field cleaning and decontamination activities will generate rinsates and other waste waters that might be considered RCRA hazardous waste or may require special handling.

2 Introduction to Field Equipment Cleaning and Decontamination

2.1 General

The procedures outlined in this document are intended for use by field investigators for cleaning and decontaminating sampling and other equipment in the field. These procedures should be followed in order that equipment is returned to the FEC in a condition that will minimize the risk of transfer of contaminants from a site.

Sampling and field equipment cleaned in accordance with these procedures must meet the minimum requirements for the Data Quality Objectives (DQOs) of the study or investigation. If deviations from these procedures need to be made during the course of the field investigation, they will be documented in the field logbook along with a description of the circumstances requiring the use of the variant procedure.

Cleaning procedures for use at the Field Equipment Center (FEC) are found in SESD Operating Procedure for Equipment Cleaning and Decontamination at the FEC (SESDPROC-206).

2.2 Handling Practices and Containers for Cleaning Solutions

Improperly handled cleaning solutions may easily become contaminated. Storage and application containers must be constructed of the proper materials to ensure their integrity. Following are acceptable materials used for containing the specified cleaning solutions:

- <u>Detergent</u> must be kept in clean plastic, metal, or glass containers until used. It should be poured directly from the container during use.

- <u>Tap water</u> may be kept in tanks, hand pressure sprayers, squeeze bottles, or applied directly from a hose.

- <u>Deionized water</u> must be stored in clean, glass or plastic containers that can be closed prior to use. It can be applied from plastic squeeze bottles.

- <u>Organic-free water</u> must be stored in clean glass or Teflon® containers prior to use. It may be applied using Teflon® squeeze bottles, or with the portable system.

2.3 Disposal of Cleaning Solutions

Procedures for the safe handling and disposition of investigation derived waste (IDW); including used wash water and rinse water are in SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202).

2.4 Sample Collection Equipment Contaminated with Concentrated Materials

Equipment used to collect samples of concentrated materials from investigation sites must be field cleaned before returning from the study. At a minimum, this should consist of washing with detergent and rinsing with tap water. When the above procedure cannot be followed, the following options are acceptable:

1. Leave with facility for proper disposal;
2. If possible, containerize, seal, and secure the equipment and leave on-site for later disposal;
3. Containerize, bag or seal the equipment so that no odor is detected and return to the SESD.

It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.5 Sample Collection Equipment Contaminated with Environmental Media

Equipment used to collect samples of environmental media from investigation sites should be field cleaned before returning from the study. Based on the condition of the sampling equipment, one or more of the following options must be used for field cleaning:

1. Wipe the equipment clean;
2. Water-rinse the equipment;
3. Wash the equipment in detergent and water followed by a tap water rinse.
4. For grossly contaminated equipment, the procedures set forth in Section 2.4 must be followed.

Under extenuating circumstances such as facility limitations, regulatory limitations, or during residential sampling investigations where field cleaning operations are not feasible, equipment can be containerized, bagged or sealed so that no odor is detected and returned to the FEC without being field cleaned. If possible, FEC personnel should be notified that equipment will be returned without being field cleaned. It is the project leader's responsibility to evaluate the nature of the sampled material and determine the most appropriate cleaning procedures for the equipment used to sample that material.

2.6 Handling of Decontaminated Equipment

After decontamination, equipment should be handled only by personnel wearing clean gloves to prevent re-contamination. In addition, the equipment should be moved away (preferably upwind) from the decontamination area to prevent re-contamination. If the equipment is not to be immediately re-used it should be covered with plastic sheeting or wrapped in aluminum foil to prevent re-contamination. The area where the equipment is kept prior to re-use must be free of contaminants.

3 Field Equipment Decontamination Procedures

3.1 General

Sufficient equipment should be transported to the field so that an entire study can be conducted without the need for decontamination. When equipment must be decontaminated in the field, the following procedures are to be utilized.

3.2 Specifications for Decontamination Pads

Decontamination pads constructed for field cleaning of sampling and drilling equipment should meet the following minimum specifications:

- The pad should be constructed in an area known or believed to be free of surface contamination.

- The pad should not leak.

- If possible, the pad should be constructed on a level, paved surface and should facilitate the removal of wastewater. This may be accomplished by either constructing the pad with one corner lower than the rest, or by creating a sump or pit in one corner or along one side. Any sump or pit should also be lined.

- Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed.

- Water should be removed from the decontamination pad frequently.

- A temporary pad should be lined with a water impermeable material with no seams within the pad. This material should be either easily replaced (disposable) or repairable.

At the completion of site activities, the decontamination pad should be deactivated. The pit or sump should be backfilled with the appropriate material designated by the site project leader, but only after all waste/rinse water has been pumped into containers for disposal. See SESD Operating Procedure for Management of Investigation Derived Waste (SESDPROC-202) for proper handling and disposal of these materials. If the decontamination pad has leaked excessively, soil sampling may be required.

3.3 "Classical Parameter" Sampling Equipment

"Classical Parameters" are analyses such as oxygen demand, nutrients, certain inorganic compounds, sulfide, flow measurements, etc. For routine operations involving classical parameter analyses, water quality sampling equipment such as Kemmerers, buckets, dissolved oxygen dunkers, dredges, etc., may be cleaned with the sample water or tap water between sampling locations as appropriate.

Flow measuring equipment such as weirs, staff gages, velocity meters, and other stream gauging equipment may be cleaned with tap water between measuring locations, if necessary.

Note: The procedures described in Section 3.3 are not to be used for cleaning field equipment to be used for the collection of samples undergoing trace organic or inorganic constituent analyses.

3.4 Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds

For samples undergoing trace organic or inorganic constituent analyses, the following procedures are to be used for all sampling equipment or components of equipment that come in contact with the sample:

3.4.1 Standard SESD Method

1. An optional Liquinox® detergent wash step may be useful to remove gross dirt and soil.

2. Clean with tap water and Luminox® detergent using a brush, if necessary, to remove particulate matter and surface films.

3. Rinse thoroughly with tap water.
4. Rinse thoroughly with organic-free water and place on a clean foil-wrapped surface to **a**ir-dry.
5. Wrap the dry equipment with aluminum foil or bag in clean plastic. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused plastic sheeting.

3.4.2 Alternative Solvent Rinse Method

The historical solvent rinse method of cleaning equipment for trace contaminant sampling remains an acceptable method.

1. Clean with tap water and Liquinox® detergent using a brush, if necessary, to remove particulate matter and surface films. Equipment may be steam cleaned (Liquinox® detergent and high pressure hot water) as an alternative to

brushing. Sampling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. PVC or plastic items should not be steam cleaned.

2. . Rinse thoroughly with tap water.

3. Rinse thoroughly with deionized water.

4. Rinse with an appropriate solvent (generally isopropanol).

5. Rinse with organic-free water and place on a clean foil-wrapped surface to **a**ir-dry.

4. Wrap the dry equipment with aluminum foil. If the equipment is to be stored overnight before it is wrapped in foil, it should be covered and secured with clean, unused.

3.5 Well Sounders or Tapes

The following procedures are recommended for decontaminating well sounders (water level indicators) and tapes. Unless conditions warrant, it is only necessary to decontaminate the wetted portion of the sounder or tape.

1. Wash with Liquinox® detergent and tap water.
2. Rinse with tap water.
3. Rinse with deionized water.

3.6 Redi-Flo2® Pump

CAUTION – Do not wet the controller. Always disconnect power from the pump when handling the pump body.

The Redi-Flo2® pump and any associated connected hardware (e.g., check valve) should be decontaminated between each monitoring well. The following procedures are required, depending on w hether the pump is used solely for purging or used for purging and sampling.

3.6.1 Purge Only (Pump and Wetted Portion of Tubing or Hose)

1. Disconnect power and wash exterior of pump and wetted portion of the power lead and tubing or hose with Liquinox® detergent and water solution.

2. Rinse with tap water.

3. Final rinse with deionized water.

4. Place pump and reel in a clean plastic bag and keep tubing or hose contained in clean plastic or galvanized tub between uses.

3.6.2 Purge And Sample

Grundfos Redi-Flo2® pumps are extensively decontaminated and tested at the FEC to prevent contamination from being transmitted between sites. The relevant sections of SESDPROC-206, *Field Equipment Cleaning and Decontamination at the FEC,* should be implemented in the field where a high risk of cross-contamination exists, such as where NAPL or high-concentration contaminants occur. In most cases, the abbreviated cleaning procedure described below will suffice, provided that sampling proceeds from least to most contaminated areas.

1. Disconnect and discard the previously used sample tubing from the pump. Remove the check valve and tubing adapters and clean separately (See Section 3.6.3 for check valve). Wash the pump exterior with detergent and water.

2. Prepare and fill three containers with decontamination solutions, consisting of <u>Container #1</u>, a tap water/detergent washing solution. Luminox® is commonly used. An additional pre-wash container of Liquinox® may be used; <u>Container #2</u>, a tap water rinsing solution; and <u>Container #3</u>, a deionized or organic-free water final rinsing solution. Choice of detergent and final rinsing solution for all steps in this procedure is dependent upon project objectives (analytes and compounds of interest). The containers should be large enough to hold the pump and one to two liters of solution. An array of 2' long 2" PVC pipes with bottom caps is a common arrangement. The solutions should be changed at least daily.

3. Place the pump in Container #1. Turn the pump on and circulate the detergent and water solution through the pump and then turn the pump off.

4. Place the pump in Container #2. Turn the pump on and circulate the tap water through the pump and then turn the pump off.

5. Place the pump in Container #3. Turn the pump on and circulate deionized or organic-free water through the pump and then turn the pump off.

6. Disconnect power and remove pump from Container #3. Rinse exterior and interior of pump with fresh deionized or organic-free water.

7. Decontaminate the power lead by washing with detergent and water, followed by tap water and deionized water rinses. This step may be performed before washing the pump if desired.

8. Reassemble check valve and tubing adapters to pump. ALWAYS use Teflon® tape to prevent galling of threads. Firm hand-tightening of fittings or light wrench torque is generally adequate.

9. Place the pump and reel in a clean plastic bag.

3.6.3 Redi-Flo2® Ball Check Valve

1. Remove the ball check valve from the pump head. Check for wear and/or corrosion, and replace as needed. During decontamination check for free-flow in forward direction and blocking of flow in reverse direction.

2. Using a brush, scrub all components with detergent and tap water.

3. Rinse with deionized water.

4. Rethread the ball check valve to the Redi-Flo2® pump head.

3.7 Mega-Monsoon® and GeoSub® Electric Submersible Pump

As these pumps have lower velocities in the turbine section and are easier to disassemble in the field than Grundfos pumps, the outer pump housing should be removed to expose the impeller for cleaning prior to use and between each use when used as a sampling pump for trace contaminant sampling.

1. Remove check valves and adapter fittings and clean separately.
2. Remove the outer motor housing by holding the top of the pump head and unscrewing the outer housing from its O-ring sealed seat.
3. Clean all pump components per the provisions of section 3.4. Use a small bottle brush for the pump head passages
4. Wet the O-ring(s) on the pump head with organic-free water. Reassemble the outer pump housing to the pump head.
5. Clean cable and reel per Section 3.4.
6. Conduct final rinse of pump with organic-free water over pump and through pump turbine.

3.8 Bladder Pumps

Bladder pumps are presumed to be intended for use as purge-and-sample pumps. The Geotech® bladder pump and Geoprobe Systems® mechanical bladder pump can be cleaned similarly.

1. Discard any tubing returned with the pump.

2. Completely disassemble the pump, being careful to note the initial position of and retain any springs and loose ball checks.

3. Discard pump bladder.

4. Clean all parts as per the standard cleaning procedure in Section 3.4.

5. Install a new Teflon® bladder and reassemble pump.

3.9 Downhole Drilling Equipment

These procedures are to be used for drilling activities involving the collection of soil samples for trace organic and inorganic constituent analyses and for the construction of monitoring wells to be used for the collection of groundwater samples for trace organic and inorganic constituent analyses.

3.9.1 Introduction

Cleaning and decontamination of all equipment should occur at a designated area (decontamination pad) on the site. The decontamination pad should meet the specifications of Section 3.2 of this procedure.

Tap water brought on the site for drilling and cleaning purposes should be contained in a pre-cleaned tank.

A steam cleaner and/or high pressure hot water washer capable of generating a pressure of at least 2500 PSI and producing hot water and/or steam, with a detergent compartment, should be obtained.

3.9.2 Preliminary Cleaning and Inspection

Drilling equipment should be clean of any contaminants that may have been transported from off-site to minimize the potential for cross-contamination. The drilling equipment should not serve as a source of contaminants. Associated drilling and decontamination equipment, well construction materials, and equipment handling procedures should meet these minimum specified criteria:

- All downhole augering, drilling, and sampling equipment should be sandblasted before use if painted, and/or there is a buildup of rust, hard or caked matter, etc., that cannot be removed by steam cleaning (detergent and high pressure hot water), or wire brushing. Sandblasting should be performed prior to arrival on site, or well away from the decontamination pad and areas to be sampled.

- Any portion of the drilling equipment that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) and wire brushed (as needed) to remove all rust, soil, and other material which may have come from other sites before being brought on site.

- Printing and/or writing on well casing, tremie tubing, etc., should be removed before use. Emery cloth or sand paper can be used to remove the printing and/or writing. Most well material suppliers can provide materials without the printing and/or writing if specified when ordered. Items that cannot be cleaned are not acceptable and should be discarded.

- Equipment associated with the drilling and sampling activities should be inspected to insure that all oils, greases, hydraulic fluids, etc., have been removed, and all seals and gaskets are intact with no fluid leaks.

3.9.3 Drill Rig Field Cleaning Procedure

Any portion of the drill rig, backhoe, etc., that is over the borehole (kelly bar or mast, backhoe buckets, drilling platform, hoist or chain pulldowns, spindles, cathead, etc.) should be steam cleaned (detergent and high pressure hot water) between boreholes.

3.9.4 Field Decontamination Procedure for Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment. This procedure does not apply to well casings, well screens, or split-spoon samplers used to obtain samples for chemical analyses, which should be decontaminated as outlined in Section 3.4 of this procedure.

1. Wash with tap water and detergent, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high pressure hot water with detergent) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw horses at least two feet above the floor of the decontamination pad. Hollow-stem augers, drill

rods, etc., that are hollow or have holes that transmit water or drilling fluids, should be cleaned on the inside with vigorous brushing.

2. Rinse thoroughly with tap water.

3. Remove from the decontamination pad and cover with clean, unused plastic. If stored overnight, the plastic should be secured to ensure that it stays in place.

3.9.5 Field Decontamination Procedure for Direct Push Technology (DPT) Equipment

1. Certain specific procedures for the decontamination of DPT tools are described in the various sampling procedures, but the following general guidelines apply:

2. Prior to return to the Field Equipment Center, all threaded tool joints should be broken apart and the equipment cleaned per the provisions of *Section 2.5, Sample Collection Equipment Contaminated with Environmental Media* of this procedure.

3. Equipment that contacts the sample media and is cleaned in the field for reuse should be cleaned per the provisions of *Section 3.4, Sampling Equipment used for the Collection of Trace Organic and Inorganic Compounds* of this procedure. This would include piston sampler points and shoes, screen point sampler screens and sheaths, and the drive rods when used for groundwater sampling.

4. Equipment that does not directly contact the sample media and is cleaned in the field for reuse can generally be cleaned per the provisions of Section *3.7.4, Field Decontamination Procedure for Drilling Equipment* of this procedure.

5. Stainless steel SP15/16 well screens require special care as the narrow slots are difficult to clean under even controlled circumstances and galvanic corrosion can release chrome from the screen surface. As soon as possible after retrieval, the screen slots should be sprayed from the outside to break loose as much material as possible before it can dry in place. To prevent galvanic corrosion, the screens must be segregated from the sampler sheaths, drive rods, and other carbon steel during return transport from the field.

3.10 Rental Pumps

Completing a groundwater sampling project may require the use of rental pumps. Rental pumps are acceptable where they are of suitable stainless steel and Teflon® construction. These pumps should be cleaned prior to use using the procedures specified herein and a rinse-blank collected prior to use.

SESD PROCEDURE SESDPROC-202-R3:

MANAGEMENT OF INVESTIGATION DERIVED WASTE

Region 4
U.S. Environmental Protection Agency
Science and Ecosystem Support Division
Athens, Georgia

OPERATING PROCEDURE

Title: **Management of Investigation Derived Waste**	
Effective Date: July 3, 2014	**Number:** SESDPROC-202-R3

Authors

Name: Art Masters
Title: Environmental Scientist, Regional Expert
Signature: Date: 7/2/14

Approvals

Name: John Deatrick
Title: Acting Chief, Enforcement and Investigations Branch
Signature: John Deatrick Date: 7/2/14

Name: Mike Bowden
Title: ~~Acting Chief,~~ Ecological Assessment Branch
Signature: M Bowden Date: 7/2/14

Name: Bobby Lewis
Title: Field Quality Manager, Science and Ecosystem Support Division
Signature: Date: 7/2/14

Revision History

The top row of this table shows the most recent changes to this controlled document. For previous revision history information, archived versions of this document are maintained by the SESD Document Control Coordinator on the SESD local area network (LAN).

History	Effective Date
SESDPROC-202-R3, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R2. **General:** Corrected typographical, grammatical and/or editorial errors. **Cover Page:** The Enforcement and Investigations Branch Chief was changed from Archie Lee to Acting Chief John Deatrick. The Ecological Assessment Branch Chief was changed from Bill Cosgrove to Acting Chief Mike Bowden. The FQM was changed from Liza Montalvo to Bobby Lewis. **Revision History:** Changes were made to reflect the current practice of only including the most recent changes in the revision history.	July 3, 2014
SESDPROC-202-R2, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R1.	October 15, 2010
SESDPROC-202-R1, *Management of Investigation Derived Waste*, replaces SESDPROC-202-R0.	November 1, 2007
SESDPROC-202-R0, Management of Investigation Derived Waste, Original Issue	February 05, 2007

TABLE OF CONTENTS

TABLES

Contents

1 General Information

1.1 Purpose

This document describes general and specific procedures and considerations to be used and observed when managing investigation derived waste (IDW) generated during the course of hazardous waste site investigations.

1.2 Scope/Application

The procedures and management options for the different categories of IDW described in this document are to be used by SESD field personnel to manage IDW generated during site investigations. On the occasion that SESD field personnel determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used to manage IDW generated at a particular site, the variant procedure will be documented in the field logbook, along with a description of the circumstances requiring its use. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by SESD management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the SESD Local Area Network (LAN). The Document Control Coordinator (DCC) is responsible for ensuring the most recent version of the procedure is placed on the LAN and for maintaining records of review conducted prior to its issuance.

1.4 References

SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, Most Recent Version

United States Environmental Protection Agency (US EPA). 2001. Environmental Investigations Standard Operating Procedures and Quality Assurance Manual. Region 4 Science and Ecosystem Support Division (SESD), Athens, GA

US EPA. Safety, Health and Environmental Management Program Procedures and Policy Manual. Region 4 SESD, Athens, GA, Most Recent Version

1.5 General Precautions

1.5.1 Safety

Proper safety precautions must be observed when managing IDW. Refer to the SESD Safety, Health and Environmental Management Program (SHEMP) Procedures and Policy Manual and any pertinent site-specific Health and Safety Plans (HASP) for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

1.5.2 Procedural Precautions

The following precautions should be considered when managing IDW:

- Due to time limitations and restrictions posed by RCRA regulations on storage of hazardous waste, accumulation start dates should be identified on all drums, buckets or other containers used to hold IDW so that it can be managed in a timely manner.
- During generation of both non-hazardous and hazardous IDW, keep hazardous IDW segregated from non-hazardous IDW to minimize the volume of hazardous IDW that must be properly managed.

2 Types of Investigation Derived Waste

Materials which may become IDW include, but are not limited to:

- Personal protective equipment (PPE) - This includes disposable coveralls, gloves, booties, respirator canisters, splash suits, etc.

- Disposable equipment and items - This includes plastic ground and equipment covers, aluminum foil, conduit pipe, composite liquid waste samplers (COLIWASAs), Teflon® tubing, broken or unused sample containers, sample container boxes, tape, etc.

- Soil cuttings from drilling or hand augering.

- Drilling mud or water used for mud or water rotary drilling.

- Groundwater obtained through well development or well purging.

- Cleaning fluids such as spent solvents and wash water.

- Packing and shipping materials.

Table 1, found at the end of this procedure, lists the types of IDW commonly generated during field investigations and the current disposal practices for these materials.

For the purpose of determining the ultimate disposition of IDW, it is typically distinguished as being either hazardous or non-hazardous. This determination is based on either clear regulatory guidance or by subsequent analysis. This determination and subsequent management is the responsibility of the program site manager.

3 Management of Non-Hazardous IDW

Disposal of non-hazardous IDW should be addressed in the study plan or QAPP for the investigation. To reduce the volume of any IDW transported back to the Field Equipment Center (FEC), it may be necessary to compact the waste into a reusable container, such as a 55-gallon drum.

If the waste is from an active facility, permission should be sought from the operator of the facility to place the non-hazardous PPE, disposable equipment, and/or paper/cardboard into the facility's dumpsters. If necessary, these materials may be placed into municipal dumpsters, with the permission of the owner. These materials may also be taken to a nearby permitted landfill. On larger studies, waste hauling services may be obtained and a dumpster located at the study site.

Disposal of non-hazardous IDW such as drill cuttings, drilling mud, purge or development water, decontamination wash water, etc., should be specified in the approved study plan or QAPP. It is recommended that these materials be placed into a unit with an environmental permit, such as a landfill or sanitary sewer. These materials must not be placed into dumpsters. If the facility at which the study is being conducted is active, permission should be sought to place these types of IDW into the facility's treatment system. It may be feasible to spread drill cuttings around the borehole, or, if the well is temporary, to place the cuttings back into the borehole. Non-hazardous monitoring well purge or development water may also be poured onto the ground down gradient of the monitoring well when site conditions permit. Purge water from private potable wells which are in service may be discharged directly onto the ground surface.

The minimum requirements for this subsection are:

- Non-hazardous liquid and soil/sediment IDW may be placed on the ground or returned to the source if doing so does not endanger human health or the environment or violate federal or state regulations. Under no circumstances, however, should monitoring well purge water be placed back into the well from which it came.
- Soap and water decontamination fluids and rinsates of such cannot be placed in any water bodies and must be collected and returned to the FEC for disposition.
- The collection, handling and proposed disposal method must be specified in the approved study plan or QAPP.

4 Management of Hazardous IDW

Disposal of hazardous or suspected hazardous IDW must be specified in the approved study plan or QAPP for the study or investigation. Hazardous IDW must be disposed as specified in USEPA regulations. If appropriate, these wastes may be placed back in an active facility waste treatment system. These wastes may also be disposed in the source area from which they originated if doing so does not endanger human health or the environment.

If on-site disposal is not feasible, and if the wastes are suspected to be hazardous, appropriate tests must be conducted to make that determination. If they are determined to be hazardous wastes, they must be properly contained and labeled. They may be stored on the site for a maximum of 90 days before they must be manifested and shipped to a permitted treatment or disposal facility. Generation of hazardous IDW must be anticipated, if possible, to allow arrangements for proper containerization, labeling, transportation and disposal/treatment in accordance with USEPA regulations.

The generation of hazardous IDW should be minimized to conserve Division resources. Most routine studies should not produce any hazardous IDW, with the possible exception of spent solvents and, possibly, purged groundwater. The use of solvents during field cleaning of equipment should be minimized by using solvent-free cleaning procedures for routine cleaning and decontamination (see SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205). If solvents are needed, the volume should be minimized by using only the amount necessary and by capturing the residual solvent separately from the aqueous decontamination fluids (detergent/wash water mixes and water rinses).

At a minimum, the requirements of the management of hazardous IDW are as follows:

- Spent solvents must be left on-site with the permission of site operator and proper disposal arranged.
- All hazardous IDW must be containerized. Proper handling and disposal should be arranged prior to commencement of field activities.

Table 1: Disposal of IDW

TYPE	HAZARDOUS	NON - HAZARDOUS
PPE-Disposable	Containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.
PPE-Reusable	Decontaminate as per SESD Operating Procedure for Field Equipment Cleaning and Decontamination, SESDPROC-205, if possible. If the equipment cannot be decontaminated, containerize in plastic 5-gallon bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise return to FEC for proper disposal.	Decontaminate as per SESDPROC-205, and return to FEC.
Spent Solvents	Containerize in original containers. Clearly identify contents. Leave on-site with permission of site operator and arrange for proper disposal.	N/A
Soil Cuttings	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in a 55-gallon steel drum with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Groundwater	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. **
Decontamination Water	Containerize in DOT-approved container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. Decontamination water may also be disposed in a sanitary sewer system, with permission from the wastewater treatment plant representative, and if doing so does not endanger human health or the environment, or violate federal or state regulations.
Disposable Equipment	Containerize in DOT-approved container or 5-gallon plastic bucket with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal.	Containerize in an appropriate container with tight-fitting lid. Identify and leave on-site with permission of site operator, otherwise arrange with program site manager for testing and disposal. If unfeasible, return to FEC for disposal in dumpster.
Trash	N/A	Place waste in trash bag. Place in dumpster with permission of site operator, otherwise return to FEC for disposal in dumpster.

**** These materials may be placed on the ground if doing so does not endanger human health or the environment or violate federal or state regulations.**

APPENDIX B

QUALITY ASSURANCE PROJECT PLAN

REMEDIAL DESIGN WORK PLAN:
QUALITY ASSURANCE PROJECT PLAN

CTS OF ASHEVILLE, INC. SUPERFUND SITE

235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared for:

CTS Corporation
2375 Cabot Drive
Lisle, Illinois 60532

Prepared by:

Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806

Amec Foster Wheeler Project 6252-16-2012

April 19, 2017

Remedial Design Work Plan: Quality Assurance Project Plan

CTS of Asheville, Inc. Superfund Site
235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared For: CTS Corporation
Prepared by: Amec Foster Wheeler Environment & Infrastructure, Inc.

April 19, 2017

Matthew G. Wa

Matthew Wallace, P.E.
Amec Foster Wheeler
Environment & Infrastructure, Inc.
Project Manager

April 19, 2017
Date

Chris Ricardi

Christian Ricardi, NRCC-EAC
Amec Foster Wheeler
Environment & Infrastructure, Inc.
Quality Assurance Manager

April 19, 2017
Date

Craig Zeller, P.E.
USEPA Region 4
Remedial Project Manager

Date

Danny France
USEPA Region 4
Quality Assurance Manager

Date

TABLE OF CONTENTS

TABLES

APPENDICES

ACRONYMS

CD	Consent Decree
COC	chain-of-custody
CLP	Contract Laboratory Program
DPT	direct-push technology
DQI	data quality indicator
DQO	data quality objective
ECD	electron capture detector
EDD	electronic data deliverable
ERH	electrical resistivity heating
FDR	field data record
FID	flame ionization detector
FOL	Field Operations Leader
FSAP	Field Sampling and Analysis Plan
GPS	Global Positioning System
HASP	Health and Safety Plan
IATA	International Air Transport Association
IDW	investigative derived waste
ISCO	in-situ chemical oxidation
LCS	laboratory control sample
LD	laboratory duplicate
MDL	method detection limit
MIP	membrane interface probe
mL	milliliter
MS/MSD	matrix spike/matrix spike duplicate
NAPL	non-aqueous phase liquid
NELAP	National Environmental Laboratory Accreditation Program
NOD	natural oxidant demand
OSHA	Occupational Safety and Health Act
PDI	Pre-design Investigation
PID	photoionization detector
PQL	practical quantitation limit
PM	Project Manager
ppm	parts per million
QA/QC	quality assurance/quality control
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
R4DART	Region 4 Data Archival and ReTrieval
RDWP	Remedial Design Work Plan
RI/FS	Remedial Investigation/Feasibility Study
RPD	relative percent difference
SDG	sample delivery group
SESD	Science and Ecosystem Support Division
TCE	trichloroethene
TCL	Target Compound List
TED	Technical Environmental Database
TS	Treatability Study
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

DISTRIBUTION LIST

Craig Zeller (1 electronic)
Remedial Project Manager
USEPA, Region 4
61 Forsyth Street, SW
Atlanta, Georgia 30303
404-562-8827
zeller.craig@epamail.epa.gov

Beth Hartzell (1 electronic)
Project Manager
NCDEQ, Superfund Section
3800 Barrett Drive
Raleigh, North Carolina 27609
919-707-8335
beth.hartzell@ncdenr.gov

Matthew Wallace (1 electronic)
Project Manager
Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806
828-252-8130
matthew.wallace@amecfw.com

Susan Kelly (1 paper, 1 electronic)
Field Operations Leader/Technical Lead
Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806
828-252-8130
susan.kelly@amecfw.com

Christian Ricardi (1 electronic)
Quality Assurance Manager
Amec Foster Wheeler Environment & Infrastructure, Inc.
511 Congress Street
Portland, Maine 04101
207-775-5401
christian.ricardi@amecfw.com

David Smoak (1 electronic)
Technical Reviewer
Amec Foster Wheeler Environment & Infrastructure, Inc.
1075 Big Shanty Road, NW, Suite 100
Kennesaw, Georgia 30144
770-421-3327
david.smoak@amecfw.com

Kevin Godwin (1 electronic)
Project Manager
Pace Analytical Services, Inc.
9800 Kincey Avenue, Suite 100
Huntersville, North Carolina 28078
704-875-9092
kevin.godwin@pacelabs.com

DOCUMENT REVISION LOG

Revision	Date	Description
0	4/19/2017	Initial Issuance

1.0 INTRODUCTION

Pursuant to Paragraph 6.7(d) of the Statement of Work, on behalf of CTS Corporation (CTS), Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) has prepared this Quality Assurance Project Plan (QAPP) for the CTS of Asheville, Inc. Superfund Site (Site) located in Asheville, Buncombe County, North Carolina. The activities described in this QAPP will be performed to comply with the Consent Decree for Interim Remedial Design/Remedial Action (CD) at the Site between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation. The CD was entered on March 7, 2017.

This QAPP has been designed to be a project document that is applicable to activities conducted during implementation of the Remedial Design Work Plan (RDWP). This QAPP, in conjunction with the Field Sampling and Analysis Plan (FSAP), are included in the RDWP and provide the framework upon which the remedial design will be conducted. This QAPP has been prepared to document how the remedial design activities will be completed and includes investigation procedures, sampling methods, analytical methods, sample management, documentation procedures and Quality Assurance (QA) review procedures. This QAPP has been prepared following the criteria for quality assurance outlined in the following United States Environmental Protection Agency (USEPA) documents: *EPA Requirements for Quality Assurance Project Plans (*QA/R-5*)*; *Guidance for Quality Assurance Project Plans (*QA/G-5*)*; and *Uniform Federal Policy for Quality Assurance Project Plans, Parts 1 through 3*.

The overall interim remedial design project (the ERH and ISCO phases) will be conducted under the Amec Foster Wheeler Environment & Infrastructure America's *Quality Management Plan* (Revision No. 3, dated June 10, 2016). The Quality Management Plan follows the criteria for quality assurance outlined in the USEPA's document *EPA Requirements for Quality Management Plans* (QA/R-2).

The interim remedial activities will be conducted in two phases: electrical resistivity heating (ERH) in the approximate 1.2-acre source area, and in-situ chemical oxidation (ISCO) in the approximate 1.9-acre downgradient dissolved-phase plume area (Northern Area). At this time, the ERH remedial design does not require any field activities upon which data will be evaluated. If data gaps are identified and it is determined that collection of additional data is required for the ERH remedial design, this QAPP will be updated to include such activities. A qualified contractor will be selected for the ERH implementation, which will include the remedial design. Therefore, this QAPP focuses on data to be collected for development of the ISCO remedial design in which data gaps have been identified.

The ISCO remedial design will be conducted in two phases: a Pre-design Investigation (PDI) and a Treatability Study (TS). The design for the TS will be based on data collected during the PDI and data from previous investigations. Known information regarding the TS has been included in this QAPP; however, if additional quality-affecting information needs to be included for performing the TS, this QAPP will be updated prior to implementation of the TS.

It should also be noted that another QAPP will be prepared for the Remedial Action Work Plan, which will be prepared after the Remedial Design Work Plan activities are substantially completed.

2.0 PROJECT MANAGEMENT

This section provides the overall approach to managing activities described in the RDWP, and includes the following:

- Project organization and responsibilities
- Problem definition
- Project description
- Data quality objectives
- Method performance objectives
- Special training, requirements, and certification
- Documentation and records management

2.1 PROJECT ORGANIZATION AND RESPONSIBILITIES

The various responsibilities of key project personnel are presented in this section and a project organizational chart is presented in Appendix A.

2.1.1 CTS Corporation

Mr. George Lytwynyshyn of CTS will serve as the Settling Defendant’s Project Coordinator for the project. Mr. Lytwynyshyn is the Director of Environment, Health & Safety at CTS.

2.1.2 Amec Foster Wheeler Environment & Infrastructure, Inc.

Amec Foster Wheeler, as the Supervising Contractor, will execute the RDWP from its Asheville, North Carolina office with support from other Amec Foster Wheeler offices. Project personnel and duties are described in the following sections. It should be noted that all personnel have a stop-work authority if they identify when adverse quality issues are encountered.

2.1.2.1 Project Manager

The Project Manager, Mr. Matthew Wallace, PE (North Carolina), will be responsible for the scope, cost, and technical considerations related to the project; staff and project coordination; and implementation of review of overall project quality related to the collection, completeness, and presentation of data. The Project Manager oversees the technical work conducted by the Field Operations Leader, quality assurance activities by the Quality Assurance Manager, review by the Technical Reviewer, and health and safety activities by the Site Health and Safety Supervisor.

2.1.2.2 Technical Lead/Field Operations Leader

The Technical Lead and Field Operations Leader (FOL), Ms. Susan Kelly, LG, PE (North Carolina), will be responsible for executing the planned work elements, issuing specific instructions for performing assigned work elements, and performing and directing the work so it is conducted in compliance with project-specific objectives and applicable QA procedures. The FOL will coordinate with the Project Manager and Quality Assurance Manager to review general work plans and specific work elements. The FOL maintains field documentation and deliverables in the project files during the performance of the assigned tasks. For field sampling activities, the FOL will be responsible for performing and/or overseeing the field work, preparing proper documentation, and ensuring proper handling of samples from sampling activities. The FOL has the authority to issue a stop work order if field sampling operations are not being conducted in accordance with the requirements specified in the Work Plan/FSAP/QAPP or when worker safety becomes an issue.

2.1.2.3 Technical Reviewer

The Technical Reviewer, Mr. David Smoak, of Amec Foster Wheeler’s Kennesaw, Georgia office, will provide technical review and support during implementation of the remedial design activities.

2.1.2.4 Quality Assurance Manager

The Quality Assurance Manager, Mr. Christian Ricardi, NRCC-EAC, of Amec Foster Wheeler’s Portland, Maine office, will be responsible for reviewing the project QA program as it relates to the collection and completeness of data from field and laboratory operations. Mr. Ricardi’s primary responsibilities include review of quality assurance/ quality control (QA/QC) protocols, ascertaining quality of environmental data collected to verify that it meets proposed data quality objectives, and identifying and verifying corrective actions, if any become necessary.

2.1.2.5 Project Chemist

The Project Chemist, Ms. Julie Ricardi of Amec Foster Wheeler's Portland, Maine office, will be responsible for reviewing laboratory reports for accuracy and completeness, and performing data validation according to the National Functional Guidelines (USEPA, 2016) modified for evaluation of USEPA SW-846 Methods. Ms. Ricardi will submit the validated laboratory reports with QA/QC evaluation sheets to the Quality Assurance Manager.

2.1.2.6 Data Manager

The Data Manager, Mr. Binks Colby-George of Amec Foster Wheeler's Portland, Maine office, will be responsible for entering data into Amec Foster Wheeler's database described in Sections 2.7 and 3.10.2. Mr. Colby-George will also submit data to the USEPA in an electronic data deliverable (EDD) with relevant field information and laboratory data in the format specified for environmental data in the USEPA Region 4 Science and Ecosystem Support Division (SESD) R4DART (Data Archival and ReTrieval) database.

2.1.2.7 Site Health and Safety Supervisor

The Site Health and Safety Supervisor, Ms. Susan Kelly, LG, PE (North Carolina), is responsible for developing, implementing, and updating the Site Health and Safety Plan (HASP) to be consistent with anticipated conditions that may be encountered during field operations. Ms. Kelly will also serve as the FOL during implementation of the RDWP.

2.1.3 Analytical Laboratory

Chemical laboratory analyses will be performed by Pace Analytical Services, LLC (Pace) of Huntersville, North Carolina. Personnel organization, responsibility, and training for the analytical laboratories can be found in Pace's Quality Assurance Manual, which is included in Appendix B.

2.1.4 Direct Sensing Subcontractor

Cascade Drilling will provide direct sensing services for the project. Cascade will operate the direct sensing equipment/instruments and will upload collected data to visualization software for interpretation.

2.1.5 Treatability Study Subcontractors

Several subcontractors are anticipated to provide services during implementation of the TS. Geo-Cleanse International, Inc. will provide consulting services related to the PDI and TS. A drilling subcontractor, to be determined, will install the injection well casings for the TS and the monitoring wells for monitoring performance of the TS. FRx, Inc. is anticipated to perform the potassium permanganate emplacements.

2.2 PROBLEM DEFINITION

2.2.1 Site Description

The Site is considered the approximate 8.7-acre property which formerly contained a manufacturing facility at 235 Mills Gap Road in Asheville, Buncombe County, North Carolina (Buncombe County tax parcel 9655-62-5706). However, it is understood that the Site also includes adjacent land containing other media that have become adversely impacted by processes/operations conducted at the former manufacturing facility.

The Site formerly contained an approximate 95,000-square foot, single-story brick and metal structure in the southern portion of the Site. The building was demolished in December 2011 and the concrete building pad remains intact. The northeastern portion of the Site contains an asphalt-paved parking area and asphalt-paved driveways are located parallel to the north (front) of the former building pad and southeast (rear) of the former building pad. A six-foot high chain-link fence surrounds the Site and a locked gate at the north end of the Site controls access to the Site from Mills Gap Road.

2.2.2 Site Operational History

Electronic components were manufactured at the former facility at the Site from 1953 until 1987, when the Site was bought by a developer who reportedly leased portions of the facility to various tenants, and otherwise utilized the building for business interests. The Site has been vacant/unoccupied since the mid-1990s.

Solvents, including trichloroethene (TCE) and acetone, were used in the process to clean and/or degrease metal objects prior to electroplating, and the spent solvents were disposed of accordingly. Disposal/recycling practices at the site prior to 1959 are not known. From 1959 to 1986, solvents and metals were reportedly reclaimed whenever possible. Between 1959 and 1980, metal-bearing rinse waters and alkaline cleaners that could not be reclaimed from the electroplating process were reportedly disposed of through the city sewer system, while concentrated metals and solvent wastes were placed in drums for off-site disposal/recycling. After 1980, all wastes were accumulated in drums on-site prior to off-site disposal or recycling.

2.2.3 Problem Definition

It is beyond the scope of this QAPP to describe the numerous investigations that have been conducted at the Site; however, the Final NAPL Area Focused Feasibility Report, dated September 10, 2015, contains a summary of previous investigations.

The results of previous investigations have determined that dissolved-phase groundwater plume is present in the “Northern Area” of the Site (i.e., in the vicinity of monitoring well pairs MW-6/6A and MW-7/7A) and migrates east and west to discharge zones. Concentrations of TCE in this area are elevated (in the tens of thousands micrograms per liter). CTS proposed a remediation strategy of ISCO via emplaced potassium permanganate to reduce the TCE concentrations in the Northern Area, and USEPA concurred with the remedial approach. In order to develop a remedial design for the ISCO remediation, data gaps have been identified and collection of additional data is necessary. The additional data will be collected in two phases: a PDI and a TS.

The objectives of the PDI include:

- Determine the horizontal and vertical distribution of VOCs in the approximate 1.9-acre Northern Area, so that efforts can be made to focus on the areas of highest contamination.
- Determine the permanganate natural oxidant demand (NOD) of the subsurface materials, which will influence the amount of permanganate required to effectively reduce TCE concentrations.

The preliminary objectives of the TS include:

- Determine process and emplacement characteristics (thickness, horizontal/vertical distribution, and pressures during emplacement).
- Determine the reduction of VOCs, primarily TCE, downgradient of the emplacements.

The objectives of the TS will be further described in the TS Work Plan.

2.3 PROJECT DESCRIPTION

A dissolved-phase groundwater plume is present in the Northern Area of the Site and remediation via emplaced potassium permanganate is proposed for the 1.9-acre area. The overall objective of the PDI and the TS is to develop parameters for the full-scale design of the interim remediation program.

2.3.1 Investigation Approach

The PDI involves collecting qualitative data to gain a relatively rapid, real-time, understanding of the contaminant distribution in the unconsolidated formation in the Northern Area at the Site. Based on the qualitative data, a subset of quantitative groundwater and soil data will be collected to develop a correlation between the qualitative data and quantitative data and to gain additional information regarding the magnitude of VOC concentrations. Data will also be collected to characterize the permanganate NOD of the subsurface materials in the area of the proposed remediation, which will affect the amount of permanganate required to effectively reduce TCE concentrations. Direct sensing, soil and groundwater data was collected in the Northern Area of the Site during the NAPL Investigation in 2013 and 2014 (Amec Foster Wheeler, 2014), and this data will also be evaluated with respect to the PDI data collected.

The TS will involve emplacing potassium permanganate at various horizontal and vertical locations in a specific area within the Northern Area. Data, such as mass of potassium permanganate delivered, injection pressures, etc. will be recorded during the emplacements. Monitoring wells will be installed prior to initiation of the Treatability Study. Groundwater samples will be collected from the monitoring wells before and after emplacement of the potassium permanganate to monitor the effectiveness of the emplaced potassium permanganate at reducing TCE concentrations. The post-emplacement monitoring schedule will be presented in the TS Work Plan.

The remediation area is depicted in Figure 3 of the RDWP. Borings for the PDI will be advanced at the approximate locations shown in Figure 3 and will be advanced to refusal of the drilling equipment. Figure 3 depicts 32 boring locations, and 35 are proposed;

therefore, three boring locations will be selected at the end of the PDI to address potential data gaps that remain. The TS injection well and monitoring well locations will be identified in the TS Work Plan.

The following methods are proposed for the RDWP:

- Measurement of depth to groundwater in monitoring wells in the Northern Area of the Site.
- Implementation of direct sensing using a membrane interface probe (MIP) for qualitative determination of the magnitude of VOC concentrations.
- Collection of groundwater samples from monitoring wells and via direct-push technology (DPT) equipment.
- Collection of soil samples via DPT equipment.
- Chemical analysis of soil and groundwater samples for quantitative determination of constituent concentrations.
- Analysis of soil samples for quantitative determination of the permanganate NOD.

2.3.2 Quality Objectives and Criteria

Qualitative and quantitative data will be collected during implementation of the RDWP. Qualitative data will generally be used to guide the field investigation, as an iterative sampling approach will be employed. A subset of quantitative data will be collected and will be used to provide correlation to the qualitative data and to gain information about the magnitude of constituent concentrations. Given the heterogeneous nature of soil and the selective nature of contaminant distributions in the subsurface, it is anticipated that there will not be an absolute correlation between the qualitative and quantitative data. However, the data will provide a basis for establishing and understanding the distribution of VOCs for development of the forthcoming TS Work Plan and ISCO Remedial Action Work Plan.

2.3.3 Schedule

The proposed schedule for the implementation of the RDWP related to ISCO in the Northern Area of the Site is included in Appendix D of the RDWP. The USEPA will be notified at least 14 days prior to any sample collection activities.

2.4 DATA QUALITY OBJECTIVES

Data collected at a site needs to be of sufficient quality and quantity to support defensible decision making. Data quality objectives (DQOs) are identified before the sampling and analysis begin. DQOs will be used to ascertain the type, quality, and quantity of data necessary to address problems. The USEPA guidance document, Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA, 2006), outlines the following seven-step process for establishing DQOs:

1. **State the Problem.** Concisely describe the problem to be studied.
2. **Identify the Goal of the Study.** State how environmental data will be used in meeting objectives and solving the problem, identify study questions, and define alternative outcomes.
3. **Identify Information Input.** Identify data and information needed to answer study questions.
4. **Define the Study Boundaries.** Specify the conditions (time periods, spatial areas, and situations) to which the decision will apply and within which the data will be collected.
5. **Develop the Analytical Approach.** Define the conditions by which the decision maker will choose among alternative risk management actions. This is usually specified in the form of an “if…then…” statement.
6. **Specify Performance or Acceptance Criteria.** Define in statistical terms the decision maker’s acceptable error rate based on the consequence of making an incorrect decision.
7. **Develop the Plan for Obtaining Data.** Evaluate the results of the previous steps and develop the most resource-efficient design for data collection that meets all of the DQOs.

2.4.1 State the Problem

Past operations at the Site have resulted in releases of chlorinated solvents, primarily TCE. The TCE has dissolved into the groundwater resulting in a dissolved-phase plume in the Northern Area of the Site. Remediation via ISCO is proposed for this area to reduce TCE concentrations in groundwater by 95 percent. Additional information is necessary to determine the design parameters for the design of the full-scale ISCO remediation.

2.4.2 Identify the Goal of the Study

The principal study questions are:

- What is the depth to water in the remediation area?

- What is the distribution of VOCs in groundwater in the overburden (i.e., above competent bedrock) in the Northern Area?
- What is the permanganate NOD of the subsurface materials?
- How much potassium permanganate is required to achieve the interim cleanup goal?
- Where should the potassium permanganate be emplaced, horizontally and vertically, to most effectively reduce TCE concentrations in the groundwater plume?
- What are the TCE concentrations in groundwater samples collected downgradient after emplacement of the potassium permanganate?

The principal study questions are for interim remediation purposes; therefore alternative actions for the study questions include collecting additional data to answer the questions. Answers to the study questions will be used to formulate the interim remediation program. The methods to answer the study questions are described in the following table.

Principal Study Questions	**Information Inputs/Methods**
What is the depth to water in the remediation area?	• Measure the depth to groundwater in monitoring wells located in the remediation area.
What is the distribution of VOCs in the overburden (i.e., above competent bedrock) in the Northern Area at the Site?	• Results of MIP data indicating the horizontal and vertical distribution of VOCs in the Northern Area (using data collected during the PDI and NAPL Investigation). • Results of groundwater samples collected from monitoring wells and DPT borings in the Northern Area. • Results of soil samples collected from DPT borings in the Northern Area.
What is the permanganate NOD of the subsurface materials?	• Collect soil samples from various soil types and analyze the samples for permanganate NOD.
How much potassium permanganate is required to achieve cleanup goals?	• Estimate the amount of oxidant required using the permanganate NOD, TCE concentrations in groundwater, and aquifer characteristics.
Where should the emplacements be located, horizontally and vertically, to most effectively remediate the groundwater plume?	• Results of MIP data indicating the horizontal and vertical distribution of VOCs in the Northern Area. • Results of groundwater samples collected from monitoring wells and DPT borings in the Northern Area. • Results of permanganate NOD from soil samples.
What are the TCE concentrations in groundwater samples collected downgradient after emplacement of the potassium permanganate?	• Collect/analyze groundwater samples from monitoring wells located downgradient of the TS area over a period of time.

2.4.3 Identify Information Inputs

The data needed to answer the principal study questions include:

- Depth to groundwater

- Visual observations of soil collected in the field at boring locations
- Field testing using direct sensing equipment (MIP)
- Off-site laboratory analyses of soil samples for NOD
- Off-site laboratory analyses of soil and groundwater samples for VOCs

The proposed PDI strategy involves collecting qualitative data to gain a relatively rapid, real-time, understanding of the contaminant distribution present in the unconsolidated formation at the Site. Based on the qualitative data, a subset of quantitative data will be collected to determine VOC concentrations in groundwater and soil samples. Also, DPT borings will be advanced to view the soil and collect samples of different soil types for permanganate NOD testing. Up to 10 groundwater and 10 soil samples will be collected for VOC analysis from the DPT borings and up to 20 soil samples will be collected for permanganate NOD testing.

The results of soil and groundwater samples will be compared to the MIP responses to establish a correlation between contaminant concentrations in groundwater and MIP responses and to gain information regarding the magnitude of the VOC concentrations. The evaluation/interpretation of the associated qualitative/quantitative data will be expanded to the rest of the qualitative data to develop a conceptual model of the contaminant distribution in the Northern Area. A one-to-one correlation is not expected given the limitations of the investigation methods; however, the collective data set will be used to develop the contaminant distribution, with reasonable assurance, in the Northern Area of the Site.

The proposed TS strategy will be described in the TS Work Plan that will be submitted to USEPA after the PDI Evaluation Report.

Limitations of the proposed PDI methods are described below.

2.4.3.1 MIP Limitations

The MIP detectors (ECD, PID, and FID) do not quantify detections of constituents, nor do the MIP detectors differentiate between the constituents detected; however, the magnitude of the response (in millivolts) corresponds to the amount/quantity of VOCs in the carrier gas that is exposed to the subsurface, which is proportional to the amount of VOCs present in the soil and/or groundwater at that location.

In areas of significant contamination, the MIP detector can become saturated, and the detector becomes unable to detect VOCs of lower concentration below the depth that saturation occurred. If saturation of the detector occurs, a replacement MIP detector will be employed and the saturated detector will be cleaned and the gas lines purged for later use.

The MIP detectors cannot speciate the compounds present in the detected VOCs. The relative abundance, or concentration, of the total VOCs present is determined. The ECD only detects chlorinated VOCs, such as TCE. The MIP detectors can also reach a maximum value; however, the maximum value can be adjusted by the controller (i.e., the detection range can be adjusted by the controller, from a low to high range and vice versa).

2.4.3.2 Soil Sampling Limitations

Soil samples will be collected to determine the permanganate NOD of the subsurface material. The NOD is expected to vary based on the soil type. Soil borings will be advanced using DPT equipment and the soil cores will be viewed to determine soil types encountered. Samples will be selected on a judgmental basis to collect as many varied soil types as possible. It is possible that the collected soil samples might not represent all of the soil types that are represented in the Northern Area.

Soil sampling for VOC analysis will be conducted adjacent to MIP borings. Limitations with soil sampling using a DPT rig equipped with a discrete sampler include: the DPT might encounter refusal by hard layers/zones above the target sample depth; dilution of the sample by the laboratory due to the elevated concentrations; and potential volatilization of constituents in the sample during collection.

2.4.3.3 Groundwater Sampling and Analysis Limitations

Groundwater sampling will be conducted adjacent to MIP borings. Limitations with groundwater sampling using a DPT rig equipped with a discrete sampler include: the DPT might encounter refusal by hard layers/zones above the target sample depth; adequate sample volume might not be obtained; dilution of the sample by the laboratory due to the elevated concentrations; and potential volatilization of constituents in the sample during collection.

Groundwater samples will also be collected from permanent monitoring wells. Limitations with sampling monitoring wells include: dilution of the sample due to the well screen not being a discrete sampling point; dilution of the sample by the laboratory due to the elevated concentrations; and potential volatilization of constituents in the sample during collection.

2.4.4 Define the Study Boundaries

The target populations for the study include:

- Data to determine the distribution of VOCs in soil and groundwater and permanganate NOD in the Northern Area

The horizontal spatial boundary is depicted in Figure 3 of the RDWP. The vertical spatial boundary is from ground surface to the depth of refusal with drilling equipment, which is expected to range from approximately 40 feet to 80 feet below ground surface. The boundaries are based on a 1.9-acre area identified in the NAPL Area Focused Feasibility Study Report Addendum.

The PDI will be initiated within six weeks of USEPA’s approval of the RDWP, QAPP, FSAP, and PDI Work Plan. The TS will be initiated within six weeks of USEPA’s approval of the TS Work Plan. Field activities will be conducted during the day, from approximately 7 a.m. to 7 p.m. from Monday through Friday. USEPA will be notified if field activities are necessary outside of the above day or time constraints. Work will be suspended when severe weather conditions, such as lightning, rain, or snow arise or are forecasted and pose a safety and/or quality control issue. The PDI field activities are expected to take up to three weeks to complete, and the PDI data evaluation and reporting is expected to take up to nine weeks to complete.

Practical constraints that might interfere with the investigation include:

- Subsurface utilities (e.g., sewer, water, natural gas)
- Overhead power lines

- Hard zones/layers above competent bedrock that cannot be penetrated with drilling equipment
- Severe weather (thunder, lightning, heavy rain or snow, etc.)

The smallest unit on which decisions regarding chlorinated VOC concentration measurements will be made are measurements with the ECD, which has a detection limit of around 250 parts per billion.

The population targets for the TS will be based on the results of the PDI and will be identified in the TS Work Plan.

2.4.5 Develop the Analytic Approach

The population parameters for the study are the individual measurements for the data collected (i.e., the concentration of a constituent in a groundwater sample determined by the groundwater analysis). The measurements will be used directly to answer the study questions or calculate a value that will be used to answer study questions.

The distribution of VOCs in soil and groundwater in the Northern Area will be based on the following:

- Relative responses from the MIP tool (i.e., low responses indicate low VOC concentrations and vice versa).
- Data collected from direct sensing conducted in the Northern Area during the NAPL Investigation (Amec Foster Wheeler, 2014).
- Concentrations of VOCs detected in soil and groundwater samples.
- Correlation of the VOC concentrations in groundwater samples to MIP responses at the same approximate location and depth.

The distribution of permanganate NOD in the Northern Area will be based on the following:

- Soil types visually identified in soil borings advanced in the Northern Area (Note: the MIP tool also has a soil electrical conductivity, which is an indicator of soil type, but soil at the Site does not vary considerably, so the electrical conductivity responses are not anticipated to provide useful information regarding soil type).
- The NOD value measured in the laboratory and possible correlation to soil type.

2.4.6 Specify Performance or Acceptance Criteria

Data is subject to random and systematic errors at different stages of the collection process and typically include the following components:

- Sampling Error: Sometimes called Statistical Sampling Error, is influenced by the inherent variability of the population over space and time, the sample collection design, and the number of samples taken. It is usually impractical to measure the entire population space, and limited sampling may miss some features of the natural variation of the measurement of interest. Sampling design error occurs when the data collection design does not capture the complete variability within the population space, to the extent appropriate for making conclusions. Sampling error can lead to random error (i.e., random variability or imprecision) and systematic error (bias) in estimates of population parameters.
- Measurement Error: Sometimes called Physical Sampling Error, is influenced by imperfections in the measurement and analytical system. Random and systematic measurement errors are introduced in the measurement process during physical sample collection, sample handling, sample preparation, sample analysis, data reduction, transmission, and storage.

The PDI implements a judgmental sampling approach and assessment of statistical error is not planned. Measurement error is addressed by establishing standardized methods of sample collection and through the validation of analytical data.

The methods proposed for the PDI each have advantages and limitations. Several investigation methods are proposed, so that multiple lines of evidence can be evaluated to determine the distribution of VOCs in the subsurface in the Northern Area. Limitations to the proposed methods are described in Section 2.4.3 herein.

Response tests will be performed on the direct sensing equipment. The results of the response tests will be compared to the manufacturer’s acceptance criteria for proper operation of the equipment. The response tests are described in Section 5.2 of the FSAP.

Data from off-Site laboratory analyses will be reviewed and validated as described in Section 5.0 herein. Standard analytical results (e.g., VOCs) will be evaluated based on criteria in the referenced analytical methods and USEPA validation guidelines. Results may be accepted without qualification or with validation qualifiers (J, UJ). Results that do not meet minimum criteria for acceptance (qualified as rejected, R, during validation) will be unacceptable for use.

2.4.7 Develop the Plan for Obtaining Data

Several investigation methods are proposed to provide converging lines of evidence for the distribution of VOCs. The PDI Work Plan describes the investigation strategy/methods and the FSAP describes the data/sample collection procedures.

To the extent practical, the design for collecting data presented in the PDI Work Plan has been optimized to achieve the stated DQOs. The scope of work and data collection process has been designed to provide near real-time data and off-Site laboratory testing. This data will be used to modify and expand the scope of field activities, as needed, to ensure the DQOs are met.

USEPA will be provided split and/or duplicate samples, if requested. USEPA can also collect additional samples that it deems necessary. USEPA will provide split/duplicate samples collected for oversight sampling to Amec Foster Wheeler, if performed and requested.

