



**Sampling and Analysis Plan
for Phase 2 Remedial Investigation at the
Tonawanda Landfill Operable Unit in the
Town of Tonawanda, New York**

**Volume I: Field Sampling Plan
Volume II: Quality Assurance Project Plan**

Revision 1

**Buffalo District
Formerly Utilized Sites Remedial Action Program**

**Prepared by:
American Remediation Solutions and Environmental Corporation
(ARSEC)
2609 N. River Road
Port Allen, LA 70767**

**For:
U.S. Army Corps of Engineers – Buffalo District
Formerly Utilized Sites Remedial Action Program
Contract No. W912P4-07-D-0009, Delivery Order 0003**

February 2010 Revision 1

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Volume I
Field Sampling Plan



SAMPLING AND ANALYSIS PLAN

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FSP APPROVALS

By their specific signature, the undersigned certify that this Field Sampling Plan is approved for use during sampling and surveys at the Tonawanda Landfill Site, Tonawanda, NY

APPROVED BY:

[Redacted Signature] ARSEC - Project Manager 02/08/10
Date

[Redacted Signature] ARSEC – Radiation Safety Officer (RSO) 02/08/10
Date

By their specific signature, the undersigned certify that they reviewed and provided comments on this FSP for use during the performance of health physicist services at the Tonawanda Landfill FUSRAP Site, Tonawanda, NY

[Redacted Signature] ARSEC – ES&H Manager 02/08/10
PE, CIH, CSP Date

[Redacted Signature] ARSEC – Chief Executive Officer 02/08/10
Date

[Redacted Signature] ARSEC – Corporate Quality Manager 02/08/10
Darrell Srdoc Date



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ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ALARA	As Low As Reasonably Achievable
ARARs	Applicable or Relevant and Appropriate Requirements
ARS	American Radiation Services
ARSEC	Joint Venture between ARS and Safety and Ecology Corporation (SEC)
bgs	below ground surface
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Response, Compensation, and Liability Act
CHP	Certified Health Physicist
cm	centimeter(s)
cpm	counts per minute
COC	Contaminant of Concern, or Chain of Custody
CQCSM	Contract Quality Control System Manager
DAC	Derived Air Concentration
DCGL	Derived Concentration Guideline Level
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQCR	Daily Quality Control Report
DQO	Data Quality Objectives
DOT	U.S. Department of Transportation
ECWA	Erie County Water Authority
EPA	U.S. Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
ft	foot (feet)
FSP	Field Sampling Plan
FSS	Final Status Survey
g	gram(s)
GPS	Global Positioning System
GWS	Gamma Walkover Survey
HDPE	High-Density Polyethylene
HP	Health Physicist
HSRPP	Health, Safety, and Radiation Protection Plan
HTRW	Hazardous, Toxic, and Radioactive Waste
IDW	Investigation Derived Waste
ILCR	Incremental Lifetime Cancer Risk
ITR	Independent Technical Reviewers
keV	kilo-electron volts
m, m ²	meter(s), square meter(s)
MARSSIM	Multi Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentration
MDCR	Minimum Detectable Count Rate
MED	Manhattan Engineer District
NaI	Sodium Iodide
NCP	National Contingency Plan
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program

NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
PCB	Polychlorinated Biphenyl
pCi, pCi/g	picoCurie(s), picoCurie(s) per gram
PG	Professional Geologist
PM	Project Manager
POC	Point of Contact
QA/QC	Quality Assurance / Quality Control
QAPP	Quality Assurance Project Plan
QCP	Quality Control Plan
Ra	Radium
RFP	Request For Proposal
RI	Remedial Investigation
RIR	Remedial Investigation Report
ROD	Record of Decision
RPP	Radiation Protection Plan
RSO	Radiation Safety Officer
SAP	Sampling and Analysis Plan
SM	Site Manager
SOP	Standard Operating Procedure
SOW	Statement of Work
SSHO	Site Safety and Health Officer
SVOC	Semi-Volatile Organic Compound
TAL	Target Analyte List
TBD	to be determined
TCLP	Toxicity Characteristic Leaching Procedure
Th	Thorium
U	Uranium
μCi/ml	microCuries per milliliter
USACE	U.S. Army Corps of Engineers
USACE–Buffalo	U.S. Army Corps of Engineers, Buffalo District
USCS	Unified Soil Classification System
VOC	Volatile Organic Compound
XRF	X-Ray Fluorescence
YSI	Yellow Springs Instrument

1.0 PROJECT BACKGROUND

1.1 Introduction

American Remediation Services and Environmental Corporation (ARSEC) have been contracted by the U.S. Army Corps of Engineers – Buffalo District (USACE-Buffalo) under Contract No. W912P4-07-D-0009, D.O. 0003 to provide Hazardous, Toxic, and Radioactive Waste (HTRW) environmental services for the Tonawanda Landfill Formerly Utilized Sites Remedial Action Program (FUSRAP) Site (hereafter referred to as the “Site”) in Tonawanda, NY. Historical field sampling and gamma survey results have indicated the presence of Manhattan Engineer District (MED)-like material in the non-operational landfill. Identified constituents of concern were uranium-238 (U-238), thorium-230 (Th-230) and radium-226 (Ra-226). As a result, the Landfill, comprised of the landfill itself and the adjoining mudflats, was designated as a FUSRAP Vicinity Property to the Linde Site in 1992. This Field Sampling Plan (FSP) outlines the requirements and methodologies for performing gamma walkover radiation surveys and surface/subsurface soil sampling in accordance with the *Scope of Work, RI Addendum, Tonawanda Landfill Operable Unit* (USACE 2009). The survey, sampling and analytical techniques prescribed herein are consistent with the Multi-Agency Radiation Site Survey and Investigation Manual (MARSSIM).

1.2 Site Description

The Tonawanda Landfill Vicinity Property is located approximately 1.5 miles north of the Linde (Praxair) FUSRAP Site in the Town of Tonawanda, New York. The site is comprised of two operable units: The Town of Tonawanda Landfill (Landfill) and the Mudflats (Mudflats). This Statement of Work (SOW) addresses the 55 acre Landfill Operable Unit (OU). The Landfill is located at the northern end of East Park Drive and is bounded by residential developments to the north and northwest, a railroad line to the east, and a right of way owned by National Grid to the south. A 48-inch diameter Erie County Water Authority (ECWA) water transmission line traverses through the National Grid right-of-way. ECWA also has another easement for a second parallel 48-inch line through the National Grid right-of-way, for future use. The property is owned by the Town of Tonawanda, NY and is zoned as commercial/industrial. The bordering property to the north is residential. A no-action Record of Decision (ROD) for the Mudflats OU was signed 30 September, 2008.

1.3 Site History and Contaminants

A Proposed Plan for the Tonawanda Site in Tonawanda, New York was originally prepared by the United States Department of Energy (DOE) in September 1993 under its authority to conduct the FUSRAP. The 1993 Proposed Plan for the DOE Tonawanda Site addressed remediation of radioactive contamination at the four (4) locations in the town of Tonawanda that comprised the DOE Tonawanda Site as defined at the time: The Linde (now Praxair) Site; the Ashland 1 Site; the Ashland 2 Site; and the Seaway Site. Due to local concern regarding the DOE’s 1993 Proposed Plan, the DOE began to address each site separately.

In 1990, the DOE raised the concern that radiological material from the Linde site might have been disposed in the nearby Town of Tonawanda Landfill and requested a team from the Oak Ridge National Laboratory (ORNL) to conduct a radiological survey of the landfill and adjoining mudflats. Field sampling and gamma survey results by ORNL indicated the presence of MED-like material in the non-operational landfill (DOE 1992, ORNL 1992). Identified constituents of concern were uranium-238 (U-238), thorium- 230 (Th-230) and radium-226 (Ra-226). As a

result, the Landfill, comprised of the landfill itself and the adjoining mudflats, was designated as a FUSRAP Vicinity Property to the Linde Site in 1992.

On October 13, 1997, the Energy and Water Development Appropriations Act (1998) was signed into law as Public Law 105-62. Pursuant to this law, FUSRAP was transferred from the DOE to the United States Army Corps of Engineers (USACE). As a result of this transfer, the responsibility for this project was transferred to the USACE. The Energy and Water Development Appropriations Act for Fiscal Year 2000, Public Law 106-60, provides authority to USACE to conduct restoration on FUSRAP sites subject to the Comprehensive Response, Compensation, and Liability Act (CERCLA), 42 United States Code 9601 et seq., as amended. At that point, USACE began addressing the four locations of the Tonawanda Site and associated vicinity properties as individual projects under CERCLA.

One of these individual projects was the Tonawanda Landfill Vicinity Property, a site including both a landfill OU and a mudflats OU. USACE study of the site began in 2001 with a whole-site field investigation that culminated in a 2005 Remedial Investigation Report (RIR). Because the Baseline Risk Assessment (BRA) portion of the RIR concluded that the incremental lifetime cancer risk (ILCR) to human receptors was within the criteria established in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a ‘No Further Action’ Proposed Plan for both operable units was issued to the public in 2007. Specific results of the RI are summarized in Table 1-1.

Table 1-1. Summary of USACE Remedial Investigation Results: Tonawanda Landfill Vicinity Property – Tonawanda, New York

Matrix	# Samples at Landfill OU	Range: Results: Landfill OU	# Samples Mudflats OU	Range: Results: Mudflats OU
Soil	280 samples 114 locations	Th-230: 0.65 – 32.5 pCi/g U-238: 2.0 - 227 pCi/g Ra-226: 0.83 – 20.1 pCi/g	224 samples 96 locations	Th-230: 1.79 – 31.5 pCi/g U-238: 1.37 – 27.9 pCi/g Ra-226: 0.65 – 22.6 pCi/g
Surface Water	4 samples	Total U: 5.16 – 459 pCi/L Ra-228 + Ra-226: 4.95 – 37.38 pCi/L	None on OU	N/A
Sediment	4 locations, 9 samples	Th-230: 1.02 – 3.90 pCi/g U-238: 0.77 – 25.30 pCi/g Ra-226: 0.87 – 5.80 pCi/g	None on OU	N/A
Groundwater	7 shallow wells, 3 deeper wells for filtered and unfiltered analysis	Well L3: Total U: Unfiltered: 175.0 pCi/L Filtered: 133.0 pCi/L	4 wells for filtered and unfiltered analysis	Th-230: no exceedances U-238: no exceedances Ra-226: no exceedances

1.4 Results of Previous Investigations

1.4.1 DOE Investigations (1990-1995): Radioactive material surveys for the presence of MED-related materials at the Landfill and Mudflats were conducted by the DOE in 1990 as part of the Linde FUSRAP Site investigation. The intent of the survey was to assess whether any MED-related materials had been transported and disposed of off-site in the general area surrounding the Linde facility. The preliminary survey was completed using a mobile gamma scanning van. An anomaly in the survey detected in the Mudflats during the mobile scanning activities was verified using handheld gamma screening devices. Subsequent soil samples collected from the

area around the anomaly indicated elevated levels of U-238 and Ra-226, which are two isotopes consistent with material expected to be in ore processing byproducts generated at the Linde Site (ORNL 1990).

A limited radiological survey was conducted by DOE in September 1991 (ORNL 1992). The survey focused on both the Landfill and Mudflats and consisted of gamma walkover scans, measurement of radiation levels, and the collection and analysis of systematic and biased soil samples. The results of the survey detected soils in the Landfill and Mudflats with elevated concentrations of Ra, Th, and U. Laboratory results received indicated some soil samples exhibited characteristics similar to the MED product formerly produced at the Linde facility and others were consistent with the by-products of the refinery process conducted at the same Linde facility. The Landfill and Mudflats were subsequently designated together as a single Vicinity Property of the Linde FUSRAP Site.

DOE conducted additional soil sampling activities at the Landfill and Mudflats in 1994 to determine the vertical extent of the radiological contamination at the site. Analytical results obtained for subsurface soil, sediment, surface water and groundwater samples indicated that the radiological contamination was mainly limited to the upper 1.5 feet of soil, but was found in lesser concentrations at 24.5 feet below ground surface (bgs). A summary of results is shown in Table 1-2.

Table 1-2. Results of DOE Investigations

Matrix	# Samples at Landfill OU	Results	# Samples Mudflats OU	Results
Soil	148 samples 92 locations	Th-230: 1.59-4300 pCi/g U-238: 2.34-1800 pCi/g Ra-226: 2.27-2000pCi/g Lead (2 samples): 740 mg/kg; 1,200 mg/kg	43 sample 21 locations	Th-230: 1.60-660 pCi/g U-238: 1.31-78 pCi/g Ra-226:2.22-120 pCi/g Lead (1 sample): 300 mg/kg
Surface Water	1 sample	Th-230: 0.2 pCi/L Th-232: 0.06 pCi/L U-238: 48.2 pCi/L Ra-226: 521 pCi/L	None on OU	N/A
Sediment	1 sample	Th-228: 2.7 pCi/G Th-230: 121.8 pCi/g Th-232:2 pCi/g U-234: 382.3 pCi/g U-235: 19.5 pCi/g U-238: 393.5 pCi/g Ra-226: 65.7 pCi/g	None on OU	N/A
Groundwater	2 samples	Th-230: 2.4, 693 pCi/L Th-232: 1.1, 6.7 pCi/L U-238: 20.2, 4328 pCi/L	3 samples	Th-228: 1.1, 0.77, 1.2 pCi/L Th-230: 7.9, 3.4 pCi/L Th-232: 1.1, 0.98, 1.5 pCi/L U-238: 6.4, 20.8, 4.1 pCi/L Ra-226: 4.2, 2.4, 4.3 pCi/L

1.4.2 USACE Investigations (1999-2007): Upon receiving responsibility for the Tonawanda Landfill Vicinity Property in 1997, USACE began a review of data previously taken for the site. Based on the data, a Radiological Human Health Assessment was performed for both the Landfill and Mudflats OUs in February 1999. Closure scenarios for the Landfill addressed during the assessment included capping the contaminated soil in place and excavation and removal of

the impacted soil. Closure alternatives evaluated for the Mudflats area included no action, covering the impacted area with clean soil, and excavation and removal of impacted soil.

Following discussions with the state regulator and other stakeholders, USACE decided there was not enough data available to make a definitive conclusion on whether action was required at the Tonawanda Landfill Vicinity Property. Therefore, USACE proceeded forward with an RI of the Tonawanda Landfill Vicinity Property. The RI was structured to include both the Landfill OU and the Mudflats OU as separate but related parcels. The objectives of the RI were as follows:

- Verify that MED-related material is present in soil, groundwater, surface water and sediment
- Confirm concentration of contaminants in areas found to be elevated by DOE
- Determine whether chemical or non-MED material is comingled with MED-related materials
- Assess long term risks posed by leaving MED-related material in place, including fate and transport profile as a function of time.

Extensive field sampling of surface and subsurface soil, groundwater, surface water and sediment was conducted in 2001. Details of sample acquisition numbers and findings are presented in the *Remedial Investigation Report, Tonawanda Landfill Vicinity Property, Tonawanda, New York* (USACE, April 2005) and summarized in Table 1-3 below.

Table 1-3. Results of USACE Investigations

Matrix	# Samples at Landfill OU	Results	# Samples Mudflats OU	Results
Soil	28 samples 114 locations	Th-230: 0.65 - 32.5 pCi/g U-238: 2.0-227 pCi/g Ra-226: 0.83-20.1 pCi/g	224 samples 96 locations	Th-230: 1.79-31.5 pCi/g U-238: 1.37-27.9 pCi/g Ra-226: 0.65 -22.6 pCi/g
Surface Water	4 samples	Total U: 5.16-459 pCi/L Ra-228 + Ra-226: 4.95-37.38 pCi/L	None on OU	N/A
Sediment	9 samples 4 locations	Th-230: 1.02-3.90 pCi/g U-238: 0.77--25.30 pCi/g Ra-226: 0.87-5.80 pCi/g	None on OU	N/A
Groundwater	7 shallow wells, 3 deep wells (filtered/unfiltered analysis)	Well L3: total U: unfiltered: 175.0 pCi/L Filtered: 133.0 pCi/L	4 wells (filtered/unfiltered analysis)	Th-230: no exceedances U-238: no exceedances Ra-226: no exceedances

Despite the proximity of USACE's samples to the locations that yielded DOE's historical elevated results, USACE was unable to find any elevated concentrations within the same order of magnitude. Based on the RI and the results of the BRA, the USACE concluded that soils containing uranium, radium and thorium could safely remain in place in their current condition. Therefore a No-Action alternative was recommended to the public in an April 25, 2007 presentation of the Proposed Plan for both the Landfill and Mudflats OUs.

Based on public comments received on the Proposed Plan and the fact that USACE did not find levels of contamination of the same order of magnitude as DOE, USACE has since decided to conduct additional sampling in the Landfill OU. USACE has proceeded forward with a No-Action ROD for the Mudflats OU, which was signed on September 30, 2008.

2.0 ORGANIZATION AND RESPONSIBILITIES

2.1 Project Manager

ARSEC's Project Manager (PM) for this effort is Steve Shirley. He is responsible for evaluating the suitability and adequacy of the technical services provided for the project and for developing the technical approaches and level of effort required to address each task. He is also responsible for the day-to-day conduct of work, including integration of input from supporting disciplines, USACE, and subcontractors. He will work closely with the Site Manager (SM) and Contractor Quality Control Systems Manager (CQCSM) during implementation of the field program. Specific responsibilities include:

- Initiating project planning and directing project activities;
- Ensuring that qualified technical personnel are assigned to various tasks, including subcontractors;
- Identifying and fulfilling equipment and other resource requirements;
- Monitoring project activities to ensure compliance with established scopes, schedules, and budgets;
- Ensuring overall technical quality and consistency of all project activities and deliverables; and
- Serving as the primary ARSEC POC with USACE.

2.2 Corporate CQC Manager

As the Corporate CQC Manager for ARSEC, Darrell Srdoc is responsible for the quality of the ARSEC work. Mr. Srdoc will be responsible for assuring the project team implements the policies and procedures required under the USACE contract and assuring that corrective action is taken if performance does not meet internal or USACE quality requirements. He will work closely with the ARSEC PM, CQCSM, and Independent Technical Reviewers (ITRs) to ensure established protocols and procedures are implemented, the work performed in accordance with the USACE's SOW, and the project work plans.

The Corporate QM is responsible for directing planning, implementing and tracking quality control (QC) activities and maintaining internal communication on QC matters. He will work with the PM, CQCSM, and ITRs to ensure that established QC procedures are implemented. He, or a designee, may conduct periodic Site and project audits as part of this process. The duties also include QC task staffing and ensuring that QC data evaluation, data verification, and reporting procedures are followed. The ultimate goal of these activities is to perform work and produce data that satisfy the project objectives as defined in the project *Quality Control Plan* [QCP, (ARSEC, 2009)] and this Field Sampling Plan (FSP) portion of the Sampling and Analysis Plan (SAP).

2.3 Project Health Physicist

Andrew Lombardo, CHP is ARSEC's Radiation Safety Officer (RSO) and Project Health Physicist (HP). In that capacity, he is responsible for oversight and review of all ARSEC radiological activities and data. Mr. Lombardo is responsible for reviewing radiological data deliverables from analytical laboratories, interfacing with the laboratory client services coordinators, and coordinating the resolution of laboratory problems. The Corporate RSO/HP has the authority to direct such activities, stop work (and restart based on consultation with the

PM), and to take appropriate actions, as required, to address radiological emergency situations. He will work directly with the SM, Site Safety and Health Officer (SSHO), and Site RSO to ensure the ARSEC Radiation Protection Plan (RPP) and SAP are properly implemented and followed.

2.4 Site Manager

ARSEC will utilize Mr. Dana Williams as the Site Manager. As the Site Manager, he will report directly to the Project Manager and is responsible for the overall direction and management of field tasks. His duties include oversight of field staff and subcontractors, ensuring procedures for field work are executed in the proper manner, activities are properly documented, the prescribed SOW is completed, and communication protocols are followed. He is also responsible for managing sampling activities in accordance with the project work plans. The SM monitors work progress and schedule, advises ARSEC's PM of variances, and assists in the preparation of work progress schedules, project reports, drawings, and required compliance submittals.

2.5 Site Safety and Health Officer

ARS will utilize Mr. Randy McCrone as the Site Safety and Health Officer (SSHO). Mr. McCrone will have reporting responsibility to ARSEC's Corporate Health and Safety Manager and Corporate RSO/HP. As SSHO, he is responsible for ensuring site personnel are appropriately trained in the provisions of the HSRPP. The SSHO has the authority to issue stop-work orders for site activities he believes to be unsafe. When so stopped, site work will not resume until ARSEC's Corporate Health and Safety Manager, Corporate RSO/HP, and PM approve the restart.

2.6 Site Radiation Safety Officer

ARSEC's Site RSO will be Mark Krohn. The alternate ARSEC Site RSO will be Mark Schaffer. The Site RSO is responsible for ensuring that radiation health and safety procedures designed to protect site personnel and the public are maintained throughout the project. The Site RSO coordinates establishing radiologically controlled areas, monitoring radiation exposure levels, and inspecting all material/equipment entering or leaving the Exclusion Zone for compliance with the RSP and other applicable requirements. The roles and responsibilities of the RSO are further defined in the project RSP.

The Site RSO will also be responsible for overseeing the maintenance and QC check of the on-site radiological instruments and will provide instrument data records to the CQCSM for storage in on-site files.

2.7 Contractor Quality Control Systems Manager

ARSEC's CQCSM, Penny Baxter, is responsible for day-to-day compliance with the CQCP and SAP, including records filing and archiving, and the provision of operational support to on-site personnel. Ms. Baxter meets the qualifications for CQCSM as identified in the USACE's SOW. She has over 20 years of technical and project management experience.

The CQCSM provides and maintains an effective QC system for all construction and sampling to ensure conformance with authorized policies, procedures, contract specifications, approved work plan and sound practices. The CQCSM also prepares the Daily Quality Control Report (DQCR)

and QC checklists, and provides such to the COR or designee. The CQCSM will be on site during the majority of the field activities.

2.8 Field Geologist

Ensol, Inc. will provide a Field Geologist. The Field Geologist will oversee all soil sampling activities. He/She will ensure all soils encountered during drilling and test pits activities are documented using applicable ASTM standards for classification, consistency, moisture content, and color. The Field Geologist is responsible for developing and maintaining soil boring logs and will visually observe and describe all materials encountered with respect to depth and location.

2.9 Field Team

The ARSEC Field Team Members are responsible for performing field activities as stipulated in this Plan and the USACE's Scope of Work entitled "RI Addendum, Tonawanda Landfill Operable Unit", June 2009, and shall report directly to the SM:

- Craft Labor [to be determined (TBD)] – An equipment operator will be on site throughout field work to support field activities. An electrician will establish temporary electrical service at the start of field work, and will be local to the Site.
- HP Technicians – A minimum of two HP Technicians will perform periodic instrument checks, perform radiological surveys and collect and prepare soil samples for laboratory analysis. The technicians will also maintain radiological zones and controls, perform surveys of personnel and equipment and complete instrument and data records with oversight by the Site RSO.
- Sample Technicians – A minimum of two ARSEC sample technicians will be utilized to collect all surface and subsurface soil samples during the field work. They will ensure the samples are collected, contained, prepared and shipped in accordance with all applicable requirements.

2.10 Other

Table 2-1 presents the key points of contact for the Tonawanda project, including USACE, ARSEC and Subcontractor information.

Table 2-1. Contact Information for Key Project Personnel

TITLE	NAME	TELEPHONE
U.S. Army Corps of Engineers – Buffalo District		
Project Manager	[REDACTED]	[REDACTED]
Project Engineer	[REDACTED]	[REDACTED]
Industrial Hygienist	[REDACTED]	[REDACTED]
Health Physicists	[REDACTED]	[REDACTED]
Chemist	[REDACTED]	[REDACTED]
Contracting Officer’s Representative (COR)	[REDACTED]	[REDACTED]
Contracting Specialist	[REDACTED]	[REDACTED]
ARSEC		
Corporate Contractor Quality Control Manager	[REDACTED]	[REDACTED]
Project Manager	[REDACTED]	[REDACTED]
Corporate Health and Safety Manager	[REDACTED]	[REDACTED] 1
Contracts Manager	[REDACTED]	[REDACTED]
Corporate RSO/Project Health Physicist	[REDACTED]	[REDACTED]
Site Manager	[REDACTED]	[REDACTED]
Site Radiation Safety Officer	[REDACTED]	[REDACTED]
Alternate Site Radiation Safety Officer	[REDACTED]	[REDACTED]
Site Safety & Health Officer	[REDACTED]	[REDACTED]
Site CQCSM	[REDACTED]	[REDACTED]
ARSEC Subcontractors		
Surveyor	-	-
Local Surveyor (TBA)	-	-
Driller	[REDACTED]	[REDACTED]
Zebra Environmental Corporation	[REDACTED]	[REDACTED]
Geologist	[REDACTED]	[REDACTED]
Ensol, Inc.	[REDACTED]	[REDACTED]

3.0 PROJECT SCOPE AND OBJECTIVES

The following section identifies the overall scope and the specific objectives of the project and the field measurement and sampling activities that will be used to satisfy the data quality objectives. This section also provides a summary of the data quality objectives (DQOs) as established in the Quality Assurance Project Plan (QAPP, ARSEC 2009). The guidance contained herein serves to ensure that the data collected during this effort will be of sufficient quantity and quality to accurately determine the remaining volume of contaminated soil at the Site.

3.1 Overall Scope

ARSEC will mobilize a team to the Site for the purpose of performing the tasks identified in the Request for Proposal (RFP) to attempt to qualify and quantify the remaining contamination at the Tonawanda Landfill site as follows:

- Conduct clearing and grubbing to prepare the site for the field work;
- Conduct a Gamma Walkover Survey to characterize the site for worker health and safety and to assist in locating surface soil contamination.
- Collect surface and subsurface soil samples in six identified Investigative Areas (IAs) from boreholes installed by direct push methodology to determine whether or not the site poses potential risks to human health or the environment;
- Install temporary well points in up to 14 of the subsurface soil boring locations for the collection of samples to determine the potential for groundwater contamination;
- Perform 100% data validation and verification of the analytical data and prepare an electronic deliverable for the USACE;
- Manage all investigation-derived waste generated during the field work in accordance with the requirements listed in the Task Order RFP.
- Prepare a comprehensive Project Report summarizing all work conducted on the project.

3.2 General Data Collection Summary

Information on COCs will be collected from three investigative field components: (1) Gamma Walkover Surveys (GWS); (2) Surface and subsurface soil sampling based on the results of the GWS scans; (3) Surface and subsurface samples collected from pre-selected systematic sampling grids, as well as replication of samples in areas where the DOE previously found high levels of radionuclide contamination, along the fence line, and along site drainage features; and (4) Groundwater samples collected from temporary well points installed in selected soil borings. Samples collected will be subject to laboratory analysis in accordance with appropriate analytical techniques (e.g., gamma spectrometry, EPA and SW846 methodologies).

3.2.1 Gamma Walkover Surveys: GWS will be performed in parallel with civil survey work being conducted by the local Professional Surveyor. The purpose of the GWS is to characterize the site for worker health and safety and to assist in the location of surface soil contamination. ARSEC will perform all GWS surveys under this task using equipment provided by the ARSEC Instrumentation Facilities located in Knoxville, Tennessee and Port Allen, Louisiana.

In addition to walkover surveys performed in the planned vegetation decomposition area, single direction GWS shall be conducted over 100% of Investigative Areas 1 through 6. The surveys shall be performed using MARSSIM methodology. The purpose of the surveys is to characterize

the site for worker health and safety and to assist in location of surface soil contamination. Figure 1 in Appendix B presents the proposed survey areas.

ARSEC will determine the GWS threshold based on elevation or background and site data. After the completion of the GWS and assimilation of the GWS data, ARSEC will provide a letter report identifying potential areas that warrant the collection of additional GWS data and/or samples to support the RI Addendum re-sampling effort. As delineated in the RFP, ARSEC will not proceed with the proposed sampling until USACE concurrence is received on the letter report conclusions and recommendations.

3.2.2 Surface/Subsurface Soil: Sampling protocols will be based on whether the investigative area has high, medium or low probability of finding radiological contamination. Proposed systematic boring locations are shown on Figure 1 in Appendix B. Boring locations will also include those coordinates where the DOE previously found radionuclide concentrations. For areas with either high or medium probabilities of radiological contamination, e.g., IA-1 through IA-5, soil borings will extend through the landfill waste to native soil. Five samples will be collected per soil boring location. In these borings, each sample collected will include a one foot segment of the boring (except for the cores surface, which will include approximately the top 6-inches of the boring) at the following locations:

1. The core surface [i.e., the top 6 inches of the current landfill surface (0.0 – 0.5 feet bgs)].
2. A soil sample from the first foot just inside the saturated zone.
3. A sample from the first foot of native soil below the landfill waste.
4. A one foot sample centered around the core area where the gamma instrument registered the highest reading. If the highest gamma instrument reading interval is the same as any of the above three fixed intervals (i.e., the highest scan reading is in either the top 6 inches, or at the saturated zone interface, or in the first foot of native soil) then the fourth sample interval should be selected at the second highest gamma reading, or by other professional judgment.
5. A one foot sample centered around the core area where the beta instrument (i.e., beta scintillator) registered the highest beta reading. If the highest beta reading interval is the same as any of the above four fixed intervals (i.e., the highest scan reading is in either the top 6 inches, or at the saturated zone interface, or in the first foot of native soil, or in the area of the highest gamma instrument reading) then the fifth sample interval should be selected using the following decision tree:
 - a. A one foot sample centered around the core area with the second highest gamma reading,
 - b. A one foot sample centered around the core area with the second highest beta reading,
or
 - c. A one foot core sample using other professional judgment.

