FINAL
QUALITY ASSURANCE PROJECT PLAN ADDENDUM NO. 2 FOR SUPPLEMENTAL INVESTIGATION CAMP SMITH TRAINING SITE, PEEKSKILL, NEW YORK

SEPTEMBER 2017

Prepared for:

UNITED STATES ARMY CORPS OF ENGINEERS, BALTIMORE DISTRICT
Baltimore, Maryland

AND

ARMY NATIONAL GUARD DIRECTORATE
Arlington, Virginia

AND

NEW YORK ARMY NATIONAL GUARD
Latham, New York

Contract Number: W912DR-12-D-0006 Task Order No. 0002

Prepared by:

EA ENGINEERING, P.C., AND ITS AFFILIATE,
EA SCIENCE AND TECHNOLOGY
6712 Brooklawn Parkway, Suite 104
Syracuse, New York 13211

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CAMP SMITH TRAINING SITE, PEEKSKILL, NEW YORK

Reviewed and Approved by:

_____ Christopher Canonica, P.E.
Vice President
EA Engineering, P.C., and its Affiliate EA Science and Technology

_____ Vince Williams, PMP
Project Manager
EA Engineering, Science, and Technology, Inc.

_____ Jennifer Bouchard, P.G.
Deputy Project Manager
EA Science and Technology

SEPTEMBER 2017

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS/ACRONYMS

ARNG	Army National Guard
ASP	Analytical services protocol
AWQS	Ambient water quality standards
BMP	Best Management Plan
CSM	Conceptual site model
DER	Division of Environmental Remediation
DFWMR	Division of Fish, Wildlife, and Marine Resources
DoD	Department of Defense
DQO	Data quality objectives
EA	EA Engineering, P.C., and Its Affiliate EA Science and Technology
ELAP	Environmental Laboratory Approval Program
EPA	United States Environmental Protection Agency
ft	Foot/feet
GPS	Global positioning system
in.	Inch(es)
MC	Munitions constituents
MCOC	Munitions constituents of concern
mg/kg	Milligrams per kilogram
MS	Matrix spike
MSD	Matrix spike duplicate
NA	Not applicable
NYARNG	New York Army National Guard
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
QAPP	Quality Assurance Project Plan
QC	Quality control
ORA	Operational range assessment
RI	Remedial Investigation
SOP	Standard operating procedure
USACE	United States Army Corps of Engineers
XRF	X-ray fluorescence

INTRODUCTION

STATUS OF INVESTIGATION

In response to the findings of the Operational Range Assessment (ORA) Phase II, the Army National Guard (ARNG) initiated a supplemental investigation[1] to focus on evaluating the nature and extent of munitions constituents of concern impacts to surface water and sediment in the off-range area of the 9-acre tidal marsh at the Camp Smith Training Site, a New York Army National Guard facility located near Peekskill, New York. The Supplemental ORA Phase II investigation was conducted at Camp Smith during three phases implemented between June 2014 and November 2015. The phased sampling included the collection of bulk chemistry data (i.e., metals in sediment and surface water), fish tissue for metals analysis, and sediment for toxicity testing, simultaneously extracted metals/acid volatile sulfide analysis, and geotechnical characterization.

The results of the Supplemental ORA Phase II indicated that the extent of MCOC impacts have been fully delineated throughout the defined tidal marsh, with a clearly observable "hot spot" identified in the upland area of the northern portion of the tidal marsh. And, metals munitions constituents of concern (MCOC) are not currently migrating from the operational ranges at levels that pose an unacceptable risk to off-range human or ecological receptors. Ranges 1A/1B were determined to be the dominant source of metals munitions constituents (MC) contribution to Putnam Brook and the downstream tidal marsh based on the former range configuration and history of use; and the historical Range 1A/1B berm was identified as a remaining source area that needs to be addressed to limit downstream migration of metals MC.

REGULATORY STATUS/COMMUNITY RELATIONS

Camp Smith is not a Superfund site (federal or state[2]); however, the investigation effort followed the general process outlined in Comprehensive Environmental Response, Compensation, and Liability Act since the ORA program follows the guidelines of the Defense Environmental Restoration Program. Throughout the technical project planning process (TPP) as well as during the three phases of investigation conducted to date (2013–2015), ARNG has engaged with the New York State Department of Environmental Conservation (NYSDEC). As agreed during the most recent TPP meeting conducted with NYSDEC (January 2017), ARNG will continue to

[1] During performance of the investigation, which was initially scoped as a Remedial Investigation (RI), it was determined that the entire tidal marsh is located within the Camp Smith boundary. The boundary was formally revised in April 2016, and the entire tidal marsh was also re-designated as operational area. With the tidal marsh now classified as operational area, the ARNG considers the investigation originally conducted under the RI effort, as well as future efforts to evaluate potential downstream impacts from the operational range, as supplemental to the ORA Phase II.

[2] Camp Smith is listed in the New York State Superfund Program database as a non-registry site (i.e., not listed in the Registry of Inactive Hazardous Waste Disposal Sites) and is assigned Classification Code A. Non-registry sites are those that are being tracked by NYSDEC because they are being investigated and remediated under another environmental remediation program. Classification Code A is assigned to non-registry sites in any remedial program where work is underway and not yet complete.

investigate the site under a voluntary basis and will share planning documents and summary reports with NYSDEC.

Development of a formal community relations plan is not required since the environmental investigation is being performed voluntarily. ARNG's plan to continue open communication/dialogue with regulatory stakeholders is intended to serve as the primary method of informing the community about the ORA program investigation activities being conducted at Camp Smith. If required, additional information/updates may be distributed to other stakeholders, including community members and/or news media by Camp Smith.

SUPPLEMENTAL INVESTIGATION

This Quality Assurance Project Plan (QAPP) Addendum, which has been prepared for the United States Army Corps of Engineers –Baltimore District, applies to the continued environmental investigation being performed at the historical Range 1A/1B impact berm and range area, located upstream from the tidal marsh. This QAPP is an Addendum to the QAPP that was included as Appendix A of the Remedial Investigation (RI) Work Plan (EA Engineering, P.C., and its Affiliate EA Science and Technology [EA] 2014) and will present project-specific information for additional data collection activities at the historical Range 1A/1B impact berm and range area. Only select worksheets are presented in this QAPP Addendum. The RI Work Plan and the Draft Final RI Data Summary Report (EA 2015) for additional information.

This QAPP Addendum provides instruction and guidance associated with the collection, analysis, and reporting of data to ensure that the data collected are scientifically valid, meet the established quality control objectives, are legally defensible, and support project objectives. Project objectives include completion of a series of projectile fragment counts in order to evaluate the nature of lead impacts in soil by providing a qualitative estimate of total projectile mass remaining within historical portions of Range 1A/1B as well as to collect soil samples from areas surrounding the historical Range 1A/1B area to delineate the horizontal extent of lead impacts originating from historical use of the range. Supplemental surface water samples will be collected from Putnam Brook upstream and downstream of Range 1A/1B to further characterize lead impacts to surface water.

REFERENCES

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QAPP Worksheets #1B and 2B
Title and Approval Page

Site Name/Project Name:	Camp Smith Remedial Investigation
Site Location/Number:	Camp Smith Training Site, Peekskill, New York
Contract/Work Assignment:	W912DR-12-D-0006, Delivery Order No. 0002
Document Title:	QAPP Addendum No. 2 for Supplemental Investigation – Camp Smith Training Site, New York
Lead Organization Project Manager:	Tim Peck – USACE, Baltimore District
State Regulatory Agency Remedial Project Manager:	Not applicable – investigation is being conducted voluntarily
Other Stakeholders	Michael Mackiewicz – Army National Guard Directorate, Pete Jensen – New York Army National Guard Sean Martin – Camp Smith Training Site
Preparation Date (Month/Year):	August 2017

The QAPP is (select one): _____ Generic __**X**__ Site(s)-Specific

List dates and titles of QAPP documents written for previous site work, if applicable:

Title	Approval Date
QAPP for Operational Range Assessment (ORA) Program Phase II Quantitative Assessment	August 2009
Final RI Work Plan	June 2014
Final QAPP Addendum No. 1 for Remedial Investigation	October 2015

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QAPP Worksheet #9B
Project Planning Session Summary

Site Name/Project Name:	Camp Smith Remedial Investigation
Site Location:	Camp Smith Training Site, New York
Date of Session:	10 January 2017
Scoping Session Purpose:	Discuss results of the Supplemental ORA Phase II Report

Name	Affiliation	E-mail Address	Project Role
Tim Peck	USACE-Baltimore District	timothy.j.peck@usace.army.mil	USACE Project Manager
Michael Mackiewicz	ARNG Directorate	michael.c.mackiewicz.civ@mail.mil	ARNG Directorate Project Manager
Pete Jensen	NYARNG Headquarters	carle.p.jensen.nfg@mail.mil	NYARNG Stakeholder
Greg Austin	NYARNG Headquarters	gregory.t.austin.nfg@mail.mil	NYARNG Stakeholder
LTC Robert Zizolfo	NYARNG, Camp Smith	Robert.zizolfo.mil@mail.mil	Camp Smith Stakeholder
CW2 David Morton	NYARNG, Camp Smith	david.t.morton.mil@mail.mil	Camp Smith Stakeholder
Michael Murphy	NYSDEC	michael.murphy1@dec.ny.gov	NYSDEC Attorney
John Swartwout	NYSDEC, DER	john.swartwout@dec.ny.gov	NYSDEC Section Chief
Amen Omorogbe	NYSDEC, DER	amen.omorogbe@dec.ny.gov	NYSDEC Program Manager
Dan Lanners	NYSDEC, DER	daniel.lanners@dec.ny.gov	NYSDEC Project Manager
Jennifer Dawson	NYSDEC, DFWMR	jennifer.dawson@dec.ny.gov	NYSDEC Aquatic Biologist
Heather Gierloff	NYSDEC, DFWMR	heather.gierloff@dec.ny.gov	NYSDEC Aquatic Biologist
Vince Williams	EA	vwilliams@eaest.com	EA Project Manager
Jennifer Martin Bouchard	EA	jmartinbouchard@eaest.com	EA Deputy Project Manager
Mike Ciarlo	EA	mciarlo@eaest.com	EA RI Technical Lead
Frank DeSantis	EA	fdesantis@eaest.com	EA Project Scientist

NOTE:
USACE = U.S. Army Corps of Engineers
ARNG = Army National Guard
NYARNG = New York Army National Guard
NYSDEC = New York State Department of Environmental Conservation
DER = Division of Environmental Remediation
DFWMR = Division of Fish, Wildlife, and Marine Resources
EA = EA Engineering, P.C., and its Affiliate EA Science and Technology

Comments

A Technical Project Planning meeting was held to discuss the results of the Supplemental ORA Phase II report and to develop a path forward for the site. Key points discussed during the meeting included changes to the operational range boundary and results of the sampling conducted to date. This sampling included additional sediment and toxicology data collected within the "hot spot" area that had been identified in the tidal marsh during previous rounds of sampling. The National Guard Bureau offered to collect additional samples to be used in a feasibility evaluation of the "hot spot" area. NYSDEC indicated that the hot spot is already well defined and they would advocate for remediation (through removal) for areas where lead concentrations exceed 1,000 milligrams per kilogram (mg/kg). NYSDEC also asked about: (1) additional sampling planned for the Annsville Creek Impoundment, (2) whether there is an existing Best Management Plan (BMP) for Camp Smith or if guidance for BMPs are available, and (3) if BMPs are planned at other ranges (in addition to the work that has been completed to date at Range 1A/1B). The regulatory status of the investigation/cleanup was also discussed and all parties agreed that the investigation/cleanup would remain voluntary. NYSDEC indicated that they would provide formal comments to the Supplemental ORA Phase II report by early March 2017.

Site Name/Project Name:	Camp Smith Remedial Investigation
Site Location:	Conference call
Date of Session:	21 June 2017
Scoping Session Purpose:	Discuss strategy for the BMP study at Range 1A/1B recommended in response to NYSDEC comments to the Supplemental ORA Phase II report

Name	Affiliation	E-mail Address	Project Role
Tim Peck	USACE-Baltimore District	timothy.j.peck@usace.army.mil	USACE Project Manager
Michael Mackiewicz	ARNG Directorate	michael.c.mackiewicz.civ@mail.mil	ARNG Directorate Project Manager
Vince Williams	EA	vwilliams@eaest.com	EA Project Manager
Jennifer Martin Bouchard	EA	jmartinbouchard@eaest.com	EA Deputy Project Manager
Frank DeSantis	EA	fdesantis@eaest.com	EA Project Scientist

NOTE:
USACE = U.S. Army Corps of Engineers
ARNG = Army National Guard
NYARNG = New York Army National Guard
NYSDEC = New York State Department of Environmental Conservation
DER = Division of Environmental Remediation
DFWMR = Division of Fish, Wildlife, and Marine Resources
EA = EA Engineering, P.C., and its Affiliate EA Science and Technology

Comments

A conference call was held to discuss the strategy for the BMP study at the Range 1A/1B "source area" based on comments received from NYSDEC on the Supplemental ORA Phase II report. All parties came to agree upon the proposed additional sampling in the Range 1A/1B area. The additional sampling includes projectile fragment counts in a subset of test grids located throughout the historical berm area of Range 1A/1B, projectile fragment counts in Putnam Brook in the reach that transects the historical Range 1A/1B firing fan, soil sampling using field X-ray fluorescence (XRF) analysis and laboratory confirmation to delineate the extent of lead impacts in soil in the upland range fan area, and surface water sampling upstream of Range 1A/1B, downstream of Range 1A/1B, and at the outlet of the tidal marsh.

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QAPP Worksheet #10B
Conceptual Site Model

The conceptual site model (CSM) for the Camp Smith tidal marsh was presented in Worksheet #10 of the Final QAPP (Appendix A of the RI Work Plan) (EA 2014) and was updated and presented in the Final ORA Supplemental Phase II Quantitative Assessment Report (EA 2016) for the Camp Smith Training Site. Results of the Supplemental ORA Phase II investigation indicated that metals migrating from the upstream small arms ranges were being bound in tidal marsh sediments, thereby limiting bio-availability and impacts to potential human and/or ecological receptors located farther downstream in off-range areas. Based on a review of previous investigations (including the ORA Phase II and the Supplemental ORA Phase II investigations), it was determined that Range 1A/1B was the primary source of lead (EA 2016).

During the 1996 Aquatic Resources Survey at Camp Smith, surface water and sediment samples were collected from a location within Putnam Brook downstream from Range 1A/1B (EA 2009, 2016). Lead was not detected in the surface water sample, and the lead concentration in sediment was within Class A thresholds. Additional surface water, sediment, and soil samples were collected on and adjacent to Range 1A/1B as part of the 1997 Evaluation of Small-Arms Range Lead Contamination at Camp Smith. All surface water samples (including those collected immediately downstream of Range 1A/1B) exceeded NYSDEC Ambient Water Quality Standards (AWQS) chronic criteria for lead including two background samples; however, the dissolved lead concentrations in samples downstream of the firing ranges were four times greater than the Putnam Brook upstream reference sample. Lead concentrations in sediment samples collected immediately downstream from Range 1A/1B and from the Putnam Brook tributary adjacent to Range 1A/1B exceeded the Class C threshold. The sediment sample collected from Putnam Brook upstream of Range 1A/1B was within the Class B threshold for lead. A single surface soil sample was collected from the Range 1A/1B impact berm located immediately west of Putnam Brook. The reported lead concentration exceeded the NYSDEC Restricted Use – Industrial Soil Cleanup Objective.

During site walks conducted as part of the ORA Phase II investigation site reconnaissance, projectiles and projectile fragments were observed within the Putnam Brook stream channel within and downstream of Range 1A/1B. This indicates that migration and direct deposition of projectiles into Putnam Brook, as a result of small arms firing on the range, had occurred. Conclusions presented in the ORA Phase II investigation indicated that previous investigations, and surface water and sediment data collected as part of the ORA Phase II, provided compelling evidence that a release of munitions constituents of concern (MCOC) is occurring and is likely originating from operational small arms ranges located along Putnam Brook, specifically Range 1A/1B (EA 2016). Based on a review of previous investigations and the conclusions and recommendations made as part of the Supplemental ORA Phase II investigation, it was determined that the dominant mechanism for the introduction of metals into Putnam Brook (and eventual transport to the tidal marsh) was through historical small-arms firing on Range 1A/1B, which is located approximately 1,500 feet (ft) upstream of the tidal marsh (Figure 10B-1) (EA 2016).

Until 2015, firing at Range 1A/1B was directed at targets located east of Putnam Brook with bullets impacting the hillslope located west of Putnam Brook. Putnam Brook flows along the base of this slope and receives runoff directly from the hill. To limit future metals loading into Putnam Brook, the ARNG implemented range Best Management Practices in 2015 by implementing a range realignment.

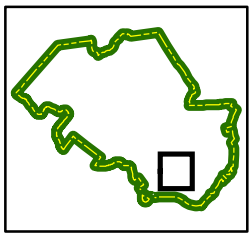
Range 1A/1B has been realigned with the addition of newly configured berms designed to prevent the direct deposition and limit migration of lead into Putnam Brook (Figure 10B-1). The range is now bermed on three sides, and all impacts are contained within the range footprint. The stable slope design of the berms minimizes the potential for metals transport from the range by mitigating the load-capacity of erosion and migration of sediment in stormwater runoff. Erosion and stormwater runoff are further limited by the vegetative cover established on the berm faces.

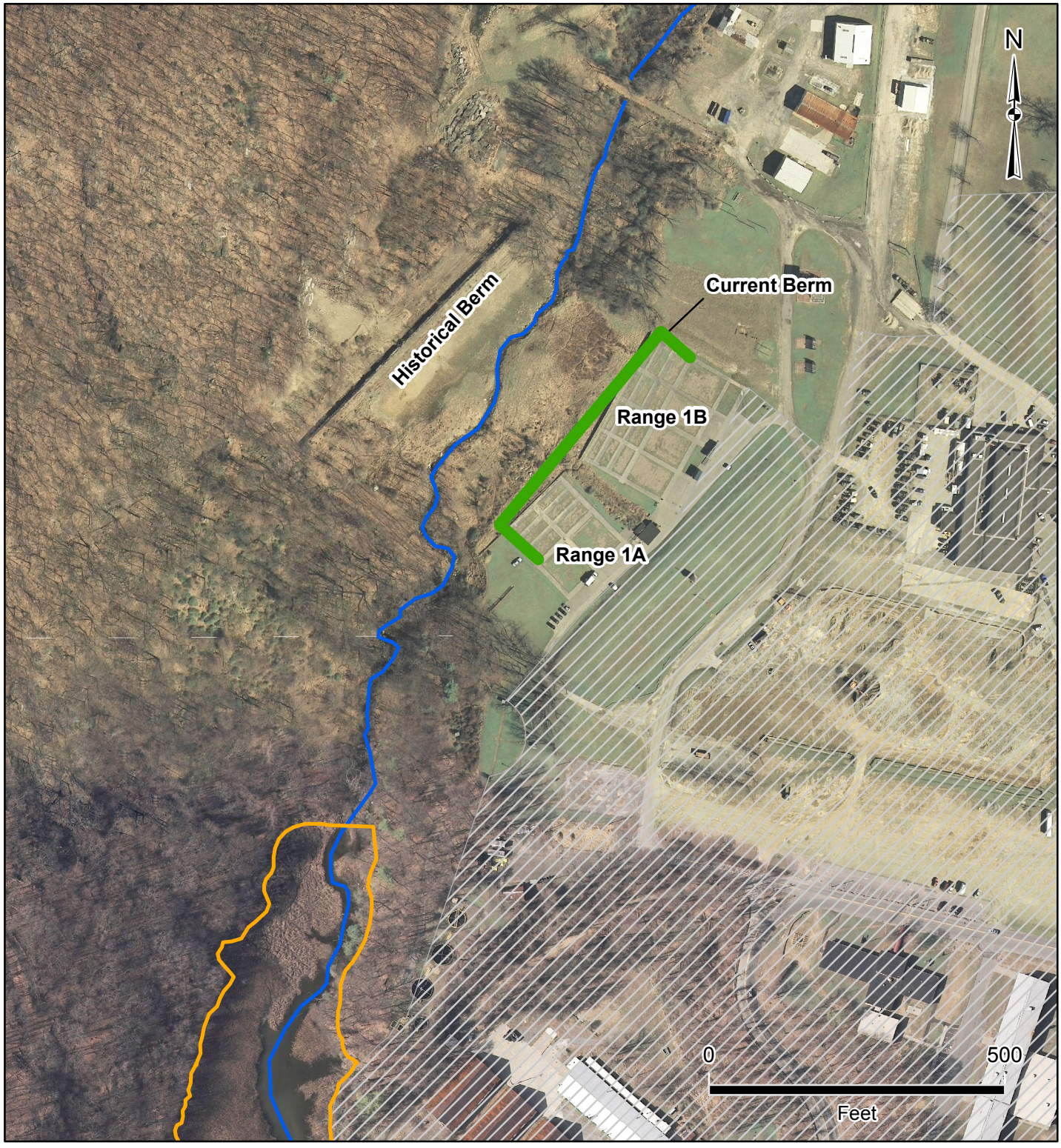
Limiting chemical migration is an important part of any lead management program for active ranges. Lead has greater mobility in soils and sediments with low pH values because acidity facilitates lead corrosion. Adding lime, in the form of limestone, can neutralize acidic soils and sediments, minimizing the potential for metallic lead to speciate into more soluble forms (U.S. Environmental Protection Agency [EPA] 2005). The incorporation of limestone as a substrate in the drainage ditches in the Range 1A/1B realignment aids in buffering the pH of sediments and receiving waters. This is expected to decrease the solubility of lead in surface waters and sediment porewater, decreasing the concentrations that are carried downstream.

While the range reconfiguration is expected to eliminate future lead deposition and/or migration of metals into Putnam Brook from Range 1A/1B, the historical Range 1A/1B berm and Putnam Brook stream bed at the base of the berm remains a source of metals munitions constituents (MC). Although sampling has been conducted on and adjacent to Range 1A/1B in the past, the data are limited (e.g., one on-range soil sample collected from the impact berm) and are insufficient to determine the nature and extent of lead present on and immediately downstream from historical portions of Range 1A/1B. To fill this data gap, a series of projectile fragment counts will be completed in order to provide an estimate of total projectile mass remaining within historical portions of Range 1A/1B. Additionally, soil samples will be collected from areas surrounding the historical Range 1A/1B area to delineate the horizontal extent of metals (i.e., lead) impacts originating from historical use of the range. Supplemental surface water samples will be collected from Putnam Brook upstream and downstream of Range 1A/1B and at the outlet of the Camp Smith tidal marsh to further characterize lead concentrations in surface water.

QAPP Addendum No. 2
for Remedial Investigation
Camp Smith Training Site, NY

Figure 10B-1
Camp Smith Range 1A/1B
Location and Best Management Practices





Legend

- Range 1A/1B Current Impact Berm - Constructed during implementation of Best Management Practices in 2015
- Non-Operational Area
- Camp Smith Tidal Marsh
- Putnam Brook

Data Sources:
Orthoimagery from NYSDMNA 2015
Tidal marsh boundary digitized from available orthoimagery.

Date:.....September 2017

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QAPP Worksheet #11B
Project/Data Quality Objectives

This worksheet is used to develop and document project data quality objectives (DQOs) using a systematic planning process that follows the EPA DQO Process and documents the environmental decisions that need to be made and the level of data quality needed.

THE PROBLEM TO BE ADDRESSED BY THE PROJECT

Based on a review of previous investigations and the conclusions and recommendations made as part of the Supplemental ORA Phase II investigation, it was determined that the dominant mechanism for the introduction of metals into Putnam Brook (and eventual transport to the tidal marsh) was through historical small-arms firing on Range 1A/1B, which is located approximately 1,500 ft upstream of the tidal marsh (Figure 10B-1).

Until 2015, firing at Range 1A/1B was directed at targets located east of Putnam Brook with bullets impacting the hillslope located west of Putnam Brook. Putnam Brook flows along the base of this slope and receives runoff directly from the hill. To limit future metals loading into Putnam Brook, the ARNG implemented range Best Management Practices in 2015 by implementing a range realignment. While the range reconfiguration is expected to eliminate future lead deposition and/or migration of metals into Putnam Brook from Range 1A/1B, the historical Range 1A/1B berm and Putnam Brook stream bed at the base of the berm remains a significant source of metals MC that should be addressed. Although sampling has been conducted on and adjacent to Range 1A/1B in the past, the data are limited (e.g., one on-range soil sample collected from the impact berm) and are insufficient to determine the nature and extent of lead present on and immediately downstream from historical portions of Range 1A/1B.

GOALS OF THE STUDY

The Range 1A/1B investigation will provide additional data that will be used to define the nature and extent of the remaining metals source area associated with historical portions of Range 1A/1B. Data will be collected in sufficient quantity to fill the data gaps identified above and will be used to estimate the total projectile mass remaining within historical portions of Range 1A/1B, delineate the horizontal extent of metals (i.e., lead) impacts surrounding the historical Range 1A/1B area, and further characterize lead concentrations in Putnam Brook surface water both upstream and downstream of Range 1A/1B.

INFORMATION INPUTS AND STUDY BOUNDARIES

To provide an estimate of total projectile mass and to delineate the horizontal extent of metals impacts, the following data will be collected:

- Soil samples will be collected for counts of visible, lead projectile fragments from the top 0-6 inches (in.) of soil at 18 locations (i.e., grid squares) within distinct portions of the historical Range 1A/1B area to define the nature of contamination and estimate the total projectile mass remaining within historical portions of the range.

- Sediment samples will be collected for counts of visible, lead projectile fragments from the top 0-6 in. of sediment at 12 locations within the Putnam Brook stream channel within and downstream of the historical Range 1A/1B area to define the nature of contamination and estimate the total projectile mass remaining within Putnam Brook as a result of migration and direct deposition from historical portions of the range.

- Soil samples will be collected for XRF field screening of lead from the top 0-6 in. of soil from a minimum of 20 locations (i.e., grid squares) in areas surrounding the historical Range 1A/1B berm and impact area to define the horizontal extent of metals (i.e., lead) impacts.

- Surface water samples will be collected as grab samples at three locations within Putnam Brook both upstream and downstream of the historical Range 1A/1B area to further characterize lead concentrations in Putnam Brook surface water both upstream and downstream of historical portions of the range.

- A subset of soil samples collected for XRF field screening will be submitted for confirmatory laboratory analysis.

Soil samples submitted to the laboratory will be analyzed for metals MC. The sample design and rationale are discussed in Worksheet #17B. Worksheet #18B summarizes the sampling program (including target analytes, analytical groups, and sample collection methods) that is proposed to satisfy the scope of the investigation.

Figures included in Worksheet #17 (i.e., Figures 17B-1, 17B-2, and 17B-3 present the proposed soil, sediment, and surface water sampling locations; thereby, defining the lateral boundaries for the sample media. The temporal extent of the field activities to be performed under this plan is Fall 2017.

ANALYTICAL APPROACH AND PLAN FOR OBTAINING DATA

Soil will be collected for counts of visible, lead projectile fragments within the historical Range 1A/1B area from the top 0-6 in. of soil at 18 locations. Sample locations will target distinct portions of the historical range (i.e., southeast of Putnam Brook and the historical berm/impact area) and will be selected to provide adequate coverage of the historical range area.

Sediment samples will be collected for counts of visible, lead projectile fragments from the top 0-6 in. of sediment at 10 locations within the Putnam Brook stream channel as it flows through the historical range area. Two additional sediment samples will be collected for counts of visible, lead projectile fragments downstream of the historical range area; one upstream from the falls into the Camp Smith tidal marsh and one downstream of the falls.

Soil will also be collected from areas surrounding the historical Range 1A/1B berm and impact area from the top 0-6 in. of soil at a minimum of 20 locations. These samples will be analyzed for lead in the field via XRF. The New York State Restricted Residential Use Soil Cleanup

Objective for lead (i.e., 400 mg/kg) (NYSDEC 2006) will be used as the limit to delineate the horizontal extent of metals impacts. A subset of soil samples used for XRF field screening will be split and submitted for laboratory analysis of metals MC.

Surface water samples will be collected as grab samples during periods of low tide at three locations within Putnam Brook (upstream of the historical Range 1A/1B area, downstream of the historical Range 1A/1B area and upstream of the falls into the Camp Smith tidal marsh, and at the outlet of the Camp Smith tidal marsh).

PERFORMANCE OR ACCEPTANCE CRITERIA

Projectile fragment counts and associated soil sampling will be completed in accordance with EA Standard Operating Procedure (SOP) No. 25 and SOP No. 25a. XRF samples will be collected and analyzed in accordance with EA SOP No. 56a. Laboratory analyses of confirmatory soil samples will be performed by a Department of Defense and New York State Department of Health (NYSDOH) Environmental Laboratory Approval Program (ELAP)-certified laboratory, using the most current NYSDEC Analytical Services Protocol (ASP) methods, as per NYSDEC Division of Environmental Remediation-10 guidance (2010). As per NYSDEC ASP requirements, Category B laboratory data packages will be obtained for data validation. Following the receipt of analytical laboratory results, Data Usability Summary Reports will be prepared by an independent third-party. Data validation changes will be incorporated into the electronic data deliverables. Per EA SOP No. 56a, a least squares regression analysis will be conducted for lead in order to assess the comparability of the XRF field screening data and confirmatory data obtained from laboratory analysis.

Additional detail on sampling methodology, analyses, and equipment is provided in subsequent QAPP Addendum No. 2 worksheets.

DEVELOP A DETAILED PLAN FOR DATA COLLECTION

Worksheet #17B provides the sample design and rationale; Worksheet #18B provides additional detail on sample locations, media, suite of analytes, and sample collection tools; and Worksheet #20B provides information on QC samples. Worksheets #26 through #28 of the original QAPP (EA 2014) provide specific detail on the analytical requirements.

DATA USE AND ANALYSIS

The project goal of the historical Range 1A/1B investigation is to define the nature and extent of the remaining metals source area associated with historical portions of Range 1A/1B, and to support future range Best Management Practices that will further mitigate the transport of metals (primarily lead) into Putnam Brook and the tidal marsh. Evaluation of impacts within the historical range will focus on estimating the total mass of projectiles remaining in the historical range area and delineating the horizontal extent of metals (i.e., lead) impacts. Data collected as part of the historical Range 1A/1B investigation will be used to:

- Produce tables showing projectile fragment count results for each sample location and an estimate of total projectile mass.

- Produce maps showing the estimated distribution and density of projectiles.

- Produce tables showing lead concentrations detected during XRF field screening and confirmatory soils analysis.

- Produce maps showing lead concentrations detected during XRF field screening and the estimated horizontal extent of lead impact.

- Produce tables and maps showing lead concentrations detected during surface water sample analysis.

- Provide recommendations for future BMPs at the historical Range 1A/1B area.

QAPP Worksheet #12B
Measurement Performance Criteria

Matrix:	**Soil**
Analytical Group:	**Lead – XRF (field)**
Concentration Level:	**Low**

Sampling Procedure	Analytical Method / SOP	Quality Control Sample and/or Activity Used to Assess Measurement Performance	Data Quality Indicators	Measurement Performance Criteria	Quality Control Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
SOP 5, SOP 15, SOP 16, SOP 25, SOP 56a	EPA SW846 6200 / EA SOP 56a	Duplicate	Precision	≥20% RPD	S&A
		Standard reference material	Accuracy	80-120% of actual concentration	A
		Instrument blank	Accuracy	Non-detect	A
		Site sample with lead ~XX mg/kg, analyzed 10 times in succession	Precision	<20% Relative Standard Deviation	A
		Data completeness check	Completeness	95%	S&A

NOTES: EPA = U. S. Environmental Protection Agency.
mg/kg = Milligram(s)/kilogram.
RPD = Relative Percent Difference.
SOP = Standard operating procedure.
XRF = X-ray fluorescence.

Matrix:	Soil
Analytical Group:	Metals - Confirmatory
Concentration Level:	Low

Sampling Procedure	Analytical Method / SOP	Quality Control Sample and/or Activity Used to Assess Measurement Performance	Data Quality Indicators	Measurement Performance Criteria	Quality Control Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
SOP 1, SOP 2, SOP 3, SOP 4, SOP 5, SOP 15, SOP 16, SOP 25, SOP 31, SOP 39	SOP #3.4; EPA SW6020A (antimony, copper, lead, and zinc only)	Not applicable	Completeness	90%	S&A
		Field duplicate	Precision	≤50% RPD	S&A
		Blanks (method blank and field blanks)	Accuracy/bias/ contamination	≤½ of the limit of quantitation	A
		Initial calibration blank and continuing calibration blanks	Accuracy/bias/ contamination	<Limit of detection	A
		ICV and CCV	Accuracy/bias	≤10%Recovery	A
		Low-level calibration check (only if one-point calibration is used)	Accuracy/bias	≤20%Recovery	A
		ICS	Accuracy/bias	ICS-A: the non-spiked analytes < limit of quantitation, ICS-AB: within ±20% of expected value	A
		Laboratory control sample, matrix spike, and matrix spike duplicate	Accuracy	%Recovery, DoD Quality Systems Manual (Version 5.0) limits	A
		Laboratory control sample duplicate and matrix spike duplicate	Precision	≤20% RPD	A
		Serial dilution	Accuracy/bias	5-fold dilution within ±10% of original value	A
		Post-digestion spike	Accuracy/bias	Within ±25% of expected value	A

NOTES: CCV = Continuing calibration verification.
DoD = Department of Defense.
EPA = U.S. Environmental Protection Agency.
ICS = Interfering element check standards.
ICV = Initial calibration verification.
RPD = Relative Percent Difference.
SOP = Standard operating procedure.

QAPP Worksheet #15B

Reference Limits for Soil

Analyte	Analytical Method	CAS	Units	PAL[1, 2]	QAPP RLs[3]	Achievable Laboratory Limits			Laboratory
						LOQ	LOD	MDL	
Total Metals									
Antimony	EPA SW6020A	7440-36-0	mg/kg	NS	1.0	1.0	0.5	0.0054	Accutest
Copper	EPA SW6020A	7440-50-8	mg/kg	270	27	2.0	1.0	0.2	Accutest
Lead	EPA SW6020A	7439-92-1	mg/kg	400	40	1.0	0.5	0.0029	Accutest
Zinc	EPA SW6020A	7440-66-6	mg/kg	10,000	1,000	2.0	1.5	0.093	Accutest

1. NYSDEC Division of Environmental Remediation. 2006. 6 NYCRR Part 375 Environmental Remediation Programs, Table 375-6.8(b): Restricted Use SCOs, Restricted Residential. December.
2. Analytes with NS for PAL will have the QAPP RL set at the achievable laboratory LOQ.
3. QAPP RLs are set to one-tenth the PAL, if achievable. If not achievable (lower than the LOQ) the QAPP RLs are set to at least one-third the PAL.