2.5 METHOD PERFORMANCE OBJECTIVES

Performance objectives are defined for field data and fixed laboratory data. Method performance objectives for work performed are expressed in terms of precision, accuracy, representativeness, comparability, completeness, and sensitivity. Target analytes for VOCs and detection limits are summarized in Table 1. Sample collection, preservation, and holding time goals are summarized in Table 2. Measurement performance criteria for surrogates, spikes, and duplicate analyses are summarized in Table 3. The following sections describe the method performance parameters and calculations, as appropriate.

2.5.1 Precision

Precision is described as the agreement among a set of duplicate or replicate measurements.

2.5.1.1 <u>Field Precision</u>

For qualitative measurements, precision will be evaluated by the agreement of results. Replicate borings (i.e., within approximately two feet of each other) will be conducted and the same direct sensing method be employed at the two borings. Data collected from the two borings will be compared and the FOL will use professional judgment to assess the agreement of the data. Replicate borings will be conducted at a frequency of five percent and the locations will be biased toward borings that have detections in the original boring.

Field duplicates will be collected at a frequency of one per ten investigative samples per matrix/media per analytical parameter. Precision will be measured through the calculation of relative percent difference (RPD) using the following equation:

$$RPD = \frac{|X_1 - X_2| x100}{(X_1 + X_2)/2}$$

where: RPD = relative percent difference between duplicate results
X_1 and X_2 = results of original sample and duplicate analyses
$|X_1 - X_2|$ = absolute difference between duplicates X_1 and X_2

The resulting information will be used to assess sample homogeneity, spatial variability of samples, sample collection reproducibility, and analytical variability. The field precision goals are presented in Table 3. As described in Section 3.3.2, the permanganate NOD test is conducted in triplicate, so a method for determining precision is built into the test method.

2.5.1.2 Laboratory Precision

The precision of laboratory analyses of VOCs can be inferred through one of the following: laboratory control sample duplicates (LCSDs), matrix spike (MS) and matrix spike duplicate (MSD) samples, or unspiked duplicate samples. The laboratory analyzes one or more of these duplicate samples at a rate of one per batch of 20 samples per matrix. The MS/MSD samples provide information about the effect of the sample matrix on extraction and measurement methodology. A MS/MSD pair will be analyzed at a rate of one per batch of 20 or fewer investigative samples per matrix. The precision of laboratory analyses will be assessed by calculating the RPD for each pair of MS/MSD duplicate samples, laboratory control sample spike duplicates, unspiked duplicate samples, and field duplicate sets. The laboratory precision goals are presented in Table 3. Note, MS/MSD samples will not be analyzed for the NOD soil samples.

2.5.2 Accuracy

Accuracy is the degree of agreement between a measurement or observation and an accepted value.

2.5.2.1 Field Accuracy

Field accuracy, assessed through appropriate field equipment and trip blanks, is achieved by adhering to sampling, handling, preservation, and holding time requirements. Field blank samples will be analyzed to check for possible procedural contamination that could affect samples. Equipment rinsate blanks will be used to assess the adequacy of decontamination of sampling equipment between individual sample collections. Trip blanks will be used to assess the potential for contamination of samples due to migration of contaminants (e.g., VOCs) during sample shipment, handling, and/or storage. Accuracy of field instruments will be assessed by daily instrument calibration and calibration checks.

The accuracy of the direct sensing equipment will be determined by conducting a response test before and after use at each boring. If a response test or operational observation indicates a performance issue, the subcontractor will notify the FOL, and appropriate steps to rectify the issue will be performed before additional data is collected with the equipment.

2.5.2.2 Laboratory Accuracy

Laboratory accuracy will be assessed by analyzing matrix spikes and laboratory control samples (LCS). The results will be expressed as a percent recovery. Surrogate recoveries will also be used to assess accuracy. Method blanks will be used to assess possible contamination from laboratory procedures. Laboratory control samples, method blanks, and preparation blanks will be analyzed at least once with each analytical batch, with a minimum of one for every 20 samples. The percent recovery (% R) is calculated with the following equation:

$$\%\ recovery = \left(\frac{X - B}{T} \right) x\,100$$

where: X = measured amount in sample after spiking
B = background amount in sample
T = amount of spike added

The laboratory accuracy goals are presented in Table 3.

2.5.3 Representativeness

Representativeness is a qualitative measure of the degree to which sample data accurately and precisely represent a characteristic environmental condition. Representativeness is demonstrated in the project planning documents by providing full descriptions of the sampling techniques and the rationale used for selecting sampling locations. Representativeness of field data is dependent upon the proper design of the data collection procedures and will be evaluated by assessing whether this QAPP was followed during sample collection. In addition, the analytical results from method, trip and rinse blank samples will be used to evaluate the representativeness of field sampling procedures. The blank samples will be used during data validation to determine if contamination in the laboratory or field (from equipment or during transport) has potentially impacted the representativeness of the field samples (i.e., contamination in a blank sample could bias the field sample results). Laboratory data will be evaluated for representativeness by assessing whether the laboratory followed the analytical methods prescribed in this QAPP, evaluating holding time criteria, and evaluating the results of method, instrument, trip, and rinse blank samples and field duplicate samples.

2.5.4 Completeness

Completeness is a measure of the quantity of valid data obtained from a measurement system compared to the quantity that was planned under normal conditions. Percent completeness is calculated with the following equation:

$$\%\ Completeness = \frac{Valid\ Data\ Obtained}{Total\ Data\ Planned}\ x\ 100$$

Valid analytical results used to meet completeness objectives are those results that provide defensible estimates of the true concentration of an analyte in a sample. These valid results include data that is not qualified and data for which QC results indicate qualification is necessary but which may still be used to meet project objectives. Invalid results are those data for which there is an indication that the prescribed sampling or analytical protocol was not followed.

The groundwater samples to be submitted for analysis are anticipated to contain elevated concentrations of contaminants, which can result in qualified or rejected data due to compromised analytical procedures (e.g., significant dilution of samples). Therefore, a reasonable goal for completeness on this project is 90 percent. If insufficient valid data are obtained, the QA Manager will initiate corrective action.

2.5.5 Comparability

Comparability is the degree of confidence with which one data set can be compared to another. Throughout sampling on this project, standard methodologies as discussed in the FSAP and in this QAPP will be used for both sampling and analysis activities to insure comparability. The intention is to use the same laboratory (Pace) for standard analyses (i.e., VOCs) throughout the duration of the PDI and T and there should not be a need to assess the comparability of data from different laboratories.

2.5.6 Sensitivity

Sensitivity is the measure of the concentration at which an analytical method can positively identify and report analytical results. The sensitivity of a given method commonly is referred to as the detection limit. Although there is no single definition of this term, the following definitions of detection limits will be used:

- Method detection limit (MDL) is a statistically determined concentration. It is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero as determined in the same or a similar matrix. Because of the lack of analytical precision in this range, sample results greater than the MDL but less than the practical quantitation limit will be reported as estimated and flagged with a “J.”
- Practical quantitation limit (PQL) is the concentration of the target analyte that the laboratory has demonstrated the ability to measure within specified limits of precision and accuracy during routine laboratory operating conditions. This value is variable and highly matrix-dependent. It is the minimum concentration that the laboratory will report as unqualified.

For sensitivity, the quality objective is to analyze data using a method that achieves PQLs that are less than or equal to the task-specific target analysis goals or concentrations. Target compounds and detection limits are listed in Table 1.

2.6 SPECIAL TRAINING/CERTIFICATION

Training of field personnel will be provided by the FOL. Routine training will be completed at the beginning of each field event if required. The FOL will review applicable procedures with field personnel to verify that the project requirements and procedures are understood and implemented properly.

The direct sensing subcontractor will use personnel that have been trained and certified by the direct sensing equipment manufacturers (i.e., Geoprobe Systems®). The drilling subcontractor will be trained and experienced in operating the DPT rig and a North Carolina Certified Well Contractor will conduct and/or oversee the drilling operations.

Pace will maintain a North Carolina Wastewater/Groundwater Laboratory Certification, which is applicable to the analytical methods that will be performed during implementation of the RDWP. Geo-Cleanse's laboratory is not required to maintain a North Carolina Certification for the analysis which it will be performing (permanganate NOD). Field personnel will review and follow manufacturer's operating procedures for field equipment, such as the water level indicator and groundwater sampling equipment.

Personnel conducting work at the Site will be appropriately trained in health and safety procedures. If appropriate, personnel conducting work covered by this QAPP will have obtained at a minimum, the 40-hour hazardous waste-site worker training program and the 8-hour annual refresher course in compliance with regulations stated in 29 CFR Part 1910.120. Certificates or documentation representing completion of training shall be maintained in personnel files. The FOL will verify that personnel have the necessary training and certifications prior to the implementation of the project.

A Site HASP has been developed specific to the Site activities discussed in this QAPP. The HASP applies to Amec Foster Wheeler employees and Amec Foster Wheeler subcontractors, only. Each field team will have access to a copy of the HASP during field activities. Personnel working at the Site will be required to read, understand, and conform to the requirements of the HASP. As Site activities progress and if new information arises, the HASP will be updated, as necessary, to comply with the Occupational Safety and Health Act (OSHA) and safe working conditions.

2.7 DOCUMENTS AND RECORDS

Project records for the work will be maintained in Amec Foster Wheeler's Asheville, North Carolina, office. File maintenance will be under the direct control of the Project Manager. Project records will be organized with a project-specific file and document numbering system in accordance with Amec Foster Wheeler protocols.

The anticipated hard copy project records include:

- Project log book(s)
- Field data records (FDRs)
- Safety records, as specified in the Site HASP
- Chain of custody records

The anticipated electronic records include:

- Laboratory reports
- Laboratory EDDs
- Final validated laboratory analytical results
- Direct sensing data
- Surveying data
- Photographs (digital)
- Scanned hard copy information (e.g., log books, FDRs, etc.)

Hard copy records will be stored in Amec Foster Wheeler's Asheville, North Carolina office and electronic records will be stored on Amec Foster Wheeler's Asheville, North Carolina office server, which is backed up daily. Electronic data will be available to other Amec Foster Wheeler office servers, as necessary for data validation, presentation, etc.; however, the original data documents will be stored on the Asheville server.

Pace will submit analytical results in electronic formats. The electronic analytical data from Pace will be submitted as laboratory reports and EDDs in accordance with the format described in Table 5. The analytical results will be imported into the Amec Foster Wheeler Technical Environmental Database (TED). The TED is an Oracle-based relational database designed with using Microsoft structured query language. The TED is used to manage and store a variety of records generated during field investigations, including sample location information and analytical data. The TED can provide output files, such as Excel, for use in data validation and subsequent importation of data qualification actions. The TED data are permanently stored on a secure Amec Foster Wheeler server that is backed up daily.

The MIP data will be collected/processed using proprietary software developed by Geoprobe®. The raw data will be transferred to an Excel file and then posted daily to a secure server (Network Solutions). Amec Foster Wheeler will download the data from the secure server and save it on the Amec Foster Wheeler server. The MIP borings will be surveyed using Magellan Global Positioning System (GPS) equipment, which has a three-meter or better accuracy. The direct sensing data and GPS data will be combined using RockWorks™ software for three-dimensional visualization. Additionally, the locations of borings advanced for the collection of soil and groundwater samples will be surveyed for inclusion with the three-dimensional visualization.

If this QAPP, or the associated RDWP or FSAP, is updated/modified, the updated version(s) will be distributed to those persons identified in the distribution list. If the modifications are minor, then only the portions of the document with the modifications will be disturbed; otherwise, the entire document(s) will be distributed. Data and document management is further discussed in Section 3.10.

Retention of files associated with this QAPP will be in accordance with the CD, which requires the preservation and retention of records and documents during the implementation of the CD and for a minimum of ten years after USEPA's Certification of Work Completion.

3.0 MEASUREMENT AND DATA ACQUISITION

The following sections describe the design and implementation of measurement procedures and discuss the methods to be used for sampling, analysis, data handling, and QC in support of the tasks performed.

3.1 PDI SAMPLING PROCESS DESIGN

The PDI Work Plan describes the proposed sampling plan, including planned sampling locations, rationale for the sampling locations and measurement methods, the media to be sampled, and measurements that will be taken for the PDI. The TS, which will be developed after submittal of the PDI Evaluation Report, will describe sampling locations and measurements that will be made during the TS. The FSAP describes the field procedures associated with the PDI Work Plan. The PDI sampling design is judgmental and will be based on historical information/data and real-time measurements collected in the field using direct sensing methods. The objective of the PDI sampling design is to determine the distribution of VOCs and permanganate NOD in the Northern Area so that the TS and full-scale interim remedy can be appropriately designed.

Information will initially be obtained from six Site monitoring wells (MW-5, MW-5A, MW-6, MW-6A, MW-7, and MW-7A). The depth to water will be measured in six Site monitoring wells so the water table elevation in the area of the PDI is known.

Boring locations will initially be generally based on a grid pattern, but boring locations might be modified in the field to maximize the investigation at determining the distribution of contaminants. Direct sensing borings were advanced in the Northern Area during the NAPL Investigation conducted in 2013 and 2014 and an approximate 100-foot grid spacing was implemented. Borings for the PDI will be located approximately half-way between borings advanced during the NAPL Investigation. Direct sensing information gathered from the NAPL Investigation will also be evaluated in the PDI. Therefore, the grid-spacing for the PDI will essentially be 50 feet. Boring/sampling locations might also be modified due to the presence of access barriers, as described in Section 2.4.4 herein. Modifications to boring/sampling locations will be documented in the field logbook.

Soil and groundwater samples will be collected adjacent to direct sensing boring locations generally where the highest contamination is suspected/identified based on qualitative data. The samples will be analyzed for VOCs to determine constituent concentrations. Data obtained from the MIP investigations will be used to determine where and at what depth to collect groundwater samples. Up to ten soil and ten groundwater samples will be collected.

Soil samples will be collected from various areas to determine the permanganate NOD throughout the remediation area. The permanganate NOD will vary based on soil type and the presence of organic materials, so samples will be collected based on observations of soil type and potential organic materials present. Up to 20 soil samples will be collected for permanganate NOD testing.

3.1.1 Sampling Methods

The following methods are proposed for the RDWP, and are described in the FSAP:

- Depth to groundwater in monitoring wells (FSAP Section 5.1).
- Direct sensing method: MIP for qualitative identification and magnitude of chlorinated VOCs (FSAP Section 5.2)
- Collection of soil and groundwater samples for off-Site laboratory analysis (FSAP Sections 5.4 and 5.5)

Field equipment for the project includes:

- Water level meter (depth to water)
- DPT rig with the capability to advance macro-core samplers and MIP
- Direct sensing equipment, which generally includes a probe/sensor, trunkline (delivers data and fluids from ground surface to the probe), controller (controls pressure, flow, as appropriate to probe), a detector system, and a data acquisition system/computer
- PID
- Pumps for collecting groundwater samples
- Water quality meter
- Surveying/GPS equipment

Field supplies for the project include:

- FDRs and log books

- Personal protective equipment, as specified in the HASP
- Measuring tapes (engineers scale)
- Stainless steel spoons
- Shipping containers (coolers)
- Ice (shipment of samples to Pace)
- Packing tape (shipment of samples)
- Black ink pens
- Digital camera
- Calibration solutions/gases (supplied with rented equipment)
- Decontamination soap
- Organic-free water
- Sample containers
- Pump tubing
- Trash bags and Ziploc®-type bags

Support supplies/equipment include:

- Sampling table (portable)
- Vehicles for personnel and sample transport
- Safety supplies
- Drums for investigative derived waste (IDW)
- Buckets for purge water or miscellaneous storage/transport of field supplies
- Fire hydrant meter (for obtaining potable water from hydrant)
- Plastic sheeting (for placement on ground if there is the potential for release of contaminated media during sampling, etc.)

Sample collection procedures are described in the FSAP. Sample information (e.g., analysis method, preservation, volume, hold time, etc.) is summarized in Table 3.

Measurements made in the field will be recorded on FDRs. Direct sensing data will be uploaded daily to a secure host server and Amec Foster Wheeler will download the data and save it on the Amec Foster Wheeler server.

3.1.2 Equipment Decontamination Procedures

Decontamination procedures will be employed to reduce the potential for cross contamination between sampling locations. Equipment decontamination procedures are described in Section 6.0 of the FSAP.

3.1.3 Management of Investigative Derived Waste

The management of investigative derived waste is described in Section 7.0 of the FSAP.

3.1.4 Field Sampling Documentation

Documentation of field activities will be completed using a combination of logbooks, FDRs, and sample custody records. A Site logbook will be completed to provide a general record of activities and events that occur during each field task. FDRs have been designed for exploration or sample collection tasks to provide a record of data obtained during the activity. Examples of FDRs that will be used during the PDI are included as Appendix C.

Deviations from the procedures specified in the QAPP and the FSAP will be documented in the field logbook and applicable FDRs. Such deviations may be dictated by Site-specific conditions encountered during the sampling activity.

3.1.4.1 Field Logbooks

The field logbooks provide a daily hand written account of all field activities. Logbooks will be permanently bound and entries will be made in permanent black or blue ink, and corrections will be made with a single line with the author's initials and date. Each page of the logbook will be dated and signed by the person completing the log. Partially completed pages will have a line drawn through the unused portion at the end of each day. The following information will generally be entered into the field logbooks:

- Project name and number
- Date and time of each entry
- Weather conditions anticipated for the day, or as weather conditions change
- Site personnel
- Descriptions of important tasks or subtasks
- A description of samples collected (if not documented on a FDR)

- Documentation of equipment maintenance and calibration activities (if not documented on a FDR)
- Documentation of equipment decontamination procedures
- A summary of problems encountered during the day, including cause of problem and corrective actions implemented, if appropriate

3.1.4.2 Field Data Records

Field data records contain sample collection and/or exploration details. Examples of FDR forms anticipated to be used during implementation of the Work Plan are contained in Appendix C. FDRs will be completed in the field by field personnel at the time testing/sampling is performed. The goal of the FDR is to document exploration and sample collection methods, materials, dates and times, and sample locations and identifiers. Field measurements and observations associated with a given exploration or sample collection task are recorded on the FDR. FDRs will be maintained throughout the field program in files that become a permanent record of field program activities. A listing of FDRs anticipated for the PDI is presented below. Additional FDRs may be developed to the TS.

- Depth to water measurement in monitoring wells
- Groundwater purging/sampling record
- Soil boring record
- Instrument calibration record
- Drum management record
- Sample/boring record (summary for project)

3.2 SAMPLE HANDLING AND CUSTODY

The following sections describe how samples will be identified, contained, packaged, transported, and tracked during sampling and analysis activities. The FOL will maintain the field log book and will be responsible for sample custody in the field.

3.2.1 Sample Designation

Multiple borings and samples might be collected from a similar location (i.e., within a 10 square foot area); therefore, a “common” location numbering system will be used so that the data collected from each location can be correlated.

Borings that are advanced for the purpose of direct sensing applications will be designated as MIP-YY, where YY is the sequential location number (for example, MIP-35 is a MIP boring at location 35) starting at 73, which is one number after the last sequential boring number used during the NAPL Investigation. Soil borings advanced adjacent to the direct sensing borings for the purpose of collecting soil and/or groundwater samples will be designated as SB-YY, with YY being the sequential location number of the corresponding direct sensing boring number.

Soil and groundwater samples will be identified using the common location number, as well. Soil sample will be designated as SS-YY-ZZ with YY being the sequential location number and ZZ being the approximate depth of the sample in feet measured from ground surface. The designated depth will be a whole number value that represents the depth of the approximate center of the soil sample. Groundwater samples will be designated as GW-YY-ZZ with YY being the sequential location number and ZZ being the approximate depth of the center of the interval from which the groundwater sample was collected. Groundwater samples collected from existing monitoring wells will be identified using the monitoring well identification (e.g., MW-6).

The soil and groundwater sample data will be recorded on FDRs or in the field logbook with sample designation information while in the custody of the sampling team. A sample label will be completed and attached to each sample container for every sample collected. Labels will consist of a waterproof material backed with a water-resistant adhesive. Labels will be completed using waterproof ink, and will contain at least the following information:

- Project name
- Date and time of sample collection
- Sample identification number
- Preservatives, if applicable
- Sampler’s initials
- Analysis to be conducted

Each sample submitted for analysis at the laboratory will be identified with a unique identification number (sample ID). These sample IDs will be tracked from collection through laboratory analysis and into the final reports. The sample ID will be cross-referenced with the sample location on the chain-of-custody (COC) form.

The field QC samples will be cross-referenced on the sample FDRs or in the field log book. The QC samples will have a prefix identifying their purpose, followed by a sequential number, as follows:

- FD-01 (field duplicate)
- EB-01 (equipment rinse blank)
- MS/MSD-01 (matrix spike/matrix duplicate)
- TB-01 (trip blank)

The numbing will begin at one number after the last sequential number used during the NAPL Investigation.

3.2.2 Sample Collection and Preservation

Sample container and preservation requirements for samples submitted for analysis are summarized in Table 2. Sample container requirements are based on specifications from the referenced analytical methods. Samples for analysis of VOCs will be collected in laboratory-supplied containers. Samples for analysis of permanganate NOD will be collected in containers obtained from a laboratory-supply company.

3.2.3 Sample Packaging and Shipment

Sample containers will be sealed in bubble-wrap and/or plastic sealable bags and placed into an iced cooler for shipment to the laboratory. The contents of the cooler will be placed in a plastic bag to minimize leakage of water from the cooler. Containers will be packed tightly so that movement of the containers is minimized. Appropriate packaging materials (e.g., Styrofoam, “bubble wrap”) will be used if needed. Ice will be placed in the cooler, generally around the sample containers, so that the samples are maintained at 4 degrees Celsius (^{o}C) [+/- 2^{o}C]. The COC will be placed in a sealable plastic bag and affixed to the underside of the cooler lid, if the cooler is being shipped to the laboratory. The cooler will be securely closed with packaging tape to prevent the cooler from opening during transport.

Custody seals, which are preprinted, adhesive-backed seals designed to break if disturbed, will be placed on the cooler prior to shipment to provide security. The custody seals will be signed and dated before leaving Amec Foster Wheeler’s possession. Upon receipt by the laboratory, the sample custodian will confirm that the seals on coolers are intact or notify the Project Manager or FOL if any custody seals have been broken.

Regulations for packaging, marking/labeling and shipping hazardous waste materials and waste are issued by U.S. Department of Transportation (USDOT). Air carriers which transport hazardous material, such as Federal Express, may also require compliance with the current edition of the International Air Transport Association (IATA) Dangerous Goods Regulations. Current IATA Regulations will ensure compliance with USDOT protocol.

3.2.4 Chain-of-Custody Records

The COC will be placed in a sealable plastic bag and affixed to the underside of the cooler lid when being shipped to the laboratory. An example of the Pace COC is included in Appendix C. The FOL will retain a copy of the COC. The custody record will include the following information:

- Name of person collecting the samples
- Date and time samples were collected
- The media sampled
- Type of sampling conducted (composite/grab)
- Sample ID
- Number and type of containers used
- Sample preservation notes
- Analyses requested
- Signature of the sampling person relinquishing samples to a non-sampling person (such as a Federal Express agent or laboratory courier), with the date and time of transfer

In addition, if samples are known to require expedited turnaround in the laboratory due to project time constraints or analytical concerns such as extraction time or sample retention period limitations, the person completing the COC record will note these constraints in the remarks section of the custody record and will notify the Laboratory Project Manager of the expedited turnaround requirement.

3.2.5 Laboratory Custody Procedures

Information regarding the laboratory's sample receipt, handling and custody procedures are presented in the Pace's Quality Assurance Manual (Pace QAM; Appendix B, Section 2.0). Below is a brief overview of lab custody procedures.

Upon arriving at the laboratory, samples are logged in by a designated sample custodian giving each sample a unique ID code. Sample receipt protocols and storage conditions include the following:

- Determine if the temperature requirement has been maintained during shipment, notifying the Laboratory Project Manager if the temperature requirements have not been maintained, and documenting on the cooler receipt form and COC.
- Verify samples received are listed in the COC. Notify Laboratory Project Manager if not listed.
- Verify appropriate sample preservation.
- Verify all sample holding times have not been exceeded. Notify Laboratory Project Manager if hold times have been exceeded.
- Examine shipping records for accuracy and completeness.
- Sign COC and attach the waybill.
- Note any other problems with the coolers and samples on the cooler receipt form, specifically with preservation and contact the Laboratory Project Manager if problems are identified.
- Log samples into the Master Logbook and into the Laboratory Information Management System, and attach the laboratory sample numbers to each sample bottle.
- Place the samples into proper laboratory storage.

The Laboratory Project Manager will send a copy of the laboratory sample receipt form via email to the Amec Foster Wheeler Project Manager, or an acceptable representative, and Amec Foster Wheeler will verify that the samples were received intact and properly preserved. The laboratory will also generate an intra-lab COC that will be maintained while the samples are being analyzed and remain in custody of the laboratory. This ensures that the samples are maintained at the proper storage temperature, and that the sample integrity is maintained through adequate protection from contamination from outside sources or from highly contaminated samples.

Holding times are the responsibility of the laboratory for samples received within 48 hours of sampling or if less than half of the holding time has passed. If a holding time is exceeded, the laboratory will identify and document the root cause of the failure, and will contact the Laboratory Project Manager.

3.3 ANALYTICAL METHODS

The following sections outline the analytical methods that will be used during implementation of the RDWP. The analytical method holding times, containers, and preservation requirements are summarized in Table 2. The method analytes and associated laboratory reporting limits are contained in Table 1 (VOCs). Table 3 contains a summary of the project quality control limits.

3.3.1 Volatile Organic Compounds

Target Compound List (TCL) VOCs in water matrices and associated QC samples will be analyzed by USEPA Method 8260B or latest version. The VOCs are introduced into the gas chromatograph by purge-and-trap Method 5030 (aqueous samples) and Method 5035 (solid samples). Analytes eluted from the capillary column are introduced into the mass spectrometer. Identification of target analytes is accomplished by comparing their mass spectra with the electron impact spectra of certified standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard with a five-point calibration curve.

3.3.2 Permanganate Natural Oxidant Demand

Soil samples will be analyzed according to ASTM Method D 7262-07 Test Method A to determine the 48-hour permanganate NOD. Samples are dried at 105°C for 24 hours, blended, and passed through a U.S. 10 sieve (2 millimeters). Reactors (250-milliliter glass bottles) are loaded in triplicate with 50 grams of soil and 100 milliliters of 20 grams per liter (g/L) potassium permanganate. The reactors are initially mixed by inversion and allowed to react for 48 hours, after which residual permanganate concentration is measured. A control sample of the stock (20 g/L potassium permanganate) solution is used for blank determination for initial permanganate concentration. The permanganate NOD is expressed as the mass of potassium permanganate consumed per mass of dry soil.

3.4 FIELD QUALITY CONTROL

The field quality control program ensures that samples collected are representative of the media being sampled and that the data generated are valid. Field quality control criteria are summarized in Table 3. Field quality control will be accomplished through:

- Accurate record keeping in the field logbooks and FDRs.
- Proper calibration of field equipment according to manufacturer's instructions.
- Collection and analysis of QC samples potentially including field duplicates, equipment blanks, trip blanks, and matrix spike/matrix spike duplicate (MS/MSD) samples.

Problems that require corrective action may be encountered in the field. Findings that require corrective action will be communicated to the Project Manager and documented in the field log book. The Project Manager will confirm that corrective actions have been implemented and that the problem has been resolved. If more easily addressed problems are encountered in the field, such problems will be addressed and the corrective action noted in the field log book. If an error is made on an accountable document assigned to one individual, that individual will make all corrections by crossing a line through the error, entering the correct information, and initialing and dating the correction. The erroneous information will not be obliterated. The person who made the entry will correct any subsequent error discovered on an accountable document.

The following sections describe quality control samples that will be collected during implementation of the RDWP.

3.4.1 Field Duplicates

Field duplicates are two samples taken from the same location and depth/interval, but submitted to the laboratory under blind identification protocol and analyzed separately. Aqueous duplicates will be collected by alternately filling sample containers from the same sampling device for each parameter. Soil duplicate samples for VOCs will be collected at the same location within the soil core. As described in Section 3.3.2, collection of permanganate NOD duplicates is not necessary, as the test is conducted with three samples.

3.4.2 Equipment Blanks

A rinsate blank, commonly referred to as an equipment blank, is used to demonstrate the effectiveness of field cleaning/decontamination procedures. Contaminant-free water is poured over the equipment that has been cleaned in the field and is collected in the appropriate sample containers. One rinsate blank will be collected per week when non-dedicated sampling equipment is used (e.g., split-spoon sampler for collection of soil samples).

3.4.3 Trip Blanks

A trip blank is utilized to detect possible VOC contamination of samples to be analyzed for VOCs. VOCs are susceptible to contamination by introduction or migration of contaminants through the vial septum. Trip blanks will be prepared by filling volatile vials with purged organic-free water. The trip blanks will be prepared in the laboratory and will accompany the sample containers during transit, during sampling activities, and during storage with the collected samples prior to analysis. Trip blanks will be shipped with each cooler containing samples collected for VOC analysis.

3.4.4 Matrix Spike and Matrix Spike Duplicate Samples

Matrix spike and matrix spike duplicate (MS/MSD) samples are additional samples collected with the field samples, and spiked by the laboratory and analyzed according to standard laboratory procedures. They are collected at a frequency of one MS/MSD pair per twenty environmental samples of the same matrix. MS/MSD samples also provide field precision data.

3.5 LABORATORY QUALITY CONTROL

Laboratory performance for VOC analyses will be monitored by the inclusion of various internal QC checks that allow an evaluation of method control (batch QC) and the effect of the sample matrix on the data being generated (matrix-specific QC). The overall data quality indicators (DQIs) are to implement procedures for the laboratory analysis and reporting of the data that are indicative of the degree of quality consistent with their intended use. Laboratory batch QC samples consist of method and instrument blanks, LCSs, and calibration verification samples. Matrix specific QC samples consist of

MS/MSDs, sample duplicates, and the use of surrogate compounds and internal standards. Pace's QC procedures are included in Section 4.0 of their QAM (Appendix B).

3.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

Maintenance and inspection of field and laboratory equipment are described in the following sections.

3.6.1 Field Equipment

Preventative maintenance of field measurement instrumentation and equipment will be performed according to the procedures presented in the manufacturer's instructions. The field staff and/or subcontractors are responsible for ensuring instrumentation is operating properly prior to use. If problems are encountered, they will be communicated to the FOL and documented in the field logbook. The faulty instrumentation/equipment will be scheduled for repair and then sequestered and tagged until repaired and qualified for re-use.

3.6.2 Laboratory Equipment

Testing, inspection, and maintenance of laboratory instruments/equipment will be conducted in accordance with the procedures specified in Section 6.4 of Pace's QAM (Appendix B).

3.7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

General guidance regarding calibration and frequency of calibration of field and laboratory equipment are described in the following sections.

3.7.1 Field Equipment

Equipment that requires field calibration during the PDI include a PID meter, a water quality meter, and the direct sensing equipment (MIP). Proper maintenance, calibration, and operation of each instrument will be the responsibility of the sampling personnel assigned/subcontractor to a particular field activity. Instruments and equipment used during the field investigations will be maintained, calibrated, and operated according to the manufacturer's guidelines and recommendations. Relevant manuals will be kept with field sampling team personnel during the performance of field activities. Equipment will receive routine maintenance checks to minimize equipment breakdown in the field. Any items found to be inoperable will be taken out of use and a note stating the time and date of this action will be made in the daily field records.

A water level meter will also be used during the PDI. The meter will be rented from an environmental supply company that will conduct a verification check on the instrument prior to shipping for use. The verification records will be reviewed to ensure that the instrument is operating to within the specified accuracy of the instrument.

3.7.1.1 PID Meter Calibration

A PID meter will be used to scan soil cores that are retrieved during soil and groundwater sampling. The PID will be calibrated daily when being utilized. A post-operation verification check will be conducted at the end of the day after use, or more frequently if erroneous readings are suspected. If the verification check indicates the PID meter is out of calibration (within 10 percent of the standard, as described below) the PID will be recalibrated.

The PID will be calibrated using a two-point calibration. One point will be ambient air that contains no detectable VOCs (i.e., zero parts per million; ppm) and the second point is a standard reference gas (isobutylene) of known concentration (i.e., 100 ppm). The PID's computer has a set of known/pre-programmed gases and concentrations, so isobutylene (100 ppm) will be selected for calibration. The calibration will be verified after the two-point procedure. The calibration will be acceptable when the fresh air concentration is within 5 ppm of zero, and the gas concentration is within 10 percent of the standard gas concentration. Calibration information will be recorded on the Field Instrument Calibration Record included for reference in Appendix D.

3.7.1.2 Water Quality Meter Calibration

A water quality meter will be used to monitor water quality parameters during groundwater purging prior to collection of a groundwater sample. The objective of the purging is to collect a groundwater sample that is representative of groundwater at that location, as described in Section 5.6 of the FSAP. The water quality meter will be calibrated daily prior to use. A post-operation verification check will be conducted at the end of the day after use, or more frequently if erroneous readings are suspected. If the verification check indicates the water quality meter is out of calibration (as described below) the PID will be recalibrated.

A water quality meter that measures pH, conductivity, temperature, dissolved oxygen, and oxygen reduction potential will be used. The water quality meter will be calibrated in accordance with the manufacturer's instructions. Calibration information will be recorded on the Field Instrument Calibration Record included for reference in Appendix C.

3.7.1.3 Direct Sensing Equipment Response Testing

Response tests will be performed on the direct sensing equipment. The results of the response tests will be compared to the manufacturer's acceptance criteria for proper operation of the equipment. The response tests for the MIP is described in Section 5.2 of the FSAP.

3.7.2 Laboratory Equipment

The calibration of laboratory instruments and support equipment is necessary to ensure that the analytical system is operating correctly and functioning within the guidelines of precision, accuracy, and sensitivity. The frequency and type of calibration for laboratory equipment/procedures and control limits/acceptance criteria are presented the laboratory quality plans.

Reference standards are used to calibrate the equipment. Physical reference standards include weights for scales and balances, and certified thermometers for calibrating working thermometers. Chemical reference standards include reference materials traceable to recognized standards suppliers, and are generally associated with normal instrument calibrations. The standards must be verified by quantitation against a second known standard before the data is reported, and must meet specified QC criteria for calibration verification.

At minimum, the laboratory equipment must be calibrated and maintained at intervals prescribed by the analytical method. An instrument is said to be calibrated when an instrument response can be directly related to the concentration of an analyte graphically through the use of a calibration curve. The low standard of the curve shall be established by the laboratory as the PQL. Results above the highest standard will be diluted into the calibration range and reanalyzed.

Laboratory calibration procedures are described in Section 6.2 of Pace's QAM (Appendix B).

3.8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Supplies and consumables that are anticipated to be used during water supply monitoring program are described in Section 3.1.1 herein. Sample containers will have certification papers for each lot that is used. The field samplers will inspect containers to verify that containers are not broken and that caps fit securely. If dirt or foreign material is observed in the container, they will be replaced with a new container. The remaining supplies (i.e., those presented in Section 3.1.1 herein) will be accepted based on the judgment of the field personnel.

Project team members obtaining supplies and consumables are responsible for confirming that the materials meet the required specifications, are intact and in good condition, are available in adequate supply, and are stored appropriately until use. Project team members will direct any questions or any identified problems regarding supplies and consumables to the FOL for resolution.

Environmental equipment (water level meter, water quality meter, PID, and pumps) will be rented from an environmental equipment supplier, and calibration solutions will be requested with the rented equipment that requires field calibration (e.g., water quality meter and PID). Calibration solution certifications will be reviewed to ensure that they are at the concentration ranges specified for the project and that they are within their expiration dates. Certification records will be maintained in the project files. Calibration acceptance criteria are indicated on the calibration record in Appendix C.

3.9 NON-DIRECT MEASUREMENTS

For the purposes of the PDI, non-direct measurements will include information/data from previous investigation reports, such as well construction information and direct sensing data from the NAPL Investigation. This information will be appended to non-direct measurements to ensure data quality is communicated and understood before use.

3.10 DATA MANAGEMENT

The objective of data management is to establish procedures to be used during field investigations for documenting, tracking, and presenting investigative data. Data generated during the field investigations, as well as previously existing data, form the basis for developing conclusions and recommendations. Efficient utilization and comprehensive consideration of available data requires that the data be properly organized for review. Organization of the data will be planned prior to collection to assure the generation of identifiable and useable data. This section describes procedures necessary to provide for collecting sufficient data to accurately validate raw data and to transfer validated data to a data management system through which it can be evaluated with minimal effort. This section also describes the operating practices to be followed by personnel while collecting and reporting data.

3.10.1 Field Investigation Data

The following data will be collected in the field and maintained in the project file:

- A summary spreadsheet of data collected for each boring/location
- Well measurement information (depth to water measurement)
- Soil boring logs containing:
  - Soil descriptions
  - PID measurements
  - Identification of soil and/or groundwater samples collected, if applicable
- Instrument calibration information
- Direct sensing data
- Photographs

The flow of data for the project will be as follows:

- Field data records, including COCs, will be forwarded to the FOL, if collected by others.
- Direct sensing data will be uploaded daily for review by the FOL.
- Soil and groundwater samples will be sent directly from the field to the selected laboratory.

- Laboratory results, including EDDs and hard copies, will be sent to the FOL; the FOL will forward the laboratory results, including EDDs to the Quality Assurance Manager.
- The Project Chemist will perform data validation with oversight by the Quality Assurance Manager. The validated data will be transferred in electronic format to the FOL.

3.10.2 Off-Site Laboratory Data (Pace)

The laboratory will provide a hardcopy analytical report to document the chemical testing and report analytical results. Data deliverables will include sample result and QC summary forms and all supporting raw data needed to verify sample results. For USEPA SW-846 methods used in this investigation, forms similar to those defined under the USEPA Contract Laboratory Program (CLP) deliverables will be required. The laboratory can use customized reporting forms providing they contain equivalent information as CLP forms.

At a minimum, the data packages from Pace will include the following:

- Data package narrative
  - summary of analytical methods used
  - correlation of field sample identifications and laboratory sample identifications
  - data qualifier definitions
  - deviations from established QA/QC procedures with corrective action
- Sample results
  - project name
  - field sample identification
  - lab ID
  - unit of measurement
  - batch number
  - collection/extraction/analysis dates
  - detection limits
  - dilution factors
  - percent moisture
- Sample documentation
  - original chain-of-custody
  - shipping documents
  - cooler receipt forms
- Quality Assurance/Quality Control

  - spike recoveries (surrogates/deuterated monitoring compounds, MS/MSDs, LCSs)
  - internal standard summary
  - initial calibration summaries
  - GC/MS tuning summaries
  - continuing calibration summaries
  - QC blank summaries
  - CLP Form 10 – dual column summary (applicable GC methods)
  - measures of precision (laboratory duplicates, MS/MSDs)
  - control limits for accuracy and precision

- Raw data including instrument printouts (analytical sequence/acquisition files, chromatograms and quantitation reports), instrument logbook pages, and sample preparation logs

Sample results will be provided by the laboratory in electronic format. Laboratory reports and EDDs from the laboratory will be transmitted to the Amec Foster Wheeler Data Manager and Project Chemist. The electronic data will be provided in a format described in Table 4. Electronic lab results will be imported into the Amec Foster Wheeler TED. Files of the unvalidated electronic data are provided to the Project Chemist for use during data validation. The project chemist will make any necessary data qualification and changes based on the data validation review, and qualified results are entered back into the TED database. During data validation a quality assurance review of sample results will be completed to ensure that the data in the database match the hard copy provided by the laboratory.

Final validated laboratory data will be maintained in the TED database to allow easy retrieval of information and electronic transfer of the data to other parties. Once final data are entered into the TED and validation is completed, data reports will be generated as needed to support contamination assessments and report preparation. A data validation report will be prepared and will be organized by sample collection task and might include multiple sample delivery groups (SDGs). The validation report(s) will include the following information:

- Introduction
  - description of sampling task
  - identity of the laboratory used for analysis
  - a summary of analytical methods
  - a table summarizing summary of SDGs and samples are included in the report
  - a description of the data validation process

    - a table summarizing project QC limits

- Validation actions and observations
    - a discussion of data validation actions, qualifications, and observations
    - a table summarizing all data qualification actions
    - a tabulation of validated samples results

- References cited

Upon completion of the field investigation and subsequent validation of off-Site laboratory data, an EDD will be prepared with relevant field information and laboratory data in the format specified for environmental data in the USEPA Region 4 SESD R4DART database. This database is the USEPA Region 4 repository for storing Superfund data, which includes location, geological, and analytical data. Data will be submitted in accordance with the Environmental Data Submission Guideline SESDGUID-106-RO (USEPA, 2010).

4.0 ASSESSMENT AND OVERSIGHT

Internal and external checks (assessments) have been built into this project to assure the following:

- Elements of this QAPP have been properly implemented as prescribed.
- The quality of the data generated is adequate and satisfies the DQOs and DQIs that have been identified in this QAPP.
- Corrective actions, when needed, are implemented in a timely manner and their effectiveness is confirmed.

Formal audits are not planned for this project. The FOL will provide training and oversight to field crews and review field records on a daily basis to verify that sample collection procedures and record keeping steps are being completed in accordance with the FSAP and QAPP. The USEPA may complete reviews and audits of the field sampling events at any time during the monitoring program.

If deviations from the Work Plan, this QAPP, or the FSAP are identified, the information will be verbally reported to the Project Manager and noted in the field logbook. Based on the severity of the deviation, the Project Manager might request formal documentation of the deviation in the form of a memorandum to the project file. The Project Manager will determine the timeframe required for corrective action, if corrective action is necessary. Corrective actions will be completed and an assessment of the potential impact on data quality will be made. Project reviews and summaries of issues requiring corrective actions will be summarized in the Site logbook. If potential impact to data quality is identified, a summary of the issues, corrective actions, and impacts to data will be provided to the Quality Assurance Manager for use during the validation of the analytical data.

5.0 DATA VALIDATION AND USABILITY

Data validation involves reviewing and accepting, qualifying, or rejecting data based on requirements in the referenced analytical methods, data validation guidelines, and QC goals established for this project in Section 2.5 herein. Data validation for VOC analyses will be based on procedures in the USEPA Region 4 guidelines (USEPA, 2016). Validation guidelines will be modified based on USEPA SW-846 methods used in this investigation. Project QC limits identified in Table 3 will be used to evaluate sample results during validation. Validation will be performed by the Project Chemist, under the direction of the Quality Assurance Manager.

Data validation will consist of a systematic review of the analytical results and associated QC methods and results. In any area not specifically addressed by USEPA guidelines, best professional judgment will be utilized and described in the Usability Assessment portion of the data validation report.

In general, data validation will include a check of data completeness for data in each data package, a transcription check for sample results, and a thorough review of laboratory reporting forms. Specifically, this review will include the following:

- Data package completeness
- Required reporting summary forms to determine whether the QC requirements were met and to determine the effect of QC requirements on the precision, accuracy, and/or sensitivity of the data
- Additional QA/QC parameters, such as field duplicates and rinsate blanks to assess the technical usability of the data
- Application of standard data quality qualifiers to the data

In addition, each data validation effort will include a comprehensive review of the following data quality indicators:

- Sample collection, preservation, and holding times (to assess potential for degradation that could affect accuracy)
- Blanks (to assess cross-contamination)
- System monitoring compounds (to assess method accuracy)
- Laboratory Control Samples and MS/MSD samples to assess accuracy of a method and precision of the method relative to the specific sample matrix, if applicable)

- Instrument tuning and calibration
- Compound quantitation limits and method detection limits (to assess sensitivity compared to project-specific requirements)
- Field duplicate relative percent differences (to assess precision of the method relative to field sampling techniques, the specific sample matrix, and representativeness of the sample aliquot to the area sampled, if applicable)

Full validation including raw data verification and calculation checks will be completed on ten percent of the samples. If during full validation, significant errors are discovered in the QC summary forms, calculations, or data reporting, full validation will be performed on a larger subset of data packages and raw data will be examined.

Analytical results may be qualified by the data validator based on actions described in the USEPA validation guidelines or professional judgment. Results may be accepted without qualification or with validation qualifiers (e.g., U, J, UJ, N). Results that don't meet minimum criteria for acceptance (i.e., qualified as rejected during validation) will be unacceptable for decision making purposes. At a minimum, data rejection criteria identified in the USEPA validation documents will be applied to results.

The following validation qualifiers may be applied to sample results:

- U = target analyte is not detected above the associated detection limit
- J = the reported sample concentration is an estimate value
- UJ = the reported quantitation limit is an estimated value
- N = there is uncertainty in the identification of the reported analyte
- R = constituent rejected and unusable for detect and non-detects

The results of the data validation and any corrective actions implemented will be recorded on a QA/QC worksheet, which will be initialed and dated by the data reviewer. The Quality Assurance Manager or appropriate designee will provide secondary review of the QA/QC worksheet and will also initial and date the worksheet. The initialed and dated QA/QC worksheet will be attached to the final analytical laboratory report that is retained in the project files.

Results will be qualified using general procedures described in the USEPA validation guideline and the judgment of the project chemist. Upon completion of the validation task, a report will be prepared. Validation reports will be organized by sample collection task and may include multiple sample delivery groups. The validation report(s) will include the following information:

- Identity of the laboratory used for analysis
- A summary of analytical methods
- A summary of samples that are included in the sample set
- A discussion of data validation actions, qualifications, and observations
- A tabulation of validated samples results

Qualifiers applied to the data during validation will be entered into the electronic data deliverables in the database.

6.0 RECONCILIATION OF DATA TO PROJECT OBJECTIVES

At the end of the project there will be an assessment of field records, field data, laboratory analytical data usability, and project completeness to determine if project objectives defined in the FSAP and QAPP have been met. The FOL and Project Manager will review field records and reports to verify completeness of field records and identify any issues regarding project procedures, collection of field data that did not meet quality objectives, the completeness of the samples collected, or corrective actions. A review of the data validation report associated with the laboratory data will also be completed by the Quality Assurance Manager in cooperation with the FOL and Project Manager to identify data that is qualified. An assessment of impacts from field issues or data qualification actions will be performed and documented in a data usability report. Impacts might include identification of entire samples or a subset of analytes where data are considered unusable. In other cases, uncertainties in the accuracy of usable data might be identified.

In the PDI Evaluation Report, a data quality and completeness summary will be provided that identifies data gaps or analytical data quality issues that are identified in field operation reports or analytical data validation reports. The following items will be included in the data usability summary:

- Field investigation scope modifications
- Field investigation data quality issues
- Field investigation data gaps (data that was planned for collection and not obtained)
- Field and analytical data completeness
- Analytical data validation qualification actions and impacts on data usability
- Analytical detection limits and impacts on data usability

The need for recollection of sample or other actions related to the data usability will be determined on a case by case basis with input from the USEPA Project Manager.

7.0 REFERENCES

Amec Foster Wheeler, 2014. NAPL Investigation Report, CTS of Asheville, Inc. Superfund Site, EPA ID: NCD003149556 May 5, 2014.

Amec Foster Wheeler, 2015. Final NAPL Area Focused Feasibility Study, CTS of Asheville, Inc. Superfund Site, EPA ID: NCD003149556 September 10, 2015.

USEPA, 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA-G4), EPA/240/B-06/001, February 2006.

USEPA, 2016. USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review, USEPA 540-R-2016-02, OLEM 9355.0-134, September 2016.

USEPA, 2010. Environmental Data Submission Guideline, Science and Ecosystem Support Division, Athens, GA; SESDGUID-106-RO, December 17, 2010.

TABLES

TABLE 1
Laboratory Reporting Limits for VOCs
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Analyte	Water			Soil		
	PQL	MDL	Units	PQL	MDL	Units
Acetone	25	10.00	ug/L	100	10	ug/kg
Benzene	1	0.25	ug/L	5	1.6	ug/kg
Bromochloromethane	1	0.17	ug/L	5	1.7	ug/kg
Bromodichloromethane	1	0.18	ug/L	5	1.9	ug/kg
Bromoform	1	0.26	ug/L	5	2.3	ug/kg
Bromomethane	2	0.29	ug/L	10	2.5	ug/kg
2-Butanone (MEK)	5	0.96	ug/L	100	2.9	ug/kg
Carbon disulfide	2	1.15	ug/L	10	3	ug/kg
Carbon tetrachloride	1	0.25	ug/L	5	2.6	ug/kg
Chlorobenzene	1	0.23	ug/L	5	1.9	ug/kg
Chloroethane	1	0.54	ug/L	10	2.4	ug/kg
Chloroform	1	0.14	ug/L	5	1.6	ug/kg
Chloromethane	1	0.11	ug/L	10	2.4	ug/kg
Cyclohexane	1	0.36	ug/L	5	1.6	ug/kg
1,2-Dibromo-3-chloropropane	2	2.00	ug/L	5	3.6	ug/kg
Dibromochloromethane	1	0.21	ug/L	5	1.8	ug/kg
1,2-Dibromoethane (EDB)	1	0.27	ug/L	5	1.8	ug/kg
1,2-Dichlorobenzene	1	0.3	ug/L	5	1.9	ug/kg
1,3-Dichlorobenzene	1	0.24	ug/L	5	2	ug/kg
1,4-Dichlorobenzene	1	0.33	ug/L	5	1.7	ug/kg
Dichlorodifluoromethane	1	0.21	ug/L	10	3.6	ug/kg
1,1-Dichloroethane	1	0.32	ug/L	5	1.5	ug/kg
1,2-Dichloroethane	1	0.24	ug/L	5	2.2	ug/kg
1,1-Dichloroethene	1	0.56	ug/L	5	1.8	ug/kg
cis-1,2-Dichloroethene	1	0.19	ug/L	5	1.4	ug/kg
trans-1,2-Dichloroethene	1	0.49	ug/L	5	1.9	ug/kg
1,2-Dichloropropane	1	0.27	ug/L	5	1.7	ug/kg
cis-1,3-Dichloropropene	1	0.13	ug/L	5	1.8	ug/kg
trans-1,3-Dichloropropene	1	0.26	ug/L	5	1.5	ug/kg
1,4-Dioxane (p-Dioxane)	150	78.36	ug/L	150	120	ug/kg
Ethylbenzene	1	0.3	ug/L	5	1.8	ug/kg
2-Hexanone	5	0.46	ug/L	50	3.9	ug/kg
Isopropylbenzene (Cumene)	1	0.4	ug/L	5	1.9	ug/kg
Methyl acetate	10	0.82	ug/L	10	1.4	ug/kg
Methylcyclohexane	10	1.87	ug/L	10	1.5	ug/kg
Methylene Chloride	2	0.97	ug/L	20	3	ug/kg
4-Methyl-2-pentanone (MIBK)	5	0.33	ug/L	50	3.7	ug/kg
Methyl-tert-butyl ether	1	0.21	ug/L	5	1.5	ug/kg

TABLE 1
Laboratory Reporting Limits for VOCs
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Analyte	Water			Soil		
	PQL	MDL	Units	PQL	MDL	Units
Styrene	1	0.26	ug/L	5	1.8	ug/kg
1,1,2,2-Tetrachloroethane	1	0.4	ug/L	5	1.9	ug/kg
Tetrachloroethene	1	0.46	ug/L	5	1.7	ug/kg
Toluene	1	0.26	ug/L	5	1.8	ug/kg
1,2,3-Trichlorobenzene	1	0.33	ug/L	5	2.2	ug/kg
1,2,4-Trichlorobenzene	1	0.35	ug/L	5	1.6	ug/kg
1,1,1-Trichloroethane	1	0.48	ug/L	5	1.8	ug/kg
1,1,2-Trichloroethane	1	0.29	ug/L	5	2.1	ug/kg
Trichloroethene	1	0.47	ug/L	5	2.1	ug/kg
Trichlorofluoromethane	1	0.2	ug/L	5	2.2	ug/kg
1,1,2-Trichlorotrifluoroethane	1	0.19	ug/L	5	1.9	ug/kg
Vinyl chloride	1	0.62	ug/L	10	1.8	ug/kg
m&p-Xylene	2	0.66	ug/L	10	3.6	ug/kg
o-Xylene	1	0.23	ug/L	5	1.9	ug/kg

Notes:
PQL - Pratical Quantitative Limit
MDL - Method Detection Limit
ug/L - micrograms per liter
ug/kg - micrograms per kilogram

TABLE 2
Sample Container, Preservation, and Holding Time Requirements
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

	Water					
Analysis	Preparation Method	Analysis Method	Container	Sample Volume	Preservative	Hold Time
VOCs	EPA 5030	EPA 8260B	VOA with Teflon®-lined septum	3 x 40 mL	HCl to pH<2; 4°C	14 days

	Soil					
Analysis	Preparation Method	Analysis Method	Container	Sample Volume	Preservative	Hold Time
VOCs	EPA 5035	EPA 8260B	Terracore Kit	3 x 5 grams 1 x 100 grams	2 vials with $NaHSO_4$; 1 vial with MeOH; 1 vial/jar unpreserved; 4°C	14 days
Permanganate NOD	ASTM D7262-07	ASTM D7262-07	250-mL glass jar with oxidant-resistant lid	600 grams	4°C	28 days

Notes:

VOCs - volatile organic compounds
NOD - natural oxidant demand
mL - milliliter
°C - degrees Celsius

$NaHSO_4$ - sodium bisulphate
MeOH - methanol
HCl - hydrochloric acid

Prepared By: SEK 3/30/17
Checked By: RMC 3/30/17

TABLE 3
Measurement Performance Criteria for Laboratory and Field Samples
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-12-2012

QC Sample	Analytical Group	Frequency	Data Quality Indicators	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S) or Analytical (A) or both
Method Blank	VOCs - EPA 8260	One per preparation batch	Accuracy/ Bias-Contamination (verify system is contaminant free)	Analytes ND above one-half the PQL and 1/10 the amount measured in a sample. No common laboratory contaminants detected greater than PQL.	A
LCS/LCD	VOCs - EPA 8260	One LCS/LCD pair per preparation batch per matrix	Precision and accuracy	VOCs Recovery: 70 - 130% RPD ≤ 30%	A
Surrogate Recovery	VOCs - EPA 8260	Every field and QC sample	Accuracy	VOC Recovery: 70 - 130%	A
MS/MSD	VOCs - EPA 8260	One MS/MSD pair per 20 field samples collected per matrix	Precision and accuracy	VOCs Recovery: 70 - 130% RPD ≤ 30%	A
Field Duplicate	VOCs - EPA 8260	One per 10 field samples collected per matrix	Precision	VOCs RPD ≤ 30% (soil and water)	S & A
Equipment Blank	VOCs - EPA 8260	When non-dedicated sampling equipment used, one equipment blank will be collected per day.	Accuracy/ Bias-Contamination (verify decontamination procedure)	Analytes ND above one-half the PQL; acetone and methylene chloride ND above PQL	S
Temperature Blank	VOCs - EPA 8260	Each cooler shipped to laboratory	Accuracy (verify correct temperature maintained during transport)	0 to 4 degrees Celcius	S
Trip Blank	VOCs - EPA 8260	One per cooler containing samples for VOC analysis	Accuracy/ Bias-Contamination (verify that cross-contamination has not occurred during transport)	Analytes ND above one-half the PQL; acetone and methylene chloride ND above PQL	S
Replicate Direct Sensing Borings	Visual Assessment	One replicate boring per 20 borings; locations will be biased to those borings where there are detections with direct sensing equipment	Precision	Professional judgement as to agreement between borings	S

Notes:

LCS - laboratory control sample
LCSD - laboratory control sample duplicate
MS - matrix spike
MSD - matrix spike duplicate
RPD - relative percent difference
VOCs - volatile organic compounds
ND - not detected
PQL - practical quantitation limit

Prepared By: SEK 3/30/17
Checked By: CSR 4/12/17

TABLE 4
Laboratory Electronic Data Deliverable Format
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Equis "EZEDD01" Field Name	data type	Required for "EDD"	Description	"TED" Table	"TED" Column
project_code	1 Text20	X	This field contains the internal project_code used by TED to identify a unique site. This will be provided to the lab on a per project basis.	Location	Site_id
sample_name	2 Text30	X	This field contains the sample number as written in the Analysis Request and Chain of Custody (AR/COC) form sent to the laboratory with the field samples for analysis. This is a unique number assigned to each sample by sampling personnel. For laboratory samples enter "LAB QC".	sample_collection	field_sample_id
sys_sample_code	3 Text20				
sample_date	4 Date	X	mm/dd/yyyy. Date sample was collected in the field. Date information must be identical with the date from the AR/COC form. Leave blank for lab samples. Year may be entered as yyyy.	sample_collection	field_sample_date
sample_time	5 Time				
analysis_location	6 Text2				
lab_name_code	7 Text10	X	Laboratory that performed the analysis.	sample_analysis	lab_id
lab_sample_id	8 Text20	X	Unique sample ID internally assigned by the laboratory.	sample_analysis	lab_sample_id
sample_type_code	9 Text10	X	Specifies sample type. For field samples, enter FS (regular environmental sample), otherwise, use values listed in the LOV. For example, normal field samples must be distinguished from laboratory method blank samples, etc.	sample_collection	qc_code
Lab_Del_Group	10 Text20	X	Tracking code used by the laboratory. Commonly called Sample Delivery Group (SDG).	sample_analysis	lab_sample_delivery_group
Lab_Batch_Number	11 Text20		Tracking number used by the laboratory to identify a group of samples analyzed in the same batch. This field, in conjunction with laboratory blank ID, is used to link the relationship between field samples and laboratory blank and other QC samples.		
lab_anl_method_name	12 Text35	X	Test method used in the analysis of the analyte.	sample_analysis	analysis_method
cas_rn	13 Text15	X	Unique analyte identifier. Use assigned CAS number when one is identified for an analyte. Tentatively Identified Compounds (TICs) and a number of other analytes are not assigned a standard CAS number. The laboratory is required to assign a UNIQUE identifier for all chemical_names.	sample_analysis_results	casno
chemical_name	14 Text60	X	Name of analyte or parameter analyzed.		