For areas with low probability of contamination, e.g., IA-6, the borings will extend through the structural fill placed by the Town of Tonawanda to a depth of 12 feet beneath the structural fill. The entire length of the soil cores, including those in the structural fill, will be scanned and considered for potential sample selection. Greater depths will only be obtained if a positive result is obtained in the bottom interval of the soil core during core scanning; the reading that constitutes a positive result shall be determined based on evaluation of background and site data. In that case, the final depth of a sample will be determined by communicating with the COR. The direct push Geoprobe unit that will be used at the site can penetrate to depths greater than 40

feet bgs. Four samples will be collected per soil boring location and will consist of a one foot segment of the boring (except for the cores surface, which will include approximately the top 6 inches of the boring) at the following locations:

1. The core surface [i.e., the top 6 inches of the current landfill surface (0.0 – 0.5 feet bgs)]. If the boring location is on the access road, then the sample will be from the first 6 inches of soil beneath the current road bed material (i.e., below any pavement and gravel base). The depth of the interface between the road and the soil-like materials will be recorded on USACE ENG Form 5056-R or Form 5056A-R. Sample depth will be recorded on the ARSEC Soil Core Survey Form.
2. A soil sample from the first foot just inside the saturated zone. If the saturated zone is not reached in the boring (i.e., it is deeper than the termination depth of the boring), then the sample will be from the bottom one foot of the boring.
3. A one foot sample centered around the core area where the gamma instrument registered the highest reading. If the highest gamma instrument reading interval is the same as any of the above two fixed intervals (i.e., the highest scan reading is in either the top 6 inches, or at the saturated zone interface) then the third sample interval should be selected at the second highest gamma reading, or by other professional judgment.
4. A one foot sample centered around the core area where the beta instrument (i.e., beta scintillator) registered the highest beta reading. If the highest beta reading interval is the same as any of the above three fixed intervals (i.e., the highest scan reading is in either the top 6 inches, or at the saturated zone interface, or in the area of the highest gamma instrument reading) then the fourth sample interval should be selected using the following decision tree:
 - a. A one foot sample centered around the core area with the second highest gamma reading,
 - b. A one foot sample centered around the core area with the second highest beta reading, or
 - c. A one foot core sample using other professional judgment.

If fill is encountered in the low contamination potential investigative areas, up to four additional borings per investigative area will be installed extending down to native soil, per direction of the COR. Sampling and analysis in these borings will follow the protocols used for high or medium areas of potential of contamination. In the event that extensive contamination is found along the core in any low probability area, ARSEC shall communicate with the COR to determine final depth. Additional sample collection will be directed by the COR.

3.2.3 Groundwater: ARSEC will install up to 14 temporary well points in the approximate locations shown Figure 1, Appendix B. The well points will be constructed in previously-drilled soil borings. Final locations will be selected based on preliminary screening of soils data. Additional consideration on the final locations of well points will be based on guidance in EM 1110-1-4000, 6-3a, on observed conditions, considering historical groundwater data gaps in the landfill area and adjacent natural (less to undisturbed) areas. The well points will be constructed of 1.25-inch to 2.0-inch PVC with #5 sand (or best equivalent) with a 5-to-10-foot section of 0.010-inch slotted screen. Each well point shall be finished to grade with hydrated bentonite chips with a locking cap on the riser. Well point depth will vary depending on location, but are averaged to be approximately 20-feet bgs.

Sampling of the well points will be after purging is completed; no later than 10 days following installation. Each well point will be sampled as specified in Table 6-2 to determine whether residual MED-like material has impacted site groundwater.

3.3 Data Quality Objectives

Project Data Quality Objectives (DQOs) for field sampling activities have been established based on available site investigation data and potential ARARs pertaining to the Landfill OU. The DQOs have been established to ensure compliance with applicable Federal, State and local regulations for handling and assessing radiological contaminants present at the site, and to evaluate potential remedial activities associated with the handling and/or removal of radiologically impacted material. The project goals/DQOs are:

- Determine the extent and concentration of MED-related material currently in the Landfill OU.
- Estimate potential risks to human health and the environment associated with exposures to MED related contamination which may exist at the site.
- Confirm or update DOE's findings of elevated concentrations of radiological constituents of concern.
- Determine the likelihood and pathways of contaminant migration.
- Evaluate the potential for migration of MED material into residents' back yards and/or presence of material in yards due to historic disposal operations and haulways.
- Bound the depth of MED contamination
- Confirm depth to groundwater, groundwater flow rates and direction of groundwater flow
- Re-evaluate both persistent and intermittent surface water drainages, both historical and present, considering the recent re-contouring of the landfill.
- Obtain data to support technically defensible contaminated soil volume determination.
- Evaluate the characteristics of soil and groundwater for waste disposal

4.0 FIELD ACTIVITIES

A number of field activities will be conducted as part of this characterization effort. The principal activities include:

- Clearing and Grubbing
- Gamma Walkover Surveys
- Surface and Subsurface Soil Sample Collection
- Temporary Well Installation
- Groundwater Sample Collection

Investigative Areas

The field work will be focused within six Investigative Areas exhibiting residual contamination identified from historical investigations by DOE. Collected information and data will be used to determine whether or not the site poses potential risks to human health and the environment. The six areas were selected by USACE through an evaluation of previous field investigation results and site history. They include:

- **IA-1** – A 42,150 SF area that is centered on one of the two locations where screening levels were exceeded during past sampling events. Because of this historical data, IA-1 is considered a “high potential” area for finding radiological contamination.
- **IA-2** – A 31,370 SF area that is centered on the second of the two locations where screening levels were exceeded during past sampling events. This area is also considered a “high potential” for finding radiological contamination.
- **IA-3** – A 397,060 SF area that includes the 1940-1960s waste disposal area and the Town of Tonawanda “buffer zone” of waste that must be moved to cap the landfill. This area is considered a “moderate potential” for finding radiological contamination.
- **IA-4** – A 298,020 SF area that is located on the eastern portion of the 1940-1960s waste disposal area. This area is considered a “moderate potential” for finding radiological contamination.
- **IA-5** – A 229,860 SF area that is located on the western portion of the 1940-1960s waste disposal area. This area is considered a “moderate potential” for finding radiological contamination.
- **IA-6** – A 551,500 SF area that covers the remainder of the Landfill OU and is outside of the 1940-1960s waste disposal area. This area is considered a “low potential” for finding radiological contamination.

IAs 1, 2, 4, 5, 6, and the majority of IA-3 are within the property boundary of the Tonawanda Landfill OU, for which the USACE possess an existing Right of Entry. A portion of IA-3 follows the site surface drainage and is located on National Grid property.

The remainder of this section describes each of these activities in more detail. A current Project Schedule is included as Appendix A to this SAP.

4.1 Site Clearing

In order to prepare the site for the GWS and other work, ARSEC will perform clearing and grubbing consistently over planned Study Areas IA-1 through IA-6 to ensure that 100% coverage of the area by gamma walkover surveys (GWSs) are possible and that all areas are accessible to drill rigs as required.

ARSEC personnel will clear the lower tree limbs and remove foliage and trees < 6-inches in diameter at breast/shoulder height to ground level; will displace bushes or undergrowth that will obscure the efforts of our Professional Surveyor. Where extensive clearing is required, ARSEC will cut trees that are < 6-inches in diameter, larger bushes/brush, and other vegetation flush, within 2-4 inches, with the ground, except for areas where the COR authorizes the growth to stand. Trees that are to be left standing will be cleared of dead branches 1.5-inches in diameter or greater at a height to allow easy access of personnel and survey equipment. All tree limbs, vegetation, and other cleared materials will be shredded onsite using a wood chipper or similar equipment. All chipped and non-chipped material will be staged in USACE and Town of Tonawanda authorized areas for decomposition, noting that the decomposition area shall only be selected if it has a low probability for either chemical and/or radiological contamination, verified by a GWS to verify no elevated surface contamination. ARSEC will coordinate with the Town of Tonawanda prior to initiating the wood chipping process, as it may be possible to use the Town of Tonawanda's wood chipper.

Once the clearing and grubbing is complete, the local State of New York Professional Surveyor will conduct a civil survey to establish the baseline elevations for the site and to locate and mark the locations of USACE delineated sampling locations. The Surveyor will conduct all subsequent surveys, including but not limited to locating and marking of biased sampling locations, locating and marking of Well Point locations, and the confirmation/re-survey of actual installed boring and Well Point locations. This information will be included in the final report.

4.2 Gamma Walkover Surveys (GWS)

The ARSEC health physics (HP) technicians will begin the Gamma Walkover Survey (GWS) in parallel with civil survey work being conducted by the Professional Surveyor.

To satisfy the requirements of the Task Order RFP, ARSEC will conduct Minimum Detectable Concentration (MDC) bench tests for various field instruments to determine the most appropriate unit for performing the GWS. As such, ARSEC shall check the scan MDC for instruments including but not necessarily limited to a 2-inch x 2-inch sodium iodide (NaI) scintillation detector, a 3-inch x 3-inch sodium iodide (NaI) scintillation detector, and a FIDLER. The HPs will follow the guidance established in MARSSIM/NUREG-1507 to carefully determine the scan MDC and the minimum detectable count rate (MDCR) for the selected instrument to be used during the course of the field investigation activities with respect to the following radionuclides:

- Radium-226,
- Thorium-230,
- Thorium-232 Decay Series, and
- Natural Uranium (U-235, U-238 and U-234).

The calculations that delineate the approximate sensitivity of each radiological detector for all of the above listed contaminants of concern (COCs) will be submitted to USACE for review and approval. It should be noted that Th-232 was not a COC at Linde or any of the other Tonawanda FUSRAP sites and is not expected to be a COC at Town of Tonawanda Landfill based on previous sampling results. However, it is felt that it is prudent to include MDC and MDCR calculations for Th-232 at this stage of the investigation.

Survey Procedures: The GWS surveys shall be performed using the most appropriate detector selected as described above. The detector will be coupled with a rate meter that has a current annual calibration results of which will be kept on site during the survey. Daily QC checks

associated with use of these instruments shall follow the standard operating procedures as detailed in the Sampling and Analysis Plan (SAP). This includes the GPS equipment as well. The detector/rate meter will be linked to a Trimble Global Positioning System (GPS) and a data logger in a portable configuration. Count rate information will be recorded simultaneously with geospatial coordinates in one-second intervals. Data files shall be downloaded from the data logger to the project computer for backup and distribution at least once per day.

Prior to the start of the GWS activities, surface specific background measurements shall be made by averaging 10 one minute integrated counts, distributed within a 10 meter by 10 meter grid type likely to be encountered on site. Surface types will include soil, asphalt and concrete. Surveys of the three background survey units shall be conducted using MARSSIM Class 1 methodology. Background Reference Areas shall be established with USACE concurrence since different areas of the site may have varying background activity due to previous operational history and/or varying geological properties of soil. Prior to beginning a survey, ARSEC technicians will inspect the targeted survey area (grid) and identify physical obstacles and overhead obstructions. Obstacles and obstructions shall be noted on the field map and the survey shall be designed to optimize collection of GPS data.

The GWS surveys shall be performed at a rate not to exceed 0.5 meters per second. The NaI detector shall be maintained approximately 10 centimeters above the surface being surveyed. When elevated activity is identified, surveyors shall bound the area using markers for a visual reference. In areas where the satellite coverage is limited, the count rate will be collected by the data logger while the surveyor makes a reasonable effort to walk in a straight line at a constant rate.

Each survey unit shall have its own data file with a unique file name. Each transect path shall begin and end in a GPS coverage area, or at a location that can be referenced to a control point or monument. Each data file for that grid shall be annotated on the field map. All GWS data, including data collected by conventional means, shall be entered into a GIS application such as ArcView to generate site maps depicting gamma survey results. The entire study area will receive 100 % GWS coverage in one direction, only. The GPS data shall undergo differential correction from a continuously operating reference station. The data shall be processed for illustration on a base map. On GPS walkover maps, any survey data point with a count rate greater than the surface-specific MDCR shall be color-coded to indicate that the reading is greater than background. As count rate readings increase, colors shall be graduated to reflect the increasing values.

4.3 Surface Soil/Subsurface Soil Sample Collection

To confirm the presence or absence of residual contamination, ARSEC will collect continuous soil samples from approximately 192 boreholes installed in the locations shown on Figure 1 and at those locations, specified by USACE, in the areas where the DOE found high concentrations of radionuclides.

Drilling: ARSEC has selected ZEBRA Environmental Corporation (ZEBRA) of Niagara Falls, New York to conduct the drilling activities. Drilling will be performed by direct push methodology with a fully equipped track-mounted Geoprobe. The Geoprobe will be operated by an experienced drilling operator and technician, directed by a representative from ARSEC.

A track-mounted 6620 Geoprobe unit with a RS-60 sampling system and a track mounted Geoprobe Dual tube 325 (DT 325) sampling system will be used. The RS-60 sampling system utilizes a

3.25” drive casing as the sample sheath. The sheath is fitted with an inner liner which will collect a sample core which is approximately 2.5” in diameter. The RS-60 system is driven to depth to collect the soil core. The soil sample is retrieved by pulling the sampler and rod string to the surface. The sampler is fitted with a new liner and deployed back down the borehole to collect the next sample interval. The RS-60 also has the option of being operated in a closed fashion.

The DT 325 sampling system also utilizes a 3.25” drive casing as the sample sheath. The sheath is fitted with a cutting shoe and inner liner (DT 32) which will collect a sample core which is approximately 1.85” in diameter. The sample sheath is held in place with an inner rod string.

The DT 325 system is driven to depth to collect the soil core. The soil sample is retrieved by pulling the inner rod string and liner to the surface. The 3.25” casing is left in place downhole. A new liner is deployed thru the casing to depth with the inner rods and secured. The system is then advanced to the next sample interval and the process repeated. The system allows the borehole to remain cased during sampling.

The direct push Geoprobe RS-60 sampling system is capable of penetrating to depths greater than 30 feet. The direct push DT 325 sampling system is capable of penetrating to depths of 60 feet. If refusal is encountered at a borehole location, ARSEC shall make one (1) additional attempt at an offset distance of approximately one meter, and then move on. The direction from the original boring location to the offset location shall be determined in the field by ARSEC and the drilling operators.

The Geoprobe unit will set up on each identified drilling location. Each location will be surveyed in by the onsite Surveyor. It is anticipated that approximately 4,608 linear feet will be drilled in IA-3 through IA-6, and 1,920 linear feet will be drilled in IA-1 and IA-2 during the field effort (6,528 linear feet total). Samples will be collected as outlined in Section 4.4 below.

Ground areas along the fence line, ditch, and residential areas where drilling will take place will be wetted to prevent dust generation.

Borehole Locations: Systematic borehole locations and IA vertex coordinates are listed in Table 4-1. Seven of 60 biased borehole locations have been established and are listed in Table 4-2. Remaining biased borehole locations will be established by the USACE after review of GWS results and other data. Actual borehole locations may vary slightly due to obstructions both below and on the ground’s surface. Borehole locations will not be changed without the permission of the COR. Actual “as drilled” borehole locations will be reported in the Final Project Report.

Soil samples will be collected from 132 systematic boreholes as shown in Figure 1, and 60 biased boreholes located at previous DOE sample locations, along the fence line, along site drainage features, and at areas of elevated radioactivity or other points of interest identified in the field and agreed up by ARSEC and USACE.

The order of importance for boreholes in IA’s 1 – 6 is listed below:

- IA-1 Systematic and Current Identified Biased
- IA-2 Systematic and Current Identified Biased
- IA-3 Systematic and Current Identified Biased
- IA-5 Systematic and Current Identified Biased
- IA-4 Systematic and Current Identified Biased
- IA-3 Fence Line and Drainage Ditch

- Additional IA-3 Biased
- Additional IA-5 Biased
- Additional IA-4 Biased
- IA-6 Systematic and Current Identified Biased
- Additional IA-6 Biased

Table 4-1. Systematic Borehole/Sampling Locations and IA Vertex Coordinates
Coordinates in NAD NYS Plane 3103 (ft)

Borehole/Sampling Location	IA Locale	Point X (Easting)	Point Y (Northing)
Gridded	IA-6	1066413.02	1092583.92
Gridded	IA-6	1066250.59	1092583.92
Gridded	IA-6	1066088.15	1092583.92
Gridded	IA-6	1065925.72	1092583.92
Gridded	IA-6	1065763.28	1092583.92
Gridded	IA-6	1065600.85	1092583.92
Gridded	IA-6	1065438.41	1092583.92
Gridded	IA-6	1065275.97	1092583.92
Gridded	IA-6	1065113.54	1092583.92
Gridded	IA-6	1064951.10	1092583.92
Gridded	IA-6	1064788.67	1092583.92
Gridded	IA-6	1064626.23	1092583.92
Gridded	IA-6	1066413.02	1092746.35
Gridded	IA-6	1066250.59	1092746.35
Gridded	IA-6	1066088.15	1092746.35
Gridded	IA-6	1065925.72	1092746.35
Gridded	IA-6	1065763.28	1092746.35
Gridded	IA-6	1065600.85	1092746.35
Gridded	IA-6	1065438.41	1092746.35
Gridded	IA-6	1065275.97	1092746.35
Gridded	IA-6	1065113.54	1092746.35
Gridded	IA-6	1064951.10	1092746.35
Gridded	IA-4	1066312.89	1092858.14
Gridded	IA-4	1066210.59	1092858.14
Gridded	IA-4	1066517.48	1092952.13
Gridded	IA-4	1066415.19	1092952.13
Gridded	IA-4	1066312.89	1092952.13
Gridded	IA-4	1066210.59	1092952.13
Gridded	IA-4	1066517.48	1093054.43
Gridded	IA-4	1066415.19	1093054.43
Gridded	IA-4	1066312.89	1093054.43
Gridded	IA-4	1066210.59	1093054.43
Gridded	IA-4	1066517.48	1093156.72
Gridded	IA-4	1066415.19	1093156.72
Gridded	IA-4	1066312.89	1093156.72
Gridded	IA-4	1066210.59	1093156.72
Gridded	IA-4	1066517.48	1093259.02
Gridded	IA-4	1066415.19	1093259.02
Gridded	IA-4	1066312.89	1093259.02
Gridded	IA-4	1066210.59	1093259.02
Gridded	IA-4	1066517.48	1093361.31
Gridded	IA-4	1066415.19	1093361.31
Gridded	IA-4	1066312.89	1093361.31

Table 4-1. Systematic Borehole/Sampling Locations and IA Vertex Coordinates
Coordinates in NAD NYS Plane 3103 (ft)

Borehole/Sampling Location	IA Locale	Point X (Easting)	Point Y (Northing)
Gridded	IA-4	1066517.48	1093463.61
Gridded	IA-3	1063923.95	1092331.10
Gridded	IA-3	1063419.79	1092179.83
Gridded	IA-3	1064112.14	1092433.71
Gridded	IA-3	1063547.45	1092277.03
Gridded	IA-3	1064309.05	1092505.96
Gridded	IA-3	1063774.23	1092397.72
Gridded	IA-3	1064478.05	1092608.88
Gridded	IA-3	1063995.54	1092493.42
Gridded	IA-3	1064703.86	1092721.78
Gridded	IA-3	1063696.22	1092234.31
Gridded	IA-3	1064929.66	1092834.68
Gridded	IA-3	1065033.11	1092831.17
Gridded	IA-3	1065151.65	1092910.72
Gridded	IA-3	1065038.75	1092910.72
Gridded	IA-3	1065264.56	1093023.62
Gridded	IA-3	1065682.19	1093204.02
Gridded	IA-3	1065494.71	1093119.03
Gridded	IA-3	1065837.18	1093276.52
Gridded	IA-3	1066160.28	1093369.83
Gridded	IA-3	1066047.38	1093369.83
Gridded	IA-3	1066428.58	1093502.73
Gridded	IA-3	1066315.68	1093502.73
Gridded	IA-1	1065749.26	1093062.69
Gridded	IA-1	1065705.49	1093062.69
Gridded	IA-1	1065880.57	1093106.46
Gridded	IA-1	1065836.80	1093106.46
Gridded	IA-1	1065793.03	1093106.46
Gridded	IA-1	1065749.26	1093106.46
Gridded	IA-1	1065705.49	1093106.46
Gridded	IA-1	1065968.11	1093150.24
Gridded	IA-1	1065924.34	1093150.24
Gridded	IA-1	1065880.57	1093150.24
Gridded	IA-1	1065836.80	1093150.24
Gridded	IA-1	1065793.03	1093150.24
Gridded	IA-1	1065749.26	1093150.24
Gridded	IA-1	1065705.49	1093150.24
Gridded	IA-1	1065924.34	1093194.01
Gridded	IA-1	1065880.57	1093194.01
Gridded	IA-1	1065836.80	1093194.01
Gridded	IA-1	1065793.03	1093194.01
Gridded	IA-1	1065749.26	1093194.01
Gridded	IA-1	1065924.34	1093237.78
Gridded	IA-1	1065880.57	1093237.78
Gridded	IA-1	1065836.80	1093237.78
Gridded	IA-2	1065219.71	1092861.27
Gridded	IA-2	1065295.23	1092899.03
Gridded	IA-2	1065257.47	1092899.03
Gridded	IA-2	1065219.71	1092899.03
Gridded	IA-2	1065181.95	1092899.03

Table 4-1. Systematic Borehole/Sampling Locations and IA Vertex Coordinates
Coordinates in NAD NYS Plane 3103 (ft)

Borehole/Sampling Location	IA Locale	Point X (Easting)	Point Y (Northing)
Gridded	IA-2	1065370.75	1092936.79
Gridded	IA-2	1065332.99	1092936.79
Gridded	IA-2	1065295.23	1092936.79
Gridded	IA-2	1065257.47	1092936.79
Gridded	IA-2	1065219.71	1092936.79
Gridded	IA-2	1065181.95	1092936.79
Gridded	IA-2	1065408.52	1092974.55
Gridded	IA-2	1065370.75	1092974.55
Gridded	IA-2	1065332.99	1092974.55
Gridded	IA-2	1065295.23	1092974.55
Gridded	IA-2	1065257.47	1092974.55
Gridded	IA-2	1065219.71	1092974.55
Gridded	IA-2	1065370.75	1093012.32
Gridded	IA-2	1065332.99	1093012.32
Gridded	IA-2	1065295.23	1093012.32
Gridded	IA-2	1065370.75	1093050.08
Gridded	IA-5	1066091.90	1092867.41
Gridded	IA-5	1065989.69	1092867.41
Gridded	IA-5	1065887.47	1092867.41
Gridded	IA-5	1065785.26	1092867.41
Gridded	IA-5	1065683.04	1092867.41
Gridded	IA-5	1065580.83	1092867.41
Gridded	IA-5	1065478.61	1092867.41
Gridded	IA-5	1065376.40	1092867.41
Gridded	IA-5	1066091.90	1092969.63
Gridded	IA-5	1065989.69	1092969.63
Gridded	IA-5	1065887.47	1092969.63
Gridded	IA-5	1065785.26	1092969.63
Gridded	IA-5	1065683.04	1092969.63
Gridded	IA-5	1065580.83	1092969.63
Gridded	IA-5	1065478.61	1092969.63
Gridded	IA-5	1066091.90	1093071.84
Gridded	IA-5	1065989.69	1093071.84
Gridded	IA-5	1065887.47	1093071.84
Gridded	IA-5	1066091.90	1093174.06
Gridded	IA-5	1065989.69	1093174.06
Gridded	IA-5	1066091.90	1093276.27
Gridded	IA-5	1065580.79	1093051.77
Gridded	IA-2	1065181.39	1092970.84
Vertex A	Rounded to Nearest Foot	1066607.00	1092540.00
Vertex B	Rounded to Nearest Foot	1066607.00	1092830.00
Vertex C	Rounded to Nearest Foot	1066607.00	1093557.00
Vertex D	Rounded to Nearest Foot	1066607.00	1093667.00
Vertex E	Rounded to Nearest Foot	1066120.00	1092830.00
Vertex F	Rounded to Nearest Foot	1066120.00	1093328.00
Vertex G	Rounded to Nearest Foot	1065050.00	1092830.00
Vertex H	Rounded to Nearest Foot	1064465.00	1092540.00
Vertex I	Rounded to Nearest Foot	1063618.00	1092141.00
Vertex J	Rounded to Nearest Foot	1063618.00	1092251.00
Vertex K	Verified via Erie County GIS Parcel Coverage	1063162.00	1092057.00

Table 4-1. Systematic Borehole/Sampling Locations and IA Vertex Coordinates
Coordinates in NAD NYS Plane 3103 (ft)

Borehole/Sampling Location	IA Locale	Point X (Easting)	Point Y (Northing)
Vertex L	Verified via Erie County GIS Parcel Coverage	1063524.00	1092322.00
Vertex M	Verified via Erie County GIS Parcel Coverage	1063745.00	1092434.00
Vertex N	Verified via Erie County GIS Parcel Coverage	1063875.00	1092558.00
Vertex O	Rounded to Nearest Foot	1064187.00	1092522.00
Vertex P	Rounded to Nearest Foot	1065148.00	1092957.00
Vertex Q	Rounded to Nearest Foot	1065208.00	1092848.00
Vertex R	Rounded to Nearest Foot	1065434.00	1092955.00
Vertex S	Rounded to Nearest Foot	1065372.00	1093066.00
Vertex T	Rounded to Nearest Foot	1065654.00	1093157.00
Vertex U	Rounded to Nearest Foot	1065718.00	1093030.00
Vertex V	Rounded to Nearest Foot	1065980.00	1093155.00
Vertex W	Rounded to Nearest Foot	1065910.00	1093285.00

Table 4-2. Biased Borehole/Sampling Locations Selected to Date

Coordinates in NAD NYS Plane 3103 (ft)

Investigative Area	Sampling Justification	Point X (Easting)	Point Y (Northing)
IA-2	DOE Biased	1065207.784	1092936.734
IA-1	DOE Biased	1065813.000	1093108.000
IA-1	DOE Biased	1065779.557	1093131.330
IA-1	DOE Biased	1065811.999	1093150.858
IA-1	DOE Biased	1065798.007	1093111.811
IA-1	DOE Biased	1065819.158	1093099.934
IA-5	DOE Biased	1066011.144	1093253.847

Surface/Subsurface Sampling Preparations:

At each boring location, ARSEC will stage a sample table and prepare for core sampling to begin. Sample tables will either be coated with a low VOC content paint or plastic sheeting to allow for ease of table decontamination. All sample tools and containers will be on hand for sampling. Paper sheeting will be placed on tables using plastic sheeting instead of a low VOC paint coat for chemical sampling. A ruler or other measuring device will be available at the sample table to measure the cores. Measurements will reflect the depth bgs for all segments of the core.

Sample Collection: A continuous core of soil will be collected from an approximate depth of 12'-40' below grade for sampling purposes. At each borehole location, either a Macro Core (MC) sampler or a Closed Piston Macro Core (CPMC) drive point sampler will be used to collect the soil core for sampling purposes. The MC samplers are open-tube design and measure approximately 2-inches in diameter by 46-inches long. The samplers are fitted with a removable cutting shoe and clear acetate liner. Samples can be collected from 0' to 4', 4' to 8', 8' to 12' below grade and possibly deeper depending on subsurface conditions. A MC sampler will be used with the track mounted 6620 Geoprobe unit with a RS-60 sampling system. If the potential for "cave-in" is significant in a borehole at lower depths, it may be necessary to use the CPMC assembly that fits into the MC cutting shoe. CPMC drive point samplers can be used to collect soil samples at points where subsurface conditions prevent the use of MC open samplers or where continuous

sampling is not necessary. The CPMC samplers can be driven closed to a desired sampling depth. A CPMC sampler will be used with the DT 325 sampling system.

In order to collect samples with the CPMC drive point sampler, it is first driven to the desired sampling depth, then opened and driven four (4) feet further. The CPMC sampler remains completely closed while it is being driven to depth and is opened by releasing a stop pin from the surface. Releasing the stop pin allows a piston to retract inside the sample tube as the soil core is displacing it. Each of the samplers used will be fitted with a new acetate liner prior to use. The acetate liner assists in the removal of the soil sample from the tube and helps insure sample integrity.

Soil Scan: Soil cores in their acetate liner shall be removed from the boreholes. The sample table, sampling tools, and the outside of the acetate liner will be verified free of loose radioactive contamination. Sampling tools, sample tables, and external surfaces of acetate liners with loose radioactive contamination will be decontaminated by wiping the surface with a damp cloth, masslin, or paper towel or as otherwise directed by the Site RSO. Soil cores in their acetate liner will be placed on the table in a low-background area for scanning and visual inspections. The outside of the acetate liner shall be wiped down to remove any possible moisture and to allow for visual inspections of the core soil.

HP technicians will scan four foot lengths of the core for gross gamma count rates using a 2 x 2 NaI detector and record the count rate range observed. The acetate liner will then be removed from the core and the core material flattened to a width of approximately four inches, e.g., split into two lengths and arranged flat side up, side by side, to provide a better measurement geometry for beta scans/counts. HP technicians will then scan the four foot lengths of the flattened core material for gross beta count rates using a beta scintillator and record the count rate range observed. Removal of the cores from the acetate liner, core flattening, and beta scans may be discontinued at the direction of the USACE. Count rate range information shall as a minimum be recorded on USACE ENG Form 5056-R or Form 5056A-R.

A one minute static gamma count and a one minute static beta count shall be performed and counts recorded for those areas of the core which will be sampled. Static sample count rate information shall as a minimum be recorded on sample log sheets.

The drilling operations will be continuously monitored by a Professional Geologist (PG). The PG will utilize GPS and geographic information system (GIS) equipment to record, document, and report the location of the soil borings required under the base contract. Each soil boring will also be surveyed for location and elevation by a local registered Professional Surveyor (PS). ARSEC will work with the Professional Surveyor to ensure that all data, including the gamma scan data, is documented on a GIS generated figure based on NAD 1983 New York North State Plane Coordinates and NGVD 88 Datum.

Boring logs and logs of core scanning results will be documented into bound log books that will be turned over to USACE at the end of the project. All soil borings will be classified by the PG using USACE Engineer Form 5056-R and 5056A-R. A copy of the completed form will be submitted to the USACE Project Manager upon completion of the boring and included in the final report.

Surface/Subsurface Sampling Protocol: ARSEC will implement a sampling protocol that is based on the probability that the investigation area has a “high”, “moderate”, or “low” potential of encountering radiological contamination. For areas where the probabilities are either “high” or

“moderate” e.g., IA-1 through IA-5, soil borings will extend through the landfill waste to native soil. Five samples will be collected per soil boring location. For these borings, each sample acquired for analysis shall include a 1-foot segment of the boring (except for the cores surface, which will include approximately the top 6-inches of the boring) as follows:

1. The core surface [i.e., the top 6 inches of the current landfill surface (0.0 – 0.5 feet bgs)].
2. A soil sample from the first foot just inside the saturated zone.
3. A sample from the first foot of native soil below the landfill waste.
4. A one foot sample centered around the core area where the gamma instrument registered the highest reading. If the highest gamma instrument reading interval is the same as any of the above three fixed intervals (i.e., the highest scan reading is in either the top 6 inches, or at the saturated zone interface, or in the first foot of native soil) then the fourth sample interval should be selected at the second highest gamma reading, or by other professional judgment.
5. A one foot sample centered around the core area where the beta instrument (i.e., beta scintillator) registered the highest beta reading. If the highest beta reading interval is the same as any of the above four fixed intervals (i.e., the highest scan reading is in either the top 6 inches, or at the saturated zone interface, or in the first foot of native soil, or in the area of the highest gamma instrument reading) then the fifth sample interval should be selected using the following decision tree:
 - a. A one foot sample centered around the core area with the second highest gamma reading,
 - b. A one foot sample centered around the core area with the second highest beta reading,
or
 - c. A one foot core sample using other professional judgment.