NOTE: CAS = Chemical Abstract Service.
PAL = Project Action Limit.
QAPP = Quality Assurance Project Plan.
RL = Reporting Limit.
LOQ = Limit of Quantitation.
LOD = Limit of Detection.
MDL = Method Detection Limit.
NS = No Standard.
EPA = U.S. Environmental Protection Agency.
NYSDEC = New York State Department of Environmental Conservation.
NYCRR = New York Code of Rules and Regulations.
SCO = Soil Cleanup Objective.

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QAPP Worksheet #17B
Sample Design and Rationale

Applicable field sampling methodologies and activities (e.g., surface water sampling) will be consistent with those detailed in the QAPP for the RI Work Plan (EA 2014) unless noted in the sections below. Additional information regarding the number of samples to be taken and sampling frequency is presented in Worksheets #18B and #20B. Prior to identification of sampling locations, a grid consisting of 50-ft by 50-ft grid squares was placed over the historical Range 1A/1B area. The grid was used in development of the sample design as identified in the sections below.

PROJECTILE FRAGMENT COUNTS

A total of 18 locations (i.e., 20 percent of the grid squares) within distinct portions of the historical Range 1A/1B area have been designated for soil sampling and subsequent projectile fragment counts (Figure 17B-1). Sampling locations were biased to the central portions of the historical Range 1A/1B area and were also selected to provide adequate coverage of each distinct area of the historical range (i.e., southeast of Putnam Brook and the historical berm/impact area). Soil sampling locations designated for projectile fragment counts will be pre-loaded into a high-precision global positioning system (GPS) unit that will be used to navigate to each sampling location in the field. Once located, samples will be collected from the centroid of the grid square using a hand auger and placed into plastic bags for transport and storage. The bag will be sealed for transport and labeled with sample identification information as described in the section below.

Ten locations within the Putnam Brook stream channel (as it flows through the historical Range 1A/1B area) have been designated for sediment sampling and subsequent projectile fragment counts. The length of Putnam Brook within the historical Range 1A/1B area was measured using aerial imagery. The 10 sampling locations were established at even intervals, longitudinally, throughout the stream but may be adjusted in the field to capture variations in stream channel morphology (e.g., point bars, riffles, and pools).. Two additional sediment samples will be collected for projectile fragment counts downstream of the historical Range 1A/1B area; one upstream from where Putnam Brook falls into the Camp Smith tidal marsh and one downstream from the falls (Figure 17B-2).[1] Sediment sampling locations designated for projectile fragment counts will be pre-loaded into a high-precision GPS unit that will be used to navigate to each sampling location in the field. Samples will be collected using a hand auger and placed into plastic bags for transport and storage. Samples will be collected at each location from the top 0-6 in. of sediment. The bag will be sealed for transport and labeled with sample identification information as described in the section below.

Soil and sediment samples will either be processed onsite or transported to an EA office. Projectile fragment counts and estimates of total projectile mass remaining at the historical Range 1A/1B will be completed in accordance with EA SOP No. 25a (Attachment 1).

[1] Sediment sampling locations may be modified in the field depending on observations of stream conditions and morphology.

XRF FIELD SCREENING

A minimum of 20 locations (i.e., grid squares) surrounding the historical Range 1A/1B berm and impact area have been designated for soil sampling and subsequent XRF field screening (Figure 17B-3). Sampling locations were selected in areas surrounding the historical impact area and berm to delineate the horizontal extent of lead impacts in soil. Soil sampling locations designated for XRF field screening will be pre-loaded into a high-precision GPS unit that will be used to navigate to each sampling location in the field.

Soil samples will initially be collected from the centroid of each grid square using a decontaminated stainless steel hand auger from the top 0-6 in. of soil and placed into a plastic bag. Samples will be homogenized in the plastic bag, and any foreign particles will be removed (including projectiles and projectile fragments) to provide an accurate average lead concentration for the soil sample. The bag will be sealed for transport and labeled with sample identification information as described in the section below. Soil samples will be transported to a covered staging area to be established southeast of the historical range area. XRF field screening will be completed to delineate the extent of lead in soil greater than 400 mg/kg surrounding the historical berm and impact area. XRF field screening will be conducted in accordance with EA SOP No. 056a.

Based on initial XRF sampling results, additional soil samples may be collected at up to 30 additional sampling locations. The additional samples would be collected to provide further delineation of lead impacts surrounding the historical berm and impact area, as needed, moving in a step-wise approach across the grid. For example, if an XRF field screening result indicates that the lead concentration in soil is greater than 400 mg/kg at one of the sampling locations, then an additional sample would be collected 50-ft away from the original location moving in an outward direction (i.e., further away from areas of higher lead concentration). If the original sampling location was at the extent of the sampling grid, a new grid square will be established for collection of the additional sample.

Confirmatory samples collected as splits of homogenized sample material will be submitted for laboratory analysis for metals MC at a rate of one sample for every five XRF-analyzed samples. The samples will be selected in the field to encompass the lower, middle, and upper range of lead concentrations measured by the XRF. They will also include samples with lead concentrations at or near the project action limit of 400 mg/kg. The results of the confirmatory analysis and XRF analyses will be evaluated with a least squares linear regression analysis. If the measured concentrations span more than one order of magnitude, the data will be log-transformed to standardize variance, which is proportional to the magnitude of measurement. The correlation coefficient (r) for the results should be 0.7 or greater for the XRF data to be considered screening-level data. If the r is 0.9 or greater and inferential statistics indicate the XRF data and the confirmatory data are statistically equivalent at a 99 percent confidence level, the data may meet definitive level data criteria (EPA 2007).

SURFACE WATER

Surface water samples will be collected as grab samples at three locations within Putnam Brook

(upstream of the historical Range 1A/1B area, downstream of the historical Range 1A/1B area and upstream of the falls into the Camp Smith tidal marsh, and at the outlet of the Camp Smith tidal marsh) (Figure 17B-2). Surface water sampling will begin at the outlet of the Camp Smith tidal marsh during low tide and progress upstream away from tidally influenced reaches of Putnam Brook. Surface water sampling methodologies will be consistent with those detailed in the QAPP for the RI Work Plan (EA 2014).

SAMPLE IDENTIFICATION

Projectile Fragment Counts (Soil)

2-SO-B3-PC = (QAPP Addendum No.-Media/Type-Grid Location-Test Type)

Media/Type	QA/QC	Test Type
SO – Soil	Not applicable	PC – Projectile Fragment Count

Projectile Fragment Counts (Sediment)

2-SD-01-PC = (QAPP Addendum No.-Media/Type-Sample Location[2]-Test Type)

Media/Type	QA/QC	Test Type
SD – Sediment	Not applicable	PC – Projectile Fragment Count

XRF Field Screening

2-SO-B1-MS-XRF = (QAPP Addendum No.-Media/Type-Grid Location-QA/QC-Test Type)

Media/Type	QA/QC	Test Type
SO – Soil	FD – Field Duplicate EB – Equipment Blank MS – Matrix Spike MSD – Matrix Spike Duplicate	XRF – X-Ray Fluorescence

Surface Water

2-SW-05-MS-L = (QAPP Addendum No.-Media/Type-Sample Location[2]-QA/QC-Tide)

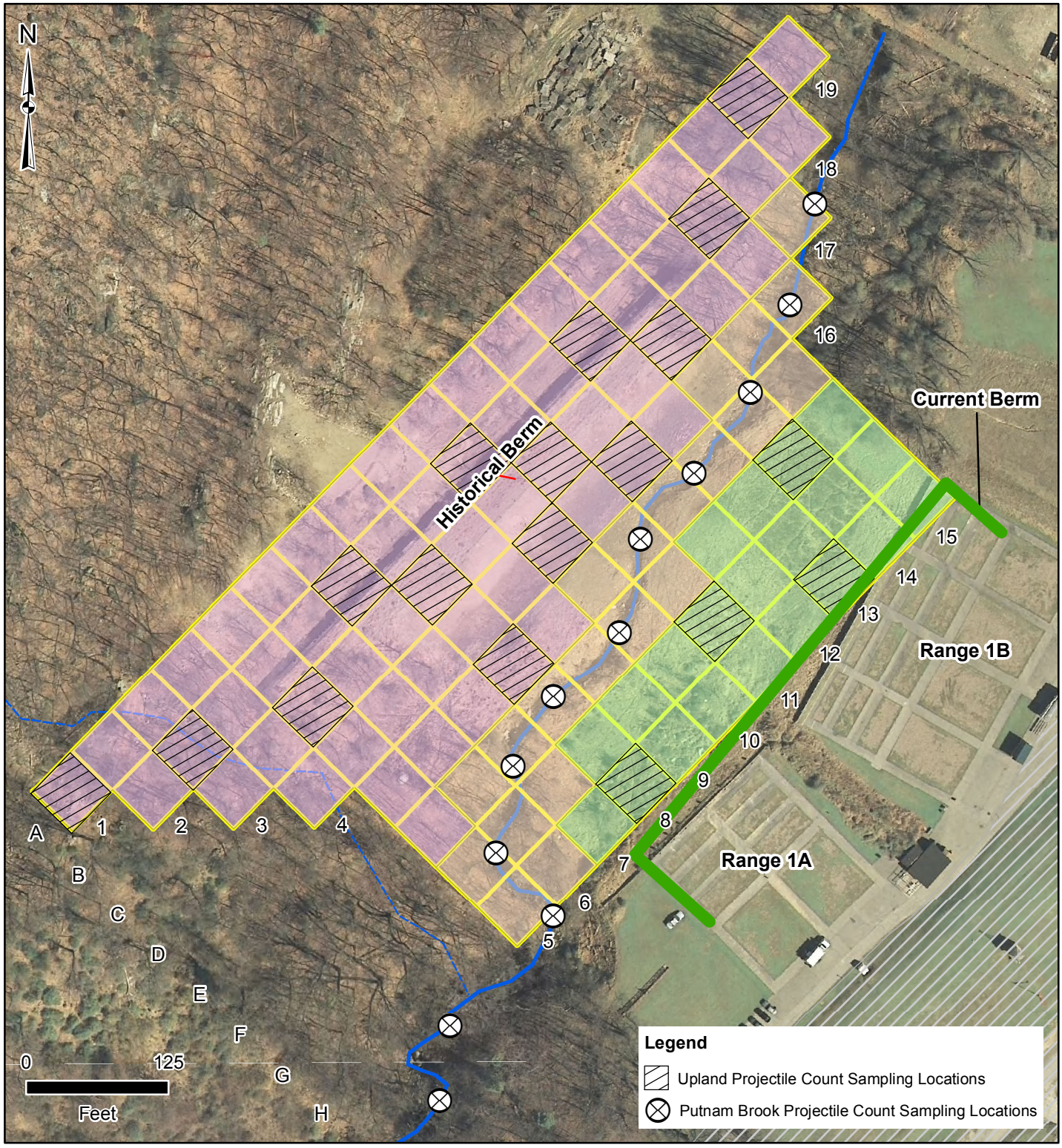
Media/Type	QA/QC	Tide[3]
SW – Surface Water	FD – Field Duplicate EB – Equipment Blank CB – Container Blank MS – Matrix Spike MSD – Matrix Spike Duplicate	L – Low Tide

[2] Sample locations are to be recorded in the field book.
[3] All surface water samples will be collected during periods of low tide.

If one or more components of the file naming convention are not necessary, they will not appear in the Sample ID number (e.g., 2-SO-B1-XRF). Duplicate samples will be labeled 2-SO-FD-MMDDYY. If multiple duplicate samples are taken on same day from same site, "-01," "-02," etc. will be appended to the end of the sample name. Confirmatory samples designated for submittal to the analytical laboratory are splits of homogenized sample material used for XRF field screening and will be assigned the same sample ID number as the native XRF field screening sample ID. Matrix spike and matrix spike duplicate samples will only be collected for confirmatory XRF samples.

QAPP Addendum No. 2
for Remedial Investigation
Camp Smith Training Site, NY

Figure 17B-1
Camp Smith Range 1A/1B
On-Range Projectile Fragment Count Sampling Locations



Legend

- Range 1A/1B 50-ft x 50-ft Sampling Grid
- Non-Operational Area
- Historical Range 1A/1B Impact Area
- Putnam Brook Floodplain
- Putnam Brook Southeast
- Putnam Brook
- Putnam Brook tributary

Data Sources:
Orthoimagery from
NYSDMNA 2015

Date:.....September 2017

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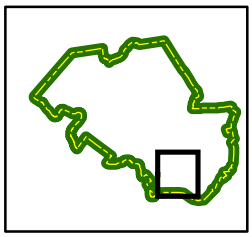
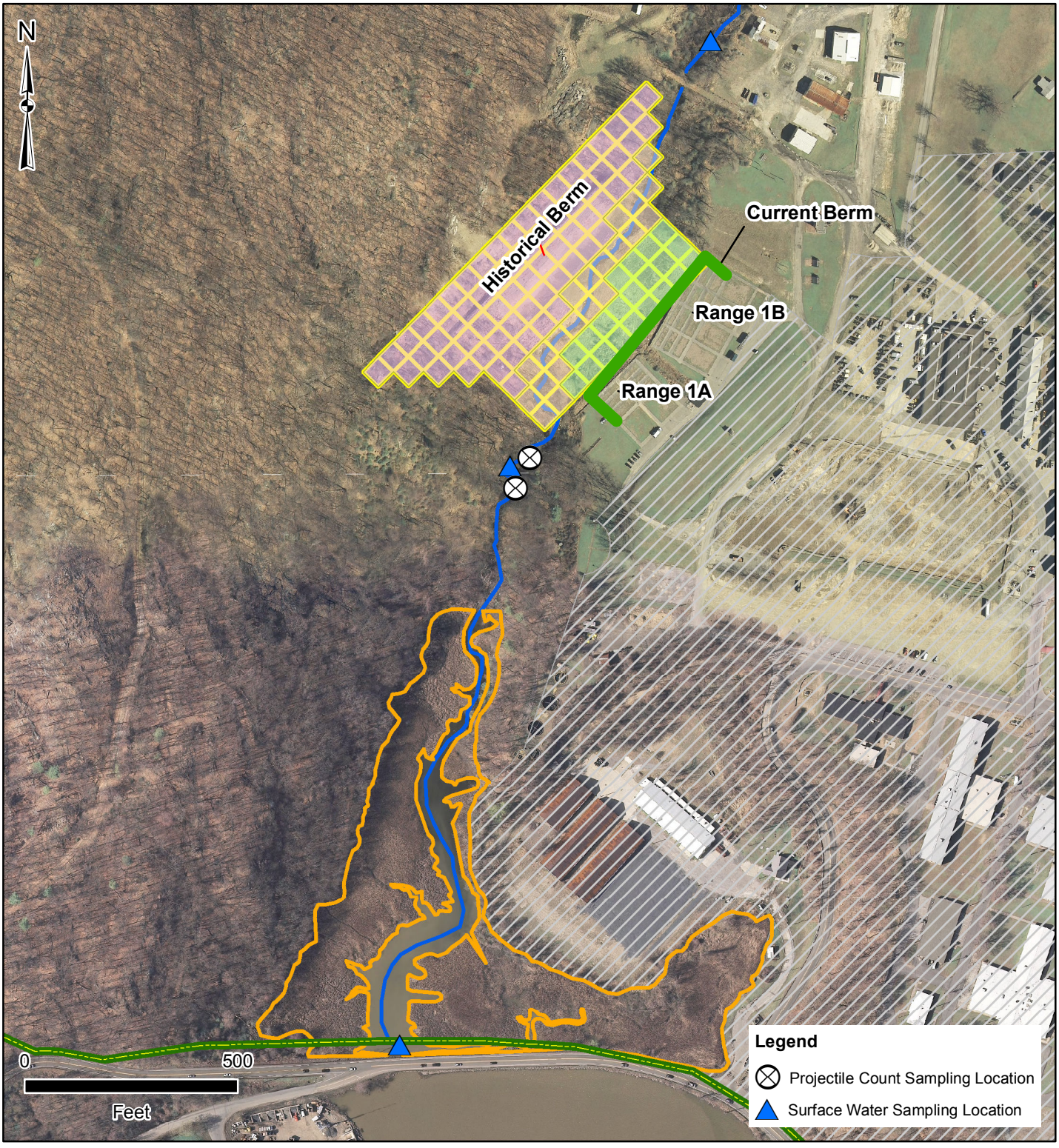
QAPP Addendum No. 2
for Remedial Investigation
Camp Smith Training Site, NY

Figure 17B-2
Camp Smith Range 1A/1B
Putnam Brook Projectile Fragment Count Sampling Locations and Surface Water Sampling Locations





Legend

- Range 1A/1B 50-ft x 50-ft Sampling Grid
- Non-Operational Area
- Installation Boundary
- Historical Range 1A/1B Impact Area
- Putnam Brook Floodplain
- Putnam Brook Southeast
- Putnam Brook
- Camp Smith Tidal Marsh

Data Sources:
Orthoimagery from NYSDMNA 2015
Tidal marsh boundary digitized from available orthoimagery.

Date:.....September 2017

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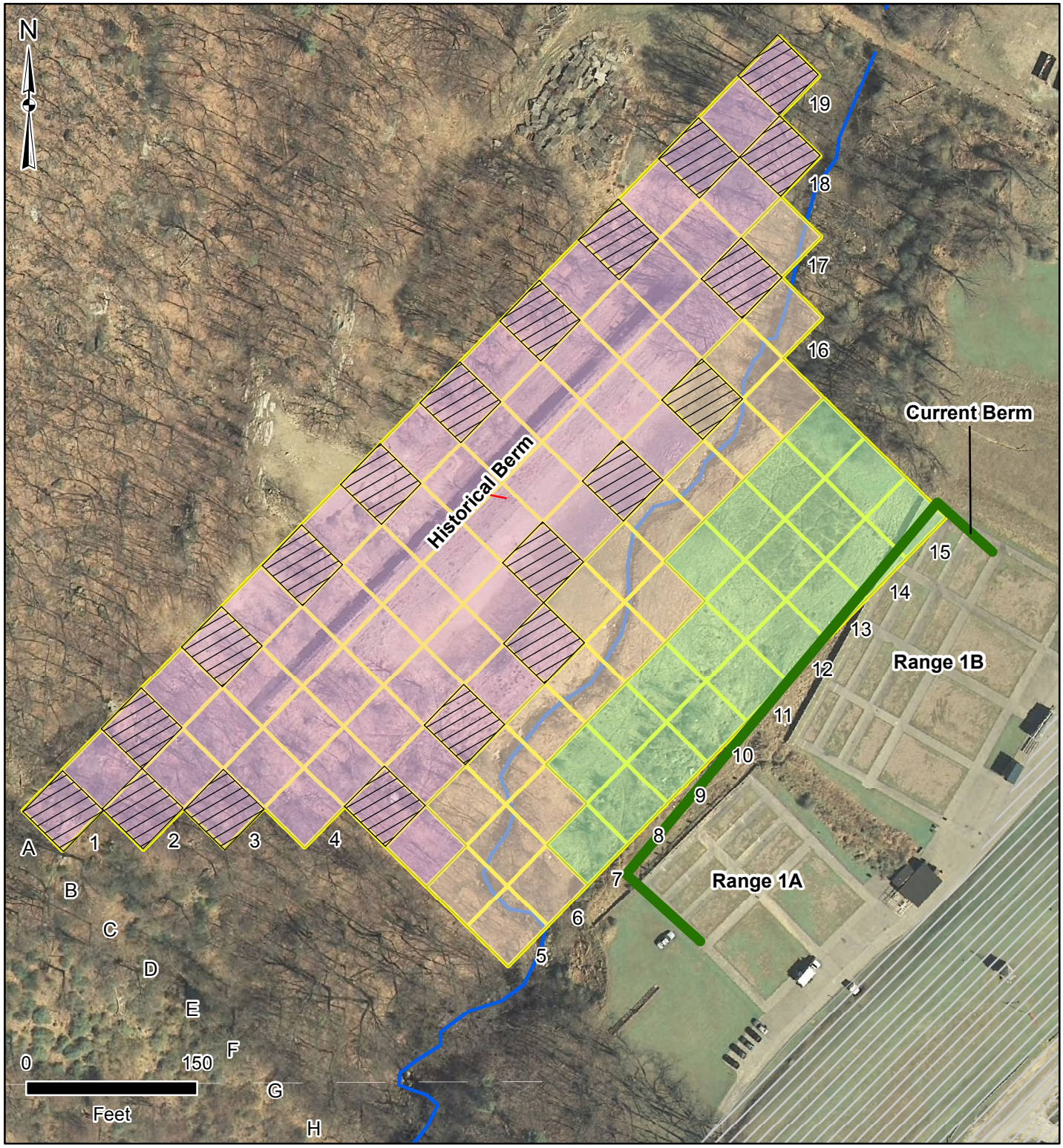
QAPP Addendum No. 2
for Remedial Investigation
Camp Smith Training Site, NY

Figure 17B-3
Camp Smith Range 1A/1B
XRF Field Screening Locations



Legend

- XRF Field Screening Locations
- Range 1A/1B 50-ft x 50-ft Sampling Grid
- Non-Operational Area
- Historical Range 1A/1B Impact Area
- Putnam Brook Floodplain
- Putnam Brook Southeast
- Putnam Brook
- Putnam Brook tributary

Data Sources:
Orthoimagery from
NYSDMNA 2015

Date:.....September 2017

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Table 18B-1 Sampling Locations and Methods

Sampling Location	Sample Identification Number	Matrix	Approximate Depth (in bgs)	Sample Type [1]	Collection Method	Analyte/ Analytical Group [2]	Sampling SOP [3]	Comments
Projectile Fragment Counts (Soil)								
2-SO-A1	2-SO-A1-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-A18	2-SO-A18-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-B3	2-SO-B3-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-B7	2-SO-B7-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-B10	2-SO-B10-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-B13	2-SO-B13-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-B16	2-SO-B16-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-C5	2-SO-C5-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-C8	2-SO-C8-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-C11	2-SO-C11-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-C14	2-SO-C14-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-D10	2-SO-D10-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-D12	2-SO-D12-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-E8	2-SO-E8-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-F14	2-SO-F14-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-G11	2-SO-G11-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None

Table 18B-1 Sampling Locations and Methods

Sampling Location	Sample Identification Number	Matrix	Approximate Depth (in bgs)	Sample Type [1]	Collection Method	Analyte/ Analytical Group [2]	Sampling SOP [3]	Comments
2-SO-H8	2-SO-H8-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
2-SO-H13	2-SO-H13-PC	Soil	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 25, and 25a	None
Projectile Fragment Counts (Sediment)								
2-SD-01	2-SD-01-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-02	2-SD-02-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-03	2-SD-03-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-04	2-SD-04-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-05	2-SD-05-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-06	2-SD-06-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-07	2-SD-07-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-08	2-SD-08-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-09	2-SD-09-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-10	2-SD-10-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-11	2-SD-11-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
2-SD-12	2-SD-12-PC	Sediment	0-6	Primary Field Sample	Hand auger	Projectile Fragment Count	3, 16, 21, and 25a	None
XRF Field Screening[4,5]								
2-SO-A1	2-SO-A1-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None

Table 18B-1 Sampling Locations and Methods

Sampling Location	Sample Identification Number	Matrix	Approximate Depth (in bgs)	Sample Type [1]	Collection Method	Analyte/ Analytical Group [2]	Sampling SOP [3]	Comments
2-SO-A3	2-SO-A3-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-A5	2-SO-A5-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-A7	2-SO-A7-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-A9	2-SO-A9-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-A11	2-SO-A11-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-A13	2-SO-A13-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-A15	2-SO-A15-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-A17	2-SO-A17-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-A19	2-SO-A19-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-B2	2-SO-B2-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-B18	2-SO-B18-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-C3	2-SO-C3-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-C16	2-SO-C16-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-D10	2-SO-D10-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-D12	2-SO-D12-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-D14	2-SO-D14-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None

Table 18B-1 Sampling Locations and Methods

Sampling Location	Sample Identification Number	Matrix	Approximate Depth (in bgs)	Sample Type [1]	Collection Method	Analyte/ Analytical Group [2]	Sampling SOP [3]	Comments
2-SO-E5	2-SO-E5-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-E7	2-SO-E7-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
2-SO-E9	2-SO-E9-XRF	Soil	0-6	Primary Field Sample	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
TBD	2-SO-FD-MMDDYY-XRF	Soil	0-6	Field Duplicate	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
TBD	2-SO-FD-MMDDYY-XRF	Soil	0-6	Field Duplicate	Hand auger	Lead - XRF (field)	5, 15, 16, 25, 56a	None
TBD	TBD	Soil	0-6	Primary Field Sample	Hand auger	Metals - Confirmatory	1-5, 15, 16, 25, 31, 39	None
TBD	TBD	Soil	0-6	Primary Field Sample	Hand auger	Metals - Confirmatory	1-5, 15, 16, 25, 31, 39	None
TBD	TBD	Soil	0-6	Primary Field Sample	Hand auger	Metals - Confirmatory	1-5, 15, 16, 25, 31, 39	None
TBD	TBD	Soil	0-6	Primary Field Sample	Hand auger	Metals - Confirmatory	1-5, 15, 16, 25, 31, 39	None
TBD	2-SO-FD-MMDDYY-XRF	Soil	0-6	Field Duplicate	Hand auger	Metals - Confirmatory	1-5, 15, 16, 25, 31, 39	None
TBD	TBD	Soil	0-6	Matrix Spike/Matrix Spike Duplicate	Hand auger	Metals - Confirmatory	1-5, 15, 16, 25, 31, 39	None
Surface Water Sampling								
2-SW-01	2-SW-01-L	Surface Water	NA	Primary Field Sample	Grab (Peristaltic)	Metals MC, hardness, water quality field parameters	1-5, 7, EPA Method 1669, 15, 16, 31, 39, and 43	None
2-SW-02	2-SW-02-L	Surface Water	NA	Primary Field Sample	Grab (Peristaltic)	Metals MC, hardness, water quality field parameters	1-5, 7, EPA Method 1669, 15, 16, 31, 39, and 43	None

Table 18B-1 Sampling Locations and Methods

Sampling Location	Sample Identification Number	Matrix	Approximate Depth (in bgs)	Sample Type [1]	Collection Method	Analyte/ Analytical Group [2]	Sampling SOP [3]	Comments
2-SW-03	2-SW-03-L	Surface Water	NA	Primary Field Sample	Grab (Peristaltic)	Metals MC, hardness, water quality field parameters	1-5, 7, EPA Method 1669, 15, 16, 31, 39, and 43	None
TBD	2-SW-FD-MMDDYY	Surface Water	NA	Field Duplicate	Grab (Peristaltic)	Metals MC, hardness, water quality field parameters	1-5, 7, EPA Method 1669, 15, 16, 31, 39, and 43	None
TBD	TBD	Surface Water	NA	Matrix Spike/Matrix Spike Duplicate	Grab (Peristaltic)	Metals MC, hardness, water quality field parameters	1-5, 7, EPA Method 1669, 15, 16, 31, 39, and 43	None

1. Quality Assurance / Quality Control samples will be collected at a rate of one per 10 samples for field duplicates and one per 20 samples for MS/MSD per matrix, per analyte group, and per sample delivery group, with the exception of the Projectile Fragment Count analytical group.

2. Metals analyte group includes: antimony, copper, lead, and zinc; as listed in Worksheet #15 and #15B.

3. From the Project Sampling SOP References table (Worksheet #21 and #21B).

4. A total of 20 initial XRF samples are planned; however, 30 additional XRF samples may be collected dependent on field screening results.

5. Confirmatory soil samples will be collected at a rate of 1 sample for every 5 XRF analyzed samples. A total of 20 initial XRF samples are planned; however, 30 additional XRF samples may be collected. The samples will be selected in the field to encompass the lower, middle, and upper range of lead concentrations measured by the XRF.

NOTES:

bgs = Below Ground Surface.
SOP = Standard Operating Procedure.
NA = Not Applicable.
MC = Munitions Constituents.
EPA = U.S. Environmental Protection Agency.
TBD = To Be Determined.
QA/QC = Quality Assurance/Quality Control.
MS/MSD = Matrix Spike/Matrix Spike Duplicate.
XRF = X-ray fluorescence.
DO = Dissolved Oxygen.
ORP = Oxidation-Reduction Potential.

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QAPP Worksheets #19B and 30B
Sample Containers, Preservation, and Hold Times

Laboratory: SGS Accutest Inc. – Orlando, Florida
4405 Vineland Road, Suite C-15
Orlando, Florida 32811
407-425-6700
Point-of-Contact: Andrea Colby <andrea.colby@sgs.com>

List any required accreditations/certifications: Department of Defense ELAP (expires December 2018) and NYSDOH Environmental Laboratory Certification Program (expires April 2018) (Attachment 2).

Back-up Laboratory: None.

Sample Delivery Method: Expedited courier service.

Analyte/ Analytical Group	Matrix	Method / SOP	Accreditation Expiration Date	Container Size/Type	Preservation	Preparation Holding Time	Analytical Holding Time	Data Package Turnaround
Metals – Confirmatory	Soil	SW6020A/ SOP #3.4	See above	(1) 4-ounce glass jar with Teflon®-lined lid	Cool to ≤4°C; not frozen	180 days from sample collection until analysis	Not Applicable	5 working days unless otherwise specified in project planning documents

NOTE: °C = Degrees Celsius.
EPA = U.S. Environmental Protection Agency.
SOP = Standard operating procedure.

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QAPP Worksheet #20B
Field Quality Control Sample Summary

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference	No. of Sampling Locations	Total No. of Samples	No. of Field Duplicate Pairs	No. of MS/MSD	No. of Container Blanks	No. of Equip. Blanks	Total No. of Samples to Lab
Soil	Lead – XRF (field) Worksheet #15B	Low	Worksheets #23B	20[1]	20[1]	2	0	0	4	Not applicable
Soil	Metals - Confirmatory Worksheet #15B	Low	QAPP Worksheets #23 and #28	4[2]	4[2]	1	1/1	0	4	11
Surface Water	Metals QAPP Worksheet #15 (Table 15-2)	Low	QAPP Worksheets #23 and #28	3	3	1	1/1	0	0	6
Surface Water	Hardness QAPP Worksheet #15 (Table 15-2)	Low	QAPP Worksheets #23 and #28	3	3	1	1/1	0	0	6

[1] A total of 20 initial XRF samples are planned; however, 30 additional XRF samples may be collected dependent on field screening results.
[2] Confirmatory soil samples will be collected at a rate of 1 sample for every 5 XRF analyzed samples. A total of 20 initial XRF samples are planned; however, 30 additional XRF samples may be collected. The total number of confirmatory samples will be dependent on the total number of XRF samples analyzed.

NOTES: SOP = Standard Operating Procedure.
MS/MSD = Matrix Spike/Matrix Spike Duplicate.

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QAPP Worksheet #21B
Field Standard Operating Procedures

Field SOPs are included as Attachment 1.

SOP # or Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work (Check if yes)	Comments
SOP-25	Soil Sampling	EA	Various, including shovel/trowel, mixing bowls, labels, sampling jars, field forms, chain-of-custody forms, decontamination supplies.		
SOP-56a	XRF Analysis of Soil Using ThermoScientific/Niton XL3t GOLDD	EA	ThermoScientific/Niton XL3t GOLDD XRF		
Draft SOP-25a	Projectile/Lead Shot Counts	EA	Various, including shovel, storage bags, sieves, field forms.		

NOTES: SOP = Standard operating procedure.
XRF = X-ray fluorescence.

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QAPP Worksheet #22B
Field Equipment Calibration, Maintenance, Testing, and Inspection

Field SOPs are included as Attachment 1.

Field Equipment	Activity	SOP Reference	Title or Position of Responsible Person	Frequency	Acceptance Criteria	Corrective Action
ThermoScientific XL3t GOLDD XRF	Calibration – follow manufacturer's instructions. Calibration verification – a minimum of twice daily using known concentration standard reference material.	SOP 56a and equipment manual	Field personnel	Calibrate daily, before use and when unstable readings occur. Inspect daily when used.	Within calibration standard(s) range.	Cleaning and recalibration
	Maintenance – return to manufacturer for required maintenance	SOP 56a and equipment manual	Instrument manufacturer	As needed	Refer to manufacturer's instructions	Refer to manufacturer's instructions
	Inspect for external damage	SOP 56a and equipment manual	Field personnel	As needed	Refer to manufacturer's instructions	Refer to manufacturer's instructions

NOTES: SOP = Standard operating procedure.
XRF = X-ray fluorescence.

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QAPP Worksheet #23B
Analytical Standard Operating Procedure References

SOP	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
EPA Method 6200	Field Portable XRF Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment. February 2007.	Screening Data	Lead – XRF (field)	ThermoScientific/Niton XL3t GOLDD XRF	EA	
EA SOP No. 056a	XRF Analysis of Soil Using ThermoScientific/Niton XL3t GOLDD	Screening Data	Lead – XRF (field)	ThermoScientific/Niton XL3t GOLDD XRF	EA	

NOTES: EPA = U. S. Environmental Protection Agency.
SOP = Standard operating procedure.
XRF = X-ray fluorescence.

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Attachment 1

Standard Operating Procedures

Contents:

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FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT

SW-846 is not intended to be an analytical training manual. Therefore, method procedures are written based on the assumption that they will be performed by analysts who are formally trained in at least the basic principles of chemical analysis and in the use of the subject technology.