TABLE 4
Laboratory Electronic Data Deliverable Format
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Equis "EZEDD01" Field Name	data type	Required for "EDD"	Description	"TED" Table	"TED" Column
result_value	15 Text20	X	Must only be a numeric value. It is stored as a string of characters so that significant digits can be retained. Must be identical with values presented in the hard copy. Analytical result is reported left justified. Reported as the reporting_detection_limit for non-detects.	sample_analysis_results	lab_result
lab_qualifiers	16 Text7	X	Qualifier flags assigned by the laboratory.	sample_analysis_results	lab_qualifier
result_unit	17 Text15	X	This format assumes that the result value and detect limit have the same units.	sample_analysis_results	result_uom
result_type_code	18 Text10	X	Parameter list type. Valid Values = Targer analytes (TCL, TAL or TRG); Surrogates (SUR); and TICs	sample_analysis_results	result_type
detect_flag	19 Text2	X	Enter “Y” for detected analytes or “N” for non-detected analytes.	sample_analysis_results	report_hit_flag
reporting_detection_limit	20 Text20	X	Must only be a numeric value. Use the value of the Reported Detection Limit (RDL), Practical Quantitation Limit (PQL), or Contract Required Quantitation Limit. Value is stored as a string to retain significant figures. Unit of measure must be identical with result_unit value.	sample_analysis_results	detection_limit
dilution_factor	21 Text6	X	Must be a numeric entry. The factor by which the sample was diluted as part of the preparation process. If no dilution was done, enter the value 1. Value is stored as a string to retain significant figures.	sample_analysis	dilution_factor
sample_matrix_code	22 Text10	X	Code which distinguishes between different type of sample matrix. For example, soil samples must be distinguished from ground water samples, etc. Valid codes for HESE are "G" (gas), "L" (liquid), "S" (solid), and "P" (free or raw liquid product).	sample_collection	matrix
total_or_dissolved (or fraction)	23 Text1	X	Must be “T” for total metal concentration, “D” for dissolved or filtered metal concentration, or “N” for organic (or other) parameters for which neither “total” nor “dissolved” is applicable. Also, HESE requires "C" for TCLP and "S" for SPLP fractions.	sample_analysis	fraction
basis	24 Text10				
analysis_date	25 Date	X	mm/dd/yyyy. Date sample was analyzed.	sample_analysis	analysis_date
analysis_time	26 Time				
method_detection_limit	27 Text20				
lab_prep_method_name	28 Text35		Description of sample preparation or extraction method.	sample_analysis	prep_method_name
prep_date	29 Date	X	mm/dd/yyyy. This field is used to determine whether holding times for field samples have been exceeded.	sample_analysis	extraction_date

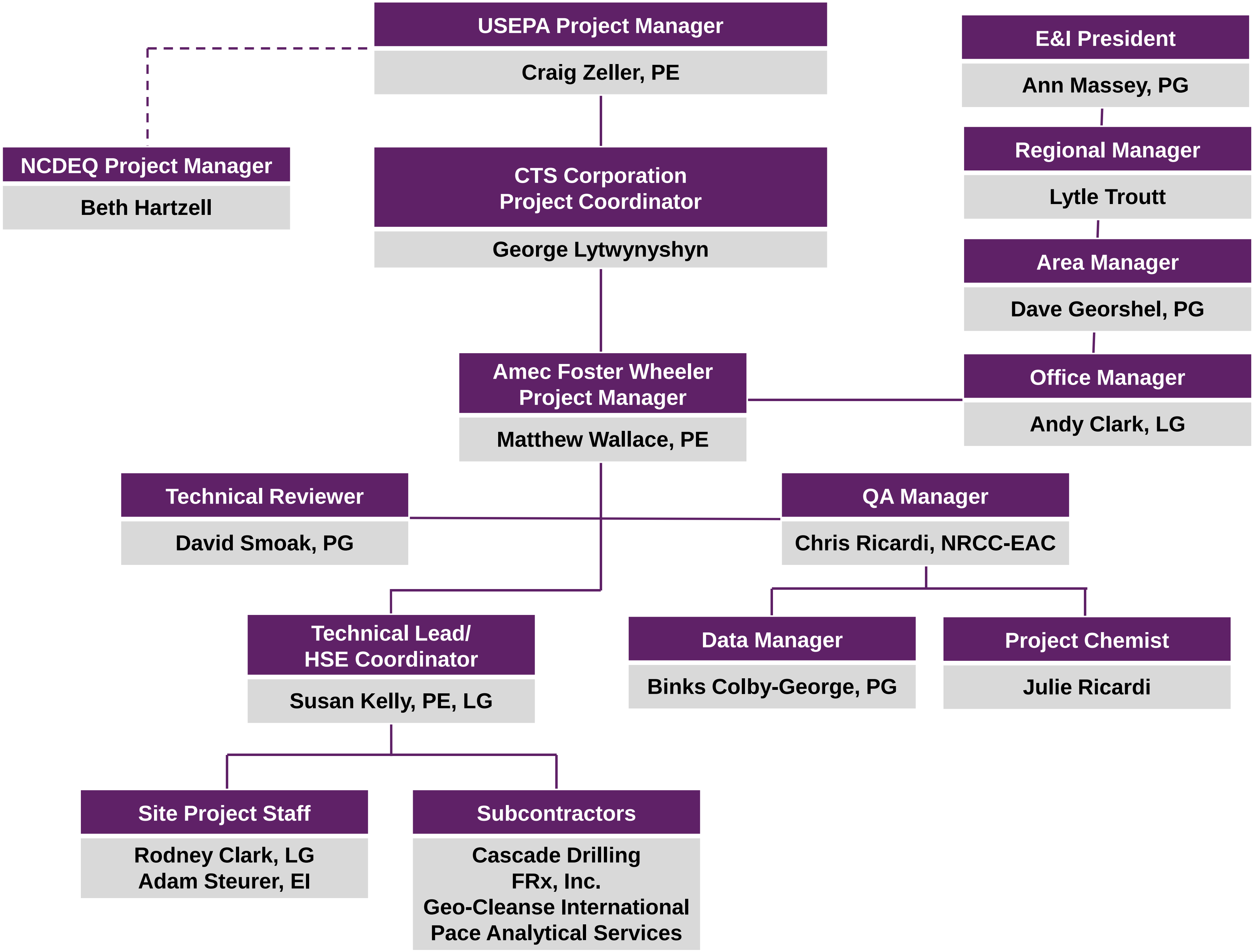
TABLE 4
Laboratory Electronic Data Deliverable Format
CTS of Asheville, Inc. Superfund Site
Asheville, North Carolina
Amec Foster Wheeler Project 6252-16-2012

Equis "EZEDD01" Field Name	data type	Required for "EDD"	Description	"TED" Table	"TED" Column
prep_time	30 Time				
test_batch_id	31 Text20	X	Default is 1 for primary results. Other valid values are 2, 3, 4, 5, and RE. Primary use is for reanalyses and dilutions where more than one result may be reported.	sample_analysis	run_id
result_error_delta	32 Text20				
TIC_retention_time	33 Text8				
qc_level	34 Text10		Laboratory QC level associated with the analysis	sample_analysis	qc_level
result_comment	35 Text255		Any comments related to the analysis.	sample_analysis_results	comments
sample_quantitation_limit (may be REQUIRED FIELD for certain projects)	36 Text20		Must only be a numeric value. Use the value of the Sample Quantitation Limit (SQL). Value is stored as a string to retain significant figures. Unit of measure must be identical with result_unit value.	sample_analysis_results	TBD

Note: All "X" marked fields are minimum data required to load data to "TED".

APPENDIX A

ORGANIZATION CHART



USEPA Project Manager
Craig Zeller, PE

NCDEQ Project Manager
Beth Hartzell

CTS Corporation Project Coordinator
George Lytwynyshyn

E&I President
Ann Massey, PG

Regional Manager
Lytle Troutt

Area Manager
Dave Georshel, PG

Office Manager
Andy Clark, LG

Amec Foster Wheeler Project Manager
Matthew Wallace, PE

Technical Reviewer
David Smoak, PG

QA Manager
Chris Ricardi, NRCC-EAC

Technical Lead/ HSE Coordinator
Susan Kelly, PE, LG

Data Manager
Binks Colby-George, PG

Project Chemist
Julie Ricardi

Site Project Staff
Rodney Clark, LG
Adam Steurer, EI

Subcontractors
Cascade Drilling
FRx, Inc.
Geo-Cleanse International
Pace Analytical Services

APPENDIX B

PACE ANALYTICAL SERVICES, INC. QUALITY ASSURANCE MANUAL

QUALITY ASSURANCE MANUAL

Quality Assurance/Quality Control Policies and Procedures

Pace Analytical Services – Carolinas

Asheville Laboratory
225 Riverside Dr
Asheville, NC 28808
(828) 254-7176

Charlotte Laboratory
9800 Kincey Ave, Suite 100
Huntersville, NC 28078
(704) 875-9092

Eden Laboratory
205 East Meadow Rd, Suite A
Eden, NC 27288
(336) 623-8921

Raleigh Laboratory
6701 Conference Drive
Raleigh, NC 27607
(919) 834-4984

Greenwood Laboratory
816 Durst Avenue East
Greenwood, SC 29649
(864)-229-4413

CORPORATE APPROVAL

Steve A. Vanderboom
President/CEO
1800 Elm Street, Suite 200
Minneapolis, MN 55414 (612) 607-6400

8-21-2015
Date

Richard M. Henson
Corporate Director of Quality
1800 Elm Street, Suite 200
Minneapolis, MN 55414 (612) 607-6400

8/21/2015
Date

LOCAL APPROVAL

Jeff Graham
Laboratory Senior General Manager

08/31/2015
Date

Felicia Grogan

Felicia Grogan
Laboratory General Manager

08/25/2015
Date

This is **COPY#** ____ Distributed on 9/21/15 by BKM and is ____ **CONTROLLED or** X **UNCONTROLLED**

08/24/2015

C. Barry Johnson
Date
Laboratory Quality Manager – Asheville, Eden, Raleigh, Greenwood

Cheryl Johnson
08/25/2015

Cheryl Johnson
Date
Laboratory Quality Manager – Charlotte

08/31/2015

William Billings
Date
Laboratory Technical Director – Asheville

08/24/2015

Elizabeth Culbertson
Date
Laboratory Technical Director – Greenwood

09/01/2015

Robert Hobson
Date
Laboratory Technical Director – Charlotte

Felicia Grogan
08/25/2015

Felicia Grogan
Date
Laboratory Technical Director – Eden

08/25/2015

Eric Setzer
Date
Laboratory Supervisor – Raleigh

Effective Date is the date of the last signature.

Table of Contents

1.0. INTRODUCTION AND ORGANIZATIONAL STRUCTURE

“Working together to protect our environment and improve our health”
Pace Analytical Services Inc. - Mission Statement

1.1. Introduction to PASI

1.1.1. Pace Analytical Services, Inc. (PASI) is a privately held, full-service analytical testing firm operating a nationwide system of laboratories. PASI offers extensive services beyond standard analytical testing, including: bioassay for aquatic toxicity, air toxics, industrial hygiene testing, explosives, dioxins and coplanar PCB’s by high resolution mass spectroscopy , radiochemical analyses, product testing, pharmaceutical testing, field services and mobile laboratory capabilities. PASI has implemented a consistent Quality System in each of its laboratories and service centers. In addition, the company utilizes an advanced data management system that is highly efficient and allows for flexible data reporting. Together, these systems ensure data reliability and superior on-time performance. This document defines the Quality System and QA/QC protocols.

1.1.2. Our goal is to combine our expertise in laboratory operations with customized solutions to meet the specific needs of our customers.

1.2. Statement of Purpose

1.2.1. To meet the business needs of our customers for high quality, cost-effective analytical measurements and services.

1.3. Quality Policy Statement and Goals of the Quality System

1.3.1. PASI management is committed to maintaining the highest possible standard of service for our customers by following a documented quality system that is fully compliant with the applicable NELAC, TNI, or ISO standards and is in accordance with the stated methods and customer requirements. The overall objective of this quality system is to provide reliable data of known quality through adherence to rigorous quality assurance policies and quality control procedures as documented in this Quality Assurance Manual.

1.3.2. All personnel within the PASI network are required to be familiar with all facets of the quality system relevant to their position and implement these policies and procedures in their daily work. This daily focus on quality is applied with initial project planning, continued through all field and laboratory activities, and is ultimately included in the final report generation.

1.3.3. PASI management demonstrates its commitment to quality by providing the resources, including facilities, equipment, and personnel to ensure the adherence to these documented policies and procedures and to promote the continuous improvement and effectiveness of the quality system. All PASI personnel must comply with all current applicable state, federal, and industry standards (2003 NELAC Standard, 2009 TNI Standard, ISO/IEC 17025 standard, etc.), and are required to perform all tests in accordance with stated methods and customer requirements.

1.4. Core Values

1.4.1. **Integrity-** Pace personnel are required to abide by the PASI Code of Ethics and all Pace employees must go through Data Integrity/Ethics training upon initial orientation and as an annual refresher.

1.4.2. **Value Employees-** Pace management views employees as our most important asset and communicates to them the relevance and importance of their activities within their job functions and how they contribute to the achievement of the objectives of the quality management system.

1.4.3. **Know Our Customers-** Pace makes every effort to know our customers and address their sampling and analytical needs. More information on this item can be found in section 2.0.

1.4.4. **Honor Commitments-** Pace labs focus on making solid commitments with regards to quality, capacity, and agreed upon turnaround time to our customers.

1.4.5. **Flexible Response To Demand-** Pace labs are equipped with both the material and personnel resources to enable them to be responsive to the demands of customers when situations or projects need change.

1.4.6. **Pursue Opportunities-** Pace is committed to pursuing opportunities for the growth of the company by constantly exploring markets and areas where we can expand.

1.4.7. **Continuously Improve-** Pace has committed much time and effort into establishing a continuous improvement program where company personnel meet on a regular basis to share ideas in cost reduction, production improvement and standardization in order to develop best practices. This information, as well as company financial and production metrics, are tracked, evaluated, and shared with each Pace facility.

1.5. Code of Ethics

1.5.1. PASI's fundamental ethical principles are as follows:

1.5.1.1. Each PASI employee is responsible for the propriety and consequences of his or her actions;

1.5.1.2. Each PASI employee must conduct all aspects of Company business in an ethical and strictly legal manner, and must obey the laws of the United States and of all localities, states and nations where PASI does business or seeks to do business;

1.5.1.3. Each PASI employee must reflect the highest standards of honesty, integrity and fairness on behalf of the Company with customers, suppliers, the public, and one another.

1.5.1.4. Each PASI employee must recognize and understand that our daily activities in environmental laboratories affect public health as well as the environment and that environmental laboratory analysts are a critical part of the system society depends upon to improve and guard our natural resources:

1.5.2. Strict adherence by each PASI employee to this Code of Ethics and to the Standards of Conduct is essential to the continued vitality of PASI and to continue the pursuit of our common mission to protect our environment and improve our health.

1.5.3. Failure to comply with the Code of Ethics and Standards of Conduct will result in disciplinary action up to and including termination and referral for civil or criminal prosecution where appropriate. An employee will be notified of an infraction and given an opportunity to explain, as prescribed under current disciplinary procedures.

1.5.4. Any Pace employee can contact corporate management to report an ethical concern by calling the anonymous hotline at 612-607-6431.

1.6. Standards of Conduct

1.6.1. Data Integrity

1.6.1.1. The accuracy and integrity of the analytical results and its supporting documentation produced at PASI are the cornerstones of the company. Lack of data integrity is an assault on our most basic values putting PASI and its employees at grave financial and legal risk and will not be tolerated. Therefore, employees are to accurately prepare and maintain all technical records, scientific notebooks, calculations, and databases. Employees are prohibited from making false entries or misrepresentations of data for any reason.

1.6.1.2. Managerial staff must make every effort to ensure that personnel are free from any undue pressures that may affect the quality or integrity of their work including commercial, financial, over-scheduling, and working condition pressures.

1.6.2. Confidentiality

1.6.2.1. PASI employees must not use or disclose confidential or proprietary information except when in connection with their duties at PASI. This is effective over the course of employment and for an additional period of two years thereafter.

1.6.2.2. Confidential or proprietary information, belonging to either PASI and/or its customers, includes but is not limited to test results, trade secrets, research and development matters, procedures, methods, processes and standards, company-specific techniques and equipment, marketing and customer information, inventions, materials composition, etc.

1.6.3. Conflict of Interest

1.6.3.1. PASI employees must avoid situations that might involve a conflict of interest or could appear questionable to others. The employee must be careful in two general areas:

1.6.3.1.1. Participation in activities that conflict or appear to conflict with the employees' PASI responsibilities.

1.6.3.1.2. Offering or accepting anything that might influence the recipient or cause another person to believe that the recipient may be influenced to behave or in a different manner than he would normally. This includes bribes, gifts, kickbacks, or illegal payments.

1.6.3.2. Employees are not to engage in outside business or economic activity relating to a sale or purchase by the Company. Other problematic activities include service on the Board of Directors of a competing or supplier company, significant ownership in a competing or supplier company, employment for a competing or supplier company, or participation in any outside business during the employee's work hours.

1.6.4. **Compliance**

1.6.4.1. All employees are required to read, understand, and comply with the various components of the standards listed in this document. As confirmation that they understand their responsibility, each employee is required to sign an acknowledgment form annually that then becomes part of the employee's permanent record. Employees will be held accountable for complying with the Quality Systems as summarized in the Quality Assurance Manual.

1.7. Laboratory Organization

1.7.1. The PASI Corporate Office centralizes company-wide accounting, business development, financial management, human resources development, information systems, marketing, quality, safety, and training activities. PASI's Director of Quality is responsible for assisting the development, implementation and monitoring of quality programs for the company. See Attachment IIB for the Corporate Organizational structure.

1.7.2. Each laboratory within the system operates with local management, but all labs share common systems and receive support from the Corporate Office.

1.7.3. A Senior General Manager (SGM) oversees all laboratories and service centers in their assigned region. Each laboratory or facility in the company is then directly managed by an SGM, a General Manager (GM), an Assistant General Manager (AGM), or an Operations Manager (OM). Quality Managers (QM) or Senior Quality Managers (SQM) at each laboratory report directly to the highest level of local laboratory management, however named, that routinely makes day-to-day decisions regarding that facility's operations. The QMs and SQMs will also receive guidance and direction from the corporate Director of Quality.

1.7.4. The SGM, GM, AGM or OM, or equivalent functionality in each facility, bears the responsibility for the laboratory operations and serves as the final, local authority in all matters. In the absence of these managers, the SQM/QM serves as the next in command. He or she assumes the responsibilities of the manager, however named, until the manager is available to resume the duties of their position. In the absence of both the manager and the SQM/QM, management responsibility of the laboratory is passed to the Technical Director, provided such a position is identified, and then to the most senior department manager until the return of the lab manager or SQM/QM. The most senior department manager in charge may include the Client Services Manager or the Administrative Business Manager at the discretion of the SGM/GM/AGM/OM.

1.7.5. A Technical Director who is absent for a period of time exceeding 15 consecutive calendar days shall designate another full-time staff member meeting the qualifications of the technical director to temporarily perform this function. The laboratory SGM/GM/AGM/OM or SQM/QM has the authority to make this designation in the event the existing Technical Director is unable to do so. If this absence exceeds 35 consecutive calendar days, the primary accrediting authority shall be notified in writing.

1.7.6. The SQM/QM has the responsibility and authority to ensure the Quality System is implemented and followed at all times. In circumstances where a laboratory is not meeting the established level of quality or following the policies set forth in this Quality Assurance Manual, the SQM/QM has the authority to halt laboratory operations should he or she deem such an action necessary. The SQM/QM will immediately communicate the halting of operations to the SGM/GM/AGM/OM and keep them posted on the progress of corrective actions. In the event the SGM/GM/AGM/OM and the SQM/QM are not in agreement as to the need for the suspension, the Chief Operating Officer and Director of Quality will be called in to mediate the situation.

1.7.7. The lab is required to appoint deputies for key managerial personnel. These deputies must be documented for auditing purposes.

1.7.8. The technical staff of the laboratory is generally organized into the following functional groups:

- Organic Sample Preparation
- Wet Chemistry Analysis
- Metals Analysis
- Volatiles Analysis
- Semi-volatiles Analysis
- Radiochemical Analysis
- Microbiology

1.7.9. Appropriate support groups are present in each laboratory. The actual organizational structure for PASI – Carolinas is listed in Attachment IIA. In the event of a change in SGM/GM/AGM/OM, SQM/QM, or any Technical Director, the laboratory will notify its accrediting authorities and revise the organizational chart in the Quality Assurance Manual (QAM) within 30 days. For changes in Department Managers or Supervisors or other laboratory personnel, no notifications will be sent to the laboratory's accrediting agencies; changes to the organizational chart will be updated during or prior to the annual review process. Changes or additions in these key personnel will also be noted by additional signatures on the QAM, as applicable. In any case, the QAM will remain in effect until the next scheduled revision.

1.8. Laboratory Job Descriptions

1.8.1. Senior General Manager

- Oversees all functions of all the operations within their designated region;
- Oversees the development of local GMs/AGMs/OMs within their designated region;
- Oversees and authorizes personnel development including staffing, recruiting, training, workload scheduling, employee retention and motivation;
- Oversees the preparation of budgets and staffing plans for all operations within their designated region;
- Ensures compliance with all applicable state, federal and industry standards;
- Works closely with Regional Sales Management.

1.8.2. General Manager

- Oversees all functions of their assigned operations;
- Authorizes personnel development including staffing, recruiting, training, workload scheduling, employee retention and motivation;
- Prepares budgets and staffing plans;
- Monitors the Quality Systems of the laboratory and advises the SQM/QM accordingly;
- Ensures compliance with all applicable state, federal and industry standards.

1.8.3. Assistant General Manager / Operations Manager

- In the absence of the SGM/GM, performs all duties as listed above for the SGM or GM;
- Oversees the daily production and quality activities of all departments;
- Manages all departments and works with staff to ensure department objectives are met;
- Works with all departments to ensure capacity and customer expectations are accurately understood and met;
- Works with SGM/GM to prepare appropriate budget and staffing plans for all departments;
- Responsible for prioritizing personnel and production activities within all departments;
- Performs formal and informal performance reviews of departmental staff.

1.8.4. Senior Quality Manager

- Provides quality oversight for multiple laboratories where there is not a local quality manager or for labs where there are multiple and separately distinct quality systems in the same facility;
- Responsible for implementing, maintaining and improving the quality system while functioning independently from laboratory operations. Reports directly to the highest level of local laboratory facility management, however named, that routinely makes day-to-day decisions regarding laboratory operations, but receives direction and assistance from the Corporate Director of Quality;
- Ensures that communication takes place at all levels within the lab regarding the effectiveness of the quality system and that all personnel understand their contributions to the quality system;
- Monitors Quality Assurance/Quality Control activities to ensure that the laboratory achieves established standards of quality (as set forth by the Corporate Quality office). The Quality Manager is responsible for reporting the lab's level of compliance to these standards to the Corporate Director of Quality on a quarterly basis;
- Maintains records of quality control data and evaluates data quality;
- Conducts periodic internal audits and coordinates external audits performed by regulatory agencies or customer representatives;
- Reviews and maintains records of proficiency testing results;
- Maintains the document control system;
- Assists in development and implementation of appropriate training programs;
- Provides technical support to laboratory operations regarding methodology and project QA/QC requirements;
- Maintains certifications from federal and state programs;
- Ensures compliance with all applicable state, federal and industry standards;
- Maintains the laboratory training records, including those in the Learning Management System (LMS), and evaluates the effectiveness of training;
- Monitors corrective and preventive actions;
- Maintains the currency of the Quality Manual.

1.8.5. Quality Manager

- Responsible for implementing, maintaining and improving the quality system while functioning independently from laboratory operations. Reports directly to the highest level of local laboratory facility management, however named, that routinely makes day-to-day decisions regarding laboratory operations, but receives direction and assistance from the Corporate Director of Quality. They may also report to a Senior Quality Manager within the same facility;

- Ensures that communication takes place at all levels within the lab regarding the effectiveness of the quality system and that all personnel understand their contributions to the quality system;
- Monitors Quality Assurance/Quality Control activities to ensure that the laboratory achieves established standards of quality (as set forth by the Corporate Quality office). The Quality Manager is responsible for reporting the lab's level of compliance to these standards to the Corporate Director of Quality on a quarterly basis;
- Maintains records of quality control data and evaluates data quality;
- Conducts periodic internal audits and coordinates external audits performed by regulatory agencies or customer representatives;
- Reviews and maintains records of proficiency testing results;
- Maintains the document control system;
- Assists in development and implementation of appropriate training programs;
- Provides technical support to laboratory operations regarding methodology and project QA/QC requirements;
- Maintains certifications from federal and state programs;
- Ensures compliance with all applicable state, federal and industry standards;
- Maintains the laboratory training records, including those in the Learning Management System (LMS), and evaluates the effectiveness of training;
- Monitors corrective and preventive actions;
- Maintains the currency of the Quality Manual.

1.8.6. Quality Assurance Analyst

- Assists the SQM/QM in the performance of quality department responsibilities as delegated by the SQM/QM;
- Assists in monitoring QA/QC data;
- Assists in internal audits;
- Assists in maintaining training records;
- Assists in maintaining the document control system;

1.8.7. Technical Director

- Monitors the standards of performance in quality assurance and quality control data;
- Monitors the validity of analyses performed and data generated;
- Reviews tenders, contracts and QAPPs to ensure the laboratory can meet the data quality objectives for any given project;
- Serves as the manager of the laboratory in the absence of the SGM/GM/AGM/OM and SQM/QM;
- Provides technical guidance in the review, development, and validation of new methodologies.

1.8.8. Administrative Business Manager

- Responsible for financial and administrative management for the entire facility;
- Provides input relative to tactical and strategic planning activities;
- Organizes financial information so that the facility is run as a fiscally responsible business;
- Works with staff to confirm that appropriate processes are put in place to track revenues and expenses;
- Provide ongoing financial information to the SGM/GM/AGM/OM and the management team so they can better manage their business;
- Utilizes historical information and trends to accurately forecast future financial positions;
- Works with management to ensure that key measurements are put in place to be utilized for trend analysis—this will include personnel and supply expenses, and key revenue and expense ratios;
- Works with SGM/GM/AGM/OM to develop accurate budget and track on an ongoing basis;
- Works with entire management team to submit complete and justified capital budget requests and to balance requests across departments;
- Works with project management team and administrative support staff to ensure timely and accurate invoicing.

1.8.9. Client Services Manager

- Oversees all the day to day activities of the Client Services Department which includes Project Management and, possibly, Sample Control;
- Responsible for staffing and all personnel management related issues for Client Services;
- Serves as the primary senior consultant to customers on all project related issues such as set up, initiation, execution and closure;
- Performs or is capable of performing all duties listed for that of Project Manager.

1.8.10. Project Manager

- Coordinates daily activities including taking orders, reporting data and analytical results;
- Serves as the primary technical and administrative liaison between customers and PASI;
- Communicates with operations staff to update and set project priorities;
- Provides results to customers in the requested format (verbal, hardcopy, electronic, etc.);
- Works with customers, laboratory staff, and other appropriate PASI staff to develop project statements of work or resolve problems of data quality;
- Responsible for solicitation of work requests, assisting with proposal preparation and project initiation with customers and maintain customer records;
- Mediation of project schedules and scope of work through communication with internal resources and management;
- Responsible for preparing routine and non-routine quotations, reports and technical papers;
- Interfaces between customers and management personnel to achieve customer satisfaction;
- Manages large-scale complex projects;
- Supervises less experienced project managers and provide guidance on management of complex projects;
- Arranges bottle orders and shipment of sample kits to customers;
- Verifies login information relative to project requirements and field sample Chains-of-Custody.

1.8.11. Project Coordinator

- Responsible for preparation of project specifications and provides technical/project support;
- Coordinates project needs with other department sections and assists with proposal preparation;
- Prepares routine proposals and invoicing;
- Responsible for scanning, copying, assembling and binding final reports;
- Other duties include filing, maintaining forms, process outgoing mail, maintaining training database and data entry.

1.8.12. Department Manager/Supervisor

- Oversees the day-to-day production and quality activities of their assigned department;
- Ensures that quality assurance and quality control criteria of analytical methods and projects are satisfied;
- Assesses data quality and takes corrective action when necessary;
- Approves and releases technical and data management reports;
- Ensures compliance with all applicable state, federal and industry standards.

1.8.13. Group Supervisor/Leader

- Trains analysts in laboratory operations and analytical procedures;
- Organizes and schedules analyses with consideration for sample holding times;
- Implements data verification procedures by assigning data verification duties to appropriate personnel;
- Evaluates instrument performance and supervises instrument calibration and preventive maintenance programs;
- Reports non-compliance situations to laboratory management including the SQM/QM.

1.8.14. Laboratory Analyst

- Performs detailed preparation and analysis of samples according to published methods and laboratory procedures;
- Processes and evaluates raw data obtained from preparation and analysis steps;
- Generates final results from raw data, performing primary review against method criteria;
- Monitors quality control data associated with analysis and preparation. This includes examination of raw data such as chromatograms as well as an inspection of reduced data, calibration curves, and laboratory notebooks;
- Reports data in LIMS, authorizing for release pending secondary approval;
- Conducts routine and non-routine maintenance of equipment as required;
- Performs or is capable of performing all duties associated with that of Laboratory Technician.

1.8.15. Laboratory Technician

- Prepares standards and reagents according to published methods or in house procedures;
- Performs preparation and analytical steps for basic laboratory methods;
- Works under the direction of a Laboratory Analyst on complex methodologies;
- Assists Laboratory Analysts on preparation, analytical or data reduction steps for complex methodologies;
- Monitors quality control data as required or directed. This includes examination of raw data such as chromatograms as well as an inspection of reduced data, calibration curves, and laboratory notebooks.

1.8.16. Field Technician

- Prepares and samples according to published methods, PASI Quality Assurance Manual and/or customer directed sampling objectives;
- Capable of the collection of representative environmental or process related air samples;
- Use computer software to compile, organize, create tables, create graphics and write test reports;
- Reviews project documentation for completeness, method compliance and contract fulfillment;
- Train less experienced environmental technicians and provide guidance on sampling and analysis;
- Responsible for project initiation and contact follow-up;
- Develop sampling plans and prepare test plan documents.

1.8.17. Field Analyst

- Analyzes field samples according to published methods, PASI Quality Assurance Manual and/or customer directed sampling objectives,
- Capable of the collection and analysis of representative environmental or process related air samples,
- Proficient in a variety of analytical tests; specifically on-site gas-phase organic and inorganic compounds by extractive fourier transform infrared spectroscopy (FTIR),
- Train less experienced staff and provide guidance on FTIR sampling and analysis,
- Assist in reporting tasks and project management responsibilities, and
- Perform back-up support for manager tasks such as reporting needs and customer concerns.

1.8.18. Sample Management Personnel

- Signs for incoming samples and verifies the data entered on the Chain of custody forms;
- Enters the sample information into the Laboratory Information Management System (LIMS) for tracking and reporting;
- Stages samples according to EPA requirements;
- Assists Project Managers and Coordinators in filling bottle orders and sample shipments.

1.8.19. Systems Administrator or Systems Manager

- Assists with the creation and maintenance of electronic data deliverables (EDDs);
- Coordinates the installation and use of all hardware, software and operating systems;
- Performs troubleshooting on all aforementioned systems;
- Trains new and existing users on systems and system upgrades;
- Maintains all system security passwords;
- Maintains the electronic backups of all computer systems.

1.8.20. Safety/Chemical Hygiene Officer

- Maintains the laboratory Chemical Hygiene Plan;
- Plans and implements safety policies and procedures;
- Maintains safety records;
- Organizes and/or performs safety training;
- Performs safety inspections and provides corrective/preventative actions;
- Assists personnel with safety issues.

1.8.21. Program Director/Hazardous Waste Coordinator (or otherwise named)

- Evaluates waste streams and helps to select appropriate waste transportation and disposal companies;
- Maintains complete records of waste disposal including waste manifests and state reports;
- Assists in training personnel on waste-related issues such as waste handling and storage, waste container labeling, proper satellite accumulation, secondary containment, etc.;
- Conducts a weekly inspection of the waste storage areas of the laboratory.

1.9. Training and Orientation

1.9.1. Training for Pace employees is managed through a web-based Learning Management System. After a new employee has been instructed in matters of human resources, they are given instructional materials for the LMS and a password for access.

1.9.2. A new hire training checklist is provided to the new employee that lists training items for the employee to work through either independently on LMS or with their supervisor or trainer. The training items that can be completed independently include:

- Reading through applicable Standard Operating Procedures;
- Reviewing the Quality Manual and Chemical Hygiene Plan;
- Core training modules such as quality control indicators, basic laboratory skills, etc.;
- Quality Systems training including traceability of measurements, method calibration, calibration verification, accuracy, precision and uncertainty of measurements, corrective actions, documentation, and root cause analysis;
- Data Integrity/Ethics training.

1.9.3. The new employee's Department Supervisor provides the employee with a basic understanding of the role of the laboratory within the structure of PASI and the basic elements of that individual's position. Supervised training uses the following techniques:

- Hands-on training

- Training checklists/worksheets
- Lectures and training sessions
- Method-specific training
- Conferences and seminars
- Short courses
- Specialized training by instrument manufacturers
- Proficiency testing programs.
- On-line courses

1.9.4. Group Supervisors/Leaders are responsible for providing documentation of training and proficiency for each employee under their supervision. The employee's training file indicates what procedures an analyst or a technician is capable of performing, either independently or with supervision. The files also include documentation of continuing capability, which are fully detailed in Section 3.4. Training documentation files for each person are maintained by the Quality Office either in hardcopy format or within the LMS.

1.9.5. All procedures and training records are maintained and available for review during laboratory audits. These procedures are reviewed/updated periodically by laboratory management. Additional information can be found in SOP S-ALL-Q-020 **Training and Employee Orientation** or its equivalent revision or replacement.

1.10. Data Integrity System

1.10.1. The data integrity system at PASI provides assurances to management that a highly ethical approach is being applied to all planning, training and implementation of methods. Data integrity is crucial to the success of our company and Pace Analytical is committed to creating and maintaining a culture of quality throughout the organization. To accomplish this goal, PASI has implemented a data integrity system that encompasses the following four requirements:

1.10.1.1. A data integrity training program: standardized training is given to each new employee and a yearly refresher is presented to all employees. Key topics addressed by this training include:

1.10.1.1.1. Need for honesty and transparency in analytical reporting
1.10.1.1.2. Process for reporting data integrity issues
1.10.1.1.3. Specific examples of unethical behavior and improper practices
1.10.1.1.4. Documentation of non-conforming data that is still useful to the data user
1.10.1.1.5. Consequences and punishments for unethical behavior
1.10.1.1.6. Examples of monitoring devices used by management to review data and systems

1.10.1.2. Signed data integrity documentation for all employees: this includes a written quiz following the Ethics training session and written agreement to abide by the Code of Ethics and Standards of Conduct explained in the employee manual.

1.10.1.3. In-depth, periodic monitoring of data integrity including peer data review and validation, internal raw data audits, proficiency testing studies, etc.

1.10.1.4. Documentation of any review or investigation into possible data integrity infractions. This documentation, including any disciplinary actions involved, corrective actions taken, and notifications to customers must be retained for a minimum of five years.

1.10.2. PASI management makes every effort to ensure that personnel are free from any undue pressures that affect the quality of their work including commercial, financial, over scheduling, and working condition pressures.

1.10.3. Corporate management also provides all PASI facilities a mechanism for confidential reporting of data integrity issues that ensures confidentiality and a receptive environment in which all employees are comfortable discussing items of ethical concern. The anonymous message line is monitored by the Corporate Director of Quality who will ensure that all concerns are evaluated and, where necessary, brought to the attention of executive management and investigated. Any Pace employee can contact corporate management to report an ethical concern by calling the anonymous hotline at 612-607-6431.

1.11. Laboratory Safety

1.11.1. It is the policy of PASI to make safety and health an integral part of daily operations and to ensure that all employees are provided with safe working conditions, personal protective equipment, and requisite training to do their work without injury. Each employee is responsible for his/her own safety as well as those working in the immediate area by complying with established company rules and procedures. These rules and procedures as well as a more detailed description of the employees' responsibilities are contained in the corporate Safety Manual and Chemical Hygiene Plan.

1.12. Security and Confidentiality

1.12.1. Security is maintained by controlled access to laboratory buildings. Exterior doors to laboratory buildings remain either locked or continuously monitored by PASI staff. Posted signs direct visitors to the reception office and mark all other areas as off limits to unauthorized personnel. All visitors, including PASI staff from other facilities, must sign the Visitor's Logbook maintained by the receptionist. A staff member will accompany them during the duration of their stay on the premises unless the SGM/GM/AGM/OM, SQM/QM, or Technical Director specify otherwise. In this instance, the staff member will escort the visitor back to the reception area at the end of his/her visit where he/she signs out. The last staff member to leave their department for the day must ensure that all outside access points to that area are secure.

1.12.2. Additional security is provided where necessary, (e.g., specific secure areas for sample, data, and customer report storage), as requested by customers, or cases where national security is of concern. These areas are lockable within the facilities, or are securely offsite. Access is limited to specific individuals or their designees. Security of sample storage areas is the responsibility of the Sample Custodian. Security of samples and data during analysis and data reduction is the responsibility of Group Supervisors. Security of customer report archives is the responsibility of the Client Services Manager. These secure areas are locked whenever these individuals or their designees are not present in the facility.

1.12.3. Access to designated laboratory sample storage locations is limited to authorized personnel only. Provisions for lock and key access are provided. No samples are to be removed without proper authorization. If requested by customer or contract, samples are not to be removed from secure storage areas without filling out an associated internal chain of custody.

1.12.4. Standard business practices of confidentiality are applied to all documents and information regarding customer analyses. Specific protocols for handling confidential documents are described in

PASI SOPs. Additional protocols for sample identification by internal laboratory identification numbers only are implemented as required under contract specific Quality Assurance Project Plans (QAPPs).

1.12.5. All information pertaining to a particular customer, including national security concerns will remain confidential. Data will be released to outside agencies only with written authorization from the customer or where federal or state law requires the company to do so.

1.13. Communications

1.13.1. Management within each lab bears the responsibility of ensuring that appropriate communication processes are established and that communication takes place regarding the effectiveness of the management/quality system. These communication processes may include email, regular staff meetings, senior management meetings, etc.

1.13.2. Corporate management bears the responsibility of ensuring that appropriate communication processes are established within the network of facilities and that communication takes place at a company-wide level regarding the effectiveness of the management/quality systems of all Pace facilities. These communication processes may include email, quarterly continuous improvement conference calls for all lab departments, and annual continuous improvement meetings for all department supervisors, quality managers, client services managers, and other support positions.

2.0. SAMPLE CUSTODY

2.1. Sampling Support

2.1.1. Each individual PASI laboratory provides shipping containers, properly preserved sample containers, custody documents, and field quality control samples to support field-sampling events. Guidelines for sample container types, preservatives, and holding times for a variety of methods are listed in Attachment VIII. Note that all analyses listed are not necessarily performed at all PASI laboratories and there may be additional laboratory analyses performed that are not included in these tables. Customers are encouraged to contact their local Pace Project Manager for questions or clarifications regarding sample handling. PASI - Carolinas may provide pick-up and delivery services to their customers when needed.

2.2. Field Services

2.2.1. Pace Analytical has a large Field Services Division which is based in their Minneapolis facility as well as limited field service capabilities in some of our other facilities. Field Services provides comprehensive nationwide service offerings including:

- Stack Testing
- Ambient Air
- CEM Certification Testing
- Air Quality Monitoring
- Onsite Analytical Services- FTIR and GC
- Real-time Process Diagnostic/Optimization Testing
- Wastewater, Groundwater and Drinking Water Monitoring
- Storm Water and Surface Water Monitoring
- Soil and Waste Sampling
- Mobile Laboratory Services

2.2.2. Field Services operates under the PASI Corporate Quality System, with applicable and necessary provisions to address the activities, methods, and goals specific to Field Services. All procedures and methods used by Field Services are documented in Standard Operating Procedures and Procedure Manuals.

2.3. Project Initiation

2.3.1. Prior to accepting new work, the laboratory reviews its performance capability. The laboratory confirms that sufficient personnel, equipment capacity, analytical method capability, etc., are available to complete the required work. Customer needs, certification requirements, and data quality objectives are defined and the appropriate sampling and analysis plan is developed to meet the project requirements by project managers or sales representatives. Members of the management staff review current instrument capacity, personnel availability and training, analytical procedures capability, and projected sample load. Management then informs the sales and client services personnel whether or not the laboratory can accept the new project via written correspondence, email, and/or daily operations meetings.

2.3.2. The laboratory maintains records of all such reviews, including discussions with customers. Routine analytical project documentation of quotes, notes, dates, initials, and/or recordings is maintained in a project folder by project management. Conditions for new and more complex contracts are determined by the SGM/GM/AGM/OM and sales representatives. Quality Management is consulted on technical requirements and operations staff provides input on volume capacities. Evidence of these reviews is maintained in the form of awarded Request for Proposals (RFPs), signed quotes or contracts, and a Customer Relationship Management (CRM) database. If a review identifies a potential mismatch between customer requirements and laboratory capabilities and/or capacities, Pace will specify its level of commitment by listing these exceptions to the requirements within the RFP, quote or contract.

2.3.3. Additional information regarding specific procedures for reviewing new work requests can be found in SOP SOT-ALL-C-006 **Review of Analytical Requests** or its equivalent revision or replacement.

2.4. Chain of Custody

2.4.1. A chain of custody (COC) provides the legal documentation of samples from time of collection to completion of analysis. PASI has implemented Standard Operating Procedures to ensure that sample custody traceability and responsibility objectives are achieved for every project.

2.4.2. Field personnel or client representatives must complete a chain of custody for all samples that are received by the laboratory. The importance of completeness of COCs is stressed to the samplers and is critical to efficient sample receipt and to insure the requested methods are used to analyze the correct samples.

2.4.3. If sample shipments are not accompanied by the correct documentation, the Sample Receiving department notifies a Project Manager. The Project Manager then obtains the correct documentation/information from the customer in order for analysis of samples to proceed.

2.4.4. The sampler is responsible for providing the following information on the chain of custody form:

- Customer project name
- Project location or number
- Field sample number/identification
- Date and time sampled
- Sample matrix
- Preservative
- Requested analyses
- Sampler signature
- Relinquishing signature
- Date and time relinquished
- Sampler remarks as needed
- Custody Seal Number if present
- Regulatory Program Designation
- The state where the samples were collected to ensure all applicable state requirements are met
- Turnaround time requested
- Purchase order number

2.4.5. The COC is filled out completely and legibly with indelible ink. Errors are corrected by drawing a single line through the initial entry and initialing and dating the change. All transfers of samples are recorded on the chain of custody in the “relinquished” and “received by” sections. All information except signatures is printed.

2.4.6. Additional information can be found in SOT-ALL-C-001 **Sample Management** or its equivalent revision or replacement.

2.5. Sample Acceptance Policy

2.5.1. In accordance with regulatory guidelines, PASI complies with the following sample acceptance policy for all samples received.

2.5.2. If the samples do not meet the sample receipt acceptance criteria outlined below, the laboratory is required to document all non-compliances, contact the customer, and either reject the samples or fully document any decisions to proceed with analyses of samples which do not meet the criteria. Any results reported from samples not meeting these criteria are appropriately qualified on the final report.

2.5.3. All samples must:

- Have unique customer identification that is clearly marked with indelible ink on durable waterproof labels affixed to the sample containers that match the chain of custody.
- Have clear documentation on the chain of custody related to the location of the sampling site with the time and date of sample collection.
- Have the sampler’s name and signature.
- Have all requested analyses clearly designated on the COC.
- Have clear documentation of any special analytical or data reporting requirements.
- Be in appropriate sample containers with clear documentation of the preservatives used.
- Be correctly preserved unless the method allows for laboratory preservation.
- Be received within holding time. Any samples with hold times that are exceeded will not be processed without prior customer approval.
- Have sufficient sample volume to proceed with the analytical testing. If insufficient sample volume is received, analysis will not proceed without customer approval.
- Be received within appropriate temperature ranges - not frozen but ≤6°C $^{\text{(See Note 1)}}$, unless program requirements or customer contractual obligations mandate otherwise $^{\text{(see Note 2)}}$. The cooler temperature is recorded directly on the COC and the SCUR. Samples that are delivered to the laboratory immediately after collection are considered acceptable if there is evidence that the chilling process has been started. For example, by the arrival of the samples on ice. If samples arrive that are not compliant with these temperature requirements, the customer will be notified. The analysis will NOT proceed unless otherwise directed by the customer. If less than 72 hours remain in the hold time for the analysis, the analysis may be started while the customer is contacted to avoid missing the hold time. Data associated with any deviations from the above sample acceptance policy requirements will be appropriately qualified.

Note 1: Temperature will be read and recorded based on the precision of the measuring device. For example, temperatures obtained from a thermometer graduated to 0.1°C will be read and recorded to ±0.1°C. Measurements obtained from a thermometer graduate to 0.5°C will be read to ±0.5°C. Measurements read at the specified precision are not to be rounded down to meet the ≤6°C limit

Note 2: Some microbiology methods allow sample receipt temperatures of up to 10°C. Consult the specific method for microbiology samples received above 6°C prior to initiating corrective action for out of temperature preservation conditions.

2.5.4. Upon sample receipt, the following items are also checked and recorded:

- Presence of custody seals or tapes on the shipping containers;
- Sample condition: Intact, broken/leaking, bubbles in VOA samples;
- Sample holding time;
- Sample pH and residual chlorine when required;
- Appropriate containers.

2.5.5. Samples for drinking water analysis that are improperly preserved, or are received past holding time, are rejected at the time of receipt, with the exception of VOA samples that are tested for pH at the time of analysis.

2.5.6. Additional information can be found in SOT-ALL-C-001 **Sample Management** or its equivalent revision or replacement.

2.6. Sample Log-in

2.6.1. After sample inspection, all sample information on the chain of custody is entered into the Laboratory Information Management System (LIMS). This permanent record documents receipt of all sample containers including:

- Customer name and contact
- Customer number
- Pace Analytical project number
- Pace Analytical Project Manager
- Sample descriptions
- Due dates
- List of analyses requested
- Date and time of laboratory receipt
- Field ID code
- Date and time of collection
- Any comments resulting from inspection for sample rejection

2.6.2. All samples received are logged into the LIMS within one working day of receipt. Sample login may be delayed due to customer clarification of analysis needed, corrective actions for sample receipt non-conformance, or other unusual circumstances. If the time collected for any sample is unspecified and Pace is unable to obtain this information from the customer, the laboratory will use 00:00 am as the time sampled. All hold times will be based on this sampling time and qualified accordingly if exceeded.

2.6.3. The Laboratory Information Management System automatically generates a unique identification number for each sample created in the system. The LIMS sample number follows the general convention of BBXXXXXXYYY. The BB represents the laboratory identification within Pace's laboratory network. The six digit "X" number represents the project number. The project number is a sequential number that is assigned as a new project is created and may contain more or less than six digits. The three digit "Y" represents the sample number. The sample number corresponds to the number of samples submitted by the client. In addition to the unique sample ID, there is a sample container ID that consists of the sample number, the container type (ex. BP1U), and bottle 1 of Y where Y represents the total number of containers of that particular type. Together the sample LIMS number and sample container ID create a unique barcode encryption that can be linked to sample analysis as requested by the client. This unique identification number is placed on the sample container as a durable label and becomes the link between the laboratory's sample management system and the customer's field identification; it will be a permanent reference number for all future interactions.

2.6.4. Current division codes are noted below. These division codes are used primarily for accounting purposes and LIMS sample identifications. More division codes may be added without updating this document.

00 = Corporate
10 = Minnesota/Montana/Virginia MN
12 = Virginia/Duluth MN
20 = New Orleans/Puerto Rico
30 = Pittsburgh
35 = Florida/South Florida
36 = South Florida (accounting only)
40 = Green Bay
50 = Indianapolis/Columbus
51 = Columbus (accounting only)
55/56 = Pace Energy Labs
60 = Kansas
65 = New York (Schenectady)
70 = Long Island
75 = Dallas
92 = Carolinas

2.6.5. Sample labels are printed from the LIMS and affixed to each sample container.

2.6.6. Samples with hold times that are near expiration date/time may be sent directly to the laboratory for analysis at the discretion of the Project Manager and/or SGM/GM/AGM/OM.

2.6.7. Additional information can be found in SOT-ALL-C-001 **Sample Management** or its equivalent revision or replacement.

2.7. Sample Storage

2.7.1. Storage Conditions

2.7.1.1. Samples are stored away from all standards, reagents, or other potential sources of contamination. Samples are stored in a manner that prevents cross contamination. Volatile samples are stored separately from other samples. All sample fractions, extracts, leachates, and other sample preparation products are stored in the same manner as actual samples or as specified by the analytical method.

2.7.1.2. Storage blanks, consisting of two 40mL aliquots of reagent water, are stored with volatile samples and are used to measure cross-contamination acquired during storage. If applicable, laboratories must have documented procedures and criteria for evaluating storage blanks, appropriate to the types of samples being stored.

2.7.1.3. Additional information can be found in SOT-ALL-Q-018 **Monitoring Temperature Controlled Units.**

2.7.2. Temperature Monitoring

2.7.2.1. Samples are taken to the appropriate storage location immediately after sample receipt and check-in procedures are completed. All sample storage areas are located in limited access areas and are monitored to ensure sample integrity.

2.7.2.2. The temperature of each refrigerated storage area is maintained at ≤6°C unless state or program requirements differ. The temperature of each freezer storage area is maintained at <-10°C unless state or program requirements differ. The temperature of each storage area is checked and documented each day of use (each calendar day). If the temperature falls outside the acceptable limits, the following corrective actions are taken and appropriately documented:

- The temperature is rechecked after two hours to verify temperature exceedance. Corrective action is initiated and documented if necessary.
- The SQM/QM and/or laboratory management are notified if the problem persists.
- The samples are relocated to a proper environment if the temperature cannot be maintained after corrective actions are implemented.
- The affected customers are notified.
- Documentation is provided on analytical report.

Additional information can be found in SOT-ALL-Q-018 **Monitoring Temperature Controlled Units.**

2.7.3. **Hazardous Materials**

2.7.4. Samples determined to be hazardous by analysis are labeled and stored in the hazardous waste location until removed by a qualified vendor.

2.7.5. **Foreign/Quarantined Soils**

2.7.5.1. Depending on the soil disposal practices of the laboratory, foreign soils and soils from USDA regulated areas are adequately segregated to enable proper sample disposal. The USDA requires these samples to be incinerated or sterilized by an approved treatment procedure. Additional information regarding USDA regulations and sample handling can be found in applicable local laboratory SOPs.

2.7.5.2. Additional information on sample storage can be found in SOP S-CAR-C-001 **Sample Management**, SOP S-CHR-S-002 **Waste Handling and Management** (Charlotte Laboratory), and SOP S-ASV-S-002 **Waste Handling and Management** (Asheville, Eden, and Raleigh Laboratories) or the equivalent revisions or replacements.

2.8. Sample Protection

2.8.1. PASI laboratory facilities are operated under controlled access protocols to ensure sample and data integrity. Visitors must register at the front desk and be properly escorted at all times.

2.8.2. Samples are removed from storage areas by designated personnel and returned to the storage areas, if necessary, immediately after the required sample quantity has been taken.

2.8.3. Upon customer request, additional and more rigorous chain of custody protocols for samples and data can be implemented. For example, some projects may require internal chain-of-custody protocols.

2.8.4. Additional information can be found in SOT-ALL-C-001 **Sample Management** or its equivalent revision or replacement.

2.9. Subcontracting Analytical Services

2.9.1. Every effort is made to perform all analyses for PASI customers within the laboratory that receives the samples. When subcontracting to a laboratory other than the receiving laboratory, whether inside or outside the PASI network, becomes necessary, a preliminary verbal communication with that laboratory is undertaken. Customers are notified in writing of the laboratory's intention to subcontract any portion of the testing to another laboratory. Work performed under specific protocols may involve special considerations.

2.9.2. Prior to subcontracting samples to a laboratory outside Pace Analytical, the potential sub-contract laboratory will be pre-qualified by verifying that the subcontractor meets the following criteria:

- All certifications required for the proposed subcontract are in effect,
- Sufficient professional liability and other required insurance coverage is in effect, and
- Is not involved in legal action by any federal, state, or local government agency for data integrity issues and has not been convicted in such investigation at any time during the past 5 years.

2.9.3. The contact and preliminary arrangements are made between the PASI Project Manager and the appropriate subcontract laboratory personnel. The specific terms of the subcontract laboratory agreement include:

- Method of analysis
- Number and type of samples expected
- Project specific QA/QC requirements
- Deliverables required
- Laboratory certification requirement
- Price per analysis
- Turn-around time requirements

2.9.4. Chain-of-custody forms are generated for samples requiring subcontracting to other laboratories. Sample receiving personnel re-package the samples for shipment, create a transfer chain of custody form and record the following information:

- Pace Analytical Laboratory Number
- Matrix
- Requested analysis
- Special instructions regarding turnaround, required detection or reporting limits, or any unusual information known about the samples or analytical procedure.
- Signature in "Relinquished By"

2.9.5. All subcontracted sample data reports are sent to the PASI Project Manager. Pace will provide a copy of the subcontractor's report to the client.

2.9.6. Any Pace Analytical work sent to other labs within the PASI network is handled as subcontracted work and all final reports are labeled clearly with the name of the laboratory performing the work. Any non-TNI work is clearly identified. PASI will not be responsible for analytical data if the subcontract laboratory was designated by the customer.

2.9.7. Additional information can be found in SOT-ALL-C-003 **Subcontracting Samples** or its equivalent revision or replacement.

2.10. Sample Retention and Disposal

2.10.1. Samples, extracts, digestates, and leachates must be retained by the laboratory for the period of time necessary to protect the interests of the laboratory and the customer.

2.10.2. Unused portions of samples are retained by each laboratory based on program or customer requirements for sample retention and storage. The minimum sample retention time is 30 days from receipt of the samples. ***Samples requiring thermal preservation may be stored at ambient temperature when the hold time is expired, the report has been delivered, and/or allowed by the customer, program, or contract.*** Samples requiring storage beyond the minimum sample retention time due to special requests or contractual obligations may be stored at ambient temperature unless the laboratory has sufficient capacity and their presence does not compromise the integrity of other samples.

2.10.3. After this period expires, non-hazardous samples are properly disposed of as non-hazardous waste. The preferred method for disposition of hazardous samples is to return the excess sample to the customer. If it is not feasible to return samples, or the customer requires PASI to dispose of excess samples, proper arrangements will be made for disposal by an approved contractor.

2.10.4. Additional information can be found in SOP S-CHR-S-002 **Waste Handling and Management** (Charlotte laboratory), SOP S-ASV-S-002 **Waste Handling and Management** (Asheville, Eden, and Raleigh laboratories), and SOP S-CAR-C-001 **Sample Management** or the equivalent revisions or replacements.