For areas with low probability of contamination, e.g., IA-6, the borings will extend through the structural fill placed by the Town of Tonawanda to a depth of 12 feet beneath the structural fill. The entire length of the soil cores, including those in the structural fill, will be scanned and considered for potential sample selection. Greater depths will only be obtained if a positive result is obtained in the bottom interval of the soil core during core scanning; the reading that constitutes a positive result shall be determined based on evaluation of background and site data. In that case, the final depth of a sample will be determined by communicating with the COR. The direct push Geoprobe unit that will be used at the site can penetrate to depths greater than 40 feet bgs. Four samples will be collected per soil boring location and will consist of a one foot segment of the boring (except for the cores surface, which will include approximately the top 6 inches of the boring) at the following locations:

1. The core surface [i.e., the top 6 inches of the current landfill surface (0.0 – 0.5 feet bgs)]. If the boring location is on the access road, then the sample will be from the first 6 inches of soil beneath the current road bed material [i.e., below any pavement and gravel base]. The depth of the interface between the road and the soil-like materials will be recorded on USACE ENG Form 5056-R or Form 5056A-R. Sample depth will be recorded on the ARSEC Soil Core Survey Form.
2. A soil sample from the first foot just inside the saturated zone. If the saturated zone is not reached in the boring (i.e., it is deeper than the termination depth of the boring), then the sample will be from the bottom one foot of the boring.
3. A one foot sample centered around the core area where the gamma instrument registered the highest reading. If the highest gamma instrument reading interval is the same as any

of the above two fixed intervals (i.e., the highest scan reading is in either the top 6 inches, or at the saturated zone interface) then the third sample interval should be selected at the second highest gamma reading, or by other professional judgment.

4. A one foot sample centered around the core area where the beta instrument (i.e., beta scintillator) registered the highest beta reading. If the highest beta reading interval is the same as any of the above three fixed intervals (i.e., the highest scan reading is in either the top 6 inches, or at the saturated zone interface, or in the area of the highest gamma instrument reading) then the fourth sample interval should be selected using the following decision tree:
 - a. A one foot sample centered around the core area with the second highest gamma reading,
 - b. A one foot sample centered around the core area with the second highest beta reading, or
 - c. A one foot core sample using other professional judgment.

If fill is encountered in a “low” potential area, then up to four (4) additional borings per investigative area shall be installed and sampled, as directed by the COR, using the sampling protocol for “high” or “moderate” potential areas. If extensive contamination is encountered along the core in any “low” potential area, the ARSEC Site Manager/CHP will confer with the COR to determine how to proceed.

All soil and core samples, including field QA/QC samples, will be analyzed for the radiological parameters specified in Table 6-1. In addition, 10% of all soil and core samples will be analyzed for the non-radiological parameters specified in Table 6-1.

Radiological investigative samples have top priority for collection from a sample interval. Selection samples for non-radiological analysis will be biased first towards those samples exhibiting the highest gamma radioactivity levels. Quality Control (QC) samples may be selected from whatever remaining intervals have sufficient sample volume, including the prescribed-depth intervals (i.e., just inside the saturated zone, native soil interval) as well as the scan-based intervals.

Sample Quantities: Table 4-3 delineates the anticipated sampling requirements for systematic and biased borings in IA-1 through IA-6 and for the biased borings to be installed at the Corps direction along the fence line and within the ditch.

Table 4-3. Soil Sampling Quantities per Investigative Area and Other Areas¹

IA	Systematic Borings	Biased Borings	Routine Samples	Field Duplicate Samples	MS/MSD Samples ²	Total # of Samples
IA-1 (H)	22	14	180 (18)	9 (2) ³	(1)	198 (19)
IA-2 (H)	22	6	140 (14)	7 (2) ³	(1)	154 (15)
IA-3 (M)	22	4	130 (13)	7 (2) ³	(1)	144 (14)
IA-4 (M)	22	4	130 (13)	7 (2) ³	(1)	144 (14)
IA-5 (M)	22	4	130 (13)	7 (2) ³	(1)	144 (14)
IA-6 (L)	22	4	104 (11)	5 (2) ³	(1)	114 (12)

Table 4-3. Soil Sampling Quantities per Investigative Area and Other Areas¹

IA	Systematic Borings	Biased Borings	Routine Samples	Field Duplicate Samples	MS/MSD Samples ²	Total # of Samples
Fenceline (L)	0	12	48 (5)	2 (2) ³	(1)	52 (6)
Ditch (L)	0	12	48 (5)	2 (2) ³	(1)	52 (6)
Total	132	60	910 (92)	46 (16)	(8)	1,002 (108)

¹ Numbers outside of parentheses are for radiological samples. Numbers in parentheses are for chemical analysis.

² MS/MSD samples are not required for the soil radiochemical analyses being performed for this project for the following reasons:

- Radium-226, Americium-241, and Uranium 235 and 238 are analyzed by gamma spectroscopy for which a matrix spike is not appropriate.
- Isotopic Thorium uses a tracer and therefore does not require MS/MSD (Reference MARLAP 18.4.3 and DOD QSM D 4.1.b.2).

³ One QA duplicate for the off-site laboratory and one QA duplicate for the USACE.

Sampling Methods: Soil samples will be collected by using a stainless steel trowel or sampling spoon and will be homogenized in a stainless steel bowl or container prior to containerization. Visually identifiable non-soil components such as stones, twigs, and foreign objects will be manually separated in the field and excluded from the laboratory samples to avoid biasing results low. A label shall be affixed to each sample container in accordance with Section 5.4.2 of this FSP. All protocols for trip blanks, field blanks, etc., will be implemented as required by SW 846.

Field sampling equipment used during soil sampling will be free from contamination and shall be decontaminated after use. Refer to Section 4.7 of this FSP for decontamination procedures. Groundwater sample collection is discussed in Section 4.5 of this FSP.

Core Archiving: Once soil sampling is complete, residual core material (IDW) shall be wrapped in plastic sheeting, taped, and labeled. The label shall contain the boring location, core depth interval bgs, and indication of the top and bottom end of the core, and the date and time of sample completion). All boring IDW shall be placed in suitable storage containers on site for final disposition.

Laboratories, Sampling Containers, Preservation, and Holding Times: American Radiation Services, Inc. (DBA ARS International), of Port Allen, Louisiana, an independent off-site laboratory, will provide radiochemical analysis. TestAmerica of Earth City, Missouri, also an independent off-site laboratory, will provide non-radiochemical analysis. The TestAmerica laboratory has U.S. Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP) accreditation in the non-radiochemistry analytical parameters associated with the project. The ARS laboratory was audited for DoD ELAP accreditation the first week in October 2009 for the radiochemistry analytical parameters associated with the project. All required corrective actions resulting from the audit have been addressed. All sample bottles and preservation requirements will be provided by the laboratory and documented in the QAPP. Holding times and requirements will also be specified in the QAPP. As a minimum, sample container, preservation, and holding time requirements shall conform to the guidance provided in EM-200-1-3. Sample container, preservation, and holding time requirements are contained in Appendix D. To ensure that required temperatures are met for volatile organic compound (VOC) samples, after sample collection, VOC sample containers will be placed in an onsite sample refrigerator or a cooler to ensure 4° C from the time of collection until being shipped to the laboratory.

4.4 Temporary Well Point Installation

ARSEC will install up to 14 temporary well points in accordance with the requirements of the RFP. The well points will be installed in previously drilled soil boring locations using the Geoprobe drilling rig under the direction of the Project Geologist. The well points will be installed to a depth of 20-feet bgs and constructed with 1.25-inch Schedule 40 polyvinyl chloride (PVC) tubing, with a maximum 10-foot section of slotted 0.010-inch well screen. The screen shall be surrounded with filter sand fine enough to prohibit the entry of soil fines into the temporary wells. Bentonite chips will be added into the annulus space from the base of the hole to ground surface and hydrated. The completed well point will be finished with a locking cap. Final disposition of the wells has not yet been decided by the USACE. Wells will be either properly finished at grade if needed for additional monitoring (pads and pro-casings) or decommissioned according to NYSDEC guidelines by a NYS licensed driller.

4.5 Groundwater Sample Collection

All temporary well points will be sampled in accordance with standard low-flow technologies delineated in EPA/540/S-95-504 (April 1996) using either peristaltic and/or bladder pumps connected to dedicated (by location) high-density polyethylene (HDPE) tubing for radiological testing or Teflon tubing for radiological and organic testing. The wells shall be purged at a rate of 100 ml per minute or less. If wells cannot provide enough water volume, and purge dry at a purge rate of 100 ml/min or less, priority shall be given to collection of radiological parameters once the well has recovered. Wells will be sampled with dedicated sampling equipment (tubing) to avoid cross contamination between sampling locations.

Field parameters such as temperature, pH, redox potential, turbidity, dissolved oxygen, and specific conductivity will be collected using a Yellow Springs Instrument (YSI) Company Model 556 Handheld Multi-parameter Instrument for each well during the sampling activities in accordance with EM 200-1-3 C 2.4.7.

All purge water will be containerized in DOT approved containers and managed as investigation derived waste (IDW).

Filtering of ground water samples will be performed by the laboratory performing the required analysis. ARSEC will communicate with the laboratory that the ground water sample should be divided into equal segments, and that one of the two groundwater segments should be filtered to remove suspended solids. Required analyses shall be performed on both the filtered and unfiltered segments of the ground water sample.

4.6 QA Samples

In order to comply with USACE sampling protocols, the number of field duplicates, MS/MSD samples, and Quality Assurance (QA) splits shall be 10%, 5%, and 5%, respectively, of the total number of soil samples collected. Field QA and USACE QA duplicate samples will be collected simultaneously, or in immediate succession, with the original sample.

The duplicates will be recovered in the same manner as the original, homogenized and split between the appropriate containers. Duplicate samples will be numbered, logged, and transferred, under the ARSEC chain of custody procedures, to the USACE and off-site laboratory for analyses. The off-site laboratory will prepare and provide containers that meet their analytical requirements. The containers will have sufficient capacity to hold the contents of

a one-liter marinelli sample container. These same containers will be used for collecting USACE QA duplicate samples.

4.7 Decontamination

Sampling equipment used during surface/subsurface soil sampling and groundwater sampling will be free from contamination and decontaminated prior to use. A field decontamination location shall be established and approved by the COR prior to use. Equipment requiring decontamination may include stainless steel scoops, bowls, spoons, core barrels, etc. Other equipment used during sampling activities that does not directly contact sample materials (such as down-hole rods, shovels, etc.) shall be cleaned to remove potential soil contamination. Decontamination activities shall be conducted so that all solid and liquid wastes generated can be properly contained and collected. Decontamination waste materials shall be collected daily and stored in 55-gallon drums.

If needed, the Geoprobe drill rig will be decontaminated by constructing a decontamination pad on a level ground area. A depression will be dug in one corner of the area where the pad will be constructed to allow for a sump. The pad will be constructed using a 2" x 6" wooden frame of the required size and overlain by a dense HDPE plastic sheet. The plastic sheet will be nailed to the wooden framing using a self sealing roofing nail. The drilling portion of the unit will be decontaminated using a pressure washer. Personnel performing decontamination will utilize proper PPE, including tyvek, rubber boots, rubber gloves and a face splash shield attached to the hard hat.

A trash pump will be used to pump the decon liquids into an approved container for subsequent disposal.

4.8 Air Monitoring

Air monitoring will be performed in accordance with the HSRPP to ensure exposure to workers, the public, and the environment from airborne radioactivity and/or hazardous substances is maintained as low as reasonably achievable (ALARA). Air monitoring will be performed during site clearing activities which have the potential to generate dust and during initial intrusive activities (i.e., direct push soil borings). The Site Manager and SSHO in conjunction with the Site RSO will determine the duration of the air sampling to take place, and obtain approval from the COR.

The air monitoring will be divided into two categories; radiological and non-radiological. Both radiological and non-radiological air sampling shall take place during site clearing activities which have the potential to generate dust and during initial intrusive activities. A discussion on sampling equipment, sample collection techniques, and analysis is provided below.

4.8.1 Radiological: The two types of radiological air sampling planned for this effort are *area* and *breathing zone* (BZ).

Limited area sampling will be performed around the site perimeter to measure airborne particulate concentrations as a result of the soil boring activities. Samples will be collected using calibrated high volume air samplers such as F&J Model HV-1 or equivalent. Air samplers will be in place prior to commencement of intrusive activities at locations specified by the RSO or the SSHO. At a minimum, these locations will include one sampler downwind from the immediate

work area. The sample will be collected on 47 millimeter glass fiber filter paper. The sample will be collected continuously throughout the duration of the initial boring activities.

BZ sampling will be performed concurrently to measure potential airborne radioactivity exposure to workers during the soil boring installation. These samples will be collected using a calibrated personal air sampler (PAS) such as SKC PXR4 or equivalent. The PAS will be worn by at least one individual within the work area. The sample will be collected on a 25 millimeter glass fiber filter paper. The sample will be collected continuously throughout the duration of the intrusive activity.

Upon completion of the sampling event, the filter will be removed from the sample head and placed in a sample envelope or other container for on-site screening. After sufficient time has elapsed for short-lived radon progeny to decay (a minimum of 72 hrs), the filter will be screened on site for gross alpha-beta activity using a Ludlum Model 2929 dual scintillation sample counter or equivalent. Results of the sample will be compared against the derived air concentration (DAC) values identified in 10 CFR 20, Appendix C. For the purpose of the onsite screening, all activity will be assumed to be from Th-232. The Appendix C DAC values for Th-232 are as follows.

5 E-13 $\mu\text{Ci/ml}$	-	Occupational Value (Work Area)
4E-15 $\mu\text{Ci/ml}$	-	Effluent Concentration (Perimeter)

4.8.2 Non-Radiological: Two types of non-radiological air monitoring will also be performed concurrently with the radiological sampling discussed above; particulate dust and organic vapor.

Particulate dust monitoring will be performed to measure ambient levels of dust as a result of soil boring activities. Dust monitoring will be performed using a real-time aerosol monitor which produces real-time readings and computes time-weighted averages such as a TSI Dustrak or equivalent. Dust monitors will be in place prior to commencement of boring activities at locations specified by the SSHO. The SSHO will determine the Time Weighted Average (TWA) and maximum concentration of dust identified during the monitor period. Monitoring will be completed during initial intrusive operations to establish a baseline and effectiveness of dust suppression engineering controls.

PID and 4-gas monitoring for LEL, H₂S, O₂, and CO will be periodically performed at the bore hole location during drilling activities. Core samples shall be screened with a PID as the soil core is exposed to ambient air during the removal of the acetate liner and subsequent sampling.

The Site Manager and the SSHO will review the PID and 4 gas analyzer monitoring results, and provide the results to the COR to verify that no exposure from drilling activities is present before discontinuing any monitoring event.

PID screening will also be conducted of suspect radiological samples as evidenced by staining or organic odors. The sample jar lid will be removed and replaced with a piece of aluminum foil wrap or a modified jar lid which will allow insertion of the PID probe. The sample jar will be shaken and the PID probe tip will be inserted through a small opening in the foil wrap or the modified jar lid, to evaluate the “headspace,” while maintaining a tight seal over the remainder of the opening. This method will be used for screening purposes only; soil gas or soil vapor samples will not be collected for off-site analysis. Sample PID readings shall be documented on the core survey form.

5.0 FIELD QUALITY CONTROL

Project QC will be maintained through the implementation of the ARSEC Quality Control Plan (QCP), the Site QAPP, and ARSEC'S corporate QA procedures. Procedures from the HSRPP will be implemented for the duration of this project. Controlled copies of pertinent plans and procedures shall be available on-site for the duration of the project. The ARSEC PM and Contractor Quality Control Systems Manager (CQCSM) shall be responsible for the execution of the QC Program.

ARSEC will maintain direct, concise, and daily contact/coordination with the USACE concerning field operations and scheduling field activities. The primary POCs for all communications regarding the Site project will be Steve Shirley (ARSEC PM). The ARSEC PM, or designee, will participate in a weekly project meeting throughout the period of performance of the Contract. Participation may be by phone when field activities are not scheduled.

5.1 Daily Quality Control Report

ARSEC will submit to the COR a Daily Quality Control Report (DQCR) for each day that field activities are conducted. The DQCR form is provided in the project QCP. The field DQCR will identify the current activities, any unanticipated delays or occurrences, departures from the FSP, communications with other USACE contractors or regulators, and any needed corrective actions. The DQCR will be signed and dated by the ARSEC CQCSM or designee and will be submitted to the COR on a daily basis. Any deviation that may affect the project DQOs will be immediately communicated to the COR. The DQCR shall include, at a minimum, the following information:

- A daily summary of site activities;
- Weather information;
- Field instrument measurements;
- Identification of all field and control samples collected;
- QA sample tables that match up primary, replicate (QC/QA), and other field control samples (e.g., blanks);
- Copies of chain-of-custody forms, field-generated analytical results, and any other project forms that are generated;
- Results of QC activities performed including field instrument calibrations;
- Any deviations from the FSP including the justification for the deviation;
- AHAs, JSAs, CQM paperwork, photos, controlled access forms, equipment surveys, weekly surveys, and monthly surveys;
- Contractor/subcontractor personnel on-site and areas of responsibility and list equipment on-site;
- Safety section listing any safety issues and details on the daily tailgate meeting;
- Planned upcoming activities or planned areas / schedule of work;
- Any problems encountered during daily field activities; and,
- A summary of any instructions received from USACE or government personnel.

Any deviations that may affect the project objectives shall be immediately conveyed to the COR. ARSEC shall not commence with any deviations from the work plans without formal acceptance by the COR and/or Contracting Officer Representative.

5.2 Corrective Actions

Any non-conformance with established procedures presented in the project plans will be identified and corrected. The ARSEC PM will issue a non-conformance report for each non-conforming condition. In addition, corrective actions will be implemented and documented in the appropriate field logbook. Non-conforming conditions include, but are not limited to:

- Improper instrument calibrations or operational checks,
- Improper survey or sampling procedures,
- Physical or documentation discrepancies with samples upon receipt at the laboratory.

5.3 Field Documentation

5.3.1 Field Logbooks: Information pertinent to field activities including field instrument calibration data will be recorded in field logbooks. Each logbook shall have the site name and project name and number on the inside front cover. Sufficient information shall be recorded in the logbooks to permit reconstruction of all conducted field investigative activities. The logbooks will be bound and the pages will be consecutively numbered. Sufficient information will be recorded in the logbooks to permit reconstruction of site characterization activities conducted. Information recorded on other project documents will not be repeated in the logbooks except in summary form where determined necessary.

All field logbooks shall be kept in the possession of the Site Manager or the recording author in a secure place when not being utilized for field work. Upon completion of the field activities, all logbooks shall become part of the final project evidence file. The title page of each logbook shall be labeled as follows:

- Logbook title (e.g., Town of Tonawanda Landfill OU Site Characterization);
- Project name (e.g., Town of Tonawanda Landfill OU, USACE-Buffalo District FUSRAP Project);
- USACE contract number and project delivery order number (Contract No. W912P4-07-D-0009, Delivery Order 0003);
- Start date for field investigative activities recorded in the logbook; and,
- End date for field investigative activities recorded in the logbook.

The following will be contained in the field Logbook along with any other pertinent information:

- Name and title of author, date, and times of arrival at and departure from site
- Purpose of the site characterization activity
- Name and address of the field contact(s)
- Names and responsibilities of field crew members
- Names and titles of any field visitors
- Type, matrix, and characterization method for generated IDW
- Sample collection method
- Number and volume of sample(s) collected
- Location, description and log of sampling point photographs
- References of all maps and photographs of the sampling site(s)
- Information regarding sampling changes, scheduling modifications and change orders
- Information regarding site characterization decisions not recorded by other mechanisms
- Information regarding access agreements, if applicable
- Details of each sampling location, including a sketch map showing the location
- Date and time of sample collection, including the name of the collector

- Field observations
- Type of field instruments used and purpose of use, including calibration methods and results
- Any field measurements made (e.g. radiological activity and landfill gas)
- Sample identification number(s)
- Information on containers, reagent used, deionized and organic-free water used, etc.
- Sample type and methodology, including distinction between grab and composite samples.
- Sample preservation methods
- Sample distribution and transportation (e.g. name and address of the laboratory and courier)
- Name and address of the government QA laboratory for the project and the associated project Laboratory Information Management System (LIMS) number
- Sample documentation information including:
 - chain-of-custody record numbers
 - description of the number of shipping containers packaged (including COC records) and the shipping method employed (noting applicable tracking numbers)
- Decontamination procedures
- IDW documentation including
 - types of containers/drums
 - contents, type, and approximate volume of waste
 - type of contamination and predicted level of contamination based on available information
- Summary of daily task (including costs where appropriate) and documentation on any cost or scope of work changes required by field conditions
- Signature and date entered by personnel responsible for the recorded observations.

Field data collected during invasive soil sampling shall be recorded on boring logs formatted specifically for the field investigative activities at the Tonawanda site.

If any recorded information is noticed to be in error, the original entry shall be crossed out so that the original entry is still legible and shall be replaced with the new entry. All such changes shall be initialed by the Site Superintendent. At the conclusion of each work day, the person responsible for maintaining the logbook shall sign and date the day's documentation entries.

5.3.2 Photographs: A photographic record documenting selected aspects of the field operations will be kept. Items to be included shall be decided by the on-site government representative with input from on-site participants. For each photograph taking during field operations, the following items will be recorded in the field logbook:

- date and time
- photographer (name and signature)
- site name
- aspect and description of the subject taken
- roll number of film or memory stick number and sequential number of photograph.

Photographs taken to document sampling points will include two or more permanent reference points within the photograph to facilitate relocating the point at a later date. In addition to the information recorded in the field log book, one or more photograph reference maps shall be

prepared. If available, a GPS-enabled camera is preferred to allow map-based referencing of each photo.

5.3.3 Electronic Data: Electronic data collected during the day will be backed-up at the end of the same day in the field (e.g. to tape or zip drive) and before processing or editing. This is an archive of the raw data and, once created, shall not be altered. More than one day's data may go on a single tape or zip disk. Field computer(s) used to store GPS data will be backed up weekly. Raw archived data will be stored in a different location from weekly backups. Electronic GPS data will be provided daily to off-site data processing specialists. The date and time that data files are transmitted will be recorded in the data logbook. File names will be verified by comparison with field notes and corrected if necessary, following approval by the ARSEC PM.

5.3.4 Post-Processing: Post-processing specialists will convert daily GWS/GPS data to state plane coordinates, as necessary, and review the data for errors to fluctuations/interferences in the GPS signal. Post-processing specialists will be able to determine qualitatively, by density of recorded GPS positions, rapid or increased velocity of the surveyor performing the GWS, which could have an adverse effect on the predicted scan MDC. Post-processing specialists will inform the project manager of any identified deficiencies and will make corrections as directed. Conversions, errors, corrections, and/or adjustments to project data shall be documented in the data logbook.

5.4 Sample Documentation

5.4.1 Sample Numbering System: A unique sample numbering system specific to the project shall be used to identify each sample collected and submitted for laboratory analysis. The unique sample number shall ensure those sample identifiers are not duplicated, and do not coincide sample identifiers used during any previous sampling efforts. The sample identification numbers shall be maintained by the Site Superintendent in the field logbook and on sample field sheets. Sample identification numbers shall be used on all sample labels or tags, field data sheets and/or logbooks, chain of custody records, and all other applicable documentation used during the project. Each container used to collect samples shall be properly handled. Other field QC samples, however, shall be numbered so that they can be readily identified.

A summary of the sample-numbering scheme to be used for the project is presented in Table 5-1.

5.4.2 Sample Labels: Sample labels shall be affixed to all containers during sampling activities at the time of sample collection and securely affixed to the container prior to shipment. Sample label information shall include, but not be limited to, the following:

- Contractor name
- Sample identification number
- Site name
- Sample station number
- Requested analysis
- Type of sample (discrete, grab, or composite)
- Type of chemical preservative present in container
- Date and time of sample collection
- Sampler's name and signature or initials

Table 5-1. Sample ID Numbering Scheme

Sample ID Component	Description	
Project Code	TLS	Tonawanda Landfill Site
Sample Matrix Code	SSF or SSN	Surface Soil Sample-Fill or Surface Soil Sample-Native
	SB	Subsurface Soil Sample
	GW	Groundwater Sample
	RS	Radiological Survey Sample
	AS	Air Sample (air monitoring station/breathing zone)
	IDW	Soil – waste characterization
Location Code	IA-	Investigative Area Number – i.e. IA-1, IA-2, etc
	X	Sequence Identifier within IA- 1 - 6
	## -##	## -## – Sample collection depth interval, in feet below ground surface (i.e., 0.0-0.5, 1.5 – 2.0)
Date Code	MMDDYY	Date of collection – i.e. 051109

5.4.3 Cooler Receipt Checklist: The condition of shipping coolers and enclosed sample containers will be documented upon receipt at the analytical laboratory. This documentation will be accomplished using the cooler receipt checklist presented in the QAPP (ARSEC 2009).

One checklist will be placed either into each shipping cooler along with the completed COC form or provided to the laboratory at the start of the project. A copy of the checklist will be faxed to the contractor's field manager immediately after it has been completed at the laboratory. The original completed checklist will be transmitted with the final analytical results from the laboratory.

5.4.4 Chain of Custody Records: Chain of custody procedures provide documentation of the handling of each sample from the time it is collected until it is destroyed. Chain of custody procedures are implemented so that a record of sample collection, transfer of sample between personnel, sample shipping, and receipt by the laboratory that will analyze the sample is maintained. The chain of custody record serves as a legal record of possession of the sample. To simplify the chain of custody record and eliminate potential litigation problems, as few people as possible should handle the sample. The chain of custody procedures implemented for the project shall document the handling and security of each sample from the time of collection through and including completion of the laboratory analysis. A sample is considered under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession;
- The sample is in the sampler's view after being in possession;
- The sample was in the sampler's possession and then was placed into a locked area to prevent tampering; and
- The sample is in a designated secure area.

In addition to the chain of custody record, there is also a chain of custody seal. The chain of custody seal is an adhesive seal placed in areas such that if a sealed container is opened, the seal would be broken. The chain of custody seal ensures that no sample tampering occurred between the field and the laboratory analysis.

Custody shall be documented throughout the field investigative activities for all collected samples using the standard chain of custody form with one form initiated each day samples are collected. The record shall accompany the samples from the site to the laboratory and shall be

returned to the laboratory coordinator with the final analytical report. All personnel with sample custody responsibilities shall be required to sign, date, and note the time on the chain of custody form when relinquishing the samples from their immediate custody (except in the case where samples are placed into designated secure areas for storage prior to shipment). Bills of lading or air bills shall be used as custody documentation during times when samples are shipped from the site to the laboratory. These documents shall be retained as part of the permanent sample custody documentation. The air bill number or registered mail serial number shall be recorded in the remarks section of the chain of custody record. Information shall be documented on all chain of custody forms as follows:

- Sample number (for each sample in the shipment);
- Collection date and time (for each sample in the shipment);
- Number of containers for each sample;
- Sample description (i.e., environmental matrix);
- Analysis required for each sample;
- Sample preservation technique(s);
- Chain of custody or shipment number;
- Shipping address of the laboratory;
- Date, time, method of shipment, courier, and air bill number; and
- Signatures when custody is transferred between individuals.

The individual trained and responsible for shipping the samples from the field to the laboratory shall be responsible for completing the chain of custody form. This individual shall also inspect the form for completeness and accuracy and shall be responsible for ensuring International Air Transportation Association (IATA) compliance. In addition, this individual shall be responsible for determining the shipping classification for samples under United States Department of Transportation (USDOT) Regulatory Requirements. After the form has been inspected and determined to be satisfactorily completed, the responsible individual shall sign, date, and note the time of transfer on the form. For commercial carriers, the chain of custody form shall be placed in a sealable plastic bag and placed inside the cooler used for sample transport after the field copy of the form has been detached.

Shipping containers shall be secured using nylon strapping tape and chain of custody seals. Chain of custody seals shall be placed on each cooler used for sample transport. These seals shall consist of a tamper-proof adhesive material placed across the lid and body of the coolers in such a manner that if the cooler is opened, the seals will be broken. Chain of custody seals placed in this manner will ensure that no sample tampering occurs between the time of sample placement in the coolers to the time the coolers are opened for analysis at the laboratory. Cooler custody seals shall be signed and dated by the individual responsible for completing the chain of custody form contained within the cooler.

5.4.5 Receipt of Sample Forms: The contracted analytical laboratory shall document the receipt of analytical samples by accepting custody of the samples from the approved shipping company. In addition, the contracted laboratory shall document the condition of the shipping coolers and received samples upon receipt and shall immediately inform the USACE Buffalo District Project Manager and ARSEC's Project Manager if any sample containers are broken or if any tampering occurred with the seals on the cooler(s). This documentation shall be accomplished by completing the cooler receipt checklist as provided in ARSEC's QAPP (ARSEC 2009).

A cooler receipt check list shall be placed either into each shipping container together with the completed chain of custody form, or provided to the laboratory at the start of the project. A copy of the completed check list shall be faxed to both the USACE Buffalo District Project Manager and the ARSEC Project Manager immediately after it has been completed at the laboratory. The original completed checklist shall be transmitted with the final analytical results from the laboratory.

5.5 Documentation Procedures

The tracking procedure to be utilized for documentation of all samples collected during the project will involve the following series of steps:

- Collect and place samples into laboratory sample containers;
- Complete sample container label information, as defined in **Section 5.4**;
- Complete sample documentation information in the field logbook, as defined in **Section 5.3**;
- Complete project and sampling information sections of the COC form(s), as defined in **Section 5.4**, and in the QAPP (ARSEC 2009);
- Complete the air bill for the cooler to be shipped;
- Perform a completeness and accuracy check of the COC form(s);
- Complete the sample relinquishment section of the COC form(s) and place the form(s) into cooler;
- Place COC seals on the exterior of the cooler;
- Package and ship the cooler to the laboratory;
- Receive cooler at the laboratory, inspect contents, and transmit via fax of contained COC form(s), and cooler receipt form(s); and
- Transmit original COC form(s) with final analytical results from laboratory.