In addition, SW-846 methods, with the exception of required method use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique which a laboratory can use as a basic starting point for generating its own detailed Standard Operating Procedure (SOP), either for its own general use or for a specific project application. The performance data included in this method are for guidance purposes only, and are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

1.0 SCOPE AND APPLICATION

1.1 This method is applicable to the in situ and intrusive analysis of the 26 analytes listed below for soil and sediment samples. Some common elements are not listed in this method because they are considered "light" elements that cannot be detected by field portable x-ray fluorescence (FPXRF). These light elements are: lithium, beryllium, sodium, magnesium, aluminum, silicon, and phosphorus. Most of the analytes listed below are of environmental concern, while a few others have interference effects or change the elemental composition of the matrix, affecting quantitation of the analytes of interest. Generally elements of atomic number 16 or greater can be detected and quantitated by FPXRF. The following RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Antimony (Sb)	7440-36-0
Arsenic (As)	7440-38-0
Barium (Ba)	7440-39-3
Cadmium (Cd)	7440-43-9
Chromium (Cr)	7440-47-3
Cobalt (Co)	7440-48-4
Copper (Cu)	7440-50-8
Lead (Pb)	7439-92-1
Mercury (Hg)	7439-97-6
Nickel (Ni)	7440-02-0
Selenium (Se)	7782-49-2
Silver (Ag)	7440-22-4
Thallium (Tl)	7440-28-0
Tin (Sn)	7440-31-5

Analytes	CAS Registry No.
Vanadium (V)	7440-62-2
Zinc (Zn)	7440-66-6

In addition, the following non-RCRA analytes have been determined by this method:

Analytes	CAS Registry No.
Calcium (Ca)	7440-70-2
Iron (Fe)	7439-89-6
Manganese (Mn)	7439-96-5
Molybdenum (Mo)	7439-93-7
Potassium (K)	7440-09-7
Rubidium (Rb)	7440-17-7
Strontium (Sr)	7440-24-6
Thorium (Th)	7440-29-1
Titanium (Ti)	7440-32-6
Zirconium (Zr)	7440-67-7

1.2 This method is a screening method to be used with confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnance atomic absorption spectrometry (GFAA), inductively coupled plasma-atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)). This method's main strength is that it is a rapid field screening procedure. The method's lower limits of detection are typically above the toxicity characteristic regulatory level for most RCRA analytes. However, when the obtainable values for precision, accuracy, and laboratory-established sensitivity of this method meet project-specific data quality objectives (DQOs), FPXRF is a fast, powerful, cost effective technology for site characterization.

1.3 The method sensitivity or lower limit of detection depends on several factors, including the analyte of interest, the type of detector used, the type of excitation source, the strength of the excitation source, count times used to irradiate the sample, physical matrix effects, chemical matrix effects, and interelement spectral interferences. Example lower limits of detection for analytes of interest in environmental applications are shown in Table 1. These limits apply to a clean spiked matrix of quartz sand (silicon dioxide) free of interelement spectral interferences using long (100 -600 second) count times. These sensitivity values are given for guidance only and may not always be achievable, since they will vary depending on the sample matrix, which instrument is used, and operating conditions. A discussion of performance-based sensitivity is presented in Sec. 9.6.

1.4 Analysts should consult the disclaimer statement at the front of the manual and the information in Chapter Two for guidance on the intended flexibility in the choice of methods, apparatus, materials, reagents, and supplies, and on the responsibilities of the analyst for demonstrating that the techniques employed are appropriate for the analytes of interest, in the matrix of interest, and at the levels of concern.

In addition, analysts and data users are advised that, except where explicitly specified in a regulation, the use of SW-846 methods is *not* mandatory in response to Federal testing requirements. The information contained in this method is provided by EPA as guidance to be used by the analyst and the regulated community in making judgments necessary to generate results that meet the data quality objectives for the intended application.

1.5 Use of this method is restricted to use by, or under supervision of, personnel appropriately experienced and trained in the use and operation of an XRF instrument. Each analyst must demonstrate the ability to generate acceptable results with this method.

2.0 SUMMARY OF METHOD

2.1 The FPXRF technologies described in this method use either sealed radioisotope sources or x-ray tubes to irradiate samples with x-rays. When a sample is irradiated with x-rays, the source x-rays may undergo either scattering or absorption by sample atoms. This latter process is known as the photoelectric effect. When an atom absorbs the source x-rays, the incident radiation dislodges electrons from the innermost shells of the atom, creating vacancies. The electron vacancies are filled by electrons cascading in from outer electron shells. Electrons in outer shells have higher energy states than inner shell electrons, and the outer shell electrons give off energy as they cascade down into the inner shell vacancies. This rearrangement of electrons results in emission of x-rays characteristic of the given atom. The emission of x-rays, in this manner, is termed x-ray fluorescence.

Three electron shells are generally involved in emission of x-rays during FPXRF analysis of environmental samples. The three electron shells include the K, L, and M shells. A typical emission pattern, also called an emission spectrum, for a given metal has multiple intensity peaks generated from the emission of K, L, or M shell electrons. The most commonly measured x-ray emissions are from the K and L shells; only metals with an atomic number greater than 57 have measurable M shell emissions.

Each characteristic x-ray line is defined with the letter K, L, or M, which signifies which shell had the original vacancy and by a subscript alpha (α), beta (β), or gamma (γ) etc., which indicates the higher shell from which electrons fell to fill the vacancy and produce the x-ray. For example, a K_α line is produced by a vacancy in the K shell filled by an L shell electron, whereas a K_β line is produced by a vacancy in the K shell filled by an M shell electron. The K_α transition is on average 6 to 7 times more probable than the K_β transition; therefore, the K_α line is approximately 7 times more intense than the K_β line for a given element, making the K_α line the choice for quantitation purposes.

The K lines for a given element are the most energetic lines and are the preferred lines for analysis. For a given atom, the x-rays emitted from L transitions are always less energetic than those emitted from K transitions. Unlike the K lines, the main L emission lines (L_α and L_β) for an element are of nearly equal intensity. The choice of one or the other depends on what interfering element lines might be present. The L emission lines are useful for analyses involving elements of atomic number (Z) 58 (cerium) through 92 (uranium).

An x-ray source can excite characteristic x-rays from an element only if the source energy is greater than the absorption edge energy for the particular line group of the element, that is, the K absorption edge, L absorption edge, or M absorption edge energy. The absorption edge energy is somewhat greater than the corresponding line energy. Actually, the K absorption edge energy is approximately the sum of the K, L, and M line energies of the particular element, and the L absorption edge energy is approximately the sum of the L and M line energies. FPXRF is more sensitive to an element with an absorption edge energy close to but less than

the excitation energy of the source. For example, when using a cadmium-109 source, which has an excitation energy of 22.1 kiloelectron volts (keV), FPXRF would exhibit better sensitivity for zirconium which has a K line energy of 15.77 keV than to chromium, which has a K line energy of 5.41 keV.

2.2 Under this method, inorganic analytes of interest are identified and quantitated using a field portable energy-dispersive x-ray fluorescence spectrometer. Radiation from one or more radioisotope sources or an electrically excited x-ray tube is used to generate characteristic x-ray emissions from elements in a sample. Up to three sources may be used to irradiate a sample. Each source emits a specific set of primary x-rays that excite a corresponding range of elements in a sample. When more than one source can excite the element of interest, the source is selected according to its excitation efficiency for the element of interest.

For measurement, the sample is positioned in front of the probe window. This can be done in two manners using FPXRF instruments, specifically, in situ or intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. The sample cup is then placed on top of the window inside a protective cover for analysis.

Sample analysis is then initiated by exposing the sample to primary radiation from the source. Fluorescent and backscattered x-rays from the sample enter through the detector window and are converted into electric pulses in the detector. The detector in FPXRF instruments is usually either a solid-state detector or a gas-filled proportional counter. Within the detector, energies of the characteristic x-rays are converted into a train of electric pulses, the amplitudes of which are linearly proportional to the energy of the x-rays. An electronic multichannel analyzer (MCA) measures the pulse amplitudes, which is the basis of qualitative x-ray analysis. The number of counts at a given energy per unit of time is representative of the element concentration in a sample and is the basis for quantitative analysis. Most FPXRF instruments are menu-driven from software built into the units or from personal computers (PC).

The measurement time of each source is user-selectable. Shorter source measurement times (30 seconds) are generally used for initial screening and hot spot delineation, and longer measurement times (up to 300 seconds) are typically used to meet higher precision and accuracy requirements.

FPXRF instruments can be calibrated using the following methods: internally using fundamental parameters determined by the manufacturer, empirically based on site-specific calibration standards (SSCS), or based on Compton peak ratios. The Compton peak is produced by backscattering of the source radiation. Some FPXRF instruments can be calibrated using multiple methods.

3.0 DEFINITIONS

3.1 FPXRF -- Field portable x-ray fluorescence.

3.2 MCA -- Multichannel analyzer for measuring pulse amplitude.

3.3 SSCS -- Site-specific calibration standards.

3.4 FP -- Fundamental parameter.

3.5 ROI -- Region of interest.

3.6 SRM -- Standard reference material; a standard containing certified amounts of metals in soil or sediment.

3.7 eV -- Electron volt; a unit of energy equivalent to the amount of energy gained by an electron passing through a potential difference of one volt.

3.8 Refer to Chapter One, Chapter Three, and the manufacturer's instructions for other definitions that may be relevant to this procedure.

4.0 INTERFERENCES

4.1 The total method error for FPXRF analysis is defined as the square root of the sum of squares of both instrument precision and user- or application-related error. Generally, instrument precision is the least significant source of error in FPXRF analysis. User- or application-related error is generally more significant and varies with each site and method used. Some sources of interference can be minimized or controlled by the instrument operator, but others cannot. Common sources of user- or application-related error are discussed below.

4.2 Physical matrix effects result from variations in the physical character of the sample. These variations may include such parameters as particle size, uniformity, homogeneity, and surface condition. For example, if any analyte exists in the form of very fine particles in a coarser-grained matrix, the analyte’s concentration measured by the FPXRF will vary depending on how fine particles are distributed within the coarser-grained matrix. If the fine particles "settle" to the bottom of the sample cup (i.e., against the cup window), the analyte concentration measurement will be higher than if the fine particles are not mixed in well and stay on top of the coarser-grained particles in the sample cup. One way to reduce such error is to grind and sieve all soil samples to a uniform particle size thus reducing sample-to-sample particle size variability. Homogeneity is always a concern when dealing with soil samples. Every effort should be made to thoroughly mix and homogenize soil samples before analysis. Field studies have shown heterogeneity of the sample generally has the largest impact on comparability with confirmatory samples.

4.3 Moisture content may affect the accuracy of analysis of soil and sediment sample analyses. When the moisture content is between 5 and 20 percent, the overall error from moisture may be minimal. However, moisture content may be a major source of error when analyzing samples of surface soil or sediment that are saturated with water. This error can be minimized by drying the samples in a convection or toaster oven. Microwave drying is not recommended because field studies have shown that microwave drying can increase variability between FPXRF data and confirmatory analysis and because metal fragments in the sample can cause arcing to occur in a microwave.

4.4 Inconsistent positioning of samples in front of the probe window is a potential source of error because the x-ray signal decreases as the distance from the radioactive source increases. This error is minimized by maintaining the same distance between the window and each sample. For the best results, the window of the probe should be in direct contact with the sample, which means that the sample should be flat and smooth to provide a good contact surface.

4.5 Chemical matrix effects result from differences in the concentrations of interfering elements. These effects occur as either spectral interferences (peak overlaps) or as x-ray absorption and enhancement phenomena. Both effects are common in soils contaminated with heavy metals. As examples of absorption and enhancement effects; iron (Fe) tends to absorb copper (Cu) x-rays, reducing the intensity of the Cu measured by the detector, while chromium (Cr) will be enhanced at the expense of Fe because the absorption edge of Cr is slightly lower in energy than the fluorescent peak of iron. The effects can be corrected mathematically through the use of fundamental parameter (FP) coefficients. The effects also can be compensated for using SSCS, which contain all the elements present on site that can interfere with one another.

4.6 When present in a sample, certain x-ray lines from different elements can be very close in energy and, therefore, can cause interference by producing a severely overlapped spectrum. The degree to which a detector can resolve the two different peaks depends on the energy resolution of the detector. If the energy difference between the two peaks in electron volts is less than the resolution of the detector in electron volts, then the detector will not be able to fully resolve the peaks.

The most common spectrum overlaps involve the K_β line of element Z-1 with the K_α line of element Z. This is called the K_α/K_β interference. Because the K_α:K_β intensity ratio for a given element usually is about 7:1, the interfering element, Z-1, must be present at large concentrations to cause a problem. Two examples of this type of spectral interference involve the presence of large concentrations of vanadium (V) when attempting to measure Cr or the presence of large concentrations of Fe when attempting to measure cobalt (Co). The V K_α and K_β energies are 4.95 and 5.43 keV, respectively, and the Cr K_α energy is 5.41 keV. The Fe K_α and K_β energies are 6.40 and 7.06 keV, respectively, and the Co K_α energy is 6.92 keV. The difference between the V K_β and Cr K_α energies is 20 eV, and the difference between the Fe K_β and the Co K_α energies is 140 eV. The resolution of the highest-resolution detectors in FPXRF instruments is 170 eV. Therefore, large amounts of V and Fe will interfere with quantitation of Cr or Co, respectively. The presence of Fe is a frequent problem because it is often found in soils at tens of thousands of parts per million (ppm).

4.7 Other interferences can arise from K/L, K/M, and L/M line overlaps, although these overlaps are less common. Examples of such overlap involve arsenic (As) K_α/lead (Pb) L_α and sulfur (S) K_α/Pb M_α. In the As/Pb case, Pb can be measured from the Pb L_β line, and As can be measured from either the As K_α or the As $K_ß$ line; in this way the interference can be corrected. If the As K_β line is used, sensitivity will be decreased by a factor of two to five times because it is a less intense line than the As K_α line. If the As K_α line is used in the presence of Pb, mathematical corrections within the instrument software can be used to subtract out the Pb interference. However, because of the limits of mathematical corrections, As concentrations cannot be efficiently calculated for samples with Pb:As ratios of 10:1 or more. This high ratio of Pb to As may result in reporting of a "nondetect" or a "less than" value (e.g., <300 ppm) for As, regardless of the actual concentration present.

No instrument can fully compensate for this interference. It is important for an operator to understand this limitation of FPXRF instruments and consult with the manufacturer of the FPXRF instrument to evaluate options to minimize this limitation. The operator’s decision will be based on action levels for metals in soil established for the site, matrix effects, capabilities of the instrument, data quality objectives, and the ratio of lead to arsenic known to be present at the site. If a site is encountered that contains lead at concentrations greater than ten times the concentration of arsenic it is advisable that all critical soil samples be sent off site for confirmatory analysis using other techniques (e.g., flame atomic absorption spectrometry (FLAA), graphite furnance atomic absorption spectrometry (GFAA), inductively coupled plasma-

atomic emission spectrometry, (ICP-AES), or inductively coupled plasma-mass spectrometry, (ICP-MS)).

4.8 If SSCS are used to calibrate an FPXRF instrument, the samples collected must be representative of the site under investigation. Representative soil sampling ensures that a sample or group of samples accurately reflects the concentrations of the contaminants of concern at a given time and location. Analytical results for representative samples reflect variations in the presence and concentration ranges of contaminants throughout a site. Variables affecting sample representativeness include differences in soil type, contaminant concentration variability, sample collection and preparation variability, and analytical variability, all of which should be minimized as much as possible.

4.9 Soil physical and chemical effects may be corrected using SSCS that have been analyzed by inductively coupled plasma (ICP) or atomic absorption (AA) methods. However, a major source of error can be introduced if these samples are not representative of the site or if the analytical error is large. Another concern is the type of digestion procedure used to prepare the soil samples for the reference analysis. Analytical results for the confirmatory method will vary depending on whether a partial digestion procedure, such as Method 3050, or a total digestion procedure, such as Method 3052, is used. It is known that depending on the nature of the soil or sediment, Method 3050 will achieve differing extraction efficiencies for different analytes of interest. The confirmatory method should meet the project-specific data quality objectives (DQOs).

XRF measures the total concentration of an element; therefore, to achieve the greatest comparability of this method with the reference method (reduced bias), a total digestion procedure should be used for sample preparation. However, in the study used to generate the performance data for this method (see Table 8), the confirmatory method used was Method 3050, and the FPXRF data compared very well with regression correlation coefficients (r often exceeding 0.95, except for barium and chromium). The critical factor is that the digestion procedure and analytical reference method used should meet the DQOs of the project and match the method used for confirmation analysis.

4.10 Ambient temperature changes can affect the gain of the amplifiers producing instrument drift. Gain or drift is primarily a function of the electronics (amplifier or preamplifier) and not the detector as most instrument detectors are cooled to a constant temperature. Most FPXRF instruments have a built-in automatic gain control. If the automatic gain control is allowed to make periodic adjustments, the instrument will compensate for the influence of temperature changes on its energy scale. If the FPXRF instrument has an automatic gain control function, the operator will not have to adjust the instrument's gain unless an error message appears. If an error message appears, the operator should follow the manufacturer's procedures for troubleshooting the problem. Often, this involves performing a new energy calibration. The performance of an energy calibration check to assess drift is a quality control measure discussed in Sec. 9.2.

If the operator is instructed by the manufacturer to manually conduct a gain check because of increasing or decreasing ambient temperature, it is standard to perform a gain check after every 10 to 20 sample measurements or once an hour whichever is more frequent. It is also suggested that a gain check be performed if the temperature fluctuates more than 10° F. The operator should follow the manufacturer's recommendations for gain check frequency.

5.0 SAFETY

5.1 This method does not address all safety issues associated with its use. The user is responsible for maintaining a safe work environment and a current awareness file of OSHA regulations regarding the safe handling of the chemicals listed in this method. A reference file of material safety data sheets (MSDSs) should be available to all personnel involved in these analyses.

NOTE: No MSDS applies directly to the radiation-producing instrument because that is covered under the Nuclear Regulatory Commission (NRC) or applicable state regulations.

5.2 Proper training for the safe operation of the instrument and radiation training should be completed by the analyst prior to analysis. Radiation safety for each specific instrument can be found in the operator's manual. Protective shielding should never be removed by the analyst or any personnel other than the manufacturer. The analyst should be aware of the local state and national regulations that pertain to the use of radiation-producing equipment and radioactive materials with which compliance is required. There should be a person appointed within the organization that is solely responsible for properly instructing all personnel, maintaining inspection records, and monitoring x-ray equipment at regular intervals.

Licenses for radioactive materials are of two types, specifically: (1) a general license which is usually initiated by the manufacturer for receiving, acquiring, owning, possessing, using, and transferring radioactive material incorporated in a device or equipment, and (2) a specific license which is issued to named persons for the operation of radioactive instruments as required by local, state, or federal agencies. A copy of the radioactive material license (for specific licenses only) and leak tests should be present with the instrument at all times and available to local and national authorities upon request.

X-ray tubes do not require radioactive material licenses or leak tests, but do require approvals and licenses which vary from state to state. In addition, fail-safe x-ray warning lights should be illuminated whenever an x-ray tube is energized. Provisions listed above concerning radiation safety regulations, shielding, training, and responsible personnel apply to x-ray tubes just as to radioactive sources. In addition, a log of the times and operating conditions should be kept whenever an x-ray tube is energized. An additional hazard present with x-ray tubes is the danger of electric shock from the high voltage supply, however, if the tube is properly positioned within the instrument, this is only a negligible risk. Any instrument (x-ray tube or radioisotope based) is capable of delivering an electric shock from the basic circuitry when the system is inappropriately opened.

5.3 Radiation monitoring equipment should be used with the handling and operation of the instrument. The operator and the surrounding environment should be monitored continually for analyst exposure to radiation. Thermal luminescent detectors (TLD) in the form of badges and rings are used to monitor operator radiation exposure. The TLDs or badges should be worn in the area of maximum exposure. The maximum permissible whole-body dose from occupational exposure is 5 Roentgen Equivalent Man (REM) per year. Possible exposure pathways for radiation to enter the body are ingestion, inhaling, and absorption. The best precaution to prevent radiation exposure is distance and shielding.

6.0 EQUIPMENT AND SUPPLIES

The mention of trade names or commercial products in this manual is for illustrative purposes only, and does not constitute an EPA endorsement or exclusive recommendation for

use. The products and instrument settings cited in SW-846 methods represent those products and settings used during method development or subsequently evaluated by the Agency. Glassware, reagents, supplies, equipment, and settings other than those listed in this manual may be employed provided that method performance appropriate for the intended application has been demonstrated and documented.

6.1 FPXRF spectrometer -- An FPXRF spectrometer consists of four major components: (1) a source that provides x-rays; (2) a sample presentation device; (3) a detector that converts x-ray-generated photons emitted from the sample into measurable electronic signals; and (4) a data processing unit that contains an emission or fluorescence energy analyzer, such as an MCA, that processes the signals into an x-ray energy spectrum from which elemental concentrations in the sample may be calculated, and a data display and storage system. These components and additional, optional items, are discussed below.

6.1.1 Excitation sources -- FPXRF instruments use either a sealed radioisotope source or an x-ray tube to provide the excitation source. Many FPXRF instruments use sealed radioisotope sources to produce x-rays in order to irradiate samples. The FPXRF instrument may contain between one and three radioisotope sources. Common radioisotope sources used for analysis for metals in soils are iron Fe-55 (^{55}Fe), cadmium Cd-109 (^{109}Cd), americium Am-241 (^{241}Am), and curium Cm-244 (^{244}Cm). These sources may be contained in a probe along with a window and the detector; the probe may be connected to a data reduction and handling system by means of a flexible cable. Alternatively, the sources, window, and detector may be included in the same unit as the data reduction and handling system.

The relative strength of the radioisotope sources is measured in units of millicuries (mCi). All other components of the FPXRF system being equal, the stronger the source, the greater the sensitivity and precision of a given instrument. Radioisotope sources undergo constant decay. In fact, it is this decay process that emits the primary x-rays used to excite samples for FPXRF analysis. The decay of radioisotopes is measured in "half-lives." The half-life of a radioisotope is defined as the length of time required to reduce the radioisotopes strength or activity by half. Developers of FPXRF technologies recommend source replacement at regular intervals based on the source's half-life. This is due to the ever increasing time required for the analysis rather than a decrease in instrument performance. The characteristic x-rays emitted from each of the different sources have energies capable of exciting a certain range of analytes in a sample. Table 2 summarizes the characteristics of four common radioisotope sources.

X-ray tubes have higher radiation output, no intrinsic lifetime limit, produce constant output over their lifetime, and do not have the disposal problems of radioactive sources but are just now appearing in FPXRF instruments. An electrically-excited x-ray tube operates by bombarding an anode with electrons accelerated by a high voltage. The electrons gain an energy in electron volts equal to the accelerating voltage and can excite atomic transitions in the anode, which then produces characteristic x-rays. These characteristic x-rays are emitted through a window which contains the vacuum necessary for the electron acceleration. An important difference between x-ray tubes and radioactive sources is that the electrons which bombard the anode also produce a continuum of x-rays across a broad range of energies in addition to the characteristic x-rays. This continuum is weak compared to the characteristic x-rays but can provide substantial excitation since it covers a broad energy range. It has the undesired property of producing background in the spectrum near the analyte x-ray lines when it is scattered by the sample. For this reason a filter is often used between the x-ray tube and the sample to suppress the continuum radiation while passing the characteristic x-rays from the anode. This filter is sometimes incorporated into the window of the x-ray tube. The choice of

accelerating voltage is governed both by the anode material, since the electrons must have sufficient energy to excite the anode, which requires a voltage greater than the absorption edge of the anode material and by the instrument's ability to cool the x-ray tube. The anode is most efficiently excited by voltages 2 to 2.5 times the edge energy (most x-rays per unit power to the tube), although voltages as low as 1.5 times the absorption edge energy will work. The characteristic x-rays emitted by the anode are capable of exciting a range of elements in the sample just as with a radioactive source. Table 3 gives the recommended operating voltages and the sample elements excited for some common anodes.

6.1.2 Sample presentation device -- FPXRF instruments can be operated in two modes: in situ and intrusive. If operated in the in situ mode, the probe window is placed in direct contact with the soil surface to be analyzed. When an FPXRF instrument is operated in the intrusive mode, a soil or sediment sample must be collected, prepared, and placed in a sample cup. For FPXRF instruments operated in the intrusive mode, the probe may be rotated so that the window faces either upward or downward. A protective sample cover is placed over the window, and the sample cup is placed on top of the window inside the protective sample cover for analysis.

6.1.3 Detectors -- The detectors in the FPXRF instruments can be either solid-state detectors or gas-filled, proportional counter detectors. Common solid-state detectors include mercuric iodide (HgI_2), silicon pin diode and lithium-drifted silicon Si(Li). The HgI_2 detector is operated at a moderately subambient temperature controlled by a low power thermoelectric cooler. The silicon pin diode detector also is cooled via the thermoelectric Peltier effect. The Si(Li) detector must be cooled to at least -90 °C either with liquid nitrogen or by thermoelectric cooling via the Peltier effect. Instruments with a Si(Li) detector have an internal liquid nitrogen dewar with a capacity of 0.5 to 1.0 L. Proportional counter detectors are rugged and lightweight, which are important features of a field portable detector. However, the resolution of a proportional counter detector is not as good as that of a solid-state detector. The energy resolution of a detector for characteristic x-rays is usually expressed in terms of full width at half-maximum (FWHM) height of the manganese K_α peak at 5.89 keV. The typical resolutions of the above mentioned detectors are as follows: HgI_2-270 eV; silicon pin diode-250 eV; Si(Li)–170 eV; and gas-filled, proportional counter-750 eV.

During operation of a solid-state detector, an x-ray photon strikes a biased, solid-state crystal and loses energy in the crystal by producing electron-hole pairs. The electric charge produced is collected and provides a current pulse that is directly proportional to the energy of the x-ray photon absorbed by the crystal of the detector. A gas-filled, proportional counter detector is an ionization chamber filled with a mixture of noble and other gases. An x-ray photon entering the chamber ionizes the gas atoms. The electric charge produced is collected and provides an electric signal that is directly proportional to the energy of the x-ray photon absorbed by the gas in the detector.

6.1.4 Data processing units -- The key component in the data processing unit of an FPXRF instrument is the MCA. The MCA receives pulses from the detector and sorts them by their amplitudes (energy level). The MCA counts pulses per second to determine the height of the peak in a spectrum, which is indicative of the target analyte's concentration. The spectrum of element peaks are built on the MCA. The MCAs in FPXRF instruments have from 256 to 2,048 channels. The concentrations of target analytes are usually shown in ppm on a liquid crystal display (LCD) in the instrument. FPXRF instruments can store both spectra and from 3,000 to 5,000 sets of numerical analytical results. Most FPXRF instruments are menu-driven from software built into the

units or from PCs. Once the data–storage memory of an FPXRF unit is full or at any other time, data can be downloaded by means of an RS-232 port and cable to a PC.

6.2 Spare battery and battery charger.

6.3 Polyethylene sample cups -- 31 to 40 mm in diameter with collar, or equivalent (appropriate for FPXRF instrument).

6.4 X-ray window film -- Mylar™, Kapton™, Spectrolene™, polypropylene, or equivalent; 2.5 to 6.0 µm thick.

6.5 Mortar and pestle -- Glass, agate, or aluminum oxide; for grinding soil and sediment samples.

6.6 Containers -- Glass or plastic to store samples.

6.7 Sieves -- 60-mesh (0.25 mm), stainless-steel, Nylon, or equivalent for preparing soil and sediment samples.

6.8 Trowels -- For smoothing soil surfaces and collecting soil samples.

6.9 Plastic bags -- Used for collection and homogenization of soil samples.

6.10 Drying oven -- Standard convection or toaster oven, for soil and sediment samples that require drying.

7.0 REAGENTS AND STANDARDS

7.1 Reagent grade chemicals must be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 Pure element standards -- Each pure, single-element standard is intended to produce strong characteristic x-ray peaks of the element of interest only. Other elements present must not contribute to the fluorescence spectrum. A set of pure element standards for commonly sought analytes is supplied by the instrument manufacturer, if designated for the instrument; not all instruments require the pure element standards. The standards are used to set the region of interest (ROI) for each element. They also can be used as energy calibration and resolution check samples.

7.3 Site-specific calibration standards -- Instruments that employ fundamental parameters (FP) or similar mathematical models in minimizing matrix effects may not require SSCS. If the FP calibration model is to be optimized or if empirical calibration is necessary, then SSCSs must be collected, prepared, and analyzed.

7.3.1 The SSCS must be representative of the matrix to be analyzed by FPXRF. These samples must be well homogenized. A minimum of 10 samples spanning the concentration ranges of the analytes of interest and of the interfering elements must be obtained from the site. A sample size of 4 to 8 ounces is recommended, and standard glass sampling jars should be used.

7.3.2 Each sample should be oven-dried for 2 to 4 hr at a temperature of less than 150 °C. If mercury is to be analyzed, a separate sample portion should be dried at ambient temperature as heating may volatilize the mercury. When the sample is dry, all large, organic debris and nonrepresentative material, such as twigs, leaves, roots, insects, asphalt, and rock should be removed. The sample should be homogenized (see Sec. 7.3.3) and then a representative portion ground with a mortar and pestle or other mechanical means, prior to passing through a 60-mesh sieve. Only the coarse rock fraction should remain on the screen.

7.3.3 The sample should be homogenized by using a riffle splitter or by placing 150 to 200 g of the dried, sieved sample on a piece of kraft or butcher paper about 1.5 by 1.5 feet in size. Each corner of the paper should be lifted alternately, rolling the soil over on itself and toward the opposite corner. The soil should be rolled on itself 20 times. Approximately 5 g of the sample should then be removed and placed in a sample cup for FPXRF analysis. The rest of the prepared sample should be sent off site for ICP or AA analysis. The method use for confirmatory analysis should meet the data quality objectives of the project.

7.4 Blank samples -- The blank samples should be from a "clean" quartz or silicon dioxide matrix that is free of any analytes at concentrations above the established lower limit of detection. These samples are used to monitor for cross-contamination and laboratory-induced contaminants or interferences.

7.5 Standard reference materials -- Standard reference materials (SRMs) are standards containing certified amounts of metals in soil or sediment. These standards are used for accuracy and performance checks of FPXRF analyses. SRMs can be obtained from the National Institute of Standards and Technology (NIST), the U.S. Geological Survey (USGS), the Canadian National Research Council, and the national bureau of standards in foreign nations. Pertinent NIST SRMs for FPXRF analysis include 2704, Buffalo River Sediment; 2709, San Joaquin Soil; and 2710 and 2711, Montana Soil. These SRMs contain soil or sediment from actual sites that has been analyzed using independent inorganic analytical methods by many different laboratories. When these SRMs are unavailable, alternate standards may be used (e.g., NIST 2702).

8.0 SAMPLE COLLECTION, PRESERVATION, AND STORAGE

Sample handling and preservation procedures used in FPXRF analyses should follow the guidelines in Chapter Three, "Inorganic Analytes."

9.0 QUALITY CONTROL

9.1 Follow the manufacturer’s instructions for the quality control procedures specific to use of the testing product. Refer to Chapter One for additional guidance on quality assurance (QA) and quality control (QC) protocols. Any effort involving the collection of analytical data should include development of a structured and systematic planning document, such as a Quality Assurance Project Plan (QAPP) or a Sampling and Analysis Plan (SAP), which translates project objectives and specifications into directions for those that will implement the project and assess the results.

9.2 Energy calibration check -- To determine whether an FPXRF instrument is operating within resolution and stability tolerances, an energy calibration check should be run. The energy calibration check determines whether the characteristic x-ray lines are shifting,

which would indicate drift within the instrument. As discussed in Sec. 4.10, this check also serves as a gain check in the event that ambient temperatures are fluctuating greatly (more than 10 °F).

9.2.1 The energy calibration check should be run at a frequency consistent with manufacturer's recommendations. Generally, this would be at the beginning of each working day, after the batteries are changed or the instrument is shut off, at the end of each working day, and at any other time when the instrument operator believes that drift is occurring during analysis. A pure element such as iron, manganese, copper, or lead is often used for the energy calibration check. A manufacturer-recommended count time per source should be used for the check.

9.2.2 The instrument manufacturer's manual specifies the channel or kiloelectron volt level at which a pure element peak should appear and the expected intensity of the peak. The intensity and channel number of the pure element as measured using the source should be checked and compared to the manufacturer's recommendation. If the energy calibration check does not meet the manufacturer's criteria, then the pure element sample should be repositioned and reanalyzed. If the criteria are still not met, then an energy calibration should be performed as described in the manufacturer's manual. With some FPXRF instruments, once a spectrum is acquired from the energy calibration check, the peak can be optimized and realigned to the manufacturer's specifications using their software.

9.3 Blank samples -- Two types of blank samples should be analyzed for FPXRF analysis, specifically, instrument blanks and method blanks.

9.3.1 An instrument blank is used to verify that no contamination exists in the spectrometer or on the probe window. The instrument blank can be silicon dioxide, a polytetraflurorethylene (PTFE) block, a quartz block, "clean" sand, or lithium carbonate. This instrument blank should be analyzed on each working day before and after analyses are conducted and once per every twenty samples. An instrument blank should also be analyzed whenever contamination is suspected by the analyst. The frequency of analysis will vary with the data quality objectives of the project. A manufacturer-recommended count time per source should be used for the blank analysis. No element concentrations above the established lower limit of detection should be found in the instrument blank. If concentrations exceed these limits, then the probe window and the check sample should be checked for contamination. If contamination is not a problem, then the instrument must be "zeroed" by following the manufacturer's instructions.

9.3.2 A method blank is used to monitor for laboratory-induced contaminants or interferences. The method blank can be "clean" silica sand or lithium carbonate that undergoes the same preparation procedure as the samples. A method blank must be analyzed at least daily. The frequency of analysis will depend on the data quality objectives of the project. If the method blank does not contain the target analyte at a level that interferes with the project-specific data quality objectives then the method blank would be considered acceptable. In the absence of project-specific data quality objectives, if the blank is less than the lowest level of detection or less than 10% of the lowest sample concentration for the analyte, whichever is greater, then the method blank would be considered acceptable. If the method blank cannot be considered acceptable, the cause of the problem must be identified, and all samples analyzed with the method blank must be reanalyzed.

9.4 Calibration verification checks -- A calibration verification check sample is used to check the accuracy of the instrument and to assess the stability and consistency of the analysis for the analytes of interest. A check sample should be analyzed at the beginning of each working day, during active sample analyses, and at the end of each working day. The frequency of calibration checks during active analysis will depend on the data quality objectives of the project. The check sample should be a well characterized soil sample from the site that is representative of site samples in terms of particle size and degree of homogeneity and that contains contaminants at concentrations near the action levels. If a site-specific sample is not available, then an NIST or other SRM that contains the analytes of interest can be used to verify the accuracy of the instrument. The measured value for each target analyte should be within ±20 percent (%D) of the true value for the calibration verification check to be acceptable. If a measured value falls outside this range, then the check sample should be reanalyzed. If the value continues to fall outside the acceptance range, the instrument should be recalibrated, and the batch of samples analyzed before the unacceptable calibration verification check must be reanalyzed.