3.0. ANALYTICAL CAPABILITIES

3.1. Analytical Method Sources

3.1.1. PASI laboratories are capable of analyzing a full range of environmental samples from a variety of matrices, including air, surface water, wastewater, groundwater, soil, sediment, biota, and other waste products. The latest valid editions of methodologies are applied from regulatory and professional sources including EPA, ASTM, USGS, NIOSH, Standard Methods, and State Agencies. Section 11 is a representative listing of general analytical protocol references. PASI discloses in writing to its customers and regulatory agencies any instances in which modified methods are being used in the analysis of samples.

3.1.2. In the event of a customer-specific need, instrumentation constraint or regulatory requirement, PASI laboratories reserve the right to use valid versions of methods that may not be the most recent edition available.

3.2. Analytical Method Documentation

3.2.1. The primary form of PASI laboratory documentation of analytical methods is the Standard Operating Procedure (SOP). SOPs contain pertinent information as to what steps are required by an analyst to successfully perform a procedure. The required contents for the SOPs are specified in the company-wide SOP for Preparation of SOPs (SOT-ALL-Q-001).

3.2.2. The SOPs may be supplemented by other training materials that further detail how methods are specifically performed. This training material will undergo periodic, documented review along with the other Quality System documentation.

3.3. Analytical Method Validation and Instrument Validation

3.3.1. In some situations, PASI develops and validates methodologies that may be more applicable to a specific problem or objective. When non-standard methods are required for specific projects or analytes of interest, or when the laboratory develops or modifies a method, the laboratory validates the method prior to applying it to customer samples. Method validity is established by meeting criteria for precision and accuracy as established by the data quality objectives specified by the end user of the data. The laboratory records the validation procedure, the results obtained and a statement as to the usability of the method. The minimum requirements for method validation include evaluation of sensitivity, quantitation, precision, bias, and selectivity of each analyte of interest.

3.4. Demonstration of Capability (DOC)

3.4.1. Analysts complete an initial demonstration of capability (IDOC) study prior to performing a method or when there is a change in instrument type, personnel, or test method, or at any time that a method has not been performed by the laboratory or analyst in a 12-month period. The mean recovery and standard deviation of each analyte, taken from 4 replicates of a quality control standard is calculated and compared to method criteria (if available) or established laboratory criteria for evaluation of acceptance. Each laboratory maintains copies of all demonstrations of capability, including those that fail acceptance criteria and corresponding raw data for future reference and must document the acceptance criteria prior to the analysis of the DOC. Demonstrations of capability are verified on an annual basis.

3.4.1.1. Initial demonstrations of capability must use a quality control standard with a concentration that is one to four times the limit of quantitation unless otherwise specified by the method.

3.4.2. For Continuing Demonstrations of Capability, the laboratories may use Performance Testing (PT) samples in lieu of the 4-replicate approach listed above. For methods or procedures that do not lend themselves to the "4-replicate" approach, the demonstration of capability requirements will be specified in the applicable SOP. Drinking Water DOCs must be done at or below the MCL.

3.4.3. Additional information can be found in SOP S-ALL-Q-020 **Training and Employee Orientation** or its equivalent revision or replacement.

3.5. Regulatory and Method Compliance

3.5.1. PASI understands that expectations of our customers commonly include the assumption that laboratory data will satisfy specific regulatory requirements. Therefore PASI attempts to ascertain, prior to beginning a project, what applicable regulatory jurisdiction, agency, or protocols apply to that project. This information is also required on the chain of custody submitted with samples.

3.5.2. PASI makes every effort to detect regulatory or project plan inconsistencies, based upon information from the customer, and communicate them immediately to the customer in order to aid in the decision making process. PASI will not be liable if the customer chooses not to follow PASI recommendations.

3.5.3. It is PASI policy to disclose in a forthright manner any detected noncompliance affecting the usability of data produced by our laboratories. The laboratory will notify customers within 30 days of fully characterizing the nature of the nonconformance, the scope of the nonconformance and the impact it may have on data usability.

4.0. QUALITY CONTROL PROCEDURES

Quality control data is analyzed and where they are found to be outside pre-defined criteria, planned action is taken to correct the problem in order to prevent incorrect results from being reported. Quality control samples are to be processed in the same manner as client samples.

4.1. Method Blank

4.1.1. A method blank is used to evaluate contamination in the preparation/analysis system and is processed through all preparation and analytical steps with its associated samples.

4.1.2. A method blank is processed at a minimum frequency of one per preparation batch (see glossary section of this document for further clarification of the definition of batch). In the case of a method that has no separate preparation step, a method blank is processed with no more than 20 samples of a specific matrix performed by the same analyst, using the same method, standards, and reagents.

4.1.3. The method blank consists of a matrix similar to the associated samples that is known to be free of analytes of interest. Method blanks are not applicable for certain analyses, such as pH, conductivity, flash point and temperature.

4.1.4. Each method blank is evaluated for contamination. The source of any contamination is investigated and documented corrective action is taken when the concentration of any target analyte is detected above the reporting limit and is greater than 1/10 of the amount of that analyte found in any associated sample. Some labs, due to client requirements, etc., may have to evaluate their method blanks down to ½ the reporting limit or down to the method detection limit as opposed to the reporting limit itself. Corrective actions for blank contamination may include the re-preparation and re-analysis of all samples (where possible) and quality control samples. Data qualifiers must be applied to results that are considered affected by contamination in a method blank.

4.1.5. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.2. Laboratory Control Sample

4.2.1. The Laboratory Control Sample (LCS) is used to evaluate the performance of the entire analytical system including preparation and analysis.

4.2.2. An LCS is processed at a minimum frequency of one per preparation batch. In the case of a method that has no separate preparation step, an LCS will be processed with no more than 20 samples of a specific matrix performed by the same analyst, using the same method, standards, and reagents.

4.2.3. The LCS consists of a matrix similar to the associated samples that is known to be free of the analytes of interest that is then spiked with known concentrations of target analytes.

4.2.4. The LCS contains **all** analytes specified by a specific method or by the customer or regulatory agency, which may include full list of target compounds, with certain exceptions. These exceptions may include analyzing only specific Aroclors when PCB analysis is requested or not spiking with all EPA Appendix IX compounds when a full Appendix IX list of compounds is requested. However, the lab must ensure that all target components in its scope of accreditation are included in the spike mixture for the LCS over a two (2) year period. In the absence of specified components, the laboratory will spike the LCS with the following compounds:

- For multi-peak analytes (e.g. PCBs, technical chlordane, toxaphene), a representative standard will be processed.
- For methods with long lists of analytes, a representative number of target analytes may be chosen. The following criteria is used to determine the number of LCS compounds used:
    - For methods with 1-10 target compounds, the laboratory will spike with all compounds;
    - For methods with 11-20 target compounds, the laboratory will spike with at least 10 compounds or 80%, whichever is greater;
    - For methods with greater than 20 compounds, the laboratory will spike with at least 16 compounds.

4.2.5. The LCS is evaluated against the method default or laboratory-derived acceptance criteria. For those methods that require laboratory-derived limits, method default control limits may be used until the laboratory has a minimum of 20, but preferably greater than 30, data points from which to derive internal acceptance criteria. Any compound that is outside of these limits is considered to be 'out of control' and must be qualified appropriately. Any associated sample containing an 'out-of-control' compound must either be re-analyzed with a successful LCS or reported with the appropriate data qualifier. When the acceptance criteria for the LCS are exceeded high, and there are associated samples that are non-detects, then those non-detects can be reported with data qualifiers, or when the acceptance criteria are exceeded low, those associated sample results may be reported if they exceed the maximum regulatory limit/decision level with data qualifiers.

4.2.6. For LCSs containing a large number of analytes, it is statistically likely that a few recoveries will be outside of control limits. This does not necessarily mean that the system is out of control, and therefore no corrective action would be necessary (except for proper documentation). TNI has allowed for a minimum number of marginal exceedances, defined as recoveries that are beyond the LCS control limits (3X the standard deviation) but less than the marginal exceedance limits (4X the standard deviation). The number of allowable exceedances depends on the number of compounds in the LCS. If more analyte recoveries exceed the LCS control limits than is allowed (see below) or if any one analyte exceeds the marginal exceedance limits, then the LCS is considered non-compliant and corrective actions are necessary. The number of allowable exceedances is as follows:

- >90 analytes in the LCS- 5 analytes
- 71-90 analytes in the LCS- 4 analytes
- 51-70 analytes in the LCS- 3 analytes
- 31-50 analytes in the LCS- 2 analytes
- 11-30 analytes in the LCS- 1 analyte
- <11 analytes in the LCS- no analytes allowed out

4.2.6.1. The use of marginal exceedences is not acceptable for any data reported to South Carolina Department of Health and Environmental Control.

4.2.7. A matrix spike (MS) can be used in place of a non-compliant LCS in a batch as long as the MS passes the LCS acceptance criteria (this is a TNI allowance). Note: the use of the MS to replace a non-compliant LCS is not approved for work from the state of South Carolina. When this happens, full documentation must be made available to the data user. If this is not allowed by a customer or regulatory body, the associated samples must be rerun with a compliant LCS (if possible) or reported with appropriate data qualifiers.

4.2.8. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.3. Matrix Spike/Matrix Spike Duplicate (MS/MSD)

4.3.1. A matrix spike (MS) is used to determine the effect of the sample matrix on compound recovery for a particular method. The information from these spikes is sample or matrix specific and is not used to determine the acceptance of an entire batch unless the MS is actually used as the LCS.

4.3.2. A **Matrix Spike/Matrix Spike Duplicate** (MS/MSD) set is processed at a frequency specified in a particular method or as determined by a specific customer request. This frequency will be specified in the applicable method SOP or customer QAPP. In the absence of such requirements, an MS/MSD set is routinely analyzed once per every 20 samples per matrix per method.

4.3.3. The MS and MSD consist of the sample matrix that is then spiked with known concentrations of target analytes. Laboratory personnel spike customer samples that are specifically designated as MS/MSD samples or, when no designated samples are present in a batch, randomly select samples to spike that have adequate sample volume or weight. Spiked samples are prepared and analyzed in the same manner as the original samples and are selected from different customers if possible.

4.3.4. The MS and MSD contain all analytes specified by a specific method or by the customer or regulatory agency. In the absence of specified components, the laboratory will spike the MS/MSD with the same number of compounds as previously discussed in the LCS section. However, the lab must ensure that all targeted components in its scope of accreditation are included in the spike mixture for the MS/MSD over a two (2) year period.

4.3.5. The MS and MSD are evaluated against the method or laboratory derived criteria. Any compound that is outside of these limits is considered to be ‘out of control’ and must be qualified appropriately. Batch acceptance, however, is based on method blank and LCS performance, not on MS/MSD recoveries. The spike recoveries give the data user a better understanding of the final results based on their site specific information.

4.3.6. A matrix spike and sample duplicate will be performed instead of a matrix spike and matrix spike duplicate when specified by the customer or method.

4.3.7. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.4. Sample Duplicate

4.4.1. A sample duplicate is a second portion of sample that is prepared and analyzed in the laboratory along with the first portion. It is used to measure the precision associated with preparation and analysis. A sample duplicate is processed at a frequency specified by the particular method or as determined by a specific customer.

4.4.2. The sample and duplicate are evaluated against the method or laboratory derived criteria for relative percent difference (RPD). Any duplicate that is outside of these limits is considered to be ‘out of control’ and must be qualified appropriately.

4.4.3. EPIC Pro randomly selects the sample used for duplication.

4.4.4. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.5. Surrogates

4.5.1. Surrogates are compounds that reflect the chemistry of target analytes and are typically added to samples for organic analyses to monitor the effect of the sample matrix on compound recovery.

4.5.2. Surrogates are added to each customer sample (for applicable organics), method blank, LCS, MS, and calibration standard prior to extraction or analysis. The surrogates are evaluated against the method or laboratory derived acceptance criteria or against project-specific acceptance criteria specified by the client, if applicable. Any surrogate compound that is outside of these limits is considered to be 'out of control' and must be qualified appropriately. Samples with surrogate failures are typically re-extracted and/or re-analyzed to confirm that the out-of-control value was caused by the matrix of the sample and not by some other systematic error. An exception to this would be samples that have high surrogate values but no reportable hits for target compounds. These samples would be reported, with a qualifier, because the implied high bias would not affect the final results. For methods with multiple surrogates, documentation regarding acceptance and associated compounds will be found in the individual method SOPs.

4.5.3. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.6. Internal Standards

4.6.1. Internal Standards are method-specific analytes added to every standard, method blank, laboratory control sample, matrix spike, matrix spike duplicate, sample, and calibration standard at a known concentration, prior to analysis for the purpose of adjusting the response factor used in quantifying target analytes. At a minimum, the laboratory will follow method specific guidelines for the treatment of internal standard recoveries as they are related to the reporting of data.

4.6.2. Deviations made from this policy must be approved by the SQM/QM prior to release of the data.

4.7. Field Blanks

4.7.1. Field blanks are blanks prepared at the sampling site in order to monitor for contamination that may be present in the environment where samples are collected. These field quality control samples are often referenced as field blanks, rinsate blanks, or equipment blanks. The laboratory analyzes these field blanks as normal samples and informs the customer if there are any target compounds detected above the reporting limits.

4.8. Trip Blanks

4.8.1. Trip blanks are blanks that originate from the laboratory as part of the sampling event and are used to monitor for contamination of samples during transport. These blanks accompany the empty sample containers to the field and then accompany the collected samples back to the laboratory.

These blanks are routinely analyzed for volatile methods where ambient background contamination is likely to occur.

4.9. Limit of Detection (LOD)

4.9.1. PASI laboratories are required to use a documented procedure to determine a limit of detection for each analyte of concern in each matrix reported. All sample processing steps of the preparation and analytical methods are included in this determination including any clean ups. For any test that does not have a valid LOD, sample results below the limit of quantitation (LOQ) cannot be reported.

4.9.2. The LOD is initially established for the compounds of interest for each method in a clean matrix with no target analytes present and no interferences at a concentration that would impact the results. The LOD is then determined every time there is a change in the test method that affects how the test is performed or when there has been a change in the instrument that affects the sensitivity. If required by customer, method or accreditation body, the LOD will be re-established annually for all applicable methods.

4.9.3. Unless otherwise noted, the method used by PASI laboratories to determine LODs is based on the Method Detection Limit (MDL) procedure outlined in 40 CFR Part 136, Appendix B. Where required by regulatory program or customer, the above referenced procedure will be followed.

4.9.4. Where specifically stated in the published method, LODs or MDLs will be performed at the listed frequency.

4.9.5. The validity of the LOD must be shown by detection (a value above zero) of the analytes in a QC sample in each quality system matrix. The QC sample must contain the analyte at no more than 3X the LOD for a single analyte test and 4X the LOD for multiple analyte tests. This verification must be performed on each instrument used for sample analysis and reporting of data. The validity of the LOD must be verified as part of the LOD determination process. This verification must be done prior to the use of the LOD for sample analysis.

4.9.6. An LOD study is not required for any analyte for which spiking solutions or quality control samples are not available such as temperature.

4.9.7. The LOD, if required, shall be verified annually for each quality system matrix, technology and analyte. In lieu of performing full LOD (MDL) studies annually, the laboratory can verify the LOD (MDL) on an annual basis, providing this verification is fully documented and does not contradict other customer or program requirements that the laboratory must follow. The requirements of this verification are:

- The spike concentration of the verification must be no more than 3X times the LOD for single analyte tests and 4X the LOD for multiple analyte tests.
- The laboratory must verify the LOD on each instrument used for the reporting of sample data.
- The laboratory must be able to identify all target analytes in the verification standard (distinguishable from noise).

4.9.8. Additional information can be found in SOP SOT-ALL-Q-004 **Determination of LOD and LOQ** or its equivalent revision or replacement.

4.10. Limit of Quantitation (LOQ)

4.10.1. A limit of quantitation (LOQ) for every analyte of concern must be determined. For PASI laboratories, this LOQ is referred to as the RL, or Reporting Limit. This RL is based on the lowest calibration standard concentration that is used in each initial calibration. Results below this level are not allowed to be reported without qualification since the results would not be substantiated by a calibration standard. For methods with a determined LOD, results can be reported out below the LOQ but above the LOD if they are properly qualified (e.g., J flag).

4.10.2. The LOQ must be higher than the LOD.

4.10.3. To verify the LOQ, the laboratory will prepare a sample in the same matrix used for the LCS. The sample will be spiked with each target analyte at a concentration equivalent to the RL or 2X the RL. This sample must undergo the routine sample preparation procedure including any routine sample cleanup steps. The sample is then analyzed and the recovery of each target analyte determined. The recovery for each target analyte must meet the laboratories current control limits for an LCS. The annual LOQ verification is not required if the LOD was determined or verified annually on that instrument.

4.10.4. Additional information can be found in SOP SOT-ALL-Q-004 **Determination of LOD and LOQ** or its equivalent revision or replacement.

4.11. Estimate of Analytical Uncertainty

4.11.1. PASI laboratories can provide an estimation of uncertainty for results generated by the laboratory. The estimate quantifies the error associated with any given result at a 95% confidence interval. This estimate does not include bias that may be associated with sampling. The laboratory has a procedure in place for making this estimation. In the absence of a regulatory or customer-specific procedure, PASI laboratories base this estimation on the recovery data obtained from the Laboratory Control Spikes. The uncertainty is a function of the standard deviation of the recoveries multiplied by the appropriate Student's t Factor at 95% confidence. Additional information pertaining to the estimation of uncertainty and the exact manner in which it is derived are contained in the SOP SOT-ALL-Q-031 **Estimation of Measurement Uncertainty** or its equivalent revision or replacement.

4.11.2. The measurement of uncertainty is provided only on request by the customer, as required by specification or regulation and when the result is used to determine conformance within a specification limit.

4.12. Proficiency Testing (PT) Studies

4.12.1. PASI laboratories participate in the TNI defined proficiency testing program. PT samples are obtained from NIST approved providers and analyzed and reported at a minimum of two times per year for the relevant fields of testing per matrix.

4.12.2. The laboratory initiates an investigation whenever PT results are deemed 'unacceptable' by the PT provider. All findings and corrective actions taken are reported to the SQM/QM or their designee. A corrective action plan is initiated and this report is sent to the appropriate state accreditation agencies for their review. Additional PTs will be analyzed and reported as needed for certification purposes.

4.12.3. PT samples are treated as typical customer samples, utilizing the same staff, methods, equipment, facilities, and frequency of analysis. PT samples are included in the laboratory's normal analytical processes and do not receive extraordinary attention due to their nature.

4.12.4. Comparison of analytical results with anyone participating in the same PT study is prohibited prior to the close of the study.

4.12.5. Additional information can be found in SOP SOT-ALL-Q-010 **Proficiency Testing Program** or its equivalent revision or replacement.

4.13. Rounding and Significant Figures

4.13.1. In general, the PASI laboratories report data to no more than three significant digits. Therefore, all measurements made in the analytical process must reflect this level of precision. In the event that a parameter that contributes to the final result has less than three significant figures of precision, the final result must be reported with no more significant figures than that of the parameter in question. The rounding rules listed below are descriptive of the LIMS and not necessarily of any supporting program such as Excel.

4.13.2. Data is compared to the reporting limits and MDLs to determine if qualifiers are needed before the rounding step occurs.

4.13.3. **Rounding:** PASI-Carolinas follows the odd / even guidelines for rounding numbers:

- If the figure following the one to be retained is less than five, that figure is dropped and the retained ones are not changed (with three significant figures, 2.544 is rounded to 2.54).
- If the figure following the ones to be retained is greater than five, that figure is dropped and the last retained one is rounded up (with three significant figures, 2.546 is rounded to 2.55).
- If the figure following the ones to be retained is five and if there are no figures other than zeros beyond that five, then the five is dropped and the last figure retained is unchanged if it is even and rounded up if it is odd (with three significant figures, 2.525 is rounded to 2.52 and 2.535 is rounded to 2.54).

4.13.4. **Significant Digits**

4.13.4.1. Unless specified by federal, state, or local requirements or on specific request by a customer, PASI-Carolinas reports all analytical results to X significant digits, regardless of the magnitude of the value reported.

4.13.4.2. PASI-Carolinas follows the following convention for reporting to a specified number of significant figures. Unless specified by federal, state, or local requirements or on specific request by a customer, the laboratory reports:

Values > 10 – Reported to 3 significant digits
Values ≤ 10 – Reported to 2 significant digits

4.14. Retention Time Windows

4.14.1. When chromatographic conditions are changed, retention times and analytical separations are often affected. As a result, two critical aspects of any chromatographic method are the determination and verification of retention times and analyte separation. Retention time windows must be established for the identification of target analytes. The retention times of all target analytes in all calibration verification standards must fall within the retention time windows. If an analyte falls outside the retention time window in an ICV or CCV, new absolute retention time windows must be calculated, unless instrument maintenance fixes the problem. When a new column is installed, a new retention time window study must be performed.

4.14.2. One process for the production of retention time windows: Make 3 injections of all single component or multi-component analytes over a 72-hour period. Record the retention time in minutes for each analyte and surrogate to 3 decimal places. Calculate the mean and standard deviation of the three absolute retention times for each target analyte and surrogate. For multi-component analytes, choose 3-5 major peaks and calculate the mean and standard deviation for each of the peaks. If the standard deviation of the retention times of a target analyte is 0.000, the lab may use a default standard deviation of 0.01. The width of the retention time window for each analyte and surrogate and major peak in a multi-component analyte is defined as +/- 3 times the standard deviation of the mean absolute retention time established during that 72-hour period or 0.03 minutes, whichever is greater.

4.14.3. The center of the retention time window is established for each analyte and surrogate by using the absolute retention times from the CCV at the beginning of the analytical shift. For samples run with an initial calibration, use the retention time of the mid-point standard of the initial calibration curve.

4.14.4. For more information, please reference the local facility's analytical SOPs.

5.0. DOCUMENT MANAGEMENT AND CHANGE CONTROL

5.1. Document Management

5.1.1. Additional information can be found in SOP SOT-ALL-Q-002 **Document Control and Management** or its equivalent revision or replacement. Information on Pace's policy for electronic signatures can also be found in this SOP.

5.1.2. Pace Analytical Services, Inc. has an established procedure for managing documents that are part of the quality system. The list of managed documents includes, but is not limited to, Standard Operating Procedures (both technical and non-technical), Quality Assurance Manuals, quality policy statements, training documents, work-processing documents, charts, posters, memoranda, notices, forms, software, and any other procedures, tables, plans, etc. that have a direct bearing on the quality system (including applicable data records and non-technical documents).

5.1.3. A master list of all managed documents is maintained at each facility identifying the current revision status and distribution of the controlled documents. This establishes that there are no invalid or obsolete documents in use in the facility. All documents are reviewed periodically and revised if necessary. Obsolete documents are systematically discarded or archived for audit or knowledge preservation purposes.

5.1.4. Each managed document is uniquely identified to include the date of issue, the revision identification, page numbers, the total number of pages and the issuing authorities. For complete information on document numbering, refer to SOP S-ALL-Q-003 **Document Numbering**.

5.1.5. SOPs, specifically, are available to all laboratory staff via the Learning Management System (LMS) which is a secure repository that is accessed through an internet portal. As a local alternative to the hard copy system of controlled documents, secured electronic copies of controlled documents may be maintained on the laboratory's local server. These document files must be read-only for all personnel except the Quality Department and system administrator. Other requirements for this system are as follows:

- Electronic documents must be readily accessible to all facility employees.
- Electronic documents must be locked from printing. All hardcopy SOPs must be obtained from the Quality Department.

5.1.6. **Quality Assurance Manual (QAM):** The Quality Assurance Manual is the company-wide document that describes all aspects of the quality system for PASI. The base QAM template is distributed by the Corporate Quality Department to each of the SQMs/QMs. The local management personnel modify the necessary and permissible sections of the base template and submit those modifications to the Corporate Director of Quality for review. Once approved and signed by both the CEO and the Director of Quality; the SGM/GM/AGM/OM, the SQM/QM, and any Technical Directors sign the Quality Assurance Manual. Each SQM/QM is then in charge of distribution to employees, external customers or regulatory agencies and maintaining a distribution list of controlled document copies. The Quality Assurance Manual template is reviewed on an annual basis by all of the PASI SQMs/QMs and revised accordingly by the Director of Quality.

5.1.7. Standard Operating Procedures (SOPs)

5.1.7.1. SOPs fall into two categories: company-wide documents and facility specific documents. Company-wide SOPs start with the prefix S-ALL- and local SOPs start with the individual facility prefix.

5.1.7.2. The purpose of the company-wide SOPs is to establish policies and procedure that are common and applicable to all PASI facilities. Company-wide SOPs are document-controlled by the corporate quality office and signed copies are distributed to all of the SQMs/QMs. The local management personnel sign the company-wide SOPs. The SQM/QM is then in charge of distribution to employees, external customers, or regulatory agencies and maintaining a distribution list of controlled document copies.

5.1.7.3. Local PASI facilities are responsible for developing facility-specific SOPs applicable to their respective facility. The local facility develops these facility-specific SOPs based on the corporate-wide SOP template. This template is written to incorporate a set of minimum method requirements and PASI best practice requirements. The local facilities may add to or modify the corporate-wide SOP template provided there are no contradictions to the minimum method or best practice requirements. Facility-specific SOPs are controlled by the applicable SQM/QM according to the corporate document management policies.

5.1.7.4. SOPs are reviewed every two years at a minimum although a more frequent review may be required by some state or federal agencies or customers. If no revisions are made based on this review, documentation of the review itself is made by the addition of new signatures on the cover page. If revisions are made, documentation of the revisions is made in the revisions section of each SOP and a new revision number is applied to the SOP. This provides a historical record of all revisions.

5.1.7.5. All copies of superseded SOPs are removed from general use and the original copy of each SOP is archived for audit or knowledge preservation purposes. This ensures that all PASI employees use the most current version of each SOP and provides the SQM/QM with a historical record of each SOP.

5.1.7.6. Additional information can be found in SOP SOT-ALL-Q-001 **Preparation of SOPs** or its equivalent revision or replacement.

5.2. Document Change Control

5.2.1. Changes to managed documents are reviewed and approved in the same manner as the original review. Any revision to a document requires the approval of the applicable signatories. After revisions are approved, a revision number is assigned and the previous version of the document is officially retired. Copies may be kept for audit or knowledge preservation purposes.

5.2.2. All controlled copies of the previous document are replaced with controlled copies of the revised document and the superseded copies are destroyed or archived. All affected personnel are advised that there has been a revision and any necessary training is scheduled.

5.3. Management of Change

5.3.1. The process for documenting necessary changes within the laboratory network are not typically handled using the corrective or preventive action system as outlined in section 9.0. Management of Change is a proactive approach to dealing with change to minimize the potential negative impact of systematic change in the laboratory and to ensure that each change has a positive desired outcome. This process will primarily be used for the implementation of large scale projects and information system changes as a means to apply consistent systems or procedures within the laboratory network. The request for change is submitted by the initiator and subsequently assigned to an individual or team for development and planning. The final completion of the process culminates in final approval and verification that the procedure was effectively implemented. Additional information can be found in SOP S-CAR-Q-036 **Management of Change** or its equivalent revision or replacement.

6.0 EQUIPMENT AND MEASUREMENT TRACEABILITY

Each PASI facility is equipped with sufficient instrumentation and support equipment to perform the relevant analytical testing or field procedures performed by each facility. Support equipment includes chemical standards, thermometers, balances, disposable and mechanical pipettes, etc. This section details some of the procedures necessary to maintain traceability and to perform proper calibration of instrumentation and support equipment. See Attachment III for a list of equipment currently used at the Carolinas PASI facility.

6.1. Standards and Traceability

6.1.1. Each PASI facility retains all pertinent information for standards, reagents, and chemicals to assure traceability to a national standard. This includes documentation of purchase, receipt, preparation, and use.

6.1.2. Upon receipt, all purchased standard reference materials are recorded into a standard logbook or database and assigned a unique identification number. The entries include the facility's unique identification number, the chemical name, manufacturer name, manufacturer's identification numbers, receipt date, and expiration date. Vendor's certificates of analysis for all standards, reagents, or chemicals are retained for future reference.

6.1.3. Subsequent preparations of intermediate or working solutions are also documented in a standard logbook or database. These entries include the stock standard name and lot number, the manufacturer name, the solvents used for preparation, the solvent lot number and manufacturer, the preparation steps, preparation date, expiration dates, preparer's initials, and a unique PASI identification number. This number is used in any applicable sample preparation or analysis logbook so the standard can be traced back to the standard preparation record. This process ensures traceability back to the national standard.

6.1.4. All prepared standard or reagent containers include the PASI identification number, the standard or chemical name, the date of preparation, the date of expiration, the concentration with units, and the preparer's initials. This ensures traceability back to the standard preparation logbook or database.

6.1.5. For containers that are too small to accommodate labels that list all of the above information associated with a standard, the minimum required information will be PASI standard ID, concentration, and expiration date. This assures that no standard will be used past its assigned expiration date.

6.1.6. If a second source standard is required to verify an existing calibration or spiking standard, this standard must be obtained from a different manufacturer or from a different lot unless client specific QAPP requirements state otherwise.

6.1.7. Additional information concerning the procurement of standards and reagent and their traceability can be found in the SOP SOT-ALL-Q-025 **Standard and Reagent Management and Traceability** or its equivalent revision or replacement.

6.2. General Analytical Instrument Calibration Procedures (Organic and Inorganic)

6.2.1. All support equipment and instrumentation are calibrated or checked before use to ensure proper functioning and verify that the laboratory's requirements are met. All calibrations are performed by, or under the supervision of, an experienced analyst at scheduled intervals against either certified standards traceable to recognized national standards or reference standards whose values have been statistically validated.

6.2.2. Calibration standards for each parameter are chosen to establish the linear range of the instrument and must bracket the concentrations of those parameters measured in the samples. The lowest calibration standard is the lowest concentration for which quantitative data may be reported. Data reported below this level is considered to have less certainty and must be reported using appropriate data qualifiers or explained in a narrative. The highest calibration standard is the highest concentration for which quantitative data may be reported. Data reported above this level is considered to have less certainty and must be reported using appropriate data qualifiers or explained in the narrative. Any specific method requirement for number and type of calibration standards supersedes the general requirement. Instrument and method specific calibration criteria are explained within the specific analytical standard operating procedures for each facility.

6.2.3. Results from all calibration standards analyzed must be included in constructing the calibration curve with the following exceptions:

6.2.3.1. The lowest level calibration standard may be removed from the calibration as long as the remaining number of concentration levels meets the minimum established by the method and standard operating procedure. For multi-parameter methods, this may be done on an individual analyte basis. The reporting limit must be adjusted to the lowest concentration included in the calibration curve;

6.2.3.2. The highest level calibration standard may be removed from the calibration as long as the remaining number of concentration levels meets the minimum established by the method and standard operating procedure. For multi-parameter methods, this may be done an individual analyte basis. The upper limit of quantitation must be adjusted to the highest concentration included in the calibration curve;

6.2.3.3. Multiple points from either the high end or the low end of the calibration curve may be excluded as long as the remaining points are contiguous in nature and the minimum number of levels remains as established by method or standard operating procedure. The reporting limit or quantitation range, whichever is appropriate, must be adjusted accordingly;

6.2.3.4. Results from a concentration level between the lowest and highest calibration levels can only be excluded from an initial calibration curve for a documentable and acceptable cause with approval from the responsible department supervisor and the local SQM/QM or their designee. An acceptable cause is defined as an obvious sample introduction issue that resulted in no response, documentation of an incorrectly prepared standard, or a documented response of a single standard that is greater than 2X the difference from the expected value of that standard. The results for all analytes are to be excluded and the point must be replaced by re-analysis. Re-analysis of this interior standard must occur within the same method-specified tune time period for GC/MS methodologies and within 8 hours of the initial analysis of that standard for non-GC/MS methodologies. All samples analyzed prior to the re-analyzed calibration curve point must be re-analyzed after the calibration curve is completed and re-processed against the final calibration curve.

6.2.4. Instrumentation or support equipment that cannot be calibrated to specification or is otherwise defective is clearly labeled as out-of-service until it has been repaired and tested to demonstrate it meets the laboratory's specifications. All repair and maintenance activities including service calls are documented in the maintenance log. Equipment sent off-site for calibration testing is packed and transported to prevent breakage and is in accordance with the calibration laboratory's recommendations.

6.2.5. In the event that recalibration of a piece of test equipment indicates the equipment may have been malfunctioning during the course of sample analysis, an investigation is performed. The results of the investigation along with a summary of the information reviewed are documented and maintained by the quality manager. Customers must be notified within 30 days after the data investigation is completed and the impact to final results is assessed. This allows for sufficient investigation and review of documentation to determine the impact on the analytical results. Instrumentation found to be consistently out of calibration is either repaired and positively verified or taken out of service and replaced.

6.2.6. Raw data records are retained to document equipment performance. Sufficient raw data is retained to reconstruct the instrument calibration and explicitly connect the continuing calibration verification to the initial calibration.

6.2.7. General Organic Calibration Procedures

6.2.7.1. Calibration standards are prepared at a minimum of five concentrations for organic analyses (unless otherwise stipulated in the method).

6.2.7.2. Initial calibration curves are evaluated against appropriate statistical models as required by the analytical methods. Curves that do not meet the appropriate criteria require corrective action that may include re-running the initial calibration curve. Rounding to meet initial calibration criteria is not allowed, that is, 15.3 cannot be rounded down to meet a $\leq$ 15% RSD requirement. This also applies to linear and non-linear fit requirements. All initial calibrations are verified with an initial calibration verification standard (ICV) obtained from a second manufacturer or second lot from the same manufacturer if that lot can be demonstrated as prepared independently from other lots prior to the analysis of samples. Sample results are quantitated from the initial calibration unless otherwise required by regulation, method, or program.

6.2.7.3. The calibration curve is periodically verified by the analysis of a mid-level continuing calibration verification (CCV) standard during the course of sample analysis. This standard is from the same source as the initial calibration unless otherwise specified in the source method to be from an alternate source material. Rounding to meet continuing calibration criteria is not allowed. Continuing calibration verification is performed at the beginning and end of each analytical batch except if an internal standard is used, then only one verification at the beginning of the batch is needed, whenever it is expected that the analytical system may be out of calibration, if the time period for calibration has expired, or for analytical systems that have specific calibration verification requirements. This verification standard must meet acceptance criteria in order for sample analysis to proceed.

6.2.7.4. In the event that the CCV does not meet the acceptance criteria, a second CCV may be injected as part of the diagnostic evaluation and corrective action investigation. If the second CCV is acceptable, the analytical sequence may be continued. If both CCVs fail, the analytical sequence is terminated and corrective action is initiated. Sample analysis cannot begin until after documented corrective action has been completed and either two consecutive passing CCVs have been analyzed or the instrument has successfully passed a new initial calibration. All samples analyzed since the last compliant CCV are re-analyzed for methodologies utilizing external calibration.

6.2.7.5. When instruments are operating unattended, autosamplers may be programmed to inject consecutive CCVs as a preventative measure against CCV failure with no corrective action. In this case, both CCVs must be evaluated to determine potential impact to the results. A summary of the decision tree and necessary documentation are listed below:

- If both CCVs meet the acceptance criteria, the analytical sequence is allowed to continue without corrective action. The 12 hour clock begins with the injection of the second CCV.
- If the first CCV does not meet the acceptance criteria and the second CCV is acceptable, the analytical sequence is continued and the results are reported.
- If the first CCV meets the acceptance criteria and the second CCV is out of control, the samples after the out of control CCV must be re-analyzed in a compliant analytical sequence.
- If both CCVs are out of control, all samples since the last acceptable CCV must be re-analyzed in a compliant analytical sequence.

6.2.7.6. Some analytical methods require that samples be bracketed by passing CCVs analyzed both before and after the samples. This is specific to each method but, as a general rule, all external calibration methods require bracketing CCVs. Most internal standard calibrations do not require bracketing CCVs.

6.2.7.7. Some analytical methods require verification based on a time interval; some methods require a frequency based on an injection interval. The type and frequency of the calibration verifications is dependent on both the analytical method and possibly on the quality program associated with the samples. The type and frequency of calibration verification will be documented in the method specific SOP employed by each laboratory.

6.2.8. General Inorganic Calibration Procedures

6.2.8.1. The instrument is initially calibrated with standards at multiple concentrations to establish the linearity of the instrument's response. A calibration blank is also included. Initial calibration curves are evaluated against appropriate statistical models as required by the analytical methods. Rounding to meet initial calibration criteria is not allowed. This also applies to linear and non-linear fit requirements. The number of calibration standards used depends on the specific method criteria or customer project requirements, although normally a minimum of three standards is used.

6.2.8.2. The ICP and ICP/MS can be standardized with a zero point and a single point calibration if:

- Prior to analysis, the zero point and the single point calibration are analyzed and a linear range has been established,
- Zero point and single point calibration standards are analyzed with each batch
- A standard corresponding to the LOQ is analyzed with the batch and meets the established acceptance criteria
- The linearity is verified at the frequency established by the method or manufacturer.

6.2.8.3. All initial calibrations are verified with an initial calibration verification standard (ICV) obtained from a second manufacturer or second lot from the same manufacturer if the lot can be demonstrated as prepared independently from other lots prior to the analysis of samples. Sample results are quantitated from the initial calibration unless otherwise required by regulation, method, or program.

6.2.8.4. During the course of analysis, the calibration curve is periodically verified by the analysis of calibration verification standards (CCV). A calibration verification standard is analyzed within each analytical batch at method/program specific intervals to verify that the initial calibration is still valid. The CCV is also analyzed at the end of the analytical batch.

6.2.8.5. A calibration blank is also run with each calibration verification standard to verify the cleanliness of the system. All reported results must be bracketed by acceptable CCVs. Instrument and method specific calibration acceptance criteria are explained within the specific analytical standard operating procedures for each facility.

6.2.8.6. Interference check standards are also analyzed per method requirements and must meet acceptance criteria for metals analyses.

6.3. Support Equipment Calibration Procedures

6.3.1. All support equipment is calibrated or verified at least annually using NIST traceable references over the entire range of use. The results of calibrations or verifications must be within the specifications required or the equipment will be removed from service until repaired. The laboratory maintains records to demonstrate the correction factors applied to working thermometers.

6.3.2. On each day the equipment is used, balances, ovens, refrigerators (those used to keep samples and standards at required temperatures), freezers, and water baths are checked in the expected use range with NIST traceable references in order to ensure the equipment meets laboratory specifications and these checks are documented appropriately.

6.3.3. Analytical Balances

6.3.3.1. Each analytical balance is calibrated or verified at least annually by a qualified service technician. The calibration of each balance is verified each day of use with weights traceable to NIST bracketing the range of use. Calibration weights are ASTM Class 1 or other class weights that have been calibrated against a NIST standard weight and are re-certified every 5 years at a minimum against a NIST traceable reference. Some accrediting agencies may require more frequent checks. If balances are calibrated by an external agency, verification of their weights must be provided. All information pertaining to balance maintenance and calibration is recorded in the individual balance logbook and/or is maintained on file in the Quality department.

6.3.4. Thermometers

6.3.4.1. Certified, or reference, thermometers are maintained for checking calibration of working thermometers. Reference thermometers are provided with NIST traceability for initial calibration and are re-certified, at a minimum, every 3 years with equipment directly traceable to NIST.

6.3.4.2. Working thermometers are compared with the reference thermometers annually according to corporate metrology procedures. Each thermometer is individually numbered and assigned a correction factor based on the NIST reference source. In addition, working thermometers are visually inspected by laboratory personnel prior to use and temperatures are documented.

6.3.4.3. Laboratory thermometer inventory and calibration data are maintained in the Quality department.

6.3.5. pH/Electrometers

6.3.5.1. The meter is calibrated before use each day, using fresh buffer solutions.

6.3.6. Spectrophotometers

6.3.6.1. During use, spectrophotometer performance is checked at established frequencies in analysis sequences against initial calibration verification (ICV) and continuing calibration verification (CCV) standards.

6.3.7. Mechanical Volumetric Dispensing Devices

6.3.7.1. Mechanical volumetric dispensing devices including bottle top dispensers (those that are critical in measuring a required amount of reagent), pipettes, and burettes, excluding Class A volumetric glassware, are checked for accuracy on a quarterly basis.

6.3.7.2. Additional information regarding calibration and maintenance of laboratory support equipment can be found in SOP SOT-ALL-Q-013 **Support Equipment** or its equivalent revision or replacement.

6.4. Instrument/Equipment Maintenance

6.4.1. The objectives of the Pace Analytical maintenance program are twofold: to establish a system of instrument care that maintains instrumentation and equipment at required levels of calibration and sensitivity, and to minimize loss of productivity due to repairs.

6.4.2. The Operations Manager and/or department manager/supervisors are responsible for providing technical leadership to evaluate new equipment, solve equipment problems, and coordinate instrument repair and maintenance. Analysts have the primary responsibility to perform routine maintenance.

6.4.3. To minimize downtime and interruption of analytical work, preventative maintenance is routinely performed on each analytical instrument. Up-to-date instructions on the use and maintenance of equipment are available to staff in the department where the equipment is used.

6.4.4. Department manager/supervisors are responsible for maintaining an adequate inventory of spare parts required to minimize equipment downtime. This inventory includes parts and supplies that are subject to frequent failure, have limited lifetimes, or cannot be obtained in a timely manner should a failure occur.

6.4.5. All major equipment and instrumentation items are uniquely identified to allow for traceability. Equipment/instrumentation is, unless otherwise stated, identified as a system and not as individual pieces. The laboratory maintains equipment records that include the following:

- The name of the equipment and its software
- The manufacturer’s name, type, and serial number
- Approximate date received and date placed into service
- Current location in the laboratory
- Condition when received (new, used, etc.)
- Copy of any manufacturer’s manuals or instructions
- Dates and results of calibrations and next scheduled calibration (if known)
- Details of past maintenance activities, both routine and non-routine
- Details of any damage, modification or major repairs

6.4.6. All instrument maintenance is documented in maintenance logbooks that are assigned to each particular instrument or system.

6.4.7. The maintenance log entry must include a summary of the results of that analysis and verification by the analyst that the instrument has been returned to an in-control status. In addition, each entry must include the initials of the analyst making the entry, the dates the maintenance actions were performed, and the date the entry was made in the maintenance logbook, if different from the date(s) of the maintenance.

6.4.8. Any equipment that has been subjected to overloading or mishandling, or that gives suspect results, or has been shown to be defective, is taken out of service and clearly identified. The equipment shall not be used to analyze customer samples until it has been repaired and shown to perform satisfactorily. In the event of instrumentation failure, to avoid hold time issues, the lab may subcontract the necessary samples to another Pace lab or to an outside subcontract lab if possible.

7.0. CONTROL OF DATA

Analytical results processing, verification, and reporting are procedures employed that result in the delivery of defensible data. These processes include, but are not limited to, calculation of raw data into final concentration values, review of results for accuracy, evaluation of quality control criteria and assembly of technical reports for delivery to the data user.

All analytical data undergo a well-defined, well-documented multi-tier review process prior to being reported to the customer. This section describes procedures used by PASI for translating raw analytical data into accurate final sample reports as well as PASI data storage policies.

7.1. Analytical Results Processing

7.1.1. When analytical, field, or product testing data is generated, it is either recorded in a bound laboratory logbook (e.g., Run log or Instrument log) or copies of computer-generated printouts that are appropriately labeled and filed. These logbooks and other laboratory records are kept in accordance with each facility's Standard Operating Procedure for documentation storage and archival. If the laboratory chooses to minimize or eliminate its paper usage, these records can be kept on electronic media. In this case, the laboratory must ensure that there are sufficient redundant electronic copies so no data is lost due to unforeseen computer issues.

7.1.2. The primary analyst is responsible for initial data reduction and review. This includes confirming compliance with required methodology, verifying calculations, evaluating quality control data, noting non-conformances in logbooks or as footnotes or narratives, and uploading analytical results into the LIMS. The primary analyst must be clearly identified in all applicable logbooks, spreadsheets and LIMS fields.

7.1.3. The primary analyst then compiles the initial data package for verification. This compilation must include sufficient documentation for data review. It may include standard calibrations, chromatograms, manual integration documentation, electronic printouts, chain of custody forms, and logbook copies.

7.1.4. Some agencies or customers require different levels of data reporting. For these special levels, the primary analyst may need to compile additional project information, such as initial calibration data or extensive spectral data, before the data package proceeds to the verification step.

7.2. Data Verification

7.2.1. Data verification is the process of examining data and accepting or rejecting it based on pre-defined criteria. This review step is designed to ensure that reported data are free from calculation and transcription errors, that quality control parameters are evaluated, and that any non-conformances are properly documented.

7.2.2. Analysts performing the analysis and subsequent data reduction have primary responsibility for quality of the data produced. The primary analyst initiates the data verification process by reviewing and accepting the data, provided QC criteria have been met for the samples being reported. Data review checklists, either hardcopy or electronic, are used to document the data review process. The primary analyst is responsible for the initial input of the data into the LIMS. The primary analyst and reviewer must be clearly identified on all applicable data review checklists.

7.2.3. The completed data package is then sent to a designated qualified reviewer (this cannot be the primary analyst). The following criteria have been established to qualify someone as a data reviewer. To perform secondary data review, the reviewer must:

7.2.3.1. Have a current Demonstration of Capability (DOC) study on file and have an SOP acknowledgement form on file for the method/procedure being reviewed; or, See Note

7.2.3.2. Have a DOC on file for a similar method/technology (i.e., GC/MS) and have an SOP acknowledgment form on file for the method/procedure being reviewed; or, See Note

7.2.3.3. Supervise or manage a Department and have an SOP acknowledgment form on file for the method/procedure being reviewed; or,

7.2.3.4. Have significant background in the department/methods being reviewed through education or experience and have an SOP acknowledgment form on file for the method/procedure being reviewed.

7.2.4. **Note:** Secondary reviewer status must be approved personally by the SQM/QM or SGM/GM/AGM/OM in the event that this person has no prior experience on the specific method or general technology.

7.2.5. This reviewer provides an independent technical assessment of the data package and technical review for accuracy according to methods employed and laboratory protocols. This assessment involves a quality control review for use of the proper methodology and detection limits, compliance to quality control protocol and criteria, presence and completeness of required deliverables, and accuracy of calculations and data quantitation. The reviewer validates the data entered into the LIMS and documents approval of manual integrations.

7.2.6. Once the data have been technically reviewed and approved, authorization for release of the data from the analytical section is indicated by initialing and dating the data review checklist or otherwise initialing and dating the data (or designating the review of data electronically). The Operations or Project Manager examines the report for method appropriateness, detection limits and QC acceptability. Any deviations from the referenced methods are checked for documentation and validity, and QC corrective actions are reviewed for successful resolution. Alternately, final reports can be set to auto email to the client after the analytical results are final and have been run through the Data Checker program for errors. These are set up on a case-by-case basis.

7.2.7. Additional information regarding data review procedures can be found in SOP SOT-ALL-Q-037 **Data Review** or its equivalent revision or replacement, as well as in SOP SOT-ALL-Q-016 **Manual Integration** or its equivalent revision or replacement.

7.2.8. The Data Checker program will process validated data for a given project against a set of pre-determined requirements and known chemistry relationships. The program creates a report that includes a series of warnings and errors for any requirement or condition determined to be suspect or incorrect. These warnings and error counts are displayed on the "Project Inquiry by Client" screen and on the final Data Checker reports. For projects that have any number of warnings or errors, the Data Checker report will provide a message that identifies the source and condition of the error or warning.

7.3. Data Reporting

7.3.1. Data for each analytical fraction pertaining to a particular PASI project number are delivered to the Project Manager for assembly into the final report. All points mentioned during technical and QC reviews are included in data qualifiers on the final report or in a separate case narrative if there is potential for data to be impacted.

7.3.2. Final reports are prepared according to the level of reporting required by the customer and can be transmitted to the customer via hardcopy or electronic deliverable. A standard PASI final report consists of the following components:

7.3.2.1. A title which designates the report as "Final Report", "Laboratory Results", "Certificate of Results", etc.;

7.3.2.2. Name and address of laboratory (or subcontracted laboratories, if used);

7.3.2.3. Phone number and name of laboratory contact to where questions can be referred;

7.3.2.4. A unique identification number for the report. The pages of the report shall be numbered and a total number of pages shall be indicated;

7.3.2.5. Name and address of customer and name of project;

7.3.2.6. Unique identification of samples analyzed as well as customer sample IDs;

7.3.2.7. Identification of any sample that did not meet acceptable sampling requirements of the relevant governing agency, such as improper sample containers, holding times missed, sample temperature, etc.;

7.3.2.8. Date and time of collection of samples, date of sample receipt by the laboratory, dates of sample preparation and analysis, and times of sample preparation and analysis when the holding time for either is 72 hours or less;

7.3.2.9. Identification of the test methods used;

7.3.2.10. Identification of sampling procedures if sampling was conducted by the laboratory;

7.3.2.11. Deviations from, additions to, or exclusions from the test methods. These can include failed quality control parameters, deviations caused by the matrix of the sample, etc., and can be shown as a case narrative or as defined footnotes to the analytical data;

7.3.2.12. Identification of whether calculations were performed on a dry or wet-weight basis;

7.3.2.13. Reporting limits used;

7.3.2.14. Final results or measurements, supported by appropriate chromatograms, charts, tables, spectra, etc.;

7.3.2.15. A signature and title, electronic or otherwise, of person accepting responsibility for the content of the report;

7.3.2.16. Date report was issued;

7.3.2.17. A statement clarifying that the results of the report relate only to the samples tested or to the samples as they were received by the laboratory;

7.3.2.18. If necessary, a statement indicating that the report must not be reproduced except in full, without the written approval of the laboratory;

7.3.2.19. Identification of all test results provided by a subcontracted laboratory or other outside source;

7.3.2.20. Identification of results obtained outside of quantitation levels.

In addition to the requirements listed above, final reports shall also contain the following items when necessary for the interpretation of results:

7.3.2.21. Deviations from, additions to, or exclusions from the test method, and information on specific test conditions, such as environmental conditions;

7.3.2.22. Where relevant, a statement of compliance/non-compliance with requirements and/or specifications (e.g., the TNI standard);

7.3.2.23. Where applicable, a statement on the estimated uncertainty of measurement; information on uncertainty is needed in test reports when it is relevant to the validity or application of the test results, when a customer's instruction so requires, or when the uncertainty affects compliance to a specification limit;

7.3.2.24. Where appropriate and needed, opinions and interpretations, which may include opinions on the compliance/non-compliance of the results with requirements, fulfillment of contractual requirements, recommendations on how to use the results, and guidance to be used for improvement;

7.3.3. Any changes made to a final report shall be designated as "Revised" or equivalent wording. The laboratory must keep sufficient archived records of all laboratory reports and revisions. For higher levels of data deliverables, a copy of all supporting raw data is sent to the customer along with a final report of results. When possible, the PASI facility will provide electronic data deliverables (EDD) as required by contracts or upon customer request.

7.3.4. Customer data that requires transmission by telephone, telex, facsimile or other electronic means undergoes appropriate steps to preserve confidentiality.

7.3.5. The following positions are the only approved signatories for PASI final reports:

- Senior General Manager
- General Manager
- Assistant General Manager
- Senior Quality Manager
- Quality Manager
- Client Services Manager
- Project Manager
- Project Coordinator

7.4. Data Security

7.4.1. All data including electronic files, logbooks, extraction/digestion/distillation worksheets, calculations, project files and reports, and any other information used to produce the technical report are maintained secured and retrievable by the PASI facility.

7.5. Data Archiving

7.5.1. All records compiled by PASI are maintained legible and retrievable and stored secured in a suitable environment to prevent loss, damage, or deterioration by fire, flood, vermin, theft, and/or environmental deterioration. Records are retained for a minimum of five years unless superseded by federal, state, contractual, and/or accreditation requirements. These records may include, but are not limited to, customer data reports, calibration and maintenance of equipment, raw data from instrumentation, quality control documents, observations, calculations, and logbooks. These records are retained in order to provide for possible historical reconstruction including sampling, receipt, preparation, analysis, and personnel involved. TNI-related records will be made readily available to accrediting authorities. Access to archived data is documented and controlled by the SQM/QM or a designated Data Archivist.

7.5.2. Records that are computer generated have either a hard copy or electronic write protected backup copy. Hardware and software necessary for the retrieval of electronic data is maintained with the applicable records. Archived electronic records are stored protected against electronic and/or magnetic sources.

7.5.3. In the event of a change in ownership, accountability or liability, reports of analyses performed pertaining to accreditation will be maintained by the acquiring entity for a minimum of five years. In the event of bankruptcy, laboratory reports and/or records will be transferred to the customer and/or the appropriate regulatory entity upon request.

7.6. Data Disposal

7.6.1. Data that has been archived for the facility’s required storage time may be disposed of in a secure manner by shredding, returning to customer, or utilizing some other means that does not jeopardize data confidentiality. Records of data disposal will be archived for a minimum of five years unless superseded by federal, contractual, and/or accreditation requirements. Data disposal includes any preliminary or final reports that are disposed.

8.0. QUALITY SYSTEM AUDITS AND REVIEWS

8.1. Internal Audits

8.1.1. Responsibilities

8.1.1.1. The SQM/QM is responsible for managing and/or conducting internal audits in accordance with a predetermined schedule and procedure. Since internal audits represent an independent assessment of laboratory functions, the auditor must be functionally independent from laboratory operations to ensure objectivity. The auditor must be trained, qualified, and familiar enough with the objectives, principles, and procedures of laboratory operations to be able to perform a thorough and effective evaluation. The SQM/QM evaluates audit observations and verifies the completion of corrective actions. In addition, a periodic corporate audit will be conducted. The corporate audits will focus on the effectiveness of the Quality System as outlined in this manual but may also include other quality programs applicable to an individual laboratory.

8.1.2. Scope and Frequency of Internal Audits

8.1.2.1. The complete internal audit process consists of the following four sections:

- Raw Data Review audits- conducted according to a schedule per local SQM/QM. A certain number of these data review audits are conducted per quarter to accomplish this yearly schedule;
- Quality System audits- considered the traditional internal audit function and includes analyst interviews to help determine whether practice matches method requirements and SOP language;
- Final Report reviews;
- Corrective Action Effectiveness Follow-up.

8.1.2.2. Internal systems audits are conducted yearly at a minimum. The scope of these audits includes evaluation of specific analytical departments or a specific quality related system as applied throughout the laboratory.

8.1.2.3. Where the identification of non-conformities or departures cast doubt on the laboratory's compliance with its own policies and procedures, the lab must ensure that the appropriate areas of activity are audited as soon as possible. Examples of system-wide elements that can be audited include:

- Quality Systems documents, such as Standard Operating Procedures, training documents, Quality Assurance Manual, and all applicable addenda
- Data records and non-technical documents
- Personnel and training files.
- General laboratory safety protocols.
- Chemical handling practices, such as labeling of reagents, solutions, and standards as well as all associated documentation.
- Documentation concerning equipment and instrumentation, calibration/maintenance records, operating manuals.
- Sample receipt and management practices.
- Analytical documentation, including any discrepancies and corrective actions.

- General procedures for data security, review, documentation, reporting, and archiving.
- Data integrity issues such as proper manual integrations.

8.1.2.4. When the operations of a specific department are evaluated, a number of additional functions are reviewed including:

- Detection limit studies
- Internal chain of custody documentation
- Documentation of standard preparations
- Quality Control limits and Control charts

8.1.2.5. Certain projects may require an internal audit to ensure laboratory conformance to site work plans, sampling and analysis plans, QAPPs, etc.

8.1.2.6. A representative number of data audits are completed annually. Findings from these data audits are handled in the same manner as those from other internal and external audits.

8.1.2.7. The laboratory, as part of their overall internal audit program, ensures that a review is conducted with respect to any evidence of inappropriate actions or vulnerabilities related to data integrity. Discovery and reporting of potential data integrity issues are handled in a confidential manner. All investigations that result in findings of inappropriate activity are fully documented, including the source of the problem, the samples and customers affected the impact on the data, the corrective actions taken by the laboratory, and which final reports had to be re-issued. Customers must be notified within 30 days after the data investigation is completed and the impact to final results is assessed.

8.1.3. Internal Audit Reports and Corrective Action Plans

8.1.3.1. Additional information can be found in SOP SOT-ALL-Q-011 **Internal and External Audits** or its equivalent revision or replacement.