5.6 Corrections to Documentation

Original information and data in field logbooks, on sample labels, on COC forms, and on any other project-related documentation will be recorded in black waterproof ink and in a completely legible manner. Errors made on any accountable document will be corrected by crossing out the error and entering the correct information or data. An error discovered on a document will be corrected by the individual responsible for the entry, as possible. Erroneous information or data will be corrected in a manner that will not obliterate the original entry, and corrections will be initialed and dated by the individual responsible for the entry.

5.7 Sample Packaging and Shipping

5.7.1 Sample Packaging: Sample containers shall be packaged in thermally insulated rigid-body coolers. Sample packaging and shipping shall be conducted in accordance with applicable DOT specifications. Packaging and shipping procedures for all samples collected during the project shall include:

- Contents of sample containers shall be identified with definitive labels placed onto each container.
- All bottles containing samples shall be tightly closed to prevent leakage.
- Each sample bottle shall be placed into a separate plastic bag, which will be sealed closed. As much air as possible shall be forced from the sample container bags before sealing.

- The sample containers shall be placed upright in the shipping coolers. Ice is not required for shipping most radiological solid samples, but must be used for shipping radiological groundwater samples and TCL/TAL samples. Before initial placement of samples into a rigid-body cooler, the cooler drain plug shall be taped shut both inside and outside the container, and the cooler shall be lined with a large plastic bag.
- Inert packing material shall be placed into the cooler, if required, to prevent shifting of the sample containers during transport.
- All required laboratory paperwork, including the COC form(s), will be placed inside a plastic bag and taped to the inside of the cooler lid. If a laboratory-provided courier is used, the paperwork may be attached to the outside of the cooler to facilitate exchange of sample custody.
- Upon completion of the packing process, the cooler lid shall be closed and two signed/dated custody seals shall be placed on the cooler, one across the front and one across the side of the cooler, such that opening the cooler will result in breaking the custody seals.
- Rigid-body coolers shall be sealed by applying strapping tape directly to the cooler body.
- The airbill for the shipment shall be completed and attached to the top of the cooler, which will then be transferred to the courier for delivery to the laboratory.

5.7.2 Requirements for Samples Classified as Radioactive Materials: Transportation of radioactive waste is regulated by the International Air Transportation Association (IATA) and by the Department of Transportation (DOT). Overnight shippers (e.g. Federal Express) typically ship by air and follow IATA regulations (IATA 2005), while overland transport is governed by regulations promulgated in 49 CFR Subpart I. Samples generated during project activities will be transported in accordance with procedures that ensure compliance with regulatory requirements. Historical data and processing information has demonstrated that no Town of Tonawanda FUSRAP material contains fissile material.

Radiological samples will be shipped in accordance with the following, or equivalent, specifications:

- Each bagged sample container will be placed in a cooler in upright position
- Each cooler shall have its drain plug taped shut, both inside and out
- Inert packaging material shall be placed in the cooler to prevent shifting during transport
- All required laboratory paperwork, including the COC form(s) shall be placed in a plastic bag and taped to the inside of the cooler lid. If a laboratory-provided courier is used, the paperwork may be attached to the outside of the cooler to facilitate exchange of the sample custody.
- Rigid-body coolers shall be sealed by applying strapping tape directly to the cooler body.
- Upon completion of the packing process, the cooler lid shall be closed and two signed/dated custody seals shall be placed on the cooler, one across the front and one across the side.
- The cooler shall be surveyed for radiation and contamination in accordance with HP-702 “Transfer of Radioactive Material” to ensure the package meets the requirements for limited quantity as found in 49 CFR.
- A notice must be placed on the outside of each cooler that includes the name of the cosigner and the statement “This package conforms to the conditions and limitations specified in 49 CFR 173.421 for radioactive material, excepted package-limited quantity of material, UN2910”. The outside of the inner packaging or, if there is no inner

packaging, the outside of the package itself, must be labeled “Radioactive” if fully applicable.

- The following label will be placed on the cooler(s):
 - Arrows indicating “This way up”
 - Appropriate hazard class label
 - “Cargo Aircraft Only”, if applicable
- The airbill for the shipment shall be completed and attached to the top of each cooler, which will then be transferred to the courier for delivery to the laboratory. If required, dangerous goods airbills shall be used for the shipment.

5.7.3 Sample Shipping: All environmental samples collected during the project shall be shipped no later than 48 to 72 hours after time of collection. The latter time of 72 hours may be necessary if the samples are collected on a Friday and have to be shipped Monday via commercial courier. During the time between collection and shipment, all samples shall be stored in a secure area to maintain custody. All coolers containing environmental samples shall be shipped overnight to the laboratory by Federal Express, similar courier, or laboratory courier. Due to holding time limitations, the Contractor shall discourage shipping of samples on Fridays unless it is absolutely necessary and provided that the laboratory has assured that personnel will be present on Saturdays to receive and carry out any necessary processing within the holding time and temperatures when applicable.

5.8 Documentation Procedures/Data Management and Retention

Original copies of field data, field records, analytical data, training records, and other project-specific documentation will be retained in the ARSEC Knoxville Office.

5.9 Investigation-Derived Waste

Investigation-Derived Waste (IDW) will be generated as a result of the field activities for this project. When accumulated, the media must be managed appropriately to minimize the exposure to human health and the environment while adhering to applicable regulatory requirements. All IDW management will be under the direct oversight of our proposed Site Manager, Dana Williams. Mr. Williams will be assisted by ARSEC environmental technicians and laborers. Care will be exercised to ensure that the IDW does not cross contaminate the site and that all non-indigenous wastes will be containerized and proactively managed.

IDW includes all materials generated during the field activities at the Tonawanda Landfill that cannot be effectively reused, recycled, or decontaminated in the field. Two types of IDW will be generated during the implementation of field activities: indigenous and non-indigenous. The types of indigenous IDW expected to be generated include subsurface and surface soils. The types of non-indigenous IDW expected to be generated include decontamination fluid/water and miscellaneous trash including PPE. ARSEC will implement proactive protocols and procedures to ensure that incoming and outgoing equipment and tools are free from contamination. To the extent practical, ARSEC will use dry decontamination techniques to minimize liquid IDW. When generated, decontamination fluids will be collected and stored in DOT approved 55-gallon drums that will be sampled when full to determine the disposition pathway. PID and 4 gas screening will be performed when IDW containers are opened to add or remove IDW.

Consolidated wastes stored within the IDW containers will be sampled and the samples will be submitted to the off-site Laboratory for waste characterization analysis. The waste characterization analysis shall be based on the Waste Acceptance Criteria for the USACE

accepted disposal facility. All wastes will be characterized and dispositioned in accordance with guidance from USACE. All IDW will be cataloged and tracked. All tracking will be documented in logbooks and those results reported in the Final Reports.

In the event that off-site disposal for any of the wastes is the selected alternative, all wastes shall be handled and transported by a Contractor licensed and/or permitted to transport waste both in the State of New York and all states through which the waste must travel to reach the approved disposal facility. Generated wastes shall be disposed only at facilities licensed and permitted to accept the material.

PPE and associated wastes that are non-contaminated shall be bagged and placed in a sanitary waste dumpster. The dumpster type and supplier shall be approved by the USACE prior to use. No free liquids or hazardous substances shall be placed in the dumpster. Contaminated non-hazardous waste of this type shall be disposed of off-site in accordance with all applicable EPA, DOT and State of New York regulations at a permitted landfill capable of accepting the waste.

6.0 LABORATORY ANALYSIS

ARS of Port Allen, Louisiana, an independent off-site laboratory, will provide radiochemical analysis. TestAmerica of Earth City, Missouri, also an independent off-site laboratory, will provide non-radiochemical analysis. ARS and TestAmerica are National Environmental Laboratory Accreditation Program (NELAP) accredited laboratories with prior FUSRAP and USACE experience and are fully capable of providing the analytical services required to meet the project DQOs. The TestAmerica laboratory has DoD ELAP accreditation for the non-radiochemistry analytical parameters associated with the project. The ARS laboratory was audited for DoD ELAP accreditation the first week in October 2009 for the radiochemistry analytical parameters associated with the project. All required corrective actions resulting from the audit have been addressed. Samples will be transferred to ARS and TestAmerica for analyses in accordance with documented laboratory specific standard methods.

All soil and core samples, including field QA/QC samples, will be analyzed for the radiological parameters specified in Table 6-1. In addition, 10% of all soil and core samples will be analyzed for the non-radiological parameters specified in Table 6-1. Selection of soil and core samples for non-radiological analysis will be biased first towards those samples exhibiting the highest radioactivity levels and secondly towards those samples exhibiting positive PID readings, unusual odors or staining.

Table 6-1. Soil and Core Sample Analytical Requirements for the Tonawanda Landfill Project

Analytical Parameter	Test Method
Ra-226	EPA 901.1 (Gamma Spec)
Ra-228	EPA 901.1 (Gamma Spec)
Uranium-234, 235 & 238	EPA 901.1 (Gamma Spec) for Uranium-235, 238
Isotopic Thorium-228, 230 and 232	DOE EML HASL 300 Series for Thorium
Americium-241	EPA 901.1 (Gamma Spec)
Total VOCs	SW-846 8260
TCLP Volatile Organic Compounds (VOCs)	EPA SW-846 1311 (ZHE) followed by SW-846 8260
Total SVOCs	SW-846 8270
TCLP Semi-Volatile Organic Compounds (SVOCs)	EPA SW-846 1311 followed by SW-846 8270
Target Analyte List (TAL) Metals	EPA SW-846 6010/6020/7471
TCLP Metals	EPA SW-846 1311 Followed by SW-846 6010/6020/7471
Pesticides	EPA SW-846 8081
TCLP Pesticides	EPA SW-846 1311 followed by SW-846 8081
PCBs	EPA SW-846 8082

Temporary well point samples, including temporary well point QA/QC samples, will be analyzed as outlined in Table 6-2. Analysis shall be performed on both filtered and unfiltered temporary well point samples. It will be the responsibility of the laboratory performing the analysis to filter the temporary well point samples.

Table 6-2. Temporary Well Point Analytical Requirements for the Tonawanda Landfill

Parameter	Analytical Method	# of Samples	# of Field Duplicates	# of MS/MSD Samples	# of USACE QA Samples
Ra-226	EPA 903.1	14	1	-	1
Ra-228	EPA 904	14	1	-	1
Isotopic U (234, 235, 238)	HASL 300 - Alpha Spectroscopy – Eichrom Modification	14	1	-	1
Isotopic Th (228, 230, 232)	HASL 300 - Alpha Spectroscopy – Eichrom Modification	14	1	-	1
Target Analyte List (TAL) Metals	EPA SW-846 6010/6020/7471	14	1	1	1
Anions (Cl, F, NO ₂ /NO ₃ o-PO ₄ , SO ₄)	EPA SW-846 9056/EPA 300 Series	14	1	-	-
Total Dissolved Solids (Filtered Only)	EPA 160.1	14	1	-	-
Alkalinity (Carbonate/Bicarbonate)	EPA 310.2	14	1	-	-

Analysis of IDW samples will be based on the acceptance criteria of the anticipated disposal facilities. At a minimum, IDW solids will be analyzed for the parameters defined for soil analysis in Table 6-1. IDW liquids will be analyzed as outlined in Table 6-3.

Table 6-3. IDW Liquid Sample Analytical Requirements for the Tonawanda Landfill Project

Analytical Parameter	Test Method
Ra-226	EPA 903.1
Ra-228	EPA 904
Isotopic U (234, 235, 238)	HASL 300 - Alpha Spectroscopy – Eichrom Modification
Isotopic Th (228, 230, 232)	HASL 300 - Alpha Spectroscopy – Eichrom Modification
Total VOCs	SW-846 8260
Total SVOCs	SW-846 8270
Target Analyte List (TAL) Metals	EPA SW-846 6010/6020/7471
Pesticides	EPA SW-846 8081
PCBs	EPA SW-846 8082
Ignitability	EPA SW-846 1010A/1020A
Corrosivity	EPA SW-846 9040C
Reactivity	No required methods

7.0 REPORTING

Several reporting requirements exist for the project, including:

- Electronic Data Deliverable (EDD)
- Risk Assessment Database Deliverable
- Final Project Report

7.1 Electronic Data Deliverable (EDD)

Analytical laboratory results for the Tonawanda Landfill investigation shall be provided from the laboratory to the USACE District Chemist in Microsoft Excel (xls) or .csv format and that of the defensible data package in Adobe (.pdf). The contractor shall review and confirm 100% data verification of the project data. The required content of each sample delivery group (SDG) is described in Attachment 4, Sections 2.1.2 and 2.1.3 of the SOW. See SOW Attachment 4: Analytical Laboratory Requirements, and Data Deliverables Section: 4.0 Analytical Requirements Tables for method detection limits and methodology.

The contents presented in the EDD (xls/csv file) will contain those items necessary (DoD QSM – April 2009, Appendix E – SW-846 Reporting Requirements, reference applicable contents of Sections 4, 5, and 6) to conduct a data validation with a minimum of, but not limited to, those items listed in the SOW. The EDD file is subject to approval by USACE. ARSEC shall make the file content available to USACE prior to data generation for review.

7.2 Risk Assessment Data Deliverable

In addition to providing the EDD, the contractor shall generate a separate electronic data deliverable, database, for use by USACE for performing the project risk assessment. The database record contents shall include those of the above EDD and that of the below table. Final format will be approved by the USACE.

- The contractor shall review the EDD data base for completeness of the fields as shown below.
- The data base shall be delivered in Microsoft Access format.
- A separate file containing all the locations and X and Y coordinates shall be provided
- Quality results shall be removed to their own separate table in the data base.

Data must be present for each record in the following fields shown below.

Field	Comment
Location	
Date Collected	
Matrix	Review for consistency
Starting Depth	In feet bgs, use the "#.#" format (e.g., 0.5, 2.0, 4.5, etc.). Use "NA" if not applicable.
Ending Depth	In feet bgs, use the "#.#" format (e.g., 0.5, 2.0, 4.5, etc.). Use "NA" if not applicable.
Sample Code	N for Normal, FD for Field Duplicate, etc.
Analyte Category	RAD, VOC, etc. review for consistency
Parameter Name	Review for consistency
CAS Number	
Units	
MDL	

Field	Comment
Final Data Validator's Flag (in addition to the laboratory qualified/flag)	One field that contains final flag to be used for risk assessment (U indicates non-detect, R indicates rejected, etc)
Analytical Method Code	Review for consistency
Uncertainty	Rad only

7.3 Final Project Report

ARSEC shall prepare a Project Report that includes all results associated with the data collection and field investigation efforts tasked in this study, as well as the QA/QC procedures utilized to verify field investigative results.

ARSEC will ensure the Project Report identifies any additional data that must be collected, if any, to further delineate the boundaries of the vertical and horizontal extent of any soil contamination requiring excavation during future remedial activities. The Project Report shall include, but not be limited to, the following components:

- An executive summary containing the objective(s) and generalized interpretation;
- Purpose and scope of the investigation including data quality objectives;
- Dates and location of the investigation (i.e. figures, maps);
- Personnel and organization(s) involved;
- Amount and type of data collected;
- Quality (reliability) of data collected;
- Methods of investigation and equipment employed;
- Methods of analyses and interpretations;
- Figures/maps showing sampling locations and results;
- Tables/figures showing location and magnitude of radiological and chemical contamination;
- Form I laboratory analytical results;
- Summary and conclusions of field investigative results and data;
- Appendices, which shall include, but not be limited to, field data and notes (originals or usable/reproducible copies), finalized response to comments package, QC information, data summary tables, waste manifests, field logbooks, boring logs, and other relevant information related to the field investigative activities; and
- Airborne monitoring data and any dose data.

Five (5) hard copies and one (1) electronic copy of the draft Project Report shall be supplied in Microsoft Word, Excel, and Adobe Acrobat PDF formats to the Tonawanda Landfill Project Manager within thirty-one (31) calendar days after data acquisition. The draft project report will be reviewed by USACE personnel and comments will be supplied to the Contractor. The Contractor shall formally respond to these comments and revise the report accordingly within fifteen (15) calendar days from receipt of the comments. The Contractor shall send ten (10) hard copies and five (5) compact discs (in Adobe PDF and Microsoft Word format) of the final Project Report.

The draft Project Report will be submitted for USACE's review and comment and a comment resolution log developed and submitted to the District prior to the revision of the document and its resubmission to USACE. ARSEC is committed to fully support the overall requirements of the Task Order in the following areas:

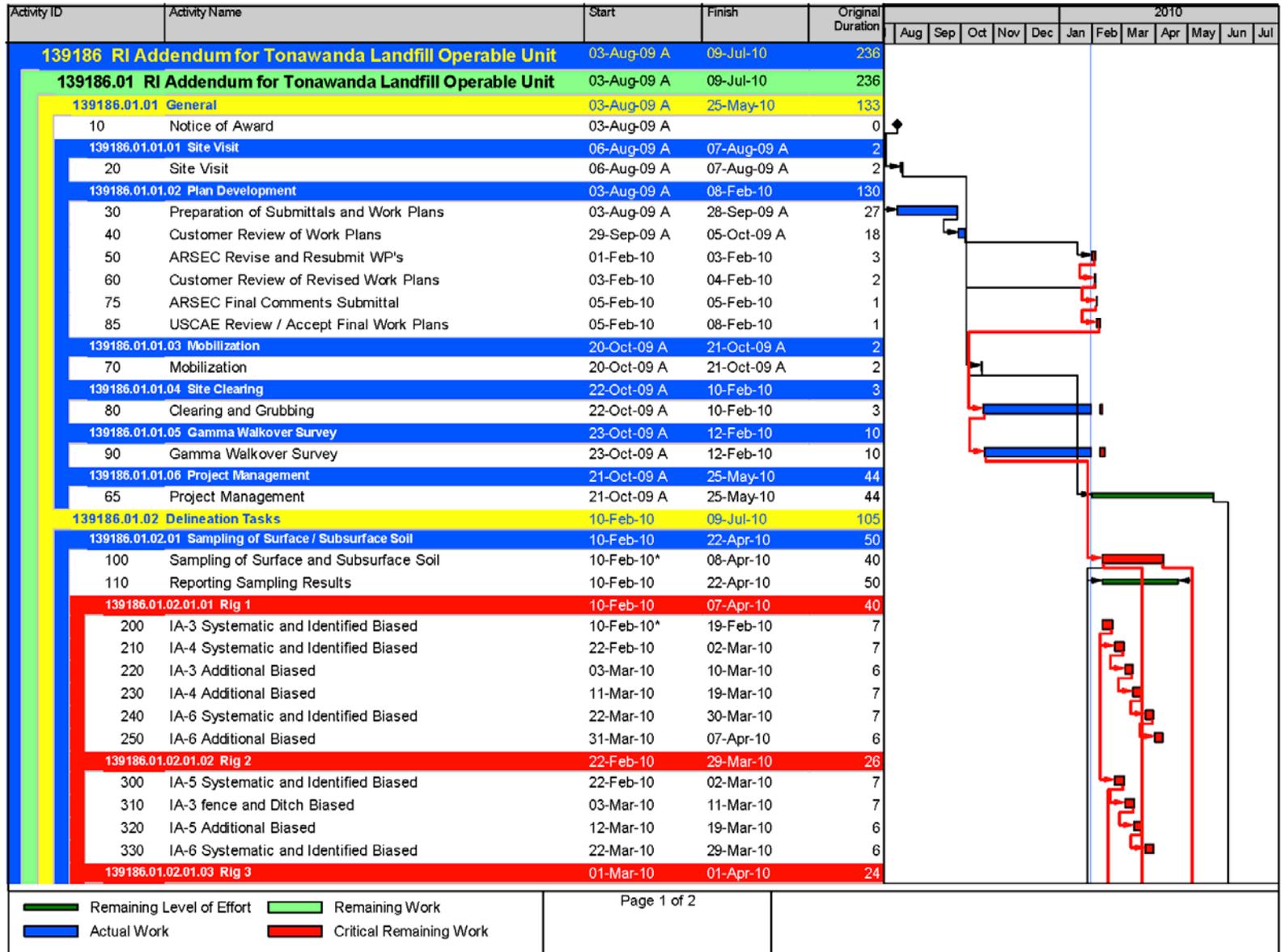
- Correspondence and Progress Reporting
- Public Affairs,
- Submittals,
- Written Weekly Reports,
- Payment Requests,
- Accruals,
- Other Project Management activities, and
- American Recovery and Reinvestment Act of 2009 (ARRA) reporting and certifications.

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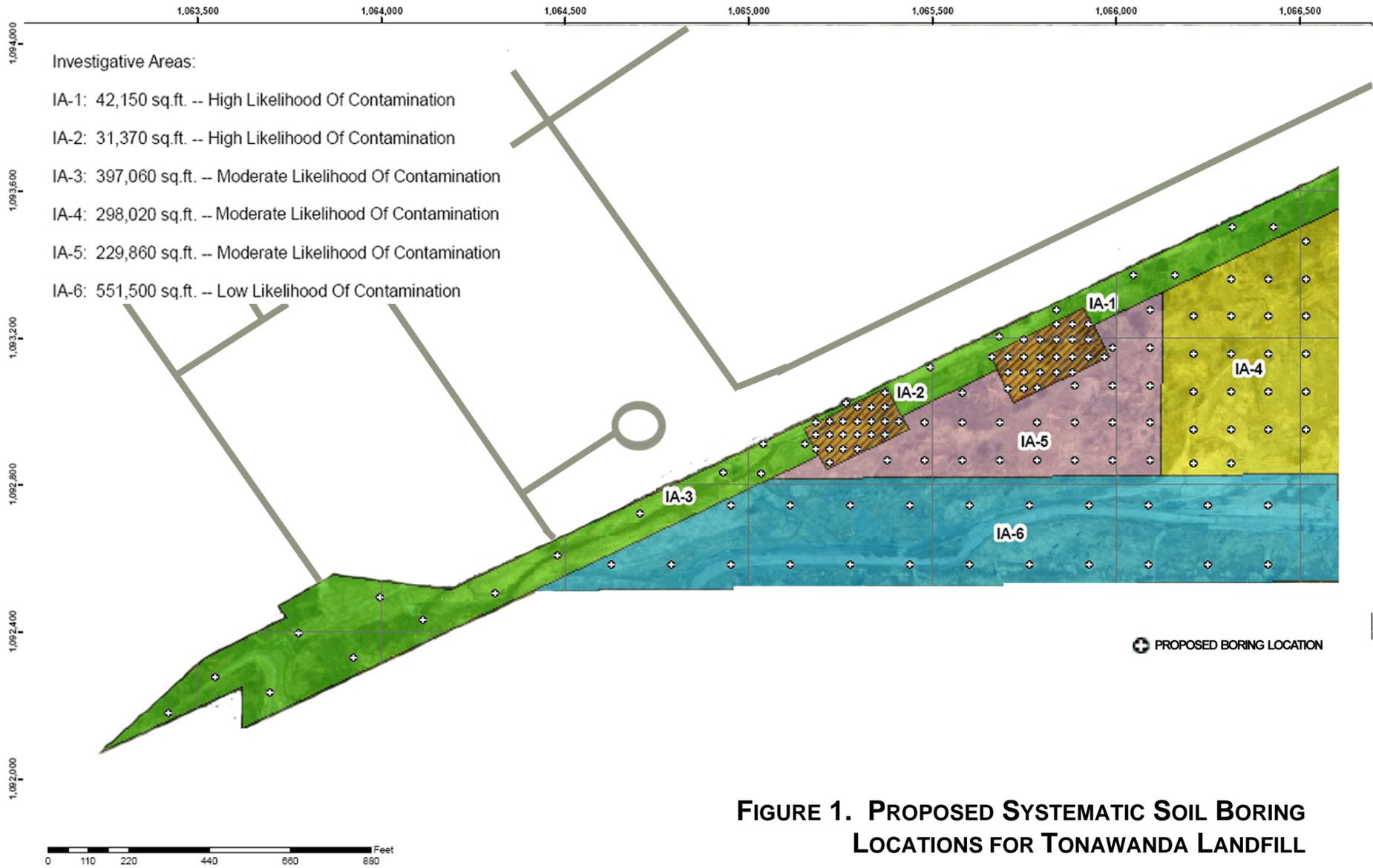
APPENDIX A

PROPOSED SCHEDULE FOR FIELD ACTIVITIES



APPENDIX B

FIGURE SHOWING PROPOSED SYSTEMATIC SAMPLING LOCATIONS



APPENDIX C

SCAN MINIMUM DETECTABLE CONCENTRATIONS (NaI)

C.0 SCAN MDC CALCULATIONS

C.1 INTRODUCTION

The purpose of this Appendix is to provide estimated gamma walkover scan sensitivities for the COCs. Site-specific scan sensitivity analyses (bench tests) will be performed in the field for 2-inch by 2-inch, 3-inch by 3-inch and FIDLER scintillation detectors. These results will be applied for the surveys to be performed.

C.2 ESTIMATION OF MINIMUM DETECTABLE CONCENTRATIONS (MDC)

ARSEC will utilize standard operating procedures that follow the methodology and approach documented in MARSSIM¹ for MDC calculations for the different detectors. Scan MDCs will be derived using MARSSIM/NUREG-1507 methods. Factors included in the analyses are the surveyor scan efficiency, index of sensitivity, the natural background of the surveyed area, scan rate, detector to source geometry, areal extent of the potential hot spot(s), and energy and yield of gamma emissions.

The computer code Microshield will be used to model the presence of normalized sources of the COCs and K-40 in soil with the assumption that the activity is uniformly distributed to a depth of 15 cm and spread over a disk shaped area with a diameter of 56 cm. This is consistent with the NUREG-1507 methodology and provides for a count rate to exposure ratio (CPM/ μ R/hr) to be calculated.

The tables provided herein are examples of estimated MDC values that are based upon the NUREG-1507 methodology. Additional details and discussion describing the NUREG analysis methodology are described in that publication. Factors for determining MDC are presented below.

C.3 FLUENCE RATE TO EXPOSURE RATE (FRER)

The fluence rate to exposure rate (FRER) may be approximated by: $1 \mu\text{R} / \text{hr}$

$$FRER \approx \frac{1 \mu\text{R} / \text{hr}}{(E_{\gamma})(\mu_{en} / \rho)_{air}}$$

Where:

E_{γ} = energy of the gamma photon of concern, keV

(μ_{en}/ρ) = the mass energy absorption coefficient for air, cm^2/g

C.4 PROBABILITY OF INTERACTION (P) THROUGH DETECTOR END FOR A GIVEN ENERGY

The probability, P, of a gamma ray interaction in the NaI scintillation crystal entering through the end of the crystal is given by:

¹ Nuclear Regulatory Commission; *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*; NUREG-1575, Rev. 1; August 2000

$$\text{Probability}(P) = 1 - e^{-(\mu/\rho)_{\text{NaI}}(X)(\rho_{\text{NaI}})}$$

Where:

- $(\mu/\rho)_{\text{NaI}}$ = the mass attenuation coefficient for NaI, cm^2/g
 X = the thickness through the end of the NaI crystal, cm
 (ρ_{NaI}) = the density of the NaI crystal, g/cm^3

C.5 RELATIVE DETECTOR RESPONSE (RDR)

The Relative Detector Response (RDR) as a function of energy is determined by multiplying the relative fluence rate to exposure rate (FRER) by the probability (P) of an interaction and is given by:

$$RDR = (FRER)(P)$$

C.6 DETERMINATION OF CPM PER $\mu\text{R}/\text{HR}$ AS A FUNCTION OF ENERGY

The equivalent FRER, P, and finally RDR may be calculated for the NaI scintillation detector at the Cesium-137 (Cs-137) energy of 662 keV. Manufacturers of this equipment typically provide an instrument response in terms of CPM and $\mu\text{R}/\text{hr}$ at the Cs-137 energy. This point allows one to determine the CPM per $\mu\text{R}/\text{hr}$ and ultimately activity concentration and minimum detection sensitivity level in terms of pCi/g for a specific instrument.

Based on a manufacturer's NaI response specification and using the same methodology as shown above, the FRER, P, and RDR are calculated. The mass energy absorption coefficient for air and the mass attenuation coefficient for NaI are interpolated from tables in the Radiological Health Handbook², Revised Edition January 1970, pages 139, and 140.

$$\text{FRER} = 0.0514$$

$$\text{Energy}_{\gamma}, \text{keV} = 662$$

$$(\mu_{\text{en}}/\rho)_{\text{air}}, \text{cm}^2/\text{g} = 0.0294$$

$$(\mu/\rho)_{\text{NaI}}, \text{cm}^2/\text{g} = 0.0780$$

$$P = 0.89$$

therefore:

$$\text{Cs-137 RDR (662 keV)} = 0.0456$$

² Radiological Health Handbook, U.S. Department of HEW, 1970 Edition

The detector response (CPM) to energy is based upon the ratio of the RDR at a specific energy to the known CS-137 energy RDR:

$$CPM / \mu R / hr, E_i = \frac{(CPM / \mu R / hr_{Cs-137})(RDR_{E_i})}{(RDR_{Cs-137})}$$

C.7 MINIMUM DETECTABLE COUNT RATE

The minimum detectable count rate (MDCR) is calculated using the NUREG-1507 methodology where:

- There is a six inch layer of compacted brush/cattail cuttings on the ground surface with an estimated density of 0.4 g/cc,
- The detector scan rate is such that the detector is over the source for a time interval of one second at nine inches above the ground surface (six inches of compacted brush/cattails and a three inch air gap),
- The average number of background counts in a one second interval, $b_i = CPM/60$, and
- The detector generic count rate to exposure rate ratio value (XXXX CPM per $\mu R/hr$) and actual measured background gives:

$$B_i = (BKG\mu R/hr)(XXXX CPM/\mu R/hr)/(60) = XXX \text{ counts}$$

The MDCR is therefore calculated as:

$$MDCR = (d')(b_i)^{0.5}(60 \text{ sec}/1 \text{ min})$$

Where d' represents the rate of detections at 95% and a false positive rate of 60%, and b_i is the background counts

The MDCR for the surveyor is given as:

$$MDCR_{\text{surveyor}} = MDCR / (P)^{0.5}$$

Where P is the surveyor efficiency equal to 0.5 to 0.75 as given by NUREG-1507. A conservative value of 0.5 will be used for surveyor efficiency.

C.8 ESTIMATE OF SCAN MDC

The minimum detectable exposure rate is obtained from the $MDCR_{\text{surveyor}}$ divided by the weighted count rate to exposure rate value for a 1 pCi/g normalized concentration.

The scan MDC is then equal to the ratio of the Minimum Detectable Exposure Rate in the field to the exposure rate determined for the normalized 1 pCi/g concentration.