9.5 Precision measurements -- The precision of the method is monitored by analyzing a sample with low, moderate, or high concentrations of target analytes. The frequency of precision measurements will depend on the data quality objectives for the data. A minimum of one precision sample should be run per day. Each precision sample should be analyzed 7 times in replicate. It is recommended that precision measurements be obtained for samples with varying concentration ranges to assess the effect of concentration on method precision. Determining method precision for analytes at concentrations near the site action levels can be extremely important if the FPXRF results are to be used in an enforcement action; therefore, selection of at least one sample with target analyte concentrations at or near the site action levels or levels of concern is recommended. A precision sample is analyzed by the instrument for the same field analysis time as used for other project samples. The relative standard deviation (RSD) of the sample mean is used to assess method precision. For FPXRF data to be considered adequately precise, the RSD should not be greater than 20 percent with the exception of chromium. RSD values for chromium should not be greater than 30 percent. If both in situ and intrusive analytical techniques are used during the course of one day, it is recommended that separate precision calculations be performed for each analysis type.

The equation for calculating RSD is as follows:

$$RSD = (SD/Mean\ Concentration) \times 100$$

where:

RSD = Relative standard deviation for the precision measurement for the analyte
SD = Standard deviation of the concentration for the analyte
Mean concentration = Mean concentration for the analyte

The precision or reproducibility of a measurement will improve with increasing count time, however, increasing the count time by a factor of 4 will provide only 2 times better precision, so there is a point of diminishing return. Increasing the count time also improves the sensitivity, but decreases sample throughput.

9.6 The lower limits of detection should be established from actual measured performance based on spike recoveries in the matrix of concern or from acceptable method performance on a certified reference material of the appropriate matrix and within the appropriate calibration range for the application. This is considered the best estimate of the true method sensitivity as opposed to a statistical determination based on the standard deviation of

replicate analyses of a low-concentration sample. While the statistical approach demonstrates the potential data variability for a given sample matrix at one point in time, it does not represent what can be detected or most importantly the lowest concentration that can be calibrated. For this reason the sensitivity should be established as the lowest point of detection based on acceptable target analyte recovery in the desired sample matrix.

9.7 Confirmatory samples -- The comparability of the FPXRF analysis is determined by submitting FPXRF-analyzed samples for analysis at a laboratory. The method of confirmatory analysis must meet the project and XRF measurement data quality objectives. The confirmatory samples must be splits of the well homogenized sample material. In some cases the prepared sample cups can be submitted. A minimum of 1 sample for each 20 FPXRF-analyzed samples should be submitted for confirmatory analysis. This frequency will depend on project-specific data quality objectives. The confirmatory analyses can also be used to verify the quality of the FPXRF data. The confirmatory samples should be selected from the lower, middle, and upper range of concentrations measured by the FPXRF. They should also include samples with analyte concentrations at or near the site action levels. The results of the confirmatory analysis and FPXRF analyses should be evaluated with a least squares linear regression analysis. If the measured concentrations span more than one order of magnitude, the data should be log-transformed to standardize variance which is proportional to the magnitude of measurement. The correlation coefficient (r) for the results should be 0.7 or greater for the FPXRF data to be considered screening level data. If the r is 0.9 or greater and inferential statistics indicate the FPXRF data and the confirmatory data are statistically equivalent at a 99 percent confidence level, the data could potentially meet definitive level data criteria.

10.0 CALIBRATION AND STANDARDIZATION

10.1 Instrument calibration -- Instrument calibration procedures vary among FPXRF instruments. Users of this method should follow the calibration procedures outlined in the operator's manual for each specific FPXRF instrument. Generally, however, three types of calibration procedures exist for FPXRF instruments, namely: FP calibration, empirical calibration, and the Compton peak ratio or normalization method. These three types of calibration are discussed below.

10.2 Fundamental parameters calibration -- FP calibration procedures are extremely variable. An FP calibration provides the analyst with a "standardless" calibration. The advantages of FP calibrations over empirical calibrations include the following:

- No previously collected site-specific samples are necessary, although site-specific samples with confirmed and validated analytical results for all elements present could be used.

- Cost is reduced because fewer confirmatory laboratory results or calibration standards are necessary.

However, the analyst should be aware of the limitations imposed on FP calibration by particle size and matrix effects. These limitations can be minimized by adhering to the preparation procedure described in Sec. 7.3. The two FP calibration processes discussed below are based on an effective energy FP routine and a back scatter with FP (BFP) routine. Each FPXRF FP calibration process is based on a different iterative algorithmic method. The calibration procedure for each routine is explained in detail in the manufacturer's user manual for each FPXRF instrument; in addition, training courses are offered for each instrument.

10.2.1 Effective energy FP calibration -- The effective energy FP calibration is performed by the manufacturer before an instrument is sent to the analyst. Although SSCS can be used, the calibration relies on pure element standards or SRMs such as those obtained from NIST for the FP calibration. The effective energy routine relies on the spectrometer response to pure elements and FP iterative algorithms to compensate for various matrix effects.

Alpha coefficients are calculated using a variation of the Sherman equation, which calculates theoretical intensities from the measurement of pure element samples. These coefficients indicate the quantitative effect of each matrix element on an analyte's measured x-ray intensity. Next, the Lachance Traill algorithm is solved as a set of simultaneous equations based on the theoretical intensities. The alpha coefficients are then downloaded into the specific instrument.

The working effective energy FP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of sampling. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. A manufacturer-recommended count time per source should be used for the calibration check. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A percent difference (%D) is then calculated for each target analyte. The %D should be within ±20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line or the y-intercept value for the analyte. The SRM or SSCS is reanalyzed until the %D falls within ±20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

The equation to calibrate %D is as follows:

$$\%D = ((C_s - C_k) / C_k) \times 100$$

where:

%D = Percent difference
C_k = Certified concentration of standard sample
C_s = Measured concentration of standard sample

10.2.2 BFP calibration -- BFP calibration relies on the ability of the liquid nitrogen-cooled, Si(Li) solid-state detector to separate the coherent (Compton) and incoherent (Rayleigh) backscatter peaks of primary radiation. These peak intensities are known to be a function of sample composition, and the ratio of the Compton to Rayleigh peak is a function of the mass absorption of the sample. The calibration procedure is explained in detail in the instrument manufacturer's manual. Following is a general description of the BFP calibration procedure.

The concentrations of all detected and quantified elements are entered into the computer software system. Certified element results for an NIST SRM or confirmed and validated results for an SSCS can be used. In addition, the concentrations of oxygen and silicon must be entered; these two concentrations are not found in standard metals analyses. The manufacturer provides silicon and oxygen concentrations for typical soil types. Pure element standards are then analyzed using a manufacturer-recommended

count time per source. The results are used to calculate correction factors in order to adjust for spectrum overlap of elements.

The working BFP calibration curve must be verified before sample analysis begins on each working day, after every 20 samples are analyzed, and at the end of the analysis. This verification is performed by analyzing either an NIST SRM or an SSCS that is representative of the site-specific samples. This SRM or SSCS serves as a calibration check. The standard sample is analyzed using a manufacturer-recommended count time per source to check the calibration curve. The analyst must then adjust the y-intercept and slope of the calibration curve to best fit the known concentrations of target analytes in the SRM or SSCS.

A %D is then calculated for each target analyte. The %D should fall within ±20 percent of the certified value for each analyte. If the %D falls outside this acceptance range, then the calibration curve should be adjusted by varying the slope of the line the y-intercept value for the analyte. The standard sample is reanalyzed until the %D falls within ±20 percent. The group of 20 samples analyzed before an out-of-control calibration check should be reanalyzed.

10.3 Empirical calibration -- An empirical calibration can be performed with SSCS, site-typical standards, or standards prepared from metal oxides. A discussion of SSCS is included in Sec. 7.3; if no previously characterized samples exist for a specific site, site-typical standards can be used. Site-typical standards may be selected from commercially available characterized soils or from SSCS prepared for another site. The site-typical standards should closely approximate the site's soil matrix with respect to particle size distribution, mineralogy, and contaminant analytes. If neither SSCS nor site-typical standards are available, it is possible to make gravimetric standards by adding metal oxides to a "clean" sand or silicon dioxide matrix that simulates soil. Metal oxides can be purchased from various chemical vendors. If standards are made on site, a balance capable of weighing items to at least two decimal places is necessary. Concentrated ICP or AA standard solutions can also be used to make standards. These solutions are available in concentrations of 10,000 parts per million, thus only small volumes have to be added to the soil.

An empirical calibration using SSCS involves analysis of SSCS by the FPXRF instrument and by a conventional analytical method such as ICP or AA. A total acid digestion procedure should be used by the laboratory for sample preparation. Generally, a minimum of 10 and a maximum of 30 well characterized SSCS, site-typical standards, or prepared metal oxide standards are necessary to perform an adequate empirical calibration. The exact number of standards depends on the number of analytes of interest and interfering elements. Theoretically, an empirical calibration with SSCS should provide the most accurate data for a site because the calibration compensates for site-specific matrix effects.

The first step in an empirical calibration is to analyze the pure element standards for the elements of interest. This enables the instrument to set channel limits for each element for spectral deconvolution. Next the SSCS, site-typical standards, or prepared metal oxide standards are analyzed using a count time of 200 seconds per source or a count time recommended by the manufacturer. This will produce a spectrum and net intensity of each analyte in each standard. The analyte concentrations for each standard are then entered into the instrument software; these concentrations are those obtained from the laboratory, the certified results, or the gravimetrically determined concentrations of the prepared standards. This gives the instrument analyte values to regress against corresponding intensities during the modeling stage. The regression equation correlates the concentrations of an analyte with its net intensity.

The calibration equation is developed using a least squares fit regression analysis. After the regression terms to be used in the equation are defined, a mathematical equation can be developed to calculate the analyte concentration in an unknown sample. In some FPXRF instruments, the software of the instrument calculates the regression equation. The software uses calculated intercept and slope values to form a multiterm equation. In conjunction with the software in the instrument, the operator can adjust the multiterm equation to minimize interelement interferences and optimize the intensity calibration curve.

It is possible to define up to six linear or nonlinear terms in the regression equation. Terms can be added and deleted to optimize the equation. The goal is to produce an equation with the smallest regression error and the highest correlation coefficient. These values are automatically computed by the software as the regression terms are added, deleted, or modified. It is also possible to delete data points from the regression line if these points are significant outliers or if they are heavily weighing the data. Once the regression equation has been selected for an analyte, the equation can be entered into the software for quantitation of analytes in subsequent samples. For an empirical calibration to be acceptable, the regression equation for a specific analyte should have a correlation coefficient of 0.98 or greater or meet the DQOs of the project.

In an empirical calibration, one must apply the DQOs of the project and ascertain critical or action levels for the analytes of interest. It is within these concentration ranges or around these action levels that the FPXRF instrument should be calibrated most accurately. It may not be possible to develop a good regression equation over several orders of analyte concentration.

10.4 Compton normalization method -- The Compton normalization method is based on analysis of a single, certified standard and normalization for the Compton peak. The Compton peak is produced from incoherent backscattering of x-ray radiation from the excitation source and is present in the spectrum of every sample. The Compton peak intensity changes with differing matrices. Generally, matrices dominated by lighter elements produce a larger Compton peak, and those dominated by heavier elements produce a smaller Compton peak. Normalizing to the Compton peak can reduce problems with varying matrix effects among samples. Compton normalization is similar to the use of internal standards in organics analysis. The Compton normalization method may not be effective when analyte concentrations exceed a few percent.

The certified standard used for this type of calibration could be an NIST SRM such as 2710 or 2711. The SRM must be a matrix similar to the samples and must contain the analytes of interests at concentrations near those expected in the samples. First, a response factor has to be determined for each analyte. This factor is calculated by dividing the net peak intensity by the analyte concentration. The net peak intensity is gross intensity corrected for baseline reading. Concentrations of analytes in samples are then determined by multiplying the baseline corrected analyte signal intensity by the normalization factor and by the response factor. The normalization factor is the quotient of the baseline corrected Compton K_{α} peak intensity of the SRM divided by that of the samples. Depending on the FPXRF instrument used, these calculations may be done manually or by the instrument software.

11.0 PROCEDURE

11.1 Operation of the various FPXRF instruments will vary according to the manufacturers' protocols. Before operating any FPXRF instrument, one should consult the manufacturer's manual. Most manufacturers recommend that their instruments be allowed to warm up for 15 to 30 minutes before analysis of samples. This will help alleviate drift or energy calibration problems later during analysis.

11.2 Each FPXRF instrument should be operated according to the manufacturer's recommendations. There are two modes in which FPXRF instruments can be operated: in situ and intrusive. The in situ mode involves analysis of an undisturbed soil sediment or sample. Intrusive analysis involves collection and preparation of a soil or sediment sample before analysis. Some FPXRF instruments can operate in both modes of analysis, while others are designed to operate in only one mode. The two modes of analysis are discussed below.

11.3 For in situ analysis, remove any large or nonrepresentative debris from the soil surface before analysis. This debris includes rocks, pebbles, leaves, vegetation, roots, and concrete. Also, the soil surface must be as smooth as possible so that the probe window will have good contact with the surface. This may require some leveling of the surface with a stainless-steel trowel. During the study conducted to provide example performance data for this method, this modest amount of sample preparation was found to take less than 5 min per sample location. The last requirement is that the soil or sediment not be saturated with water. Manufacturers state that their FPXRF instruments will perform adequately for soils with moisture contents of 5 to 20 percent but will not perform well for saturated soils, especially if ponded water exists on the surface. Another recommended technique for in situ analysis is to tamp the soil to increase soil density and compactness for better repeatability and representativeness. This condition is especially important for heavy element analysis, such as barium. Source count times for in situ analysis usually range from 30 to 120 seconds, but source count times will vary among instruments and depending on the desired method sensitivity. Due to the heterogeneous nature of the soil sample, in situ analysis can provide only “screening” type data.

11.4 For intrusive analysis of surface or sediment, it is recommended that a sample be collected from a 4- by 4-inch square that is 1 inch deep. This will produce a soil sample of approximately 375 g or 250 cm^3, which is enough soil to fill an 8-ounce jar. However, the exact dimensions and sample depth should take into consideration the heterogeneous deposition of contaminants and will ultimately depend on the desired project-specific data quality objectives. The sample should be homogenized, dried, and ground before analysis. The sample can be homogenized before or after drying. The homogenization technique to be used after drying is discussed in Sec. 4.2. If the sample is homogenized before drying, it should be thoroughly mixed in a beaker or similar container, or if the sample is moist and has a high clay content, it can be kneaded in a plastic bag. One way to monitor homogenization when the sample is kneaded in a plastic bag is to add sodium fluorescein dye to the sample. After the moist sample has been homogenized, it is examined under an ultraviolet light to assess the distribution of sodium fluorescein throughout the sample. If the fluorescent dye is evenly distributed in the sample, homogenization is considered complete; if the dye is not evenly distributed, mixing should continue until the sample has been thoroughly homogenized. During the study conducted to provide data for this method, the time necessary for homogenization procedure using the fluorescein dye ranged from 3 to 5 min per sample. As demonstrated in Secs. 13.5 and 13.7, homogenization has the greatest impact on the reduction of sampling variability. It produces little or no contamination. Often, the direct analysis through the plastic bag is possible without the more labor intensive steps of drying, grinding, and sieving given in Secs. 11.5 and 11.6. Of course, to achieve the best data quality possible all four steps should be followed.

11.5 Once the soil or sediment sample has been homogenized, it should be dried. This can be accomplished with a toaster oven or convection oven. A small aliquot of the sample (20 to 50 g) is placed in a suitable container for drying. The sample should be dried for 2 to 4 hr in the convection or toaster oven at a temperature not greater than 150 °C. Samples may also be air dried under ambient temperature conditions using a 10- to 20-g portion. Regardless of what drying mechanism is used, the drying process is considered complete when a constant sample weight can be obtained. Care should be taken to avoid sample cross-contamination and these measures can be evaluated by including an appropriate method blank sample along with any sample preparation process.

CAUTION: Microwave drying is not a recommended procedure. Field studies have shown that microwave drying can increase variability between the FPXRF data and confirmatory analysis. High levels of metals in a sample can cause arcing in the microwave oven, and sometimes slag forms in the sample. Microwave oven drying can also melt plastic containers used to hold the sample.

11.6 The homogenized dried sample material should be ground with a mortar and pestle and passed through a 60-mesh sieve to achieve a uniform particle size. Sample grinding should continue until at least 90 percent of the original sample passes through the sieve. The grinding step normally takes an average of 10 min per sample. An aliquot of the sieved sample should then be placed in a 31.0-mm polyethylene sample cup (or equivalent) for analysis. The sample cup should be one-half to three-quarters full at a minimum. The sample cup should be covered with a 2.5 µm Mylar (or equivalent) film for analysis. The rest of the soil sample should be placed in a jar, labeled, and archived for possible confirmation analysis. All equipment including the mortar, pestle, and sieves must be thoroughly cleaned so that any cross-contamination is below the established lower limit of detection of the procedure or DQOs of the analysis. If all recommended sample preparation steps are followed, there is a high probability the desired laboratory data quality may be obtained.

12.0 DATA ANALYSIS AND CALCULATIONS

Most FPXRF instruments have software capable of storing all analytical results and spectra. The results are displayed in ppm and can be downloaded to a personal computer, which can be used to provide a hard copy printout. Individual measurements that are smaller than three times their associated SD should not be used for quantitation. See the manufacturer's instructions regarding data analysis and calculations.

13.0 METHOD PERFORMANCE

13.1 Performance data and related information are provided in SW-846 methods only as examples and guidance. The data do not represent required performance criteria for users of the methods. Instead, performance criteria should be developed on a project-specific basis, and the laboratory should establish in-house QC performance criteria for the application of this method. These performance data are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

13.2 The sections to follow discuss three performance evaluation factors; namely, precision, accuracy, and comparability. The example data presented in Tables 4 through 8 were generated from results obtained from six FPXRF instruments (see Sec. 13.3). The soil samples analyzed by the six FPXRF instruments were collected from two sites in the United States. The soil samples contained several of the target analytes at concentrations ranging from "nondetect" to tens of thousands of mg/kg. These data are provided for guidance purposes only.

13.3 The six FPXRF instruments included the TN 9000 and TN Lead Analyzer manufactured by TN Spectrace; the X-MET 920 with a SiLi detector and X-MET 920 with a gas-filled proportional detector manufactured by Metorex, Inc.; the XL Spectrum Analyzer manufactured by Niton; and the MAP Spectrum Analyzer manufactured by Scitec. The TN 9000 and TN Lead Analyzer both have a HgI_2 detector. The TN 9000 utilized an Fe-55, Cd-109, and Am-241 source. The TN Lead Analyzer had only a Cd-109 source. The X-Met 920 with the SiLi detector had a Cd-109 and Am-241 source. The X-MET 920 with the gas-filled proportional detector had only a Cd-109 source. The XL Spectrum Analyzer utilized a silicon pin-diode

detector and a Cd-109 source. The MAP Spectrum Analyzer utilized a solid-state silicon detector and a Cd-109 source.

13.4 All example data presented in Tables 4 through 8 were generated using the following calibrations and source count times. The TN 9000 and TN Lead Analyzer were calibrated using fundamental parameters using NIST SRM 2710 as a calibration check sample. The TN 9000 was operated using 100, 60, and 60 second count times for the Cd-109, Fe-55, and Am-241 sources, respectively. The TN Lead analyzer was operated using a 60 second count time for the Cd-109 source. The X-MET 920 with the Si(Li) detector was calibrated using fundamental parameters and one well characterized site-specific soil standard as a calibration check. It used 140 and 100 second count times for the Cd-109 and Am-241 sources, respectively. The X-MET 920 with the gas-filled proportional detector was calibrated empirically using between 10 and 20 well characterized site-specific soil standards. It used 120 second times for the Cd-109 source. The XL Spectrum Analyzer utilized NIST SRM 2710 for calibration and the Compton peak normalization procedure for quantitation based on 60 second count times for the Cd-109 source. The MAP Spectrum Analyzer was internally calibrated by the manufacturer. The calibration was checked using a well-characterized site-specific soil standard. It used 240 second times for the Cd-109 source.

13.5 Precision measurements -- The example precision data are presented in Table 4. These data are provided for guidance purposes only. Each of the six FPXRF instruments performed 10 replicate measurements on 12 soil samples that had analyte concentrations ranging from "nondetects" to thousands of mg/kg. Each of the 12 soil samples underwent 4 different preparation techniques from in situ (no preparation) to dried and ground in a sample cup. Therefore, there were 48 precision data points for five of the instruments and 24 precision points for the MAP Spectrum Analyzer. The replicate measurements were taken using the source count times discussed at the beginning of this section.

For each detectable analyte in each precision sample a mean concentration, standard deviation, and RSD was calculated for each analyte. The data presented in Table 4 is an average RSD for the precision samples that had analyte concentrations at 5 to 10 times the lower limit of detection for that analyte for each instrument. Some analytes such as mercury, selenium, silver, and thorium were not detected in any of the precision samples so these analytes are not listed in Table 4. Some analytes such as cadmium, nickel, and tin were only detected at concentrations near the lower limit of detection so that an RSD value calculated at 5 to 10 times this limit was not possible.

One FPXRF instrument collected replicate measurements on an additional nine soil samples to provide a better assessment of the effect of sample preparation on precision. Table 5 shows these results. These data are provided for guidance purposes only. The additional nine soil samples were comprised of three from each texture and had analyte concentrations ranging from near the lower limit of detection for the FPXRF analyzer to thousands of mg/kg. The FPXRF analyzer only collected replicate measurements from three of the preparation methods; no measurements were collected from the in situ homogenized samples. The FPXRF analyzer conducted five replicate measurements of the in situ field samples by taking measurements at five different points within the 4-inch by 4-inch sample square. Ten replicate measurements were collected for both the intrusive undried and unground and intrusive dried and ground samples contained in cups. The cups were shaken between each replicate measurement.

Table 5 shows that the precision dramatically improved from the in situ to the intrusive measurements. In general there was a slight improvement in precision when the sample was dried and ground. Two factors caused the precision for the in situ measurements to be poorer. The major factor is soil heterogeneity. By moving the probe within the 4-inch by 4-inch square,

measurements of different soil samples were actually taking place within the square. Table 5 illustrates the dominant effect of soil heterogeneity. It overwhelmed instrument precision when the FPXRF analyzer was used in this mode. The second factor that caused the RSD values to be higher for the in situ measurements is the fact that only five instead of ten replicates were taken. A lesser number of measurements caused the standard deviation to be larger which in turn elevated the RSD values.

13.6 Accuracy measurements -- Five of the FPXRF instruments (not including the MAP Spectrum Analyzer) analyzed 18 SRMs using the source count times and calibration methods given at the beginning of this section. The 18 SRMs included 9 soil SRMs, 4 stream or river sediment SRMs, 2 sludge SRMs, and 3 ash SRMs. Each of the SRMs contained known concentrations of certain target analytes. A percent recovery was calculated for each analyte in each SRM for each FPXRF instrument. Table 6 presents a summary of this data. With the exception of cadmium, chromium, and nickel, the values presented in Table 6 were generated from the 13 soil and sediment SRMs only. The 2 sludge and 3 ash SRMs were included for cadmium, chromium, and nickel because of the low or nondetectable concentrations of these three analytes in the soil and sediment SRMs.

Only 12 analytes are presented in Table 6. These are the analytes that are of environmental concern and provided a significant number of detections in the SRMs for an accuracy assessment. No data is presented for the X-MET 920 with the gas-filled proportional detector. This FPXRF instrument was calibrated empirically using site-specific soil samples. The percent recovery values from this instrument were very sporadic and the data did not lend itself to presentation in Table 6.

Table 7 provides a more detailed summary of accuracy data for one particular FPXRF instrument (TN 9000) for the 9 soil SRMs and 4 sediment SRMs. These data are provided for guidance purposes only. Table 7 shows the certified value, measured value, and percent recovery for five analytes. These analytes were chosen because they are of environmental concern and were most prevalently certified for in the SRM and detected by the FPXRF instrument. The first nine SRMs are soil and the last 4 SRMs are sediment. Percent recoveries for the four NIST SRMs were often between 90 and 110 percent for all analytes.

13.7 Comparability -- Comparability refers to the confidence with which one data set can be compared to another. In this case, FPXRF data generated from a large study of six FPXRF instruments was compared to SW-846 Methods 3050 and 6010 which are the standard soil extraction for metals and analysis by inductively coupled plasma. An evaluation of comparability was conducted by using linear regression analysis. Three factors were determined using the linear regression. These factors were the y-intercept, the slope of the line, and the coefficient of determination (r^2).

As part of the comparability assessment, the effects of soil type and preparation methods were studied. Three soil types (textures) and four preparation methods were examined during the study. The preparation methods evaluated the cumulative effect of particle size, moisture, and homogenization on comparability. Due to the large volume of data produced during this study, linear regression data for six analytes from only one FPXRF instrument is presented in Table 8. Similar trends in the data were seen for all instruments. These data are provided for guidance purposes only.

Table 8 shows the regression parameters for the whole data set, broken out by soil type, and by preparation method. These data are provided for guidance purposes only. The soil types are as follows: soil 1--sand; soil 2--loam; and soil 3--silty clay. The preparation methods are as follows: preparation 1--in situ in the field; preparation 2--intrusive, sample collected and homogenized; preparation 3--intrusive, with sample in a sample cup but sample still wet and not

ground; and preparation 4–intrusive, with sample dried, ground, passed through a 40-mesh sieve, and placed in sample cup.

For arsenic, copper, lead, and zinc, the comparability to the confirmatory laboratory was excellent with r^2 values ranging from 0.80 to 0.99 for all six FPXRF instruments. The slopes of the regression lines for arsenic, copper, lead, and zinc, were generally between 0.90 and 1.00 indicating the data would need to be corrected very little or not at all to match the confirmatory laboratory data. The r^2 values and slopes of the regression lines for barium and chromium were not as good as for the other for analytes, indicating the data would have to be corrected to match the confirmatory laboratory.

Table 8 demonstrates that there was little effect of soil type on the regression parameters for any of the six analytes. The only exceptions were for barium in soil 1 and copper in soil 3. In both of these cases, however, it is actually a concentration effect and not a soil effect causing the poorer comparability. All barium and copper concentrations in soil 1 and 3, respectively, were less than 350 mg/kg.

Table 8 shows there was a preparation effect on the regression parameters for all six analytes. With the exception of chromium, the regression parameters were primarily improved going from preparation 1 to preparation 2. In this step, the sample was removed from the soil surface, all large debris was removed, and the sample was thoroughly homogenized. The additional two preparation methods did little to improve the regression parameters. This data indicates that homogenization is the most critical factor when comparing the results. It is essential that the sample sent to the confirmatory laboratory match the FPXRF sample as closely as possible.

Sec. 11.0 of this method discusses the time necessary for each of the sample preparation techniques. Based on the data quality objectives for the project, an analyst must decide if it is worth the extra time necessary to dry and grind the sample for small improvements in comparability. Homogenization requires 3 to 5 min. Drying the sample requires one to two hours. Grinding and sieving requires another 10 to 15 min per sample. Lastly, when grinding and sieving is conducted, time has to be allotted to decontaminate the mortars, pestles, and sieves. Drying and grinding the samples and decontamination procedures will often dictate that an extra person be on site so that the analyst can keep up with the sample collection crew. The cost of requiring an extra person on site to prepare samples must be balanced with the gain in data quality and sample throughput.

13.8 The following documents may provide additional guidance and insight on this method and technique:

13.8.1 A. D. Hewitt, "Screening for Metals by X-ray Fluorescence Spectrometry/Response Factor/Compton K_α Peak Normalization Analysis," American Environmental Laboratory, pp 24-32, 1994.

13.8.2 S. Piorek and J. R. Pasmore, "Standardless, In Situ Analysis of Metallic Contaminants in the Natural Environment With a PC-Based, High Resolution Portable X-Ray Analyzer," Third International Symposium on Field Screening Methods for Hazardous Waste and Toxic Chemicals, Las Vegas, Nevada, February 24-26, 1993, Vol 2, pp 1135-1151, 1993.

13.8.3 S. Shefsky, "Sample Handling Strategies for Accurate Lead-in-soil Measurements in the Field and Laboratory," *International Symposium of Field Screening Methods for Hazardous Waste and Toxic Chemicals*, Las Vegas, NV, January 29-31, 1997.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity and/or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the Agency recommends recycling as the next best option.

14.2 For information about pollution prevention that may be applicable to laboratories and research institutions consult *Less is Better: Laboratory Chemical Management for Waste Reduction* available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th St., N.W. Washington, D.C. 20036, http://www.acs.org.

15.0 WASTE MANAGEMENT

The Environmental Protection Agency requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any sewer discharge permits and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management, consult *The Waste Management Manual for Laboratory Personnel* available from the American Chemical Society at the address listed in Sec. 14.2.

16.0 REFERENCES

1. Metorex, X-MET 920 User's Manual.

2. Spectrace Instruments, "Energy Dispersive X-ray Fluorescence Spectrometry: An Introduction," 1994.

3. TN Spectrace, Spectrace 9000 Field Portable/Benchtop XRF Training and Applications Manual.

4. Unpublished SITE data, received from PRC Environment Management, Inc.

17.0 TABLES, DIAGRAMS, FLOWCHARTS, AND VALIDATION DATA

The following pages contain the tables referenced by this method. A flow diagram of the procedure follows the tables.

TABLE 1

EXAMPLE INTERFERENCE FREE LOWER LIMITS OF DETECTION

Analyte	Chemical Abstract Series Number	Lower Limit of Detection in Quartz Sand (milligrams per kilogram)
Antimony (Sb)	7440-36-0	40
Arsenic (As)	7440-38-0	40
Barium (Ba)	7440-39-3	20
Cadmium (Cd)	7440-43-9	100
Calcium (Ca)	7440-70-2	70
Chromium (Cr)	7440-47-3	150
Cobalt (Co)	7440-48-4	60
Copper (Cu)	7440-50-8	50
Iron (Fe)	7439-89-6	60
Lead (Pb)	7439-92-1	20
Manganese (Mn)	7439-96-5	70
Mercury (Hg)	7439-97-6	30
Molybdenum (Mo)	7439-93-7	10
Nickel (Ni)	7440-02-0	50
Potassium (K)	7440-09-7	200
Rubidium (Rb)	7440-17-7	10
Selenium (Se)	7782-49-2	40
Silver (Ag)	7440-22-4	70
Strontium (Sr)	7440-24-6	10
Thallium (Tl)	7440-28-0	20
Thorium (Th)	7440-29-1	10
Tin (Sn)	7440-31-5	60
Titanium (Ti)	7440-32-6	50
Vanadium (V)	7440-62-2	50
Zinc (Zn)	7440-66-6	50
Zirconium (Zr)	7440-67-7	10

Source: Refs. 1, 2, and 3
These data are provided for guidance purposes only.

TABLE 2

SUMMARY OF RADIOISOTOPE SOURCE CHARACTERISTICS

Source	Activity (mCi)	Half-Life (Years)	Excitation Energy (keV)	Elemental Analysis Range	
Fe-55	20-50	2.7	5.9	Sulfur to Chromium Molybdenum to Barium	K Lines L Lines
Cd-109	5-30	1.3	22.1 and 87.9	Calcium to Rhodium Tantalum to Lead Barium to Uranium	K Lines K Lines L Lines
Am-241	5-30	432	26.4 and 59.6	Copper to Thulium Tungsten to Uranium	K Lines L Lines
Cm-244	60-100	17.8	14.2	Titanium to Selenium Lanthanum to Lead	K Lines L Lines

Source: Refs. 1, 2, and 3

TABLE 3

SUMMARY OF X-RAY TUBE SOURCE CHARACTERISTICS

Anode Material	Recommended Voltage Range (kV)	K-alpha Emission (keV)	Elemental Analysis Range	
Cu	18-22	8.04	Potassium to Cobalt Silver to Gadolinium	K Lines L Lines
Mo	40-50	17.4	Cobalt to Yttrium Europium to Radon	K Lines L Lines
Ag	50-65	22.1	Zinc to Technicium Ytterbium to Neptunium	K Lines L Lines

Source: Ref. 4

Notes: The sample elements excited are chosen by taking as the lower limit the same ratio of excitation line energy to element absorption edge as in Table 2 (approximately 0.45) and the requirement that the excitation line energy be above the element absorption edge as the upper limit (L2 edges used for L lines). K-beta excitation lines were ignored.

TABLE 4

EXAMPLE PRECISION VALUES

Analyte	Average Relative Standard Deviation for Each Instrument at 5 to 10 Times the Lower Limit of Detection					
	TN 9000	TN Lead Analyzer	X-MET 920 (SiLi Detector)	X-MET 920 (Gas-Filled Detector)	XL Spectrum Analyzer	MAP Spectrum Analyzer
Antimony	6.54	NR	NR	NR	NR	NR
Arsenic	5.33	4.11	3.23	1.91	12.47	6.68
Barium	4.02	NR	3.31	5.91	NR	NR
Cadmium	29.84[a]	NR	24.80[a]	NR	NR	NR
Calcium	2.16	NR	NR	NR	NR	NR
Chromium	22.25	25.78	22.72	3.91	30.25	NR
Cobalt	33.90	NR	NR	NR	NR	NR
Copper	7.03	9.11	8.49	9.12	12.77	14.86
Iron	1.78	1.67	1.55	NR	2.30	NR
Lead	6.45	5.93	5.05	7.56	6.97	12.16
Manganese	27.04	24.75	NR	NR	NR	NR
Molybdenum	6.95	NR	NR	NR	12.60	NR
Nickel	30.85[a]	NR	24.92[a]	20.92[a]	NA	NR
Potassium	3.90	NR	NR	NR	NR	NR
Rubidium	13.06	NR	NR	NR	32.69[a]	NR
Strontium	4.28	NR	NR	NR	8.86	NR
Tin	24.32[a]	NR	NR	NR	NR	NR
Titanium	4.87	NR	NR	NR	NR	NR
Zinc	7.27	7.48	4.26	2.28	10.95	0.83
Zirconium	3.58	NR	NR	NR	6.49	NR

These data are provided for guidance purposes only.
Source: Ref. 4

[a] These values are biased high because the concentration of these analytes in the soil samples was near the lower limit of detection for that particular FPXRF instrument.