8.1.3.2. A full description of the audit, including the identification of the operation audited, the date(s) on which the audit was conducted, the specific systems examined, and the observations noted are summarized in an internal audit report. Although other personnel may assist with the performance of the audit, the SQM/QM writes and issues the internal audit report identifying which audit observations are deficiencies that require corrective action.

8.1.3.3. When audit findings cast doubt on the effectiveness of the operations or on the correctness of validity of the laboratory's environmental test results, the laboratory will take timely corrective action and notify the customer in writing within three business days, if investigations show that the laboratory results may have been affected.

8.1.3.4. Once completed, the internal audit report is issued jointly to the SGM/GM/AGM/OM and the manager(s)/supervisor(s) of the audited operation at a minimum. The responsible manager(s)/supervisor(s) responds within 14 days with a proposed plan to correct all of the deficiencies cited in the audit report. The SQM/QM may grant additional time for responses to large or complex deficiencies (not to exceed 30 days). Each response must include timetables for completion of all proposed corrective actions.

8.1.3.5. The SQM/QM reviews the audit responses. If the response is accepted, the SQM/QM uses the action plan and timetable as a guideline for verifying completion of the corrective action(s). If the SQM/QM determines that the audit response does not adequately address the correction of cited deficiencies, the response will be returned for modification.

8.1.3.6. To complete the audit process, the SQM/QM performs a re-examination of the areas where deficiencies were found to verify that all proposed corrective actions have been implemented. An audit deficiency is considered closed once implementation of the necessary corrective action has been audited and verified. This is usually within 60-90 days after implementation. If corrective action cannot be verified, the associated deficiency remains open until that action is completed.

8.2. External Audits

8.2.1. PASI laboratories are audited regularly by regulatory agencies to maintain laboratory certifications and by customers to maintain appropriate specific protocols.

8.2.2. Audit teams external to the company review the laboratory to assess the effectiveness of systems and degree of technical expertise. The SQM/QM and other QA staff host the audit team and assist in facilitation of the audit process. Generally, the auditors will prepare a formalized audit report listing deficiencies observed and follow-up requirements for the laboratory. In some cases, items of concern are discussed during a debriefing convened at the end of the on-site review process.

8.2.3. The laboratory staff and supervisors develop corrective action plans to address any deficiencies with the guidance of the SQM/QM. The SGM/GM/AGM/OM provides the necessary resources for staff to develop and implement the corrective action plans. The SQM/QM collates this information and provides a written response to the audit team. The response contains the corrective action plan and expected completion dates for each element of the plan. The SQM/QM follows-up with the laboratory staff to ensure corrective actions are implemented and that the corrective action was effective.

8.3. Quarterly Quality Reports

8.3.1. The SQM/QM is responsible for preparing a quarterly report to management summarizing the effectiveness of the laboratory Quality Systems. This status report will include:

- Overview of quality activities for the quarter
- Certification status
- Proficiency Testing study results
- SOP revision activities
- Internal audit (method/system) findings
- Manual integration audit findings (Mintminer)
- Raw Data and Final Report review findings
- MDL activities
- Other significant Quality System items

8.3.2. The Corporate Director of Quality utilizes the information from each laboratory to make decisions impacting the quality program compliance of the company as a whole. Each SGM/GM/AGM/OM utilizes the quarterly report information to make decisions impacting Quality Systems and operational systems at a local level.

8.3.3. Additional information can be found in SOP S-ALL-Q-014 **Quality System Review** or its equivalent revision or replacement.

8.4. Annual Managerial Review

8.4.1. A managerial review of Management and Quality Systems is performed on an annual basis at a minimum. This allows for assessing program effectiveness and introducing changes and/or improvements.

8.4.2. The managerial review must include the following topics of discussion:

- Suitability of quality management policies and procedures
- Manager/Supervisor reports
- Internal audit results
- Corrective and preventive actions
- External assessment results
- Proficiency testing studies
- Sample capacity and scope of work changes
- Customer feedback, including complaints
- Recommendations for improvement,
- Other relevant factors, such as quality control activities, resources, and staffing.

8.4.3. This managerial review must be documented for future reference by the SQM/QM and copies of the report are distributed to laboratory staff. Results must feed into the laboratory planning system and must include goals, objectives, and action plans for the coming year. The laboratory shall ensure that any actions identified during the review are carried out within an appropriate and agreed upon timescale.

8.5. Customer Service Reviews

8.5.1. As part of the annual managerial review listed previously, the sales staff is responsible for reporting on customer feedback, including complaints. The acquisition of this information is completed by performing surveys.

8.5.2. The sales staff continually receives customer feedback, both positive and negative, and reports this feedback to the laboratory management in order for them to evaluate and improve their management system, testing activities and customer service.

8.5.3. In addition, the labs must be willing to cooperate with customers or their representatives to clarify customer requests and to monitor the laboratory's performance in relation to the work being performed for the customers. This cooperation may include providing the customer reasonable access to relevant areas of the lab for the witnessing of tests being performed; or the preparation of samples or data deliverables to be used for verification purposes. If the lab has a customer feedback SOP, please refer to that SOP for more details.

8.5.4. Customer service is an important aspect to Pace's overall objective of providing a quality product. Good communication should be provided to the customer's throughout projects. The lab should inform the customer of any delay or major deviations in the performance of analytical tests.

9.0. CORRECTIVE ACTION

Additional information can be found in SOP SOT-ALL-Q-012 **Corrective and Preventive Actions** or its equivalent revision or replacement.

During the process of sample handling, preparation, and analysis, or during review of quality control records, or during reviews of non-technical portions of the lab, certain occurrences may warrant the necessity of corrective actions. These occurrences may take the form of analyst errors, deficiencies in quality control, method deviations, or other unusual circumstances. The Quality System of PASI provides systematic procedures for the documentation, monitoring, completion of corrective actions, and follow-up verification of the effectiveness of these corrective actions. This can be done using PASI's LabTrack system or other system that lists among at a minimum, the deficiency by issue number, the deficiency source, responsible party, root cause, resolution, due date, and date resolved.

9.1. Corrective Action Documentation

9.1.1. The following items are examples of sources of laboratory deviations or non-conformances that warrant some form of documented corrective action:

- Internal Laboratory Non-Conformance Trends
- PE/PT Sample Results
- Internal and External Audits
- Data or Records Review (including non-technical records)
- Client Complaints
- Client Inquiries
- Holding Time violations

9.1.2. Documentation of corrective actions may be in the form of a comment or footnote on the final report that explains the deficiency (e.g., matrix spike recoveries outside of acceptance criteria) or it may be a more formal documentation (either paper system or computerized spreadsheet). This depends on the extent of the deficiency, the impact on the data, and the method or customer requirements for documentation.

9.1.3. The person who discovers the deficiency or non-conformance initiates the corrective action documentation on the Non-Conformance Corrective/ Preventive Action report and/or LabTrack. The documentation must include the affected projects and sample numbers, the name of the applicable Project Manager, the customer name, and the sample matrix involved. The person initiating the corrective action documentation must also list the known causes of the deficiency or non-conformance as well as any corrective/preventative actions that they have taken. Preventive actions must be taken in order to prevent or minimize the occurrence of the situation.

9.1.4. In the event that the laboratory is unable to determine the cause, laboratory personnel and management staff will start a root cause analysis by going through an investigative process. During this process, the following general steps must be taken into account: defining the non-conformance, assigning responsibilities, determining if the condition is significant, and investigating the root cause of the nonconformance. General non-conformance investigative techniques follow the path of the sample through the process looking at each individual step in detail. The root cause must be documented within LabTrack or on the Corrective/Preventive Action Report.

9.1.5. After all the documentation is completed, the routing of the Corrective/Preventive Action Report and /or LabTrack will continue from the person initiating the corrective action, to their immediate supervisor or the applicable Project Manager and finally to the SQM/QM, if applicable, who may be responsible for final review and signoff of corrective/preventive actions.

9.1.6. In the event that analytical testing or results do not conform to documented laboratory policies or procedures, customer requirements, or standard specifications, the laboratory shall investigate the significance of the non-conformance and document appropriate corrective actions. The proper level of laboratory management will review any departure from these requirements for technical suitability. These departures are permitted only with the approval of the SGM/GM/AGM/OM or the SQM/QM. Where necessary, Project Management will notify the customer of the situation and will advise of any ramifications to data quality (with the possibility of work being recalled). The procedures for handling non-conforming work are detailed in SOP SOT-ALL-Q-012 **Corrective and Preventive Actions** or its equivalent revision or replacement.

9.2. Corrective Action Completion

9.2.1. Internal Laboratory Non-Conformance Trends

9.2.1.1. There are several types of non-conformance trends that may occur in the laboratory that would require the initiation of a corrective action report. Laboratories may choose to initiate a corrective action for all instances of one or more of these categories if they so choose, however the intent is that each of these would be handled according to its severity; one time instances could be handled with a footnote or qualifier whereas a systemic problem with any of these categories may require an official corrective action process. These categories, as defined in the Corrective Action SOP are as follows:

- Login error
- Preparation Error
- Contamination
- Calibration Failure
- Internal Standard Failure
- LCS Failure
- Laboratory accident
- Spike Failure
- Instrument Failure
- Final Reporting error

9.2.2. PE/PT Sample Results

9.2.2.1. Any PT result assessed as “not acceptable” requires an investigation and applicable corrective actions. The operational staff is made aware of the PT failures and they are responsible for reviewing the applicable raw data and calibrations and list possible causes for error. The SQM/QM reviews their findings and initiates another external PT sample or an internal PT sample to try and correct the previous failure. Replacement PT results must be monitored by the SQM/QM and reported to the applicable regulatory authorities.

9.2.2.2. Additional information, such as requirements regarding time frames for reporting failures to states, makeup PTs, and notifications of investigations, can be found in SOP template SOT-ALL-Q-010 **Proficiency Testing Program** or its equivalent revision or replacement.

9.2.3. Internal and External Audits

9.2.3.1. The SQM/QM is responsible for documenting all audit findings and their corrective actions. This documentation must include the initial finding, the persons responsible for the corrective action, the due date for responding to the auditing body, the root cause of the finding, and the corrective actions needed for resolution. The SQM/QM is also responsible for providing any back-up documentation used to demonstrate that a corrective action has been completed.

9.2.4. Data Review

9.2.4.1. In the course of performing primary and secondary review of data or in the case of raw data reviews (e.g., by the SQM/QM), errors may be found which require corrective actions. Any finding that affects the quality of the data requires some form of corrective action, which may include revising and re-issuing of final reports.

9.2.5. Client Complaints

9.2.5.1. Project Managers are responsible for issuing corrective action forms, when warranted, for customer complaints. As with other corrective actions, the possible causes of the problem are listed and the form is passed to the appropriate analyst or supervisor for investigation. After potential corrective actions have been determined, the Project Manager reviews the corrective action form to ensure all customer needs or concerns are being adequately addressed.

9.2.6. Client Inquiries

9.2.6.1. When an error on the customer report is discovered, the Project Manager is responsible for initiating a formal corrective action form that describes the failure (e.g., incorrect analysis reported, reporting units are incorrect, or reporting limits do not meet objectives). The Project Manager is also responsible for revising the final report if necessary and submitting it to the customer.

9.2.7. Holding Time Violations

9.2.7.1. In the event that a holding time has been missed, the analyst or supervisor must complete a formal corrective action form. The Project Manager and the SQM/QM must be made aware of all holding time violations.

9.2.7.2. The Project Manager must contact the customer in order that appropriate decisions are made regarding the hold time excursion and the ultimate resolution is then documented and included in the customer project file.

9.3. Preventive Action Documentation

9.3.1. Pace laboratories can take advantage of several available information sources in order to identify needed improvements in all of their systems including technical, managerial, and quality. These sources may include:

- Management Continuous Improvement Plan (CIP) metrics which are used by all production departments within Pace. When groups compare performance across the company, ways to improve systems may be discovered. These improvements can be made within a department or laboratory-wide.
- Annual managerial reviews- part of this TNI-required and NVLAP-required review is to look at all processes and procedures used by the laboratory over the past year and to determine ways to improve these processes in the future.

- Quality systems reviews- any frequent checks of quality systems (monthly logbook reviews, etc.) can uncover issues that can be corrected or adjusted before they become a larger issue.

9.3.2. When improvement opportunities are identified or if preventive action is required, the laboratory can develop, implement, and monitor preventive action plans.

10.0. GLOSSARY

The source of some of the definitions is indicated previous to the actual definition (e.g., TNI, DoD).

Terms and Definitions	
3P Program	The Pace Analytical continuous improvement program that focuses on Process, Productivity, and Performance. Best Practices are identified that can be used by all PASI labs.
Acceptance Criteria	TNI- Specified limits placed on characteristics of an item, process, or service defined in requirement documents.
Accreditation	TNI- The process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory.
Accreditation Body	Authoritative body that performs accreditation.
Accuracy	TNI- The degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations; a data quality indicator.
Aliquot	A discrete, measured, representative portion of a sample taken for analysis.
Analysis	A combination of sample preparation and instrument determination.
Analysis Code (Acode)	All the set parameters of a test, such as Analytes, Method, Detection Limits and Price.
Analysis Sequence	A compilation of all samples, standards and quality control samples run during a specific amount of time on a particular instrument in the order they are analyzed.
Analyst	TNI- The designated individual who performs the “hands-on” analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality.
Analyte	The specific chemicals or components for which a sample is analyzed; it may be a group of chemicals that belong to the same chemical family and are analyzed together.
Analytical Uncertainty	TNI- A subset of Measurement Uncertainty that includes all laboratory activities performed as part of the analysis.
Assessment	TNI - The evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its system to defined criteria (to the standards and requirements of laboratory accreditation).
Atomic Absorption Spectrometer	Instrument used to measure concentration in metals samples.
Atomization	A process in which a sample is converted to free atoms.
Audit	TNI- A systematic and independent examination of facilities, equipment, personnel, training, procedures, record-keeping, data validation, data management, and reporting aspects of a system to determine whether QA/QC and technical activities are being conducted as planned and whether these activities will effectively achieve quality objectives.

Batch	TNI- Environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same quality systems matrix, meeting the above-mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An analytical batch is composed of prepared environmental samples (extracts, digestates or concentrates) which are analyzed together as a group. An analytical batch can include prepared samples originating from various quality system matrices and can exceed 20 samples. South Carolina- same definition as TNI except 24 hours should be changed to 8 hours.
Bias	TNI- The systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value).
Blank	TNI - A sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results.
Blind Sample	A sub-sample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process.
BNA (Base Neutral Acid compounds)	A list of semi-volatile compounds typically analyzed by mass spectrometry methods. Named for the way they can be extracted out of environmental samples in an acidic, basic or neutral environment.
BOD (Biochemical Oxygen Demand)	Chemical procedure for determining how fast biological organisms use up oxygen in a body of water.
Calibration	TNI- A set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards. 1) In calibration of support equipment, the values realized by standards are established through the use of reference standards that are traceable to the International System of Units (SI); 2) In calibration according to test methods, the values realized by standards are typically established through the use of Reference Materials that are either purchased by the laboratory with a certificate of analysis or purity, or prepared by the laboratory using support equipment that has been calibrated or verified to meet specifications.
Calibration Curve	TNI- The mathematical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response.
Calibration Method	A defined technical procedure for performing a calibration.

Calibration Range	The range of values (concentrations) between the lowest and highest calibration standards of a multi-level calibration curve. For metals analysis with a single-point calibration, the low-level calibration check standard and the high standard establish the linear calibration range, which lies within the linear dynamic range.
Calibration Standard	TNI- A substance or reference material used for calibration.
Certified Reference Material (CRM)	TNI- Reference material accompanied by a certificate, having a value, measurement uncertainty, and stated metrological traceability chain to a national metrology institute.
Chain of Custody	An unbroken trail of accountability that verifies the physical security of samples, data, and records.
Chain of custody Form (COC)	TNI- Record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and type of containers; the mode of collection, the collector, time of collection; preservation; and requested analyses.
Chemical Oxygen Demand (COD)	A test commonly used to indirectly measure the amount of organic compounds in water.
Client (referred to by ISO as Customer)	Any individual or organization for whom items or services are furnished or work performed in response to defined requirements and expectations.
Code of Federal Regulations (CFR)	A codification of the general and permanent rules published in the Federal Register by agencies of the federal government.
Comparability	An assessment of the confidence with which one data set can be compared to another. Comparable data are produced through the use of standardized procedures and techniques.
Completeness	The percent of valid data obtained from a measurement system compared to the amount of valid data expected under normal conditions. The equation for completeness is: % Completeness = (Valid Data Points/Expected Data Points)*100
Confirmation	TNI- Verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to: second-column confirmation; alternate wavelength; derivatization; mass spectral interpretation; alternative detectors; or additional cleanup procedures.
Conformance	An affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements.
Congener	A member of a class of related chemical compounds (e.g., PCBs, PCDDs).
Consensus Standard	A standard established by a group representing a cross-section of a particular industry or trade, or a part thereof.
Continuing Calibration Blank (CCB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method.
Continuing Calibration Check Compounds (CCC)	Compounds listed in mass spectrometry methods that are used to evaluate an instrument calibration from the standpoint of the integrity of the system. High variability would suggest leaks or active sites on the instrument column.

Continuing Calibration Verification	The verification of the initial calibration. Required prior to sample analysis and at periodic intervals. Continuing calibration verification applies to both external and internal standard calibration techniques, as well as to linear and non-linear calibration models.
Continuing Calibration Verification (CCV) Standard	Also referred to as a CVS in some methods, it is a standard used to verify the initial calibration of compounds in an analytical method. CCVs are analyzed at a frequency determined by the analytical method.
Continuous Emission Monitor (CEM)	A flue gas analyzer designed for fixed use in checking for environmental pollutants.
Contract Laboratory Program (CLP)	A national network of EPA personnel, commercial labs, and support contractors whose fundamental mission is to provide data of known and documented quality.
Contract Required Detection Limit (CRDL)	Detection limit that is required for EPA Contract Laboratory Program (CLP) contracts.
Contract Required Quantitation Limit (CRQL)	Quantitation limit (reporting limit) that is required for EPA Contract Laboratory Program (CLP) contracts.
Control Chart	A graphic representation of a series of test results, together with limits within which results are expected when the system is in a state of statistical control (see definition for Control Limit)
Control Limit	A range within which specified measurement results must fall to verify that the analytical system is in control. Control limit exceedances may require corrective action or require investigation and flagging of non-conforming data.
Correction	Action taken to eliminate a detected non-conformity.
Corrective Action	The action taken to eliminate the causes of an existing non-conformity, defect, or other undesirable situation in order to prevent recurrence. A root cause analysis may not be necessary in all cases.
Corrective and Preventative Action (CAPA)	The primary management tools for bringing improvements to the quality system, to the management of the quality system's collective processes, and to the products or services delivered which are an output of established systems and processes.
Customer	Any individual or organization for which products or services are furnished or work performed in response to defined requirements and expectations.
Data Quality Objective (DQO)	Systematic strategic planning tool based on the scientific method that identifies and defines the type, quality, and quantity of data needed to satisfy a specified use or end user.
Data Reduction	TNI- The process of transforming the number of data items by arithmetic or statistical calculation, standard curves, and concentration factors, and collating them into a more usable form.
Definitive Data	Analytical data of known quantity and quality. The levels of data quality on precision and bias meet the requirements for the decision to be made. Data that is suitable for final decision-making.
Demonstration of Capability	TNI- A procedure to establish the ability of the analyst to generate analytical results of acceptable accuracy and precision.

Detection Limit (DL)	The smallest analyte concentration that can be demonstrated to be different than zero or a blank concentration at the 99% confidence. At the DL, the false positive rate (Type 1 error) is 1%. A DL may be used as the lowest concentration for reliably reporting a detection of a specific analyte in a specific matrix with a specific method with 99% confidence.
Diesel Range Organics (DRO)	A range of compounds that denote all the characteristic compounds that make up diesel fuel (range can be state or program specific).
Digestion	A process in which a sample is treated (usually in conjunction with heat and acid) to convert the sample to a more easily measured form.
Document Control	The act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed.
Documents	Written components of the laboratory management system (e.g., policies, procedures, and instructions).
Dry Weight	The weight after drying in an oven at a specified temperature.
Duplicate (also known as Replicate or Laboratory Duplicate)	The analyses or measurements of the variable of interest performed identically on two subsamples of the same sample. The results of duplicate analyses are used to evaluate analytical or measurement precision but not the precision of sampling, preservation or storage internal to the laboratory.
Electron Capture Detector (ECD)	Device used in GC methods to detect compounds that absorb electrons (e.g., PCB compounds).
Electronic Data Deliverable (EDD)	A summary of environmental data (usually in spreadsheet form) which clients request for ease of data review and comparison to historical results.
Eluent	A solvent used to carry the components of a mixture through a stationary phase.
Elute	To extract, specifically, to remove (absorbed material) from an absorbent by means of a solvent.
Elution	A process in which solutes are washed through a stationary phase by movement of a mobile phase.
Environmental Data	Any measurements or information that describe environmental processes, locations, or conditions; ecological or health effects and consequences; or the performance of environmental technology.
Environmental Monitoring	The process of measuring or collecting environmental data.

Environmental Sample	A representative sample of any material (aqueous, non-aqueous, or multimedia) collected from any source for which determination of composition or contamination is requested or required. Environmental samples can generally be classified as follows: • Non Potable Water (Includes surface water, ground water, effluents, water treatment chemicals, and TCLP leachates or other extracts) • Drinking Water - Delivered (treated or untreated) water designated as potable water • Water/Wastewater - Raw source waters for public drinking water supplies, ground waters, municipal influents/effluents, and industrial influents/effluents • Sludge - Municipal sludges and industrial sludges. • Soil - Predominately inorganic matter ranging in classification from sands to clays. • Waste - Aqueous and non-aqueous liquid wastes, chemical solids, and industrial liquid and solid wastes
Equipment Blank	A sample of analyte-free media used to rinse common sampling equipment to check effectiveness of decontamination procedures.
Facility	A distinct location within the company that has unique certifications, personnel and waste disposal identifications.
False Negative	A result that fails to identify (detect) an analyte or reporting an analyte to be present at or below a level of interest when the analyte is actually above the level of interest.
False Positive	A result that erroneously identifies (detects) an analyte or reporting an analyte to be present above a level of interest when the analyte is actually present at or below the level of interest.
Field Blank	A blank sample prepared in the field by filling a clean container with reagent water and appropriate preservative, if any, for the specific sampling activity being undertaken.
Field Measurement	Determination of physical, biological, or radiological properties, or chemical constituents that are measured on-site, close in time and space to the matrices being sampled/measured, following accepted test methods. This testing is performed in the field outside of a fixed-laboratory or outside of an enclosed structure that meets the requirements of a mobile laboratory.
Field of Accreditation	TNI- Those matrix, technology/method, and analyte combinations for which the accreditation body offers accreditation.
Finding	TNI- An assessment conclusion referenced to a laboratory accreditation standard and supported by objective evidence that identifies a deviation from a laboratory accreditation standard requirement.
Flame Atomic Absorption Spectrometer (FAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the fact that ground state metals absorb light at different wavelengths. Metals in a solution are converted to the atomic state by use of a flame.
Flame Ionization Detector (FID)	A type of gas detector used in GC analysis where samples are passed through a flame which ionizes the sample so that various ions can be measured.
Gas Chromatography (GC)	Instrumentation which utilizes a mobile carrier gas to deliver an environmental sample across a stationary phase with the intent to separate compounds out and measure their retention times.

Gas Chromatograph/ Mass Spectrometry (GC/MS)	In conjunction with a GC, this instrumentation utilizes a mass spectrometer which measures fragments of compounds and determines their identity by their fragmentation patterns (mass spectra).
Gasoline Range Organics (GRO)	A range of compounds that denote all the characteristic compounds that make up gasoline (range can be state or program specific).
Graphite Furnace Atomic Absorption Spectrometry (GFAA)	Instrumentation used to measure the concentration of metals in an environmental sample based on the absorption of light at different wavelengths that are characteristic of different analytes.
High Pressure Liquid Chromatography (HPLC)	Instrumentation used to separate, identify and quantitate compounds based on retention times which are dependent on interactions between a mobile phase and a stationary phase.
Holding Time	TNI- The maximum time that can elapse between two specified activities. 40 CFR Part 136- The maximum time that samples may be held prior to preparation and/or analysis as defined by the method and still be considered valid or not compromised. For sample prep purposes, hold times are calculated using the time of the start of the preparation procedure.
Homogeneity	The degree to which a property or substance is uniformly distributed throughout a sample.
Homologue	One in a series of organic compounds in which each successive member has one more chemical group in its molecule than the next preceding member. For instance, methanol, ethanol, propanol, butanol, etc., form a homologous series.
Improper Actions	Intentional or unintentional deviations from contract-specified or method-specified analytical practices that have not been authorized by the customer.
Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)	Analytical technique used for the detection of trace metals which uses plasma to produce excited atoms that emit radiation of characteristic wavelengths.
Inductively Coupled Plasma- Mass Spectrometry (ICP/MS)	An ICP that is used in conjunction with a mass spectrometer so that the instrument is not only capable of detecting trace amounts of metals and non-metals but is also capable of monitoring isotopic speciation for the ions of choice.
Infrared Spectrometer (IR)	An instrument that uses infrared light to identify compounds of interest.
Initial Calibration (ICAL)	The process of analyzing standards, prepared at specified concentrations, to define the quantitative response relationship of the instrument to the analytes of interest. Initial calibration is performed whenever the results of a calibration verification standard do not conform to the requirements of the method in use or at a frequency specified in the method.
Initial Calibration Blank (ICB)	A blank sample used to monitor the cleanliness of an analytical system at a frequency determined by the analytical method. This blank is specifically run in conjunction with the Initial Calibration Verification (ICV) where applicable.
Initial Calibration Verification (ICV)	Verifies the initial calibration with a standard obtained or prepared from a source independent of the source of the initial calibration standards to avoid potential bias of the initial calibration.

Instrument Blank	A clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination.
Instrument Detection Limits (IDLs)	Limits determined by analyzing a series of reagent blank analyses to obtain a calculated concentration. IDLs are determined by calculating the average of the standard deviations of three runs on three non-consecutive days from the analysis of a reagent blank solution with seven consecutive measurements per day.
Interference, spectral	Occurs when particulate matter from the atomization scatters incident radiation from the source or when the absorption or emission from an interfering species either overlaps or is so close to the analyte wavelength that resolution becomes impossible.
Interference, chemical	Results from the various chemical processes that occur during atomization and later the absorption characteristics of the analyte.
Internal Standards	TNI- A known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method.
Intermediate Standard Solution	Reference solutions prepared by dilution of the stock solutions with an appropriate solvent.
International System of Units (SI)	The coherent system of units adopted and recommended by the General Conference on Weights and Measures.
Ion Chromatography (IC)	Instrumentation or process that allows the separation of ions and molecules based on the charge properties of the molecules.
Isomer	One of two or more compounds, radicals, or ions that contain the same number of atoms of the same element but differ in structural arrangement and properties. For example, hexane (C6H14) could be n-hexane, 2-methylpentane, 3-methylpentane, 2,3-dimethylbutane, 2,2-dimethylbutane.
Laboratory	A body that calibrates and/or tests.
Laboratory Control Sample (LCS)	TNI- (however named, such as laboratory fortified blank (LFB), spiked blank, or QC check sample): A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes and taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a reference method. It is generally used to establish intra-laboratory or analyst-specific precision and bias or to evaluate the performance of all or a portion of the measurement system.
Laboratory Duplicate	Aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently.
Laboratory Information Management System (LIMS)	The entirety of an electronic data system (including hardware and software) that collects, analyzes, stores, and archives electronic records and documents.
LabTrack	Database used by Pace Analytical to store and track corrective actions and other laboratory issues.
Learning Management System (LMS)	A web-based database used by the laboratories to track and document training activities. The system is administered by the corporate training department and each laboratory's learn centers are maintained by a local administrator.

Legal Chain-of-Custody Protocols	TNI- Procedures employed to record the possession of samples from the time of sampling through the retention time specified by the client or program. These procedures are performed at the special request of the client and include the use of a Chain-of-Custody (COC) Form that documents the collection, transport, and receipt of compliance samples by the laboratory. In addition, these protocols document all handling of the samples within the laboratory.
Limit(s) of Detection (LOD)	TNI- A laboratory's estimate of the minimum amount of an analyte in a given matrix that an analytical process can reliably detect in their facility.
Limit(s) of Quantitation (LOQ)	TNI- The minimum levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence.
Linear Dynamic Range	Concentration range where the instrument provides a linear response.
Liquid chromatography/ tandem mass spectrometry (LC/MS/MS)	Instrumentation that combines the physical separation techniques of liquid chromatography with the mass analysis capabilities of mass spectrometry.
Lot	A quantity of bulk material of similar composition processed or manufactured at the same time.
Management	Those individuals directly responsible and accountable for planning, implementing, and assessing work.
Management System	System to establish policy and objectives and to achieve those objectives.
Manager (however named)	The individual designated as being responsible for the overall operation, all personnel, and the physical plant of the environmental laboratory. A supervisor may report to the manager. In some cases, the supervisor and the manager may be the same individual.
Matrix	TNI- The substrate of a test sample.
Matrix Duplicate	TNI- A replicate matrix prepared in the laboratory and analyzed to obtain a measure of precision.
Matrix Spike (MS) (spiked sample or fortified sample)	TNI- A sample prepared, taken through all sample preparation and analytical steps of the procedure unless otherwise noted in a referenced method, by adding a known amount of target analyte to a specified amount of sample for which an independent test result of target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency.
Matrix Spike Duplicate (MSD) (spiked sample or fortified sample duplicate)	TNI- A replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte.
Measurement Performance Criteria (MPC)	Criteria that may be general (such as completion of all tests) or specific (such as QC method acceptance limits) that are used by a project to judge whether a laboratory can perform a specified activity to the defined criteria.
Measurement System	TNI - A test method, as implemented at a particular laboratory, and which includes the equipment used to perform the sample preparation, test and the operator(s).

Measurement Uncertainty	An estimate of the error in a measurement often stated as a range of values that contain the true value, within a certain confidence level. The uncertainty generally includes many components which may be evaluated from experimental standard deviations based on repeated observations or by standard deviations evaluated from assumed probability distributions based on experience or other information. For DoD/DOE, a laboratory's Analytical Uncertainty (such as use of LCS control limits) can be reported as the minimum uncertainty.
Method	TNI- A body of procedures and techniques for performing an activity (e.g., sampling, chemical analysis, quantification), systematically presented in the order in which they are to be executed.
Method Blank	TNI- A sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses.
Method Detection Limit (MDL)	One way to establish a Detection Limit; defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte.
Method of Standard Additions	A set of procedures adding one or more increments of a standard solution to sample aliquots of the same size in order to overcome inherent matrix effects. The procedures encompass the extrapolation back to obtain the sample concentration.
MintMiner	Program used by Pace Analytical to review large amounts of chromatographic data to monitor for errors or data integrity issues.
Mobile Laboratory	TNI- A portable enclosed structure with necessary and appropriate accommodation and environmental conditions for a laboratory, within which testing is performed by analysts. Examples include but are not limited to trailers, vans, and skid-mounted structures configured to house testing equipment and personnel.
National Institute of Standards and Technology (NIST)	TNI- A federal agency of the US Department of Commerce's Technology Administration that is designed as the United States national metrology institute (or NMI).
National Pollutant Discharge Elimination System (NPDES)	A permit program that controls water pollution by regulating point sources that discharge pollutants into U.S. waters.
Negative Control	Measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results.
Nitrogen Phosphorus Detector (NPD)	A detector used in GC analyses that utilizes thermal energy to ionize an analyte. With this detector, nitrogen and phosphorus can be selectively detected with a higher sensitivity than carbon.
Nonconformance	An indication or judgment that a product or service has not met the requirement of the relevant specifications, contract, or regulation; also the state of failing to meet the requirements.
Not Detected (ND)	The result reported for a compound when the detected amount of that compound is less than the method reporting limit.

Operator Aid	A technical posting (such as poster, operating manual, or notepad) that assists workers in performing routine tasks. All operator aids must be controlled documents (i.e., a part of the laboratory management system).
Performance Based Measurement System (PBMS)	An analytical system wherein the data quality needs, mandates or limitations of a program or project are specified and serve as criteria for selecting appropriate test methods to meet those needs in a cost-effective manner.
Photo-ionization Detector (PID)	An ion detector which uses high-energy photons, typically in the ultraviolet range, to break molecules into positively charged ions.
Polychlorinated Biphenyls (PCB)	A class of organic compounds that were used as coolants and insulating fluids for transformers and capacitors. The production of these compounds was banned in the 1970's due to their high toxicity.
Positive Control	Measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects.
Post-Digestion Spike	A sample prepared for metals analyses that has analytes spike added to determine if matrix effects may be a factor in the results.
Power of Hydrogen (pH)	The measure of acidity or alkalinity of a solution.
Practical Quantitation Limit (PQL)	Another term for a method reporting limit. The lowest reportable concentration of a compound based on parameters set up in an analytical method and the laboratory's ability to reproduce those conditions.
Precision	TNI- The degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms.
Preservation	TNI - Any conditions under which a sample must be kept in order to maintain chemical, physical, and/or biological integrity prior to analysis.
Procedure	TNI- A specified way to carry out an activity or process. Procedures can be documented or not.
Proficiency Testing	TNI- A means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source.
Proficiency Testing Program	TNI- The aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories.
Proficiency Testing Sample (PT)	TNI- A sample, the composition of which is unknown to the laboratory and is provided to test whether the laboratory can produce analytical results within the specified acceptance criteria.
Protocol	TNI- A detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) that must be strictly followed.
Qualitative Analysis	Analysis designed to identify the components of a substance or mixture.
Quality Assurance (QA)	TNI- An integrated system of management activities involving planning, implementation, assessment, reporting and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the client.

Quality Assurance Manual (QAM)	A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.
Quality Assurance Project Plan (QAPP)	A formal document describing the detailed quality control procedures by which the quality requirements defined for the data and decisions pertaining to a specific project are to be achieved.
Quality Control (QC)	TNI- The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer; operational techniques and activities that are used to fulfill requirements for quality; also the system of activities and checks used to ensure that measurement systems are maintained within prescribed limits, providing protection against "out of control" conditions and ensuring that the results are of acceptable quality.
Quality Control Sample (QCS)	TNI- A sample used to assess the performance of all or a portion of the measurement system. One of any number of samples, such as Certified Reference Materials, a quality system matrix fortified by spiking, or actual samples fortified by spiking, intended to demonstrate that a measurement system or activity is in control.
Quality Manual	TNI- A document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users.
Quality System	TNI - A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required quality assurance and quality control activities.

Quality System Matrix	TNI - These matrix definitions are to be used for purposes of batch and quality control requirements: • **Air and Emissions**: Whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbant tube, impinger solution, filter, or other device • **Aqueous**: Any aqueous sample excluded from the definition of Drinking Water or Saline/Estuarine. Includes surface water, groundwater effluents, and TCLP or other extracts. • **Biological Tissue**: Any sample of a biological origin such as fish tissue, shellfish or plant material. Such samples shall be grouped according to origin. • **Chemical Waste**: A product or by-product of an industrial process that results in a matrix not previously defined. • **Drinking Water**: Any aqueous sample that has been designated a potable or potentially potable water source. • **Non-aqueous liquid**: Any organic liquid with <15% settleable solids • **Saline/Estuarine**: Any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake. • **Solids**: Includes soils, sediments, sludges, and other matrices with >15% settleable solids.
Quantitation Range	The range of values (concentrations) in a calibration curve between the LOQ and the highest successively analyzed initial calibration standard. The quantitation range lies within the calibration range.
Quantitative Analysis	Analysis designed to determine the amounts or proportions of the components of a substance.
Random Error	The EPA has established that there is a 5% probability that the results obtained for any one analyte will exceed the control limits established for the test due to random error. As the number of compounds measured increases in a given sample, the probability for statistical error also increases.
Raw Data	TNI- The documentation generated during sampling and analysis. This documentation includes, but is not limited to, field notes, electronic data, magnetic tapes, untabulated sample results, QC sample results, print outs of chromatograms, instrument outputs, and handwritten records.
Reagent Blank (method reagent blank)	A sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps.
Reagent Grade	Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents that conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.
Records	The output of implementing and following management system documents (e.g., test data in electronic or hand-written forms, files, and logbooks).
Reference Material	TNI- Material or substance one or more of whose property values are sufficiently homogenized and well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials.

Reference Standard	TNI- Standard used for the calibration of working measurement standards in a given organization or at a given location.
Relative Percent Difference (RPD)	A measure of precision defined as the difference between two measurements divided by the average concentration of the two measurements.
Reporting Limit (RL)	The level at which method, permit, regulatory and customer-specific objectives are met. The reporting limit may never be lower than the Limit of Detection (i.e., statistically determined MDL). Reporting limits are corrected for sample amounts, including the dry weight of solids, unless otherwise specified. There must be a sufficient buffer between the Reporting Limit and the MDL.
Reporting Limit Verification Standard (or otherwise named)	A standard analyzed at the reporting limit for an analysis to verify the laboratory's ability to report to that level.
Representativeness	A quality element related to the ability to collect a sample reflecting the characteristics of the part of the environment to be assessed. Sample representativeness is dependent on the sampling techniques specified in the project work plan.
Requirement	Denotes a mandatory specification; often designated by the term "shall".
Retention Time	The time between sample injection and the appearance of a solute peak at the detector.
Sample	Portion of material collected for analysis, identified by a single, unique alphanumeric code. A sample may consist of portions in multiple containers, if a single sample is submitted for multiple or repetitive analysis.
Sample Condition Upon Receipt Form (SCURF)	Form used by Pace Analytical sample receiving personnel to document the condition of sample containers upon receipt to the laboratory (used in conjunction with a COC).
Sample Delivery Group (SDG)	A unit within a single project that is used to identify a group of samples for delivery. An SDG is a group of 20 or fewer field samples within a project, received over a period of up to 14 calendar days. Data from all samples in an SDG are reported concurrently.
Sample Receipt Form (SRF)	Letter sent to the client upon login to show the tests requested and pricing.
Sample Tracking	Procedures employed to record the possession of the samples from the time of sampling until analysis, reporting and archiving. These procedures include the use of a Chain of custody Form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples.
Sampling	TNI- Activity related to obtaining a representative sample of the object of conformity assessment, according to a procedure.
Selected Ion Monitoring (SIM)	A mode of analysis in mass spectrometry where the detector is set to scan over a very small mass range, typically one mass unit. The narrower the range, the more sensitive the detector.
Selectivity	TNI- The ability to analyze, distinguish, and determine a specific analyte or parameter from another component that may be a potential interferent or that may behave similarly to the target analyte or parameter within the measurement system.

Sensitivity	TNI- The capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest.
Serial Dilution	The stepwise dilution of a substance in a solution.
Shall	Denotes a requirement that is mandatory whenever the criterion for conformance with the specification requires that there be no deviation. This does not prohibit the use of alternative approaches or methods for implementing the specification as long as the requirement is fulfilled.
Should	Denotes a guideline or recommendation whenever noncompliance with the specification is permissible.
Signal-to-Noise Ratio (S/N)	S/N is a measure of signal strength relative to background noise. The average strength of the noise of most measurements is constant and independent of the magnitude of the signal. Thus, as the quantity being measured (producing the signal) decreases in magnitude, S/N decreases and the effect of the noise on the relative error of a measurement increases.
Spike	A known mass of target analyte added to a blank sample or sub-sample; used to determine recovery efficiency or for other quality control purposes.
Standard (Document)	TNI- The document describing the elements of a laboratory accreditation that has been developed and established within the consensus principles of standard setting and meets the approval requirements of standard adoption organizations procedures and policies.
Standard (Chemical)	Standard samples are comprised of a known amount of standard reference material in the matrix undergoing analysis. A standard reference material is a certified reference material produced by US NIST and characterized for absolute content, independent of analytical test method.
Standard Blank (or Reagent Blank)	A calibration standard consisting of the same solvent/reagent matrix used to prepare the calibration standards without the analytes. It is used to construct the calibration curve by establishing instrument background.
Standard Method	A test method issued by an organization generally recognized as competent to do so.
Standard Operating Procedure (SOP)	TNI- A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps. SOPs are officially approved as the methods for performing certain routine or repetitive tasks.
Standard Reference Material (SRM)	A certified reference material produced by the US NIST or other equivalent organization and characterized for absolute content, independent of analytical method.
Statement of Qualifications (SOQ)	A document that lists information about a company, typically the qualifications of that company to compete on a bid for services.
Stock Standard	A concentrated reference solution containing one or more analytes prepared in the laboratory using an assayed reference compound or purchased from a reputable commercial source.
Storage Blank	A sample of analyte-free media prepared by the laboratory and retained in the sample storage area of the laboratory. A storage blank is used to record contamination attributable to sample storage at the laboratory.

Supervisor	The individual(s) designated as being responsible for a particular area or category of scientific analysis. This responsibility includes direct day-to-day supervision of technical employees, supply and instrument adequacy and upkeep, quality assurance/quality control duties and ascertaining that technical employees have the required balance of education, training and experience to perform the required analyses.
Surrogate	A substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes.
Systems Audit	An on-site inspection or assessment of a laboratory's quality system.
Target Analytes	Analytes or chemicals of primary concern, identified by the customer on a project-specific basis.
Technical Director	Individual(s) who has overall responsibility for the technical operation of the environmental testing laboratory.
Technology	TNI- A specific arrangement of analytical instruments, detection systems, and/or preparation techniques.
Test	A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. The result of a test is normally recorded in a document sometimes called a test report or a test certificate.
Test Method	A definitive procedure that determines one or more characteristics of a given substance or product.
Test Methods for Evaluating Solid Waste, Physical/ Chemical (SW-846)	EPA Waste's official compendium of analytical and sampling methods that have been evaluated and approved for use in complying with RCRA regulations.
Total Petroleum Hydrocarbons (TPH)	A term used to denote a large family of several hundred chemical compounds that originate from crude oil. Compounds may include gasoline components, jet fuel, volatile organics, etc.
Toxicity Characteristic Leaching Procedure (TCLP)	A solid sample extraction method for chemical analysis employed as an analytical method to simulate leaching of compounds through a landfill.
Traceability	TNI- The ability to trace the history, application, or location of an entity by means of recorded identifications. In a calibration sense, traceability relates measuring equipment to national or international standards, primary standards, basic physical conditions or properties, or reference materials. In a data collection sense, it relates calculations and data generated throughout the project back to the requirements for the quality of the project.
Training Document	A training resource that provides detailed instructions to execute a specific method or job function.
Trip Blank	This blank sample is used to detect sample contamination from the container and preservative during transport and storage of the sample. A cleaned sample container is filled with laboratory reagent water and the blank is stored, shipped, and analyzed with its associated samples.
Tuning	A check and/or adjustment of instrument performance for mass spectrometry as required by the method.

Ultraviolet Spectrophotometer (UV)	Instrument routinely used in quantitative determination of solutions of transition metal ions and highly conjugated organic compounds.
Uncertainty Measurement	The parameter associated with the result of a measurement that characterized the dispersion of the values that could be reasonably attributed to the measurand (i.e. the concentration of an analyte).
Unethical actions	Deliberate falsification of analytical or quality control results, where failed method or contractual requirements are made to appear acceptable.
Unregulated Contaminate Monitoring Rule (UCMR)	EPA program to monitor unregulated contaminates in drinking water.
Validation	The confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled.
Verification	TNI- Confirmation by examination and objective evidence that specified requirements have been met. Note: In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment. The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.
Whole Effluent Toxicity (WET)	The aggregate toxic effect to aquatic organisms from all pollutants contained in a facility's wastewater (effluent).

11.0. REFERENCES

11.1. "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act." Federal Register, 40 CFR Part 136.

11.2. "Test Methods for Evaluating Solid Wastes: Physical/Chemical Methods." SW-846.

11.3. "Methods for Chemical Analysis of Water and Wastes", EPA 600-4-79-020, 1979 Revised 1983, U.S. EPA.

11.4. U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis.

11.5. U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis.

11.6. "Standard Methods for the Examination of Water and Wastewater." Current Edition APHA-AWWA-WPCF.

11.7. "Annual Book of ASTM Standards", Section 4: Construction, Volume 04.04: Soil and Rock; Building Stones, American Society of Testing and Materials.

11.8. "Annual Book of ASTM Standards", Section 11: Water and Environmental Technology, American Society of Testing and Materials.

11.9. "NIOSH Manual of Analytical Methods", Third Edition, 1984, U.S. Department of Health and Human Services, National Institute for Occupational Safety and Health.

11.10. "Methods for the Determination of Organic Compounds in Finished Drinking Water and Raw Source Water", U.S. EPA, Environmental Monitoring and Support Laboratory – Cincinnati (September 1986).

11.11. Quality Assurance of Chemical Measurements, Taylor, John K.; Lewis Publishers, Inc. 1987.

11.12. Methods for Non-conventional Pesticides Chemicals Analysis of Industrial and Municipal Wastewater, Test Methods, EPA-440/1-83/079C.

11.13. Environmental Measurements Laboratory (EML) Procedures Manual, HASL-300, US DOE, February, 1992.

11.14. Requirements for Quality Control of Analytical Data, HAZWRAP, DOE/HWP-65/R1, July, 1990.

11.15. Requirements for Quality Control of Analytical Data for the Environmental Restoration Program, Martin Marietta, ES/ER/TM-16, December, 1992.

11.16. Quality Assurance Manual for Industrial Hygiene Chemistry, AIHA, 1988.

11.17. National Environmental Laboratory Accreditation Conference, Constitution, Bylaws, and Standards. Most recent version.

11.18. ISO/IEC 17025:2005, General requirements for the competence of testing and calibration laboratories.

11.19. Department of Defense Quality Systems Manual (QSM), version 5.0, March 2013.

11.20. TNI (The NELAC Institute) Standards; most recent version.

11.21. UCMR3 Laboratory Approval Requirements and Information Document, version 2.0, January 2012.

12.0. REVISIONS

The PASI Corporate Quality Office files both a paper copy and electronic version of a Microsoft Word document with tracked changes detailing all revisions made to the previous version of the Quality Assurance Manual. This document is available upon request. All revisions are summarized in the table below.

Document Number	Reason for Change	Date
Quality Assurance Manual 18.0	Header: Added wording "Effective date of last signature". Sections 1.3.1 and 1.3.3: reworded to match ISO/TNI standards. Section 1.7.7: Added section requiring deputies for key personnel. Included specifics from DoD QSM. Section 1.12.2: changed Sample Custodian to titles listed in section 1.8. Section 2.5.3 note 3: clarified the temperature requirements for tissue samples. Removed old section 2.6.5 (LIMS codes): not needed; already appear in an SOP. Sections 4.2.6 and 4.2.7: added red letter text regarding state of SC. Sections 6.2.3.4 and 6.2.7.5: changes "12 hour" to "method-specified". Section 9.2.2.2: added new section referencing the PT SOT. Attachment IIB: updated to April 2015 version. Attachment VIII (Analyses/Preservatives/etc.): made several updates based on QM input and method requirements.	12May2015
Carolina QAM 18	Updated Title Removed red text not pertaining to Carolinas Added Section 1.8.17 Added Section 3.4.1.1 Added Section 4.13.4.2 Added Section 9.2.2.2 Removed Attachment IX.	23June2015

ATTACHMENT I- QUALITY CONTROL CALCULATIONS

PERCENT RECOVERY (%REC)

$$\%REC = \frac{(MSConc - SampleConc)}{TrueValue} * 100$$

NOTE: The SampleConc is zero (0) for theLCS and Surrogate Calculations

PERCENT DIFFERENCE (%D)

$$\%D = \frac{MeasuredValue - TrueValue}{TrueValue} * 100$$

where:
TrueValue = Amount spiked (can also be the $\overline{CF}$ or $\overline{RF}$ of the ICAL Standards)
Measured Value = Amount measured (can also be the CF or RF of the CCV)

PERCENT DRIFT

$$\%Drift = \frac{Calculated Concentration - TheoreticalConcentration}{TheoreticalConcentrtion} * 100$$

RELATIVE PERCENT DIFFERENCE (RPD)

$$RPD = \frac{|(R1 - R2)|}{(R1 + R2)/2} * 100$$

where:
R1 = Result Sample 1
R2 = Result Sample 2

CORRELATION COEFFICIENT (R)

$$CorrCoeff = \frac{\sum_{i=1}^{N} W_i * (X_i - \overline{X}) * (Y_i - \overline{Y})}{\sqrt{\left(\sum_{i=1}^{N} W_i * (X_i - \overline{X})^2\right) * \left(\sum_{i=1}^{N} W_i * (Y_i - \overline{Y})^2\right)}}$$

With:		
	N	Number of standard samples involved in the calibration
	i	Index for standard samples
	Wi	Weight factor of the standard sample no. i
	Xi	X-value of the standard sample no. i
	X(bar)	Average value of all x-values
	Yi	Y-value of the standard sample no. i
	Y(bar)	Average value of all y-values

ATTACHMENT I- QUALITY CONTROL CALCULATIONS (CONTINUED)

STANDARD DEVIATION (S)

$$S = \sqrt{\sum_{i=1}^{n} \frac{(X_i - \overline{X})^2}{(n-1)}}$$

where:
n = number of data points
X_i = individual data point
$\overline{X}$ = average of all data points

AVERAGE ($\overline{X}$)

$$\overline{X} = \frac{\sum_{n=1}^{i} X_i}{n}$$

where:
n = number of data points
X_i = individual data point

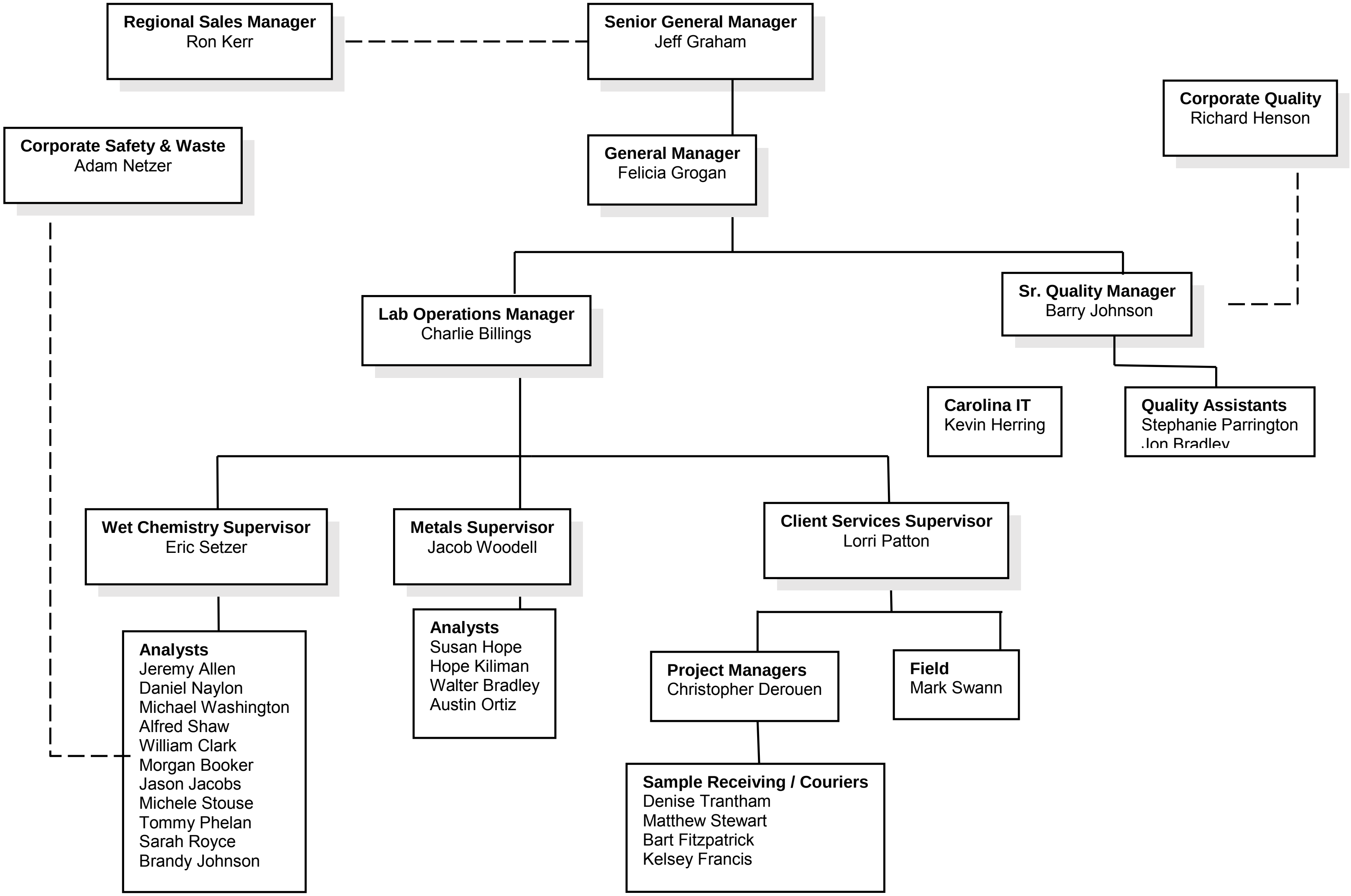
RELATIVE STANDARD DEVIATION (RSD)

$$RSD = \frac{S}{\overline{X}} * 100$$

where:
S = Standard Deviation of the data points
$\overline{X}$ = average of all data points

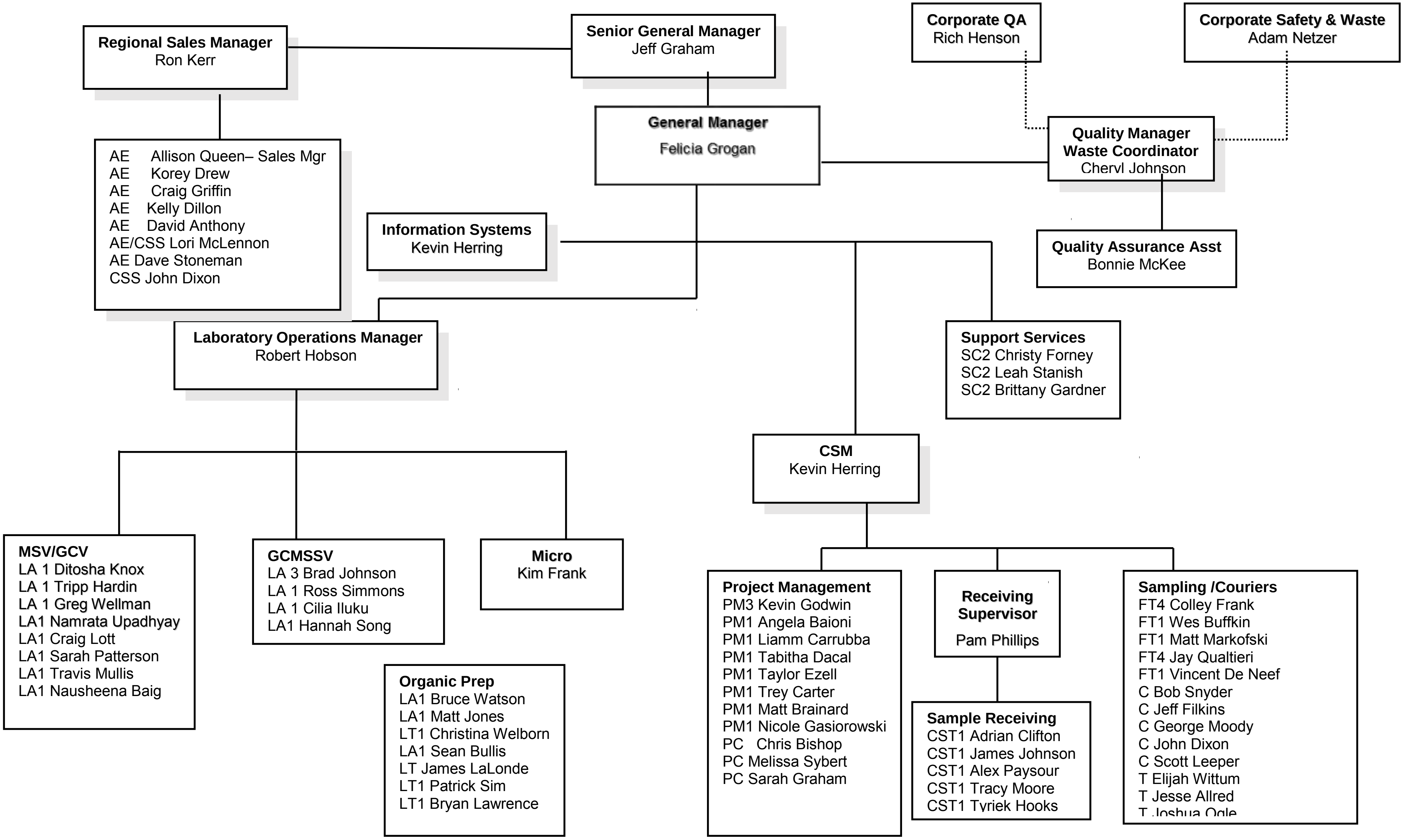
ATTACHMENT IIA LABORATORY ORGANIZATIONAL CHART

ASHEVILLE



ATTACHMENT IIA LABORATORY ORGANIZATIONAL CHART

CHARLOTTE



Regional Sales Manager
Ron Kerr

AE Allison Queen– Sales Mgr
AE Korey Drew
AE Craig Griffin
AE Kelly Dillon
AE David Anthony
AE/CSS Lori McLennon
AE Dave Stoneman
CSS John Dixon