C.9 TABLES

Table C-1. Typical Detector Scan MDCs for Common Radiological Contaminants

Gamma Scan with a 2"x2" NaI detector for:	B (cpm)	ϵ_i (cpm / μ R/h)	d'	s_i (counts)	MDCR (ncpm)	MDCR _s (ncpm)	Scan MDC (μ R/h)	CF (pCi/g / μ R/h)	Scan MDC (pCi/g)
Ra-226 ^a	6500	760	1.380	20	609	704	0.93	1.41	1.3
	10000	760	1.380	18	1069	1512	1.99	1.41	2.8
U-natural ^b	5000	3990	1.380	13	756	1069	0.27	211	57
	10000	3990	1.380	18	1069	1512	0.38	211	80
Th-232 ^a	5000	830	1.380	13	756	1069	1.29	0.99	1.3
	10000	830	1.380	18	1069	1512	1.82	0.99	1.8

Gamma Scan with a 3"x3" NaI detector for:	B (cpm)	ϵ_i (cpm / μ R/h)	d'	s_i (counts)	MDCR (ncpm)	MDCR _s (ncpm)	Scan MDC (μ R/h)	CF (pCi/g / μ R/h)	Scan MDC (pCi/g)
Cs-137	5000	2300	1.380	13	756	1069	0.46	3.81	1.8
	10000	2300	1.380	18	1069	1512	0.66	3.81	2.5
Co-60	5000	1100	1.380	13	756	1069	0.97	0.97	0.9
	10000	1100	1.380	18	1069	1512	1.37	0.97	1.3

Gamma Scan with a FIDLER detector for:	B (cpm)	ϵ_i (cpm / μ R/h)	d'	s_i (counts)	MDCR (ncpm)	MDCR _s (ncpm)	Scan MDC (μ R/h)	CF (pCi/g / μ R/h)	Scan MDC (pCi/g)
Natural U	12500	44786	1.38	20	1195	1690	0.04	191	7.2
Natural Th	12500	3881	1.38	20	1195	1690	0.44	1.03	0.4

Notes:

B = background count rate (cpm)

cpm = counts per minute

i = scan time interval

p = surveyor efficiency (ranges from 0.5 to 0.75)

 ϵ_i = instrument efficiency (from Table 6.4 of NUREG-1507)

d' = value selected from Table 6.1 of NUREG-1507

 s_i = minimal number of net source counts

MDCR = minimum detectable count rate

CF - Derived using Microshield software code and NUREG-1507 standard geometry.

MDCR_s = surveyor MDCR

MDC = minimum detectable concentration

CF = conversion factor (Microshield/NUREG-1507)

ncpm = net counts per minute

pCi/g = pico-curies per gram

 μ R/h = micro- Roentgen per hour^aIn Equilibrium with progeny^bSum of U-234, 235 and 238

APPENDIX D

**SAMPLE CONTAINER, PRESERVATION AND HOLDING
TIME TABLES**

D.0 SAMPLE CONTAINERS, PRESERVATION AND HOLDING TIMES**Table D-1. Soil Sample Container, Preservation and Holding Time Requirements**

Analytical Parameter	Test Method	Bottle Type	Preserv.	Holding Time
Ra-226	EPA 901.1 (Gamma Spec)	500 mL WM HDPE	None	180 days
Ra-228	EPA 901.1 (Gamma Spec)	500 mL WM HDPE	None	180 days
Uranium-234, 235, and 238	EPA 901.1 (Gamma Spec) for Uranium-235, 238	500 mL WM HDPE	None	180 days
Isotopic Thorium-228, 230, and 232	DOE EML HASL 300 Series for Thorium	500 mL WM HDPE	None	180 days
Americium-241	EPA 901.1 (Gamma Spec)	500 mL WM HDPE	None	180 days
Total VOCs	SW-846 8260	4 oz glass jar No Headspace	None, <6°C	14 days
TCLP Volatile Organic Compounds (VOCs)	EPA SW-846 1311 (ZHE) followed by SW-846 8260	4 oz glass jar No Headspace		
Total SVOCs	SW-846 8270	8 oz WM clear glass	None, <6°C	14 days to extraction, 40 days after extraction
TCLP Semi-Volatile Organic Compounds (SVOCs)	EPA SW-846 1311 followed by EPA SW-846 8270	8 oz WM clear glass		
Target Analyte List (TAL) Metals	EPA SW-846 6010/6020/7471	8 oz WM clear glass	None, <6°C	180 days except mercury (mercury 28 days)
TCLP Metals	EPA SW-846 1311 followed by SW-846 6010/6020/7471	8 oz WM clear glass		
Pesticides	EPA SW-846 8081	250 ml WM clear glass	None, <6°C	7 days to extraction, 40 days after extraction
TCLP Pesticides	EPA SW-846 1311 followed by SW-846 8081	8 oz WM clear glass		
PCBs	EPA SW-846 8082	500 ml WM clear glass	None, <6°C	No holding time

Table D-2. Groundwater Sample Container, Preservation and Holding Time Requirements

Analytical Parameter	Test Method	Bottle Type	Preserv.	Holding Time
Isotopic Uranium (234,235,238)	HASL 300 – Alpha Spectroscopy – Eichrom Modification	1 L HDPE	HNO ₃ pH<2	180 days
Isotopic Thorium (228,230,232)	HASL 300 – Alpha Spectroscopy – Eichrom Modification	1 L HDPE	HNO ₃ pH<2	180 days
Radium 226	EPA 903.1	1 L HDPE	HNO ₃ pH<2	180 days
Radium 228	EPA 904	1 L HDPE	HNO ₃ pH<2	180 days
Target Analyte List (TAL) Metals	EPA SW-846 6010/6020/7471	500 mL HDPE	HNO ₃ pH<2	180 days except mercury (mercury 28 days)
Anions (Cl, F, NO ₂ , NO ₃ , o-PO ₄ , SO ₄)	EPA SW-846 9056/EPA 300 Series	1 L HDPE	None, <6°C	None for Fluoride, Nitrite, and ortho-phosphate; 28 days for Chloride; 48 hrs for Nitrate; 28 days for Sulfate
Total Dissolved Solids (Filtered Only)	EPA 160.1	1 L HDPE	None, <6°C	None
Alkalinity (Carbonate/Bicarbonate)	EPA 310.2	1 L HDPE	None, <6°C	None

Table D-3. IDW Liquid Sample Container, Preservation and Holding Time Requirements

Analytical Parameter	Test Method	Bottle Type	Preserv.	Holding Time
Ra-226	EPA 903.1	1 L HDPE	HNO ₃ pH<2	180 days
Ra-228	EPA 904	1 L HDPE	HNO ₃ pH<2	180 days
Isotopic U (234, 235, 238)	HASL 300 - Alpha Spectroscopy – Eichrom Modification	1 L HDPE	HNO ₃ pH<2	180 days
Isotopic Th (228, 230, 232)	HASL 300 - Alpha Spectroscopy – Eichrom Modification	1 L HDPE	HNO ₃ pH<2	180 days
Total VOCs	SW-846 8260	(3) 40ml glass vials	HCl pH<2,<6°C	14 days
Total SVOCs	SW-846 8270	1 L WM amber glass	None,<6°C	40 days
Target Analyte List (TAL) Metals	EPA SW-846 6010/6020/7471	125 mL HDPE	HNO ₃ pH<2	180 days except mercury (mercury 28 days)
Pesticides	EPA SW-846 8081	1 L amber glass	None,<6°C	40 days
PCBs	EPA SW-846 8082	1 L amber glass	None,<6°C	No holding time
Ignitability	EPA SW-846 1010A/1020A	100 ml clear glass, No Headspace	None,<6°C	No holding time
Corrosivity	EPA SW-846 9040C	250 ml poly	None,<6°C	No holding time
Reactive CN	No required methods	250 ml poly	NaOH to pH>12,<6°C	No holding time
Reactive S	No required methods	250 ml poly	NaOH Ainc Acetate to pH>9,<6°C	No holding time

Requirements for IDW solid container, preservation, and holding time requirements are the same as those defined for soil analysis in Table D-1.

Volume II
Quality Assurance Project Plan



SAMPLING AND ANALYSIS PLAN

Volume II – Quality Assurance Project Plan for Phase 2 Remedial Investigation – Tonawanda Landfill Operable Unit

Revision 1

Buffalo District Formerly Utilized Sites Remedial Action Program

**Prepared by:
American Remediation Solutions and Environmental Corporation
(ARSEC)
2609 North River Road
Port Allen, LA 70767**

**For:
U.S. Army Corps of Engineers – Buffalo District
Formerly Utilized Sites Remedial Action Program
Contract No. W912P4-07-D-0009, Delivery Order 0002**

February 2010, Revision 1

Sampling and Analysis Plan

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February 2010, Revision 1

**QUALITY ASSURANCE PROJECT PLAN (QAPP)
TONAWANDA LANDFILL OPERABLE UNIT, TONAWANDA, NEW YORK**

Contract No. W912P4-07-D-0009, Delivery Order 003

QAPP APPROVALS

By their specific signature, the undersigned certify that they reviewed and provided comments on this QAPP for sampling and analysis at the Tonawanda Landfill Site, Tonawanda, NY.

APPROVED BY:

[Redacted Signature]

ARSEC – Project Manager

[Redacted]

02/08/10

Date

[Redacted Signature]

ARSEC – Quality Assurance Coordinator

[Redacted]

02/08/10

Date

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ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AEC	Atomic Energy Commission
Am-241	Americium-241
ARS	American Radiation Services, Inc.
ARSEC	American Remediation Solutions and Environmental Corporation
ASTM	American Society for Testing and Materials
CAR	Corrective Action Report
CF	Confidence Factor
CFR	Code of Federal Regulations
COC	Chain of Custody
COR	Contracting Officer's Representative
CQCP	Contractor Quality Control Plan
CQCSM	Contractor Quality Control System Manager
CR	Chemical Recovery
CSU	Combined Standard Uncertainty
CU	Counting Uncertainty
CV	Coefficient of Variation
DER	Normalized Absolute Difference Statistic
DF	Decay Correction Factor
D.O.	Delivery Order
DoD QSM	Department of Defense Quality Systems Manual
DOE	U.S. Department of Energy
DOT	Department of Transportation
dpm	disintegrations per minute
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
eV	electron Volt
FSP	Field Sampling Plan
ft	foot (or feet)
FUSRAP	Formerly Utilized Sites Remedial Action Program
HP	Health Physicist
HSRPP	Health, Safety, and Radiation Protection Plan
IDW	Investigation Derived Waste
ITR	Independent Technical Review
LCS	Laboratory Control Sample
LIMS	Laboratory Information Management System
LQAP	Laboratory Quality Assurance Plan
LQAO	Laboratory QA Officer
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDL	Method Detection Limit
μCi/ml	microCuries per milliliter
mrem	millirem
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NCR	Nonconformance Report

NELAP	National Environmental Laboratory Accreditation Program
NRC	U.S. Nuclear Regulatory Commission
PCB	Polychlorinated Biphenyl
pCi	picoCuries
PDF	Adobe® Acrobat Portable Document Format
PM	Project Manager
POC	Point of Contact
PQCR	Project Quality Control Representative
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
QM	Quality Manager
QSM	Quality Systems Manual
Ra-226	Radium-226
RCA	Radiological Control Area
RE	Relative Error
RDL	Reporting Limit
RPD	Relative Percent Difference
RPP	Radiation Protection Plan
RSD	Relative Standard Deviation
RSP	Radiation Safety Program
SAP	Sampling and Analysis Plan
SDG	Sample Delivery Group
SEC	Safety and Ecology Corporation
SM	Site Manager
SOW	Scope of Work
SSHO	Site Safety and Health Officer
SVOC	Semi-Volatile Organic Compound
TA	TestAmerica
TAL	Target Analyte List
TAT	Turnaround Time
TBD	To Be Determined
TCLP	Toxicity Characteristic Leaching Procedure
Th-228	Thorium-228
Th-230	Thorium-230
Th-232	Thorium-232
TWP	Temporary Well Point
U-234	Uranium 234
U-235	Uranium-235
U-238	Uranium-238
U.S.	United States
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound
Y	Yield
YU	Yield Uncertainty
ZHE	Zero Headspace Extraction

1.0 INTRODUCTION

1.1 Overview

American Remediation Solutions and Environmental Corporation (ARSEC) has been contracted by the United States (U.S.) Army Corps of Engineers (USACE) – Buffalo District under Contract Number **W912P4-07-D-0009, Delivery Order (D.O.) 0003** (hereafter referred to as the “contract”), to perform Phase 2 Remedial Investigation activities at the Tonawanda Landfill Operable Unit (hereafter referred to as the “Site”) located in Tonawanda, New York. This Remedial Investigation is being completed under the USACE’s Formerly Utilized Sites Remedial Action Program (FUSRAP), which was established to identify, investigate, and clean up or control sites previously used by the Atomic Energy Commission (AEC). Historical data has indicated that the site has concerns related to radioactive contamination from past Manhattan Engineer District/Atomic Energy Commission (MED/AEC) activities. Identified contaminants of concern include uranium-238 (U-238), thorium-230 (Th-230) and radium-226 (Ra-226). In addition, other hazardous substances, pollutants or contamination resulting both from MED/AEC activities and non MED/AEC activities that have been comingled with MED/AEC waste must be investigated.

The primary objective of this remedial investigation effort is to better delineate the extent of radiological contamination and to update the radiological fate and transport assessment.

This *Quality Assurance Project Plan* (QAPP, or Plan), which is Volume II of the *Sampling and Analysis Plan* (SAP), establishes an overall project quality assurance (QA) plan for measurement and analytical operations on this project. The *Field Sampling Plan* (FSP) (ARSEC, 2009), Volume I of the SAP, addresses field activities, including all aspects of sampling and any field data gathering activities. Together, the FSP and QAPP provide the background, site description, study objectives, technical approaches, and QA/quality control (QC) procedures for project measurement and analytical requirements for pre-remediation sampling operations on this project. This document follows the recommended format for QAPPs described in USACE Engineering Manual EM-200-1-3, *Requirements for the Preparation of Sampling and Analysis Plans* (USACE, 2001).

This QAPP identifies data quality objectives (DQOs), laboratory analysis methodologies and requirements, specific QA/QC activities, and data assessment activities designed to achieve the data quality goals of the project. This QAPP also presents the project organization, objectives, procedures, functional activities, and specific QA/QC activities associated with the radiological surveying, sampling and analysis activities to be performed at the site. The collection, screening, and management of samples and other field data gathering activities for this project are described in the project FSP (ARSEC, 2009).

1.2 Purpose and Scope

The purpose of this QAPP is to describe the standards for laboratory analysis activities in support of remedial investigation activities. These standards include the DQOs, work to be performed to fulfill the objectives, and methods used to obtain defensible, interpretable data.

This document provides appropriate QA procedures and QC measures to be applied for analysis of remedial investigation samples from the Tonawanda Landfill Operable Unit FUSRAP Site and to describe the following items:

- The organization and responsibilities of key individuals on ARSEC's project team and the ARS laboratory;
- QA objectives;
- Analytical laboratory procedures;
- Laboratory custody procedures;
- Equipment Calibration and maintenance
- Data reduction, validation, and reporting;
- Internal QC checks;
- QA performance and system audits;
- Preventive maintenance procedures and schedules;
- Data assessment and presentation;
- Nonconformance and Corrective actions

The organization for the projects is designed to provide clear lines of responsibility and authority. This control structure provides for the following:

- Identifying lines of communication and coordination;
- Monitoring project schedules and performance;
- Managing key technical resources;
- Providing periodic progress reports;
- Coordinating support functions such as laboratory analysis and data management; and Rectifying deficiencies.

American Radiation Services, Inc. (dba ARS International), the majority member of ARSEC, will provide the offsite radioanalytical services for this Task Order. TestAmerica Laboratories (TA) will provide the standard chemistry services. Both laboratories participate in the DOD Environmental Laboratory Approval Program (DOD ELAP) and are accredited by the National Environmental Laboratory Accreditation Program (NELAP). Laboratory personnel providing services in support of this project will perform work in strict compliance with the scope of work (SOW) for the activity. Laboratory QA personnel (independent of the project QA personnel) will have the authority to review, audit, document compliance, identify deficiencies, and recommend corrective actions and will have sufficient authority, organizational freedom, and ability to:

- Identify QA problems;
- Stop Work if necessary;
- Initiate, recommend, or provide solutions to QA problems through designated channels;

- Ensure that program activities, including processing of information, deliverables, and installation or use of equipment, are reviewed in accordance with QA objectives;
- Ensure that deficiencies and non-conformances are corrected; and
- Ensure that further processing, delivery, or use of data is controlled until the proper disposition of a non-conformance, deficiency, or unsatisfactory condition.

2.0 ORGANIZATION AND RESPONSIBILITIES - OFF-SITE LABORATORIES

American Radiation Services, Inc. (ARS) of Port Allen, Louisiana is responsible for performing laboratory analyses of environmental samples for radiological parameters on this project. ARS will subcontract the standard chemistry analyses to TestAmerica Laboratories (TA) of Earth City, Missouri. Both laboratories participate in the DOD Environmental Laboratory Accreditation Program (DOD ELAP) and are accredited by the National Environmental Laboratory Accreditation Program (NELAP).

The functional roles for ARS and for ARS oversight of the subcontracted analyses are described in this subsection. From the project perspective, the structure is designed to facilitate information exchange between the ARS laboratory, USACE and ARSEC project team members. Information exchanges include planning, technical requirements, schedules, sample identification; preservation procedures; sample container requirements; sample collection procedures; decontamination protocols; and sample labeling, packing, holding times, and shipping.

2.1 Technical Manager

The ARS Vice President of Laboratory Services, Virgene Ideker-Mulligan (phone: 225-381-2991), will be the Technical Manager and the Data Management Coordinator. She will ensure that project needs are identified to ARS laboratory personnel and to the TA laboratory. She will ensure that the laboratories understand and conform with elements of this QAPP as they relate to their activities. She will provide direction/support for administrative and technical project staff, interface with laboratories on technical issues and overall QA oversight for analytical data.

2.2 Laboratory Project Manager

The ARS laboratory Project Manager (PM), Shonda Joshua (phone: 225-381-2991), will schedule project analytical requirements, monitor analytical status/deadlines, approve laboratory reports, and coordinate data revisions/corrections and re-submittal of packages to project staff. She will be the primary point of contact (POC) for ARSEC project personnel.

2.3 Laboratory QA Coordinator

The ARS laboratory QA Officer (LQAO), Tony Byrd (phone: 225-381-2991), reports to the Vice President for Laboratory Services and is independent of daily operation and production requirements. Therefore, the LQAO is able to evaluate data objectively and perform assessments without production influence. The LQAO has authority to stop work if systems are sufficiently out of control to compromise the integrity of the data generated.

The LQAO has documented training and/or experience in QA/QC procedures; knowledge of quality systems as defined by the DOD Quality Systems Manual (QSM); and a general knowledge of the analytical test methods for which data review is performed.

The LQAO (and/or designee) is responsible for:

- Defining and implementing the quality system;

- Developing and maintaining a pro-active program for prevention and detection of improper, unethical, or illegal practices (e.g., single- or double-blind proficiency testing studies, electronic data audits, maintaining documents that identify appropriate and inappropriate laboratory and data manipulation practices);
- Ensuring continuous improvement of laboratory procedures via training, control charts, proficiency testing studies, internal audits, and external audits;
- Coordinating the laboratory's participation in state and Federal certification programs;
- Scheduling the review and distribution and maintaining distribution records of controlled documents, including standard operating procedures;
- Reviewing Requests For Proposal to ensure compliance with required QA/QC practices;
- Facilitating external audits;
- Overseeing or conducting internal audits of the entire operation annually (technical, system, data, electronic);
- Coordinating and preparing external and internal audit responses and corrective actions;
- Managing the laboratory's participation in proficiency testing studies;
- Reviewing non-conformances and approving corrective actions;
- Reviewing and updating control chart QC limits per established procedures;
- Ensuring that Method Detection Limit (MDL) studies are analyzed per requirements;
- Managing the reference standards used in the calibration and/or verification of support equipment (e.g., weights, thermometers, balances);
- Revising the LQAP annually in accordance with industry standards;
- Maintaining an archival system for data records;
- Maintaining technical and QA training records including employee demonstrations of capability; and
- Ensuring subcontract laboratories conform to all contractual and quality requirements.

2.4 Information Systems Manager

The laboratory Information Systems Manager reports to the Chief Administrative Officer (CAO) and supports the Laboratory Information Management System (LIMS) and network, which serves the needs of the technical, business and management functions of the laboratory.

2.5 Laboratory Analysts

ARS Laboratory Analysts have the following QA/QC responsibilities:

- Maintaining familiarity with, and conforming to, the procedures and policies contained in the LQAP;
- Conducting routine maintenance, standardization, and calibration of instruments and other analytical equipment;

- Reviewing analytical results with the Laboratory PM; and
- Reporting irregular results or practices to the Laboratory PM.

2.6 Sample Custodians

ARS laboratory Sample Custodians will receive samples from the field, sign and date Chain-of-Custody forms, record the date and time of sample receipt, perform a radioactive survey on the shipping and sample containers, and record the condition of both shipping containers and sample containers.

Sample Custodians will verify and record agreement with information on sample documents. The Sample Custodian will record the problems/inconsistencies for the samples, complete a “Discrepant Sample Receipt Report” form and submit the form to Laboratory PM to resolve the discrepancy. The Sample Custodian will also label samples with laboratory sample numbers, and place samples and spent samples into appropriate storage and/or secure areas in accordance with laboratory standard operating procedures.

2.7 Subcontracted Laboratory Services

The TestAmerica laboratory, which the ARS laboratory employs for providing chemical analyses for this project, will maintain its own internal quality assurance system. The TestAmerica Quality Assurance Program must meet the standards defined in the DOD QSM and the ARS Laboratory Quality Assurance Program and shall have been audited by the DOD ELAP. ARS will maintain records of the subcontracted laboratory’s quality assurance system and ARS shall be responsible to the USACE for TestAmerica’s work.

3.0 DATA QUALITY OBJECTIVES

The overall QA objective for laboratory analysis on this project is to provide legally defensive results by implementing procedures for Chain-of-Custody, analysis and reporting of physical/chemical and radiological data. Specific procedures for Chain-of-Custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal QC, audits, preventive maintenance of equipment and corrective action are described in other sections of this QAPP. DQOs for analysis of Site remedial investigation samples are presented below.

3.1 Requirements for Data Quality Objectives

DQOs are designed to address the data requirements of a project and should include the following elements:

Data Need Requirements:

- Data user perspective (i.e., risk, compliance, remedy, or responsibility) satisfied;
- Contaminant or characteristic of interest identified;
- Media of interest identified;
- Reference concentration of interest or other performance criteria (e.g., action level, compliance standard, decision level, design tolerance) identified.
- Analytical method (e.g., sample preparation, laboratory analysis, MDL and quantification limit, laboratory QA/QC) identified.

Appropriate Analysis Methods:

DQOs are qualitative and quantitative statements that specify the quality of data required to support decisions during pre-remediation activities. Overall, the objective is to assure that the analytical data meets qualitative standards for adequacy (i.e., how “good” is the data) and produces quantitative values to document/confirm compliance of the data with respect to reference standards or values. This requires that data meet certain basic characteristics of satisfactory usability (e.g., precision, accuracy, representativeness, completeness, comparability, and sensitivity of data) as well as be able to meet or exceed certain numerical standards or values such that the end user(s) can reasonably rely on the data.

The characteristics of precision, accuracy, representativeness, completeness and comparability (PARCC) are discussed in Sections 3.2 through 3.6, respectively. Details on how each of these characteristic requirements are calculated and implemented as part of the QA process are described in Section 7.0.

3.2 Precision

3.2.1 Definition

Precision is a measure of the degree to which two or more measurements are in agreement.

3.2.2 Laboratory Precision Objectives

Precision in the laboratory is assessed through the calculation of relative percent differences (RPDs) and relative standard deviations (RSDs) for two or more replicate samples. Precision can be expressed as standard deviation. The control limits will be at least as stringent as the Department of Defense Quality Systems Manual (DoD QSM).

3.3 Accuracy

3.3.1 Definition

Accuracy is the degree of agreement between observed and accepted reference values.

3.3.2 Laboratory Accuracy Objectives

Laboratory accuracy is assessed through the analysis of laboratory control samples (LCSs) and the determination of percent (%) recoveries. The equation to be used for accuracy in this project can be found in Section 7.0 of this QAPP. Accuracy control limits are given in the laboratory standard operating procedures. The control limits will be at least as stringent as the DoD QSM.

3.4 Completeness

3.4.1 Definition

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that would be expected under normal conditions.

3.4.2 Laboratory Completeness Objectives

Laboratory completeness is an indication of the amount of valid measurements made on a project. Laboratory completeness for this project will be greater than 90%.

3.5 Representativeness

3.5.1 Definition

Representativeness expresses the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

3.5.2 Measures to Ensure Representativeness of Laboratory Data

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing laboratory duplicated samples. The sampling network is designed to provide data representative of facility conditions.

3.6 Comparability

3.6.1 Definition

Comparability is an expression of the confidence with which one data set can be compared with another. Comparability is also dependent on similar QA objectives. USACE has indicated collection and laboratory analysis of duplicate/replicate samples are required for this project.

3.6.2 Measures to Ensure Comparability of Laboratory Data

Planned analytical data will be comparable when similar analytical methods are used and documented as defined by the QAPP. Comparability is also dependent on similar QA objectives.

3.7 Analytical Data Quality Objectives

Laboratory analysis of soil, groundwater and Investigation Derived Waste (IDW) samples will provide data with which decisions can be made and the success of project operations can be assessed in support of remedial investigation. Laboratory analyses will be conducted for samples of the media identified below for the purposes stated.

3.7.1 Soil Samples

Perform chemical and radiological analysis to determine extent of contamination.

3.7.1.1 Radiological Parameters for Soil and IDW Characterization samples

- Radiological Analysis will be performed on 132 Soil Borings (a total of 910 samples) from 6 Investigative Areas, the fence line and the ditch. **Table 3-1** defines the analytical parameters, test methods and the number of analyses for the radiological testing on the solid matrices.

Table 3-1. Radioanalytical Parameters for Solid Samples for the Tonawanda Landfill Operable Unit

Analytical Parameter	Test Method	Field Samples ^a	Field Duplicate Samples	Number MS/MSDs	Total Analyses ^b	Bottle Type ^c	Preservative
Ra-226	EPA 901.1(Gamma Spectroscopy)	910	46	N/A	956	1 L Wide Mouth	None
Ra-228	EPA 901.1(Gamma Spectroscopy)	910	46	N/A	956	NOTE: A minimum of 250 grams (~ 500 ml) is required for the radiochemistry analysis. The 1 L bottle does not have to be completely filled.	
Americium 241	EPA 901.1(Gamma Spectroscopy)	910	46	N/A	956		
Uranium 235,238	EPA 901.1 EPA 901.1(Gamma Spectroscopy)	910	46	N/A	956		
Isotopic Thorium (Th-228,	DOE EML-HASL 300 Th -01-RC -	910	46	N/A	1002		

Analytical Parameter	Test Method	Field Samples ^a	Field Duplicate Samples	Number MS/MSDs	Total Analyses ^b	Bottle Type ^c	Preservative
Th-230, Th-232)	Eichrom mod						

^aSample numbers are based on information provided in the SOW by USACE

^bEstimates may be adjusted as additional data become available

^cSolid Radiological Samples can all be collected in one bottle.

- Laboratory analytical batches will be no greater than 20 samples per batch. Laboratory Quality Control samples will be used based upon the SOW requirements, the test method and guidelines established in Multi-Agency Radiological Laboratory Analytical Protocol (MARLAP) Chapter 18 and the DOD QSM.
- Quality Control Samples for the Gamma Spectroscopy analysis are run with each batch of samples. The control samples consist of a blank, a source and a source duplicate analysis. The source consists of a prepared geometry containing Am-241 at 59.5 keV, Cs-137 at 661.7 keV, and Co-60 at 1332.5 keV.
- **Table 3-2** delineates the Quality Control Samples and the Acceptance Criteria that will be used by ARS for the isotopic thorium analysis of these samples. The purpose of each Quality Control Sample is defined below.
 - Reagent Blank: A reagent blank consists of the reagents used in the procedure without the target analyte or sample matrix and carried through all steps of the procedure to determine whether any radiological contamination is introduced through the reagents.
 - Laboratory Replicate: A laboratory replicate is two or more aliquots of the sample taken after homogenization. The results of the laboratory replicates are used to determine laboratory precision. Since isotopic tracers and chemical carriers are used for the analyses required, Laboratory Replicates will be used in place of the Matrix Spike/Matrix Spike Duplicate (MS/MSD) as defined in MARLAP 18.4.3 and the DOD QSM Section D.4.
 - Laboratory Control sample: The LCS is a clean matrix that is spiked with the target analyte. It is analyzed in the same manner as the samples. The LCS provides for an evaluation of the measurement uncertainty.
 - Tracers:
 - For isotopic analysis of Thorium, a radioactive tracer will be used to determine the yield. The Thorium tracer is Thorium-229.
 - A low yield is an indication of problems with the procedure, including matrix interference, incomplete chemical separation or missing a step in the procedure. Variability in temperature, concentration and time can also affect yields.

Table 3-2. Radiochemistry Quality Control Samples and Acceptance Criteria

QC Sample	Frequency	Acceptance Criteria
Reagent Blank	1 per batch	< MDA
Laboratory Replicate	1 per batch	% Difference < 10%
Laboratory Control Sample	1 per batch	75% - 125% of known
Isotopic Tracer	Every Isotopic sample	30% - 110% of known

- Minimum Detectable Activities (MDA) limits for the radiological constituents have been defined in the SOW and are shown in **Table 3-3**.

Table 3-3. Minimum Detectable Activities for Soil

Radiological Parameter	MDA (pCi/g)
Radium 226	0.5
Radium 228	0.5
Americium 241	0.5
Uranium 235,238	0.5
Isotopic Thorium	0.5

3.7.1.2 Chemical Parameters for Soil Samples

- 10% of the soil samples, including the associated field QC samples, shall be analyzed for the chemical parameters defined in **Table 3-4**.