NR Not reported.

NA Not applicable; analyte was reported but was below the established lower limit detection.

TABLE 5

EXAMPLES OF PRECISION AS AFFECTED BY SAMPLE PREPARATION

Analyte	Average Relative Standard Deviation for Each Preparation Method		
	In Situ-Field	Intrusive-Undried and Unground	Intrusive-Dried and Ground
Antimony	30.1	15.0	14.4
Arsenic	22.5	5.36	3.76
Barium	17.3	3.38	2.90
Cadmium[a]	41.2	30.8	28.3
Calcium	17.5	1.68	1.24
Chromium	17.6	28.5	21.9
Cobalt	28.4	31.1	28.4
Copper	26.4	10.2	7.90
Iron	10.3	1.67	1.57
Lead	25.1	8.55	6.03
Manganese	40.5	12.3	13.0
Mercury	ND	ND	ND
Molybdenum	21.6	20.1	19.2
Nickel[a]	29.8	20.4	18.2
Potassium	18.6	3.04	2.57
Rubidium	29.8	16.2	18.9
Selenium	ND	20.2	19.5
Silver[a]	31.9	31.0	29.2
Strontium	15.2	3.38	3.98
Thallium	39.0	16.0	19.5
Thorium	NR	NR	NR
Tin	ND	14.1	15.3
Titanium	13.3	4.15	3.74
Vanadium	NR	NR	NR
Zinc	26.6	13.3	11.1
Zirconium	20.2	5.63	5.18

These data are provided for guidance purposes only.
Source: Ref. 4
[a] These values may be biased high because the concentration of these analytes in the soil samples was near the lower limit of detection.
ND Not detected.
NR Not reported.

TABLE 6

EXAMPLE ACCURACY VALUES

Analyte	Instrument															
	TN 9000				TN Lead Analyzer				X-MET 920 (SiLi Detector)				XL Spectrum Analyzer			
	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec.	SD	n	Range of % Rec.	Mean % Rec	SD	n	Range of % Rec.	Mean % Rec.	SD
Sb	2	100-149	124.3	NA	--	--	--	--	--	--	--	--	--	--	--	--
As	5	68-115	92.8	17.3	5	44-105	83.4	23.2	4	9.7-91	47.7	39.7	5	38-535	189.8	206
Ba	9	98-198	135.3	36.9	--	--	--	--	9	18-848	168.2	262	--	--	--	--
Cd	2	99-129	114.3	NA	--	--	--	--	6	81-202	110.5	45.7	--	--	--	--
Cr	2	99-178	138.4	NA	--	--	--	--	7	22-273	143.1	93.8	3	98-625	279.2	300
Cu	8	61-140	95.0	28.8	6	38-107	79.1	27.0	11	10-210	111.8	72.1	8	95-480	203.0	147
Fe	6	78-155	103.7	26.1	6	89-159	102.3	28.6	6	48-94	80.4	16.2	6	26-187	108.6	52.9
Pb	11	66-138	98.9	19.2	11	68-131	97.4	18.4	12	23-94	72.7	20.9	13	80-234	107.3	39.9
Mn	4	81-104	93.1	9.70	3	92-152	113.1	33.8	--	--	--	--	--	--	--	--
Ni	3	99-122	109.8	12.0	--	--	--	--	--	--	--	--	3	57-123	87.5	33.5
Sr	8	110-178	132.6	23.8	--	--	--	--	--	--	--	--	7	86-209	125.1	39.5
Zn	11	41-130	94.3	24.0	10	81-133	100.0	19.7	12	46-181	106.6	34.7	11	31-199	94.6	42.5

Source: Ref. 4. These data are provided for guidance purposes only.
n: Number of samples that contained a certified value for the analyte and produced a detectable concentration from the FPXRF instrument.
SD: Standard deviation; NA: Not applicable; only two data points, therefore, a SD was not calculated.
%Rec.: Percent recovery.
-- No data.

TABLE 7

EXAMPLE ACCURACY FOR TN 9000[a]

Standard Reference Material	Arsenic			Barium			Copper			Lead			Zinc		
	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.	Cert. Conc.	Meas. Conc.	%Rec.
RTC CRM-021	24.8	ND	NA	586	1135	193.5	4792	2908	60.7	144742	149947	103.6	546	224	40.9
RTC CRM-020	397	429	92.5	22.3	ND	NA	753	583	77.4	5195	3444	66.3	3022	3916	129.6
BCR CRM 143R	--	--	--	--	--	--	131	105	80.5	180	206	114.8	1055	1043	99.0
BCR CRM 141	--	--	--	--	--	--	32.6	ND	NA	29.4	ND	NA	81.3	ND	NA
USGS GXR-2	25.0	ND	NA	2240	2946	131.5	76.0	106	140.2	690	742	107.6	530	596	112.4
USGS GXR-6	330	294	88.9	1300	2581	198.5	66.0	ND	NA	101	80.9	80.1	118	ND	NA
NIST 2711	105	104	99.3	726	801	110.3	114	ND	NA	1162	1172	100.9	350	333	94.9
NIST 2710	626	722	115.4	707	782	110.6	2950	2834	96.1	5532	5420	98.0	6952	6476	93.2
NIST 2709	17.7	ND	NA	968	950	98.1	34.6	ND	NA	18.9	ND	NA	106	98.5	93.0
NIST 2704	23.4	ND	NA	414	443	107.0	98.6	105	106.2	161	167	103.5	438	427	97.4
CNRC PACS-1	211	143	67.7	--	772	NA	452	302	66.9	404	332	82.3	824	611	74.2
SARM-51	--	--	--	335	466	139.1	268	373	139.2	5200	7199	138.4	2200	2676	121.6
SARM-52	--	--	--	410	527	128.5	219	193	88.1	1200	1107	92.2	264	215	81.4

Source: Ref. 4. These data are provided for guidance purposes only.
[a] All concentrations in milligrams per kilogram.
%Rec.: Percent recovery; ND: Not detected; NA: Not applicable.
-- No data.

TABLE 8

EXAMPLE REGRESSION PARAMETERS FOR COMPARABILITY[1]

	Arsenic				Barium				Copper			
	n	r^2	Int.	Slope	n	r^2	Int.	Slope	n	r^2	Int.	Slope
All Data	824	0.94	1.62	0.94	1255	0.71	60.3	0.54	984	0.93	2.19	0.93
Soil 1	368	0.96	1.41	0.95	393	0.05	42.6	0.11	385	0.94	1.26	0.99
Soil 2	453	0.94	1.51	0.96	462	0.56	30.2	0.66	463	0.92	2.09	0.95
Soil 3	—	—	—	—	400	0.85	44.7	0.59	136	0.46	16.60	0.57
Prep 1	207	0.87	2.69	0.85	312	0.64	53.7	0.55	256	0.87	3.89	0.87
Prep 2	208	0.97	1.38	0.95	315	0.67	64.6	0.52	246	0.96	2.04	0.93
Prep 3	204	0.96	1.20	0.99	315	0.78	64.6	0.53	236	0.97	1.45	0.99
Prep 4	205	0.96	1.45	0.98	313	0.81	58.9	0.55	246	0.96	1.99	0.96

	Lead				Zinc				Chromium			
	n	r^2	Int.	Slope	n	r^2	Int.	Slope	n	r^2	Int.	Slope
All Data	1205	0.92	1.66	0.95	1103	0.89	1.86	0.95	280	0.70	64.6	0.42
Soil 1	357	0.94	1.41	0.96	329	0.93	1.78	0.93	—	—	—	—
Soil 2	451	0.93	1.62	0.97	423	0.85	2.57	0.90	—	—	—	—
Soil 3	397	0.90	2.40	0.90	351	0.90	1.70	0.98	186	0.66	38.9	0.50
Prep 1	305	0.80	2.88	0.86	286	0.79	3.16	0.87	105	0.80	66.1	0.43
Prep 2	298	0.97	1.41	0.96	272	0.95	1.86	0.93	77	0.51	81.3	0.36
Prep 3	302	0.98	1.26	0.99	274	0.93	1.32	1.00	49	0.73	53.7	0.45
Prep 4	300	0.96	1.38	1.00	271	0.94	1.41	1.01	49	0.75	31.6	0.56

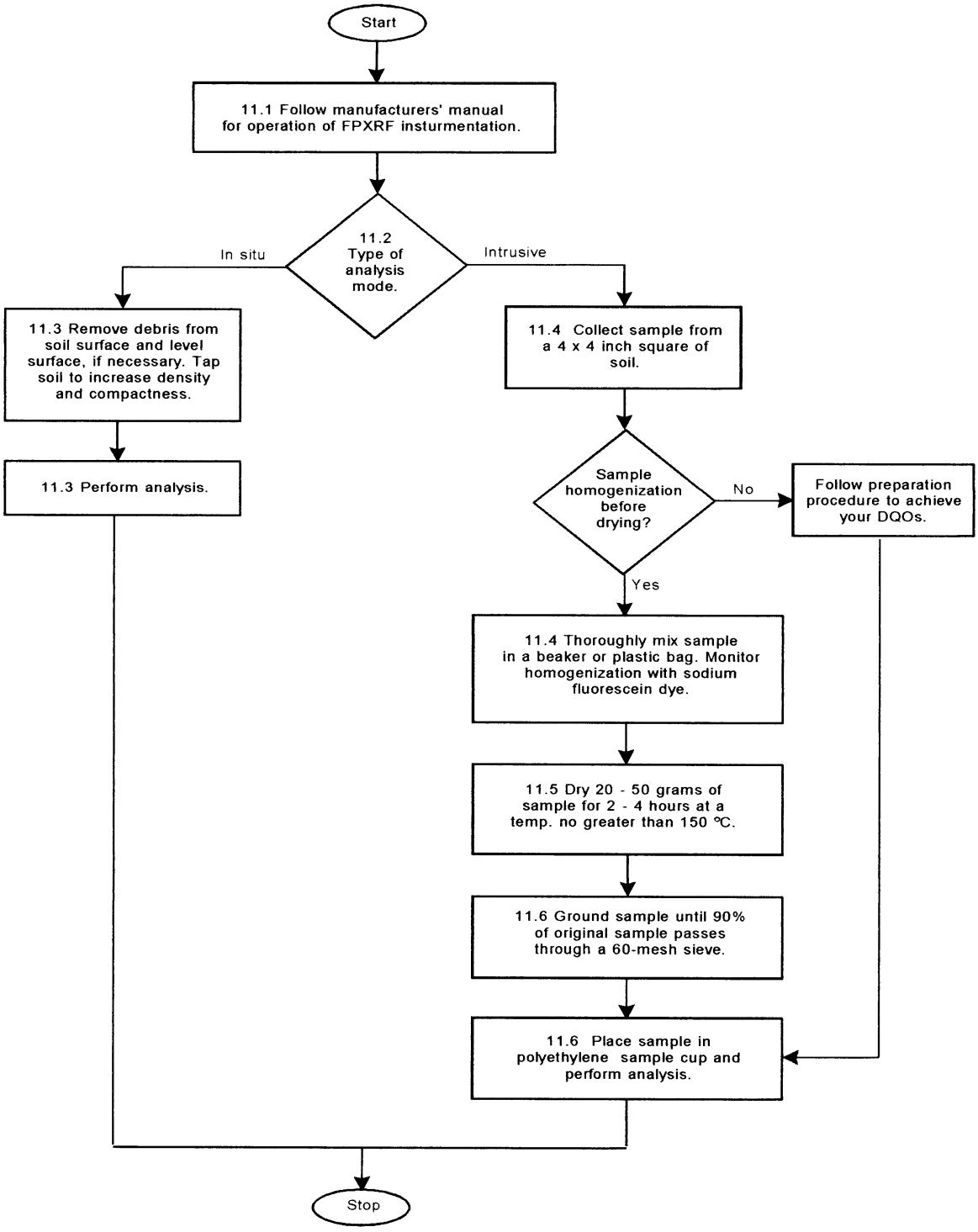
Source: Ref. 4. These data are provided for guidance purposes only.

[1] Log-transformed data

n: Number of data points; r^2: Coefficient of determination; Int.: Y-intercept

— No applicable data

FIELD PORTABLE X-RAY FLUORESCENCE SPECTROMETRY FOR THE DETERMINATION OF ELEMENTAL CONCENTRATIONS IN SOIL AND SEDIMENT



Standard Operating Procedure No. 025
for
Soil Sampling

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031

Revision 0
December 2014

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CONTENTS

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1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure is to delineate protocols for sampling surface and subsurface soils. Soil samples give an indication of the area and depth of site contamination, so a representative sample is very important.

2. MATERIALS

The following materials may be required:

Bucket auger or push tube sampler	Split-spoon, Shelby tube, or core barrel sampler
Drill rig and associated equipment	Stainless steel bowl
Personal protective equipment as required by the Health and Safety Plan	Stainless steel spoon, trowel, knife, spatula (as needed)

3. PROCEDURE

3.1 SUBSURFACE SAMPLES

Don personal protective equipment. Collect split-spoon, core barrel, or Shelby Tube samples during drilling. Upon opening sampler, or extruding sample, immediately screen soil for volatile organic compounds using either a photoionization detector or flame ionization detector. If sampling for volatile organic compounds, determining the area of highest concentration, use a stainless steel knife, trowel, or laboratory spatula to peel and sample this area. Log the sample in the Field Logbook while it is still in the sampler. Peel and transfer the remaining sample in a decontaminated stainless steel bowl. Mix thoroughly with a decontaminated stainless steel spoon or trowel. Place the sample into the required number of sample jars. Preserve samples as required. Discard any remaining sample into the drums being used for collection of cuttings. Decon sampling implements. All borings will be abandoned.

NOTE: If sample recoveries are poor, it may be necessary to composite samples before placing them in jars. In this case, the procedure will be the same, except that two split-spoon samples will be mixed together. The Field Logbook should clearly state that the samples have been composited, which samples were composited, and why the compositing was done.

Samples taken for geotechnical analysis will be undisturbed samples, collected using a thin-walled (Shelby tube) sampler.

3.2 SURFICIAL SOIL SAMPLES

Don personal protective equipment. Remove vegetative mat. Collect a sample from under the vegetative mat with a stainless steel trowel, push tube sampler, or bucket auger. If a representative sample is desired over the depth of a shallow hole or if several shallow samples are to be taken to represent an area, composite as follows:

- As each sample is collected, place a standard volume in a stainless steel bowl.
- After all samples from each hole or area are in the bucket, homogenize the sample thoroughly with a decontaminated stainless steel spoon or spatula.

If no compositing is to occur, place sample directly into the sample jars. Place the leftover soil in the auger borings and holes left by sampling. If necessary, add clean sand to bring the subsampling areas back to original grade. Replace the vegetative mat over the disturbed areas. Samples for volatile organic compounds will not be composited. A separate sample will be taken from a central location of the area being composited and transferred directly from the sampler to the sample container. Preserve samples as required. Decon sampling implements.

4. MAINTENANCE

Not applicable.

5. PRECAUTIONS

Refer to the Health and Safety Plan.

Soil samples will not include vegetative matter, rocks, or pebbles, unless the latter are part of the overall soil matrix.

6. REFERENCES

ASTM International. Method D1586-84, Penetration Test and Split-Barrel Sampling of Soils.

———. Method D1587-83, Thin Walled Sampling of Soils.

Department of the Army, Office of the Chief of Engineers. 1972. Engineer Manual 1110-2-1907 Soil Sampling. 31 March.

DRAFT
Standard Operating Procedure No. 025a
for
Projectile/Lead Shot Counts

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
6712 Brooklawn Parkway
Syracuse, NY 13211
Revision 0

Revision 0
July 2017

TABLE OF CONTENTS

1. SCOPE AND APPLICATION

This Standard Operating Procedure (SOP) provides the general procedures for conducting projectile/lead shot counts in soil and sediment.

2. MATERIALS

The following materials may be required:

- Corer, shovel, or hand auger
- Handheld GPS Unit
- Camera
- Plastic liners (if using a corer)
- Small boat (if required)
- Sample jars or storage bags
- Disposable spoon, trowel, knife, spatula, spoonula
- Stainless steel bowl
- Electronic balance
- Coarse mesh (4 mm)
- Fine mesh (0.5mm)
- Water hose/source

3. PROCEDURE

1. Don personal protective equipment (PPE).

2. Navigate to the soil or sediment sampling location using a site map and a Global Positioning System unit (pre-loaded with designated sampling locations).

3. For soil: Collect soil using a hand auger to a depth of 6 inches. Place the soil sample into a storage bag and label the storage bag with the sample identification and sampling date/time.

4. For sediment: If sampling sediment in shallow water, depths less than 1 foot, samples will be collected by wading to the sample area. For deeper water, depths greater than 1 foot, a boat will be used to move to the sample area. Wading into a waterbody disturbs the sediment. Move slowly and cautiously, approach the sample location from downstream. If flow is not strong enough to move entrained particles away from the sample location, wait for the sediment to resettle before sampling. Collect sediment using a hand auger to a depth of 6 inches. Place the sediment sample into a storage bag and label the storage bag with the sample identification and sampling date/time.

5. Subsequent to sample collection, mark the actual sampling location on a site map. Record the actual sampling location coordinates with a Global Positioning System unit and take a photograph of the sampling location.

6. Take the soil or sediment sample(s) back to the staging area (i.e., trailer or tent where samples will be processed) or to the EA office designated for sample processing.

7. Weigh the sample on an electronic balance.

8. Pass the sample through a coarse sieve (4 mm mesh) to remove large particles, including roots or other plant material.

9. Evaluate particles retained on the 4-mm sieve; identify and separate projectiles, lead pellets, and projectile/lead pellet fragments.

10. Wash the remaining material through a 0.5-mm sieve and retain any material that will not pass through the sieve.

11. Evaluate particles retained on the 0.5-mm sieve; identify and separate projectiles, lead pellets, and projectile/lead pellet fragments.

12. Count all projectiles, lead pellets, and projectile/lead pellet fragments.

13. Transfer all recovered lead (projectiles, lead pellets, and projectile/lead pellet fragments) to an electronic balance and weigh them.

14. Prepare a description of the sample and complete a pellet density analysis worksheet.

15. Dispose of investigation-derived wastes according to applicable rules and regulations.

4. SIEVES

Two types of sieves will be used: the coarse sieve (4-mm mesh) and the fine sieve (0.5-mm mesh). Many other sieve types are available; their applicability will depend upon site-specific factors.

4.1 COARSE SIEVE

The coarse sieve (4-mm mesh) is used initially to remove large particles. The sample will be screened through this sieve and the material left on the sieve will be removed.

- Place something beneath sieve to receive the material that passes through.
- Place material onto the coarse sieve.
- Shake sieve to agitate material.
- Ensure that material small enough to pass through is not left on the sieve.
- Gather the material left on the coarse sieve and set aside.
- Identify and separate projectiles, lead pellets, and projectile/lead pellet fragments.
- Use the remaining material that passed to move to the next sieve.

4.2 FINE SIEVE

The remaining material that passed the coarse sieve will then be washed through the fine sieve (0.5-mm mesh).

- Place something beneath sieve to receive the material that passes through.
- Place material that passed through the coarse sieve onto the fine sieve.
- Wash the material with a hose, which will cause the material to pass.
- The remaining material left on the sieve is to be visually inspected.
- Identify and separate projectiles, lead pellets, and projectile/lead pellet fragments.
- Record the results on a pellet count worksheet.

5. REFERENCES

None.

PROJECTILE/LEAD SHOT DENSITY ANALYSIS

PROJECT NO:	**CONTRACT NO:**		**TASK ORDER NO:**
SITE NAME AND LOCATION:			
SAMPLE NAME:			
SAMPLE DATE:	_____/_____/_____	**SAMPLE TIME:**	_____:_____ **AM or PM**
SAMPLE DEPTH INTERVAL:			
SAMPLE ANALYSIS DATE:	_____/_____/_____	**SAMPLE ANALYSIS TIME:**	_____:_____ **AM or PM**
SAMPLE DESCRIPTION:			
START WEIGHT:	*g*		
END WEIGHT (LEAD ONLY):	*g*		
OBSERVED NUMBER OF PROJECTILES AND LEAD SHOT			
OBSERVED NUMBER OF PROJECTILE AND LEAD SHOT FRAGMENTS:			
SAMPLE AREA (SEDIMENT)[1]:	$(\frac{d}{2}(in.))^2 x\ \pi\ =$ _____$in.^2$ (d=diameter)		
PROJECTILE DENSITY: (projectiles/in.^{2})	$\frac{Number\ of\ Projectiles:}{Sample\ Area:\ \ in.^2} =$ _____ $\frac{projectiles}{in.^2}$		
PROJECTILE DENSITY: (projectiles/ft.^{2})	**Multiply the pellet density (pellets/in.^{2}) by 144 to get (pellets/ft.^{2}):** $Projectile\ Density(above):$ _____ $\frac{projectiles}{in.^2} \times \frac{144\ in.^2}{ft.^2} =$ _____ $\frac{projectiles}{ft.^2}$		

Notes:
1. Sample area for soil will be 144 in.^{2}

Standard Operating Procedure No. 056a
for
X-Ray Fluorescence Analysis of Soil Using Thermoscientific/Niton XL3t GOLDD

Prepared by

EA Engineering, Science, and Technology, Inc., PBC
225 Schilling Circle, Suite 400
Hunt Valley, Maryland 21031

Revision 1
September 2015

PROJECT-SPECIFIC VARIANCE FORM

This form is to be completed to indicate if there are any client-, project-, or site-specific variances to this Standard Operating Procedure (SOP) (**also check Box A**), or if this SOP is being used with no changes (**only check Box B**).

A. ☐ **Variances required; cite section(s) of the SOP to which there is a variance (add additional pages if necessary)**

B. ☐ **No variances**

SOP No. 056a	
SOP Section	**Variance**

Project Manager (Name) Date

Project Manager (Signature) Date

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CONTENTS

DOCUMENT REVISION HISTORY

ORIGINAL (MASTER) DOCUMENT REVISION HISTORY				
Revision Number	**Revision Date**	**Revision Summary**	**Revised By**	**Reviewed By**
1	September 2015	Updated protocols/information in Section 3, 4, 5, and 7.	Caron Mierczak	Amy Sponaugle Steve Yankay Pete Garger Barb Roeper

1. SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to describe protocols for using the Niton XL3t GOLDD tube-based x-ray fluorescence (XRF) analyzer for field analysis of soil samples for metals. Quality control (QC) protocols in this SOP are consistent with the protocols identified in United States Environmental Protection Agency (EPA) Method 6200 (EPA 2007). Projects requiring adherence to U.S. Army Corps of Engineers (USACE) – Omaha District guidance *Small Arms Range Characterization of Lead Using X-Ray Fluorescence (XRF)* for QC protocols and sample preparation and analysis should refer to EA SOP 056b.

Any client-, project-, or site-specific variances to this SOP (if any) are documented on the Project-Specific Variance Form, located immediately after the SOP title page. Prior to using this SOP, field personnel should refer to the Project-Specific Variance Form to verify whether any variances are required.

Use of brand names in this SOP is not intended as an endorsement or mandate that a given brand be used. Alternative equivalent brands of detectors, sensors, meters, etc. are acceptable.

2. MATERIALS

The following materials may be required:

ThermoScientific/Niton XL3t GOLDD XRF	Mylar, Kapton, Spectroleen, polypropylene, or equivalent film
Mini-USB to USB cable	Plastic zipper-type bags (1-mil thickness)
Laptop computer and alternating current power adaptor	Containers (for sample collection and storage)
Li-ion batteries for XRF	2-mm mesh sieve(s)
Li-ion battery charger	Silicon blank
Standard Reference Material (SRM) for calibration check of XRF	Paper towels
Soil test stand/bulk sample analyzer sled	Paperwork (applicable regulations and licenses, XRF Operators' Manual, and emergency contacts)
Polyethylene sample cups (31-40 millimeters [mm] in diameter with collar)	Proper site-specific personal protective equipment and dosimetry

3. GENERAL

Procedures for handling and control of company-owned and rented equipment containing radioactive materials and x-ray tubes are specified in EA Engineering, Science, and Technology, Inc., PBC's (EA's) Radiation Protection Program (EA 2014), which is administered by the Radiation Safety Officer (RSO), under direct supervision of EA's Corporate Health and Safety Director. Personnel using this SOP must be familiar with the procedures identified in the Radiation Protection Program (EA 2014)

The use of radioactive materials and x-ray generating equipment is highly regulated by federal and state agencies. Licensees of radioactive materials and x-ray generating equipment are required to follow regulatory requirements and are subject to periodic inspections. Licensees may face disciplinary action by federal or state agencies if determined to be out of compliance with regulations. The RSO must be informed about any XRF usage (rental or company-owned) prior to use, including the scheduled timeframe of use; the state within which the XRF will be used; and the safety and security measures that will be enforced during transportation (either over land or by air), storage, and use of the instrument. Licensing, registration, or reciprocity may be required prior to using the XRF (i.e., a certificate of reciprocity or license/registration might be required from the destination state). In addition, per EA policy, the RSO will assign dosimetry badges to the operators (regardless of whether the instrument is EA-owned or rented) to measure potential radiation dose. Dosimetry is personnel-specific (i.e., cannot be shared by multiple personnel), and must be replaced every 3 months.

The XRF shall be operated by a trained operator, knowledgeable in aspects of radiation safety. Usage of the XRF is contingent on the operators successfully completing the manufacturer's *Radiation Safety for X-Ray Tube-Based Instruments* and *Transport of Li Ion Batteries* training module, as well as EA's *Radiation Safety Training* and *Hands-On XRF Operational Training*. All certificates of training completion must be received and documented by the RSO prior to using the XRF.

The XRF should be operated in a clean environment, out of direct sunlight, and without significant concentrations of dust.

The XRF shall be in direct control of a trained XRF operator at all times. When not in use, the XRF shall be stored within a locked case, and stored in a locked storage area (i.e., cabinet), in a locked room or building when not in use ("triple locked").

Batteries are provided for portable operation of the XRF; however, the batteries have a limited operating time. It is highly recommended to connect the unit to an alternating current power source, especially for operating times exceeding 4 hours. Failure of the batteries during a screening session may result in data loss. After each portable operation, the instrument batteries must be recharged before resuming operations.

4. QUALITY CONTROL

The RSO will ensure that the XRF will adhere to manufacturer specifications for calibration. Onsite calibration verification checks will be performed by the operator. The QC protocols specified in this section are consistent with the protocols identified in EPA Method 6200 (EPA 2007). Projects requiring adherence to USACE – Omaha District guidance *Small Arms Range Characterization of Lead Using X-Ray Fluorescence (XRF)* for QC protocols should refer to EA SOP 056b.

The accuracy of the XRF can be evaluated by performing calibration verification checks. These checks are performed by analyzing standard reference materials (SRMs) traceable to the National Institute of Standards and Technology (NIST). A minimum of two SRMs will be analyzed daily: once at the beginning of the day and end of the day, or at the beginning of the day and after every 20th sample, whichever occurs first. The actual (NIST certified) concentration of the SRM as well as the concentration displayed by the XRF will be recorded (NIST certified concentrations can be obtained from the RSO or the NIST website:

https://www-s.nist.gov/srmors/viewTableH.cfm?tableid=86)

The relative percent difference (RPD) between the actual and displayed concentrations will be calculated as follows:

$$RPD = [2(SRM-R)/(SRM+R)] \times 100$$

where

SRM = Concentration of the standard reference material.
R = Displayed concentration from XRF.

The result will be compared to the project data quality objectives (DQOs), if applicable, to evaluate if the XRF accuracy is within project limits. A typical DQO for this indicator is +/20 percent. Note that a site-specific sample with a known concentration of the compound(s) of interest may be used in lieu of an SRM to perform the calibration verification checks; however, this SOP deviation should be noted in the Project-Specific Variance Form.

To assess the precision of the XRF, a precision analysis may be performed. If project DQOs do not require a precision analysis it will be noted on the Project-Specific Variance Form. The precision analysis is performed by running 10 replicate analyses on the same site sample and calculating the relative standard deviation (RSD) of the sample mean as follows:

$$RSD = (SD/Mean\ Concentration) \times 100$$

where

RSD = Relative standard deviation for the precision measurement for the analyte.
SD = Standard deviation of the reported analyte concentration for the precision sample.
Mean Concentration = Mean analyte concentration of the seven replicate analyses.

The site sample should have detectable concentrations of metals (i.e., above the instrument's detection limits). Precision analysis should be performed at a minimum of once per day, but may be required more often depending upon the project DQOs (the Project-Specific Variance Form will document if this analysis is not required). A typical DQO for this indicator is <20 percent.

Duplicate (or triplicate) analysis is another quality control check that may be performed on the XRF (the Project-Specific Variance Form will document if this analysis is not required). As defined by the U.S. Environmental Protection Agency (EPA), Method 6200, a typical duplicate analysis scheme would require the preparation and analysis of a duplicate sample at a rate of 1 per every 20 normal site samples. Duplicates are a second sample collected and prepared as a normal sample would be. The duplicate is analyzed and the results compared to the normal sample by calculating the RPD. The DQO for duplicate samples is project specific; however, a typical objective is an RPD of no more than 30 percent (EPA 2007).

An alternative to duplicate sample analysis would be replicate sample analysis. Replicate sample analyses are two analyses of the same prepared sample. Generally, the sample is moved/rotated; re-homogenized; or, if prepared in a sample cup, inverted (on a double open ended cup) for the second analysis. This approach assesses comparability between results without interference from field sampling variability. The replicate sample results are compared to the normal sample results in the same manner as a duplicate sample analysis.

Blank analyses may be performed to assess whether equipment cross contamination is occurring. Two types of blank sample analyses are typical: instrument blank and method blank.

The instrument blank is performed by analyzing silicon dioxide (or clean sand), a Teflon block, or a quartz block. The frequency of blank analysis is dependent upon project DQOs but is typically performed twice daily, prior to and after sample analyses for that day (the Project-Specific Variance Form will document if this analysis is not required). Typically, the instrument blank analysis is performed concurrently with the SRM calibration verification analysis. Instrument blanks may also be performed after every 20 samples; again, depending on project DQOs. Results should be below detection.

Method blanks are performed to monitor decontamination efficiency on equipment that is not dedicated. The blank is performed by substituting clean sand in the sample preparation process, and analyzing in the same manner as a site sample. Results should be below the instrument's detection limits.

5. SITE SAMPLE PREPARATION AND ANALYSIS

Sample preparation is dependent upon project DQOs and may be different than the preparation described herein (consult the Project-Specific Variance Form for any deviations to this protocol). More rigorous sample preparation protocols are available (e.g., EPA Method 6200 [2007]). Projects requiring adherence to USACE – Omaha District guidance *Small Arms Range Characterization of Lead Using X-Ray Fluorescence (XRF)* for sample preparation and analysis should refer to EA SOP 056b. The project planning document and DQOs should be referenced to determine if the method described herein is adequate for any specific project.

- Don appropriate personal protective equipment (PPE) as required by the project health and safety plan; at a minimum gloves and radiation dosimetry will be utilized.

- Collect soil sample as described in the project planning documents, including a minimum of 50 grams of soil for XRF analysis.

- If the sample is noticeably wet (>20 percent moisture), dry the sample in an oven. Alternatively, the samples may be dried with paper towels and/or by allowing the sun to evaporate the moisture. Microwave drying is not recommended; field studies have shown that microwave drying can increase variability between XRF data and confirmatory analysis and metal fragments in the sample can cause arcing to occur in a microwave.

- Inspect the sample to ensure no foreign (non-soil) materials are present in the sample (i.e., paint chips, lead shot, concrete chips, leaves, rocks, or asphalt). Note the presence of foreign matter in the project log. If the quantity of foreign material is such that removal is impractical, note in the project log that the foreign material could not be removed.

- Pass soil through a decontaminated 2-mm mesh sieve collecting the soil in a dedicated zipper-type plastic bag, labeled with the sample identification. This step may be eliminated in lieu of hand processing (removal of stone, debris, lead shot, paint chips, and organic material) of the sample simultaneously with the following step, but should be noted on the Variance Form if this method is performed.

- Homogenize the soil by rolling the soil within the bag, being sure to break up large clumps of soil.

- Assemble a disposable sample cup, label with sample identification, and pack the soil tightly into the cup. Cover the cup with polypropylene (or equivalent) film and use the collar to secure in place. This step may be eliminated for the analysis of the sample through the zipper-type plastic bag, but should be noted on the Project-Specific Variance Form if this method is to be performed.

- Place the sample cup/zipper-type bag onto the soil test platform. Inconsistent positioning of samples in front of the probe window is a potential source of error because the x-ray signal decreases as the distance from the radioactive source increases. This error is minimized by maintaining the same distance between the window and each sample. For the best results, the window of the probe should be in direct contact with the sample, which means that the sample should be flat and smooth to provide a good contact surface.

- Initiate the XRF reading using the trigger or start button on the personal digital assistant.

- Allow the analyzer to run and collect data for a nominal sample time of 60 seconds; a project-specific variation to the nominal sample time will be noted on the Project-Specific Variance Form.

- Record the sample designation and result(s) in either a field logbook or on appropriate data sheets.

- Retain the cupped/bagged sample for possible laboratory confirmatory analysis.

- Use the same procedure for the analysis of method blank, duplicate, replicate, SRMs, and precision analysis samples.

- Download the XRF data daily to a computer (if possible). Back up the data to a server, disc, or compact disc.

The comparability and quality of the XRF analysis is determined by submitting XRF-analyzed samples for confirmatory analysis to a laboratory. The confirmatory samples must be splits of the homogenized sample material. A minimum of 1 sample for each 20 XRF-analyzed samples should be submitted for confirmatory analysis. The Project-Specific Variance Form will note if there is a deviation from this frequency. The confirmatory samples should be selected from the lower, middle, and upper range of concentrations measured by the XRF. They should also include samples with analyte concentrations at or near the site action levels or project remedial goals. The results of the confirmatory analysis and XRF analyses should be evaluated with a least squares linear regression analysis. If the measured concentrations span more than one order of magnitude, the data should be log-transformed to standardize variance which is proportional to the magnitude of measurement. The correlation coefficient (r) for the results should be 0.7 or greater for the XRF data to be considered screening level data. If the r is 0.9 or greater and inferential statistics indicate the XRF data and the confirmatory data are statistically equivalent at a 99 percent confidence level, the data could potentially meet definitive level data criteria (EPA 2007).