Senior General Manager
Jeff Graham

Corporate QA
Rich Henson

Corporate Safety & Waste
Adam Netzer

General Manager
Felicia Grogan

Quality Manager
Waste Coordinator
Cheryl Johnson

Information Systems
Kevin Herring

Quality Assurance Asst
Bonnie McKee

Laboratory Operations Manager
Robert Hobson

Support Services
SC2 Christy Forney
SC2 Leah Stanish
SC2 Brittany Gardner

CSM
Kevin Herring

MSV/GCV
LA 1 Ditosha Knox
LA 1 Tripp Hardin
LA 1 Greg Wellman
LA1 Namrata Upadhyay
LA1 Craig Lott
LA1 Sarah Patterson
LA1 Travis Mullis
LA1 Nausheena Baig

GCMSSV
LA 3 Brad Johnson
LA 1 Ross Simmons
LA 1 Cilia Iluku
LA1 Hannah Song

Micro
Kim Frank

Organic Prep
LA1 Bruce Watson
LA1 Matt Jones
LT1 Christina Welborn
LA1 Sean Bullis
LT James LaLonde
LT1 Patrick Sim
LT1 Bryan Lawrence

Project Management
PM3 Kevin Godwin
PM1 Angela Baioni
PM1 Liamm Carrubba
PM1 Tabitha Dacal
PM1 Taylor Ezell
PM1 Trey Carter
PM1 Matt Brainard
PM1 Nicole Gasiorowski
PC Chris Bishop
PC Melissa Sybert
PC Sarah Graham

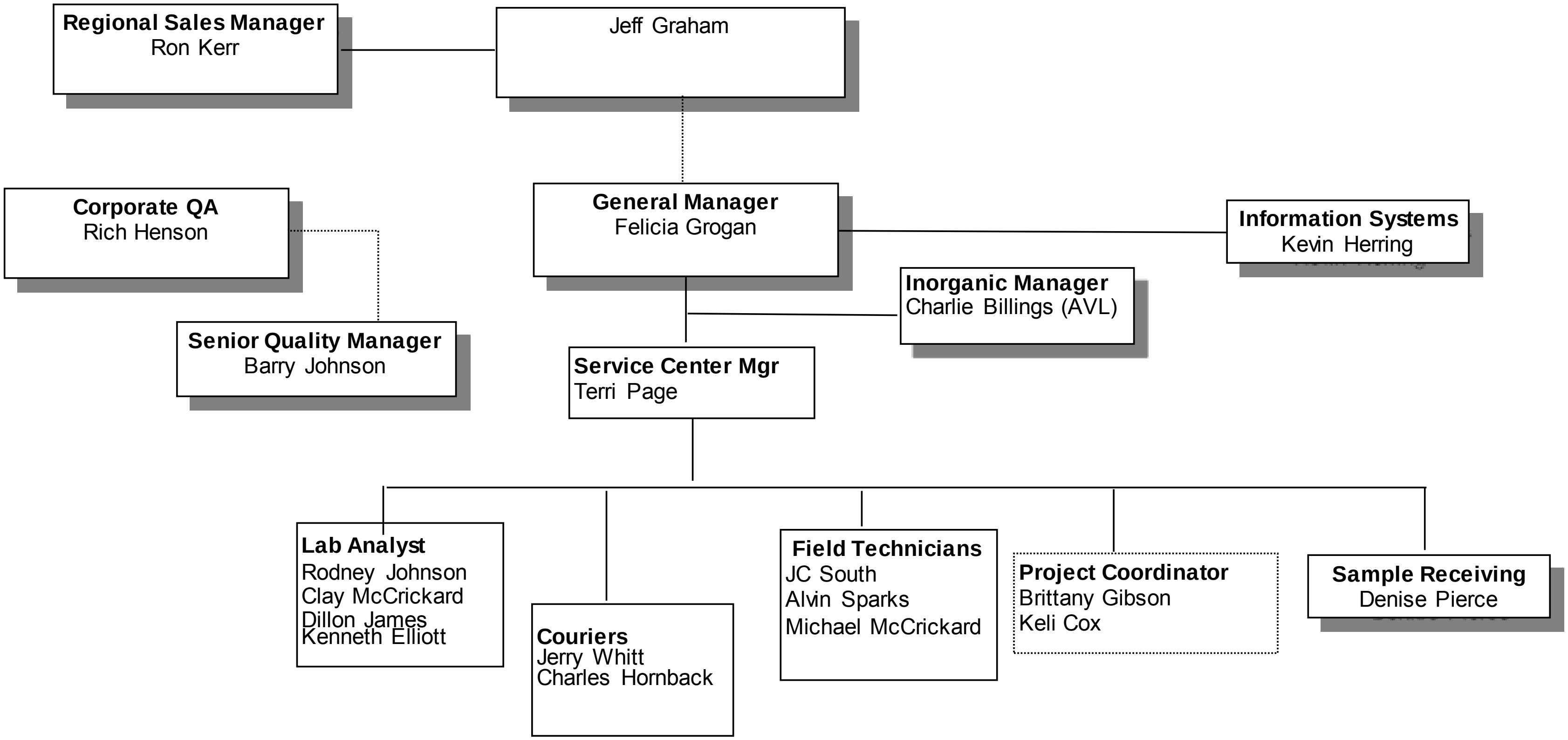
Receiving Supervisor
Pam Phillips

Sample Receiving
CST1 Adrian Clifton
CST1 James Johnson
CST1 Alex Paysour
CST1 Tracy Moore
CST1 Tyriek Hooks

Sampling /Couriers
FT4 Colley Frank
FT1 Wes Buffkin
FT1 Matt Markofski
FT4 Jay Qualtieri
FT1 Vincent De Neef
C Bob Snyder
C Jeff Filkins
C George Moody
C John Dixon
C Scott Leeper
T Elijah Wittum
T Jesse Allred
T Joshua Ogle

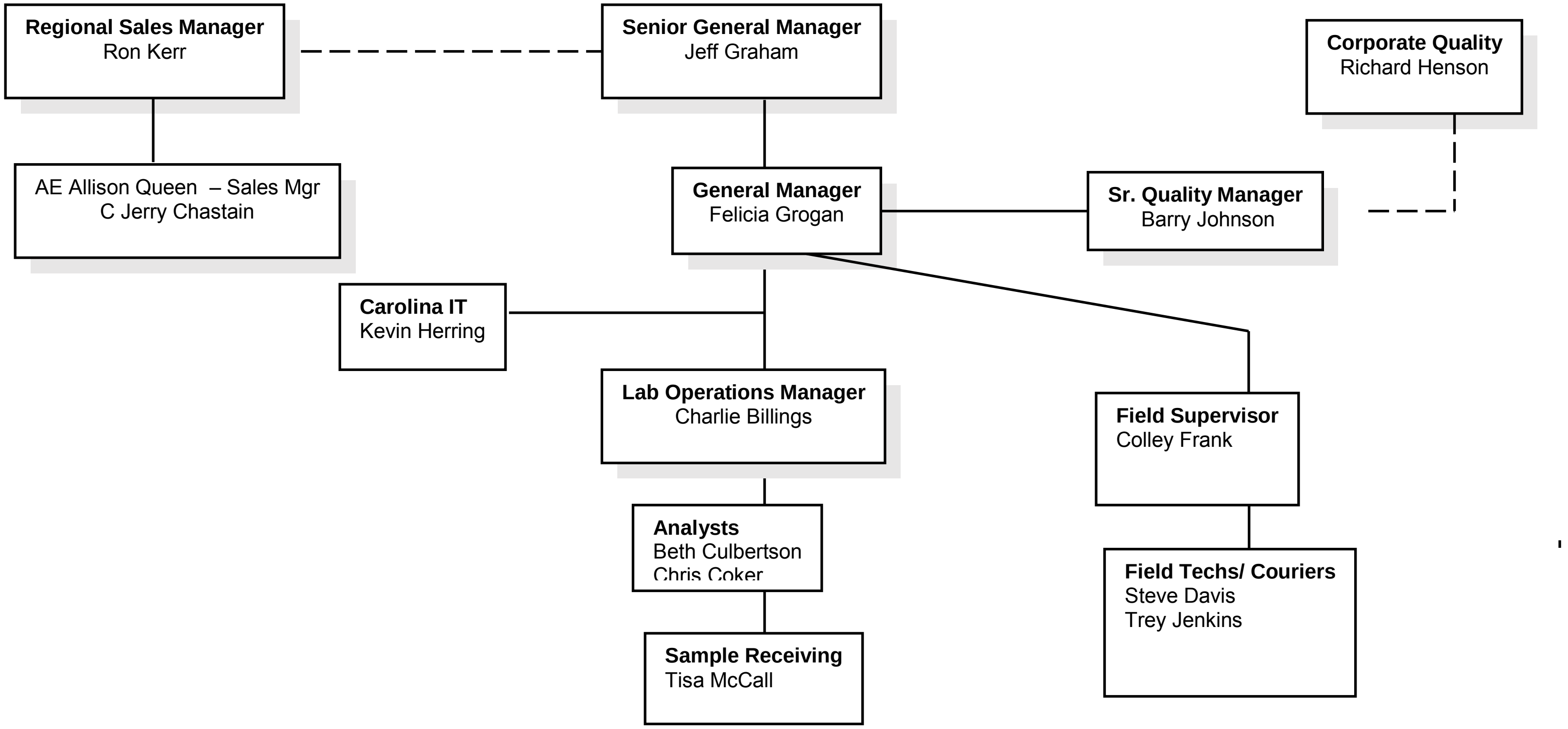
ATTACHMENT IIA LABORATORY ORGANIZATIONAL CHART

EDEN



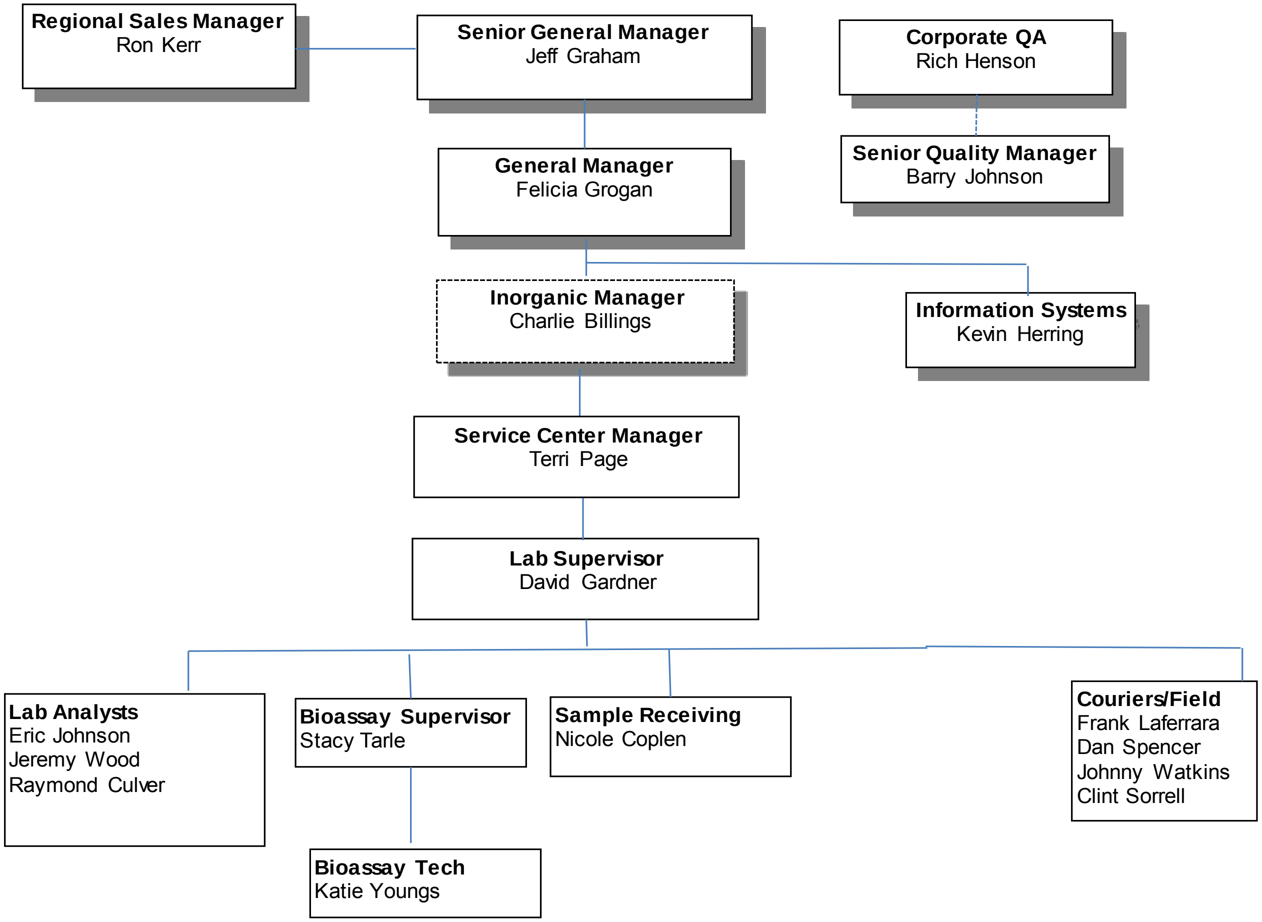
ATTACHMENT IIA LABORATORY ORGANIZATIONAL CHART

GREENWOOD

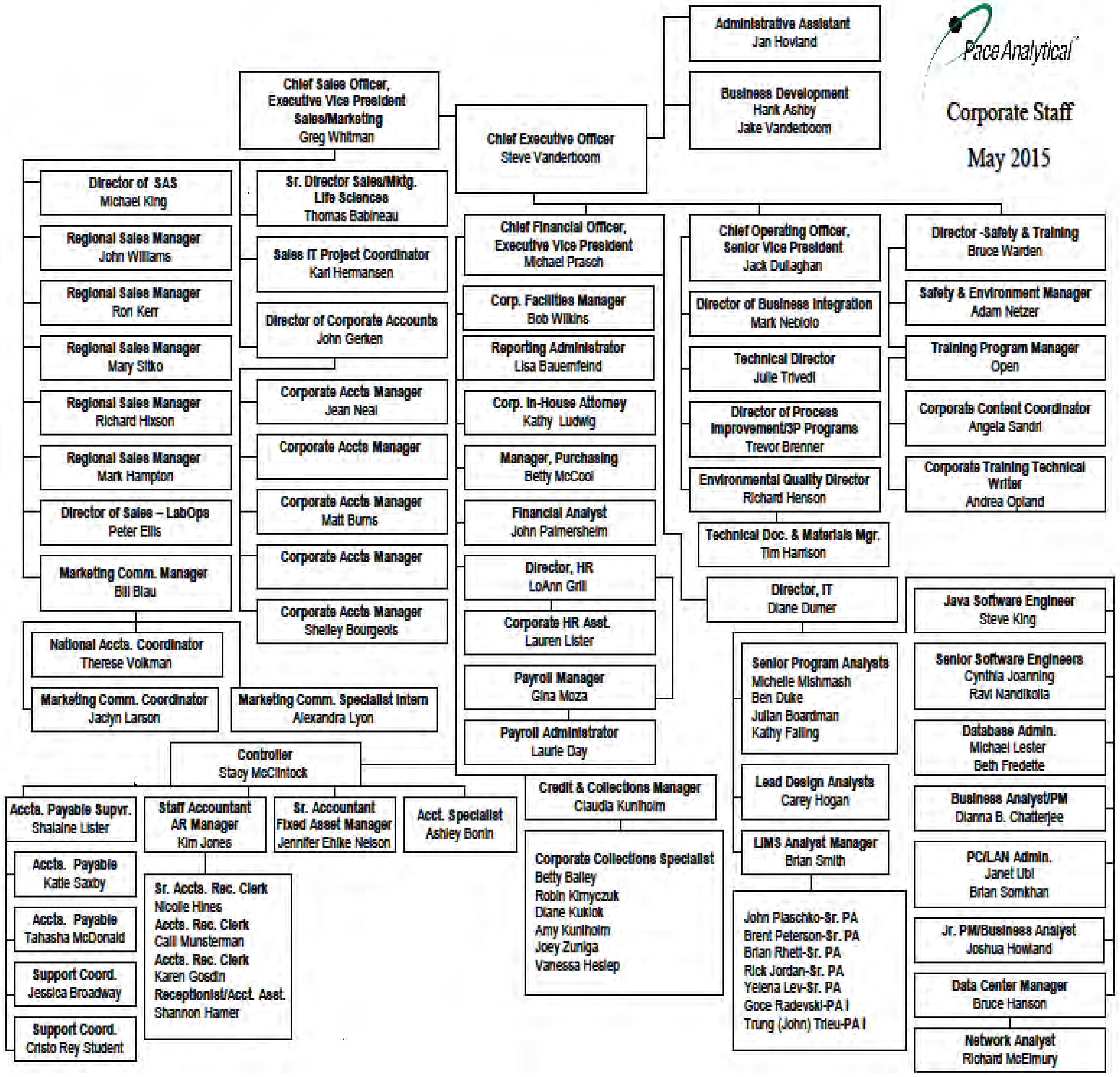


ATTACHMENT IIA- LABORATORY ORGANIZATIONAL CHART

Raleigh



ATTACHMENT IIB- CORPORATE ORGANIZATIONAL CHART



Attachment III- Equipment List

Location	Equipment ID	Lab	Model / Detector	Equipment	Manufacturer	Serial #	Use
Semivolatiles	92GCS4	CHLT	6890		Hewlett-Packard	US00042026	Mass EPH
		CHLT	Dual FID				
Semivolatiles	92GCS5	CHLT	6890		Hewlett-Packard	US00043919	8011, 504.1, 552.2, 8081B, 8082A
		CHLT	Dual micro ECD				
Semivolatiles	92GCS6	CHLT	6890N		Hewlett-Packard	CN10426006	8011, 504.1, 552.2, 8081B, 8082A
		CHLT	Dual micro ECD				
Semivolatiles	92GCS8	CHLT	6890		Hewlett-Packard	CN10820003	DRO
		CHLT	Dual FID				
Semivolatiles	92GCS9	CHLT	7890A		Agilent	CN11111076	8011, 504.1, 552.2, 8081B, 8082A
		CHLT	Dual micro ECD				
Semivolatiles	92GCS10	CHLT	6890N		Agilent	US10302103	8011/504.1
		CHLT	7683			CN25222732	
Semivolatiles	92GCS10	CHLT	6890N (G1530N)		Agilent	US10302103	HAA
		CHLT	Dual micro ECD				
Semivolatiles	92MSS3	CHLT	7890A		Agilent	CN10816094	8270D, 625, 8270D SIM
		CHLT	MS-5970C			US80819094	
Semivolatiles	92MSS4	CHLT	7890A		Hewlett-Packard	CN10031110	8270D, 625, 8270D SIM
		CHLT	MS-5975C			US10040001	
Semivolatiles	92MSS5	CHLT	6890N		Agilent	US10628085	8270D, 625, 8270D SIM
		CHLT	MS-5975C			US81819411	

Semivolatiles	92MSS6	CHLT	7890N		Agilent	CN10251042	8270, 625
		CHLT	5975C			US10236321	
Volatiles	92GCV1	CHLT	5890A Series II		Hewlett-Packard	2921A23623	Mass VPH, (GRO)
		CHLT	PID/FID				
Volatiles	92GCV4	CHLT	5890E		Hewlett-Packard	3336A56045	GRO, (VPH)
		CHLT	PID/FID				
Volatiles	92GCV5	CHLT	6890N (G1530N)		Agilent	CN10430013	GRO, (VPH)
		CHLT	FID/PID				
Volatiles	92MSV1	CHLT	6890N		Agilent	CN10430013	8260/524/624
		CHLT	MS-5973			US43146820	
Volatiles	92MSV2	CHLT	5890 Series II		Hewlett-Packard	2921A24454	Out of Service
		CHLT	MS-5972			3449A02064	
Volatiles	92MSV3	CHLT	6850		Agilent	CN10805009	6200B
		CHLT	MS-5975C			US92012898	
Volatiles	92MSV4	CHLT	7890A		Agilent	CN10251038	8260/624/6200
		CHLT	MS-5975C			US10313603	
Volatiles	92MSV5	CHLT	6890		Agilent	US00026359	8260B, 524.2
		CHLT	MS-5973			US82322063	
Volatiles	92MSV6	CHLT	6850		Agilent	CN10802003	8260B
		CHLT	MS-5975C			US80118209	
Volatiles	92MSV7	CHLT	5890 Series II		Hewlett-Packard	3336A55208	Screening
		CHLT	MS-5972			3434A01684	
Volatiles	92MSV8	CHLT	7890A		Agilent	CN11461033	8260B
		CHLT	MS-5975C			US71236032	
Volatiles	92MSV9	CHLT	7890A		Agilent	CN10251038	8260

		CHLT	MS-5973			US10313603	
Extractions	MW-1	CHLT	MARSX		CEM	PASI19706	Soil Extraction (3546)
Extractions	OG-3	CHLT	SPE-DEX 3000XL		Horizon	14-1947	Oil&Grease (1664B)
Extractions	OG-4	CHLT	3000XL		Horizon	14-1948	Oil&Grease (1664B)
Extractions	DRYVAP-1	CHLT	5000		Horizon	1008	Concentration
Extractions	DRYVAP-2	CHLT	5000		Horizon	1065	Concentration
Extractions	DRYVAP-3	CHLT	5000		Horizon	1093	Concentration
Extractions	DRYVAP-4	CHLT	5000		Horizon	1092	Concentration
Extractions	SPEEDVAP -3	CHLT	SpeedVap III		Horizon	14-0881	Concentration (1664B, 9071B)
Extractions	SPEEDVAP -4	CHLT	SpeedVap III		Horizon	14.0883	Concentration (1664B, 9071B)
Extractions	B-1	CHLT	R200D		Sartorius	40040069	Analytical Balance
Semivolatiles	B-3	CHLT	PM2500		Mettler	K59661	Top-loading balance
Volatiles	B-4	CHLT	SC4010		Ohaus	BJ436720	Top-loading balance
Volatiles	B-5	CHLT	SP202		Ohaus	7123170886	Top-loading balance
Client Services	B-9	CHLT	CPA124S		Sartorius	27050691	Analytical Balance
Extractions	B-10	CHLT	SP601		Ohaus	B236286983	Top-loading balance
Client Services	I-3	CHLT	Isotemp 503		Fisher	361	Total Coliform (SM 9223B)

CLIENT SERVICES	I-4	CHLT	COLIFORM INCUBATOR BATH		PRECISION	9608-007	FECAL COLIFORM (SM 9222D)
CLIENT SERVICES	I-5	CHLT	307 / QUANTI-TRAY INCUBATOR		FISHER	211R0329	FECAL COLIFORM (QUANTI-TRAY)
CLIENT SERVICES	O-3	CHLT	DK43		BAXTER	A04356	OVEN (SM 2540G)
CLIENT SERVICES	O-2	CHLT	ISOTEMP		FISHER	7859	OVEN (SM 2540G)
EXTRACTIONS LAB		CHLT	TCLP ROTATOR / 42R5BFCI-E3		BODINE ELECTRIC COMPANY	0685PXLG0005	1311/ 1312
SUPPLY ROOM	TCLP-3	CHLT	GENERATOR / 1LPP4A		DAYTON		1311 / 1312
		CHLT	MOTOR / 5KH33GNC 140A		MARATHON	A12J110062	
SUPPLY ROOM	TCLP-4	CHLT	BOX TUMBLER / 5K939B		DAYTON	V00212AY10	1311/1312
SUPPLY ROOM	TCLP-5	CHLT	GENERATOR /1LPP4A		DAYTON		1311 / 1312
		CHLT	MOTOR / 5KH33GNC 140A		MARATHON	K12J290164	
EXTRACTIONS	O-4	CHLT	5890 SERIES II		HEWLETT-PACKARD		OVEN

EXTRACTIONS	O-5	CHLT	5890 SERIES II		HEWLETT-PACKARD		OVEN
EXTRACTIONS	O-6	CHLT	31609		THELCO	9606-003	OVEN
EXTRACTIONS	O-7	CHLT	DX41		BAXTER	A05113	OVEN
EXTRACTIONS	SHAKER-1	CHLT	3D SHAKER		GLAS-COL		SEP FUNNEL SHAKER
EXTRACTIONS	WB-1	CHLT	ISOTEMP 120		FISHER		CONCENTRATION
EXTRACTIONS	WB-2	CHLT	120 (CAT #: 15-460-20)		ISOTEMP	1603060749858	HAA
EXTRACTIONS	AE-1	CHLT	120		ORGANOMATION	10723	CONCENTRATION
CLIENT SERVICES	PH-1	CHLT	ACCUMET AP61		FISHER	220713	pH METER
EXTRACTIONS	TURBOVAP 1	CHLT	II		BIOTAGE	TV1121N16573	CONCENTRATION
EXTRACTIONS	TURBOVAP 2	CHLT	II		BIOTAGE	TV1121N16576	CONCENTRATION
EXTRACTIONS	TURBOVAP 3	CHLT	II		BIOTAGE	TV1126N16618	CONCENTRATION
EXTRACTIONS	TURBOVAP 4	CHLT	II		BIOTAGE	TV1121N16577	CONCENTRATION
EXTRACTIONS	TURBOVAP 6	CHLT	II / 46368-A		ZYMARK	TV9445N5821	CONCENTRATION
SEMIVOLATILES	DI-2	CHLT			DEIONIZED WATER TAP		
VOLATILES - MSV OLD	DI-3	CHLT			DEIONIZED WATER TAP		
VOLATILES - MSV NEW	DI-4	CHLT			DEIONIZED WATER TAP		
VOLATILES - GCV	DI-5	CHLT			DEIONIZED WATER TAP		
EXTRACTIONS - WINDOW	DI-6	CHLT			DEIONIZED WATER TAP		
EXTRACTIONS - SHAKE OUT	DI-7	CHLT			DEIONIZED WATER TAP		

Extractions - concentration	DI-8	CHLT			Deionized Water Tap		
Field	DI-9	CHLT			MilliQ DI water system		
Volatiles	GEN-1	CHLT	PEAK Scientific Inst. Ltd		Zero Air Gas Generator	B-11-08-172	Air for FIDs
Sample Receiving	F-1	CHLT	U2016FA14		VWR Scientific	VO5F-3008808-VF	8260/5035 Soils in DI
SVOA	R-36	CHLT	GDM-72		TRUE	1021623	VOA Waters
Prep	O-8	CHLT	DX-41		Baxter	2500021	Oven
Main Lab	TCLP-7	CHLT	Rotary Extractor		Lars Lande Mfg Inc	NA	TCLP/SPLP
Wet Chemistry	Eden001	EDN	CTX17KAB		Hotpoint	HV776598	Storage
Wet Chemistry	Eden002	EDN	CTX17		Hotpoint	RT733500	Ice Packs
Wet Chemistry	Eden003	EDN	307		Fisher		BOD
Wet Chemistry	Eden004	EDN	4		Precision	22AJ-11	Total Coliform
Wet Chemistry	Eden005	EDN	1545		VWR	901391	Total Coliform
Wet Chemistry	Eden006	EDN	GP400		Neslab	44.5 C	Fecal Coliform
Wet Chemistry	Eden007	EDN	STM-F		Market Forge	120 208 240	Sterilization
Wet Chemistry	Eden008	EDN	3510FS		Fisher	1879070501400	Solids
Wet Chemistry	Eden009	EDN	2X		Idexx	4518	Ecoli
Wet Chemistry	Eden010	EDN	YSI5100		YSI	00K0582	BOD
Wet Chemistry	Eden011	EDN	DR2800		HACH	1207494	Color, Hex Chrom,
Wet Chemistry	Eden012	EDN	2020E		Lamatte	SN-ME12981	Turbidity
Wet Chemistry	Eden013	EDN	Colorimeter		HACH	1230128764	Chlorine
Wet Chemistry	Eden014	EDN	SA55NXGT		Emerson	L87 7	Fecal Coliform

			E				
Wet Chemistry	Eden015	EDN			Fisher	803N0752	Fecal Coliform
Wet Chemistry	Eden016	EDN	720A+		Thermo Orion	92569	Nitrate
Wet Chemistry	Eden017	EDN	A-160		Denver Instrument	N0090021	Solids
Wet Chemistry	Eden018	EDN	UVL-56		Blak-Ray	C22.2	Total Coliform
Wet Chemistry	Eden019	EDN	AP5		Fisher		pH
Wet Chemistry	Eden020	EDN	AP61		Fisher		pH & Temp
Wet Chemistry	Eden021	EDN	Safeaire		Hamilton	NA	
Wet Chemistry	Eden022	EDN	R-55-ST		Migali	1192185	Sample Receiving
Wet Chemistry	Eden023	EDN	Isotemp		FisherScientifc	NA	BOD
Wet Chemistry	Eden024	EDN	420A		Orion	8759	pH
Wet Chemistry	Eden025	EDN	VOLTS		Precision	9301-02	BOD
Wet Chemistry	Eden026	EDN					TSS
Field	Eden027	EDN	Pocket Colormeter		HACH		Chlorine
Wet Chemistry	Eden028	EDN	Moch 1-37L		Percival	92J3561.5	BOD
Wet Chemistry	Eden029	EDN	130D		Precision	9606-003	TSS
Wet Chemistry	Eden030	EDN	1-35 L		Percival	91F3518.7	Fecal Colilert 18
Wet Chemistry	Eden031	EDN					
Wet Chemistry	Eden032	EDN	1350G	Oven	Shell-Lab	1861350	TSS oven
Wet Chemistry	Eden033	EDN	GR-1310W		NA	80402713	Media Plate Supplies
Wet Chemistry	Eden034	EDN	420A		Orion	8609	pH Meter
Wet Chemistry	Eden035	EDN	2340M		Brinkmann	9701428	Sterilization
Wet Chemistry	Eden036	EDN	516D		Fisher	111N0097	Enterococci

					Scientific		
Bioassay	BAL3	RAL	CP225D	Balance	Sartorius	22011529	Bioassay 5 Place
Bioassay	BA1	RAL	818	Balance	Precision	699091193	Bioassay
Bioassay	BA2	RAL	LabLine 844	Balance	Barnstead	NA	Bioassay
Bioassay	BA3	RAL	818	Balance	Precision	305212	Bioassay
Bioassay	BA4	RAL	2020	Balance	VWR	0701999	Bioassay
Bioassay	Microscope 1	RAL	EMZ	Microscope	MEIJI	265999	Bioassay
Bioassay	Microscope 2	RAL	EMZ	Microscope	MEIJI	20930	Bioassay
Bioassay	Microscope 3	RAL	NA	Microscope	Nikon	50274	Bioassay
Bioassay	Meter 3	RAL	Orion 5 Star	Combo Meter	Thermo	014144	Bioassay/pH/Cond/DO
Bioassay	Refrigerator 4	RAL	FRT17L3FW7	Refrigerator	Frigidaire	BA94912835	Bioassay Reagent Storage
Bioassay	Refrigerator 5	RAL	RT18BKXKQ02	Refrigerator	ROPER	VSR3486634	Chloraphyl A
Metals	DI 1	RAL	Academic A10	DI Water	Milli-Q	NA	DI water for LLHg
Micro	NA	RAL	Sterilmatic	Autoclave	Market Forge	NA	Micro
Micro	NA	RAL	3323		Leica	NA	Micro
Micro	Incubator 1	RAL	6LM	Incubator	Precision Scientific	9508-006	Total Coliform/Sludge
Micro	Water Bath 1	RAL	1275PC	Water Bath	VWR	NA	Sludge Fecal/Colilert 18
Micro	Water Bath 2	RAL	253	Water Bath	Precision Scientific	3412-103	

MICRO	WATER BATH 3	RAL	51221033	WATER BATH	PRECISION SCIENTIFIC	69910439	SLUDGE FECAL
MICRO	INCUBATOR 2	RAL	IMPERIAL III	INCUBATOR	LAB LINE	0598-0329	HPC
MICRO	INCUBATOR	RAL	ECONOMY	INCUBATOR	PRECISION	601091184	ENTEROCOCCUS
MICRO	SEALER 1	RAL	2X	SEALER	IDEXX	5459	E. COLI
MICRO	REFRIGERATOR #14	RAL	TBX18SIBQ LWW	REFRIGERATOR	GE	SV538399	MICRO MEDIA STORAGE
MICRO	STEREOMASTER 1	RAL	STEREOMASTER	NA	FISHER	J1405-0744-007	FECAL COUNTING
MICRO	BAL 1	RAL	TS400	BALANCE	OHAUS	5826	MAKING MEDIA
MICRO	BAL 2	RAL	PB303-S	BALANCE	METTLER TOLEDO	119010966	WET CHEM AREA
SAMPLE RECEIVING	FREEZER 1	RAL	20163	FREEZER	KENMORE	E02941700	SAMPLE RECEIVING
SAMPLE RECEIVING	NONE	RAL		ICE MACHINE	MANITOWAC		ICE MAKER FOR SAMPLE RECEIVING
SAMPLE RECEIVING	REFRIGERATOR 7	RAL	TMC	REFRIGERATOR	TRUE	NA	REAGENT STORAGE/REFRIGERATOR FOR SAMPLES NOT LOGGED IN YET
SAMPLE RECEIVING	REFRIGERATOR 11	RAL	564	REFRIGERATOR	SEARS	940300503	SAMPLE RECEIVING/SAMPLES TO BE SENT TO ASH/CHAR/ETC.
SAMPLE RECEIVING	REFRIGERATOR 9	RAL	GDM-37	REFRIGERATOR	TRUE	957271	REFRIGERATOR FOR SAMPLES TO BE ANALYZED IN RALEIGH
SAMPLE RECEIVING	REFRIGERATOR 15	RAL	RBBCFA27 B	REFRIGERATOR	BLACK & DECKER	BS04TE7X0JBKS 1V1988	VOA SAMPLE HOLDING

Sample Receiving	Refrigerator 16	RAL	11EO	Refrigerator	Baxter Scientific	Y20B-128986-YB	Raleigh Short Hold Samples
Wet Chemistry	91BAL1	RAL	AB204-S	Balance	Mettler Toledo	1120142348	All Solids
Wet Chemistry	BODI 1	RAL	FU199A	Incubator	Fisher	1314	BOD Incubator
Wet Chemistry	BODI 2	RAL	LR1201WWW/0	Incubator	Norlake	11020288	BOD Incubator
Wet Chemistry	BODI 4	RAL	11-679-25c	Incubator	Fisher Scientific	2018090423472	BOD Incubator
Wet Chemistry	Sonicator 1	RAL	1210	Sonicator	Branson	1200R-MT	BOD Sonicator
Wet Chemistry	DO 1	RAL	50B	DO Meter	YSI	93L12195	BOD/CBOD
Wet Chemistry	91WET6	RAL	52	DO Meter	YSI	05A2582	BOD/CBOD
Wet Chemistry	91WET4	RAL	QuickChem 8000	Lachat	Lachat	A83000-2257	NOX
Not In use	Furnace 1	RAL	30400	Furnace	Thermolyne	NA	Volatile Solids
Wet Chemistry	Furnace 2	RAL	62700	Furnace	Thermolyne	6.27951E+11	Volatile Solids
Wet Chemistry	Oven 1	RAL	Empiral V	Oven	Barnstead	NA	103-105 °C
Wet Chemistry	Meter 4	RAL	Star A211	Combo Meter	Orion	X16842	pH & Conductivity/ BOD pH meter
Wet Chemistry	Meter 2	RAL	AR20	Combo Meter	Accumet	AR81201543	pH & Conductivity
Wet Chemistry	Refrigerator 13	RAL	253.6580251	Refrigerator	Kenmore	BA63117872	Wet Chem Reagent Storage
Wet Chemistry	Spec 1	RAL	Pocket Colorimeter II	Spec	HACH	NA	Chlorine
Wet Chemistry	91WET5	RAL	DR/2010	Spec	HACH	990900014809	COD/MBAS/OP

WET CHEMISTRY	91WET2	RAL	965	TURB. METER	ORBECO-HELLIGE	5099	TURBIDITY
MICRO		RAL	516D		FISHER SCIENTIFIC	111N0097	
		RAL	2020		VWR	303698	
BOD INCUBATOR		RAL	2020		VWR	303698	RECEIVED FROM VA - BACKUP INCUBATOR
WET CHEMISTRY	EDEN037	EDN	1350F		VWR	0100100	ECOLI
WET CHEMISTRY	92WTAB	GWD	881		METROHM	1881000116126	ANIONS
WET CHEMISTRY	92WTAC	GWD	APOLLO 9000		TEKMAR-DOHRMANN	US02179008	TOC
WET CHEMISTRY	REF-16	GWD	564.954994		SEARS	#040830696	WC REAGENTS
WET CHEMISTRY	PH-1	GWD	720A		ORION	#001033	NOT IN USE-2/25/2014
WET CHEMISTRY	THE-1	GWD	4001		THERMO SPECTRONIC	3SGF344011	PHENOLS/TOT. PO4
WET CHEMISTRY	THE-2	GWD	4001		THERMO SPECTRONIC	3SGM189015	NOT IN USE-2/25/2014
WET CHEMISTRY	ASTP-1	GWD	2002AL		AQUA SOLUTIONS	042252AL	WC/MICRO/ASBESTOS/FIELD
WET CHEMISTRY	HD-3	GWD	UNKNOWN		KEWAUNEE SC	UNKNOWN	EXHAUST HOOD
WET CHEMISTRY	HD-4	GWD	UNKNOWN		KEWAUNEE SC	UNKNOWN	EXHAUST HOOD
WET CHEM/MICROBIOLOGY	WB-5	GWD	66885		PRECISION	10AZ-11	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	BAR-4	GWD	ST75935		BARNSTEAD	1118990871243	STERILIZATION
WET	UVP-1	GWD	CC-10		UVP	NONE	MICROBIOLOGY

CHEM/MICROBIOLOGY							
WET CHEM/MICROBIOLOGY	UVP-2	GWD	UVSL-58		UVP	17077	MICROBIOLOGY
WET CHEM/MICROBIOLOGY	UVP-3	GWD	J-225		UVP	44399	UV INTENSITY MEASUREMENT
WET CHEM/MICROBIOLOGY	INC-10	GWD	IC-43		YAMATO	211010	TOTAL COLIFORM/E. COLI
WET CHEM/MICROBIOLOGY	QUE-2	GWD	3325		QUEBEC	NONE	FECAL COLIFORM/HPC
WET CHEM/MICROBIOLOGY	INC-6	GWD	2		PRECISION	227I	SPORE CHECK INCUBATOR
WET CHEM/MICROBIOLOGY	IDX-2	GWD	2X		IDEXX	12-083-07416	E. COLI
WET CHEM/MICROBIOLOGY	SAR-4	GWD	AC120S		SARTORIUS	30103189	WC/MICRO/ASBESTOS
WET CHEM/MICROBIOLOGY	EEX-1	GWD	SC100		ENVIRONMENTAL EXPRESS	145CECD240	TOTAL PO4
WET CHEM/MICROBIOLOGY	PH-3	GWD	720A		ORION	#011749	PHENOLS/MICRO
WET CHEM/MICROBIOL	FUN-1	GWD	4238		GELMAN	NA	FECAL COLIFORM

OGY							
WET CHEM/MICROBIOLOGY	FUN-2	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	FUN-3	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	FUN-4	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	FUN-5	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	FUN-7	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	FUN-8	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	FUN-9	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	FUN-10	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	FUN-11	GWD	4238		GELMAN	NA	FECAL COLIFORM
WET CHEM/MICROBIOLOGY	TI-2	GWD	TI-36X PRO		TEXAS INSTRUMENTS	K0413A	CALCULATIONS

Wet Chem/Microbiology	HD-5	GWD	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
Wet Chem/Microbiology	HD-6	GWD	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
Asbestos	BAL-1	GWD	StereoZoom 6		Bausch & Lomb	Unknown	Stereoscopic Exam of Asbestos
Asbestos	BAL-2	GWD	StereoZoom 6		Bausch & Lomb	Unknown	Stereoscopic Exam of Asbestos
Asbestos	OLY-1	GWD	BH-2		Olympus	#031520	PLM Exam of Asbestos
Asbestos	OLY-2	GWD	BH-2		Olympus	#036854	PLM Exam of Asbestos
Asbestos	OVN-10	GWD	AC 299186		Yamato	DX401B5200046	WC/Asbestos
Asbestos	OVN-11	GWD	FB1415M		Barnstead-Therm	746951030721	Asbestos
Asbestos	OVN-9	GWD	48000		Thermolyne	Unknown	Asbestos
Asbestos	TI-1	GWD	TI-36X Pro		Texas Instruments	K1212A	Calculations
Asbestos	HD-7	GWD	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
Asbestos	HD-8	GWD	Unknown		Kewaunee Sc	Unknown	Exhaust Hood
Mold	OLY-4	GWD	BX40F-3		Olympus	5J02789	Mold Analysis
Mold	CI-01	GWD	Z30 L		Cambridge Instruments	1153TP	Mold Analysis
Sample	REF-0	GWD	W		Hobart	53 680 960	Sample Storage

RECEIVING							
SAMPLE RECEIVING	REF-13	GWD	ESUF15HW		AMANA	9404903621	MICRO REAGENTS STORAGE
SAMPLE RECEIVING	ORN-4	GWD	135		ORION	83701033	NOT IN USE-2/25/2014
RECEIVING OFFICE	TRO-8	GWD	7036-1		TROEMNER	1000019942	2 MG ASTM CLASS 1 WEIGHT
RECEIVING OFFICE	TRO-10	GWD	NA		TROEMNER	#07621	CALIBRATE BALANCE
FIELD	OVN-12	GWD	6936		THERMOFISHER	272308-107	TCLP PREP
FIELD	HFI-2	GWD	DRT-15CE		HF SCIENTIFIC	UNKNOWN	TURBIDITY
FIELD	HFI-3	GWD	DRT-15CE		HF SCIENTIFIC	UNKNOWN	TURBIDITY
FIELD	SAR-2	GWD	L2200P		SARTORIUS	37040166	TCLP PREP
FIELD	YSI-1	GWD	59		YSI	95J38730	FIELD DISSOLVED OXYGEN
FIELD	CLM-6	GWD	POCKET COLORIMETER II		HACH	06100D059464	FIELD TRC
FIELD	CLM-7	GWD	POCKET COLORIMETER II		HACH	#040100009468	FIELD TRC
FIELD	HAC-5	GWD	S180060		HACH	09070C751896	FIELD SPECIFIC CONDUCTIVITY
FIELD	HAC-6	GWD	SENSIONS		HACH	09080C852014	FIELD SPECIFIC CONDUCTIVITY
FIELD	HAC-7	GWD	5953004		HACH	13080E228377	OZONE
FIELD	INS-1	GWD	MDU-420		INDUST. SCIENT.	9803108-006	METHANE
FIELD	PH-13	GWD	SP70P		VWR	#000684	FIELD PH

FIELD	PH-16	GWD	SP20		VWR	#002134	FIELD pH
FIELD	PH-19	GWD	SP70P		VWR	C01937	FIELD pH
FIELD	PH-20	GWD	SP70P		VWR	C02016	FIELD pH
FIELD	PH-22	GWD	SP70P		VWR	C02476	FIELD pH
FIELD	PH-23	GWD	SP70P		VWR	C03259	FIELD pH
FIELD	YSI-3	GWD	58		YSI	92A035993	FIELD DISSOLVED OXYGEN
FIELD	YSI-6	GWD	58		YSI	92E038703	FIELD DISSOLVED OXYGEN
FIELD	YSI-7	GWD	PROPLUS-4		YSI	JC019719	FIELD DISSOLVED OXYGEN
FIELD	BARO-1	GWD	UNKNOWN		EBERBACH	UNKNOWN	BAROMETER
SAMPLE RECEIVING	R-1	MEC	FFRT18TP HWO		FRIGIDAIRE	BA02405585	SAMPLE STORAGE
SAMPLE RECEIVING	R-2	MEC	ET4WSkXS T00		WHIRLPOOL	VST460936	SAMPLE STORAGE
METALS	92ICP3	AVL	ICAP 6500	ICP ANALYZER	THERMO ELEMENTAL	ICP-2010-4901	ICP
METALS	92ICP1	AVL	VISTA PRO	ICP ANALYZER	VARIAN	EL06024119	ICP
METALS	TUMBLER #2	AVL	NA	TCLP TUMBLER	ENVIRONMENTAL EXPRESS	NA	TCLP
METALS	TUMBLER #3	AVL	NA	TCLP TUMBLER	ENVIRONMENTAL EXPRESS	NA	TCLP
METALS	92HG1	AVL	M7500		CETAC	100402QTA	MERCURY
METALS	HOTBLOCK1 (36A)	AVL	96 POSITION	METALS HOTBLOCK	ENVIRONMENTAL EXPRESS	NA	METALS
METALS	HOTBLOCK2	AVL	36 POSITION	METALS	ENVIRONME	NA	METALS

	(36B)			Hotblock	ntal Express		
Metals	Hotblock2	AVL	36 Position	Metals Hotblock	Environmental Express	NA	Metals
Metals	Hotblock (5)	AVL	54 Position	Metals Hotblock	Environmental Express	NA	Metals
Metals	Hotblock1 (36)	AVL	SC Custom 96 position	Metals Hotblock	Environmental Express	6815CECW3105	Metals
Metals		AVL	36 Position	Metals Hotblock	Environmental Express	NA	Metals
Metals	92LLHG	AVL	M-8000	Hg Analyzer	CETAC	071202 QM8	LL Hg
Metals	92HG3	AVL	M6100	Hg Analyzer	CETAC	020501 QT6	Hg
Metals	92ICP4	AVL	730-ES	ICP Analyzer	Varian	EL06123880	ICP
Metals	Centrifuge #1	AVL	Rotina 465	Centrifuge	Henttich	000331802CS	Metals Prep
Metals	NA	AVL	SC Custom 96 position	Metals Hotblock	Environmental Express	8940CECW3899	Metals
Wet Chemistry	Balance #5	AVL	200DS	Balance	Fisher	BO27039	TSS, TDS, reagents
Wet Chemistry	Balance (top loader)	AVL	PE 400	Balance	Mettler	B2915	Solids/Others
Wet Chemistry	Balance #2	AVL	xs105DU	Balance	Mettler Toledo AG	1129312116	Solids/Others
Wet Chemistry	pH meter#2	AVL	EA 420A	Expandable Ion Analyzer	Orion	24455	pH
Wet Chemistry	COD	AVL	45600	COD Reactor	HACH	900602688	COD

	Reactors (3)						
Wet Chemistry	COD Reactors (1)	AVL	45600	COD Reactor	HACH	900601686	COD
Wet Chemistry	92WTA4	AVL	QuickChem 8000	Lachat Analyzer I	Lachat	A83000-1064	Nitrate + Nitrite, Phenol
Wet Chemistry	92WTA8	AVL	QuickChem 8500	Lachat Analyzer II	Lachat	10080001233	TCN, TKN, Chloride, TP, NH3
Wet Chemistry	Lachat Micro Dist #2	AVL	NA	Lachat Hot block	Lachat Micro Dist.	100700002077	Ammonia
Wet Chemistry	Lachat Micro Dist #3	AVL	Turb 550T	Lachat Hot block	VWR	20101008	Turbidity
Wet Chemistry	Oven #2	AVL	655F	Oven	Fisher Isotemp	80600048	TDS<100°C
Wet Chemistry	NA	AVL	5100	DO Meter	YSI	98E0889	BOD
Wet Chemistry	92WTA1	AVL	NA	Smartchem Analyzer	Westco	W0601081	Ammonia, Ferrous Iron
Wet Chemistry	NA	AVL	Aim600	TKN Block or Controller	NA	4826A13455	TKN
Wet Chemistry	92WTA6	AVL	TOC-Vcpn	TOC Analyzer	Shimadzu	H51404535060CS	TOC
Wet Chemistry	92EXT2	AVL	4001	Spec Meter	Spectronic 20 Genesys	3SGD037010	Sulfide/COD/LLCOD/OP
Wet Chemistry	92WTA7	AVL	761	IC Analyzer	Metrohm	11145	F and SO4
Wet Chemistry	Filtration Processor	AVL	788	IC Analyzer Sampler	Metrohm	4119	F and SO4
Wet Chemistry	NA	AVL	NA	Refrigerator	Norlake	NA	Std/Reg Refrigerator

WET CHEMISTRY	WALK-IN #2	AVL	LSCO5ZAS	WALKIN REFRIGERATOR	HEAT CRAFT	D95M 03829	BOD WALK IN
WET CHEMISTRY	FREEZER #6	AVL	NA	FREEZER	GENERAL ELECTRIC	NA	BOD SEED
WET CHEMISTRY	REF #6	AVL	NA	REFRIGERATOR	GENERAL ELECTRIC	NA	NA
WET CHEMISTRY	CONDUCTIVITY METER #2	AVL	ORION 3 STAR BENCHTOP COND METER	SP. COND. METER	THERMO SCIENTIFIC	B29683	CONDUCTIVITY
WET CHEMISTRY	NA	AVL	1530	INCUBATOR	VWR	NA	TOTAL COLIFORM 35°C
WET CHEMISTRY	NA	AVL	NA	AUTOCLAVE	MARKET FORGE	NA	STERILIZATION
WET CHEMISTRY	92WETC	AVL	399-W001-01	SMARTCHEM ANALYZER	WESTCO	W0404051	AMMONIA, FERROUS IRON, HEX CHROM
WET CHEMISTRY	92WETD	AVL	888 TITRANDO	IC ANALYZER	METROHM	1789002162	PH, COND, ALK
WET CHEMISTRY	NA	AVL	5100	DO METER	YSI	01K0797	BOD
WET CHEMISTRY	NA	AVL	NA	?	WESTCO	1166	TKN
WET CHEMISTRY	NA	AVL	NA	?	WESTCO	1206	TKN
WET CHEMISTRY	NA	AVL	NA	?	WESTCO	1265	TKN
WET CHEMISTRY	COD BLOCK 4	AVL	DRB 200	COD BLOCK	HACH	1105719	COD
WET CHEMISTRY	COD BLOCK 5	AVL	45600	COD BLOCK	HACH	890700288	COD
WET CHEMISTRY	91WET1	AVL	GENESYS 10 UV	UV METER	GENESYS	2GBC259001	UV
WET CHEMISTRY	92WTA9	AVL	761	IC ANALYZER	METROHM	12193	F AND SO4
WET CHEMISTRY	NA	AVL	788	IC ANALYZER	METROHM		F AND SO4

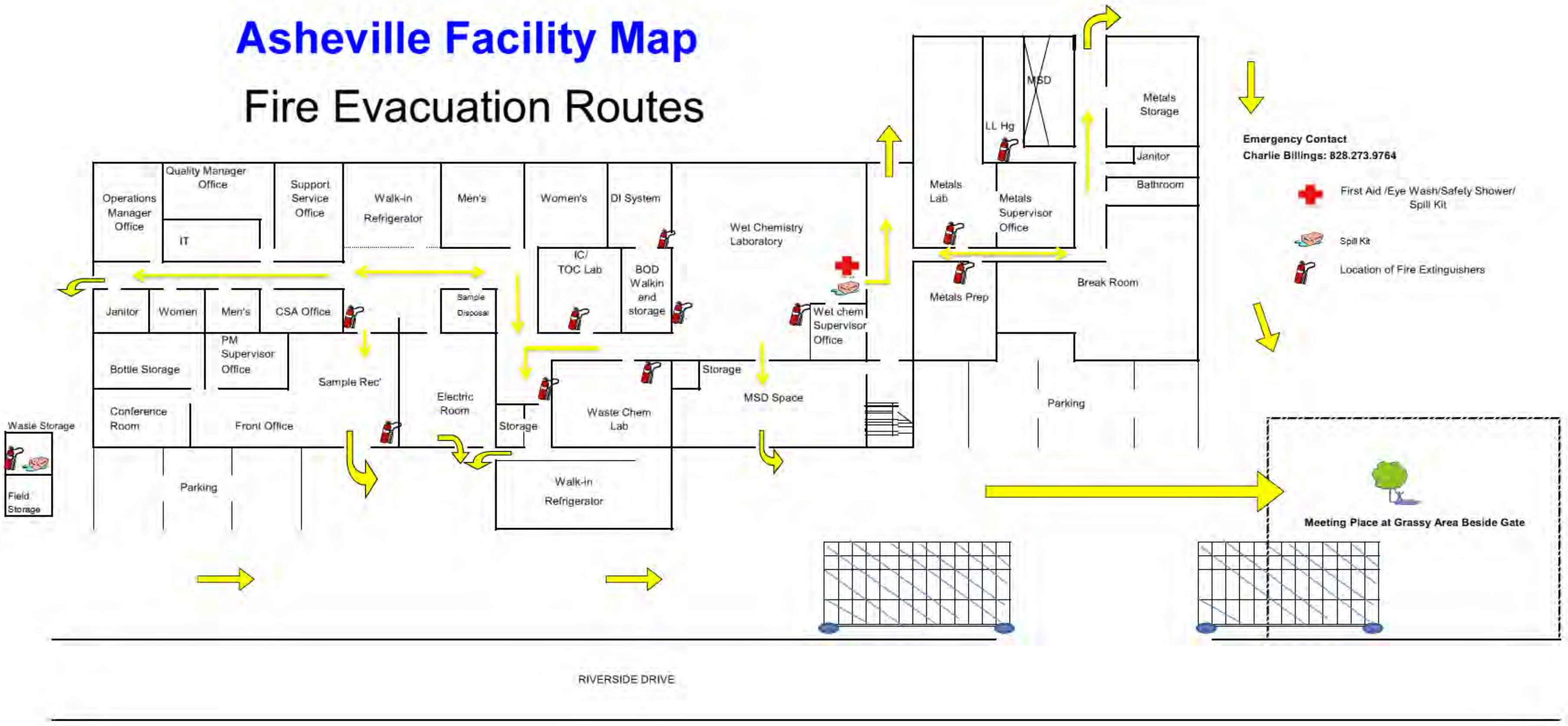
				SAMPLER			
WET CHEMISTRY	OVEN #3	AVL	130	OVEN	PRECISION	9606-003	TDS
WET CHEMISTRY		AVL	TUB 800 2457	TURBIDITY METER	VWR	TUB 800 2457	TURBIDITY
WET CHEMISTRY	EDEN039	EDN		COD BLOCK	HACH	941200011843	COD
WET CHEMISTRY	COD BLOCK 7	AVL	45600-00	COD BLOCK	HACH	920300006758	COD
WET CHEMISTRY	EDEN040	EDN	45600-00	COD BLOCK	HACH	920900013148	COD
WET CHEMISTRY	FLASHPOINT #3	AVL	K16200	FLASHPOINT APPARATUS	KOEHLER	R0700296-B	FLASHPOINT
WET CHEMISTRY	92WTAB	AVL	PHOENIX 8000	TOC ANALYZER	TELEDYNE TEKMAR DOHRMANN	99342014	TOC DW
WET CHEMISTRY	F-1	AVL	NA	TOC ANALYZER SAMPLER	NA	NA	TOC DW
WET CHEMISTRY	92WTAA	AVL	QUICKCHEM 8000	LACHAT ANALYZER III	LACHAT	A83000-2000	CHLORINE, TCN, TP
MICRO / FIELD	92WET8	AVL	DR 2800	CHLORINE METER	HACH	1198691	LOW LEVEL CHLORINE LAB FIELD
MICRO	NA	AVL	182	?	PRECISION	10AZ-11	NA
MICRO	NA	AVL	66850	WATER BATH	PRECISION	10AY-4	FECAL WATER BATH
MICRO	NA	AVL	302 IMPERIAL III	INCUBATOR	LAB LINE	0390-0143	FECAL COLIFORM
MICRO	92BIO5	AVL	89-108 94.02	?	IDEXX	04412-06-0127	FECAL COLIFORM
SAMPLE RECEIVING	WALK-IN #1	AVL	NA	WALKIN REFRIGERATOR	ARCTIC	NA	NA
SAMPLE RECEIVING	REF #7	AVL	NA	REFRIGERATOR	TRUE	NA	NA