Table 3-4. Chemical Parameters for Solid Samples for the Tonawanda Landfill Operable Unit

Analytical Parameter	Test Method	Field Samples	Field Duplicate Samples	Field Blank Samples	Number MS/MSD	Total Analyses	Bottle Type	Preserv.
Total VOCs	SW-846 8260	91	5	5	5	106	4 oz (125 ml) WM glass NO HEADSPACE	None, <6°C
TCLP Volatile Organic Compounds (VOCs)	EPA SW-846 1311 (ZHE) followed by SW-846 8260	91	5	N/A	5	101	4 oz (125 ml) WM glass NO HEADSPACE	None, <6°C
Total SVOCs	SW-846 8270	91	5	5	5	106	8 oz (250 mL) WM glass NOTE: All of the analyses can be combined in one bottle	None, <6°C
TCLP Semi-Volatile Organic Compounds (SVOCs)	EPA SW-846 1311 followed by EPA SW-846 8270	91	5	N/A	5	101		
Target Analyte List (TAL) Metals	EPA SW-846 6010/6020/7471	91	5	5	5	106		
TCLP Metals	EPA SW-846 1311 followed by SW-846 6010/6020/7471	91	5	N/A	5	101		
Pesticides	EPA SW-846 8081	91	5	5	5	106		
TCLP Pesticides	EPA SW-846 1311 followed by SW-846 8081	91	5	N/A	5	101		
PCBs	EPA SW-846 8082	91	5	5	5	106		

- The DOD QSM Version 4.1 Appendix G delineates the Quality Control Samples and the Acceptance Criteria that will be used by ARS for the analysis.

- Field Quality Assurance samples for the non-radiological analyses include Field Duplicates and Field Blanks taken at a frequency of one (1) per every 20 samples at an Investigative Area or one (1) per Investigative area if fewer than 20 samples are taken. The field duplicates and field blanks will be analyzed for all parameters. Field duplicates indicate the precision of the sampling and the heterogeneity of the sample. Field blanks are analyzed to determine if cross contamination occurred during the sampling process.
- Holding Times for Chemical Parameters are defined in **Table 3-5** below:

Table 3-5. Chemical Parameter Holding Times

Chemical Parameter	Holding Time
VOC	14 days
SVOC	14 days to extraction 40 days after extraction
Metals (except Mercury)	180 days
Mercury	28 days
Pesticides	7 days to extraction 40 days after extraction
PCBs	No Holding Time

- Instrument Detection Limits (IDLs) and Practical Quantitation Limits (PQLs) for the specified analyses are delineated in **Table 3-6 to Table 3-10** below.

Table 3-6. Metals Instrument Detection Limits (IDLs) for Soil/Sed/Solid and IDW

Method	Analyte	CAS Number	IDL (µg/kg)
SW-846 6010/6020/7471	Aluminum	7429-90-5	3000
	Antimony	7440-36-0	400
	Arsenic	7440-38-2	1000
	Barium	7440-39-3	400
	Beryllium	7440-41-7	100
	Boron	7440-42-8	3000
	Cadmium	7440-43-9	200
	Calcium	7440-70-2	20000
	Chromium	7440-47-3	600
	Cobalt	7440-48-4	200
	Copper	7440-50-8	200
	Iron	7439-89-6	5000
	Lead	7439-92-1	400
	Lithium	7439-93-2	2000
	Magnesium	7439-95-4	3000
	Manganese	7439-96-5	3000
	Mercury	7439-97-6	0.99
	Nickel	7440-02-0	100
	Potassium	7440-09-7	16000
	Selenium	7782-49-2	500
	Silver	7440-22-4	40
Sodium	7440-23-5	16000	
Thallium	7440-28-0	40	
Vanadium	7440-62-2	400	
Zinc	7440-66-6	400	

Table 3-7. Volatile Organic Analysis Practical Quantitation Limits (PQLs) in Soil/Sed/Solid and IDW

Method	Analyte	CAS Number	PQL (µg/kg)
SW-846 8260C	1,1,1,2-Tetrachloroethane	630-20-6	1
	1,1,1-Trichloroethane	71-55-6	1
	1,1,2,2-Tetrachloroethane	79-34-5	1
	1,1,2-Trichloroethane	79-00-5	1
	1,1-Dichloroethane	75-34-3	1
	1,1-Dichloroethylene	75-34-4	1
	1,1-Dichloropropene	563-58-6	1
	1,2,3-Trichlorobenzene	87-61-6	1
	1,2,3-Trichloropropane	96-18-4	1
	1,2,4-Trichlorobenzene	120-82-1	1
	1,2,4-Trimethylbenzene	95-63-6	1
	1,2-Dibromo-3-chloropropane	96-12-8	1
	1,2-Dibromoethane	106-93-4	1
	1,2-Dichlorobenzene	95-50-1	1
	1,2-Dichloroethane	107-06-2	1
	1,2-Dichloroethylene (total)	540-59-0	1
	1,2-Dichloropropane	78-87-5	1
	1,3,5-Trimethylbenzene	108-67-8	1
	1,3-Dichlorobenzene	541-73-1	1
	1,3-Dichloropropane	142-28-9	1
	1,4-Dichlorobenzene	106-46-7	1
	1,4-Dioxane	123-91-1	50
	2,2-Dichloropropane	594-20-7	1
	2-Butanone	78-93-3	5
	2-Chloro-1,3-butadiene	126-99-8	1
	2-Chloroethylvinyl ether	110-75-8	5
	2-Chlorotoluene	95-49-8	1
	2-Hexanone	591-78-6	5
	2-Methylpentane	107-83-5	1
	2-Nitropropane	79-46-9	5
	4-Chlorotoluene	106-43-4	1
	4-Isopropyltoluene	99-87-6	1
	4-Methyl-2-pentanone	108-10-1	5
	Acetone	67-64-1	5
	Acetonitrile	75-05-8	25
	Acrolein	107-02-8	10
	Acrylonitrile	107-13-1	5
	Allyl Chloride	107-05-1	5
	Benzene	71-43-2	1
	Benzyl chloride	100-44-7	5
	Bromobenzene	108-86-1	1
	Bromochloromethane	74-97-5	1
	Bromodichloromethane	75-27-4	1
	Bromoform	75-25-2	1
	Bromomethane	74-83-9	1
	Carbon disulfide	75-15-0	5
	Carbon tetrachloride	56-23-5	1
	Chlorobenzene	108-90-7	1
	Chloroethane	75-00-3	1
	Chloroform	67-66-3	1
Chloromethane	74-87-3	1	
Cyclohexane	110-82-7	2	

Method	Analyte	CAS Number	PQL (µg/kg)
SW-846 8260C	Cyclohexanone	108-94-1	50
	Dibromochloromethane	124-48-1	1
	Dibromomethane	74-95-3	1
	Dichlorodifluoromethane	75-71-8	1
	Ethyl acetate	141-78-6	10
	Ethyl ether	60-29-7	1
	Ethyl methacrylate	97-63-2	5
	Ethylbenzene	100-41-4	1
	Hexachlorobutadiene	87-68-3	1
	Hexane	110-54-3	10
	Iodomethane	74-88-4	5
	Isobutyl alcohol	78-83-1	50
	Isopropylbenzene	98-82-8	1
	Methacrylonitrile	126-98-7	5
	Methyl acetate	79-20-9	10
	Methyl methacrylate	80-62-6	5
	Methylcyclohexane	108-87-2	2
	Methylene chloride	75-09-2	5
	Napthalene	91-20-3	1
	Pentachloroethane	76-01-7	5
	Propionitrile	107-12-0	5
	Styrenne	100-42-5	1
	Tetrachloroethylene	127-18-4	1
	Tetrahydrofuran	109-99-9	5
	Toluene	108-88-3	1
	Trichloroethylene	79-01-6	1
	Trichlorofluoromethane	75-69-4	1
	Trichlorotrifluoroethane	76-13-1	5
	Vinyl acetate	108-05-4	5
	Vinyl chloride	75-01-4	1
	Xylenes (total)	1330-20-7	1
	Bis(2-Chloroisopropyl) ether	108-60-1	5
	Cis-1,2-Dichloroethylene	156-59-2	1
	Cis-1,3-Dichloropropylene	10061-01-5	1
	Cis-1,4-Dichloro-2-butene	1476-11-5	5
	M,p-Xylenes	179601-23-1	2
	n-Butyl alcohol	71-36-3	50
	n-Butylbenzene	104-51-8	1
	n-Propylbenzene	103-65-1	1
	o-Xylene	95-47-6	1
	sec-Butylbenzene	135-98-8	1
	tert-Butyl methyl ether	1634-04-4	1
	tert-Butylbenzene	98-06-6	1
	trans-1,2-Dichloroethylene	156-60-5	1
	trans-1,3-Dichloropropylene	10061-02-6	1
	trans-1,4-Dichloro-2-butene	110-57-6	5

Table 3-8. Semi-Volatile Organic Analysis Practical Quantitation Limits (PQLs) in Soil/Sed/Solid and IDW

Method	Analyte	CAS Number	PQL (µg/kg)
SW-846 8270D	1,2-Dichlorobenzene	95-50-1	330
	1,2-Diphenylhydrazine	122-66-7	330
	1,3-Dichlorobenzene	541-73-1	330
	1,4-Dichlorobenzene	106-46-7	330
	2,4,6-Trichlorophenol	88-06-2	330
	2,4-Dichlorophenol	120-83-2	330
	2,4-Dimethylphenol	105-67-9	330
	2,4-Dinitrophenol	51-28-5	330
	2,4-Dinitrotoluene	121-14-2	330
	2,6-Dinitrotoluene	606-20-2	330
	2-Chloronaphthalene	91-58-7	330
	2-Chlorophenol	95-57-8	330
	2-Methylnaphthalene	91-57-6	330
	2-Methylphenol	95-48-7	330
	2-Nitroaniline	88-74-4	330
	2-Nitrophenol	88-75-5	330
	3,3'-Dichlorobenzidine	91-94-1	330
	4-Methylphenol	106-44-5	330
	3-Nitroaniline	99-09-2	330
	4,6-Dinitro-2-methylphenol	534-52-1	330
	4-Bromophenyl phenyl ether	101-55-3	330
	4-Chloro-3-methylphenol	59-50-7	330
	4-Chloroaniline	106-47-8	330
	4-Chlorophenyl phenyl ether	7005-72-3	330
	4-Nitroaniline	100-01-6	330
	4-Nitrophenol	100-02-7	330
	Acenaphthene	83-32-9	330
	Acenaphthylene	208-96-8	330
	Anthracene	120-12-7	330
	Benz(a)anthracene	56-55-3	330
	Benzo(a)pyrene	50-32-8	330
	Benzo(b)fluoranthene	205-99-2	330
	Benzo(g,h,i)perylene	191-24-2	330
	Benzo(k)fluoranthene	207-08-9	330
	Benzoic acid	65-85-0	330
	Benzyl alcohol	100-51-6	330
	Bis(2-chlorethoxy) methane	111-91-1	330
	Bis(2-chloroethyl) ether	111-44-4	330
	Bis(2-chloroisopropyl) ether	108-60-1	330
	Bis(2-ethylhexyl) phthalate	117-81-7	330
	Butyl benzyl phthalate	85-68-7	330
	Carbazole	86-74-8	330
	Chrysene	218-01-9	330
	Dibenz(a,h)anthracene	53-70-3	330
	Dibenzofuran	132-64-9	330
	Diethyl phthalate	84-66-2	330
	Dimethyl phthalate	131-11-3	330
	Di-n-butyl phthalate	84-74-2	330
	Di-n-octyl phthalate	117-84-0	330
	Hexachlorobutadiene	87-68-3	330
	Fluoranthene	206-44-0	330

Method	Analyte	CAS Number	PQL (µg/kg)
SW-846 8270D	Fluorene	86-73-7	330
	Hexachlorobenzene	118-74-1	330
	Hexachloroethane	67-72-1	330
	Indeno(1,2,3-cd)pyrene	193-39-5	330
	Isophorone	78-59-1	330
	Naphthalene	91-20-3	330
	Nitrobenzene	98-95-3	330
	N-Nitrosodi-n-propylamine	621-64-7	330
	N-Nitrosodiphenylamine	86-30-6	330
	2,4,5-Trichlorophenol	95-95-4	330
	Pentachlorophenol	87-66-5	330
	Phenanthrene	85-01-8	330
	Phenol	108-95-2	330
	Pyrene	129-00-0	330
Hexachlorocyclopentadiene	77-47-4	330	

Table 3-9. Pesticide Analysis Practical Quantitation Limits (PQLs) in Soil/Sed/Solid and IDW

Method	Analyte	CAS Number	PQL (µg/kg)
SW-846 8081A	4,4'-DDD	72-54-8	3.0
	4,4'-DDE	72-55-9	3.0
	4,4'-DDT	50-29-3	3.0
	Aldrin	309-00-2	3.0
	Dieldrin	60-57-1	3.0
	Endosulfan I	959-98-8	3.0
	Endosulfan II	33213-65-9	3.0
	Endosulfan sulfate	1031-07-8	3.0
	Endrin	72-20-8	3.0
	Endrin aldehyde	7421-93-4	3.0
	Endrin ketone	53494-70-5	3.0
	Heptachlor	76-44-8	3.0
	Heptachlor epoxide	1024-57-3	3.0
	Methoxychlor	72-43-5	3.0
	Toxaphene	8001-35-2	3.0
	Alpha-BHC	319-84-6	3.0
	Alpha-Chlordane	5103-71-9	3.0
	Beta-BHC	319-85-7	3.0
	Delta-BHC	319-86-8	3.0
	Gamma-BHC (Lindane)	58-89-9	3.0
Gamma-Chlordane	5103-74-2	3.0	

Table 3-10. PCB Analysis Practical Quantitation Limits (PQLs) in Soil/Sed/Solid and IDW

Method	Analyte	CAS Number	PQL (µg/kg)
SW-846 8082	Aroclor-1016	12674-11-2	33.0
	Aroclor-1221	11104-28-2	67.0
	Aroclor-1232	11141-16-5	33.0
	Aroclor-1242	53469-21-9	33.0
	Aroclor-1248	12672-29-6	33.0
	Aroclor-1254	11097-69-1	33.0
	Aroclor-1260	11096-82-5	33.0

3.7.2 Groundwater Samples

- A maximum of 14 Temporary Well Points (TWPs) shall be placed within soil-sample boreholes. The TWPs shall be sampled and analyzed for the parameters defined in **Table 3-11**. The samples will be filtered at the laboratory and the analyses shall be performed on filtered and unfiltered groundwater samples.

Table 3-11. Sampling and Analytical Parameters for TWP Groundwater

Analytical Parameter	Test Method	Field Samples	Field Duplicate Samples	Number MS/MSD Samples	Total Analyses (Filtered and Unfiltered)	Bottle Type	Preser.
Isotopic Uranium (234,235,238)	HASL 300 – Alpha Spectroscopy – Eichrom Modification	14	1	N/A	30	32 oz. (1L) HDPE	HNO ₃ pH<2
Isotopic Thorium (228,230,232)	HASL 300 – Alpha Spectroscopy – Eichrom Modification	14	1	N/A	30	32 oz. (1L) HDPE	HNO ₃ pH<2
Radium 226	EPA 903.1	14	1	N/A	30	32 oz. (1L) HDPE	HNO ₃ pH<2
Radium 228	EPA 904	14	1	N/A	30	32 oz. (1L) HDPE	HNO ₃ pH<2
Target Analyte List (TAL) Metals	EPA SW-846 6010 or 6020 & 7471	14	1	1	32	16 oz (500 mL) HDPE	HNO ₃ pH<2
Anions (Cl,F,NO ₂ , NO ₃ , o-PO ₄ , SO ₄)	EPA SW-846 9056/EPA 300 Series	14	1	N/A	30	32 oz. (1L) HDPE	None, <6°C
Total Dissolved Solids (Filtered Only)	EPA 160.1	14	1	N/A	15	32 oz (1 L) HDPE	None, <6°C
Alkalinity (Carbonate - Bicarbonate)	EPA 310.2	14	1	N/A	30	32 oz (1 L) HDPE	None, <6°C

- Laboratory analytical batches will be no greater than 20 samples per batch. Laboratory Quality Control samples will be used based upon the SOW requirements, the test method and guidelines established in *USEPA SW-846 Test Methods for Evaluating Solid Waste Physical/Chemical Methods* and the DOD QSM.
- Minimum Detectable Activities (MDAs), Instrument Detection Limits (IDLs) and Practical Quantitation Limits (PQLs) for the Groundwater Analysis are found in **Tables 3-12 to 3-14** below.

Table 3-12. Minimum Detectable Activities for Water

Radiological Parameter	MDA (pCi/L)
Uranium 234	0.2
Uranium 235	0.2
Uranium 238	0.2
Thorium-228	0.2
Thorium-230	0.2
Thorium-232	0.2
Radium 226	0.5
Radium 228	0.5

Table 3-13. Wet Chemistry Method Detection Limits (MDLs), Practical Quantitation Limits (PQLs), Bottle Types, Preservation and Holding Times for Water

Method	Analyte	CAS Number	MDL (µg/L)	PQL (µg/L)	Bottle Type	Preserv.	Holding Time
EPA 310.2	Alkalinity as CaCO ₃	N/A	725	1000	32 oz (1 L) HDPE	None, <6°C	None
EPA 160.1	Total Dissolved Solids	N/A	2000	N/A	32 oz (1 L) HDPE	None, <6°C	None
EPA SW-846 9056/EPA 300 Series	Chloride	16887-00-6	66	200	32 oz (1 L) HDPE	None, <6°C	28 days
	Fluoride	16984-48-8	33	100			None
	Nitrate	14797-55-8	33	100			48 hrs
	Nitrite	14797-65-0	33	100			None
	Ortho-phosphate Sulfate	14808-79-8	66	200			None
			100	400			28 days

Table 3-14. Metals Instrument Detection Limits (IDLs) for Water

Method	Analyte	CAS Number	IDL (µg/L)
SW-846 6010/6020/7471	Aluminum	7429-90-5	5
	Antimony	7440-36-0	0.5
	Arsenic	7440-38-2	1.5
	Barium	7440-39-3	0.5
	Beryllium	7440-41-7	0.1
	Boron	7440-42-8	4
	Cadmium	7440-43-9	0.11
	Calcium	7440-70-2	20
	Chromium	7440-47-3	1
	Cobalt	7440-48-4	0.1
	Copper	7440-50-8	0.2
	Iron	7439-89-6	10
	Lead	7439-92-1	0.5
	Lithium	7439-93-2	2
	Magnesium	7439-95-4	5
	Manganese	7439-96-5	1
	Mercury	7439-97-6	0.03
	Nickel	7440-02-0	0.5
	Potassium	7440-09-7	80
	Selenium	7782-49-2	1
	Silver	7440-22-4	0.2
	Sodium	7440-23-5	80
	Thallium	7440-28-0	0.3
Vanadium	7440-62-2	3	
Zinc	7440-66-6	2.6	

3.7.3 Investigative Derived Waste (IDW)

IDW samples will be analyzed for waste characterization parameters to comply with the acceptance criteria of the disposal facilities. At a minimum, the IDW solids will be analyzed for the parameters defined for soil analysis in Section 3.7.1. The IDW liquid samples will be analyzed for radiological parameters as defined in Table 3-12 and for chemical parameters as per the following tables:

Table 3-15. Chemical Parameters for IDW Liquids

Analytical Parameter	Test Method
Total VOCs	SW-846 8260
Total SVOCs	SW-846 8270
Target Analyte List (TAL) Metals	EPA SW-846 6010/6020/7471
Pesticides	EPA SW-846 8081
PCBs	EPA SW-846 8082
Ignitability	EPA SW-846 1010A/1020A
Corrosivity	EPA SW-846 9040C
Reactivity	No required methods

Table 3-16. Metals Instrument Detection Limits (IDLs) for IDW Liquids

Method	Analyte	CAS Number	IDL (µg/L)
SW-846 6010/6020/7471	Aluminum	7429-90-5	5
	Antimony	7440-36-0	0.5
	Arsenic	7440-38-2	1.5
	Barium	7440-39-3	0.5
	Beryllium	7440-41-7	0.1
	Boron	7440-42-8	4
	Cadmium	7440-43-9	0.11
	Calcium	7440-70-2	20
	Chromium	7440-47-3	1
	Cobalt	7440-48-4	0.1
	Copper	7440-50-8	0.2
	Iron	7439-89-6	10
	Lead	7439-92-1	0.5
	Lithium	7439-93-2	2
	Magnesium	7439-95-4	5
	Manganese	7439-96-5	1
	Mercury	7439-97-6	0.03
	Nickel	7440-02-0	0.5
	Potassium	7440-09-7	80
	Selenium	7782-49-2	1
	Silver	7440-22-4	0.2
	Sodium	7440-23-5	80
	Thallium	7440-28-0	0.3
Vanadium	7440-62-2	3	
Zinc	7440-66-6	2.6	

Table 3-17. Volatile Organic Analysis Practical Quantitation Limits (PQLs) in IDW Liquids

Method	Analyte	CAS Number	PQL(µg/L)
SW-846 8260C	1,1,1,2-Tetrachloroethane	630-20-6	1
	1,1,1-Trichloroethane	71-55-6	1
	1,1,2,2-Tetrachloroethane	79-34-5	1
	1,1,2-Trichloroethane	79-00-5	1
	1,1-Dichloroethane	75-34-3	1
	1,1-Dichloroethylene	75-34-4	1
	1,1-Dichloropropene	563-58-6	1
	1,2,3-Trichlorobenzene	87-61-6	1
	1,2,3-Trichloropropane	96-18-4	1
	1,2,4-Trichlorobenzene	120-82-1	1
	1,2,4-Trimethylbenzene	95-63-6	1
	1,2-Dibromo-3-chloropropane	96-12-8	1
	1,2-Dibromoethane	106-93-4	1
	1,2-Dichlorobenzene	95-50-1	1
	1,2-Dichloroethane	107-06-2	1
	1,2-Dichloroethylene (total)	540-59-0	1
	1,2-Dichloropropane	78-87-5	1
	1,3,5-Trimethylbenzene	108-67-8	1
	1,3-Dichlorobenzene	541-73-1	1
	1,3-Dichloropropane	142-28-9	1
	1,4-Dichlorobenzene	106-46-7	1
	1,4-Dioxane	123-91-1	50
	2,2-Dichloropropane	594-20-7	1
	2-Butanone	78-93-3	5
	2-Chloro-1,3-butadiene	126-99-8	1
	2-Chloroethylvinyl ether	110-75-8	5
	2-Chlorotoluene	95-49-8	1
	2-Hexanone	591-78-6	5
	2-Methylpentane	107-83-5	1
	2-Nitropropane	79-46-9	5
	4-Chlorotoluene	106-43-4	1
	4-Isopropyltoluene	99-87-6	1
	4-Methyl-2-pentanone	108-10-1	5
	Acetone	67-64-1	5
	Acetonitrile	75-05-8	25
	Acrolein	107-02-8	5
	Acrylonitrile	107-13-1	5
	Allyl Chloride	107-05-1	5
	Benzene	71-43-2	1
	Benzyl chloride	100-44-7	5
	Bromobenzene	108-86-1	1
	Bromochloromethane	74-97-5	1
	Bromodichloromethane	75-27-4	1
	Bromoform	75-25-2	1
	Bromomethane	74-83-9	1
	Carbon disulfide	75-15-0	5
	Carbon tetrachloride	56-23-5	1
	Chlorobenzene	108-90-7	1
	Chloroethane	75-00-3	1
	Chloroform	67-66-3	1
Chloromethane	74-87-3	1	
Cyclohexane	110-82-7	1	

Method	Analyte	CAS Number	PQL (µg/kg)
SW-846 8260C	Cyclohexanone	108-94-1	50
	Dibromochloromethane	124-48-1	1
	Dibromomethane	74-95-3	1
	Dichlorodifluoromethane	75-71-8	1
	Ethyl acetate	141-78-6	10
	Ethyl ether	60-29-7	1
	Ethyl methacrylate	97-63-2	5
	Ethylbenzene	100-41-4	1
	Hexachlorobutadiene	87-68-3	1
	Hexane	110-54-3	10
	Iodomethane	74-88-4	5
	Isobutyl alcohol	78-83-1	50
	Isopropylbenzene	98-82-8	1
	Methacrylonitrile	126-98-7	5
	Methyl acetate	79-20-9	10
	Methyl methacrylate	80-62-6	5
	Methylcyclohexane	108-87-2	2
	Methylene chloride	75-09-2	5
	Napthalene	91-20-3	1
	Pentachloroethane	76-01-7	5
	Propionitrile	107-12-0	5
	Styrene	100-42-5	1
	Tetrachloroethylene	127-18-4	1
	Tetrahydrofuran	109-99-9	5
	Toluene	108-88-3	1
	Trichloroethylene	79-01-6	1
	Trichlorofluoromethane	75-69-4	1
	Trichlorotrifluoroethane	76-13-1	5
	Vinyl acetate	108-05-4	5
	Vinyl chloride	75-01-4	1
	Xylenes (total)	1330-20-7	1
	Bis(2-Chloroisopropyl) ether	108-60-1	5
	Cis-1,2-Dichloroethylene	156-59-2	1
	Cis-1,3-Dichloropropylene	10061-01-5	1
	Cis-1,4-Dichloro-2-butene	1476-11-5	5
	M,p-Xylenes	179601-23-1	2
	n-Butyl alcohol	71-36-3	50
	n-Butylbenzene	104-51-8	1
	n-Propylbenzene	103-65-1	1
	o-Xylene	95-47-6	1
	sec-Butylbenzene	135-98-8	1
	tert-Butyl methyl ether	1634-04-4	1
	tert-Butylbenzene	98-06-6	1
	trans-1,2-Dichloroethylene	156-60-5	1
	trans-1,3-Dichloropropylene	10061-02-6	1
	trans-1,4-Dichloro-2-butene	110-57-6	5

Table 3-18. Semi-Volatile Organic Analysis Practical Quantitation Limits (PQLs) in IDW Liquids

Method	Analyte	CAS Number	PQL (µg/L)
SW-846 8270D	1,2-Dichlorobenzene	95-50-1	10
	1,2-Diphenylhydrazine	122-66-7	10
	1,3-Dichlorobenzene	541-73-1	10
	1,4-Dichlorobenzene	106-46-7	10
	2,4,6-Trichlorophenol	88-06-2	10
	2,4-Dichlorophenol	120-83-2	10
	2,4-Dimethylphenol	105-67-9	10
	2,4-Dinitrophenol	51-28-5	10
	2,4-Dinitrotoluene	121-14-2	10
	2,6-Dinitrotoluene	606-20-2	10
	2-Chloronaphthalene	91-58-7	10
	2-Chlorophenol	95-57-8	10
	2-Methylnaphthalene	91-57-6	10
	2-Methylphenol	95-48-7	10
	2-Nitroaniline	88-74-4	10
	2-Nitrophenol	88-75-5	10
	3,3'-Dichlorobenzidine	91-94-1	10
	4-Methylphenol	106-44-5	10
	3-Nitroaniline	99-09-2	10
	4,6-Dinitro-2-methylphenol	534-52-1	10
	4-Bromophenyl phenyl ether	101-55-3	10
	4-Chloro-3-methylphenol	59-50-7	10
	4-Chloroaniline	106-47-8	10
	4-Chlorophenyl phenyl ether	7005-72-3	10
	4-Nitroaniline	100-01-6	10
	4-Nitrophenol	100-02-7	10
	Acenaphthene	83-32-9	10
	Acenaphthylene	208-96-8	10
	Anthracene	120-12-7	10
	Benz(a)anthracene	56-55-3	10
	Benzo(a)pyrene	50-32-8	10
	Benzo(b)fluoranthene	205-99-2	10
	Benzo(g,h,i)perylene	191-24-2	10
	Benzo(k)fluoranthene	207-08-9	10
	Benzoic acid	65-85-0	10
	Benzyl alcohol	100-51-6	10
	Bis(2-chlorethoxy) methane	111-91-1	10
	Bis(2-chloroethyl) ether	111-44-4	10
	Bis(2-chloroisopropyl) ether	108-60-1	10
	Bis(2-ethylhexyl) phthalate	117-81-7	10
	Butyl benzyl phthalate	85-68-7	10
	Carbazole	86-74-8	10
	Chrysene	218-01-9	10
	Dibenz(a,h)anthracene	53-70-3	10
	Dibenzofuran	132-64-9	10
	Diethyl phthalate	84-66-2	10
	Dimethyl phthalate	131-11-3	10
	Di-n-butyl phthalate	84-74-2	10
	Di-n-octyl phthalate	117-84-0	10
	Hexachlorobutadiene	87-68-3	10
	Fluoranthene	206-44-0	10

Method	Analyte	CAS Number	PQL (µg/kg)
SW-846 8270D	Fluorene	86-73-7	10
	Hexachlorobenzene	118-74-1	10
	Hexachloroethane	67-72-1	10
	Indeno(1,2,3-cd)pyrene	193-39-5	10
	Isophorone	78-59-1	10
	Naphthalene	91-20-3	10
	Nitrobenzene	98-95-3	10
	N-Nitrosodi-n-propylamine	621-64-7	10
	N-Nitrosodiphenylamine	86-30-6	10
	2,4,5-Trichlorophenol	95-95-4	10
	Pentachlorophenol	87-66-5	10
	Phenanthrene	85-01-8	10
	Phenol	108-95-2	10
	Pyrene	129-00-0	10
	Hexachlorocyclopentadiene	77-47-4	10

Table 3-19. Pesticide Analysis Practical Quantitation Limits (PQLs) in IDW Liquids

Method	Analyte	CAS Number	PQL (µg/L)
SW-846 8081A	4,4'-DDD	72-54-8	0.10
	4,4'-DDE	72-55-9	0.10
	4,4'-DDT	50-29-3	0.10
	Aldrin	309-00-2	0.10
	Dieldrin	60-57-1	0.10
	Endosulfan I	959-98-8	0.10
	Endosulfan II	33213-65-9	0.10
	Endosulfan sulfate	1031-07-8	0.10
	Endrin	72-20-8	0.10
	Endrin aldehyde	7421-93-4	0.10
	Endrin ketone	53494-70-5	0.10
	Heptachlor	76-44-8	0.10
	Heptachlor epoxide	1024-57-3	0.10
	Methoxychlor	72-43-5	0.10
	Toxaphene	8001-35-2	0.10
	Alpha-BHC	319-84-6	0.10
	Alpha-Chlordane	5103-71-9	0.10
	Beta-BHC	319-85-7	0.10
	Delta-BHC	319-86-8	0.10
	Gamma-BHC (Lindane)	58-89-9	0.10
Gamma-Chlordane	5103-74-2	0.10	

Table 3-20. PCB Analysis Practical Quantitation Limits (PQLs) in IDW Liquids

Method	Analyte	CAS Number	PQL (µg/L)
SW-846 8082	Aroclor-1016	12674-11-2	33.0
	Aroclor-1221	11104-28-2	67.0
	Aroclor-1232	11141-16-5	33.0
	Aroclor-1242	53469-21-9	33.0
	Aroclor-1248	12672-29-6	33.0
	Aroclor-1254	11097-69-1	33.0
	Aroclor-1260	11096-82-5	33.0

4.0 LABORATORY OPERATIONS

The ARS laboratory will follow laboratory standard operating procedures for handling, identifying, and controlling samples, and Chain-of-Custody procedures to maintain the validity of the samples. A Laboratory Information Management System (LIMS) will be used for tracking samples from receipt through reporting of analytical results and excess sample disposal.