6. PRECAUTIONS

The XRF produces ionizing radiation in the x-ray spectrum. This SOP and the precautions herein are applicable to the ThermoScientific/Niton NL3t GOLDD tube-based instrument. Additional precautions not contained herein are necessary if utilizing a radioactive source-based XRF (e.g., cadmium-109). The tube-based instrument is capable of producing x-rays when the instrument is powered and an analysis initiated. The instrument has a red light near the shutter that will flash when the instrument is emitting x-rays. When the shutter is open and the light is flashing, the instrument is emitting x-rays. At this time, the following must be observed:

- Always be aware of the location of the tube and direction of the x-ray beam.

- Open the shutter only to conduct a test.

- The person conducting the XRF analysis must be a trained operator in accordance with the requirements in Section 3 and is required to wear dosimetry.

The XRF is able to function as a handheld screening tool by wielding the detector by hand and pressing it to the sample for analysis. For soil screening, this has the potential of exposing the operator to inadvertent x-ray radiation. For this reason, the operator shall use the soil test stand (or equivalent stand), which incorporates x-ray shielding and automatic x-ray beam shut-off safety features to protect the operator from exposure. Any deviation from use of the soil test stand must be approved by the RSO.

Decontamination of the soil test stand is to be restricted to wiping the test stand with a damp cloth. Any additional decontamination procedures must be approved by the RSO.

EA's emergency procedures for the XRF (in the event that the XRF unit is damaged, destroyed, lost, or stolen) are provided to authorized users and will be used in the event of an emergency.

7. REFERENCES

EA Engineering, Science, and Technology, Inc. (EA). 2014. Radiation Protection Program. August.

U.S. Army Corps of Engineers – Omaha District (USACE-Omaha). 2008. Small Arms Range Characterization of Lead Using X-Ray Fluorescence (XRF). December 04.

U.S. Environmental Protection Agency (EPA). 2007. Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment. Method 6200. February.

Attachment 2

Laboratory Certifications

Contents:

Certificate of Accreditation – SGS Accutest – Orlando

Scope of Accreditation for SGS Accutest – Orlando

New York State Department of Health Wadsworth Center – Certificate of Approval for Laboratory Service

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LABORATORY ACCREDITATION BUREAU a division of A-S-B

Certificate of Accreditation

ISO/IEC 17025:2005 Certificate Number L2229

SGS Accutest - Orlando

4405 Vineland Road, Suite C-15
Orlando FL 32811

has met the requirements set forth in L-A-B's policies and procedures, all requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the U.S. Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP).*

The accredited lab has demonstrated technical competence to a defined "Scope of Accreditation" and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

Accreditation valid through: December 15, 2018

R. Douglas Leonard, Jr., President, COO
Laboratory Accreditation Bureau
Presented the 14th of January 2016

*See the laboratory's Scope of Accreditation for details of accredited parameters
**Laboratory Accreditation Bureau is found to be in compliance with ISO/IEC 17011:2004 and recognized by ILAC (International Laboratory Accreditation Cooperation) and NACLA (National Cooperation for Laboratory Accreditation).
Form 403.14 – Rev 1 7/3/13

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Scope of Accreditation
For
SGS Accutest - Orlando

4405 Vineland Road, Suite C-15
Orlando, FL 32811
Svetlana Izosimova, Ph.D., QA Officer
407-425-6700

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (LABPR 403 DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM V5) based on the TNI Standard - Environmental Laboratory Sector, Volume 1 – Management and Technical Requirements for Laboratories Performing Environmental Analysis, Sept 2009 (EL-V1-2009); accreditation is granted to **SGS Accutest - Orlando** to perform the following tests:

Accreditation granted through: **December 15, 2018**

Testing – Environmental

Drinking Water		
Technology	**Method**	**Analyte**
LC/MS/MS	EPA 537	Perfluorohexanoic Acid
LC/MS/MS	EPA 537	Perfluoroheptanoic Acid
LC/MS/MS	EPA 537	Perfluorooctanoic Acid
LC/MS/MS	EPA 537	Perfluorononanoic Acid
LC/MS/MS	EPA 537	Perfluorodecanoic Acid
LC/MS/MS	EPA 537	Perfluoroundecanoic Acid
LC/MS/MS	EPA 537	Perfluorododecanoic Acid
LC/MS/MS	EPA 537	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537	Perfluorotetradecanoic Acid
LC/MS/MS	EPA 537	Perfluorobutanesulfonic Acid
LC/MS/MS	EPA 537	Perfluorohexanesulfonic Acid
LC/MS/MS	EPA 537	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537	N-Methyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537	N-Ethyl perfluorooctanesulfonamidoacetic acid

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-Chloropropane (DBCP)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/FID	EPA 8015C/D	Diesel range organics (DRO)
GC/FID	EPA 8015C/D	Oil Range Organics (ORO)
GC/FID	EPA 8015C/D	Gasoline range organics (GRO)
GC/FID	EPA 8015C/D	Ethanol
GC/FID	EPA 8015C/D	2-Ethoxyethanol
GC/FID	EPA 8015C/D	Isobutyl alcohol (2-Methyl-1-propanol)
GC/FID	EPA 8015C/D	Isopropyl alcohol (2-Propanol)
GC/FID	EPA 8015C/D	Methanol
GC/FID	EPA 8015C/D	n-Butyl alcohol
GC/FID	EPA 8015C/D	n-Propanol
GC/PID	EPA 602; EPA 8021B	Benzene
GC/PID	EPA 602; EPA 8021B	Ethylbenzene
GC/PID	EPA 602; EPA 8021B	Chlorobenzene
GC/PID	EPA 602; EPA 8021B	Toluene
GC/PID	EPA 602; EPA 8021B	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/PID	EPA 602; EPA 8021B	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/PID	EPA 602; EPA 8021B	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/PID	EPA 602; EPA 8021B	m,p-Xylene
GC/PID	EPA 602; EPA 8021B	o-Xylene
GC/PID	EPA 602; EPA 8021B	Methyl-tert-Butyl Ether
GC/ECD	EPA 608; EPA 8081B	4,4`-DDD
GC/ECD	EPA 608; EPA 8081B	4,4`-DDE
GC/ECD	EPA 608; EPA 8081B	4,4`-DDT
GC/ECD	EPA 608; EPA 8081B	Aldrin
GC/ECD	EPA 608; EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 608; EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 608; EPA 8081B	delta-BHC
GC/ECD	EPA 608; EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 608; EPA 8081B	Chlordane (tech.)
GC/ECD	EPA 608; EPA 8081B	alpha-Chlordane
GC/ECD	EPA 608; EPA 8081B	gamma-Chlordane
GC/ECD	EPA 608; EPA 8081B	Dieldrin
GC/ECD	EPA 608; EPA 8081B	Endosulfan I
GC/ECD	EPA 608; EPA 8081B	Endosulfan II
GC/ECD	EPA 608; EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 608; EPA 8081B	Endrin
GC/ECD	EPA 608; EPA 8081B	Endrin aldehyde
GC/ECD	EPA 608; EPA 8081B	Endrin ketone
GC/ECD	EPA 608; EPA 8081B	Heptachlor
GC/ECD	EPA 608; EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 608; EPA 8081B	Methoxychlor

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 608; EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 608; EPA 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A	Aroclor-1268 (PCB-1268)
GC/FPD	EPA 8141B	Azinphos-methyl (Guthion)
GC/FPD	EPA 8141B	Bolstar (Sulprofos)
GC/FPD	EPA 8141B	Carbophenothion
GC/FPD	EPA 8141B	Chlorpyrifos
GC/FPD	EPA 8141B	Coumaphos
GC/FPD	EPA 8141B	Demeton-o
GC/FPD	EPA 8141B	Demeton-s
GC/FPD	EPA 8141B	Diazinon
GC/FPD	EPA 8141B	Dichlorovos (DDVP Dichlorvos)
GC/FPD	EPA 8141B	Dimethoate
GC/FPD	EPA 8141B	Disulfoton
GC/FPD	EPA 8141B	EPN
GC/FPD	EPA 8141B	Ethion
GC/FPD	EPA 8141B	Ethoprop
GC/FPD	EPA 8141B	Famphur
GC/FPD	EPA 8141B	Fensulfothion
GC/FPD	EPA 8141B	Fenthion
GC/FPD	EPA 8141B	Malathion
GC/FPD	EPA 8141B	Merphos
GC/FPD	EPA 8141B	Methyl parathion (Parathion methyl)
GC/FPD	EPA 8141B	Mevinphos
GC/FPD	EPA 8141B	Monocrotophos
GC/FPD	EPA 8141B	Naled
GC/FPD	EPA 8141B	Parathion ethyl
GC/FPD	EPA 8141B	Phorate
GC/FPD	EPA 8141B	Ronnel
GC/FPD	EPA 8141B	Stirofos
GC/FPD	EPA 8141B	Sulfotepp
GC/FPD	EPA 8141B	Tetraethyl pyrophosphate (TEPP)
GC/FPD	EPA 8141B	Thionazin (Zinophos)
GC/FPD	EPA 8141B	Tokuthion (Prothiophos)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/FPD	EPA 8141B	Trichloronate
GC/FPD	EPA 8141B	O,O,O-Triethyl phosphorothioate
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop (Dichlorprop)
GC/ECD	EPA 8151A	Dinoseb (2-sec-butyl-4,6-dinitrophenol DNBP)
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2,4,5-TP)
GC/FID	RSK-175	Acetylene
GC/FID	RSK-175	Methane
GC/FID	RSK-175	Ethane
GC/FID	RSK-175	Ethene
GC/FID	RSK-175	Propane
GC/FID	FL-PRO	Total Petroleum Hydrocarbons (TPH)
GC/FID	MA-VPH	Volatile petroleum range organics (VPH)
GC/FID	MA-EPH	Extractable petroleum range organics (EPH)
GC/FID	IA-OA1	Gasoline range organics (GRO)
GC/FID	IA-OA2	Diesel range organics (DRO)
GC/FID	TN-GRO	Gasoline range organics (GRO)
GC/FID	TN-EPH	Extractable petroleum range organics (EPH)
GC/FID	WI-DRO	Diesel range organics (DRO)
GC/FID	AK-101	Gasoline range organics (GRO)
GC/FID	AK-102	Diesel range organics (DRO)
GC/FID	OK-GRO	Gasoline range organics (GRO)
GC/FID	OK-DRO	Diesel range organics (DRO)
GC/FID	TX-1005	Total Petroleum Hydrocarbons (TPH)
GC/FID	KS LRH	Low-Range Hydrocarbons (LRH)
GC/FID	KS MRH	Mid-Range Hydrocarbons (MRH)
GC/FID	KS HRH	High-Range Hydrocarbons (HRH)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1,1-Trichloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1,2-Trichloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1-Dichloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1-Dichloroethylene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,1-Dichloropropene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 624; EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2,3-Trichlorobenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2,3-Trichloropropane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2,4-Trichlorobenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2,4-Trimethylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dibromoethane (EDB Ethylene dibromide)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dichloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,2-Dichloropropane
GC/MS	EPA 8260B/C	1,2-Dichlorotrifluoroethane (Freon 123)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,3,5-Trimethylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,3-Dichloropropane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	2,2-Dichloropropane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	2-Butanone (Methyl ethyl ketone MEK)
GC/MS	EPA 624; EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	2-Chlorotoluene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	2-Hexanone
GC/MS	EPA 8260B/C	2-Nitropropane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	4-Chlorotoluene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	4-Methyl-2-pentanone (MIBK)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 624; EPA 8260B/C	Acrolein (Propenal)
GC/MS	EPA 624; EPA 8260B/C	Acrylonitrile
GC/MS	EPA 8260B/C	Allyl chloride (3-Chloropropene)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Benzene
GC/MS	EPA 8260B/C	Benzyl Chloride
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Bromobenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Bromochloromethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Bromodichloromethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Bromoform
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	n-Butylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	sec-Butylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Carbon disulfide
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Carbon tetrachloride
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Chlorobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Chloroethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Chloroform
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 624; EPA 8260B,C	Cyclohexane
GC/MS	EPA 8260B/C	Cyclohexanone
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	cis-1,2-Dichloroethylene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	trans-1,2-Dichloroethylene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	cis-1,3-Dichloropropene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	trans-1,3-Dichloropropylene
GC/MS	EPA 8260B/C	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Di-isopropylether (DIPE)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Dibromochloromethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Dibromomethane (Methylene Bromide)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Dichlorodifluoromethane
GC/MS	EPA 8260B/C	Diethyl ether
GC/MS	EPA 624, EPA 8260B/C, EPA 8260B/C SIM	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Ethanol (Ethyl Alcohol)
GC/MS	EPA 8260B/C	Ethyl acetate
GC/MS	EPA 8260B/C	Ethyl methacrylate
GC/MS	EPA 8260B/C	Ethyl tert-butyl alcohol (ETBA)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Ethyl tert-butyl ether (ETBE)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Ethylbenzene
GC/MS	EPA 8260B/C	Ethylene Oxide
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Hexane
GC/MS	EPA 8260B/C	Iodomethane (Methyl iodide)
GC/MS	EPA 8260B/C	Isobutyl alcohol (2-Methyl-1-propanol)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	p-Isopropyltoluene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Isopropylbenzene
GC/MS	EPA 8260B/C	Methacrylonitrile
GC/MS	EPA 624; EPA 8260B/C	Methyl Acetate
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Methyl bromide (Bromomethane)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Methyl chloride (Chloromethane)
GC/MS	EPA 624; EPA 8260B,C	Methylcyclohexane
GC/MS	EPA 8260B/C	Methyl methacrylate
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Methyl tert-butyl ether (MTBE)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Methylene chloride
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Naphthalene
GC/MS	EPA 8260B/C	Pentachloroethane
GC/MS	EPA 8260B/C	Propionitrile (Ethyl cyanide)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	n-Propylbenzene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Styrene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Amyl alcohol (TAA)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Amyl methyl ether (TAME)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Butyl alcohol (TBA)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	tert-Butyl formate (TBF)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B/C	Tetrahydrofuran
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Toluene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Trichlorofluoromethane
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Vinyl acetate
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Vinyl chloride
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	Xylene (total)
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	m,p-Xylene
GC/MS	EPA 624; SM 6200B-11; EPA 8260B/C	o-Xylene
GC/MS	EPA 8260B/C	1-Bromopropane
GC/MS	EPA 8260B/C	Isopropyl Alcohol
GC/MS	EPA 8260B/C	n-Butyl Alcohol
GC/MS	EPA 625; EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 625; EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 625; EPA 8270D	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 625; EPA 8270D	1,2-Diphenylhydrazine
GC/MS	EPA 8270D	1,3,5-Trinitrobenzene (1,3,5-TNB)
GC/MS	EPA 625; EPA 8270D	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8270D	1,3-Dinitrobenzene (1,3-DNB)
GC/MS	EPA 625; EPA 8270D	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8270D	1,4-Dithiane
GC/MS	EPA 8270D	1,4-Oxathiane
GC/MS	EPA 8270D	1,4-Naphthoquinone
GC/MS	EPA 8270D	1,4-Phenylenediamine
GC/MS	EPA 8270D	1-Chloronaphthalene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	1-Methylnaphthalene
GC/MS	EPA 8270D	1-Naphthylamine
GC/MS	EPA 625; EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 625; EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 625; EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 625; EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 625; EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 625; EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 625; EPA 8270D	2,4-Dinitrotoluene (2,4-DNT)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	2,6-Dichlorophenol
GC/MS	EPA 625; EPA 8270D	2,6-Dinitrotoluene (2,6-DNT)
GC/MS	EPA 8270D	2-Acetylaminofluorene
GC/MS	EPA 625; EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 625; EPA 8270D	2-Chlorophenol
GC/MS	EPA 625; EPA 8270D	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-o-cresol)
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	2-Methylnaphthalene
GC/MS	EPA 625; EPA 8270D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270D	2-Naphthylamine
GC/MS	EPA 625; EPA 8270D	2-Nitroaniline
GC/MS	EPA 625; EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	2-Picoline (2-Methylpyridine)
GC/MS	EPA 625; EPA 8270D	3,3`-Dichlorobenzidine
GC/MS	EPA 8270D	3,3`-Dimethylbenzidine
GC/MS	EPA 8270D	3-Methylcholanthrene
GC/MS	EPA 625; EPA 8270D	3&4-Methylphenol (m,p-Cresol)
GC/MS	EPA 625; EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4-Aminobiphenyl
GC/MS	EPA 625; EPA 8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 625; EPA 8270D	4-Chloro-3-methylphenol
GC/MS	EPA 625; EPA 8270D	4-Chloroaniline
GC/MS	EPA 625; EPA 8270D	4-Chlorophenyl phenylether
GC/MS	EPA 8270D	4-Dimethyl aminoazobenzene
GC/MS	EPA 625; EPA 8270D	4-Nitroaniline
GC/MS	EPA 625; EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	4,4'-methylene-bis(2-chloroaniline)
GC/MS	EPA 8270D	5-Nitro-o-toluidine
GC/MS	EPA 8270D	7,12-Dimethylbenz(a) anthracene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Acenaphthene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Acenaphthylene
GC/MS	EPA 625; EPA 8270D	Acetophenone
GC/MS	EPA 625; EPA 8270D	Aniline
GC/MS	EPA 8270D	Anilazine
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Anthracene
GC/MS	EPA 8270D	Aramite
GC/MS	EPA 625; EPA 8270D	Atrazine
GC/MS	EPA 625; EPA 8270D	Benzaldehyde
GC/MS	EPA 625; EPA 8270D	Benzidine
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Benzo(a)anthracene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Benzo(a)pyrene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Benzo(b)fluoranthene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Benzo(g,h,i)perylene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Benzo(k)fluoranthene
GC/MS	EPA 625; EPA 8270D	Benzoic acid
GC/MS	EPA 625; EPA 8270D	Benzyl alcohol
GC/MS	EPA 625; EPA 8270D	Biphenyl (1,1'-Biphenyl)
GC/MS	EPA 625; EPA 8270D	bis(2-Chloroethoxy)methane
GC/MS	EPA 625; EPA 8270D	bis(2-Chloroethyl) ether
GC/MS	EPA 625; EPA 8270D	bis(2-Chloroisopropyl) ether (2,2`-Oxybis(1-chloropropane))
GC/MS	EPA 625; EPA 8270D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 625; EPA 8270D	Butyl benzyl phthalate
GC/MS	EPA 625; EPA 8270D	Carbazole
GC/MS	EPA 625; EPA 8270D	Caprolactam
GC/MS	EPA 8270D	Chlorobenzilate
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Chrysene
GC/MS	EPA 8270D	Diallate
GC/MS	EPA 8270D	Dinoseb
GC/MS	EPA 625; EPA 8270D	Di-n-butyl phthalate
GC/MS	EPA 625; EPA 8270D	Di-n-octyl phthalate
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Dibenz(a,h)anthracene
GC/MS	EPA 8270D	Dibenz(a,j)acridine
GC/MS	EPA 625; EPA 8270D	Dibenzofuran
GC/MS	EPA 625; EPA 8270D	Diethyl phthalate
GC/MS	EPA 625; EPA 8270D	Dimethyl phthalate
GC/MS	EPA 8270D	a,a-Dimethylphenethylamine
GC/MS	EPA 8270D	Diphenyl Ether
GC/MS	EPA 8270D	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8270D	Ethyl methanesulfonate
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Fluoranthene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Fluorene
GC/MS	EPA 625; EPA 8270D	Hexachlorobenzene
GC/MS	EPA 625; EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 625; EPA 8270D	Hexachlorocyclopentadiene
GC/MS	EPA 625; EPA 8270D	Hexachloroethane
GC/MS	EPA 8270D	Hexachlorophene
GC/MS	EPA 8270D	Hexachloropropene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270D	Isodrin
GC/MS	EPA 625; EPA 8270D	Isophorone
GC/MS	EPA 8270D	Isosafrole
GC/MS	EPA 8270D	Kepone
GC/MS	EPA 8270D	Methapyrilene
GC/MS	EPA 8270D	Methyl methanesulfonate

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Naphthalene
GC/MS	EPA 8270D	Nicotine
GC/MS	EPA 625; EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	Nitroquinoline-1-oxide
GC/MS	EPA 8270D	n-Nitroso-di-n-butylamine
GC/MS	EPA 625; EPA 8270D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270D	n-Nitrosodiethylamine
GC/MS	EPA 625; EPA 8270D	n-Nitrosodimethylamine
GC/MS	EPA 625; EPA 8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine/Diphenylamine (analyte pair)
GC/MS	EPA 8270D	n-Nitrosomethylethylamine
GC/MS	EPA 8270D	n-Nitrosomorpholine
GC/MS	EPA 8270D	n-Nitrosopiperidine
GC/MS	EPA 8270D	n-Nitrosopyrrolidine
GC/MS	EPA 8270D	Pentachlorobenzene
GC/MS	EPA 8270D	Pentachloroethane
GC/MS	EPA 8270D	Pentachloronitrobenzene
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Pentachlorophenol
GC/MS	EPA 8270D	Phenacetin
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Phenanthrene
GC/MS	EPA 625; EPA 8270D	Phenol
GC/MS	EPA 8270D	Pronamide (Kerb)
GC/MS	EPA 8270D	Propazine
GC/MS	EPA 625; EPA 8270D; EPA 8270D SIM	Pyrene
GC/MS	EPA 625; EPA 8270D	Pyridine
GC/MS	EPA 8270D	Resorcinol
GC/MS	EPA 8270D	Safrole
GC/MS	EPA 8270D	Simazine
GC/MS	EPA 8270D	Thionazin (Zinophos)
GC/MS	EPA 8270D	o-Toluidine
GC/MS	EPA 8270D	Dimethoate
GC/MS	EPA 8270D	Disulfoton
GC/MS	EPA 8270D	Famphur
GC/MS	EPA 8270D	Methyl parathion (Parathion methyl)
GC/MS	EPA 8270D	Parathion ethyl
GC/MS	EPA 8270D	Phorate
GC/MS	EPA 8270D	O,O,O-Triethyl phosphorothioate
HPLC	EPA 610; EPA 8310	1-Methylnaphthalene
HPLC	EPA 610; EPA 8310	2-Methylnaphthalene
HPLC	EPA 610; EPA 8310	Acenaphthene
HPLC	EPA 610; EPA 8310	Acenaphthylene

Non-Potable Water		
Technology	**Method**	**Analyte**
HPLC	EPA 610; EPA 8310	Anthracene
HPLC	EPA 610; EPA 8310	Benzo(a)anthracene
HPLC	EPA 610; EPA 8310	Benzo(a)pyrene
HPLC	EPA 610; EPA 8310	Benzo(b)fluoranthene
HPLC	EPA 610; EPA 8310	Benzo(g h i)perylene
HPLC	EPA 610; EPA 8310	Benzo(k)fluoranthene
HPLC	EPA 610; EPA 8310	Chrysene
HPLC	EPA 610; EPA 8310	Dibenz(a,h)anthracene
HPLC	EPA 610; EPA 8310	Fluoranthene
HPLC	EPA 610; EPA 8310	Fluorene
HPLC	EPA 610; EPA 8310	Indeno(1,2,3-cd)pyrene
HPLC	EPA 610; EPA 8310	Naphthalene
HPLC	EPA 610; EPA 8310	Phenanthrene
HPLC	EPA 610; EPA 8310	Pyrene
HPLC	EPA 8330A/B	1,3,5-Trinitrobenzene (1,3,5-TNB)
HPLC	EPA 8330A/B	1,3-Dinitrobenzene (1,3-DNB)
HPLC	EPA 8330A/B	2,4,6-Trinitrotoluene (2,4,6-TNT)
HPLC	EPA 8330A/B	2,4-Dinitrotoluene (2,4-DNT)
HPLC	EPA 8330A/B	2,6-Dinitrotoluene (2,6-DNT)
HPLC	EPA 8330A/B	2-Amino-4,6-dinitrotoluene (2-am-dnt)
HPLC	EPA 8330A/B	2-Nitrotoluene
HPLC	EPA 8330A/B	3,5-Dinitroaniline
HPLC	EPA 8330A/B	3-Nitrotoluene
HPLC	EPA 8330A/B	4-Amino-2,6-dinitrotoluene (4-am-dnt)
HPLC	EPA 8330A/B	4-Nitrotoluene
HPLC	EPA 8330A/B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC	EPA 8330A/B	Nitrobenzene
HPLC	EPA 8330A/B; EPA 8332	Nitroglycerin
HPLC	EPA 8330A/B	Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
HPLC	EPA 8330A/B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC	EPA 8330A/B; EPA 8332	Pentaerythritoltetranitrate (PETN)
HPLC	EPA 8330A	2,2’,6,6’-Tetranitro-4,4’-azoxytoluene
HPLC	EPA 8330A/B	2-amino-6-Nitrotoluene
HPLC	EPA 8330A/B	4-amino-2-Nitrotoluene
HPLC	EPA 8330A/B	2-amino-4-Nitrotoluene
HPLC	EPA 8330A/B	2,4-diamino-6-Nitrotoluene
HPLC	EPA 8330A/B	2,6-diamino-4-Nitrotoluene
HPLC	EPA 8330A/B	DNX
HPLC	EPA 8330A/B	MNX
HPLC	EPA 8330A/B	TNX
HPLC	EPA 8330A	Nitroguanidine

Non-Potable Water		
Technology	**Method**	**Analyte**
HPLC	EPA 8330A	Guanidine Nitrate
LC/MS/MS	EPA 6850	Perchlorate
LC/MS/MS	EPA 537 MOD	Perfluorobutanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoropentanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorohexanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroheptanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorononanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroundecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorododecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotetradecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorobutanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorohexanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroheptanesulfonic acid
LC/MS/MS	EPA 537 MOD	Perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD	N-Methyl perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD	N-Ethyl perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD	Perfluoro-1-octanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD	N-Methyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD	N-Ethyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD	N-Methyl perfluorooctane sulfonamidoethanol
LC/MS/MS	EPA 537 MOD	N-Ethyl perfluorooctane sulfonamidoethanol
LC/MS/MS	EPA 537 MOD	6:2 Fluorotelomer sulfonate
LC/MS/MS	EPA 537 MOD	8:2 Fluorotelomer sulfonate
ICP	EPA 200.7; EPA 6010C/D	Aluminum
ICP	EPA 200.7; EPA 6010C/D	Antimony
ICP	EPA 200.7; EPA 6010C/D	Arsenic
ICP	EPA 200.7; EPA 6010C/D	Barium
ICP	EPA 200.7; EPA 6010C/D	Beryllium
ICP	EPA 200.7; EPA 6010C/D	Cadmium
ICP	EPA 200.7; EPA 6010C/D	Calcium
ICP	EPA 200.7; EPA 6010C/D	Chromium
ICP	EPA 200.7; EPA 6010C/D	Cobalt
ICP	EPA 200.7; EPA 6010C/D	Copper
ICP	EPA 200.7; EPA 6010C/D	Iron

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP	EPA 200.7; EPA 6010C/D	Lead
ICP	EPA 200.7; EPA 6010C/D	Magnesium
ICP	EPA 200.7; EPA 6010C/D	Manganese
ICP	EPA 200.7; EPA 6010C/D	Molybdenum
ICP	EPA 200.7; EPA 6010C/D	Nickel
ICP	EPA 200.7; EPA 6010C/D	Potassium
ICP	EPA 200.7; EPA 6010C/D	Selenium
ICP	EPA 200.7; EPA 6010C/D	Silver
ICP	EPA 200.7; EPA 6010C/D	Sodium
ICP	EPA 200.7; EPA 6010C/D	Strontium
ICP	EPA 200.7; EPA 6010C/D	Thallium
ICP	EPA 200.7; EPA 6010C/D	Tin
ICP	EPA 200.7; EPA 6010C/D	Titanium
ICP	EPA 200.7; EPA 6010C/D	Vanadium
ICP	EPA 200.7; EPA 6010C/D	Zinc
ICP/MS	EPA 200.8; EPA 6020A	Aluminum
ICP/MS	EPA 200.8; EPA 6020A	Antimony
ICP/MS	EPA 200.8; EPA 6020A	Arsenic
ICP/MS	EPA 200.8; EPA 6020A	Barium
ICP/MS	EPA 200.8; EPA 6020A	Beryllium
ICP/MS	EPA 200.8; EPA 6020A	Cadmium
ICP/MS	EPA 200.8; EPA 6020A	Calcium
ICP/MS	EPA 200.8; EPA 6020A	Chromium
ICP/MS	EPA 200.8; EPA 6020A	Cobalt
ICP/MS	EPA 200.8; EPA 6020A	Copper
ICP/MS	EPA 200.8; EPA 6020A	Iron
ICP/MS	EPA 200.8; EPA 6020A	Lead
ICP/MS	EPA 200.8; EPA 6020A	Magnesium
ICP/MS	EPA 200.8; EPA 6020A	Manganese
ICP/MS	EPA 200.8; EPA 6020A	Molybdenum
ICP/MS	EPA 200.8; EPA 6020A	Nickel
ICP/MS	EPA 200.8; EPA 6020A	Potassium
ICP/MS	EPA 200.8; EPA 6020A	Selenium
ICP/MS	EPA 200.8; EPA 6020A	Silver
ICP/MS	EPA 200.8; EPA 6020A	Sodium
ICP/MS	EPA 200.8; EPA 6020A	Strontium
ICP/MS	EPA 200.8; EPA 6020A	Thallium
ICP/MS	EPA 200.8; EPA 6020A	Tin
ICP/MS	EPA 200.8; EPA 6020A	Titanium
ICP/MS	EPA 200.8; EPA 6020A	Vanadium
ICP/MS	EPA 200.8; EPA 6020A	Zinc
CVAA	EPA 7470A	Mercury

Non-Potable Water		
Technology	**Method**	**Analyte**
UV/VIS	EPA 7196A	Hexavalent Chromium (Cr6+)
UV/VIS	EPA 9012B	Cyanide (Total)
IC	EPA 300; EPA 9056A	Bromide
IC	EPA 300; EPA 9056A	Chloride
IC	EPA 300; EPA 9056A	Fluoride
IC	EPA 300; EPA 9056A	Nitrate
IC	EPA 300; EPA 9056A	Nitrite
IC	EPA 300; EPA 9056A	Sulfate
IC	EPA 300; EPA 9056A	Total nitrate-nitrite
Automated Colorimetry	EPA 350.1	Ammonia
Automated Colorimetry	EPA 350.1	Ammonia, Gas Diffusion Option
Automated Colorimetry	EPA 351.2	Total Kjeldahl Nitrogen
Automated Colorimetry	EPA 420.4	Total Phenolics
Automated Colorimetry	EPA 353.2	Nitrate
Automated Colorimetry	EPA 353.2	Nitrite
Automated Colorimetry	EPA 353.2	Nitrate+Nitrite
Manual Colorimetry	EPA 365.3	Orthophosphate
Manual Colorimetry	EPA 365.3	Total Phosphorus
Titrimetric	SM 2320B-11	Alkalinity, Total
Titrimetric	SM 4500-S2 F-11	Sulfide, Iodometric
Gravimetric Methods	EPA 1664A; EPA 9070A	Oil and Grease
Gravimetric Methods	SM 2540B-11	Total Residue (Total Solids)
Gravimetric Methods	SM 2540C-11	Filterable Residue (Total Dissolved Solids)
Gravimetric Methods	SM 2540D-11	Non-Filterable Residue (Total Suspended Solids)
Electrometric Methods	SM 4500H+B-11; EPA 9040C	Hydrogen Ion (Ph)
Electrometric Methods	EPA 120.1	Specific conductivity
Combustion	EPA 9060A	Total Organic Carbon
Ignitability	EPA 1010A	Flash Point
Waste Characterization	EPA Ch.7	Reactive Cyanide and Reactive Sulfide

Non-Potable Water		
Technology	**Method**	**Analyte**
Waste Characterization	EPA Section 7.3	Reactive Cyanide
Waste Characterization	EPA Section 7.3	Reactive Sulfide
Preparation	**Method**	**Type**
Organic Preparation	EPA 3510C	Separatory Funnel Liquid-Liquid Extraction
Organic Preparation	EPA 3511	Micro-extraction
Organic Preparation	EPA 3535A; EPA 3535A MOD	Solid Phase Extraction
Organic Preparation	EPA 8015C/D	Non-Halogenated Organics (Alcohols), direct injection
Organic Preparation	EPA 8151A	Chlorinated Herbicides, Liquid-Liquid Extraction
Organic Preparation	EPA 608; EPA 610; EPA 625	Separatory Funnel Liquid-Liquid Extraction
Volatile Organic Preparation	SW836 5030B	Closed System Purge and Trap
Volatile Organic Preparation	EPA 624	Closed System Purge and Trap
Volatile Organic Preparation	SM 6200B-11	Closed System Purge and Trap
Lachat MicroDistillation	EPA 9012B	Cyanide MicroDistillation; proprietary method
Inorganic Preparation	EPA 3010A	Metals Acid Digestion by Hotblock
Inorganic Preparation	EPA 7470A	CVAA Digestion by Hotblock
Organics Cleanup	EPA 3660B	Sulfur Cleanup
Organics Cleanup	EPA 3665A	Sulfuric Acid Cleanup

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-Chloropropane (DBCP)
GC/FID	EPA 8015C/D	Diesel range organics (DRO)
GC/FID	EPA 8015C/D	Oil Range Organics (ORO)
GC/FID	EPA 8015C/D	Gasoline range organics (GRO)
GC/FID	EPA 8015C/D	Ethanol
GC/FID	EPA 8015C/D	2-Ethoxyethanol
GC/FID	EPA 8015C/D	Isobutyl alcohol (2-Methyl-1-propanol)
GC/FID	EPA 8015C/D	Isopropyl alcohol (2-Propanol)
GC/FID	EPA 8015C/D	Methanol