Sample Receiving - 4/1/2015 After Wetchem	Ref #8	AVL	GDM-72	refrigerator	TRUE	1-4434482	NA
Waste Chem	92WST5	AVL	TOX-100	TOX	Mitsubishi	A7M-30181	Chlorine
Waste Chem	92WST1	AVL	1281 Bomb Calorimeter	BTU	PARR	M1116	BTU
Waste Chem	92WST6	AVL	6300 Bomb Calorimeter	BTU	PARR	M9807	BTU
Waste Chem	NA	AVL	PJ300	Balance	Mettler	I11088	Metals Prep
Waste Chem	NA	AVL	AC121S	Balance	Sarterius	41106832	BTU
Waste Chem	92WST3	AVL	S-144DR	Sulfur	LECO	3170	Sulfur
Waste Chem	92WST7	AVL	S-632	Sulfur	LECO	3122	Sulfur
Waste Chem	NA	AVL	CP 124 S	Balance	Sarterius	19550801	Waste Chem
Waste Chem	NA	AVL	1350G	?	VWR	1861350	Waste Chem
Waste Chem	92WST4	AVL	F47900	?	Thermo Scientific	NA	Waste Chem/TVS/TVSS
Waste Chem	NA	AVL	BP 121S	Balance	Sarterius	90108632	
Field	F-1	AVL	Pocket Colormeter	Meter	HACH	960600096027	Cl2
Field	F-2	AVL	Pocket Colormeter	Meter	HACH	011100171841	Cl2
Field	F-3	AVL	PC Tester 30	Meter	Oakton	1274116	pH Temp
Field	F-4	AVL	Accumet AP 62	Meter	Accumet	1107794	pH Temp

Field	F-6	AVL	YSI Pro 20	Meter	YSI	JC 01272	DO Temp
Field	F-7	AVL	YSI 30	Meter	YSI	03K1054	Sp.Cond
Wet Chemistry	Oven #5	AVL	1350F	Oven	VWR	0100100	TSS oven
Field	F-8	AVL	YSI 30 Pro Plus	Meter	YSI	14F101975	pH Temp ORP DO
Field	F-9	AVL	2020we	Meter	LaMotte	1372-3811	Turbidity
Wet Chemistry	NA	AVL	BD-28s/BD50s	TKN Controller	Lachat	4811A13131 - Controller	TKN Block
	NA	AVL	Seal	TKN Block		4811A13137 - Block	
Micro	Eden038	EDN	Economy	Fecal Incubator	Precision Scientific	601091184	Fecal Incubator
Sample Receiving	I-6	CHLT	T26B-120085-UB		Revco		Total Coliform/HPC
Field	pH-25	GWD	250A		Orion	004900	pH
Greenwood	TRO-10	GWD	NA		Troemner	#07621	Calibra. NIST Cert. Wt.
Wetchem Lab	92WETA	AVL	DR 3900	Lachat	HACH	1582033	TRC, OP, COD, LL COD , S
Wetchem Lab	Eden041	EDN	815	BOD Incubator	Precision Scientific	9408-029	BOD Incubator
Metals	92HG4	AVL	M-7600	Hg Analyzer	CETAC	011502Q76	Hg Analyzer
Wetchem Lab	Oven #6	AVL	Heratherm OMH750	Oven	Thermo Fisher	41729011	TSS Oven
Sample Receiving/ Wetchem	Walkin #3	AVL	KPS-300	Walkin	Kysor	N/A	Sample Storage
Sample Receiving	Eden042	EDN	LFHT1817LB4	Refrigerator/ Freezer	Frigidaire	BA14821285	Sample Storage
Bioassay	BA5	RAL	818	Incubator	Precision	10-AV-5	Bioassay incubator

BIOASSAY	BA6	RAL	818	INCUBATOR	PRECISION	9206-001	BIOASSAY INCUBATOR
WETCHEM LAB	92WST8	GWD	TOX-300	TOX ANALYZER	MITSUBISHI	H0AA0034	CHLORINE
WETCHEM LAB	ABC-001	GWD	ABC-210	AUTOMATIC BOAT CONTROLLER	MITSUBISHI	D8C20564	TOTAL CHLORINE
WET CHEMISTRY	pH METER#1	AVL	EA 420A	EXPANDABLE ION ANALYZER	ORION	27727	PH
SAMPLE RECEIVING	O-9	CHLT	STM80	% MOISTURE OVEN	PRECISION SCIENTIFIC	11AV-2	% MOISTURE
WETCHEM LAB	pHMETER#5	AVL	ORION STAR A211	pH METER	FISHER / ORION	X16842	PH

ATTACHMENT IV- LABORATORY FLOOR PLAN


Asheville Facility Map

Fire Evacuation Routes

Emergency Contact
Charlie Billings: 828.273.9764

ATTACHMENT IV- CHARLOTTE FLOOR PLAN

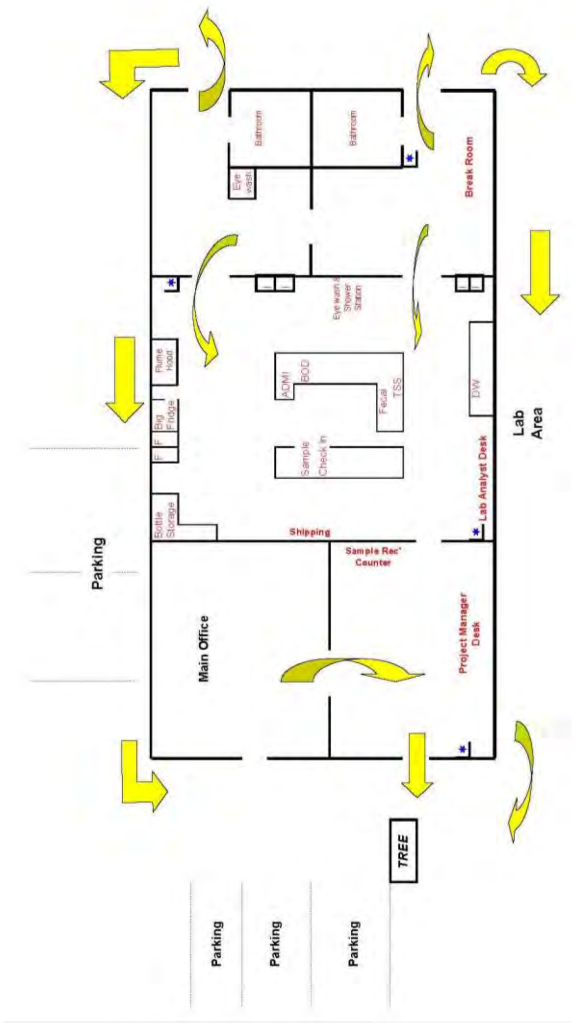
Hazardous Waste Emergency Contact

Cheryl Johnson
704-451-6904

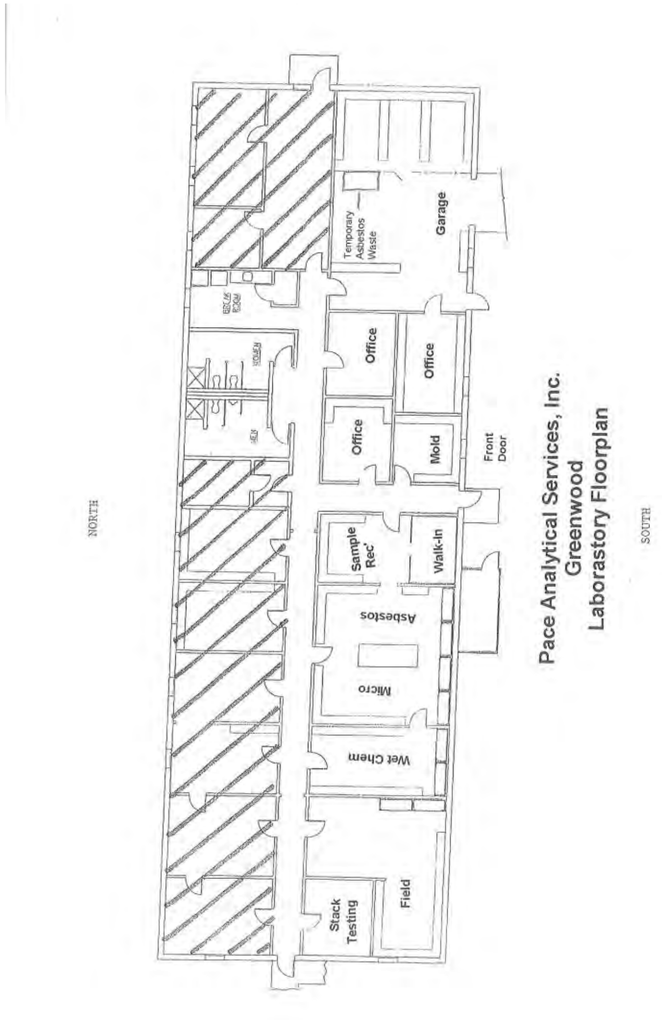
Rob Hobson
704-345-0870

Jeff Graham
704-589-0230

ATTACHMENT IV- EDEN FLOOR PLAN

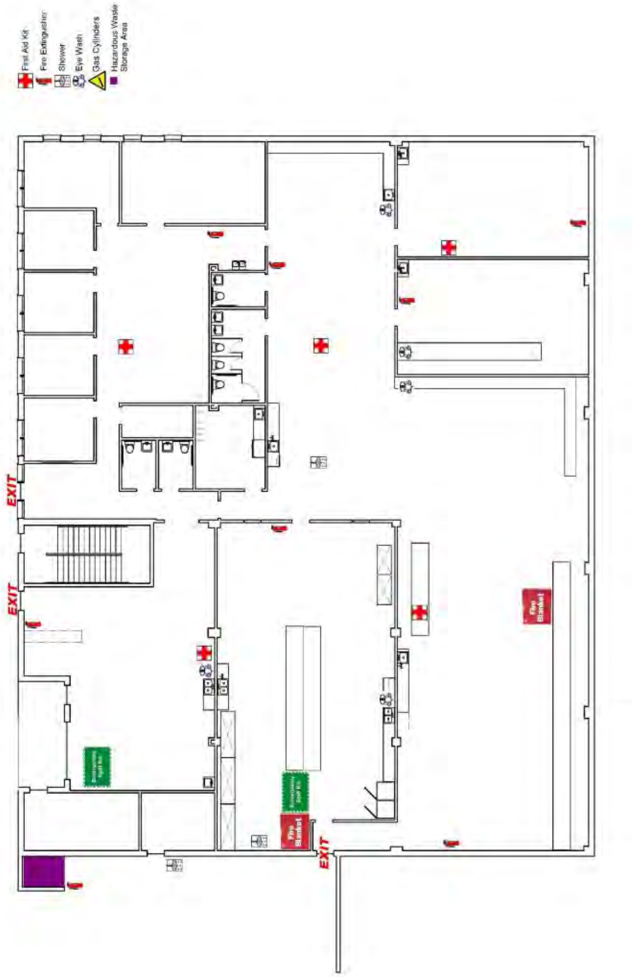


ATTACHMENT IV- GREENWOOD FLOOR PLAN



Pace Analytical Services, Inc.
Greenwood
Laborastory Floorplan

ATTACHMENT IV- RALEIGH FLOOR PLAN



ATTACHMENT V- LABORATORY SOP LIST (CURRENT AS OF ISSUE DATE)

S	CAR	O	002	02	SYNTHETIC PRECIPITATION LEACHING PROCEDURE (SPLP)	1312
S	CAR	O	001	06	TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP)	1311
S	CAR	MB	002	02	TOTAL COLIFORMS, ABSENT/PRESENT	SM 9223 B
S	CAR	C	001	06	SAMPLE MANAGEMENT	
S	CAR	C	003	05	SUBCONTRACTING SAMPLES	
S	CAR	C	004	04	BOTTLE PREPARATION	
S	ASV	I	072	000	AMMONIA NITROGEN ON THE LACHAT	EPA 350.1 REV. 2
S	EDN	S	001	00	CONTINGENCY AND EMERGENCY PROCEDURES PLAN	NA
S	CAR	MB	001	00	FECAL COLIFORMS	SM 9222 D
S	CAR	MB	005	01	E. COLI - QUANTI-TRAY	SM 9223 B QT
S	CAR	L	005	03	MEASUREMENT OF PERCENT MOISTURE IN SOILS AND SOLIDS	
S	CAR	MB	003	02	HETEROTROPHIC PLATE COUNT	IDEXX SIMPLATE
S	CAR	MB	004	01	FECAL COLIFORM - QUANTITATION BY QUANTI-TRAY/2000 COLILERT®-18	COLILERT®-18

S	CHR	O	007	07	THE EXTRACTION OF SEMI-VOLATILE ORGANICS FROM LIQUID SAMPLES IN PREPARATION FOR GC/MS ANALYSIS BY METHODS 8270D, 8270D SIM, 1,4-DIOXANE AND 625	3510C, 3535, 625
S	CHR	O	010	05	THE EXTRACTION OF DIESEL RANGE ORGANICS AND OIL RANGE ORGANICS FROM SOLIDS	3546
S	CHR	O	011	06	THE EXTRACTION OF DIESEL RANGE ORGANICS, TENNESSEE EXTRACTABLE PETROLEUM HYDROCARBONS, AND OIL RANGE ORGANICS FROM LIQUIDS	3510C
S	CHR	O	002	06	EXTRACTION OF PESTICIDES AND PCBS FROM SOLIDS	3546
S	CHR	O	004	05	THE EXTRACTION OF PCBS FROM OILS	3580
S	CHR	O	005	04	THE EXTRACTION OF SEMI-VOLATILE ORGANIC COMPOUNDS FROM NON-AQUEOUS WASTE SAMPLES	3580
S	CHR	O	041	05	THE EXTRACTION OF SEMI-VOLATILE ORGANICS FROM SOLID SAMPLES IN PREPARATION FOR GC/MS ANALYSIS BY METHOD 8270	3546
S	CHR	O	044	4	THE EXTRACTION OF PESTICIDES/PCBS FROM NON-AQUEOUS WASTE SAMPLES	3580
S	CHR	O	045	03	THE EXTRACTION OF SEMIVOLATILES FROM WIPES	3580 (MODIFIED)
S	CHR	O	056	03	THE EXTRACTION OF EXTRACTABLE PETROLEUM RANGE HYDROCARBONS (EPH) FROM SOLIDS	3546
S	CHR	O	031	08	OIL AND GREASE WATER	1664B
S	CHR	O	043	06	THE EXTRACTION OF PESTICIDES/PCBS FROM LIQUID SAMPLES IN PREPARATION FOR GC ANALYSIS BY METHODS 8081, 8082, AND 608	3510C, 3535, 608
S	EDN	W	001	00	WASTE HANDLING AND MANAGEMENT	
S	CHR	O	032	05	N-HEXANE EXTRACTABLE MATERIAL (HEM) FOR SEDIMENT AND SOIL SAMPLES	9071B

S	GWD	F	001	001	DO	SM 4500-O -2011
S	GWD	F	002	001	pH	SM 4500 HB 2011
S	GWD	F	003	000	SPCOND	EPA 120.1 REV 4
S	GWD	F	004	001	TOTAL RESIDUAL CHLORINE	SM 4500 CL G 2011
S	CAR	F	003	01	MEASURING SPECIFIC CONDUCTIVITY IN THE FIELD	EPA 120.2, SM2510B
S	CAR	F	002	01	MEASURING DISSOLVED OXYGEN IN THE FIELD	SM 4500 O G
S	CAR	F	005	00	MEASURING pH IN THE FIELD	SM4500H
S	CAR	F	006	00	MEASURING TEMPERATURE IN THE FIELD	SM2550B
S	CAR	F	007	00	MEASURING TOTAL RESIDUAL CHLORINE IN THE FIELD	SM4500 CI G
S	CAR	F	001	00	WASTE WATER SAMPLING	
S	CAR	F	008	00	CLEAN SAMPLING FOR ULTRA TRACE METALS	EPA 1669
S	CAR	F	009	01	TURBIDITY IN THE FIELD	SM 2130
S	CAR	F	010	00	FIELD SAMPLING SOP	
S	CHR	O	033	04	DETERMINATION OF HALOACETIC ACIDS IN DRINKING WATER BY LIQUID-LIQUID EXTRACTION	552.2

S	CHR	O	019	03	THE DETERMINATION OF 1,2-DIBROMOMETHANE (EDB), 1,2-DIBROMO-3-CHLOROPROPANE, AND 1,2,3-TRICHLOROPROPANE (TCP) IN WATER BY MICROEXTRACTION	504.1
S	CHR	O	020	06	THE DETERMINATION OF 1,2-DIBROMOMETHANE (EDB) AND 1,2-DIBROMO-3-CHLOROPROPANE IN WATER BY MICROEXTRACTION	8011
S	CHR	O	047	04	THE DETERMINATION OF ORGANOCHLORINE PESTICIDES BY GAS CHROMATOGRAPHY	8081B, 608
S	CHR	O	046	05	THE DETERMINATION OF POLYCHLORINATED BIPHENYLS BY GAS CHROMATOGRAPHY	8082A, 608
S	GWD	S	001	00	CONTINGENCY AND EMERGENCY PROCEDURES PLAN	NA
S	CHR	O	021	04	THE DETERMINATION OF DIESEL RANGE/ORO/TN EPH ORGANICS BY GAS CHROMATOGRAPHY	8015C
				10	CHEMICAL HYGIENE PLAN/SAFETY MANUAL	
S	CHR	O	059	00	THE DETERMINATION OF VOLATILE ORGANICS BY SELECTIVE ION MONITORING (SIM) GAS CHROMATOGRAPHY/MASS SPECTROMETRY	8260 SIM
S	ASV	M	070	02	LOW LEVEL MERCURY	EPA 1631 E
S	CAR	L	006	01	USDA REGULATED SOILS	
S	CAR	L	009	01	MONITORING LABORATORY DEIONIZED WATER	SM 9020B
S	CHR	L	007	01	USE OF THE pH METER IN SUPPORT OF ANALYTICAL METHODOLOGY	SM 4500HB 18TH
S	CAR	L	010	00	GLASSWARE WASHING	
S	CHR	L	008	00	STORAGE BLANKS	

S	CHR	L	001	02	HANDLING AND STORAGE OF RADIOACTIVE MATERIALS	
S	EDN	WC	16	001	ENTEROCOCCI	SM 5220D
S	CHR	O	014	08	THE DETERMINATION OF SEMI-VOLATILE ORGANIC COMPOUNDS IN AQUEOUS, SOLID OR WASTE SAMPLES BY GC/MS ANALYSIS	8270D
S	CHR	O	052	03	DETERMINATION OF SEMIVOLATILE ORGANICS BY GC/MS-SIM, SELECTIVE ION MONITORING	8270 SIM
S	ASV	I	012	003	FERROUS IRON	SM 3500-FC (MODIFIED)
S	ASV	I	013	008	FLASH POINT - PENSKY MARTENS CLOSED CUP	SW-846 1010
S	ASV	I	029	006	SPECIFIC CONDUCTIVITY	EPA 120.1 REV 4
S	ASV	I	032	007	SULFIDE	SM4500 S2 D REV.2011
S	ASV	I	059	003	KJELDAHL NITROGEN IN WATER AND WASTES BY FLOW INJECTION COLORIMETRY	EPA 351.2
S	ASV	I	060	005	DETERMINATION OF PHENOLIC COMPOUNDS BY FLOW INJECTION ANALYSIS COLORIMETRY	420.4
S	ASV	I	062	04	DETERMINATION OF TOTAL PHOSPHORUS BY INJECTION ANALYSIS - LACHAT METHOD	EPA 365.1
S	CAR	WC	001	001	BIOCHEMICAL OXYGEN DEMAND (BOD)	SM 5210 B
S	CAR	WC	002	003	CHEMICAL OXYGEN DEMAND (COD) IN WATER, WASTWATERS AND INDUSTRIAL WASTES	SM 5220D
S	CAR	WC	003	001	COLOR ADMI	SM 2120 E

S	CAR	WC	004	003	HEXAVALENT CHROMIUMIN IN WATER, WASTEWATER, AND SOIL	SM 3500 CR D
S	CAR	WC	005	002	MEASUREMENT OF SOLIDS IN WATER AND WASTEWATER	SM 2540 B,C,&D
S	CAR	WC	006	05	ORTHO PHOSPHORUS	EPA 365.1 SM 4500 P E-1999
S	ASV	I	003	005	AMMONIA BY SMARTCHEM ANALYSIS, COLORIMETRY	EPA 350.1 REV. 2
S	ASV	I	035	10	TOTAL ORGANIC CARBON (TOC)	SM 5310B
S	ASV	I	058	005	ION CHROMATOGRAPHY	EPA 300.0
S	ASV	I	063	08	DETERMINATION OF TOTAL CYANIDE	SM 4500 CN E, LACHAT QUIK CHEM 10-204-00-1-X, SW 846 9010C/9012 B-2002
S	ASV	I	064	04	CHLORIDE BY LACHAT	SM 4500 CL E
S	ALL	Q	030	05	OPERATION OF DATA CHECKER	
S	ALL	Q	003	09	DOCUMENT NUMBERING	
S	CHR	O	048	03	THE DETERMINATION OF 1,4-DIOXANE IN AQUEOUS SAMPLES BY GC/MS SIM ANALYSIS UTILIZING ISOTOPE DILUTION	8270 SIM
S	CHR	O	013	04	THE DETERMINATION OF SEMI-VOLATILE ORGANIC COMPOUNDS IN AQUEOUS SAMPLES BY GC/MS	625
S	ALL	Q	009	06	LABORATORY DOCUMENTATION	
S	ASV	I	024	004	PAINT FILTER LIQUIDS TEST	9095A

S	ALL	Q	014	05	Quarterly Quality Report	
S	GWD	I	005	001	Fecal Coliform by MF	SM9222D
S	GWD	I	006	001	Fecal E Coli	SM92223B-2004
S	GWD	I	007	000	HPC	SM9215B-1994
S	GWD	I	008	001	IC	EPA 300.0 EPA9056A
S	GWD	I	010	001	pH	pH SM4500HB -2000 EPA 150 9040C 9045D
S	GWD	I	011	000	Phenol	EPA 420.1 9065
S	GWD	I	014	001	Temperature	SM2550B-2000
S	GWD	I	015	1	TOC	SM5310B-200 EPA 9060
S	GWD	I	016	001	TP	SM4500PE-1997-1999
S	ASV	M	043	03	Determination of Metals by ICP 6010C	6010C
S	GWD	I	003	000	Colilert	SM 9223 B-1997
S	ALL	Q	015	02	Review of Laboratory Management System	
S	ALL	Q	020	06	Training and Employee Orientation	

S	ALL	Q	022	04	3P PROGRAM: CONTINUOUS PROCESS IMPROVEMENT	
S	ALL	Q	028	04	USE AND OPERATION OF LAB TRACK SYSTEM	
S	GWD	I	017	00	DETERMINATION OF RESIDUAL CHLORINE	SM 4500 CL G-2000/SM4500 CL G
S	GWD	I	002	001	HAMMER MILL	GRINDER FOR TCLP PREP
S	CAR	C	006	03	REVIEW OF ANALYTICAL REQUESTS	
S	CAR	Q	011	07	INTERNAL AND EXTERNAL AUDITS	
S	ALL	Q	035	03	DATA RECALL	
S	CAR	Q	001	12	PREPARATION OF STANDARD OPERATING PROCEDURES	
S	CAR	Q	002	05	DOCUMENT CONTROL AND MANAGEMENT	
S	CAR	Q	004	08	DETERMINATION OF LIMIT OF DETECTION AND LIMIT OF QUANTITATION	
S	CAR	Q	005	04	PURCHASING OF LAB SUPPLIES	
S	CAR	Q	006	06	RECEIPT AND STORAGE OF LABORATORY SUPPLIES	
S	CAR	Q	010	06	PROFICIENCY TESTING PROGRAM	
S	CAR	Q	036	01	MANAGEMENT OF CHANGE	

S	CAR	Q	012	05	CORRECTIVE AND PREVENTATIVE ACTIONS	
S	CAR	Q	013	04	SUPPORT EQUIPMENT	
S	ASV	M	020	008	MERCURY BY COLD VAPOR FOR WATERS AND SOLIDS	245.1/7470A/7471B
S	ASV	M	038	00	DETERMINATION OF METALS BY ICP 200.7	200.7
S	EDN	I	012	003	NITRATE-N	SM4500 NO3 D
S	CAR	WC	008	001	SETTLEABLE SOLIDS	SM 2540 F
S	CHR	O	057	01	THE EXTRACTION OF EXTRACTABLE PETROLEUM RANGE HYDROCARBONS (EPH) FROM LIQUIDS	3510C, 3535
S	ASV	I	065	002	ASH	ASTM D-482-95
S	ASV	I	067	002	CHLORINE - TOX	SW-846 9076
S	ASV	I	068	002	SULFUR	SM D4239
S	ASV	I	066	002	DETERMINATION OF CALORIFIC VALUE (BTU) OR WASTE MATERIALS	ASTM D-5468-95
S	CAR	Q	021	07	SAMPLE HOMOGENIZATION AND SUB-SAMPLING	
S	CHR	O	055	00	THE DETERMINATION OF EXTRACTABLE PETROLEUM RANGE HYDROCARBONS BY GAS CHROMATOGRAPHY	MADEP EPH
S	CAR	Q	026	04	SPREADSHEET VALIDATION	

S	CAR	Q	027	04	EVALUATION AND QUALIFICATION OF VENDORS	
S	CAR	Q	031	02	ESTIMATION OF MEASUREMENT UNCERTAINTY	
S	ALL	O	038	01	PROCESSING TENTATIVELY IDENTIFIED COMPOUNDS (TICS) FOR GC/MS	
S	RAL	MB	001	000	FECAL COLIFORM SLUDGE ANALYSIS (MPN TUBE)	SM 9221C E-2006 (MPN) 24HR 503
S	CAR	Q	033	03	MCL VIOLATION REPORTING	
S	CAR	WC	009	002	THE DETERMINATION OF NITRATE-NITRITE NITROGEN BY AUTOMATED COLORIMETRY	EPA 353.2 (2.0)
S	ASV	I	016	003	HARDNESS, CALCULATION	SM2340B
S	CAR	WC	011	001	TURBIDITY	EPA 180.1 REV. 2.0
S	ALL	Q	029	03	MINTMINER DATA FILE REVIEW FOR DATA INTEGRITY MONITORING	
S	ALL	C	005	03	PACEPORT CUSTOMER FEEDBACK FORM	
S	CAR	Q	037	04	DATA REVIEW PROCESS	
S	COR	Q	034	03	ANONYMOUS HOTLINE PROCEDURE	
				17.0	QUALITY MANUAL	
S	CHR	Q	002	02	HANDLING AND REPORTING RESULTS OF DRINKING WATER SAMPLES	

S	CAR	Q	039	00	REPORTING UNACCEPTABLE SAMPLE PRESERVATION TO NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES	
S	CAR	Q	016	06	MANUAL INTEGRATION	
S	CAR	Q	018	06	MONITORING STORAGE UNITS	
S	CAR	S	002	00	AIR QUALITY MONITORING AND FUME HOOD MONITORING	
S	CHR	W	002	06	WASTE HANDLING AND MANAGEMENT	
S	ASV	I	044	003	TOTAL RESIDUAL CHLORINE	SM 4500 CL G
S	CAR	Q	025	06	STANDARD AND REAGENT MANAGEMENT AND TRACEABILITY	
S	ASV	I	002	005	ALKALINITY, TITRIMETRIC	SM 2320 B
S	CAR	W	003	04	WASTE MANAGEMENT TRAINING REQUIREMENTS	
S	ASV	S	002	004	WASTE HANDLING AND MANAGEMENT	NA
S	ASV	S	003	01	CONTINGENCY AND EMERGENCY PROCEDURES PLAN	NA
S	CHR	W	002	04	WASTE HANDLING AND MANAGEMENT	NA
S	CHR	S	10	001	CHARLOTTE CONTINGENCY & EMERGENCY PLAN	N/A
S	ALL	T	002	05	LMS SUB-LEARN CENTER SYSTEM AND TRAINING ADMINISTRATOR RESPONSIBILITIES	

S	CHR	O	024	06	The Determination of Volatile Organics by Gas Chromatography/Mass Spectrometry	624
S	RAL	BIO	001	0	Aquatic Toxicity Testing	
S	CAR	WC	16	02	Nitrate-N	HACH 10206 (TNT 835)
S	RAL	S	001	001	Raleigh Emergency Continency SOP	N/A
S	CHR	O	054	05	The Determination of Volatile Petroleum Hydrocarbons in Water and Soil	MADEP VPH
S	CAR	WC	18	00	Determination of Nitrite as Nitrogen	SM 4500 NO2B-200/2011
S	RAL	WC	001	00	Determination of Total Chlorine (TRC)	TNT (866/867)
S	CHR	O	040	05	The Determination of Gasoline Range Organics in Water and Soil	5030B, 8015C
S	CHR	O	023	12	The Determination of Volatile Organics by Gas Chromatography/Mass Spectrometry	8260B
S	CAR	Q	032	02	Control Chart Generation and Trend Analysis	
S	CHR	O	053	04	The Determination of Volatile Organics by Gas Chromatography/Mass Spectrometry	6200B 20thED
S	ALL	S	001	04	Hazard Assessments	
S	CAR	WC	007	001	pH	SM 4500 / SM 9045B
S	EDN	WC	15	001	Nitrite as Nitrogen	SM 4500-NO2 B

ATTACHMENT VI- LABORATORY CERTIFICATION LIST
SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

Asheville

Analyte	Method	Program	VA VELAC ID: 460222	NC DW Lab ID: 37712	NC Lab ID: 40	SC Lab ID: 99030001	FL TNI Lab ID: E87648	WV Lab ID: 356	GA*
Nitrate/Nitrite	EPA 353.2 (as LACHAT 10-107-04-1-A)	Drinking Water	C						
Nitrite as N	EPA 353.2 (as LACHAT 10-107-04-1-A)	Drinking Water	C	C			C		
Nitrate as N	EPA 353.2 (as LACHAT 10-107-04-1-A)	Drinking Water	C	C					
Alkalinity as CaCO3	SM 2320 B – 1997	Drinking Water		C			C		
TOC	SM 5310 B	Drinking Water							
Coliform	9223 B Colilert	Drinking Water	C	C					
E.coli	9223B Colilert	Drinking Water	C	C					
Copper	EPA 200.5	Drinking Water							
Lead	EPA 200.5	Drinking Water							
Alkalinity	SM 2320 B – 1997	Non- Potable Water	C		C		C	C	
Alkalinity	SM 2320 B-2011	Non- Potable Water				C			
Ammonia as N	EPA 350.1 (as LACHAT 10-107-06-1-C)	Non- Potable Water	C		C	C	C	C	
BOD	SM 5210 B - 2001	Non- Potable Water	C				C		
BOD	SM 5210 B - 2011	Non- Potable Water			C	C			
CBOD	SM 5210 B – 2001	Non- Potable Water	C				C		
CBOD	SM 5210 B - 2011	Non- Potable Water			C				
Chloride	SM4500Cl E – 1997	Non- Potable Water	C		C		C		
Chloride	SM 4500-CL-E-2011	Non- Potable Water				C		C	
Chlorine, Residual	SM 4500 Cl G – 2000	Non- Potable Water			C				
COD	SM 5220 D – 1997	Non- Potable Water	C				C		

COD	SM 5220 D-2011	Non- Potable Water			C	C			
Conductivity	EPA 120.1	Non- Potable Water	C		C	C	C		
Conductivity	EPA 9050A	Non- Potable Water			C	C			
Cyanide	SM 4500CN E – 1999	Non- Potable Water	C		C	C	C	C	
Cyanide	SM 4500-CN C-2011	Non- Potable Water				C			
Cyanide	SM 4500-CN E-2011	Non- Potable Water				C		C	
Cyanide	EPA 9012B	Non- Potable Water	C		C	C			
Cyanide	LACHAT 10-204-00-1-X	Non- Potable Water	C		C	C	C	C	
Dissolved Oxygen	SM 4500O G – 2001	Non- Potable Water					C		
Dissolved Oxygen	SM 4500-O G-2011	Non- Potable Water			C	C			
Fecal Coliform	SM 9222D (MF) – 1997	Non- Potable Water			C				
Fecal Coliform	Colilert®-18	Non- Potable Water			C				
Flash Point	EPA 1010 A	Non- Potable Water	C		C		C		
Fluoride	EPA 300.0 - 1993 Rev 2.1	Non- Potable Water	C		C	C	C		
Free Liquids	EPA 9095 B (2004)	Non- Potable Water	C		C				
Hardness, Total	SM 2340 B – 1997	Non- Potable Water	C		C		C		
Hardness, Total	SM 2340 B-2011	Non- Potable Water				C			
Hexavalent Chromium (Cr 6+)	SM 3500-CR B-2009	Non- Potable Water	C		C		C		
Hexavalent Chromium (Cr 6+)	SM 3500-CR B-2011	Non- Potable Water			C	C		C	
Hexavalent Chromium (Cr 6+)	EPA 7196 A (1994)	Non- Potable Water	C		C		C	C	
Mercury	EPA 7470 A (1994)	Non- Potable Water	C		C	C	C	C	
Mercury	EPA 7471 B	Non- Potable Water			C				
Mercury	EPA 245.1 Rev 3 (1994)	Non- Potable Water	C		C	C	C	C	
Mercury	EPA 1631	Non- Potable Water	C		C	C	C		
Metals	EPA 200.7 - 1994 Rev 4.4	Non- Potable Water	C		C	C	C	C	
Metals	EPA 6010 C (2/07)	Non- Potable Water	C		C		C	C	
Metals, Total	EPA 3005A	Non- Potable Water	C						
Metals, Total	EPA 3010A	Non- Potable Water	C					C	
Nitrate as N	EPA 353.2 (as LACHAT 10-107-04-1-A)	Non- Potable Water	C		C	C	C	C	
Nitrate/Nitrite as N	EPA 353.2 (as LACHAT 10-107-04-1-A)	Non- Potable Water	C		C	C	C	C	
Nitrite as N	EPA 353.2 (as LACHAT 10-107-04-1-A)	Non- Potable Water	C		C	C	C	C	
Orthophosphate as P	EPA 365.1	Non- Potable Water	C		C	C			
Orthophosphate as P	SM4500 P E 1999	Non- Potable Water	C		C	C			
Paint Filter Liquids Test	EPA 9095 B	Non- Potable Water			C		C		

pH	EPA 9040 C	Non- Potable Water	C		C		C		
pH	SM 4500 H B – 2000	Non- Potable Water			C	C	C	C	
pH	SM 4500-H B - 2011	Non- Potable Water				C			
pH	EPA 9045 D	Non- Potable Water			C				
Phenol	EPA 420.4 (as LACHAT 10-210-00-1-X)	Non- Potable Water	C		C	C	C		
Phenol	EPA 9065	Non- Potable Water			C	C			
Phosphorus, Total	EPA 365.1 (as LACHAT 10-115-01-1-E)	Non- Potable Water	C		C	C	C	C	
Residue, Settleable Soids	SM 2540 F – 1997	Non- Potable Water	C		C				
Residue, Settleable Soids	SM 2540 F - 2011	Non- Potable Water				C			
Residue, Total Dissolved Solids	SM 2540 C – 1997	Non- Potable Water	C		C		C		
Residue, Total Dissolved Solids	SM 2540 C - 2011	Non- Potable Water				C		C	
Residue, Total Solids	SM 2540 B – 1997	Non- Potable Water	C		C		C		
Residue, Total Solids	SM 2540 B – 2011	Non- Potable Water				C			
Residue, Total Suspended Solids	SM 2540 D – 1997	Non- Potable Water	C		C		C		
Residue, Total Suspended Solids	SM 2540 D - 2011	Non- Potable Water				C		C	
Residue, Volatile Solids	EPA 160.4 (9/86)	Non- Potable Water	C			C	C		
Sulfate	EPA 300.0 - 1993 Rev 2.1	Non- Potable Water	C		C	C	C	C	
Sulfide	SM4500 S2 D – 2000	Non- Potable Water	C		C		C		
Sulfide	SM4500 S2 B – 2011	Non- Potable Water				C			
TKN - Total Kjeldahl Nitrogen	EPA 351.2 (as LACHAT 10-107-06-2-D)	Non- Potable Water	C		C	C	C	C	
TOC	SM 5310 B – 2000	Non- Potable Water	C				C		
TOC	SM 5310 B - 2011	Non- Potable Water			C	C			
Turbidity	EPA 180.1 Rev 2 (1993)	Non- Potable Water	C		C	C	C		
Turbidity	SM 2130 B	Non- Potable Water					C		
Hexavalent Chromium (Cr 6+)	EPA 7196 A (1994)	Solid and Chemical Materials						C	
pH	EPA 9040 C	Solid and Chemical Materials							
pH	EPA 9045 D	Solid and Chemical Materials	C		C	C	C		
Free Liquids	SW-846 9095 B	Solid and Chemical Materials	C			C			
Flash Point	EPA 1010 A	Solid and Chemical Materials	C			C	C		
Point Filter Liquid Test	EPA 9095 B	Solid and Chemical Materials					C		

Total Phosphorus	EPA 365.1	Solid and Chemical Materials	C						
TCLP	EPA 1311 - 1992	Solid and Chemical Materials	C		C	C	C		
SPLP	EPA 1312 - 1994	Solid and Chemical Materials	C		C		C		
Metals Digestion	EPA 3010 A - 1992	Solid and Chemical Materials	C			C			
Metals Digestion	EPA 3050 B - 1996	Solid and Chemical Materials	C			C		C	
Metals	EPA 6010 C - (2/07)	Solid and Chemical Materials	C		C	C	C	C	
Mercury	EPA 7471 B - (2/07)	Solid and Chemical Materials	C		C	C	C	C	

* Georgia: Approved for all NELAP accredited non-potable water and solid and chemical materials methods.

ATTACHMENT VI- LABORATORY CERTIFICATION LIST
SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

Charlotte

Analyte	Method	Program	VA VELAC ID: 460221	NC Lab ID: 12	NC DW Lab ID: 37706	NC Field ID: 5342	SC Lab ID: 99006001	WV Lab ID: 357	FL TNI Lab ID: E87627	GA *	KY $^{\#}$ UST ID: 84
EDB, DBCP, and TCP	EPA 504.1 Rev 1.1 (1995)	Drinking Water	C	C					C		
Trihalomethanes	EPA 524.2 Rev 4.1 (1995)	Drinking Water	C		C		C		C		
Haloacetic Acids	EPA 552.2 Rev 1 (1995)	Drinking Water	C		C		C		C		
Heterotrophic Plate Count	SIMPLATE	Drinking Water			C						
Escherichia coli	SM 9223B (Colilert)	Drinking Water			C						
Total Coliform	SM 9223B (Colilert)	Drinking Water			C						
Oil and Grease	EPA 1664B (2010)	Non-Potable Water	C	C			C	C	C		
Total Petroleum Hydrocarbons	EPA 1664B (2010)	Non-Potable Water	C	C			C	C	C		
Liquid-Liquid Extraction	EPA 3510C (1996)	Non-Potable Water	C	N/A			C	C	N/A		
Purge and Trap	EPA 5030B (1996)	Non-Potable Water	C	N/A			C	C	N/A		
Organochlorine Pesticides and PCBs	EPA 608	Non-Potable Water	C	C			C		C		
Purgeables	EPA 624	Non-Potable Water	C	C			C		C		
Base/Neutrals and Acids	EPA 625 (1982)	Non-Potable Water	C	C			C		C		
EDB and DBCP	EPA 8011 (7/92)	Non-Potable Water	C	C			C	C	C		
Gasoline Range Organics	EPA 8015C (2000)	Non-Potable Water	C	C				C	C		
Diesel Range Organics	EPA 8015C (2000)	Non-Potable Water	C	C				C	C		
Oil Range Organics	EPA 8015C (2000)	Non-Potable Water	C	C							
Organochlorine Pesticides	EPA 8081B (2/07)	Non-Potable Water	C	C			C	C	C		

Charlotte

Analyte	Method	Program	VA VELAC ID: 460221	NC Lab ID: 12	NC DW Lab ID: 37706	NC Field ID: 5342	SC Lab ID: 99006001	WV Lab ID: 357	FL TNI Lab ID: E87627	GA *	KY # UST ID: 84
Polychlorinated Biphenyls	EPA 8082A (2/07)	Non-Potable Water	C	C			C	C	C		
Volatile Organic Compounds	EPA 8260B (1996)	Non-Potable Water	C	C			C	C	C		
Volatile Organic Compounds	EPA 8260B SIM (1996)	Non-Potable Water	C	C			C				
Volatile Organic Compounds	EPA 8260B-OXY	Non-Potable Water	C	C			C	C	C		
Semivolatile Organic Compounds	EPA 8270D (2/07)	Non-Potable Water	C	C			C	C	C		
Semivolatile Organic Compounds	EPA 8270D SIM (2/07)	Non-Potable Water	C	C			C	C	C		
Extractable Petroleum Hydrocarbons	MADEP-EPH	Non-Potable Water		C							
Volatile Petroleum Hydrocarbons	MADEP-VPH	Non-Potable Water		C							
Volatile Organic Compounds	SM 6200 B 20th ED (1998)	Non-Potable Water		C							
Total Coliform	SM 9222D (MF)	Non-Potable Water		C							
TCLP	EPA 1311 (1992)	Solid and Chemical Materials	C	C			C	C	C		
SPLP	EPA 1312 (1994)	Solid and Chemical Materials	C	C							
Liquid-Liquid Extraction	EPA 3510C (1996)	Solid and Chemical Materials	C	N/A			C	C	N/A		
Microwave Extraction	EPA 3546 (11/00)	Solid and Chemical Materials	C	N/A			C	C	N/A		
Waste Dilution	EPA 3580A (1992)	Solid and Chemical Materials	C	N/A			C	C	N/A		
Purge and Trap	EPA 5030B (1996)	Solid and Chemical	C	N/A			C	C	N/A		

Charlotte

Analyte	Method	Program	VA VELAC ID: 460221	NC Lab ID: 12	NC DW Lab ID: 37706	NC Field ID: 5342	SC Lab ID: 99006001	WV Lab ID: 357	FL TNI Lab ID: E87627	GA *	KY # UST ID: 84
		Materials									
Closed System Purge and Trap	EPA 5035 (1996)	Solid and Chemical Materials	C	N/A			C	C	N/A		
Gasoline Range Organics	EPA 8015C (2000)	Solid and Chemical Materials	C	C				C	C		
Diesel Range Organics	EPA 8015C (2000)	Solid and Chemical Materials	C	C				C	C		
Oil Range Organics	EPA 8015C (2000)	Solid and Chemical Materials	C								
Organochlorine Pesticides	EPA 8081B (2/07)	Solid and Chemical Materials	C	C			C	C	C		
Polychlorinated Biphenyls	EPA 8082A (2/07)	Solid and Chemical Materials	C	C			C	C	C		
Volatile Organic Compounds	EPA 8260B (1996)	Solid and Chemical Materials	C	C			C	C	C		
Volatile Organic Compounds	EPA 8260B SIM (1996)	Solid and Chemical Materials	C								
Semivolatile Organic Compounds	EPA 8270D (2/07)	Solid and Chemical Materials	C	C			C	C	C		
Semivolatile Organic Compounds	EPA 8270D SIM (2/07)	Solid and Chemical Materials	C				C	C			
Oil and Grease	EPA 9071B (4/98)	Solid and Chemical Materials	C	C				C	C		
Non-polar Hexane Extracable Material	EPA 9071B (4/98)	Solid and Chemical Materials	C	C				C	C		

Charlotte

Analyte	Method	Program	VA VELAC ID: 460221	NC Lab ID: 12	NC DW Lab ID: 37706	NC Field ID: 5342	SC Lab ID: 99006001	WV Lab ID: 357	FL TNI Lab ID: E87627	GA *	KY [#] UST ID: 84
Extractable Petroleum Hydrocarbons	MADEP-EPH	Solid and Chemical Materials		C							
Volatile Petroleum Hydrocarbons	MADEP-VPH	Solid and Chemical Materials		C							
Conductivity	EPA 120.1	Field				C					
Conductivity	SM 2510B (18th)	Field				C	C				
Temperature	SM 2550B (18th)	Field				C	C				
Total Residual Chlorine	SM 4500 Cl G (18th)	Field				C					
pH	SM 4500 H B (18th)	Field				C	C				
Dissolved Oxygen	SM 4500 O G (18th)	Field				C	C				

* Georgia: Approved for all NELAP accredited non-potable water and solid and chemical materials methods.

[#] Kentucky: Certified for analytical testing related to Kentucky's Underground Storage Tank Program.

ATTACHMENT VI- LABORATORY CERTIFICATION LIST
SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

Eden

Analyte	Method	Program	VA VELAC ID: 460025	NC DW Lab ID: 37738	NC Lab ID: 633
Nitrate as N	HACH 10206	Drinking Water	C	C	
Nitrite as N	SM 4500NO2-B – 2000	Drinking Water	C	C	
Color	SM 2120 B - 2001	Drinking Water	C	C	
Turbidity	SM 2130 B - 2001	Drinking Water	C	C	
Total Coliforms / MPN	SM 9223 Colilert MPN	Drinking Water	C	C	
Total Coliforms / P/A	SM 9223 Colilert P/A	Drinking Water	C	C	
Escherichia Coliform / MPN	SM 9223 Colilert MPN	Drinking Water	C	C	
Escherichia Coliform / P/A	SM 9223 Colilert P/A	Drinking Water	C	C	
Escherichia Coliform / MPN	Colilert	Non- Potable Water	C		C
Escherichia Coliform / MPN	SM 9223 B – 2004 MPN	Non- Potable Water			C
Enterococci	Enterolert	Non- Potable Water	C		C
BOD	SM 5210 B - 2001	Non- Potable Water	C		C
CBOD	SM 5210 B - 2001	Non- Potable Water	C		C
Color, ADMI	SM 2120 E – on-line	Non- Potable Water			C
Color, PC	SM 2120 B – 2001	Non- Potable Water	C		C
Dissolved Oxygen	SM 4500O G – 2001	Non- Potable Water			C
Hexavalent Chromium (Cr 6+)	SM 3500 Cr- B – 2009	Non- Potable Water	C		C

Hexavalent Chromium (Cr 6+)	EPA 7196 A (1994)	Non- Potable Water	C		C
Fecal Coliform	SM 9222D (MF) – 1997	Non- Potable Water	C		C
Fecal Coliform	Colilert®18	Non- Potable Water			C
Nitrate as N	HACH 10206	Non- Potable Water	C		C
Nitrite as N	SM 4500-NO2 B – 2000	Non- Potable Water			C
pH	SM 4500 H+B – 2000	Non- Potable Water			C
pH	EPA 9040 C	Non- Potable Water	C		C
Residue, Settleable Solids	SM 2540 F – 1997	Non- Potable Water	C		C
Residue, Total Suspended Solids	SM 2540 D – 1997	Non- Potable Water	C		C
Turbidity	SM 2130 B – 2001	Non- Potable Water			C

ATTACHMENT VI- LABORATORY CERTIFICATION LIST
SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

Greenwood

Analyte	Method	Program	VA VELAC ID: 460250	SC Lab ID: 24110	NC Lab ID: 25
Nitrate as N	EPA 300.0	Drinking Water		C	
Nitrite as N	EPA 300.0	Drinking Water		C	
Chloride	EPA 300.0	Drinking Water		C	
Fluoride	EPA 300.0	Drinking Water		C	
Bromide	EPA 300.0	Drinking Water		C	
Sulfate	EPA 300.0	Drinking Water		C	
HPC	SM 9215 B	Drinking Water		C	
Total Coliforms / P/A	SM 9223 Colilert P/A	Drinking Water		C	
TOC	SM 5310 B (20th)	Drinking Water		C	
DOC	SM 5310 B (20th)	Drinking Water		C	
Total Phosphorus	SM 4500 P E (20th)	Drinking Water		C	
Escherichia Coliform / P/A	SM 9223 Colilert P/A	Drinking Water		C	
Nitrate as N	EPA 300.0 & EPA 9056A	Non- Potable Water	C	C	C
Nitrite as N	EPA 300.0 & EPA 9056A	Non- Potable Water	C	C	C
Chloride	EPA 300.0 & EPA 9056A	Non- Potable Water	C	C	C
Fluoride	EPA 300.0 & EPA 9056A	Non- Potable Water	C	C	C

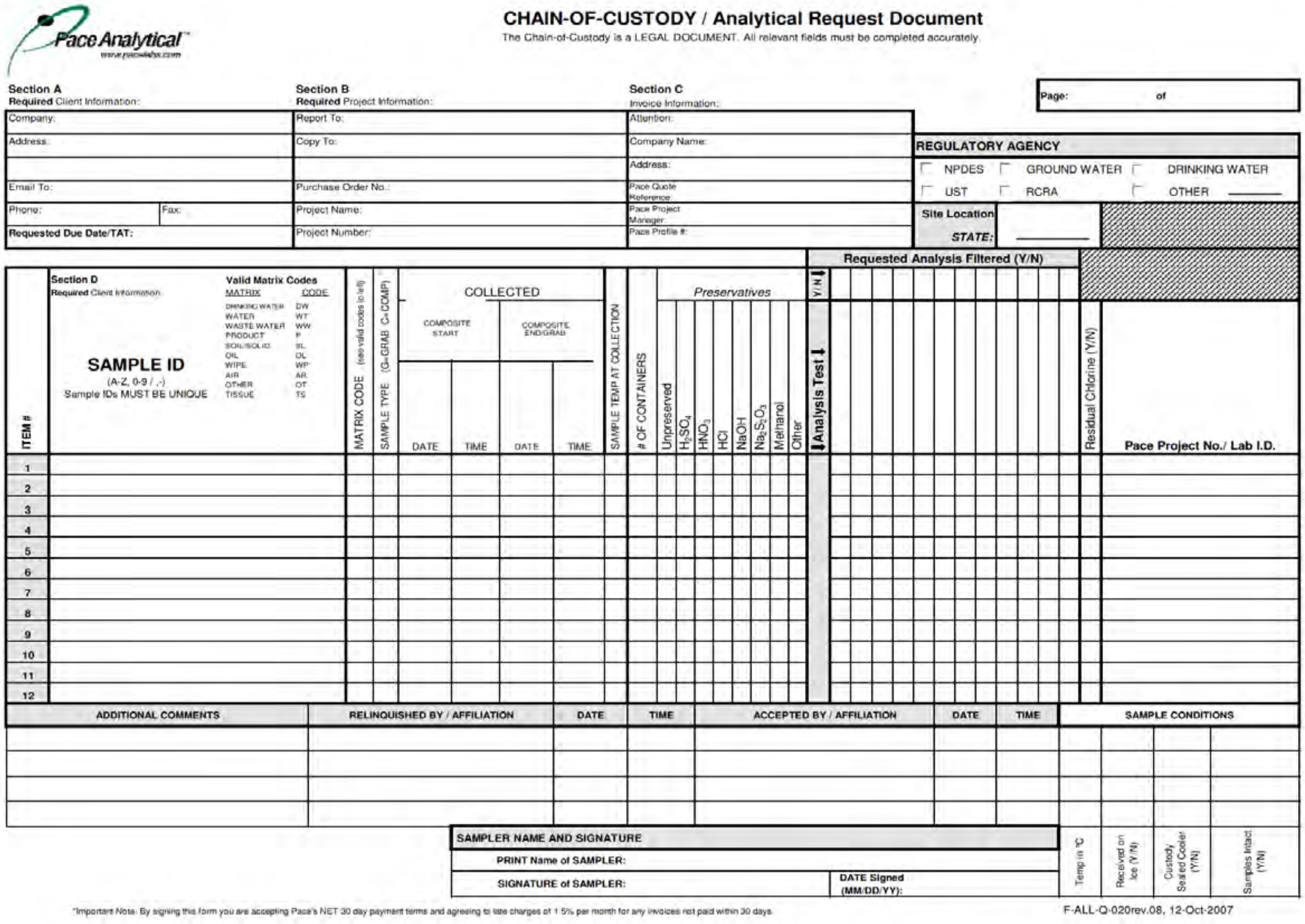
Sulfate	EPA 300.0 & EPA 9056A	Non- Potable Water	C	C	C
TOC	SM 5310 B – 2000 & EPA 9060A	Non- Potable Water	C	C	C
Escherichia Coliform / MPN	SM 9223 B – 2022 MPN	Non- Potable Water		C	
pH	EPA 9040C & 9045D	Solid Chemical Waste		C	
Phenol	EPA 9065	Solid Chemical Waste		C	
Fecal Coliform	SM 9222D (MF) – 2011	Non- Potable Water		C	
Fecal Coliform	Colilert®18	Non- Potable Water		C	
Conductivity	EPA 9050 A	Solid Chemical Waste		C	
Nitrate as N	EPA 9056A	Solid Chemical Waste	C	C	C
Nitrite as N	EPA 9056A	Solid Chemical Waste	C	C	C
Chloride	EPA 9056A	Solid Chemical Waste	C	C	C
Fluoride	EPA 9056A	Solid Chemical Waste	C	C	C
Sulfate	EPA 9056A	Solid Chemical Waste	C	C	C
Sulfate	SM 450 P E - 2001	Solid Chemical Waste		C	C

ATTACHMENT VI- LABORATORY CERTIFICATION LIST
SCOPE AND APPLICATION CERTIFICATES ARE MAINTAINED AND FILED IN THE LOCAL QUALITY DEPARTMENT

Raleigh

Analyte	Method	Program	NC DW Lab ID: 37731	NC Lab ID: 67	NC Bioassay Lab ID: 016
Heterotrophic Bacteria (HPC)	SIMPLATE	Drinking Water	C		
Coliform	Colisure	Drinking Water	C		
Coliform	SM 9223B Colilert/Colilert18	Drinking Water	C		
E. coli	Colisure	Drinking Water	C		
E. coli	SM 9223B Colilert/Colilert18	Drinking Water	C		
COD	EPA 410.4	Non-Potable Water		C	
Fecal Coliform	SM 9222D (MF) – 1997	Non-Potable Water		C	
Fecal Coliform	SM 9221C E (MPN) 24hr 503	Non-Potable Water		C	
Escherichia coli	Colilert (MPN)	Non-Potable Water		C	
Residue, Total Suspended Solids	SM 2540 D – 1997	Non-Potable Water		C	
Bioassay Category		**Parameter**			
Acute Toxicity Testing / Vertebrate		*Pimephales promelas*			C
Chronic Toxicity Testing / Invertebrate		*Ceriodaphnia dubia*			C
Chronic Toxicity Testing / Vertebrate		*Pimephales promelas*			C

ATTACHMENT VII- PACE CHAIN-OF-CUSTODY



Pace Analytical™
www.pacelabs.com

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page: of

Section A
Required Client Information:

Company:
Address:
Email To:
Phone:
Fax:
Requested Due Date/TAT:

Section B
Required Project Information:

Report To:
Copy To:
Purchase Order No.:
Project Name:
Project Number:

Section C
Invoice Information:

Attention:
Company Name:
Address:
Pace Quote Reference:
Pace Project Manager:
Pace Profile #:

REGULATORY AGENCY

☐ NPDES ☐ GROUND WATER ☐ DRINKING WATER
☐ UST ☐ RCRA ☐ OTHER ______

Site Location
STATE: ______

Section D
Required Client Information

Valid Matrix Codes

MATRIX	CODE
DRINKING WATER	DW
WATER	WT
WASTE WATER	WW
PRODUCT	P
SOIL/SOLID	SL
OIL	OL
WIPE	WP
AIR	AR
OTHER	OT
TISSUE	TS

ITEM #	SAMPLE ID (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED COMPOSITE START		COMPOSITE END/GRAB		SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	Preservatives								Requested Analysis Filtered (Y/N)													Residual Chlorine (Y/N)	Pace Project No./ Lab I.D.
				DATE	TIME	DATE	TIME			Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	Y/N ↓ Analysis Test ↓														
1																																
2																																
3																																
4																																
5																																
6																																
7																																
8																																
9																																
10																																
11																																
12																																

ADDITIONAL COMMENTS	RELINQUISHED BY / AFFILIATION	DATE	TIME	ACCEPTED BY / AFFILIATION	DATE	TIME	SAMPLE CONDITIONS			
							Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER:
SIGNATURE of SAMPLER:
DATE Signed (MM/DD/YY):

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

F-ALL-Q-020rev.08, 12-Oct-2007

ATTACHMENT VIII- METHOD HOLD TIME, CONTAINER AND PRESERVATION GUIDE

THE HOLDING TIME INDICATED IN THE CHART BELOW IS THE MAXIMUM ALLOWABLE TIME FROM COLLECTION TO EXTRACTION AND/OR ANALYSIS PER THE ANALYTICAL METHOD. FOR METHODS THAT REQUIRE PROCESSING PRIOR TO ANALYSIS, THE HOLDING TIME IS DESIGNATED AS 'PREPARATION HOLDING TIME/ANALYSIS HOLDING TIME'.