4.1 Sample Receipt

All samples will be delivered to the ARS Sample Receiving/Shipping Area. Upon receipt, the sample custodian will sign the Chain-of-Custody form (with date and time of receipt), thus assuming custody of the samples. External surveys of the sample shipping containers will be conducted. External exposure rate and count rate survey measurements must be at or below the maximum allowable levels before moving a shipping container to the inspection area.

After survey clearance, and the visual inspection of the Shipping Container shows no apparent sign of leakage, the sample shipping container(s) are moved to the Sample Inspection area (Radiological Controlled Area) and placed in a hood or within the airflow of a hood where the SC will perform a thorough examination of the shipping container(s).

If no issues were identified with the condition of the shipping container and exposure rate and removable contamination levels are within acceptable limits, the shipping containers will be opened for further inspection by the Sample Custodian (SC). Smears and a Count Rate Measurement of the inside surface of the shipping container and the external surface of individual sample containers are taken.

Upon survey clearance of sample containers, the SC will remove the samples from the shipping container and place them in a hood for inspection. All documents will be removed and inspected. The following information is recorded on the Sample Receipt Form:

- Sample Matrix
- Number of Samples Received
- Volume/weight of each sample
- Brief description of sample material
- Temperature
- Presence/absence of Custody Seals
- Condition of sample containers

Samples are logged in the Laboratory Information Management System where a unique SDG and ARS Sample IDs are assigned. A Sample Label is applied on each container within a SDG. Information includes the ARS Sample ID, Client ID, Client Name, the date of sample receipt, the analysis due date, storage location, the number of containers for a given sample and an Internal Chain of Custody barcode. A label for each analysis requested within an SDG is generated for attachment to the ARS Label Sheet. The label information includes the ARS Sample ID, Analysis Code, Client Name, the number of samples in the SDG requiring the analysis, the date of sample receipt and the analysis due date.

The SC will initiate a Discrepant Sample Receipt Report (DSRR) for discrepancies identified during the sample receiving process.

Samples for radiological or geotechnical analysis do not require temperature controls. However, samples for chemical analysis do have temperature controls and holding time (prior to analysis) constraints. ARS will store samples for chemical analyses in appropriate refrigerated units. All samples will be stored in controlled-access areas, accountability will be maintained, and provisions will be in place to address handling and potential contamination control issues.

4.2 Chain-of-Custody

The Laboratory Internal Chain of Custody (ICOC) is a system that records the movement of Samples and Sample aliquots throughout the laboratory. It is a continuous record of individuals in possession of samples or sample aliquots. When not in an individual's possession, it records the controlled zone where the sample or sample aliquot is located.

A Sample is in considered in custody if:

- It is in one's actual physical possession
- It is in one's view after being in one's physical possession
- It is one's physical possession and then locked or sealed so that no one can tamper with it; and/or
- It is kept in a secured area, restricted to authorized personnel only.

A barcoding system is utilized by ARS to track all samples and sample fractions throughout the laboratory processes.

4.3 Record Keeping

Data related to sample preparation and analysis, as well as observations by Laboratory Analysts, will be permanently recorded in bound laboratory notebooks. Laboratory notebook pages will be signed and dated daily by Laboratory Analysts. Corrections to notebook entries will be made by drawing a single line through the erroneous entry and writing the correct entry next to the one that was crossed out. Corrections will be initialed and dated by the Analyst.

4.4 Standard Operating Procedures (SOPs)

ARS maintains standard operating procedures that accurately reflect all phases of current laboratory activities including assessing data integrity, corrective actions, handling customer complaints and all test methods. Each SOP clearly indicates the effective date of the document, the revision number and the signature(s) of the approving authority.

The Standard Operating Procedures (SOP) and Plans of ARS fall into two categories; Operational and Administrative. Operational SOPs constitute the in-house methods for each test method performed by ARS and include processes that require step-by step instructions for performing hands-on operations. Included in Operational SOPs are ancillary processes (e.g. balance and temperature checks, preventive maintenance) integral to the support of method generated data. Administrative SOP and Plans document and record control procedures,

Information Technology (IT) and software configuration control procedures, quality assurance plans (QAP), health and safety plans (HSP), radiation protection plans (RPP), etc.

All Operational SOPs shall contain sections addressing all of the following items. Items that do not apply to a specific Operational SOPs shall be indicated as such in that SOP.

- identification of the test method;
- applicable matrix or matrices;
- detection limit;
- scope and application, including components to be analyzed;
- summary of the test method;
- definitions;
- interferences;
- safety;
- equipment and supplies;
- reagents and standards;
- sample collection, preservation, shipment and storage;
- QC;
- calibration and standardization;
- procedure;
- data analysis and calculations;
- method performance;
- waste minimization and pollution prevention;
- data assessment and acceptance criteria for QC measures;
- corrective actions for out-of-control data;
- contingencies for handling out-of-control or unacceptable data;
- waste management;
- references; and, where applicable; and
- any tables, diagrams, flowcharts and validation data.

4.5 Laboratory Equipment

4.5.1 Preventive Maintenance

The primary objective of a preventive maintenance program is to promote the timely and effective completion of a measurement effort. The preventive maintenance is designed to minimize the downtime of crucial analytical equipment due to expected or unexpected component failure.

Preventive maintenance procedures and/or manufacturer-supplied operator's manuals are utilized by ARS. ARS maintains a major equipment and measurement standards list. A record of instrument maintenance, calibration and repair is maintained.

Each analytical instrument is assigned an instrument logbook. Maintenance activities are recorded in the instrument logbook. The information entered includes:

- Date of maintenance,
- Person performing maintenance,
- Type of maintenance performed and reason for maintenance,
- Replacement parts installed (if appropriate), and
- Miscellaneous information.

If maintenance is performed by the manufacturer, a copy of the service record is maintained as a permanent record.

Along with a schedule for maintenance activities, an adequate inventory of spare parts is maintained to minimize equipment down time.

4.5.2 Calibration Procedures and Frequency

This subsection provides the general requirements for calibration of measuring and test equipment and instruments used in laboratory analysis. This program is designed to ensure that instruments are calibrated to operate within manufacturers' specifications and that the required traceability, sensitivity, and precision of the equipment/instruments are maintained. Measurements that affect the quality of an item or activity will be taken only with instruments, tools, gauges, or other measuring devices that are accurate, controlled, calibrated, adjusted, and maintained at predetermined intervals to ensure the specified level of precision and accuracy.

An instrument's response to known reference materials must be determined before being used as a measuring device. The manner in which various instruments are calibrated is dependent on the particular type of instrument and its intended use. Sample measurements will be performed within the calibrated range of the instrument. Preparation of reference materials used for calibration will be documented in a laboratory notebook.

ARS has a comprehensive calibration program involving all instrumentation and equipment used for making determinations, the results of which are reported.

Laboratory instrument calibration typically consists of two types: initial calibration and continuing calibration. Initial calibration procedures establish the calibration range of the instrument and determine instrument response over that range. Typically, three to five analyte concentrations are used to establish instrument response over a concentration range. The instrument response over that range is expressed as a correlation coefficient.

Continuing calibration usually includes measurement of the instrument response to fewer calibration standards and requires instrument response to compare certain limits (e.g., 10%) of

the initial measured instrument response. Continuing calibration may be used within an analytical sequence to verify stable calibration throughout the sequence and/or to demonstrate that instrument response did not drift during a period of nonuse.

Records are maintained as evidence of required calibration frequencies. All equipment is be marked to indicate calibration status.

5.0 PERFORMANCE AND SYSTEM AUDITS

5.1 Laboratory Internal Audits

Specific audits and surveillances are scheduled to be performed during a given calendar quarter. The audit and surveillance program addresses all elements of the quality system, including environmental testing and/or calibration activities. The assigned audit or surveillance may be conducted anytime during the calendar quarter.

It is the responsibility of the Quality Assurance Officer(s) to plan and organize audits and surveillances as required by the schedule and as requested by management.

An audit related to data integrity with respect to any evidence of inappropriate actions or vulnerabilities is also conducted on an as needed basis.

Audits and surveillances are carried out by trained and qualified personnel who are independent of the activity to be audited. Personnel do not audit their own activities. The person assigned the audit or surveillance conducts a thorough review of the applicable procedure before conducting the audit or surveillance. Findings and observations are documented on an "Audit and Surveillance" form. Findings are evaluated and corrected in accordance with *ARS-013 Nonconformance Reporting and Corrective Action Program*. Documentation is maintained of all audits and surveillances, associated findings, and any corrective actions taken for a minimum of five years.

5.2 Contractor Quality Control

ARSEC's Corporate QC Manager and PQCR are the persons responsible for the design and/or performance of QC systems and audits for this project, while USACE's designated QA Representative is responsible for designing and implementing QA audits. Since audits represent, by definition, independent assessments of a measurement system and associated data quality, the auditor must be functionally independent of the measurement effort to ensure objectivity. However, the auditor is experienced with the objectives, principles, and procedures of the measurement efforts to perform a thorough and effective evaluation of the measurement system. The auditor's technical background and experience provide a basis for appropriate audit standard selection, audit design, and data interpretation. The ability to identify components of the system that are critical to overall data quality is especially important, so the audit focuses heavily upon these elements. The auditor also has writing skills sufficient to clearly document the findings and recommendations of the audit. The function of the auditor is to:

- Observe procedures and techniques in use in the various measurement efforts, including field sampling and analysis;
- Check and verify instrument calibration records;
- Assess the effectiveness of and adherence to the prescribed QC procedures;
- Review document control and COC procedures;
- Submit audit samples of comparable composition as those being tested for analysis;

- Review the malfunction reporting procedures;
- Identify and correct any weaknesses in the sampling/analytical approach and techniques;
- Assess the overall data quality of the various sampling/analytical systems; and
- Challenge the various measurement systems with certified audit standards.

5.3 Project System Audits

The auditor may, on an announced or unannounced basis, call for a corporate project audit (system audit). ARSEC's PM will respond by submitting this project QAPP and the project CQCP. The auditor will determine if the QAPP and CQCP are in place functionally and whether the required reviews have been and are being conducted. Certain projects may be identified for a more formal audit. These audits will involve an in-depth evaluation of the implementation of the QAPP for the project as they apply to field and data analysis and reduction procedures.

5.4 Technical Performance Audits

Technical performance audits will be performed on an ongoing basis during the project as field data are generated, reduced, and analyzed. Numerical analyses, including manual calculations, mapping, and computer modeling, will be documented and will be the subject of performance audits in the form of QC review, numerical analysis, and peer review. Records of numerical analyses will be legible, reproduction quality, and complete enough to permit logical reconstruction by a qualified individual other than the originator.

5.5 Field Audits

Periodic in-field performance audits may be conducted by the PQCR, or designee, for the particular discipline of field activities. The purpose of field audits is to ensure that the methods and protocols detailed in this QAPP and the standard operating procedures are being consistently adhered to in the field. The QA auditor will prepare checklists prior to an audit to ensure completeness of the review and to document the results of the audit. Items to be examined may include, as appropriate:

- The availability and implementation of approved work procedures,
- Calibration and operation of equipment,
- Packaging, storage, and shipping of samples obtained, and
- Documentation procedures.

The records of field operations will be reviewed to verify that field-related activities were performed in accordance with appropriate project procedures. Items reviewed would include, but not be limited to:

- The calibration records of field equipment,
- Daily field activity logs,

- COC documentation, and
- Field logs.

During an audit and upon its completion, the auditors will discuss the findings with the individuals audited and cite any corrective actions to be initiated. Findings will be noted on the audit checklist and the results provided to ARSEC's PM and USACE's Project Engineer. ARSEC's PM will ensure that the corrective actions are implemented.

6.0 NON-CONFORMANCE/CORRECTIVE ACTIONS

During the course of the site project, it is the responsibility of ARSEC's PM, SM, PQCR, and the Field Team Members to see that measurement procedures are followed as specified and that measurement data meet the prescribed acceptance criteria. It is imperative that prompt action be taken to correct the problem(s) in the event that a problem arises.

Problems or questions about field or analytical data quality that may require corrective action are documented by the SM and reported to ARSEC's PM. Corrective actions may be required if QC results exceed method or project criteria, reporting or flagging errors are identified, or requested information has not been reported. Laboratory response usually involves a written explanation of the problem or reissuing laboratory reports and/or electronic data files. If significant data quality problems have occurred and the data are critical to decision making, samples may be reanalyzed or recollected and reanalyzed. That determination must be made by ARSEC's PM in association with ARSEC's Corporate QC Manager, PQCR, Project Health Physicist, and through discussions with USACE project staff.

6.1 Field Activities

The initial responsibility for monitoring the quality of field measurements and observations lies with the field personnel. ARSEC's PQCR is responsible for verifying that QC procedures are followed. This requires that the PQCR assess the correctness of field methods and the ability to meet QC/QA objectives. Any non-conformance with established procedures presented in the project plans will be identified and corrected. ARSEC's PM will be notified and will be responsible for issuing a non-conformance report for each non-conforming condition. In addition, corrective actions will be implemented and documented in the appropriate field logbook. Non-conforming conditions include:

- Improper instrument calibrations or operational checks,
- Improper survey or sampling procedures,
- Physical or documentation discrepancies with samples upon receipt at the laboratory, and
- Physical or documentation discrepancies with waste material upon receipt at disposal facility.

ARSEC's PM shall be notified in the event discrepancies are discovered by field personnel, during a desk or field audit or during data assessment. ARSEC's PM will immediately suspend applicable operations until the extent of the discrepancy and its impact on the accuracy and the validity of the data can be assessed. The cause of the discrepancy will be identified and corrective actions, such as procedure revisions or personnel retraining, will be instituted to prevent a reoccurrence. Re-surveys or re-sampling will be performed, if necessary, to correct the discrepancy. ARSEC's PM will notify USACE's Project Engineer of the identified problem, corrective action(s), and the impact on the overall project.

6.2 Laboratory Activities

Quality Assurance Discrepancies, Nonconforming Work and Corrective Actions are discussed in detail in Procedure *ARS-013 Nonconformance Reporting and Corrective Action Program*. The

purpose of the SOP is to specify a system to identify, investigate, control and document nonconformances; to notify applicable organizations and affected clients of deficiencies; and to provide a process for the development and implementation of corrective measures when warranted. The Nonconformance and Corrective Action Program provides a means for tracking and trending lessons learned to prevent reoccurrence of nonconformances.

6.2.1 Investigation of Nonconformance

ARS will conduct the following tasks:

- **Determination of Extent:** The extent and any generic implications of the Nonconformance shall be determined and documented on a Nonconformance Report (NCR). If analytical results were affected, record the ARS Sample IDs, SDGs, the name(s) of affected client(s), and whether client notification is required.
- **Determination of Cause:** The apparent cause of the nonconformance is determined and documented on the (NCR).
- **Determination of Root Cause:** An investigation into the root cause of the nonconformance is conducted. This investigation shall include internal and external observations and events leading to or associated with the problem. The investigation shall be documented on the NCR.

6.2.2 Proposed Resolution and/or Corrective Actions

- **Develop an Immediate Resolution:** A resolution to the nonconformance is developed and documented on the NCR. The individual responsible for implementing the resolution and a proposed date of completion is assigned. If the nonconformance involves nonconforming items/equipment, lock-out/tag-out procedures are followed and this action is documented on the NCR.
- **Develop Corrective Actions and Preventive Measures:** Corrective actions and preventive measures are developed to eliminate the root cause(s) of the nonconformance, while taking into consideration the magnitude of the problem and the risk involved. The corrective actions and preventive measures are documented on the NCR. The responsible individual(s) and an estimated completion date are assigned for each action.

7.0 DATA REDUCTION/CALCULATION

Evaluation/assessment of measurement data ensures that QA objectives for a program are met and quantitative measures of data quality are provided. Data evaluation procedures, calculations, and applications used for this project are based on the *Guidance for Data Quality Assessment Process: Practical Methods for Data Analysis* (QA/G-9), (USEPA, 2000).

There is a distinction between routine QC and data assessment conducted as a part of laboratory operations, and the project-related data assessment process conducted after data have been reported. As discussed in this section, both types of data assessment will be addressed for this project. It is assumed that the planning, standard operating procedures, and monitoring activities conducted during the sampling and analysis process serve to control the process as much as possible to produce data of sufficient quality for project needs. Any part of the process that can not be controlled and to what extent that may affect the quality of the reported data will be identified after the data are reported.

Routine QC procedures conducted at ARS are established in the published analytical methods, other information in this QAPP, and ARS LQAP and standard operating procedures. The laboratory is responsible for following those procedures and operating the analytical systems within statistical control limits. These procedures include proper instrument maintenance, calibration and continuing calibration checks, and internal QC sample analyses at the required frequencies for the project (i.e., method blanks, MS/MSDs, laboratory duplicates). ARS will provide the results of associated QC sample analyses when reporting sample data so ARSEC project staff can evaluate the performance of the analytical process.

One of the additional ongoing data assessment processes is maintaining control charts for representative QC sample analyses to monitor system performance. Control charts provide a useful tool in assessing QC efforts through graphical displays of a parameter(s) and variability over time. Control charts are established to monitor trends, warning, or out-of-control situations as they happen. A parameter plotted is related to sample testing, either directly in terms of concentration or indirectly in terms of derived information such as concentration mean (arithmetic) or range of concentration. Quality control data is recorded and monitored in such a way that trends are detectable. Statistical techniques are applied when reviewing the quality control data results, where practicable. The monitoring process is planned and reviewed.

Problems with analytical data often occur in spite of precautions taken in planning and execution of the sampling and analysis task. In these cases, the data assessment conducted by ARSEC project staff after the data have been reported will identify the problem, determine which data are affected, state how these data may be limited for use in the intended applications, and make recommendations for corrective actions as necessary.

Several of the data review/assessment acceptance criteria involve specific calculations. The appropriate formulas are presented below.

7.1 Non-radiological Instrument Response Linearity (Calibration)

Acceptance criteria for certain non-radiological instrument response linearity checks are based upon the correlation coefficient, r , of the best-fit line for the calibration data points. The correlation coefficient reflects the linearity of response to the calibration standards and is calculated as:

$$r = \frac{n \sum (xy) - (\sum x)(\sum y)}{\sqrt{[n(\sum x^2) - (\sum x)^2][n(\sum y^2) - (\sum y)^2]}}$$

Where:

- x = Calibration concentrations;
 y = Instrument response (peak area); and
 n = Number of calibration points (x, y data pairs)

7.2 Alpha Spectrometry

7.2.1 Nuclear Data

Default nuclear data for required radionuclides are tabulated below (**Table 7-1**). The tracer and analytes for each test is predefined and are tabulated with associated decay data.

Table 7-1. Default Nuclear Data – Alpha Spectroscopy**

Nuclide	Use*	$T_{1/2}$ (days)	Nuclide Abundance	Energies (keV)	Comments
U-232	T	2.51620E+04	0.997	5320.12, 5263.36	Tracer for Isotopic Uranium
U-233/234	A	8.97454E+07	0.998	4824.2, 4804, 4796, 4783.5, 4774.6, 4758, 4754, 4751, 4729, 4722.4, 4701	Half-life from U-234
U-235	A	2.57060E+11	0.861	4596.4, 4556, 4502, 4435, 4414, 4397.8, 4366.1, 4295, 4271	
U-238	A	1.63194E+12	1.000	4198, 4151	
Th-229	T	2.68056E+06	1.000	5078, 5053, 5047, 5036, 5023, 5009, 4978.5, 4967.5, 4930, 4901, 4861	Tracer for Isotopic Th
Th-230	A	2.75347E+07	0.998	4687, 4620.5, 4479.8	
Th-232	A	5.13194E+12	1.000	4012.3, 3947.2, 3811.1	

* A = Analyte, T = Tracer,

** Queried from NUDAT2. (http://www.nndc.bnl.gov/nudat2/indx_dec.jsp)

Note: The energies in bold are the energies of the most abundant peak.

7.2.2 Confidence Factor

The factor applied to the estimate of uncertainty (i.e., counting uncertainty or Total Propagated Uncertainty - CSU) to obtain the desired confidence interval. While data could be reported at any confidence interval desired, most data are reported at the one-and two-sigma levels. Several multipliers and the corresponding confidence intervals are listed in **Table 7-2**.

Table 7-2. Multipliers and Confidence Intervals

Sigma multiplier	Confidence Interval	Comment
1	68.3%	Also referred to as standard uncertainty – routinely reported under GUM and MARLAP; Routine report basis for LANL
1.65	90%	Not routinely used
1.96	95%	Routinely reported for radiochemistry results in the US. Interchangeable with 2-sigma uncertainty.
2	95.4%	Routinely reported for radiochemistry results in the US. Commonly also referred to as 2-sigma uncertainty.
3	99.7%	Not routinely used for the reporting of results but frequently used to evaluate QC results (e.g. replicates, QC charting)

7.2.3 Decay Correction (DF)

The half-lives used to determine decay correction factors for alpha spectroscopy calculations are tabulated above. Routinely, results are decay corrected to collection date (where available). Given the long half-lives of most alpha emitters of concern, the corrections applied are generally insignificant. In cases where a shorter lived nuclide is determined and one can expect that nuclide to be supported until chemical preparation/separation, the decay reference date for the measurement is assumed to be the appropriate preparation/separation date. The tracer activity added is corrected from its respective reference date to the date of the measurement prior for determining chemical yield.

$$DF_{(nuclide)} = e^{-\lambda_{(nuclide)}t_1}$$

$$\lambda_{(nuclide)} = \frac{\ln 2}{t_{1/2(nuclide)}}$$

Where:

- DF = decay correction factor
- e = base of natural logarithms = 2.718282
- $\lambda_{(nuclide)}$ = decay constant for the nuclide in question (days⁻¹)
- $t_{1/2}$ = half-life of the nuclide in question (days)
- t_1 = time elapsed between the appropriate reference date and midpoint of sample count (days)

7.2.4 Tracer Yield (Y)

The tracer yield is calculated as the quotient of recovered net tracer activity and the spiked tracer activity corrected for isotopic abundance and decay to the point of the sample count as follows:

$$Y = \frac{\frac{N_{S(tracer)}}{t_{S(tracer)}} - \frac{N_{B(tracer)}}{t_{B(tracer)}}}{(DPM_{(tracer)})(A)(DF_{(tracer)})(eff)}$$

$$DF_{tracer} = e^{-\lambda_{tracer}t_1}$$

$$\lambda_{(tracer)} = \frac{\ln 2}{t_{1/2tracer}}$$

Where:

$N_{S(tracer)}$	=	sample gross counts in tracer nuclide ROI
$N_{B(tracer)}$	=	background counts in tracer nuclide ROI
t_S	=	sample count duration (min)
t_B	=	background count duration in tracer ROI
$DPM_{(tracer)}$	=	activity of tracer added to the sample split corrected for any sample splits during analysis and is decay corrected to the date and time of the count
A	=	fractional nuclide abundance (see Table 7-1 above)
DF	=	decay correction factor
e	=	base of natural logarithms = 2.718282
$\lambda_{(tracer)}$	=	decay constant for the tracer nuclide (days ⁻¹)
$t_{1/2}$	=	half-life of the tracer nuclide (days)
$DPM_{(tracer)}$	=	activity in disintegrations/minute of tracer nuclide added to sample aliquot (or split)
t_1	=	time elapsed between the tracer activity reference date and midpoint of sample count (days)

7.2.5 Chemical Recovery (CR) Factor

Based on empirical data, the tracer yield is adjusted to account for losses during electroplating (PE = plating efficiency). PE factors are generated empirically for each analyst. Note that application of the plating efficiency for calculating CR simplifies out of final equations and thus does not play any role in the final activity results, uncertainties, MDC or DLC.

$$CR = \frac{Y}{PE}$$

Where:

PE	=	Electroplating efficiency factor – specific factor is applied for each analyst
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7.2.6 Sample Activity Concentration

The activity concentration in the sample measured in appropriate reporting units and corrected to a specified reference date is calculated as follows:

$$Activity = \frac{\frac{N_S}{t_S} - \frac{N_B}{t_B}}{(eff)(CR)(PE)(A)(DF)(aliquot)(acf)(ucf)}$$

Where:

N_S	=	sample counts in nuclide ROI
N_B	=	background counts in nuclide ROI
t_S	=	sample count duration (min)
t_B	=	background count duration (min)
eff	=	fractional detector efficiency (cpm/dpm)
$aliquot$	=	sample aliquot portion aliquoted/spiked corrected for any split (solids => g, liquids => L)
CR	=	fractional chemical recovery factor
PE	=	empirically determined fractional Plating Efficiency factor (specific to analyst)
DF	=	fractional decay correction factor (see below)
acf	=	aliquot conversion factor <u>from</u> default data entry units of grams for solids or Liters for liquids, or sample (fraction of sample) <u>to</u> desired reporting units (default reporting units are g, L and samples respectively)
ucf	=	units conversion factor from dpm to desired reporting units (default = 2.22 dpm/pCi)

7.2.7 Counting Uncertainty (CU)

The counting uncertainty, CU, at the 1-sigma confidence level is calculated as follows:

$$1sCU = \frac{\sqrt{\frac{N_S}{t_S^2} + \frac{N_B}{t_B^2}}}{(eff)(CR)(PE)(A)(DF)(aliquot)(acf)(ucf)}$$

$$CU = CF \times 1sCU$$

7.2.8 Combined Standard Uncertainty (CSU)

The following general formula is used to calculate the CSU.

$$CSU = CF * \sqrt{(1sCU)^2 + (Activity * \sqrt{Factor1^2 + Factor2^2 + Factor3^2 + Factor4^2 + Factor5^2 + Factor6^2})^2}$$

Where:

FACTOR 1 – FACTOR 6 = fractional factors accounting for the relative uncertainty associated with identified sources of systematic uncertainty

NOTE: The CSU formula assumes that the 1sCU is entered at the one-sigma level.

Factor 4 is defined as the relative counting uncertainty of the tracer analyte

$$\text{Factor 4} = \text{CU}_{\text{Rel}} = \frac{\sqrt{\frac{N_{S(\text{tracer})}}{t_{S(\text{tracer})}^2} + \frac{N_B}{t_B^2}}}{\left(\frac{N_{S(\text{tracer})}}{t_{S(\text{tracer})}^2} - \frac{N_B}{t_B^2} \right)}$$

7.2.9 MDC/MDA

The following MDC/MDA formula accounts for differences in sample and background count time:

$$\text{MDC} = \frac{2.71 + 3.29 * \sqrt{\frac{N_B}{t_B} t_S \left(1 + \frac{t_S}{t_B} \right)}}{(t_s)(\text{eff})(\text{CR})(\text{PE})(\text{A})(\text{DF})(\text{aliquot})(\text{acf})(\text{ucf})}$$

Note that this equation is the origin of, and simplifies to, the widely known MDC expression for paired counts ($t_S = t_B$) as follows:

$$\begin{aligned} \text{MDC} &= \frac{2.71 + 3.29 * \sqrt{\frac{N_B}{t_B} t_S (1+1)}}{(t_s)(\text{eff})(\text{CR})(\text{PE})(\text{A})(\text{DF})(\text{aliquot})(\text{acf})(\text{ucf})} \\ &= \frac{2.71 + (3.29 * \sqrt{(1+1)}) * \sqrt{\frac{N_B}{t_B} t_S}}{(t_s)(\text{eff})(\text{CR})(\text{PE})(\text{A})(\text{DF})(\text{aliquot})(\text{acf})(\text{ucf})} \\ &= \frac{2.71 + 4.65 * \sqrt{\frac{N_B}{t_B} t_S}}{(t_s)(\text{eff})(\text{CR})(\text{PE})(\text{A})(\text{DF})(\text{aliquot})(\text{acf})(\text{ucf})} \end{aligned}$$

7.2.10 Decision Level Concentration (DLC)

The Decision Level Concentration expression accounts for difference in sample and background count times:

$$DLC = \frac{1.645 \times \sqrt{\frac{N_B}{t_B} t_s \left(1 + \frac{t_s}{t_B}\right)}}{(t_s)(eff)(CR)(PE)(A)(DF)(aliquot)(acf)(ucf)}$$

NOTE that analogous to the MDC above, this equation is the parent formula for the tradition L_c expression and simplifies to $2.33 * S_p / K$ for paired counts ($t_s = t_B$) as follows:

$$DLC = \frac{1.645 * 1.414 * \sqrt{\frac{N_B}{t_B} t_s}}{(t_s)(eff)(CR)(PE)(A)(DF)(aliquot)(acf)(ucf)}$$

$$DLC = \frac{2.33 * \sqrt{\frac{N_B}{t_B} t_s}}{(t_s)(eff)(CR)(PE)(A)(DF)(aliquot)(acf)(ucf)}$$

7.3 Radium-226 by Method 903.1 (Radon deemanation)

7.3.1 Nuclear Data

Default nuclear data for Radium-226 are tabulated below (**Table 7-3**).

Table 7-3. Default Nuclear Data - Radium-226

Nuclide	α/β	$T_{1/2}$	λ	Nuclide Abundance	Decay Particle Energies (keV)
Ra-226	α	5.844E+05 days	1.186E-06 days ⁻¹	1.000	Ra-226: 4.784 & 4.601 MeV
Rn-222	α	3.8235 days 5505.8 min	1.8129E-01 days ⁻¹ 1.2589 E-04 min ⁻¹	1.000	Rn-222: 5.489 MeV

7.3.2 Chemical Yield

Method 903.1 does not foresee correcting results for losses due to chemical yield. The yield for calculations is assumed to be unity (1) and may be ignored during calculations.