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/FID	EPA 8015C/D	n-Butyl alcohol
GC/FID	EPA 8015C/D	n-Propanol
GC/ECD	EPA 8081B	4,4`-DDD
GC/ECD	EPA 8081B	4,4`-DDE
GC/ECD	EPA 8081B	4,4`-DDT
GC/ECD	EPA 8081B	Aldrin
GC/ECD	EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	delta-BHC
GC/ECD	EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	Chlordane (tech.)
GC/ECD	EPA 8081B	alpha-Chlordane
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 8081B	Dieldrin
GC/ECD	EPA 8081B	Endosulfan I
GC/ECD	EPA 8081B	Endosulfan II
GC/ECD	EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 8081B	Endrin
GC/ECD	EPA 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin ketone
GC/ECD	EPA 8081B	Heptachlor
GC/ECD	EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Methoxychlor
GC/ECD	EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 8082A	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A	Aroclor-1268 (PCB-1268)
GC/FPD	EPA 8141B	Azinphos-methyl (Guthion)
GC/FPD	EPA 8141B	Bolstar (Sulprofos)
GC/FPD	EPA 8141B	Carbophenothion
GC/FPD	EPA 8141B	Chlorpyrifos
GC/FPD	EPA 8141B	Coumaphos
GC/FPD	EPA 8141B	Demeton-o
GC/FPD	EPA 8141B	Demeton-s
GC/FPD	EPA 8141B	Diazinon

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/FPD	EPA 8141B	Dichlorovos (DDVP Dichlorvos)
GC/FPD	EPA 8141B	Dimethoate
GC/FPD	EPA 8141B	Disulfoton
GC/FPD	EPA 8141B	EPN
GC/FPD	EPA 8141B	Ethion
GC/FPD	EPA 8141B	Ethoprop
GC/FPD	EPA 8141B	Famphur
GC/FPD	EPA 8141B	Fensulfothion
GC/FPD	EPA 8141B	Fenthion
GC/FPD	EPA 8141B	Malathion
GC/FPD	EPA 8141B	Merphos
GC/FPD	EPA 8141B	Methyl parathion (Parathion methyl)
GC/FPD	EPA 8141B	Mevinphos
GC/FPD	EPA 8141B	Monocrotophos
GC/FPD	EPA 8141B	Naled
GC/FPD	EPA 8141B	Parathion ethyl
GC/FPD	EPA 8141B	Phorate
GC/FPD	EPA 8141B	Ronnel
GC/FPD	EPA 8141B	Stirofos
GC/FPD	EPA 8141B	Sulfotepp
GC/FPD	EPA 8141B	Tetraethyl pyrophosphate (TEPP)
GC/FPD	EPA 8141B	Thionazin (Zinophos)
GC/FPD	EPA 8141B	Tokuthion (Prothiophos)
GC/FPD	EPA 8141B	Trichloronate
GC/FPD	EPA 8141B	O,O,O-Triethyl phosphorothioate
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop (Dichlorprop)
GC/ECD	EPA 8151A	Dinoseb (2-sec-butyl-4,6-dinitrophenol DNBP)
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2,4,5-TP)
GC/FID	FL-PRO	Total Petroleum Hydrocarbons (TPH)
GC/FID	MA-VPH	Volatile petroleum range organics (VPH)
GC/FID	MA-EPH	Extractable petroleum range organics (EPH)
GC/FID	IA-OA1	Gasoline range organics (GRO)
GC/FID	IA-OA2	Diesel range organics (DRO)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/FID	TN-GRO	Gasoline range organics (GRO)
GC/FID	TN-EPH	Extractable petroleum range organics (EPH)
GC/FID	AK-101	Gasoline range organics (GRO)
GC/FID	AK-102	Diesel range organics (DRO)
GC/FID	AK-103	Residual range organics (RRO)
GC/FID	OK-GRO	Gasoline range organics (GRO)
GC/FID	OK-DRO	Diesel range organics (DRO)
GC/FID	TX-1005	Total Petroleum Hydrocarbons (TPH)
GC/FID	KS LRH	Low-range Hydrocarbons (LRH)
GC/FID	KS MRH	Mid-Range Hydrocarbons (MRH)
GC/FID	KS HRH	High-Range Hydrocarbons (HRH)
GC/MS	EPA 8260B/C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,1-Trichloroethane
GC/MS	EPA 8260B/C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,2-Trichloroethane
GC/MS	EPA 8260B/C	1,1-Dichloroethane
GC/MS	EPA 8260B/C	1,1-Dichloroethylene
GC/MS	EPA 8260B/C	1,1-Dichloropropene
GC/MS	EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
GC/MS	EPA 8260B/C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B/C	1,2,3-Trichloropropane
GC/MS	EPA 8260B/C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B/C	1,2-Dibromoethane (EDB Ethylene dibromide)
GC/MS	EPA 8260B/C	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 8260B/C	1,2-Dichloroethane
GC/MS	EPA 8260B/C	1,2-Dichloropropane
GC/MS	EPA 8260B/C	1,2-Dichlorotrifluoroethane (Freon 123)
GC/MS	EPA 8260B/C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B/C	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8260B/C	1,3-Dichloropropane
GC/MS	EPA 8260B/C	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 8260B/C	2,2-Dichloropropane
GC/MS	EPA 8260B/C	2-Butanone (Methyl ethyl ketone MEK)
GC/MS	EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B/C	2-Chlorotoluene
GC/MS	EPA 8260B/C	2-Hexanone
GC/MS	EPA 8260B/C	2-Nitropropane
GC/MS	EPA 8260B/C	4-Chlorotoluene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/C	4-Methyl-2-pentanone (MBK)
GC/MS	EPA 8260B/C	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 8260B/C	Acrolein (Propenal)
GC/MS	EPA 8260B/C	Acrylonitrile
GC/MS	EPA 8260B/C	Allyl chloride (3-Chloropropene)
GC/MS	EPA 8260B/C	Benzene
GC/MS	EPA 8260B/C	Benzyl Chloride
GC/MS	EPA 8260B/C	Bromobenzene
GC/MS	EPA 8260B/C	Bromochloromethane
GC/MS	EPA 8260B/C	Bromodichloromethane
GC/MS	EPA 8260B/C	Bromoform
GC/MS	EPA 8260B/C	n-Butylbenzene
GC/MS	EPA 8260B/C	sec-Butylbenzene
GC/MS	EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 8260B/C	Carbon disulfide
GC/MS	EPA 8260B/C	Carbon tetrachloride
GC/MS	EPA 8260B/C	Chlorobenzene
GC/MS	EPA 8260B/C	Chloroethane
GC/MS	EPA 8260B/C	Chloroform
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 8260B/C	Cyclohexane
GC/MS	EPA 8260B/C	Cyclohexanone
GC/MS	EPA 8260B/C	cis-1,2-Dichloroethylene
GC/MS	EPA 8260B/C	trans-1,2-Dichloroethylene
GC/MS	EPA 8260B/C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/C	trans-1,3-Dichloropropylene
GC/MS	EPA 8260B/C	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	Di-isopropylether (DIPE)
GC/MS	EPA 8260B/C	Dibromochloromethane
GC/MS	EPA 8260B/C	Dibromomethane (Methylene Bromide)
GC/MS	EPA 8260B/C	Dichlorodifluoromethane
GC/MS	EPA 8260B/C	Diethyl ether
GC/MS	EPA 8260B/C; EPA 8260B/C SIM	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8260B/C	Ethanol (Ethyl Alcohol)
GC/MS	EPA 8260B/C	Ethyl acetate
GC/MS	EPA 8260B/C	Ethyl methacrylate
GC/MS	EPA 8260B/C	Ethyl tert-butyl alcohol (ETBA)
GC/MS	EPA 8260B/C	Ethyl tert-butyl ether (ETBE)
GC/MS	EPA 8260B/C	Ethylbenzene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/C	Ethylene Oxide
GC/MS	EPA 8260B/C	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Hexane
GC/MS	EPA 8260B/C	Iodomethane (Methyl iodide)
GC/MS	EPA 8260B/C	Isobutyl alcohol (2-Methyl-1-propanol)
GC/MS	EPA 8260B/C	p-Isopropyltoluene
GC/MS	EPA 8260B/C	Isopropylbenzene
GC/MS	EPA 8260B/C	Methacrylonitrile
GC/MS	EPA 8260B/C	Methyl Acetate
GC/MS	EPA 8260B/C	Methyl bromide (Bromomethane)
GC/MS	EPA 8260B/C	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B/C	Methylcyclohexane
GC/MS	EPA 8260B/C	Methyl methacrylate
GC/MS	EPA 8260B/C	Methyl tert-butyl ether (MTBE)
GC/MS	EPA 8260B/C	Methylene chloride
GC/MS	EPA 8260B/C	Naphthalene
GC/MS	EPA 8260B/C	Pentachloroethane
GC/MS	EPA 8260B/C	Propionitrile (Ethyl cyanide)
GC/MS	EPA 8260B/C	n-Propylbenzene
GC/MS	EPA 8260B/C	Styrene
GC/MS	EPA 8260B/C	tert-Amyl alcohol (TAA)
GC/MS	EPA 8260B/C	tert-Amyl methyl ether (TAME)
GC/MS	EPA 8260B/C	tert-Butyl alcohol (TBA)
GC/MS	EPA 8260B/C	tert-Butyl formate (TBF)
GC/MS	EPA 8260B/C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B/C	Tetrahydrofuran
GC/MS	EPA 8260B/C	Toluene
GC/MS	EPA 8260B/C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 8260B/C	Trichlorofluoromethane
GC/MS	EPA 8260B/C	Vinyl acetate
GC/MS	EPA 8260B/C	Vinyl chloride
GC/MS	EPA 8260B/C	Xylene (total)
GC/MS	EPA 8260B/C	m,p-Xylene
GC/MS	EPA 8260B/C	o-Xylene
GC/MS	EPA 8260B/C	1-Bromopropane
GC/MS	EPA 8260B/C	Isopropyl Alcohol
GC/MS	EPA 8260B/C	n-Butyl Alcohol
GC/MS	EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270D	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 8270D	1,2-Diphenylhydrazine

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	1,3,5-Trinitrobenzene (1,3,5-TNB)
GC/MS	EPA 8270D	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8270D	1,3-Dinitrobenzene (1,3-DNB)
GC/MS	EPA 8270D	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8270D	1,4-Dithiane
GC/MS	EPA 8270D	1,4-Oxathiane
GC/MS	EPA 8270D	1,4-Naphthoquinone
GC/MS	EPA 8270D	1,4-Phenylenediamine
GC/MS	EPA 8270D	1-Chloronaphthalene
GC/MS	EPA 8270D; EPA 8270D SIM	1-Methylnaphthalene
GC/MS	EPA 8270D	1-Naphthylamine
GC/MS	EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 8270D	2,4-Dinitrotoluene (2,4-DNT)
GC/MS	EPA 8270D	2,6-Dichlorophenol
GC/MS	EPA 8270D	2,6-Dinitrotoluene (2,6-DNT)
GC/MS	EPA 8270D	2-Acetylaminofluorene
GC/MS	EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 8270D	2-Chlorophenol
GC/MS	EPA 8270D	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-o-cresol)
GC/MS	EPA 8270D; EPA 8270D SIM	2-Methylnaphthalene
GC/MS	EPA 8270D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270D	2-Naphthylamine
GC/MS	EPA 8270D	2-Nitroaniline
GC/MS	EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	2-Picoline (2-Methylpyridine)
GC/MS	EPA 8270D	3,3`-Dichlorobenzidine
GC/MS	EPA 8270D	3,3`-Dimethylbenzidine
GC/MS	EPA 8270D	3-Methylcholanthrene
GC/MS	EPA 8270D	3&4-Methylphenol (m,p-Cresol)
GC/MS	EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4-Aminobiphenyl
GC/MS	EPA 8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270D	4-Chloro-3-methylphenol
GC/MS	EPA 8270D	4-Chloroaniline
GC/MS	EPA 8270D	4-Chlorophenyl phenylether
GC/MS	EPA 8270D	4-Dimethyl aminoazobenzene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	4-Nitroaniline
GC/MS	EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	4,4'-methylene-bis(2-chloroaniline)
GC/MS	EPA 8270D	5-Nitro-o-toluidine
GC/MS	EPA 8270D	7,12-Dimethylbenz(a) anthracene
GC/MS	EPA 8270D; EPA 8270D SIM	Acenaphthene
GC/MS	EPA 8270D; EPA 8270D SIM	Acenaphthylene
GC/MS	EPA 8270D	Acetophenone
GC/MS	EPA 8270D	Aniline
GC/MS	EPA 8270D	Anilazine
GC/MS	EPA 8270D; EPA 8270D SIM	Anthracene
GC/MS	EPA 8270D	Aramite
GC/MS	EPA 8270D	Atrazine
GC/MS	EPA 8270D	Benzaldehyde
GC/MS	EPA 8270D	Benzidine
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(a)anthracene
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(a)pyrene
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(b)fluoranthene
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(g,h,i)perylene
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(k)fluoranthene
GC/MS	EPA 8270D	Benzoic acid
GC/MS	EPA 8270D	Benzyl alcohol
GC/MS	EPA 8270D	Biphenyl (1,1'-Biphenyl)
GC/MS	EPA 8270D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270D	bis(2-Chloroethyl) ether
GC/MS	EPA 8270D	bis(2-Chloroisopropyl) ether (2,2`-Oxybis(1-chloropropane))
GC/MS	EPA 8270D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 8270D	Butyl benzyl phthalate
GC/MS	EPA 8270D	Carbazole
GC/MS	EPA 8270D	Caprolactam
GC/MS	EPA 8270D	Chlorobenzilate
GC/MS	EPA 8270D; EPA 8270D SIM	Chrysene
GC/MS	EPA 8270D	Diallate
GC/MS	EPA 8270D	Dinoseb
GC/MS	EPA 8270D	Di-n-butyl phthalate
GC/MS	EPA 8270D	Di-n-octyl phthalate
GC/MS	EPA 8270D; EPA 8270D SIM	Dibenz(a,h)anthracene
GC/MS	EPA 8270D	Dibenz(a,j)acridine
GC/MS	EPA 8270D	Dibenzofuran
GC/MS	EPA 8270D	Diethyl phthalate
GC/MS	EPA 8270D	Dimethyl phthalate

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	a,a-Dimethylphenethylamine
GC/MS	EPA 8270D	Diphenyl Ether
GC/MS	EPA 8270D	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8270D	Ethyl methanesulfonate
GC/MS	EPA 8270D; EPA 8270D SIM	Fluoranthene
GC/MS	EPA 8270D; EPA 8270D SIM	Fluorene
GC/MS	EPA 8270D	Hexachlorobenzene
GC/MS	EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 8270D	Hexachlorocyclopentadiene
GC/MS	EPA 8270D	Hexachloroethane
GC/MS	EPA 8270D	Hexachlorophene
GC/MS	EPA 8270D	Hexachloropropene
GC/MS	EPA 8270D; EPA 8270D SIM	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270D	Isodrin
GC/MS	EPA 8270D	Isophorone
GC/MS	EPA 8270D	Isosafrole
GC/MS	EPA 8270D	Kepone
GC/MS	EPA 8270D	Methapyrilene
GC/MS	EPA 8270D	Methyl methanesulfonate
GC/MS	EPA 8270D; EPA 8270D SIM	Naphthalene
GC/MS	EPA 8270D	Nicotine
GC/MS	EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	Nitroquinoline-1-oxide
GC/MS	EPA 8270D	n-Nitroso-di-n-butylamine
GC/MS	EPA 8270D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270D	n-Nitrosodiethylamine
GC/MS	EPA 8270D	n-Nitrosodimethylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine/Diphenylamine (analyte pair)
GC/MS	EPA 8270D	n-Nitrosomethylethylamine
GC/MS	EPA 8270D	n-Nitrosomorpholine
GC/MS	EPA 8270D	n-Nitrosopiperidine
GC/MS	EPA 8270D	n-Nitrosopyrrolidine
GC/MS	EPA 8270D	Pentachlorobenzene
GC/MS	EPA 8270D	Pentachloroethane
GC/MS	EPA 8270D	Pentachloronitrobenzene
GC/MS	EPA 8270D; EPA 8270D SIM	Pentachlorophenol
GC/MS	EPA 8270D	Phenacetin
GC/MS	EPA 8270D; EPA 8270D SIM	Phenanthrene
GC/MS	EPA 8270D	Phenol
GC/MS	EPA 8270D	Pronamide (Kerb)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	Propazine
GC/MS	EPA 8270D; EPA 8270D SIM	Pyrene
GC/MS	EPA 8270D	Pyridine
GC/MS	EPA 8270D	Resorcinol
GC/MS	EPA 8270D	Safrole
GC/MS	EPA 8270D	Simazine
GC/MS	EPA 8270D	o-Toluidine
GC/MS	EPA 8270D	Dimethoate
GC/MS	EPA 8270D	Disulfoton
GC/MS	EPA 8270D	Famphur
GC/MS	EPA 8270D	Methyl parathion (Parathion methyl)
GC/MS	EPA 8270D	Parathion ethyl
GC/MS	EPA 8270D	Phorate
GC/MS	EPA 8270D	Sulfotepp
GC/MS	EPA 8270D	Thionazin (Zinophos)
GC/MS	EPA 8270D	O,O,O-Triethyl phosphorothioate
HPLC	EPA 8310	1-Methylnaphthalene
HPLC	EPA 8310	2-Methylnaphthalene
HPLC	EPA 8310	Acenaphthene
HPLC	EPA 8310	Acenaphthylene
HPLC	EPA 8310	Anthracene
HPLC	EPA 8310	Benzo(a)anthracene
HPLC	EPA 8310	Benzo(a)pyrene
HPLC	EPA 8310	Benzo(b)fluoranthene
HPLC	EPA 8310	Benzo(g h i)perylene
HPLC	EPA 8310	Benzo(k)fluoranthene
HPLC	EPA 8310	Chrysene
HPLC	EPA 8310	Dibenz(a h)anthracene
HPLC	EPA 8310	Fluoranthene
HPLC	EPA 8310	Fluorene
HPLC	EPA 8310	Indeno(1,2,3-cd)pyrene
HPLC	EPA 8310	Naphthalene
HPLC	EPA 8310	Phenanthrene
HPLC	EPA 8310	Pyrene
HPLC	EPA 8330A/B	1,3,5-Trinitrobenzene (1,3,5-TNB)
HPLC	EPA 8330A/B	1,3-Dinitrobenzene (1,3-DNB)
HPLC	EPA 8330A/B	2,4,6-Trinitrotoluene (2,4,6-TNT)
HPLC	EPA 8330A/B	2,4-Dinitrotoluene (2,4-DNT)
HPLC	EPA 8330A/B	2,6-Dinitrotoluene (2,6-DNT)
HPLC	EPA 8330A/B	2-Amino-4,6-dinitrotoluene (2-am-dnt)
HPLC	EPA 8330A/B	2-Nitrotoluene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
HPLC	EPA 8330A/B	3,5-Dinitroaniline
HPLC	EPA 8330A/B	3-Nitrotoluene
HPLC	EPA 8330A/B	4-Amino-2,6-dinitrotoluene (4-am-dnt)
HPLC	EPA 8330A/B	4-Nitrotoluene
HPLC	EPA 8330A/B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC	EPA 8330A/B	Nitrobenzene
HPLC	EPA 8330A/B; EPA 8332	Nitroglycerin
HPLC	EPA 8330A/B	Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
HPLC	EPA 8330A/B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC	EPA 8330A/B; EPA 8332	Pentaerythritoltetranitrate (PETN)
HPLC	EPA 8330A	2,2’,6,6’-Tetranitro-4,4’-azoxytoluene
HPLC	EPA 8330A/B	2-amino-6-Nitrotoluene
HPLC	EPA 8330A/B	4-amino-2-Nitrotoluene
HPLC	EPA 8330A/B	2-amino-4-Nitrotoluene
HPLC	EPA 8330A/B	2,4-diamino-6-Nitrotoluene
HPLC	EPA 8330A/B	2,6-diamino-4-Nitrotoluene
HPLC	EPA 8330A/B	DNX
HPLC	EPA 8330A/B	MNX
HPLC	EPA 8330A/B	TNX
HPLC	EPA 8330A	Nitroguanidine
HPLC	EPA 8330A	Guanidine Nitrate
LC/MS/MS	EPA 6850	Perchlorate
LC/MS/MS	EPA 537 MOD	Perfluorobutanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoropentanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorohexanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroheptanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorononanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroundecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorododecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorotetradecanoic Acid
LC/MS/MS	EPA 537 MOD	Perfluorobutanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorohexanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluorodecanesulfonic Acid
LC/MS/MS	EPA 537 MOD	Perfluoroheptanesulfonic acid
LC/MS/MS	EPA 537 MOD	Perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD	N-Methyl perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD	N-Ethyl perfluorooctane sulfonamide

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
LC/MS/MS	EPA 537 MOD	Perfluoro-1-octanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD	N-Methyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD	N-Ethyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD	N-Methyl perfluorooctane sulfonamidoethanol
LC/MS/MS	EPA 537 MOD	N-Ethyl perfluorooctane sulfonamidoethanol
LC/MS/MS	EPA 537 MOD	6:2 Fluorotelomer sulfonate
LC/MS/MS	EPA 537 MOD	8:2 Fluorotelomer sulfonate
ICP	EPA 6010C/D	Aluminum
ICP	EPA 6010C/D	Antimony
ICP	EPA 6010C/D	Arsenic
ICP	EPA 6010C/D	Barium
ICP	EPA 6010C/D	Beryllium
ICP	EPA 6010C/D	Cadmium
ICP	EPA 6010C/D	Calcium
ICP	EPA 6010C/D	Chromium
ICP	EPA 6010C/D	Cobalt
ICP	EPA 6010C/D	Copper
ICP	EPA 6010C/D	Iron
ICP	EPA 6010C/D	Lead
ICP	EPA 6010C/D	Magnesium
ICP	EPA 6010C/D	Manganese
ICP	EPA 6010C/D	Molybdenum
ICP	EPA 6010C/D	Nickel
ICP	EPA 6010C/D	Potassium
ICP	EPA 6010C/D	Selenium
ICP	EPA 6010C/D	Silver
ICP	EPA 6010C/D	Sodium
ICP	EPA 6010C/D	Strontium
ICP	EPA 6010C/D	Thallium
ICP	EPA 6010C/D	Tin
ICP	EPA 6010C/D	Titanium
ICP	EPA 6010C/D	Vanadium
ICP	EPA 6010C/D	Zinc
ICP/MS	EPA 6020A	Aluminum
ICP/MS	EPA 6020A	Antimony
ICP/MS	EPA 6020A	Arsenic
ICP/MS	EPA 6020A	Barium
ICP/MS	EPA 6020A	Beryllium
ICP/MS	EPA 6020A	Cadmium
ICP/MS	EPA 6020A	Calcium
ICP/MS	EPA 6020A	Chromium

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP/MS	EPA 6020A	Cobalt
ICP/MS	EPA 6020A	Copper
ICP/MS	EPA 6020A	Iron
ICP/MS	EPA 6020A	Lead
ICP/MS	EPA 6020A	Magnesium
ICP/MS	EPA 6020A	Manganese
ICP/MS	EPA 6020A	Molybdenum
ICP/MS	EPA 6020A	Nickel
ICP/MS	EPA 6020A	Potassium
ICP/MS	EPA 6020A	Selenium
ICP/MS	EPA 6020A	Silver
ICP/MS	EPA 6020A	Sodium
ICP/MS	EPA 6020A	Strontium
ICP/MS	EPA 6020A	Thallium
ICP/MS	EPA 6020A	Tin
ICP/MS	EPA 6020A	Titanium
ICP/MS	EPA 6020A	Vanadium
ICP/MS	EPA 6020A	Zinc
CVAA	EPA 7471B	Mercury
UV/VIS	EPA 7196A	Hexavalent Chromium (Cr6+)
UV/VIS	EPA 9012B	Cyanide (Total)
IC	EPA 9056A	Bromide
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrate
IC	EPA 9056A	Nitrite
IC	EPA 9056A	Sulfate
IC	EPA 9056A	Total nitrate-nitrite
Gravimetric Methods	SM 2540G	% solids
Gravimetric Methods	EPA 9071B	Oil and Grease
Electrometric Methods	EPA 9045D	Hydrogen Ion (pH)
Combustion	EPA 9060A	Total Organic Carbon
Ignitability	EPA 1010A	Flash Point
Waste Characterization	EPA Ch.7	Reactive Cyanide and Reactive Sulfide
Waste Characterization	EPA Section 7.3	Reactive Cyanide

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
Waste Characterization	EPA Section 7.3	Reactive Sulfide
Preparation	**Method**	**Type**
Organics Preparation	EPA 3510C	Separatory Funnel Liquid-Liquid Extraction; Leachates
TCLP Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure
SPLP Preparation	EPA 1312	Synthetic Precipitation Leaching Procedure
Organics Preparation	EPA 8011	Microextraction
Organics Preparation	EPA 3546	Microwave Extraction
Organics Preparation	EPA 3550C	Ultrasonic Extraction
Organics Preparation	EPA 3580A	Waste Dilution for Extractable Organics
Organics Preparation	EPA 8330A; EPA 8332	Ultrasonic Extraction
Organics Preparation	EPA 8330B	Shaker Table Extraction
Volatile Organics Preparation	EPA 3585	Waste Dilution for Volatile Organics
Volatile Organics Preparation	EPA 5030A	Closed System Purge and Trap; Bulk Soils
Volatile Organics Preparation	EPA 5030B	Closed System Purge and Trap; Leachates and Methanol Extracts
Volatile Organics Preparation	EPA 5035; EPA 5035A	Closed System Purge and Trap
Organics Cleanup	EPA 3660B	Sulfur Cleanup
Organics Cleanup	EPA 3665A	Sulfuric Acid Cleanup
Lachat MicroDistillation	EPA 9012B	Cyanide MicroDistillation; proprietary method
Inorganic Preparation	EPA 3010A	Metals Acid Digestion by Hotblock; Leachates
Inorganic Preparation	EPA 3050B	Metals Acid Digestion by Hotblock
Inorganic Preparation	EPA 3060A	Alkaline Digestion, Cr6+
Inorganic Preparation	EPA 7470A	CVAA Digestion by Hotblock; Leachates
Inorganic Preparation	EPA 7471B	CVAA Digestion by Hotblock

Notes:

1) This laboratory offers commercial testing service.

Approved by: _____ Date: January 31, 2017

R. Douglas Leonard
Chief Technical Officer

Re-Issued: 1/14/16 Revised: 6/15/16 Revised: 1/31/17

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NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2018
Issued April 01, 2017

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. NORMAN D. FARMER
SGS ACCUTEST - ORLANDO
4405 VINELAND RD STE C-15
ORLANDO, FL 32811

NY Lab Id No: 12022

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards (2003) for the category ENVIRONMENTAL ANALYSES POTABLE WATER
All approved analytes are listed below:

Perfluorinated Alkyl Acids

Perfluorooctanesulfonic acid (PFOS)	EPA 537
Perfluorooctanoic acid (PFOA)	EPA 537

Serial No.: 56346

NEW YORK STATE DEPARTMENT OF HEALTH
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is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards (2003) for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER
All approved analytes are listed below:

Acrylates	
Acrolein (Propenal)	EPA 8260C
	EPA 624
Acrylonitrile	EPA 8260C
	EPA 624
Ethyl methacrylate	EPA 8260C
Methyl methacrylate	EPA 8260C
Amines	
1,2-Diphenylhydrazine	EPA 8270D
1,4-Phenylenediamine	EPA 8270D
1-Naphthylamine	EPA 8270D
2-Naphthylamine	EPA 8270D
2-Nitroaniline	EPA 8270D
3-Nitroaniline	EPA 8270D
4-Chloroaniline	EPA 8270D
4-Nitroaniline	EPA 8270D
5-Nitro-o-toluidine	EPA 8270D
a,a-Dimethylphenethylamine	EPA 8270D
Aniline	EPA 8270D
Carbazole	EPA 8270D
Methapyrilene	EPA 8270D
Pronamide	EPA 8270D
Propionitrile	EPA 8260C
Pyridine	EPA 8270D
Benzidines	
3,3'-Dichlorobenzidine	EPA 8270D

Benzidines	
3,3'-Dimethylbenzidine	EPA 8270D
Benzidine	EPA 625
	EPA 8270D
Chlorinated Hydrocarbon Pesticides	
4,4'-DDD	EPA 8081B
	EPA 608
4,4'-DDE	EPA 8081B
	EPA 608
4,4'-DDT	EPA 8081B
	EPA 608
Aldrin	EPA 8081B
	EPA 608
alpha-BHC	EPA 8081B
	EPA 608
alpha-Chlordane	EPA 8081B
beta-BHC	EPA 8081B
	EPA 608
Chlordane Total	EPA 8081B
	EPA 608
Chlorobenzilate	EPA 8270D
delta-BHC	EPA 8081B
	EPA 608
Diallate	EPA 8270D
Dieldrin	EPA 8081B
	EPA 608

Serial No.: 56347

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NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2018
Issued April 01, 2017

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. NORMAN D. FARMER
SGS ACCUTEST - ORLANDO
4405 VINELAND RD STE C-15
ORLANDO, FL 32811

NY Lab Id No: 12022

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards (2003) for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER
All approved analytes are listed below:

Chlorinated Hydrocarbon Pesticides

Endosulfan I	EPA 8081B
	EPA 608
Endosulfan II	EPA 8081B
	EPA 608
Endosulfan sulfate	EPA 8081B
	EPA 608
Endrin	EPA 8081B
	EPA 608
Endrin aldehyde	EPA 8081B
	EPA 608
Endrin Ketone	EPA 8081B
gamma-Chlordane	EPA 8081B
Heptachlor	EPA 8081B
	EPA 608
Heptachlor epoxide	EPA 8081B
	EPA 608
Isodrin	EPA 8270D
Kepone	EPA 8270D
Lindane	EPA 8081B
	EPA 608
Methoxychlor	EPA 8081B
Toxaphene	EPA 8081B
	EPA 608

Chlorinated Hydrocarbons

1,2,3-Trichlorobenzene	EPA 8260C

Chlorinated Hydrocarbons

1,2,4,5-Tetrachlorobenzene	EPA 8270D
1,2,4-Trichlorobenzene	EPA 625
	EPA 8270D
1-Chloronaphthalene	EPA 8270D
2-Chloronaphthalene	EPA 625
	EPA 8270D
Hexachlorobenzene	EPA 8270D
Hexachlorobutadiene	EPA 8270D
Hexachlorocyclopentadiene	EPA 625
	EPA 8270D
Hexachloroethane	EPA 625
	EPA 8270D
Hexachloropropene	EPA 8270D
Pentachlorobenzene	EPA 8270D

Chlorophenoxy Acid Pesticides

2,4,5-T	EPA 8151A
2,4,5-TP (Silvex)	EPA 8151A
2,4-D	EPA 8151A
2,4-DB	EPA 8151A
Dalapon	EPA 8151A
Dicamba	EPA 8151A
Dichloroprop	EPA 8151A
Dinoseb	EPA 8151A
Pentachlorophenol	EPA 8151A

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Demand	
Biochemical Oxygen Demand	SM 5210B-01,-11
Carbonaceous BOD	SM 5210B-01,-11
Chemical Oxygen Demand	SM 5220C-97,-11
Dissolved Gases	
Acetylene	RSK-175
Ethane	RSK-175
Ethene (Ethylene)	RSK-175
Methane	RSK-175
Propane	RSK-175
Fuel Oxygenates	
Di-isopropyl ether	EPA 8260C
Ethanol	EPA 8260C
	EPA 8015D
	EPA 8015C
Methyl tert-butyl ether	EPA 8260C
	EPA 8021B
tert-amyl methyl ether (TAME)	EPA 8260C
tert-butyl alcohol	EPA 8260C
tert-butyl ethyl ether (ETBE)	EPA 8260C
Haloethers	
2,2'-Oxybis(1-chloropropane)	EPA 625
	EPA 8270D
4-Bromophenylphenyl ether	EPA 625
	EPA 8270D
Haloethers	
4-Chlorophenylphenyl ether	EPA 625
	EPA 8270D
Bis(2-chloroethoxy)methane	EPA 625
	EPA 8270D
Bis(2-chloroethyl)ether	EPA 625
	EPA 8270D
Low Level Halocarbons	
1,2-Dibromo-3-chloropropane, Low Level	EPA 8011
1,2-Dibromoethane, Low Level	EPA 8011
Low Level Polynuclear Aromatics	
Acenaphthene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Acenaphthylene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Anthracene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Benzo(a)anthracene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Benzo(a)pyrene Low Level	EPA 8310
	EPA 610
	EPA 8270D

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Low Level Polynuclear Aromatics	
Benzo(b)fluoranthene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Benzo(g,h,i)perylene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Benzo(k)fluoranthene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Chrysene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Dibenzo(a,h)anthracene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Fluoranthene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Fluorene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Indeno(1,2,3-cd)pyrene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Naphthalene Low Level	EPA 8310
	EPA 610

Low Level Polynuclear Aromatics	
Naphthalene Low Level	EPA 8270D
Phenanthrene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Pyrene Low Level	EPA 8310
	EPA 610
	EPA 8270D
Metals I	
Barium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Cadmium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Calcium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020B
	EPA 200.8 Rev. 5.4
Chromium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Copper, Total	EPA 200.7 Rev. 4.4

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Metals I	
Copper, Total	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Iron, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Lead, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Magnesium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Manganese, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Nickel, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Potassium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A

Metals I	
Potassium, Total	EPA 200.8 Rev. 5.4
Silver, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Sodium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Strontium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 200.8 Rev. 5.4
Metals II	
Aluminum, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Antimony, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4
Arsenic, Total	EPA 200.7 Rev. 4.4
	EPA 6010C
	EPA 6020A
	EPA 200.8 Rev. 5.4

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Metals II		**Metals III**	
Beryllium, Total	EPA 200.7 Rev. 4.4	Molybdenum, Total	EPA 6010C
	EPA 6010C		EPA 6020A
	EPA 6020A		EPA 200.8 Rev. 5.4
	EPA 200.8 Rev. 5.4	Thallium, Total	EPA 200.7 Rev. 4.4
Chromium VI	EPA 7196A		EPA 6010C
Mercury, Total	EPA 245.1 Rev. 3.0		EPA 6020A
	EPA 7470A		EPA 200.8 Rev. 5.4
Selenium, Total	EPA 200.7 Rev. 4.4	Tin, Total	EPA 200.7 Rev. 4.4
	EPA 6010C		EPA 6010C
	EPA 6020A		EPA 6020A
	EPA 200.8 Rev. 5.4		EPA 200.8 Rev. 5.4
Vanadium, Total	EPA 200.7 Rev. 4.4	Titanium, Total	EPA 200.7 Rev. 4.4
	EPA 6010C		EPA 6010C
	EPA 6020A		EPA 6020A
	EPA 200.8 Rev. 5.4		EPA 200.8 Rev. 5.4
Zinc, Total	EPA 200.7 Rev. 4.4	**Mineral**	
	EPA 6010C	Alkalinity	SM 2320B-97,-11
	EPA 6020A	Chloride	EPA 300.0 Rev. 2.1
	EPA 200.8 Rev. 5.4		EPA 9056A
Metals III		Fluoride, Total	EPA 300.0 Rev. 2.1
Cobalt, Total	EPA 200.7 Rev. 4.4		EPA 9056A
	EPA 6010C	Hardness, Total	SM 2340B-97,-11
	EPA 6020A	Sulfate (as SO4)	EPA 300.0 Rev. 2.1
	EPA 200.8 Rev. 5.4		EPA 9056A
Molybdenum, Total	EPA 200.7 Rev. 4.4		