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Acid Base Accounting	Sobek	Solid	Plastic/Glass	None	N/A
Acidity	SM2310B	Water	Plastic/Glass	$\leq 6^{o}C$	14 Days
Acid Volatile Sulfide	Draft EPA 1629	Solid	8oz Glass	$\leq 6^{o}C$	14 Days
Actinides	HASL-300	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Actinides	HASL-300	Solid	Plastic/Glass	None	180 Days
Alkalinity	SM2320B/310.2	Water	Plastic/Glass	$\leq 6^{o}C$	14 Days
Alkylated PAHs		Water	1L Amber Glass	$\leq 6^{o}C$; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved
Alkylated PAHs		Solid	8oz Glass	$\leq 10^{o}C$	1 Year/40 Days
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4 , bromate, chlorite, chlorate)	300.0/300.1/SM4110B	Water	Plastic/Glass	$\leq 6^{o}C$; EDA if bromate or chlorite run	All analytes 28 days except: NO_2, NO_3, o-Phos (48 Hours); chlorite (immediately for 300.0; 14 Days for 300.1). NO_2/NO_3 combo 28 days.
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4 , bromate, chlorite, chlorate)	300.0	Solid	Plastic/Glass	$\leq 6^{o}C$	All analytes 28 days except: NO_2, NO_3, o-Phos (48 hours); chlorite (immediately). NO_2/NO_3 combo 28 days.
Anions (Br, Cl, F, NO_2, NO_3, o-Phos, SO_4	9056	Water/ Solid	Plastic/Glass	$\leq 6^{o}C$	28 days
Aromatic and Halogenated Volatiles (see note 1)	8021	Solid	5035 vial kit	See note 1	14 days
Aromatic and Halogenated Volatiles	602/8021	Water	40mL vials	pH<2 HCl; $\leq 6^{o}C$; $Na_2S_2O_3$ if Cl present	14 Days (7 Days for aromatics if unpreserved)

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Asbestos	EPA 600/R-93/116	Solid	Plastic/Glass; bulk- 2" square; popcorn ceiling-2tbsp; soil-4oz	None (handling must be done in HEPA filtered fume hood; drying may be required)	N/A
Bacteria, Total Plate Count	SM9221D	Water	Plastic/WK	≤ 6°C; $Na_2S_2O_3$	24 Hours
Base/Neutrals and Acids	8270	Solid	8oz Glass	≤ 6°C	14/40 Days
Base/Neutrals and Acids	625/8270	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Base/Neutrals, Acids & Pesticides	525.2	Water	1L Amber Glass	pH<2 HCl; ≤ 6°C; Na sulfite if Cl present	14/30 Days
Biomarkers		Water	≤ 6°C; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved	≤ 6°C; pH<2 1:1 HCl (optional)
Biomarkers		Solid	≤ 10°C	1 Year/40 Days	≤ 10°C
BOD/cBOD	SM5210B	Water	Plastic/Glass	≤ 6°C	48 hours
Boiling Range Distribution of Petroleum Fractions	ASTM D2887-98	Product	10mL glass vials	≤ 6°C	N/A
BTEX/Total Hydrocarbons	TO-3	Air	Summa Canister	None	14 Days
BTEX/Total Hydrocarbons	TO-3	Air	Tedlar Bag or equivalent	None	48 Hours
Carbamates	531.1	Water	Glass	$Na_2S_2O_3$, Monochloroacetic acid pH <3; ≤ 6°C	28 Days
Carbamates	8318	Water	Glass	Monochloroacetic acid pH 4-5; ≤ 6°C	7/40 Days
Carbamates	8318	Solid	Glass	≤ 6°C	7/40 Days
Carbon Specific Isoptope Analysis (CSIA)	AM24	Water	40mL clear VOA vial with TLS	≤ 6°C, trisodium phosphate or HCl	N/A
Cation/Anion Balance	SM1030E	Water	Plastic/Glass	None	None
Cation Exchange	9081	Solid	8oz Glass	None	unknown
Cations (Ferrous Iron, Ferric Iron, Divalent Manganese)	7199 modified	Water	40mL clear VOA vials with mylar septum	≤ 6°C; HCl	48 Hours
Chloride	SM4500Cl-C,E	Water	Plastic/Glass	None	28 Days
Chlorinated Hydrocarbons in Vapor	AM4.02	Vapor	20cc vapor vial with flat	None	N/A

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
			septum		
Chlorine, Residual	SM4500Cl-D,E,G/330.5/Hach 8167	Water	Plastic/Glass	None	15 minutes
Chlorophyll	SM10200H	Water	Opaque bottle or aluminum foil	≤ 6°C	48 Hours to filtration
COD	SM5220C, D/410.4/Hach 8000	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Coliform, Fecal	SM9222D	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Fecal	SM9222D	Solid	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	24 Hours
Coliform, Fecal	SM9221E	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Fecal	SM9221E	Solid	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	24 Hours
Coliform, Total	SM9222B	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Total	SM9221B	Solid	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Total, Fecal and E. coli	Colilert/ Quanti-tray	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Coliform, Total and E. coli	SM9223B	Drinking Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	30 Hours
Color	SM2120B,E	Water	Covered Plastic/Acid Washed Amber Glass	≤ 6°C	24 Hours
Condensable Particulate Emissions	EPA 202	Air	Solutions	None	180 Days
Cyanide, Reactive	SW846 chap.7	Water	Plastic/Glass	None	28 Days
Cyanide, Reactive	SW846 chap.7	Solid	Plastic/Glass	None	28 Days
Cyanide, Total and Amenable	SM4500CN-A,B,C,D,E,G,I,N/9010/ 9012/335.4	Water	Plastic/Glass	pH≥12 NaOH; ≤ 6°C; ascorbic acid if Cl present	14 Days (24 Hours if sulfide present- applies to SM4500CN only)
Diesel Range Organics-Alaska DRO	AK102	Solid	8oz Glass	≤ 6°C	14/40 Days
Diesel Range Organics-Alaska DRO	AK102	Water	1L Glass	pH<2 HCl; ≤ 6°C	14/40 Days
Diesel Range Organics-	8015	Solid	8oz Glass Jar	≤ 6°C	14/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
TPH DRO					
Diesel Range Organics-TPH DRO	8015	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Diesel Range Organics-TPH DRO	8015	Tissue	1L Amber Glass	≤ - 10°C	1 Year if frozen/40 Days
Diesel Range Organics-TPH DRO	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	≤ 6°C but above freezing	28 Days
Diesel Range Organics-NwTPH-Dx	Nw-TPH-Dx	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Diesel Range Organics-NwTPH-Dx	Nw-TPH-Dx	Water	1L Amber Glass	pH <2 HCl; ≤ 6°C	14/40 Days; 7 Days from collection to extraction if unpreserved
Diesel Range Organics-Wisconsin DRO	WI MOD DRO	Solid	Tared 4oz Glass Jar	≤ 6°C	10/47 Days
Diesel Range Organics-Wisconsin DRO	WI MOD DRO	Water	1L Amber Glass	≤ 6°C; pH <2 HCl	14/40 Days
Dioxins and Furans	1613B	Solid	8oz Glass	≤ 6°C	1 year
Dioxins and Furans	1613B	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	1 year
Dioxins and Furans	1613B	Fish/ Tissue	Aluminum foil	≤ 6°C	1 year
Dioxins and Furans	8290	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	30/45 Days
Dioxins and Furans	8290	Solid	8oz Glass	≤ 6°C	30/45 Days
Dioxins and Furans	8290	Fish/ Tissue	Not specified	< -10°C	30/45 Days
Dioxins and Furans	TO-9	Air	PUF	None	30/45 Days
Diquat/Paraquat	549.2	Water	Amber Plastic	≤ 6°C; $Na_2S_2O_3$	7/21 Days
EDB/DBCP (8011) EDB/DBCP/1,2,3-TCP (504.1)	504.1/8011	Water	40mL vials	≤ 6°C; $Na_2S_2O_3$ if Cl present	14 Days
Endothall	548.1	Water	Amber Glass	≤ 6°C; $Na_2S_2O_3$	7/14 Days
Enterococci	EPA 1600	Water	100mL Plastic	≤ 10°C	8 Hours
Enterococci	Enterolert	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Explosives	8330/8332	Water	1L Amber Glass	≤ 6°C	7/40 Days
Explosives	8330/8332	Solid	8oz Glass Jar	≤ 6°C	14/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	MA-EPH	Water	1L Amber Glass	pH<2 HCl; ≤ 6°C	14/40 Days
Extractable Petroleum Hydrocarbons (aliphatic and aromatic)	MA-EPH	Solid	4oz Glass Jar	≤ 6°C	7/40 Days
Fecal Streptococci	SM9230B	Water	100mL Plastic	≤ 10°C; $Na_2S_2O_3$	8 Hours
Ferrous Iron	SN3500Fe-D; Hach 8146	Water	Glass	None	Immediate
Flashpoint/Ignitability	1010	Liquid	Plastic/Glass	None	28 Days
Florida PRO	FL PRO DEP (11/1/95)	Liquid	Glass, PTFE lined cap	≤ 6°C; pH <2 H_2SO_4 or HCl	7/40 Days
Fluoride	SM4500Fl-C,D	Water	Plastic	None	28 Days
Gamma Emitting Radionuclides	901.1	Water	Plastic/Glass	pH<2 HNO_3	180 days
Gasoline Range Organics	8015	Water	40mL vials	pH<2 HCl	14 Days
Gasoline Range Organics	8015	Solid	5035 vial kit	See note 1	14 days
Gasoline Range Organics (C3-C10)	8260B modified	Water	40mL vials	≤ 6°C; HCl	14 Days
Gasoline Range Organics (C3-C10)	8260B modified	Solid	4oz Glass Jar	≤ 6°C	14 Days
Gasoline Range Organics- Alaska GRO	AK101	Solid	5035 vial kit	See 5035 note*	28 Days if GRO only (14 Days with BTEX)
Gasoline Range Organics- Alaska GRO	AK101	Water	40mL vials	pH<2 HCl; ≤ 6°C	14 Days
Gasoline Range Organics- NwTPH-Gx	Nw-TPH-Gx	Water	40mL vials	pH<2 HCl; ≤ 6°C	7 Days unpreserved; 14 Days preserved
Gasoline Range Organics- NwTPH-Gx	Nw-TPH-Gx	Solid	40mL vials	≤ 6°C; packed jars with no headspace	14 Days
Gasoline Range Organics- Wisconsin GRO	WI MOD GRO	Water	40mL vials	pH<2 HCl; ≤ 6°C	14 Days
Gasoline Range Organics- Wisconsin GRO	WI MOD GRO	Solid	40mL MeOH vials	≤ 6°C in MeOH	21 Days
Glyphosate	547	Water	Glass	≤ 6°C; $Na_2S_2O_3$	14 Days (18 Months frozen)
Grain Size	ASTM D422	Solid	Not specified	Ambient	N/A
Gross Alpha (NJ 48Hr Method)	NJAC 7:18-6	Water	Plastic/Glass	pH<2 HNO_3	48 Hrs
Gross Alpha and Gross	9310/900.0	Water	Plastic/Glass	pH<2 HNO_3	180 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Beta					
Gross Alpha and Gross Beta	9310	Solid	Glass	None	180 Days
Haloacetic Acids	552.1/552.2	Water	40mL Amber vials	NH_4Cl; ≤ 6ºC	14/7 Days if extracts stored ≤ 6ºC or 14/14 Days if extracts stored at ≤ -10ºC
Hardness, Total ($CaCO_3$)	SM2340B,C/130.1	Water	Plastic/Glass	pH<2 HNO_3	6 Months
Heterotrophic Plate Count (SPC/HPC)	SM9215B	Water	100mL Plastic	≤ 10ºC; $Na_2S_2O_3$	8 Hours
Heterotrophic Plate Count (SPC/HPC)	SimPlate	Water	100mL Plastic	≤ 10ºC; $Na_2S_2O_3$	8 Hours
Herbicides, Chlorinated	8151	Solid	8oz Glass Jar	≤ 6ºC	14/40 Days
Herbicides, Chlorinated	8151	Water	1L Amber Glass	≤ 6ºC; $Na_2S_2O_3$ if Cl present	7/40 Days
Herbicides, Chlorinated	515.1/515.3	Water	1L Amber Glass	≤ 6ºC; $Na_2S_2O_3$ if Cl present	14/28 Days
Hexavalent Chromium	7196/218.6/SM3500Cr-B, C, D	Water	Plastic/Glass	≤ 6ºC	24 Hours (see note 4)
Hexavalent Chromium	218.6/SM3500Cr-B, C, D	Water	Plastic/Glass	Ammonium Buffer pH 9.3-9.7	28 Days (see note 4)
Hexavalent Chromium	218.6/218.7	Drinking Water	Plastic/Glass	Ammonium Buffer pH >8	14 Days (see note 4)
Hexavalent Chromium	7196 (with 3060A)	Solid		≤ 6ºC	30 Days from collection to extraction and 7 days from r extraction to analysis
Hydrocarbons in Vapor	AM4.02	Vapor	20cc vapor vial with flat septum	None	N/A
Hydrogen by Bubble Strip	SM9/AM20GAx	Water	20cc vapor vial with stopper septum	None	14 Days
Hydrogen Halide and Halogen Emissions	EPA 26	Air	Solutions	None	6 Months
Ignitability of Solids	1030	Non-liquid Waste	Plastic/Glass	None	28 Days
Lead Emissions	EPA 12	Air	Filter/Solutio	None	6 Months

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
			ns		
Light Hydrocarbons by Bubble Strip	SM9/AM20GAx	Water	20cc vapor vial with stopper septum	None	14 Days
Light Hydrocarbons in Vapor	AM20GAx	Vapor	20cc vapor vial with flat septum	None	14 Days
Lipids	Pace Lipids	Tissue	Plastic/Glass	≤ -10°C	1 Year if frozen
Mercury, Low-Level	1631E	Solid	Glass	None	28 Days
Mercury, Low-Level	1631E	Water	Fluoropolymer bottles (Glass if Hg is only analyte being tested)	12N HCl or BrCl	48 Hours for preservation or analysis; 28 Days to preservation if sample oxidized in bottle; 90 Days for analysis if preserved
Mercury, Low-Level	1631E	Tissue	Plastic/Glass	≤ - 10°C	28 Days if frozen
Mercury	7471	Solid	8oz Glass Jar	≤ 6°C	28 Days
Mercury	7470/245.1/245.2	Water	Plastic/Glass	pH<2 HNO_3	28 Days
Mercury	7471/245.6	Tissue	Plastic/Glass	≤ - 10°C	28 Days if frozen
Metals (GFAA)	7000/200.9	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Metals (ICP)	NIOSH 7300A/7303	Air	Filters	None	180 Days
Metals (ICP/ICPMS)	6010/6020	Solid	8oz Glass Jar	None	180 Days
Metals (ICP/ICPMS)	6010/6020/200.7/200.8	Water	Plastic/Glass	pH<2 HNO_3	180 Days
Metals (ICP/ICPMS)	6020	Tissue	Plastic/Glass	≤ -10°C	180 Days if frozen
Methane, Ethane, Ethene	8015 modified	Water	40mL vials	HCl	14 Days
Methane, Ethane, Ethene	RSK-175; PM01/AM20GAx	Water	40mL vials	HCl; or trisodium phosphate or benzalkonium chloride and ≤ 6°C	14 Days; 7 Days unpreserved
Methane, Ethane, Ethene	EPA 3C	Air	Summa Canister	None	14 Days
Methane, Ethane, Ethene	EPA 3C	Air	Tedlar Bag or equivalent	None	48 Hours
Methanol, Ethanol	8015 modified	Water	40mL vials	≤ 6°C	14 Days
Methanol, Ethanol	8015 modified	Solid	2oz Glass	≤ 6°C	14 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Methyl Mercury	1630	Water	Teflon/ fluoropolymer	Fresh water-4mL/L HCl; Saline water-2mL/L H2SO4 (must be preserved within 48 hours of collection)	6 months
Methyl Mercury	1630	Tissue	2-4oz glass jar	≤ 0°C	28 Days; ethylated distillate 48 hours
Nitrogen, Ammonia	SM4500NH3/350.1	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Kjeldahl (TKN)	351.2	Solid	Plastic/Glass	≤ 6°C	28 Days
Nitrogen, Kjeldahl (TKN)	SM4500-Norg/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Nitrate	SM4500-NO3/352.1	Water	Plastic/Glass	≤ 6°C	24 Hours preferred
Nitrogen, Nitrate & Nitrite combination	353.2	Solid	Plastic/Glass	≤ 6°C	28 Days
Nitrogen, Nitrate & Nitrite combination	SM4500-NO3/353.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Nitrogen, Nitrite or Nitrate separately	SM4500-NO2/353.2	Water	Plastic/Glass	≤ 6°C	48 Hours
Nitrogen, Organic	SM4500-Norg/351.2	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Non-Methane Organics	EPA 25C	Air	Summa Canister	None	14 Days
Non-Methane Organics	EPA 25C	Air	Tedlar Bag or equivalent	None	48 Hours
Odor	SM2150B	Water	Glass	≤ 6°C	24 Hours
Oil and Grease/HEM	1664A/SM5520B/9070	Water	Glass	pH<2 H_2SO_4 or HCl; ≤ 6°C	28 Days
Oil and Grease/HEM	9071	Solid	Glass	≤ 6°C	28 Days
Oil Range Organics	8015	Solid	Glass	≤ 6°C	14/40 Days
Oil Range Organics	8015	Water	Glass	≤ 6°C	7/40 Days
Organic Matter	ASA 29-3.5.2	Solid	Plastic/Glass	None; samples air-dried and processed prior to analysis	N/A
Oxygen, Dissolved (Probe)	SM4500-O	Water	Glass	None	15 minutes
Oxygenates on Product (GCMS SIM)	1625 modified	Product	10mL glass vial	≤ 6°C	14 Days (7 Days from extraction)
PBDEs	1614	Water	1L Amber	≤ 6°C	1 Year/1 Year

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
			Glass		
PBDEs	1614	Solid	Wide Mouth Jar	≤ 6°C	1 Year/1 Year
PBDEs	1614	Tissue	Aluminum Foil	≤ -10°C	1 Year/1 Year
PCBs and Pesticides, Organochlorine (OC)	TO-4/TO-10	Air	PUF	None	7/40 Days
PCBs and Pesticides, Organochlorine (OC)	608	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	Pest: 7/40 Days; PCB: 1 Year/1 Year
PCBs, Pesticides (OC), Herbicides	508.1	Water	Glass	Na2SO3; pH<2 HCl; ≤ 6°C	14/30 Days
Perchlorate	331	Water	Plastic/Glass	≥0-6°C, field filtered with headspace	28 Days
Permanent Gases (O2, N2, CO2)	RSK-175; PM01/AM20GAx	Water	40mL vials	benzalkonium chloride and ≤ 6°C	14 Days
Permanent Gases by Bubble Strip	SM9/AM20GAx	Water	20cc vapor vial with stopper septum	None	14 Days
Permanent Gases in Vapor	AM20GAx	Vapor	20cc vapor vial with flat septum	None	14 Days
Pesticides, Organochlorine (OC)	8081	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Pesticides, Organochlorine (OC)	8081	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Pesticides, Organochlorine (OC)	8081	Tissue	8oz Glass Jar	≤ -10°C	1 Year if frozen/40 Days
Pesticides, Organophosphorous (OP)	8141	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Pesticides, Organophosphorous (OP)	8141	Water	1L Amber Glass	pH 5-8 with NaOH or H_2SO_4; ≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
PCBs (Aroclors)	8082	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	1 Year/1 Year
PCBs (Aroclors)	8082	Solid	8oz Glass Jar	≤ 6°C	1 Year/1 Year
PCBs (Aroclors)	8082	Tissue	Plastic/Glass	≤ -10°C	1 Year if frozen/1 Year
PCB Congeners	1668A	Water	1L Amber Glass	≤ 6°C but above freezing	1 Year/1 Year
PCB Congeners	1668A	Solid	4-8oz Glass	≤ 6°C but above	1 Year/1 Year

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
			Jar	freezing	
PCB Congeners	1668A	Tissue	4-8oz Glass Jar	≤ -10°C	1 Year/1 Year
Paint Filter Liquid Test	9095	Water	Plastic/Glass	None	N/A
Particle Size	ASA 15-5 modified	Solid	Plastic/Glass (100g sample)	None	N/A
Particulates	PM-10	Air	Filters	None	180 Days
Permanent Gases	EPA 3C	Air	Summa Canister	None	14 Days
Permanent Gases	EPA 3C	Air	Tedlar Bag or equivalent	None	48 Hours
pH	SM4500H+B/9040	Water	Plastic/Glass	None	15 minutes
pH	9045	Solid	Plastic/Glass	None	7 Days
Phenol, Total	420.1/420.4/9065/9066	Water	Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Phosphorus, Orthophosphate	SM4500P/365.1/365.3	Water	Plastic	Filter; ≤ 6°C	Filter within 15 minutes, Analyze within 48 Hours
Phosphorus, Total	SM4500P/365.1/365.3/365.4	Water	Plastic/Glass	pH<2 H_2SO_4; ≤ 6°C	28 Days
Phosphorus, Total	365.4	Solid	Plastic/Glass	≤ 6°C	28 Days
Polynuclear Aromatic Hydrocarbons (PAH)	TO-13	Air	PUF	None	7/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	≤ 6°C but above freezing	28 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Solid	8oz Glass Jar	≤ 6°C	14/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Water	1L Amber Glass	≤ 6°C; $Na_2S_2O_3$ if Cl present	7/40 Days
Polynuclear Aromatic Hydrocarbons (PAH)	8270 SIM	Tissue	Plastic/Glass	≤ -10°C	1 Year if frozen/40 Days
Purgeable Organic Halides (POX)	9021	Water	Glass; no headspace	≤ 6°C	14 Days
Radioactive Strontium	905.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-226	903.0/903.1	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-228 (see note 3)	9320/904.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Radium-228 (see note 3)	9320	Solid	Plastic/Glass		
Residual Range	AK103	Solid	8oz Glass	≤ 6°C	14/40 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
Organics- Alaska RRO					
Saturated Hydrocarbons		Water	≤ 6°C; pH<2 1:1 HCl (optional)	14/40 Days preserved; 7/40 Days unpreserved	≤ 6°C; pH<2 1:1 HCl (optional)
Saturated Hydrocarbons		Solid	≤ 10°C	1 Year/40 Days	≤ 10°C
Silica, Dissolved	SM4500Si-D	Water	Plastic	≤ 6°C	28 Days
Solids, Settleable	SM2540F	Water	Glass	≤ 6°C	48 Hours
Solids, Total	SM2540B	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total	SM2540G	Solid	Plastic/Glass	≤ 6°C	7 Days
Solids, Total (FOC, OM, Ash)	ASTM D2974	Solid	Plastic/Glass	≤ 6°C	7 Days
Solids, Total Dissolved	SM2540C	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total Suspended	SM2540D/USGS I-3765-85	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total Volatile	160.4/SM2540E	Water	Plastic/Glass	≤ 6°C	7 Days
Solids, Total Volatile	160.4	Solid	Plastic/Glass	≤ 6°C	7 Days
Specific Conductance	SM2510B/9050/120.1	Water	Plastic/Glass	≤ 6°C	28 Days
Stationary Source Dioxins and Furans	EPA 23	Air	XAD Trap	None	30/45 Days
Stationary Source Mercury	EPA 101	Air	Filters	None	180 Days, 28 Days for Hg
Stationary Source Metals	EPA 29	Air	Filters	None	180 Days, 28 Days for Hg
Stationary Source PM10	EPA 201A	Air	Filters	None	180 Days
Stationary Source Particulates	EPA 5	Air	Filter/Solutions	None	180 Days
Sulfate	SM4500SO4/9036/ 9038/375.2/ASTM D516	Water	Plastic/Glass	≤ 6°C	28 Days
Sulfide, Reactive	SW-846 Chap.7	Water	Plastic/Glass	None	28 Days
Sulfide, Reactive	SW-846 Chap.7	Solid	Plastic/Glass	None	28 Days
Sulfide, Total	SM4500S/9030	Water	Plastic/Glass	pH>9 NaOH; ZnOAc; ≤ 6°C	7 Days
Sulfite	SM4500SO3	Water	Plastic/Glass	None	15 minutes
Surfactants (MBAS)	SM5540C	Water	Plastic/Glass	≤ 6°C	48 Hours
Total Alpha Radium (see note 3)	9315/903.0	Water	Plastic/Glass	pH<2 HNO_3	180 days
Total Alpha Radium (see note 3)	9315	Solid	Plastic/Glass	None	180 days
Total Inorganic Carbon (TIC)	PM01/AM20GAx	Water	40mL VOA vial with	≤ 6°C	14 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
			mylar septum		
Total Organic Carbon (TOC)	SM5310B,C,D/ 9060	Water	Glass	pH<2 H_2SO_4 or HCl; ≤ 6°C	28 Days
Total Organic Carbon (TOC)	9060/Walkley Black/Lloyd Kahn	Solid	Glass	≤ 6°C	14 Days
Total Organic Halogen (TOX)	SM5320/9020	Water	Glass; no headspace	≤ 6°C	14 Days
Total Petroleum Hydrocarbons (aliphatic and aromatic)	TPHCWG	Water	40mL vials	pH<2 HCl, no headspace, ≤ 6°C	7 Days
Total Petroleum Hydrocarbons (aliphatic and aromatic)	TPHCWG	Solid	Glass	≤ 6°C	14 days
Tritium	906.0	Water	Glass	None	180 days
Turbidity	SM2130B/180.1	Water	Plastic/Glass	≤ 6°C	48 Hours
Total Uranium	908.0/ASTM D5174-97	Water	Plastic/Glass	pH<2 HNO_3	180 days
UCMR3 Metals	200.8	Water	Plastic or glass	pH<2 HNO_3	28 Days
UCMR3 Hexavalent Chromium	218.7	Water	HDPE or propylene	Na_2CO_3/$NaHCO_3$/ $(NH_4)_2SO_4$; pH>8	14 Days
UCMR3 Chlorate	300.1	Water	Plastic or glass	EDA	28 Days
UCMR3 Hormones	539	Water	Amber glass	$Na_2S_2O_3$, 2-mercaptopyridine-1-oxide, sodium salt	28 Days
UCMR3 Perfluorinated Compounds	537	Water	Polypropylene	Trizma	14 Days
UCMR3 Volatiles	524.3	Water	40 mL amber glass vials	Ascorbic acid. Maleic acid pH~2	14 Days
UCMR3 1, 4 Dioxane	522	Water	Glass	Na_2SO_3, $NaHSO_4$; pH<4	28 Days
UV254	SM5910B	Water	Glass	≤ 6°C	48 Hours
Vermiculite	EPA 600/R-93/116	Solid	Plastic/Glass	None (handling must be done in HEPA filtered fume hood; drying may be required)	N/A
Volatile Fatty Acids	AM21G	Water	40mL clear VOA vials	≤ 6°C	21 Days
Volatile Fatty Acids (low level)	AM23G	Water	40mL clear VOA vials	≤ 6°C with benzalkonium	14 Days

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
				chloride	
Volatile Petroleum Hydrocarbons (aliphatic and aromatic)	MA-VPH	Water	40mL vials	pH<2 HCl; ≤ 6°C	14 Days preserved
Volatile Petroleum Hydrocarbons (aliphatic and aromatic)	MA-VPH	Solid	4-8oz Glass Jar	≤ 6°C; packed jars with no headspace	7/28 Days
Volatiles	TO-14	Air	Summa Canister	None	30 Days
Volatiles	TO-14	Air	Tedlar Bag or equivalent	None	48 Hours
Volatiles	TO-15	Air	Summa Canister	None	30 Days
Volatiles	TO-17	Air	Thermal desorption tubes via SKC Pocket Pumps or equivalent	≤ 6°C but above freezing	28 Days
Volatiles	TO-18/8260	Air	Tedlar Bag or equivalent	None	72 Hours
Volatiles	8260	Solid	5035 vial kit	See note 1 (analyze for acrolein and acrylonitrile per local requirements)	14 days
Volatiles	8260	Water	40mL vials	pH<2 HCl; ≤ 6°C; $Na_2S_2O_3$ if Cl present (preserve and analyze for acrolein and acrylonitrile per local requirements)	14 Days
Volatiles	8260	Conc. Waste	5035 vial kit or 40mL vials	≤ 6°C	14 Days
Volatiles	624	Water	40mL vials	pH<2 HCl; ≤ 6°C; $Na_2S_2O_3$ if Cl present (or unpreserved if run within 7 days of collection) (preserve and analyze for acrolein and	14 Days (7 Days for aromatics if unpreserved)

Parameter	Method	Matrix	Container	Preservative	Max Hold Time
				acrylonitrile per local requirements)	
Volatiles (see note 2)	524.2	Water	40mL vials (in duplicate)	pH<2 HCl; ≤ 6°C; Ascorbic acid or $Na_2S_2O_3$ if Cl present[2]	14 Days
Whole Oil	ASTM D3328 (prep); ASTM D5739	Product	10mL glass vials	≤ 6°C	N/A

[1] **5035/5035A Note**: 5035 vial kit typically contains 2 vials water, preserved by freezing **or**, 2 vials aqueous sodium bisulfate preserved at 4°C, **and** one vial methanol preserved at ≤6°C **and** one container of unpreserved sample stored at ≤6°C.

[2] Method 524.2 lists ascorbic acid as the preservative when residual chlorine is suspected, unless gases or Table 7 compounds are NOT compounds of interest and then sodium thiosulfate is the preservative recommended.

[3] Methods 9315 and 9320 both state that if samples are unpreserved, the samples should be brought to the lab within 5 days of collection, preserved in the lab, and then allowed to sit for a minimum of 16 hours before sample preparation/analysis.

[4] The holding time for hexavalent chromium may be extended by the addition of the ammonium buffer listed in EPA 218.6 per the 2012 EPA Method Update Rule. Although Method 218.6 stipulates a different pH range (9.0 to 9.5) for buffering, this method requirement was modified in the Method Update Rule to a pH range of 9.3 to 9.7.For non-potable waters, adjust the pH of the sample to 9.3 to 9.7 during collection with the method required ammonium sulfate buffer to extend the holding time to 28 days. For potable waters, addition of the buffer during collection will extend the holding time for 14 days per EPA 218.7 and the EPA UCMR3 program.

APPENDIX C

EXAMPLE FIELD DATA RECORDS

CALIBRATION RECORD

FIELD INSTRUMENT CALIBRATION RECORD

Project Name: CTS of Asheville, Inc. Superfund Site
Date: ____________

Project Number: 6252-16-2012
Name: ____________

Water Quality Meter Calibration

Manufacturer: ____________
Model No.: ____________
Unit ID: ____________

	Standard Value		Meter Value		Acceptance Criteria
pH:	SU (low)	pH:	SU		+/- 10% of standard
pH:	SU (med)	pH:	SU		+/- 10% of standard
pH:	SU (high)	pH:	SU		+/- 10% of standard
Conductivity:	mS/cm	Conductivity:	mS/cm		+/- 10% of standard
ORP:	mV	ORP:	mV		+/- 10% of standard

Turbidity Meter Calibration

Manufacturer: ____________
Model No.: ____________
Unit ID: ____________

Standard Value	Meter Value	Acceptance Criteria
NTU (low)	NTU	+/- 10% of standard
NTU (med)	NTU	+/- 10% of standard
NTU (high)	NTU	+/- 10% of standard
NTU (high)	NTU	+/- 10% of standard

Photoionization Detector

Manufacturer: ____________
Model No.: ____________
Unit ID: ____________

				Acceptance Criteria
Background:	ppmv	Meter:	ppmv	within 5 ppmv of Zero
Span Gas:	ppmv	Meter:	ppmv	+/- 10% of standard

Calibration Sources

	Source	Value	Lot Number	Expiration Date
pH (low)		SU		
pH (med)		SU		
pH (high)		SU		
Conductivity		mS/cm		
ORP:		mV		
Turbidity (low)		NTU		
Turbidity (med):		NTU		
Turbidity (high):		NTU		
Turbidity (high):		NTU		
PID gas:		ppmv		

NOTES:

If a meter reading is not within acceptance criteria, clean or replace probe and re-calibrate, or use a different meter if available. If project requiremen necessitate use of the instrument, clearly document on all data sheets and log book entries that the parameter was not calibrated to the acceptance criter

DEPTH TO WATER MEASUREMENT RECORD

DEPTH TO WATER MEASUREMENT RECORD

Project Site: CTS of Asheville, Inc. Superfund Site

Project Number: 6252-16-2012

Personnel: ____________________

Date: ____________________

Monitoring Well	Depth to Water from Reference Point	Well Condition	Comments
MW-5			
MW-5A			
MW-6			
MW-6A			
MW-7			
MW-7A			

Depth to water measurement in feet.

SOIL BORING RECORD

SOIL BORING RECORD

BORING ID

Project Name: ____________________
Project Number: ____________________
Date: ____________________
Drilling Contractor: ____________________
Equipment: ____________________
Logged By: ____________________

DEPTH (ft)	RECOVERY	STRATA/ UNIT	USCS	SOIL DESCRIPTION	PID (ppm)
	0 - 5				
1					
2					
3					
4					
5	5 - 10				
6					
7					
8					
9					
10	10 - 15				
11					
12					
13					
14					
15	15 - 20				
16					
17					
18					
19					
20	20 - 25				
21					
22					
23					
24					
25					

Recovery (%) = Run Interval / Amount Recovered

PID = photoionization detector, ppm = parts per million

Strata/Unit = deposition/formation (e.g., fill, alluvial, floodplain, residuum, bedrock, etc.)

DRUM MANAGEMENT RECORD

DRUM MANAGEMENT RECORD

Project Site: CTS of Asheville, Inc. Superfund Site

Page ____ of ____

Project Number: 6252-16-2012

Drum ID	Date Generated	Contents	Source

BORING/SAMLING SUMMARY RECORD

Boring/Sample Summary Record

Project Site: CTS of Asheville, Inc. Superfund Site
Project Number: 6252-16-2012
Name of Person Completing Form: ______________________________

Boring Location	MIP	Soil Sample	GW Sample	Comments

Page _____ of ______

Notes:
For each boring location, mark "X" for methods conducted; indicate the date conducted below the "X".
If soil and/or groundwater samples collected, indicate depth of sample.
If soil and/or groundwater samples are collected, indicate the analyses.

PACE ANALYTICAL SERVICES, INC. CHAIN OF CUSTODY RECORD

Pace Analytical®
www.pacelabs.com

CHAIN-OF-CUSTODY / Analytical Request Document

The Chain-of-Custody is a LEGAL DOCUMENT. All relevant fields must be completed accurately.

Page:	**of**

Section A **Required** Client Information:		**Section B** **Required** Project Information:	**Section C** Invoice Information:
Company:		Report To:	Attention:
Address:		Copy To:	Company Name:
			Address:
Email To:		Purchase Order No.:	Pace Quote Reference:
Phone:	Fax:	Project Name:	Pace Project Manager:
Requested Due Date/TAT:		Project Number:	Pace Profile #:

REGULATORY AGENCY

☐ NPDES	☐ GROUND WATER	☐ DRINKING WATER
☐ UST	☐ RCRA	☐ OTHER ________

Site Location	
STATE:	________

Matrix Codes

MATRIX / CODE	
Drinking Water	DW
Water	WT
Waste Water	WW
Product	P
Soil/Solid	SL
Oil	OL
Wipe	WP
Air	AR
Tissue	TS
Other	OT

ITEM #	**Section D** **Required** Client Information **SAMPLE ID** (A-Z, 0-9 / ,-) Sample IDs MUST BE UNIQUE	MATRIX CODE (see valid codes to left)	SAMPLE TYPE (G=GRAB C=COMP)	COLLECTED				SAMPLE TEMP AT COLLECTION	# OF CONTAINERS	*Preservatives*								**Y/N ➡**	**Requested Analysis Filtered (Y/N)**												Residual Chlorine (Y/N)	**Pace Project No./ Lab I.D.**
				COMPOSITE START		COMPOSITE END/GRAB																										
				DATE	TIME	DATE	TIME			Unpreserved	H_2SO_4	HNO_3	HCl	NaOH	$Na_2S_2O_3$	Methanol	Other	**➡ Analysis Test ➡**														
1																																
2																																
3																																
4																																
5																																
6																																
7																																
8																																
9																																
10																																
11																																
12																																

ADDITIONAL COMMENTS	**RELINQUISHED BY / AFFILIATION**	**DATE**	**TIME**	**ACCEPTED BY / AFFILIATION**	**DATE**	**TIME**	**SAMPLE CONDITIONS**			
							Temp in °C	Received on Ice (Y/N)	Custody Sealed Cooler (Y/N)	Samples Intact (Y/N)

SAMPLER NAME AND SIGNATURE

PRINT Name of SAMPLER:

SIGNATURE of SAMPLER:

DATE Signed (MM/DD/YY):

*Important Note: By signing this form you are accepting Pace's NET 30 day payment terms and agreeing to late charges of 1.5% per month for any invoices not paid within 30 days.

APPENDIX C

EMERGENCY RESPONSE PLAN

REMEDIAL DESIGN WORK PLAN:
EMERGENCY RESPONSE PLAN

CTS OF ASHEVILLE, INC. SUPERFUND SITE

235 Mills Gap Road
Asheville, Buncombe County, North Carolina
EPA ID: NCD003149556
Consent Decree – Civil Action No. 1:16-cv-380

Prepared for:

CTS Corporation
2375 Cabot Drive
Lisle, Illinois 60532

Prepared by:

Amec Foster Wheeler Environment & Infrastructure, Inc.
1308 Patton Avenue
Asheville, North Carolina 28806

Amec Foster Wheeler Project 6252-16-2012

April 19, 2017

TABLE OF CONTENTS

ACRONYMS

CD	Consent Decree
ERH	electrical resistance heating
ERP	Emergency Response Plan
FOL	Field Operations Leader
HASP	Health and Safety Plan
ISCO	in-situ chemical oxidation
NCDEQ	North Carolina Department of Environmental Quality
PDI	Pre-design Investigation
PM	Project Manager
PPE	personal protective equipment
RA	Remedial Action
RD	Remedial Design
RDWP	Remedial Design Work Plan
TS	Treatability Study
USEPA	United States Environmental Protection Agency

DOCUMENT REVISION LOG

Revision	Date	Description
0	4/19/2017	Initial Issuance

1.0 INTRODUCTION

On behalf of CTS Corporation (CTS), Amec Foster Wheeler Environment & Infrastructure, Inc. (Amec Foster Wheeler) has prepared this Emergency Response Plan (ERP) for the CTS of Asheville, Inc. Superfund Site (Site) located in Asheville, Buncombe County, North Carolina. This ERP has been prepared in accordance with Section 6.7(b) of the Statement of Work of the Consent Decree for Interim Remedial Design/Remedial Action (CD) at the CTS of Asheville, Inc. Superfund Site (Site) between the United States of America and CTS Corporation, Mills Gap Road Associates, and Northrop Grumman Systems Corporation (the Settling Defendants). The CD was entered on March 7, 2017.

This ERP provides information about the steps to be taken in case of an emergency during implementation of Interim Remedial Design and Remedial Action (RD/RA) activities under the CD, and to identify the parties which are responsible to take these steps. This ERP contains descriptions of the actions to comply with Paragraph 11 of the CD in the event of an incident that causes or threatens a release of waste material from the Site that constitutes an emergency or may present an immediate threat to public health or the environment.

The Interim RA activities will be conducted in two phases: electrical resistance heating (ERH) in the approximate 1.2-acre source area, and in-situ chemical oxidation (ISCO) in an approximate 1.9-acre area of the downgradient dissolved-phase plume designated the Northern Area. This ERP focuses on development and data collection associated with the ISCO remedial design. The ISCO remedial design will be conducted in two phases: a Pre-design Investigation (PDI) and a Treatability Study (TS). The ERP will be updated prior to performance of the ERH and ISCO Interim RA activities (after contractors are selected for such).

Non-emergency Site activities will be conducted in accordance with the Health and Safety Plan (HASP) which has been prepared and submitted to the United States Environmental Protection Agency (USEPA) under separate cover. The HASP was prepared to address applicable Occupational Safety and Health Administration (OSHA) regulations concerning the proposed activities at the Site.

2.0 PROJECT RESPONSIBLE PARTIES

To meet the emergency response objectives, Amec Foster Wheeler has developed a line of reporting and has tasked those individuals with emergency reporting responsibilities, as presented below. These individuals are also those that are responsible for health and safety during the Site activities.

Current contact information is contained and kept up to date in the Site HASP. Refer to Section 9.4 of the HASP for contact information for the below personnel.

2.1 AMEC FOSTER WHEELER PROJECT MANAGER

The Project Manager, Mr. Matthew Wallace, is responsible for overall project management responsibilities including:

- Ensuring that a Site-specific HASP is written and approved for the Site prior to work being conducting at the Site.
- Ensuring that necessary resources, including appropriate personal protective equipment (PPE) are available.
- Ensuring that the means and materials necessary to respond to emergency situations are identified and available.
- Investigating and reporting to the Amec Foster Wheeler Group Health, Safety and Environment (HSE) Manager each emergency event, work-related illness or injury, near-miss, accident, and damage to physical property that occurs at the Site.
- Ensuring that the ERP is updated/modified, as necessary, to reflect potential emergency situations related to new Site work tasks or when Site environmental conditions change.

2.2 AMEC FOSTER WHEELER SITE HEALTH AND SAFETY SUPERVISOR

The Site Health and Safety Supervisor, Ms. Susan Kelly, is responsible for:

- Implementing the policies and procedures outlined in this ERP, the Site-specific HASP and the Amec Foster Wheeler Health and Safety Program.
- Conducting accident investigations, as necessary in accordance with the Amec Foster Wheeler Incident Reporting procedure as outlined in the Amec Foster Wheeler Health and Safety Program.
- Being familiar with local emergency services.
- Monitoring on-Site hazards and the physical condition of Site personnel.
- Maintaining health and safety files, which will include information requiring emergency response actions, as applicable.

- Shutting down operations that threaten a release of waste material from the Site that constitutes an emergency or may present an immediate threat to public health or the environment.
- Updating the ERP, in consultation with the Project Manager and Group HSE Manager.
- Escort USEPA, the North Carolina Department of Environmental Quality (NCDEQ), OSHA, or other governmental agency personnel visiting the Site in response to emergency issues.

2.3 AMEC FOSTER WHEELER FIELD OPERATIONS LEADER

The Amec Foster Wheeler Field Operations Leader (FOL), Ms. Susan Kelly, is responsible for performing the responsibilities as vested by the PM, to carry out day-to-day Site operations, including interfacing with the Subcontractor Site Supervisor. The FOL is the primary authority for directing operations at the Site under emergency conditions. Communications both on- and off-Site will be directed through the FOL. The FOL will use discretion to determine the extent of the emergency and if evacuation is necessary.

2.4 SUBCONTRACTOR SITE SUPERVISOR

The Subcontractor Site Supervisor is responsible for:

- Performing the responsibilities as vested by the Subcontractor, to carry out day-to-day Site operations, including interfacing with the Amec Foster Wheeler FOL.
- Be familiar with local emergency services.
- Be prepared for actions requiring an emergency response due to a release caused by the Subcontractor.

2.5 SUBCONTRACTOR PERSONNEL AND FIELD PERSONNEL

Amec Foster Wheeler and Subcontractor field personnel are responsible for:

- Following and obeying the safety procedures outlined in the HASP.
- Be prepared for actions requiring an emergency response due to a release caused by the Subcontractor.

2.6 AUTHORIZED USEPA OFFICER

The authorized USEPA officer is, in order of preference/authorization: 1) the USEPA Project Coordinator, Mr. Craig Zeller, 2) the USEPA Alternate Project Coordinator (if the USEPA Project Coordinator is unavailable), or, 3) the USEPA Region 4 Superfund

Emergency Response, Removal and Prevention Branch (if neither USEPA Project Coordinator is available).

3.0 COMMUNITY INVOLVEMENT

It is our understanding that USEPA is updating the Community Involvement Plan for the Site. Prior to and during implementation of the Interim RD/RA, the USEPA will conduct community meetings to disseminate relevant Site information to the community. The Settling Defendants, through their designated Community Involvement Coordinator, will provide support for the community meetings.

Dates and agendas for the community meetings have not yet been established by USEPA. The meeting announcements will be provided to community members; local, state and federal agencies; as well as the local emergency squads and hospitals for their knowledge of the project activities, especially if an emergency response need should arise.

4.0 SPILL RESPONSE

Amec Foster Wheeler and the primary subcontractors do not anticipate using chemicals during the PDI or TS that would require an immediate response if a spill or release occurred. The Site does not contain storage vessels, therefore the potential to encounter chemicals/materials during drilling activities that would require a response in the event of a spill/rupture is unlikely. However, drilling equipment and vehicles with self-contained fuel tanks, and portable fuel tanks, represent a potential source for a liquid spill.

A Spill Prevention, Control, and Countermeasures Plan is not applicable as oil products will not be stored or handled on Site above a quantity of 1,320 U.S. gallons (40 C.F.R. Part 112). Surface waters are not located proximal to the areas of proposed Interim RD/RA activities, such that releases of oil or other chemical products would be expected to impact the closest surface waters.

Potassium permanganate, the proposed chemical oxidant to be used during the TS, has a reportable spill quantity of 100 pounds. In the event of a potassium permanganate spill in excess of 100 pounds, the National Response Center will immediately be notified. Additional information on the handling and response measures for potassium permanganate will be provided in the TS Work Plan.

Amec Foster Wheeler and subcontractor personnel will attempt to contain spills to the safest extent practical in the immediate work area through the use of those items listed below. If a release above reportable quantity, or a release which reaches surface water occurs, the FOL will immediately notify the PM. The PM will provide additional response to the release if necessary, including mobilization of an emergency response contractor(s).

The following materials will be available for spill containment on-Site with each work crew:

- Drums
- Absorbent materials (rolls, socks, sheets, adsorbent pillows, pads, etc.)
- Absorbent such as Spill-Dri™ or Speedi-dry
- Shovel, broom, and other tools as necessary for cleaning up the spill

5.0 RELEASE NOTIFICATION AND REPORTING

In accordance with Section 4.3 of the CD Statement of Work, if any event occurs during performance of the Work that causes or threatens to cause a release of waste material on, at, or from the Site and that either constitutes an emergency situation or that may present an immediate threat to public health or welfare or the environment, the Settling Defendants will: (1) immediately take all appropriate action to prevent, abate, or minimize such release or threat of release; (2) immediately notify the authorized USEPA officer orally; and (3) take such actions in consultation with the authorized USEPA officer and in accordance with all applicable provisions of the HASP, this ERP, and any other deliverable approved by USEPA for implementation of the Interim RD/RA.

Upon the occurrence of any event during implementation of the IRA that the Settling Defendants are required to report pursuant to Section 103 of CERCLA, 42 U.S.C. § 9603, or Section 304 of the Emergency Planning and Community Right-to-know Act (EPCRA), 42 U.S.C. § 11004, the Settling Defendants will immediately notify the authorized USEPA officer orally.

For any event described above, the Settling Defendants will: (1) within 14 days after the onset of such event, submit a report to USEPA describing the actions or events that occurred and the measures taken, and to be taken, in response thereto; and (2) within 30 days after the conclusion of such event, submit a report to USEPA describing all actions taken in response to such event. This reporting will be in addition to reporting required by CERCLA § 103 or EPCRA § 304, if necessary.

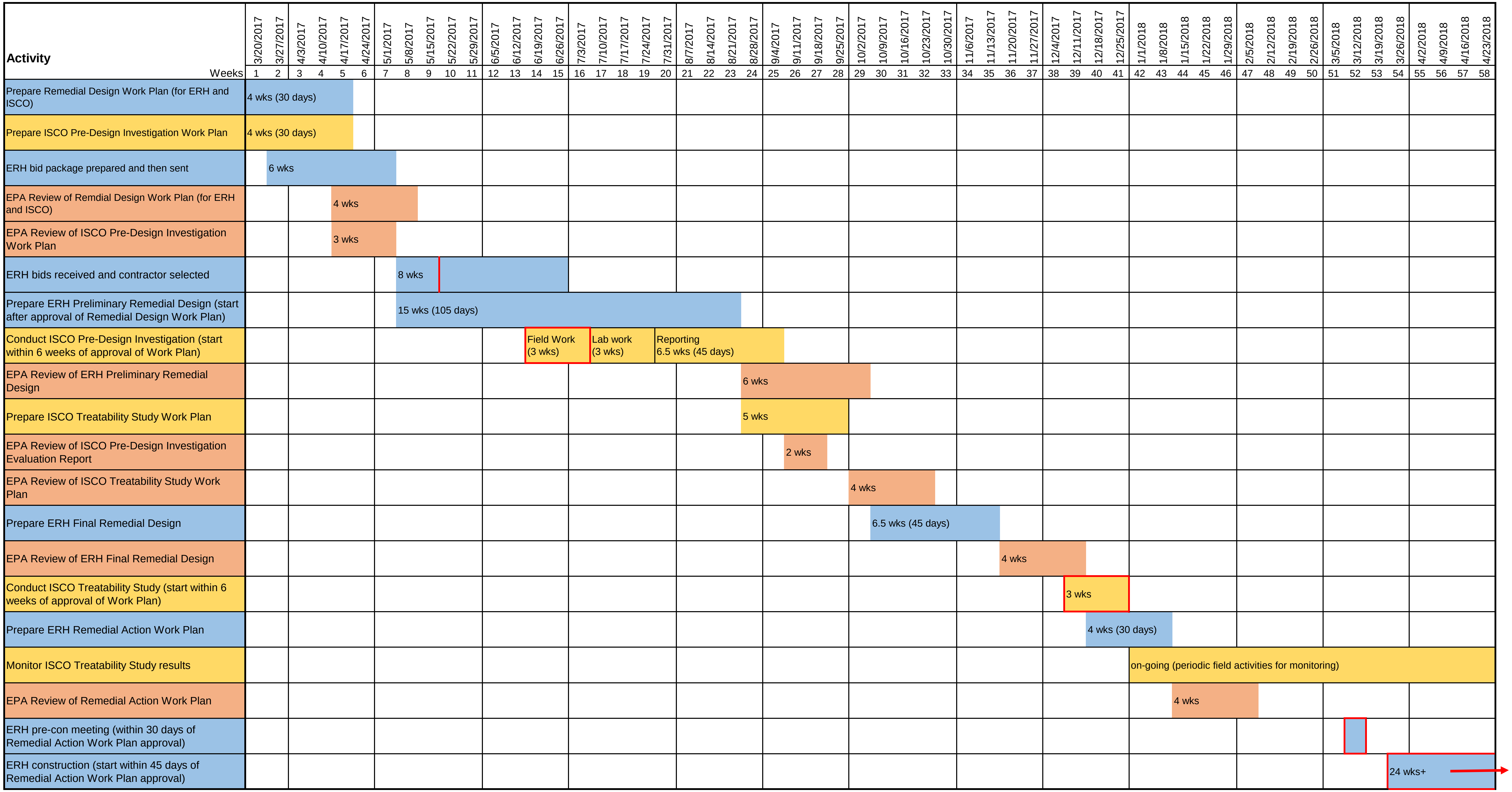
Additional agencies that will be notified, if applicable, include:

ORGANIZATION	PHONE NUMBER
North Carolina Department of Environmental Quality: Asheville Regional Office	828-296-4500
North Carolina Division of Environmental Management: Emergency Response	24-Hour: 800-662-7956
USEPA National Response (as applicable for chemicals and quantities)	24 Hour: 800-424-8802
Metropolitan Sewerage District of Buncombe County (for spills that enter the sewerage system)	828-254-9646 or Plant (24 hours) 828-252-7342

APPENDIX D

PRELIMINARY SCHEDULE FOR INTERIM REMEDIAL ACTION/ REMEDIAL DESIGN

CTS OF ASHEVILLE, INC. SUPERFUND SITE
PRELIMINARY SCHEDULE FOR INTERIM REMEDIAL DESIGN/REMEDIAL ACTION



Activity	3/20/2017	3/27/2017	4/3/2017	4/10/2017	4/17/2017	4/24/2017	5/1/2017	5/8/2017	5/15/2017	5/22/2017	5/29/2017	6/5/2017	6/12/2017	6/19/2017	6/26/2017	7/3/2017	7/10/2017	7/17/2017	7/24/2017	7/31/2017	8/7/2017	8/14/2017	8/21/2017	8/28/2017	9/4/2017	9/11/2017	9/18/2017	9/25/2017	10/2/2017	10/9/2017	10/16/2017	10/23/2017	10/30/2017	11/6/2017	11/13/2017	11/20/2017	11/27/2017	12/4/2017	12/11/2017	12/18/2017	12/25/2017	1/1/2018	1/8/2018	1/15/2018	1/22/2018	1/29/2018	2/5/2018	2/12/2018	2/19/2018	2/26/2018	3/5/2018	3/12/2018	3/19/2018	3/26/2018	4/2/2018	4/9/2018	4/16/2018	4/23/2018
Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58
Prepare Remedial Design Work Plan (for ERH and ISCO)	4 wks (30 days)																																																									
Prepare ISCO Pre-Design Investigation Work Plan	4 wks (30 days)																																																									
ERH bid package prepared and then sent		6 wks																																																								
EPA Review of Remdial Design Work Plan (for ERH and ISCO)					4 wks																																																					
EPA Review of ISCO Pre-Design Investigation Work Plan					3 wks																																																					
ERH bids received and contractor selected								8 wks																																																		
Prepare ERH Preliminary Remedial Design (start after approval of Remedial Design Work Plan)								15 wks (105 days)																																																		
Conduct ISCO Pre-Design Investigation (start within 6 weeks of approval of Work Plan)														Field Work (3 wks)			Lab work (3 wks)			Reporting 6.5 wks (45 days)																																						
EPA Review of ERH Preliminary Remedial Design																								6 wks																																		
Prepare ISCO Treatability Study Work Plan																								5 wks																																		
EPA Review of ISCO Pre-Design Investigation Evaluation Report																										2 wks																																
EPA Review of ISCO Treatability Study Work Plan																													4 wks																													
Prepare ERH Final Remedial Design																														6.5 wks (45 days)																												
EPA Review of ERH Final Remedial Design																																				4 wks																						
Conduct ISCO Treatability Study (start within 6 weeks of approval of Work Plan)																																							3 wks																			
Prepare ERH Remedial Action Work Plan																																								4 wks (30 days)																		
Monitor ISCO Treatability Study results																																										on-going (periodic field activities for monitoring)																
EPA Review of Remedial Action Work Plan																																												4 wks														
ERH pre-con meeting (within 30 days of Remedial Action Work Plan approval)																																																										
ERH construction (start within 45 days of Remedial Action Work Plan approval)																																																						24 wks+				

Notes:

The schedule is based on indicated period for EPA approval or conditional approval of submittals without significant revisions, and is dependant on weather conditions and equipment availability, as applicable.

Schedule based on notice to proceed from EPA (approval of Coordinator and Contractor) received on 3/20/17.

Date indicates the beginning of the week (period of work).

ERH - Electrical Resistance Heating
ISCO - In Situ Chemical Oxidation
EPA document review and finalization period
Field activities/site visits are in red outline