7.3.3 Radium-226 Activity

Calculate the concentration Act_{Ra226} of 226Ra as follows:

$$Act_{Ra226} = \frac{\left(\frac{N_s}{t_s}\right) - \left(\frac{N_B}{t_B}\right)}{(CC)(IF)(DF1)(DF2)(aliquot)(acf)(ucf)}$$

Where:

N_s = Gross counts registered by the scaler during the counting period (counts)

t_s = Duration of the sample counting period (min)

N_B	=	Gross counts registered by the scaler during the background measurement counting period (counts)
t_B	=	Duration of the background counting period (min)
CC	=	Cell constant for the Lucas Cell counts/disintegration of Ra-226 assuming full ingrowth (counts / disintegration Ra-226)
IF	=	The correction for the ingrowth of Rn-222 between the first and second de-emanations
$DF1$	=	Correction for the decay of Rn-222 and progeny between the time of separation and the initiation of the count.
$DF2$	=	Correction for the decay of Rn-222 and progeny during the count
$Aliquot$	=	Sample aliquot, L or g
acf	=	activity correction factor
ucf	=	aliquot units correction factor

7.3.4 Ingrowth Factor (IF)

An ingrowth correction are used to determine the build-up of Rn-222 between the completion of initial emanation (i.e., Rn purge) of the solution prior to sealing and ingrowth and the final de-emanation of Rn into the alpha scintillation cell as follows:

$$IF = 1 - e^{-(\lambda_{222\text{Rn}} * t_1)}$$

Where:

$\lambda_{222\text{Rn}}$	=	Decay constant for $^{222}\text{Rn} = 0.18129 \text{ day}^{-1}$
t_1	=	Elapsed time between the first and second de-emanations, (days)

7.3.5 Decay Factors

Two decay correction factor correct for decay of Rn-222. The first (DF1) addresses decay between the point of Rn transfer from the bubbler to the Lucas Cell (deemanation). The second factor (DF2) corrects for decay during the actual counting period.

$$DF1 = e^{-(\lambda_{222\text{Rn}} * t_2)}$$

$$DF2 = \frac{1 - e^{-(\lambda_{222\text{Rn}} * t_3)}}{\lambda_{222\text{Rn}} * t_3}$$

Where:

$\lambda_{222\text{Rn}}$	=	Decay constant in matching units for $^{222}\text{Rn} = 1.8129\text{E-}01 \text{ day}^{-1}$ OR $1.2589\text{E-}04 \text{ min}^{-1}$
t_2	=	Elapsed time between the second de-emanations and the start time of the count, (days)
t_3	=	Count duration, (min)

7.3.6 Cell Constant Calibration

The Cell Constant (CC) for each Lucas Cell used for analysis is calculated as follows:

$$CC_{Ra} = \frac{\left(\frac{N_{cal}}{t_{cal}}\right) - \left(\frac{N_B}{t_B}\right)}{(Act_{Ra})(IF)(DF1)(DF2)}$$

Where:

- Act_{Ra} = Activity of Ra-226 added to bubbler (dpm corrected to the time of deemanation)
- N_{cal} = Gross counts registered by the scaler during the calibration counting period (counts)
- T_{cal} = Duration of the calibration counting period (min)
- N_B = Gross counts registered by the scaler during the background measurement counting period (counts)
- t_B = Duration of the background counting period (min)
- IF = Correction for the ingrowth of progeny between the time of separation and the mid-point of the count – Assuming that the standards are permitted to come to full ingrowth (i.e. 21-28 days), the IF may be assumed to be equal to 1 and may be omitted from the calculation.
- $DF1$ = Correction for the decay of Rn-222 and progeny between the time of separation and the initiation of the count.
- $DF2$ = Correction for the decay of Rn-222 and progeny during the count

7.3.7 Counting Uncertainty

The one-sigma counting uncertainty (1sCU) is calculated as follows:

$$1sCU = \frac{\sqrt{\left(\frac{N_S}{t_S^2}\right) + \left(\frac{N_B}{t_b^2}\right)}}{(CC)(IF)(DF1)(DF2)(\text{aliquot})(\text{acf})(\text{ucf})}$$

The 1sCU is reported at various confidence intervals by applying the appropriate coverage factor from **Table 7-2** as follows:

$$CU = CF * 1sCU$$

7.3.8 Combined Standard Uncertainty (CSU)

The formula for the CSU is defined as follows:

$$CSU = CF * \sqrt{(1sCU)^2 + \left(\text{Activity} * \sqrt{\text{Factor}1^2 + \text{Factor}2^2 + \text{Factor}3^2 + \text{Factor}4^2 + \text{Factor}5^2 + \text{Factor}6^2}\right)^2}$$

Where:

- FACTOR 1 – FACTOR 6** = fractional factors accounting for the relative uncertainty associated with identified sources of systematic uncertainty

NOTE: The CSU formula assumes that the 1sCU is entered at the one-sigma level.

7.3.9 Minimum Detectable Concentration

The minimum detectable concentration (MDC) is calculated as follows:

$$MDC = \frac{3.29 * \sqrt{\left(\frac{N_B}{(t_B)}\right)(t_s)} \left(1 + \frac{t_s}{t_B}\right) + 2.71}{(t_s)(CC)(IF)(DF1)(DF2)(aliquot)(acf)(ucf)}$$

NOTE that this simplifies to $(2.71/t + 4.65*SB)/K$ for paired counts.

7.3.10 Decision Level Concentration

The Decision Level Concentration (DLC) is calculated as follows:

$$DLC = \frac{1.645 * \sqrt{\left(\frac{N_B}{(t_B)}\right)(t_s)} \left(1 + \frac{t_s}{t_B}\right)}{(t_s)(CC)(IF)(DF1)(DF2)(aliquot)(acf)(ucf)}$$

NOTE that this simplifies to $2.33*SB/K$ for paired counts.

7.4 Radium-228 by Method 904.0 (Radium-228)

7.4.1 Nuclear Data

Default nuclear data for Radium-228 are tabulated below (**Table 7-4**).

Table 7-4. Default Nuclear Data - Radium-228

Nuclide	α/β	$T_{1/2}$	λ	Nuclide Abundance	Decay Particle Energies (keV)
Ra-228	β	2100	3.301E-04	1.000	$\beta_{avg} = 0.380$ MeV
Ac-228	β	0.2563	2.705	1.000	Ac-228: $\beta_{avg} = 0.440$ MeV
Sr-89	β	5.053E+01	1.372E-02	1.000	Sr-89: $\beta_{max} = 1.495$ MeV; $\beta_{avg} = 0.585$ MeV

7.4.2 Abundance

Ra-228 decays 100% by beta emission to Ac-228. Ac-228 also decays 100% by beta emission to Th-228. Thus, the abundance need not be reflected in equations.

7.4.3 Aliquot

The size of the portion of sample taken for analysis is measured at initiation of the sample preparation. It is entered as measured in the appropriate units (grams for solids, liters for liquids, sample (for fraction of sample)). Unless otherwise noted, it is assumed that the aliquot for liquid samples will be entered and reported on an “as-received” basis and that the aliquot for solid samples will be entered and reported on a “dry-weight” basis.

7.4.4 Chemical Yield for Ra-228

The carrier chemical yield for Radium-228, Y_{Ra} , is calculated as the simple product of the observed yields for Ba/Ra, Y_{Ba} and Y/Ac, Y_Y as follows:

$$Y_{Ra} = Y_{Ba} * Y_Y$$

$$\%Y_{Ra} = Y_{Ra} * 100$$

The fractional gravimetric yield of Ba/Ra, Y_{Ba} , is determined by measuring the recovery of a known quantity of Ba added to each sample and recovered as the sulfate. The barium is weighed as the sulfate and the yield is calculated as follows:

$$Y_{Ba} = \frac{(M_{g(Ba)} - M_{p(Ba)})(1000)}{\left(\frac{(V_{c(Ba)})(C_{c(Ba)})}{(F_{(Ba)})} \right)}$$

$$\%Y_{Ba} = Y_{Ba} \times 100$$

Where:

$Y(Ba)$	=	Fractional gravimetric yield for Ba/Ra
$\%Y(Ba)$	=	percent yield for barium = $Y(Ba) * 100$
$Mp(Ba)$	=	Tare mass of filter / planchet (g)
$Mg(Ba)$	=	Gross mass of Ra recovered weighed as BaSO ₄ plus planchet (g)
$Cc(Ba)$	=	Concentration of Ba carrier added to sample (mg Ba ²⁺ / mL)
$Vc(Ba)$	=	Volume of Ba carrier added (mL)
$F(Ba)$	=	0.5884 = gravimetric factor g Ba ²⁺ /g BaSO ₄

$F_{(Ba)}$ may be determined empirically by precipitating Ba under the same conditions as used for the final precipitation.

The fractional gravimetric yield of Y/Ac, Y_Y , is determined by measuring the recovery of a known quantity of Y added to each sample. The yttrium is precipitated as the oxalate and may be weighed as such (in such cases, the known value is obtained empirically by precipitating yttrium under the same conditions as the final precipitation). Alternatively the oxalate precipitate may be converted to the oxide and the yield is calculated as follows:

$$Y_{(Y)} = \frac{(M_{g(Y)} - M_{p(Y)})(1000)}{\left(\frac{(V_{c(Y)})(C_{c(Y)})}{(F_{(Y)})} \right)}$$

$$\% Y_Y = Y_Y \times 100$$

Where:

$Y(Y)$	=	Fractional gravimetric yield for yttrium
$\%Y(Y)$	=	percent yield for yttrium = $Y(Y) * 100$
$Mg(Y)$	=	Gross mass of Y recovered weighed as Y_2O_3 plus planchet (g)
$Mp(Y)$	=	Tare mass of planchet (g)
$Cc(Y)$	=	Concentration of Y carrier added to sample (mg Y_{3+} / mL)
$Vc(Y)$	=	Volume of Y carrier added (mL)
$F(Y)$	=	0.7874 = gravimetric factor g Y_{3+} /g Y_2O_3

NOTE: If yttrium oxalate is weighed, a gravimetric factor (i.e., Y_{3+} /g $Y_2(C_2O_4)^{3-} \cdot nH_2O$) may be empirically determined by processing replicate aliquots of carrier solution in a manner equivalent to that used in the procedure.

7.4.5 Radium-228 Activity

Calculate the concentration of ^{228}Ra as follows:

$$Act_{Ra} = \frac{\left(\frac{N_s}{t_s} \right) - \left(\frac{N_B}{t_B} \right)}{(eff)(IF)(DF1)(DF2)(DF3)(Y_{Ra})(aliquot)(acf)(ucf)}$$

Where:

N_s	=	Beta counts registered during the counting period (counts)
t_s	=	Duration of the sample counting period (min)
N_B	=	Beta counts registered during the background measurement counting period (counts)
t_B	=	Duration of the background counting period (min)
eff	=	Detection Efficiency for Sr-89 for the detector used for the sample measurement
IF	=	Correction for the ingrowth of progeny between the time of separation and the mid-point of the count.
$DF1$	=	Correction for the decay of Ac-228 between the beginning of Ac-228 decay and the initiation of the count
$DF2$	=	Correction for the decay of Ac-228 during the count
$DF3$	=	Correction for the decay of Ra-228 between sample reference date (e.g., collection date) and the beginning of Ac-228 decay, (days)
$Aliquot$	=	Sample aliquot, L or g
acf	=	activity correction factor
ucf	=	aliquot units correction factor

7.4.6 Ingrowth Factor

An ingrowth correction is used to determine the build-up of Ac-228 following the start of Ac ingrowth (last precipitation of barium prior to ingrowth) and the separation of Ac from Ra and beginning of Ac decay (the first barium sulfate precipitation following ingrowth) as follows:

$$IF = 1 - e^{-(\lambda_{228Ac} * t_1)}$$

Where:

- λ_{228Ac} = Decay constant for $^{228}\text{Rn} = 2.705 \text{ day}^{-1}$
 t_1 = Elapsed time between the start of Ac-228 ingrowth and the start of Ac-228 decay, (days)

7.4.7 Decay Factors

Three decay correction factors correct for decay of Ac-228. The first (DF1) addresses decay between the start of Ac-228 decay and the initiation of the count. The second decay factor (DF2) corrects for decay during the actual counting period. The third decay factor (DF3) corrects for decay of radium-228 in the original sample to a reference date.

$$DF1 = e^{-(\lambda_{228Ac} * t_2)}$$

$$DF2 = \frac{1 - e^{-(\lambda_{228Ac} * t_3)}}{\lambda_{228Ac} \times t_3}$$

$$DF3 = e^{-(\lambda_{228Ra} * t_4)}$$

Where:

- λ_{228Ac} = Decay constant for $^{228}\text{Ac} = 2.705 \text{ day}^{-1}$
 λ_{228Ra} = Decay constant for $^{228}\text{Ra} = 3.301\text{E-}04 \text{ day}^{-1}$
 t_2 = Elapsed time between the beginning of Ac-228 decay and the start time of the count, (days)
 t_3 = Count duration, (days)
 t_4 = Time elapsed between sample reference date (e.g., collection date) and the beginning of Ac-228 decay, (days)

7.4.8 Efficiency Calibration

Sr-89 is used for calibrating each detector for measurement of Ac-228. The efficiency is calculated as follows:

$$Eff_{Sr89} = \frac{\left(\frac{N_{cal}}{t_{cal}}\right) - \left(\frac{N_B}{t_B}\right)}{(Act_{Sr89})(DF)}$$

Where:

- Act_{Sr89} = Activity of Sr-89 added to the calibration standard (dpm)

N_{cal}	=	Gross counts registered during the calibration counting period (counts)
T_{cal}	=	Duration of the calibration counting period (min)
N_B	=	Gross counts registered during the background measurement counting period (counts)
t_B	=	Duration of the background counting period (min)
DF	=	Correction for the decay of Sr-89 between the activity reference date/time and the midpoint of the calibration count

7.4.9 Counting Uncertainty

The one-sigma uncertainty (1sCU) in the net sample counting rate is calculated as follows:

$$1sCU = \frac{\sqrt{\left(\frac{N_s}{t_s}\right) + \left(\frac{N_B}{t_B}\right)}}{(\text{eff})(\text{IF})(\text{DF1})(\text{DF2})(\text{DF3})(Y_{Ra})(\text{aliquot})(\text{acf})(\text{ucf})}$$

The 1sCU is reported at various confidence intervals by applying the appropriate coverage factor.

$$CU = CF * 1sCU$$

7.4.10 CSU (COMBINED STANDARD UNCERTAINTY - A.K.A. TPU)

The formula for the CSU is defined as follows:

$$CSU = CF * \sqrt{(1sCU)^2 + \left(\text{Activity} * \sqrt{\text{Factor1}^2 + \text{Factor2}^2 + \text{Factor3}^2 + \text{Factor4}^2 + \text{Factor5}^2 + \text{Factor6}^2} \right)^2}$$

Where:

FACTOR1 – FACTOR 6 = fractional factors accounting for the relative uncertainty associated with identified sources of systematic uncertainty

NOTE: The CSU formula assumes that the 1sCU is entered at the one-sigma level.

7.4.11 Minimum Detectable Concentration

The minimum detectable concentration (MDC) is calculated as follows:

$$MDC = \frac{3.29 * \sqrt{\left(\frac{N_B}{t_B}\right)(t_s)} \left(1 + \frac{t_s}{t_B}\right) + 2.71}{(t_s)(\text{eff})(\text{IF})(\text{DF1})(\text{DF2})(\text{DF3})(Y_{Ra})(\text{aliquot})(\text{acf})(\text{ucf})}$$

NOTE that this simplifies to (2.71/t + 4.65*SB)/K for paired counts

7.4.12 Decision Level Concentration

The Decision Level Concentration (DLC) is calculated as follows:

$$DLC = \frac{1.645 * \sqrt{\left(\frac{N_B}{t_B}\right) \left(1 + \frac{t_s}{t_B}\right)}}{(t_s)(\text{eff})(\text{IF})(\text{DF1})(\text{DF2})(\text{DF3})(Y_{Ra})(\text{aliquot})(\text{acf})(\text{ucf})}$$

NOTE that this simplifies to 2.33* SB/K for paired counts.

7.5 Precision

The degree of agreement between the numerical values of a set of replicate/duplicate samples performed in an identical fashion constitutes the precision of the measurement. Precision is checked during collection of data using field methods and/or instruments by reporting measurements at one location and comparing results. The measurements are considered sufficiently precise only if the values are within a specified % of each other. Control limits for control sample analyses, acceptability limits for replicate analyses, and response factor agreement criteria specified for calibration and internal QC checks are based upon precision.

Control limits for control sample analyses, acceptability limits for replicate analyses, and response factor agreement criteria specified for calibration and internal QC checks for laboratory analyses subject to duplicate analysis are based upon precision in terms of the coefficient of variation (CV) or the RPD. The standard deviation (S) of a sample set is calculated as:

$$S = \sqrt{\frac{\sum (x - \bar{x})^2}{(n-1)}}$$

Where:

- x = Individual measurement result;
- \bar{x} = Mean value of individual measurement results; and
- n = Number of measurements.

The CV as a % is then calculated as:

$$CV = \left(\frac{S}{\bar{x}}\right) \times 100$$

The RPD calculation allows for the comparison of two analysis values in terms of precision with no estimate of accuracy. RPD is calculated as:

$$RPD = \left(\frac{m - M}{M}\right) \times 100$$

Where:

- m = First measurement value;

$\frac{M}{M}$ = Second measurement value; and
 $\frac{M}{M}$ = Mean value of M and m.

CV is related to RPD for duplicate measurements by the following:

$$CV = \frac{RPD}{\sqrt{2}}$$

Duplicates are also evaluated Normalized Absolute Difference (DER): The Normalized Absolute Difference between the LCS and LCSD is used to determine that the results do not differ significantly (at the 99% confidence interval) when compared to their respective combined standard uncertainty. A DER of less than or equal to 3 is considered acceptable.

$$DER = \frac{|S - D|}{\sqrt{(CSU_s)^2 + (CSU_d)^2}}$$

Where:

S = LCS result
 D = Duplicate result
 CSU_s = Combined Standard Uncertainty of the LCS
 CSU_d = Combined Standard Uncertainty of the duplicate

NOTE: A test value of '3' corresponds to a 99+% confidence level.

Unless other requirements are established by the client or program, when either the DER or the RPD meet acceptance criteria, the duplicate is considered to be acceptable. When the duplicate acceptance criteria are not met, all associated samples in the QC batch are reanalyzed beginning with preparation. A nonconformance report is filed in accordance with *ARS-013 - "Nonconformance Reporting and Corrective Action Program."* The occurrence of failed acceptance criteria and the actions taken are noted in the case narrative.

7.6 Accuracy

Accuracy is the degree of agreement of a measurement, X, with an accepted reference or true value, T. Accuracy is usually expressed as the difference between the two values, X-T, or the difference as a % of the reference or true value, 100(X-T)/T, and sometimes expressed as a ratio, X/T. Accuracy is a measure of the bias in a system and is assessed by means of reference samples and % recoveries. Error may arise from personnel, instrument, or method factors.

Two types of analytical check samples can be used: LCS (blank spike) and MS. Analytical accuracy is expressed as the % recovery of an analyte that has been added to the control samples or a standard matrix (e.g., blank soil, analyte-free water, etc.) at a known concentration prior to analysis.

The accuracy of data is typically summarized in terms of relative error (RE). This calculation reflects the degree to which the measured value agrees with the actual value, in terms of % of the actual value. RE is calculated as:

$$\% RE = \frac{\text{Measured Value} - \text{Actual Value}}{\text{Actual Value}} \times 100$$

This way of expressing accuracy allows for a comparison of accuracy at different levels (e.g., different concentrations) and for different parameters of the same type (e.g., different compounds analyzed by the same method). Control sample analyses are typically evaluated using this calculation.

Another calculation is frequently used to assess the accuracy of a procedure. Percent recovery is a calculation used to determine the performance of many of the QC checks, where:

$$\% \text{ Recovery} = \frac{\text{Measured Value}}{\text{Actual Value}} \times 100$$

Another similar calculation used to determine the performance of a method for recovery of a spike concentration added to a sample is the % spike recovery calculation. The % spike recovery is determined as:

$$\% \text{ Spike Recovery} = \frac{[(\text{Measured Sample Value Plus Spike}) - (\text{Measured Sample Value})]}{(\text{Value of Spike Added})} \times 100$$

Results that do not satisfy the objectives are assigned a data qualifier flag to indicate uncertainty associated with inaccuracy.

Confidence intervals can be calculated for an analytical method if performance audit samples are submitted or a series of LCSs or MSs are analyzed. The results are used to define confidence intervals for the recovery of each compound analyzed.

7.7 Blank Data Assessment

Method/reagent blanks are analyzed to account for other sources (external to the sample) of interference specific to radiological and chemical analyses. The samples associated with the blank may be qualified to evaluate whether some or all of the detected analytes may be from laboratory sources if interference is indicated in method blanks. If the concentrations reported in the samples are similar to the blank concentrations, it is likely that all of the contamination was introduced, and this assessment is typically made by the analytical laboratory and reported in the analytical deliverable package.

7.8 Completeness

Completeness is a measure of the degree to which the amount of sample data collected meets the scope and a measure of the relative number of analytical data points that meet the acceptance

criteria, including accuracy, precision, and any other criteria required by the specific analytical method used. Completeness is defined as a comparison of the actual numbers of valid data points and expected numbers of points expressed as a %.

The QA objectives for completeness will be based upon a project goal of 90%.

Difficulties encountered while handling samples in the laboratory (radiological or physical/chemical) as well as unforeseen complications regarding analytical methods, may affect completeness during sample analysis.

Accordingly, to ensure that 90% completeness is obtained, certain efforts may need to be employed, including, but not limited to re-sampling.

Completeness is calculated after the QC data have been evaluated, and the results applied to the measurement data. In addition to results identified as being outside of the QC limits established for the method, broken or spilled samples, or samples that could not be analyzed for any other reason are included in the assessment of completeness. The % of valid results is reported as completeness. The completeness will be calculated as follows:

$$\text{Completeness (\%)} = \frac{T - (I + NC)}{T} \times 100$$

Where:

- T = Total number of expected measurements for a method and matrix;
- I = Number of invalidated results for a method and matrix; and
- NC = Number of results not collected (e.g., bottles broken etc.) for a method and a matrix.

8.0 DATA REPORTING

The data reporting procedures described in this section will ensure that complete documentation is maintained. Laboratory data production and management are described in the ARS LQAP (Appendix A). ARSEC will maintain documentation and records to support information provided to USACE for the Tonawanda Landfill Operable Unit FUSRAP Remedial Investigation project. These records will be forwarded to USACE, if requested. Original copies of field data, field records, analytical data, training records, and other project-specific documentation will be retained by ARSEC in a manner and for durations required in ARSEC Operating Procedures.

8.1 Data Package Format and Contents

Analytical data reports will conform to the requirements of DOD QSM Appendix A. Reports will contain final results, analytical methods, detection limits, and results of QC samples. In addition, special analytical problems and/or any modifications of referenced methods will be noted in the case narrative. The number of significant figures reported will be consistent with the limits of uncertainty inherent in the analytical method. Data are generally reported in units commonly used for the analyses performed. Concentrations in TCLP extracts are expressed in terms of activity or mass per unit volume (e.g., pCi/L or µg/L). Concentrations in solid or semisolid matrices are expressed in terms of activity or mass per unit mass of sample (e.g., pCi/g or mg/kg). QC results will be reported by sample matrix and analytical method in tabular form. The measurement data will be discussed and qualified as appropriate based on the QC results.

The final data reports provided by ARS will include:

- Cover sheet
- Table of Contents
- Case Narrative
- Original Chain of Custody
- Analytical Results
- Sample Management Records
- QA/QC Information
- Raw Data
- Calibration data
- Performance Standards
- Calculations and
- Supporting documentation.

8.2 Electronic Deliverables

8.2.1 Electronic Data Deliverable

The ARS Data Management systems are fully compliant with *EPA 2185 – Good Automated Laboratory Practices (GALP)*.

Electronic data submitted by ARS will be thoroughly reviewed to ensure that it is error free and in complete agreement with the hardcopy data. The standard electronic data deliverable (EDD) will be in MS Excel format as either an .xls or .csv file. The file will contain the following fields:

- Sample ID
- Lab ID
- Sample type (normal, dup, LCS, Blank, etc)
- Matrix
- Collection, extraction and analysis dates
- Method of analysis
- Sample Delivery Group Number (SDG#)
- Batch Number
- CAS number
- Compound/Element/Isotope
- Sample result
- Combined Standard Uncertainty
- Units
- Lab qualifier
- MDC/MDL
- Dilution factor
- LCS, MS/MSD, Tracer & Chemical calculated % recoveries
- Spiked Concentration for LCS, MS/MSD, Tracer and Chemical recoveries
- RPD calculated value with upper and lower control limits

If requested by the USACE, the EDD can also be submitted in the Staged Electronic Data Deliverable (SEDD) format.

8.2.2 Risk Assessment Database Deliverable

ARSEC will develop a Microsoft Access database to be used by USACE engineers to perform risk assessment analysis. The database will include all of the information in the above listed EDD as well as the following information:

- Location
- Date Collected
- Matrix
- Starting Depth
- Ending Depth
- Sample Code

- Analyte Category (i.e. radiochemistry, VOC, SVOCs, etc.)
- Parameter Name
- CAS Number
- Units
- Final Flag (in addition to the laboratory qualifier flags)
- Analytical Method Code
- Uncertainty for radiochemical analyses

The final format of the database will be approved by the USACE prior to implementation.

8.3 Laboratory Turnaround Time

In accordance with the USACE SOW (USACE, 2009), the ARS Standard TAT is 28 calendar days (21 working days), defined as the time from sample collection until the receipt of the full data report by USACE.

8.4 Data Archival/Retention Requirements

All Quality Records and Documents which include original observations (including logbooks and forms), calculations and derived data, calibration records, report copies, reports from internal audits and management reviews, and records of corrective actions are controlled. All processes contributing to the generation of quality related data or observations are recorded in a controlled manner.

8.4.1 Security and Confidence

All Quality Records and Documents are safely stored, held secure and in confidence to the client, and available for review. Quality Records and Documents are held in a secure facility or locked storage or on a secure server with controlled access.

8.4.2 Record Retention and Disposition

The ARSEC minimum retention period for Quality Records and Documents is five years. Quality Records and Documents may be retained for longer periods if required by a client and agreed to by ARSEC.

Hardcopy data and data storage media will be archived in a manner and for durations required in ARSEC Operating Procedure, AP-001, *Record Retention* included in the FSP (ARSEC, 2009b) and ARS-049 *Document Control and Records Management*.

9.0 DATA REVIEW

9.1 Data Quality Review

Data quality review includes the review of analytical data, field and laboratory QA reports, and all data submittals. ARSEC's PM will direct the Project Team in the final verification and reconciliation of the data results and the data review process with the project DQOs in regard to:

- The perspective of the end data user;
- Concentrations of the radiological and chemical COCs;
- The final number of samples, sampling locations, and site media;
- Lateral and vertical study boundaries; and
- Performance and appropriateness of the field survey techniques and laboratory analyses and methods that were utilized.

9.2 Analytical Data Review

System reviews are performed at all levels. The individual analyst constantly reviews the quality of data through calibration checks, QC sample results, and performance evaluation samples. These reviews are performed and documented before submitting data to the ARS PM.

Criteria for analytical data review/verification include checks for internal consistency, transmittal errors, laboratory protocol, and laboratory QC. QC sample results and information documented in field notes will be used to interpret and evaluate laboratory data. The ARS QA section independently conducts a review of the data package to eliminate technical errors that might affect the quality of the data.

ARS will complete standard review procedures, including:

- Proofing analyses requested with analyses performed;
- Preliminary data proofing for anomalies—investigation and corrections, where possible;
- Proofing of laboratory data sheets for RDLs, holding times, surrogate recovery performance, and spike recovery performance; and
- Double-checking computerized data entry, if required.

The ARS Laboratory PM will review data for consistency and reasonableness with other generated data and determine whether program requirements have been satisfied. Unusual or unexpected results will be reviewed, and a resolution will be made as to whether the analyses should be repeated.

The ARS PM will verify that the report deliverable is complete and in proper format, and screen the report for compliance with laboratory and client QA/QC requirements prior to final review/signoff. The ARS QA Officer and Laboratory Manager will perform the final review. The ARS Laboratory PM will perform a final completeness check before submitting the data report to ARSEC.

The data review report will include a narrative explanation of what samples the report applies to, a reference to the criteria or procedures used for data review, and a description of which results were determined to be unacceptable for the intended application and why. This report will accompany the QC data summary.

9.3 Data Verification/Validation

Independent, third party review of the laboratory data is not currently scheduled or provided for in the USACE SOWs (USACE, 2001), but may be utilized on an as-needed basis as indicated by data-quality conditions. The USACE will be contacted for direction to proceed prior to utilization, if such is implemented.

9.4 Project Completeness Assessment

Project completeness assessment is the measure of the volume of qualified data compared to the planned data volume and whether that data is sufficient to meet project objectives. The QA objectives for completeness will be based upon a project goal of 90%.

10.0 REFERENCES

- ARSEC, 2009, *Contractor Quality Control Plan, Tonawanda FUSRAP Site*, ARSEC, October 2009.
- ARSEC, 2009a, *Health Safety and Radiation Protection Plan*, October 2009.
- ARSEC, 2009b, *Sampling and Analysis Plan – Volume I, Field Sampling Plan, Tonawanda FUSRAP Site*, October 2009
- Currie, 1968, *Limits for Qualitative Detection and Quantitative Determination*, Analytical Chem., v. 40, No. 3, pp. 586-593, 1968.
- DOT, U.S. Department of Transportation, Title 49, Code of Federal Regulations, Chapter I, Part 173.
- USACE, 1997, *Radiation Protection Manual*, Engineer Manual (EM) 385-1-80, May 1997.
- USACE, 2001, *Requirements for the Preparation of Sampling and Analysis Plans*, Engineer Manual (EM) 200-1-3, February 2001.
- USACE, 2009, *Scope of Work – RI Addendum Tonawanda Landfill Operable Unit*, June 2009.
- USEPA, 1987, *National Primary and Secondary Ambient Air Quality Standards*, Title 40 Code of Federal Regulations, Chapter I, Part 50, July 1987 (as amended).
- USEPA, 1996, *Soil Screening Guidance: Technical Background Document*, Washington, D.C., EPA/540/R-95/128, July, 1996.
- USEPA, 2000, *Guidance for Data Quality Assessment: Practical Methods for Data Analysis*, EPA QA/G-9, Washington, D.C., EPA/600/R-96/064, July 2000.
- USEPA, 2004, *Multi-Agency Radiological Laboratory Analytical Protocols Manual*, NUREG-1576, Washington, D.C., EPA/402/B-04/001A, July 2004.
- USEPA, 2007, *SW-846-Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, Office of Solid Waste, Washington, D.C.

APPENDIX A

LABORATORY QUALITY ASSURANCE PLANS –
ARS INTERNATIONAL AND
TESTAMERICA LABORATORIES
(Included on CD)

ARS INTERNATIONAL
LABORATORY QUALITY ASSURANCE PLAN

TESTAMERICA LABORATORIES
LABORATORY QUALITY ASSURANCE PLAN