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Miscellaneous	
Bromide	EPA 300.0 Rev. 2.1
	EPA 9056A
Color	SM 2120B-01,-11
Cyanide, Total	EPA 335.4 Rev. 1.0
	EPA 9012B
Oil and Grease Total Recoverable (HEM)	EPA 1664A
	EPA 1664B
	EPA 9070A (Solvent:Hexane)
Organic Carbon, Total	SM 5310B-00,-11
	EPA 9060A
Perchlorate	EPA 6850
Phenols	EPA 420.4 Rev. 1.0
Specific Conductance	EPA 120.1 Rev. 1982
Sulfide (as S)	SM 4500-S2- F-00,-11
Surfactant (MBAS)	SM 5540C-00,-11
Turbidity	EPA 180.1 Rev. 2.0
Nitroaromatics and Isophorone	
1,3,5-Trinitrobenzene	EPA 8270D
	EPA 8330A
	EPA 8330B
1,3-Dinitrobenzene	EPA 8270D
	EPA 8330A
	EPA 8330B
1,4-Naphthoquinone	EPA 8270D
2,4,6-Trinitrotoluene	EPA 8330A

Nitroaromatics and Isophorone	
2,4,6-Trinitrotoluene	EPA 8330B
2,4-Dinitrotoluene	EPA 8270D
	EPA 8330A
	EPA 8330B
2,6-Dinitrotoluene	EPA 8270D
	EPA 8330A
	EPA 8330B
2-Amino-4,6-dinitrotoluene	EPA 8330A
	EPA 8330B
2-Nitrotoluene	EPA 8330A
	EPA 8330B
3,5-Dinitroaniline	EPA 8330B
3-Nitrotoluene	EPA 8330A
	EPA 8330B
4-Amino-2,6-dinitrotoluene	EPA 8330A
	EPA 8330B
4-Nitroquinoline-1-oxide	EPA 8270D
4-Nitrotoluene	EPA 8330A
	EPA 8330B
Hexahydro-1,3,5-trinitro-1,3,5-triazine	EPA 8330A
	EPA 8330B
Isophorone	EPA 8270D
Methyl-2,4,6-trinitrophenylnitramine	EPA 8330A
	EPA 8330B
Nitrobenzene	EPA 8270D
	EPA 8330A

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Nitroaromatics and Isophorone	
Nitrobenzene	EPA 8330B
Nitroglycerine	EPA 8330B
Octahydro-tetranitro-tetrazocine	EPA 8330A
	EPA 8330B
Pentaerythritol tetranitrate	EPA 8330B
Nitrosoamines	
N-Nitrosodiethylamine	EPA 8270D
N-Nitrosodimethylamine	EPA 625
	EPA 8270D
N-Nitrosodi-n-butylamine	EPA 8270D
N-Nitrosodi-n-propylamine	EPA 625
	EPA 8270D
N-Nitrosodiphenylamine	EPA 625
	EPA 8270D
N-nitrosomethylethylamine	EPA 8270D
N-nitrosomorpholine	EPA 8270D
N-nitrosopiperidine	EPA 8270D
N-Nitrosopyrrolidine	EPA 8270D
Nutrient	
Ammonia (as N)	EPA 350.1 Rev. 2.0
Kjeldahl Nitrogen, Total	EPA 351.2 Rev. 2.0
Nitrate (as N)	EPA 353.2 Rev. 2.0
	EPA 300.0 Rev. 2.1
	EPA 9056A
Nitrite (as N)	EPA 353.2 Rev. 2.0

Nutrient	
Nitrite (as N)	EPA 300.0 Rev. 2.1
	EPA 9056A
Orthophosphate (as P)	EPA 365.3 Rev. 1978
Phosphorus, Total	EPA 365.3 Rev. 1978
Organophosphate Pesticides	
Atrazine	EPA 8270D
Azinphos methyl	EPA 8141B
Chlorpyriphos	EPA 8141B
Demeton-O	EPA 8141B
Demeton-S	EPA 8141B
Diazinon	EPA 8141B
Dimethoate	EPA 8141B
	EPA 8270D
Disulfoton	EPA 8141B
	EPA 8270D
Famphur	EPA 8141B
	EPA 8270D
Malathion	EPA 8141B
Parathion ethyl	EPA 8141B
	EPA 8270D
Parathion methyl	EPA 8141B
	EPA 8270D
Phorate	EPA 8141B
	EPA 8270D
Simazine	EPA 8270D

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Organophosphate Pesticides	
Sulfotepp	EPA 8141B
	EPA 8270D
Thionazin	EPA 8141B
	EPA 8270D
Petroleum Hydrocarbons	
Diesel Range Organics	EPA 8015D
	EPA 8015C
Gasoline Range Organics	EPA 8015D
	EPA 8015C
Phthalate Esters	
Benzyl butyl phthalate	EPA 625
	EPA 8270D
Bis(2-ethylhexyl) phthalate	EPA 625
	EPA 8270D
Diethyl phthalate	EPA 625
	EPA 8270D
Dimethyl phthalate	EPA 625
	EPA 8270D
Di-n-butyl phthalate	EPA 625
	EPA 8270D
Di-n-octyl phthalate	EPA 625
	EPA 8270D
Polychlorinated Biphenyls	
PCB-1016	EPA 8082A
	EPA 608
PCB-1221	EPA 8082A
	EPA 608
PCB-1232	EPA 8082A
	EPA 608
PCB-1242	EPA 8082A
	EPA 608
PCB-1248	EPA 8082A
	EPA 608
PCB-1254	EPA 8082A
	EPA 608
PCB-1260	EPA 8082A
	EPA 608
PCB-1262	EPA 8082A
PCB-1268	EPA 8082A
Polynuclear Aromatics	
2-Acetylaminofluorene	EPA 8270D
3-Methylcholanthrene	EPA 8270D
7,12-Dimethylbenzyl (a) anthracene	EPA 8270D
Acenaphthene	EPA 625
	EPA 8270D
Acenaphthylene	EPA 625
	EPA 8270D
Anthracene	EPA 625
	EPA 8270D

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Polynuclear Aromatics	
Benzo(a)anthracene	EPA 625
	EPA 8270D
Benzo(a)pyrene	EPA 625
	EPA 8270D
Benzo(b)fluoranthene	EPA 625
	EPA 8270D
Benzo(ghi)perylene	EPA 625
	EPA 8270D
Benzo(k)fluoranthene	EPA 625
	EPA 8270D
Chrysene	EPA 625
	EPA 8270D
Dibenzo(a,h)anthracene	EPA 625
	EPA 8270D
Fluoranthene	EPA 625
	EPA 8270D
Fluorene	EPA 625
	EPA 8270D
Indeno(1,2,3-cd)pyrene	EPA 625
	EPA 8270D
Naphthalene	EPA 625
	EPA 8270D
Phenanthrene	EPA 625
	EPA 8270D
Pyrene	EPA 625
	EPA 8270D

Priority Pollutant Phenols	
2,3,4,6 Tetrachlorophenol	EPA 8270D
2,4,5-Trichlorophenol	EPA 8270D
2,4,6-Trichlorophenol	EPA 625
	EPA 8270D
2,4-Dichlorophenol	EPA 625
	EPA 8270D
2,4-Dimethylphenol	EPA 625
	EPA 8270D
2,4-Dinitrophenol	EPA 625
	EPA 8270D
2,6-Dichlorophenol	EPA 8270D
2-Chlorophenol	EPA 625
	EPA 8270D
2-Methyl-4,6-dinitrophenol	EPA 625
	EPA 8270D
2-Methylphenol	EPA 8270D
2-Nitrophenol	EPA 625
	EPA 8270D
3-Methylphenol	EPA 8270D
4-Chloro-3-methylphenol	EPA 625
	EPA 8270D
4-Methylphenol	EPA 8270D
4-Nitrophenol	EPA 625
	EPA 8270D
Pentachlorophenol	EPA 625
	EPA 8270D

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Priority Pollutant Phenols	
Phenol	EPA 625
	EPA 8270D
Residue	
Solids, Total	SM 2540 B-97,-11
Solids, Total Dissolved	SM 2540 C-97,-11
Solids, Total Suspended	SM 2540 D-97,-11
Semi-Volatile Organics	
1,1'-Biphenyl	EPA 8270D
1,2-Dichlorobenzene, Semi-volatile	EPA 8270D
1,3-Dichlorobenzene, Semi-volatile	EPA 8270D
1,4-Dichlorobenzene, Semi-volatile	EPA 8270D
2-Methylnaphthalene	EPA 8270D
2-Picoline	EPA 8270D
4-Amino biphenyl	EPA 8270D
Acetophenone	EPA 8270D
Aramite	EPA 8270D
Benzaldehyde	EPA 8270D
Benzoic Acid	EPA 8270D
Benzyl alcohol	EPA 8270D
Caprolactam	EPA 8270D
Dibenzofuran	EPA 8270D
Ethyl methanesulfonate	EPA 8270D
Isosafrole	EPA 8270D
Methyl methanesulfonate	EPA 8270D
O,O,O-Triethyl phosphorothioate	EPA 8270D
Semi-Volatile Organics	
p-Dimethylaminoazobenzene	EPA 8270D
Phenacetin	EPA 8270D
Safrole	EPA 8270D
Volatile Aromatics	
1,2,4-Trichlorobenzene, Volatile	EPA 8260C
1,2,4-Trimethylbenzene	EPA 8260C
1,2-Dichlorobenzene	EPA 8260C
	EPA 8021B
	EPA 624
	EPA 602
1,3,5-Trimethylbenzene	EPA 8260C
1,3-Dichlorobenzene	EPA 8260C
	EPA 8021B
	EPA 624
	EPA 602
1,4-Dichlorobenzene	EPA 8260C
	EPA 8021B
	EPA 624
	EPA 602
2-Chlorotoluene	EPA 8260C
4-Chlorotoluene	EPA 8260C
Benzene	EPA 8260C
	EPA 8021B
	EPA 624
	EPA 602

Serial No.: 56347

NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2018
Issued April 01, 2017

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. NORMAN D. FARMER
SGS ACCUTEST - ORLANDO
4405 VINELAND RD STE C-15
ORLANDO, FL 32811

NY Lab Id No: 12022

is hereby APPROVED as an Environmental Laboratory in conformance with the National Environmental Laboratory Accreditation Conference Standards (2003) for the category ENVIRONMENTAL ANALYSES NON POTABLE WATER
All approved analytes are listed below:

Volatile Aromatics	
Bromobenzene	EPA 8260C
Chlorobenzene	EPA 8260C
	EPA 8021B
	EPA 624
	EPA 602
Ethyl benzene	EPA 8260C
	EPA 8021B
	EPA 624
	EPA 602
Isopropylbenzene	EPA 8260C
Naphthalene, Volatile	EPA 8260C
n-Butylbenzene	EPA 8260C
n-Propylbenzene	EPA 8260C
p-Isopropyltoluene (P-Cymene)	EPA 8260C
sec-Butylbenzene	EPA 8260C
Styrene	EPA 8260C
tert-Butylbenzene	EPA 8260C
Toluene	EPA 8260C
	EPA 8021B
	EPA 624
	EPA 602
Total Xylenes	EPA 8260C
	EPA 8021B
	EPA 624
	EPA 602

Volatile Halocarbons	
1,1,1,2-Tetrachloroethane	EPA 8260C
1,1,1-Trichloroethane	EPA 8260C
	EPA 624
1,1,2,2-Tetrachloroethane	EPA 8260C
1,1,2-Trichloroethane	EPA 8260C
	EPA 624
1,1-Dichloroethane	EPA 8260C
	EPA 624
1,1-Dichloroethene	EPA 8260C
	EPA 624
1,1-Dichloropropene	EPA 8260C
1,2,3-Trichloropropane	EPA 8260C
1,2-Dibromo-3-chloropropane	EPA 8260C
1,2-Dibromoethane	EPA 8260C
1,2-Dichloroethane	EPA 8260C
	EPA 624
1,2-Dichloropropane	EPA 8260C
	EPA 624
1,3-Dichloropropane	EPA 8260C
2,2-Dichloropropane	EPA 8260C
2-Chloro-1,3-butadiene (Chloroprene)	EPA 8260C
2-Chloroethylvinyl ether	EPA 8260C
	EPA 624
3-Chloropropene (Allyl chloride)	EPA 8260C
Bromochloromethane	EPA 8260C
Bromodichloromethane	EPA 8260C

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Volatile Halocarbons	
Bromodichloromethane	EPA 624
Bromoform	EPA 8260C
	EPA 624
Bromomethane	EPA 8260C
	EPA 624
Carbon tetrachloride	EPA 8260C
	EPA 624
Chloroethane	EPA 8260C
	EPA 624
Chloroform	EPA 8260C
	EPA 624
Chloromethane	EPA 8260C
	EPA 624
cis-1,2-Dichloroethene	EPA 8260C
cis-1,3-Dichloropropene	EPA 8260C
	EPA 624
cis-1,4-Dichloro-2-butene	EPA 8260C
Dibromochloromethane	EPA 8260C
	EPA 624
Dibromomethane	EPA 8260C
Dichlorodifluoromethane	EPA 8260C
Hexachlorobutadiene, Volatile	EPA 8260C
Methyl iodide	EPA 8260C
Methylene chloride	EPA 8260C
	EPA 624
Tetrachloroethene	EPA 8260C

Volatile Halocarbons	
Tetrachloroethene	EPA 624
trans-1,2-Dichloroethene	EPA 8260C
	EPA 624
trans-1,3-Dichloropropene	EPA 8260C
	EPA 624
trans-1,4-Dichloro-2-butene	EPA 8260C
Trichloroethene	EPA 8260C
	EPA 624
Trichlorofluoromethane	EPA 8260C
	EPA 624
Vinyl chloride	EPA 8260C
	EPA 624
Volatiles Organics	
1,4-Dioxane	EPA 8260C
2-Butanone (Methylethyl ketone)	EPA 8260C
2-Hexanone	EPA 8260C
2-Nitropropane	EPA 8260C
4-Methyl-2-Pentanone	EPA 8260C
Acetone	EPA 8260C
Acetonitrile	EPA 8260C
Carbon Disulfide	EPA 8260C
Di-ethyl ether	EPA 8260C
Ethyl Acetate	EPA 8260C
Isobutyl alcohol	EPA 8260C
	EPA 8015D

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Volatiles Organics

Isobutyl alcohol	EPA 8015C
o-Toluidine	EPA 8270D
Vinyl acetate	EPA 8260C

Sample Preparation Methods

EPA 5030C
EPA 3010A
EPA 3510C
EPA 9010C

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Acrylates

Acrolein (Propenal)	EPA 8260C
Acrylonitrile	EPA 8260C
Ethyl methacrylate	EPA 8260C
Methyl acrylonitrile	EPA 8260C
Methyl methacrylate	EPA 8260C

Amines

1,2-Diphenylhydrazine	EPA 8270D
1,4-Phenylenediamine	EPA 8270D
1-Naphthylamine	EPA 8270D
2-Naphthylamine	EPA 8270D
2-Nitroaniline	EPA 8270D
3-Nitroaniline	EPA 8270D
4-Chloroaniline	EPA 8270D
4-Nitroaniline	EPA 8270D
5-Nitro-o-toluidine	EPA 8270D
a,a-Dimethylphenethylamine	EPA 8270D
Aniline	EPA 8270D
Carbazole	EPA 8270D
Methapyrilene	EPA 8270D
Pronamide	EPA 8270D

Benzidines

3,3'-Dichlorobenzidine	EPA 8270D
3,3'-Dimethylbenzidine	EPA 8270D
Benzidine	EPA 8270D

Characteristic Testing

Corrosivity	EPA 9045D
Ignitability	EPA 1010A
Synthetic Precipitation Leaching Proc.	EPA 1312
TCLP	EPA 1311

Chlorinated Hydrocarbon Pesticides

4,4'-DDD	EPA 8081B
4,4'-DDE	EPA 8081B
4,4'-DDT	EPA 8081B
Aldrin	EPA 8081B
alpha-BHC	EPA 8081B
alpha-Chlordane	EPA 8081B
Atrazine	EPA 8270D
beta-BHC	EPA 8081B
Chlordane Total	EPA 8081B
Chlorobenzilate	EPA 8270D
delta-BHC	EPA 8081B
Diallate	EPA 8270D
Dieldrin	EPA 8081B
Endosulfan I	EPA 8081B
Endosulfan II	EPA 8081B
Endosulfan sulfate	EPA 8081B
Endrin	EPA 8081B
Endrin aldehyde	EPA 8081B
Endrin Ketone	EPA 8081B
gamma-Chlordane	EPA 8081B

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Chlorinated Hydrocarbon Pesticides

Heptachlor	EPA 8081B
Heptachlor epoxide	EPA 8081B
Isodrin	EPA 8270D
Kepone	EPA 8270D
Lindane	EPA 8081B
Methoxychlor	EPA 8081B
Pentachloronitrobenzene	EPA 8081B
Simazine	EPA 8270D
Toxaphene	EPA 8081B

Chlorinated Hydrocarbons

1,2,3-Trichlorobenzene	EPA 8260C
1,2,4,5-Tetrachlorobenzene	EPA 8270D
1-Chloronaphthalene	EPA 8270D
2-Chloronaphthalene	EPA 8270D
Hexachlorobenzene	EPA 8270D
Hexachlorobutadiene	EPA 8270D
Hexachlorocyclopentadiene	EPA 8270D
Hexachloroethane	EPA 8270D
Hexachlorophene	EPA 8270D
Hexachloropropene	EPA 8270D
Pentachlorobenzene	EPA 8270D

Chlorophenoxy Acid Pesticides

2,4,5-T	EPA 8151A
2,4,5-TP (Silvex)	EPA 8151A
2,4-D	EPA 8151A

Chlorophenoxy Acid Pesticides

2,4-DB	EPA 8151A
Dalapon	EPA 8151A
Dicamba	EPA 8151A
Dichloroprop	EPA 8151A
Dinoseb	EPA 8151A
MCPA	EPA 8151A
MCPP	EPA 8151A
Pentachlorophenol	EPA 8151A

Haloethers

2,2'-Oxybis(1-chloropropane)	EPA 8270D
4-Bromophenylphenyl ether	EPA 8270D
4-Chlorophenylphenyl ether	EPA 8270D
Bis(2-chloroethoxy)methane	EPA 8270D
Bis(2-chloroethyl)ether	EPA 8270D

Low Level Polynuclear Aromatic Hydrocarbons

Acenaphthene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Acenaphthylene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Anthracene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Benzo(a)anthracene Low Level	EPA 8310

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Low Level Polynuclear Aromatic Hydrocarbons	
Benzo(a)anthracene Low Level	EPA 8270D
	EPA 8270D SIM
Benzo(a)pyrene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Benzo(b)fluoranthene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Benzo(g,h,i)perylene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Benzo(k)fluoranthene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Chrysene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Dibenzo(a,h)anthracene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Fluoranthene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Fluorene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM

Low Level Polynuclear Aromatic Hydrocarbons	
Indeno(1,2,3-cd)pyrene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Naphthalene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Phenanthrene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Pyrene Low Level	EPA 8310
	EPA 8270D
	EPA 8270D SIM
Metals I	
Barium, Total	EPA 6010C
	EPA 6020A
Cadmium, Total	EPA 6010C
	EPA 6020A
Calcium, Total	EPA 6010C
	EPA 6020A
Chromium, Total	EPA 6010C
	EPA 6020A
Copper, Total	EPA 6010C
	EPA 6020A
Iron, Total	EPA 6010C
	EPA 6020A

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Metals I

Lead, Total	EPA 6010C
	EPA 6020A
Magnesium, Total	EPA 6010C
	EPA 6020A
Manganese, Total	EPA 6010C
	EPA 6020A
Nickel, Total	EPA 6010C
	EPA 6020A
Potassium, Total	EPA 6010C
	EPA 6020A
Silver, Total	EPA 6010C
	EPA 6020A
Sodium, Total	EPA 6010C
	EPA 6020A
Strontium, Total	EPA 6010C
	EPA 6020A

Metals II

Aluminum, Total	EPA 6010C
	EPA 6020A
Antimony, Total	EPA 6010C
	EPA 6020A
Arsenic, Total	EPA 6010C
	EPA 6020A
Beryllium, Total	EPA 6010C
	EPA 6020A

Metals II

Chromium VI	EPA 7196A
Mercury, Total	EPA 7471B
Selenium, Total	EPA 6010C
	EPA 6020A
Vanadium, Total	EPA 6010C
	EPA 6020A
Zinc, Total	EPA 6010C
	EPA 6020A

Metals III

Cobalt, Total	EPA 6010C
	EPA 6020A
Molybdenum, Total	EPA 6010C
	EPA 6020A
Thallium, Total	EPA 6010C
	EPA 6020A
Tin, Total	EPA 6010C
	EPA 6020A
Titanium, Total	EPA 6010C
	EPA 6020A

Minerals

Bromide	EPA 9056A
Chloride	EPA 9056A
Fluoride, Total	EPA 9056A
Sulfate (as SO4)	EPA 9056A

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Miscellaneous

Cyanide, Total	EPA 9012B
Organic Carbon, Total	EPA 9060A
Perchlorate	EPA 6850

Nitroaromatics and Isophorone

1,3,5-Trinitrobenzene	EPA 8270D
	EPA 8330A
	EPA 8330B
1,3-Dinitrobenzene	EPA 8270D
	EPA 8330A
	EPA 8330B
1,4-Naphthoquinone	EPA 8270D
2,4,6-Trinitrotoluene	EPA 8330A
	EPA 8330B
2,4-Dinitrotoluene	EPA 8270D
	EPA 8330A
	EPA 8330B
2,6-Dinitrotoluene	EPA 8270D
	EPA 8330A
	EPA 8330B
2-Amino-4,6-dinitrotoluene	EPA 8330A
	EPA 8330B
2-Nitrotoluene	EPA 8330A
	EPA 8330B
3,5-Dinitroaniline	EPA 8330B
3-Nitrotoluene	EPA 8330A

Nitroaromatics and Isophorone

3-Nitrotoluene	EPA 8330B
4-Amino-2,6-dinitrotoluene	EPA 8330A
	EPA 8330B
4-Dimethylaminoazobenzene	EPA 8270D
4-Nitroquinoline-1-oxide	EPA 8270D
4-Nitrotoluene	EPA 8330A
	EPA 8330B
Hexahydro-1,3,5-trinitro-1,3,5-triazine	EPA 8330A
	EPA 8330B
Isophorone	EPA 8270D
Methyl-2,4,6-trinitrophenylnitramine	EPA 8330A
	EPA 8330B
Nitrobenzene	EPA 8270D
	EPA 8330A
	EPA 8330B
Nitroglycerine	EPA 8330B
Octahydro-tetranitro-tetrazocine	EPA 8330A
	EPA 8330B
Pentaerythritol tetranitrate	EPA 8330B
Pyridine	EPA 8270D

Nitrosoamines

N-Nitrosodiethylamine	EPA 8270D
N-Nitrosodimethylamine	EPA 8270D
N-Nitrosodi-n-butylamine	EPA 8270D
N-Nitrosodi-n-propylamine	EPA 8270D

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Nitrosoamines

N-Nitrosodiphenylamine	EPA 8070A
N-nitrosomethylethylamine	EPA 8270D
N-nitrosomorpholine	EPA 8270D
N-nitrosopiperidine	EPA 8270D
N-Nitrosopyrrolidine	EPA 8270D

Nutrients

Nitrate (as N)	EPA 9056A
Nitrite (as N)	EPA 9056A

Organophosphate Pesticides

Azinphos methyl	EPA 8141B
Bolstar	EPA 8141B
Carbophenothion	EPA 8141B
Chlorpyriphos	EPA 8141B
Coumaphos	EPA 8141B
Demeton-O	EPA 8141B
Demeton-S	EPA 8141B
Diazinon	EPA 8141B
Dichlorvos	EPA 8141B
Dimethoate	EPA 8141B
	EPA 8270D
Disulfoton	EPA 8141B
	EPA 8270D
EPN	EPA 8141B
Ethion	EPA 8141B
Ethoprop	EPA 8141B

Organophosphate Pesticides

Famphur	EPA 8141B
	EPA 8270D
Fensulfothion	EPA 8141B
Fenthion	EPA 8141B
Malathion	EPA 8141B
Mevinphos	EPA 8141B
Monocrotophos	EPA 8141B
NALED	EPA 8141B
Parathion ethyl	EPA 8141B
	EPA 8270D
Parathion methyl	EPA 8141B
	EPA 8270D
Phorate	EPA 8141B
	EPA 8270D
Ronnel	EPA 8141B
Sulfotepp	EPA 8141B
	EPA 8270D
TEPP	EPA 8141B
Thionazin	EPA 8141B
	EPA 8270D
Tokuthion	EPA 8141B
Trichloronate	EPA 8141B

Petroleum Hydrocarbons

Diesel Range Organics	EPA 8015D
	EPA 8015C

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Petroleum Hydrocarbons

Gasoline Range Organics	EPA 8015D
	EPA 8015C
Oil and Grease Total Recoverable (HEM)	EPA 9071B (Solvent:Hexane)

Phthalate Esters

Benzyl butyl phthalate	EPA 8270D
Bis(2-ethylhexyl) phthalate	EPA 8270D
Diethyl phthalate	EPA 8270D
Dimethyl phthalate	EPA 8270D
Di-n-butyl phthalate	EPA 8270D
Di-n-octyl phthalate	EPA 8270D

Polychlorinated Biphenyls

PCB-1016	EPA 8082A
PCB-1221	EPA 8082A
PCB-1232	EPA 8082A
PCB-1242	EPA 8082A
PCB-1248	EPA 8082A
PCB-1254	EPA 8082A
PCB-1260	EPA 8082A
PCB-1262	EPA 8082A
PCB-1268	EPA 8082A

Polynuclear Aromatic Hydrocarbons

2-Acetylaminofluorene	EPA 8270D
3-Methylcholanthrene	EPA 8270D
7,12-Dimethylbenzyl (a) anthracene	EPA 8270D

Polynuclear Aromatic Hydrocarbons

Acenaphthene	EPA 8270D
Acenaphthylene	EPA 8270D
Anthracene	EPA 8270D
Benzo(a)anthracene	EPA 8270D
Benzo(a)pyrene	EPA 8270D
Benzo(b)fluoranthene	EPA 8270D
Benzo(ghi)perylene	EPA 8270D
Benzo(k)fluoranthene	EPA 8270D
Chrysene	EPA 8270D
Dibenzo(a,h)anthracene	EPA 8270D
Dibenzo(a,j)acridine	EPA 8270D
Fluoranthene	EPA 8270D
Fluorene	EPA 8270D
Indeno(1,2,3-cd)pyrene	EPA 8270D
Naphthalene	EPA 8270D
Phenanthrene	EPA 8270D
Pyrene	EPA 8270D

Priority Pollutant Phenols

2,3,4,6 Tetrachlorophenol	EPA 8270D
2,4,5-Trichlorophenol	EPA 8270D
2,4,6-Trichlorophenol	EPA 8270D
2,4-Dichlorophenol	EPA 8270D
2,4-Dimethylphenol	EPA 8270D
2,4-Dinitrophenol	EPA 8270D
2,6-Dichlorophenol	EPA 8270D

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All approved analytes are listed below:

Priority Pollutant Phenols	
2-Chlorophenol	EPA 8270D
2-Methyl-4,6-dinitrophenol	EPA 8270D
2-Methylphenol	EPA 8270D
2-Nitrophenol	EPA 8270D
3-Methylphenol	EPA 8270D
4-Chloro-3-methylphenol	EPA 8270D
4-Methylphenol	EPA 8270D
4-Nitrophenol	EPA 8270D
Pentachlorophenol	EPA 8270D
Phenol	EPA 8270D
Thiophenol	EPA 8270D
Semi-Volatile Organics	
1,1'-Biphenyl	EPA 8270D
1,2-Dichlorobenzene, Semi-volatile	EPA 8270D
1,3-Dichlorobenzene, Semi-volatile	EPA 8270D
1,4-Dichlorobenzene, Semi-volatile	EPA 8270D
2-Methylnaphthalene	EPA 8270D
2-Picoline	EPA 8270D
4-Amino biphenyl	EPA 8270D
Acetophenone	EPA 8270D
Aramite	EPA 8270D
Benzaldehyde	EPA 8270D
Benzoic Acid	EPA 8270D
Benzyl alcohol	EPA 8270D
Caprolactam	EPA 8270D

Semi-Volatile Organics	
Dibenzofuran	EPA 8270D
Ethyl methanesulfonate	EPA 8270D
Isosafrole	EPA 8270D
Methyl methanesulfonate	EPA 8270D
O,O,O-Triethyl phosphorothioate	EPA 8270D
Phenacetin	EPA 8270D
Safrole	EPA 8270D
Volatile Aromatics	
1,2,4-Trichlorobenzene, Volatile	EPA 8260C
1,2,4-Trimethylbenzene	EPA 8260C
1,2-Dichlorobenzene	EPA 8260C
1,3,5-Trimethylbenzene	EPA 8260C
1,3-Dichlorobenzene	EPA 8260C
1,4-Dichlorobenzene	EPA 8260C
2-Chlorotoluene	EPA 8260C
4-Chlorotoluene	EPA 8260C
Benzene	EPA 8260C
Bromobenzene	EPA 8260C
Chlorobenzene	EPA 8260C
Ethyl benzene	EPA 8260C
Isopropylbenzene	EPA 8260C
m/p-Xylenes	EPA 8260C
Naphthalene, Volatile	EPA 8260C
n-Butylbenzene	EPA 8260C
n-Propylbenzene	EPA 8260C

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NEW YORK STATE DEPARTMENT OF HEALTH
WADSWORTH CENTER

Expires 12:01 AM April 01, 2018
Issued April 01, 2017

CERTIFICATE OF APPROVAL FOR LABORATORY SERVICE

Issued in accordance with and pursuant to section 502 Public Health Law of New York State

MR. NORMAN D. FARMER
SGS ACCUTEST - ORLANDO
4405 VINELAND RD STE C-15
ORLANDO, FL 32811

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Volatile Aromatics	
o-Xylene	EPA 8260C
p-Isopropyltoluene (P-Cymene)	EPA 8260C
sec-Butylbenzene	EPA 8260C
Styrene	EPA 8260C
tert-Butylbenzene	EPA 8260C
Toluene	EPA 8260C
Total Xylenes	EPA 8260C
Volatile Halocarbons	
1,1,1,2-Tetrachloroethane	EPA 8260C
1,1,1-Trichloroethane	EPA 8260C
1,1,2,2-Tetrachloroethane	EPA 8260C
1,1,2-Trichloroethane	EPA 8260C
1,1-Dichloroethane	EPA 8260C
1,1-Dichloroethene	EPA 8260C
1,1-Dichloropropene	EPA 8260C
1,2,3-Trichloropropane	EPA 8260C
1,2-Dibromo-3-chloropropane	EPA 8260C
1,2-Dibromoethane	EPA 8260C
1,2-Dichloroethane	EPA 8260C
1,2-Dichloropropane	EPA 8260C
1,3-Dichloropropane	EPA 8260C
2,2-Dichloropropane	EPA 8260C
2-Chloro-1,3-butadiene (Chloroprene)	EPA 8260C
2-Chloroethylvinyl ether	EPA 8260C
3-Chloropropene (Allyl chloride)	EPA 8260C

Volatile Halocarbons	
Bromochloromethane	EPA 8260C
Bromodichloromethane	EPA 8260C
Bromoform	EPA 8260C
Bromomethane	EPA 8260C
Carbon tetrachloride	EPA 8260C
Chloroethane	EPA 8260C
Chloroform	EPA 8260C
Chloromethane	EPA 8260C
cis-1,2-Dichloroethene	EPA 8260C
cis-1,3-Dichloropropene	EPA 8260C
cis-1,4-Dichloro-2-butene	EPA 8260C
Dibromochloromethane	EPA 8260C
Dibromomethane	EPA 8260C
Dichlorodifluoromethane	EPA 8260C
Hexachlorobutadiene, Volatile	EPA 8260C
Methyl iodide	EPA 8260C
Methylene chloride	EPA 8260C
Tetrachloroethene	EPA 8260C
trans-1,2-Dichloroethene	EPA 8260C
trans-1,3-Dichloropropene	EPA 8260C
trans-1,4-Dichloro-2-butene	EPA 8260C
Trichloroethene	EPA 8260C
Trichlorofluoromethane	EPA 8260C
Vinyl chloride	EPA 8260C

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Volatile Organics

1,4-Dioxane	EPA 8260C
2-Butanone (Methylethyl ketone)	EPA 8260C
2-Hexanone	EPA 8260C
2-Nitropropane	EPA 8260C
4-Methyl-2-Pentanone	EPA 8260C
Acetone	EPA 8260C
Acetonitrile	EPA 8260C
Carbon Disulfide	EPA 8260C
Di-ethyl ether	EPA 8260C
Ethyl Acetate	EPA 8260C
Isobutyl alcohol	EPA 8260C
	EPA 8015D
	EPA 8015C
Isopropanol	EPA 8260C
Methyl tert-butyl ether	EPA 8260C
o-Toluidine	EPA 8270D
Propionitrile	EPA 8260C
tert-butyl alcohol	EPA 8260C
Vinyl acetate	EPA 8260C

Sample Preparation Methods

EPA 5035A-L
EPA 5035A-H
EPA 3010A
EPA 3050B
EPA 3550C

Sample Preparation Methods

EPA 3546
EPA 3060A
EPA 9010C

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