US Army Corps
of Engineers
Buffalo District

Niagara Falls Storage Site Vicinity Property X
Preliminary Assessment/Site Inspection Sampling and Analysis Plan

Gamma Walkover Survey and Composite Soil Sampling

Niagara Falls Storage Site
Vicinity Property X
Niagara County, New York

Authorized under the
Formerly Utilized Sites Remedial Action Program

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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeter
COC	Chain-of-Custody
DERP-FUDS	Defense Environmental Restoration Program for Formerly Used Defense Sites
DOD	Department of Defense
DOE	Department of Energy
DQIs	data quality indicators
DQOs	data quality objectives
DU	decision unit
ELAP	Environmental Laboratory Accreditation Program
FUSRAP	Formerly Utilized Sites Remedial Action Program
GPS	global positioning system
GWS	Gamma Walkover Survey
ID	identification
LCSs	laboratory control samples
LOOW	Lake Ontario Ordinance Works
m	meter
MARLAP	Multi-Agency Radiological Laboratory Analytical Protocols Manual
MDCR	minimum detectable count rates
MED	Manhattan Engineer District
MQOs	measurement quality objectives
MSs	matrix spikes
MSDs	matric spike duplicates
NAD	normalized absolute difference
NFSS	Niagara Falls Storage Site
OEA	Office of Economic Adjustment

PA/SI	Preliminary Assessment/Site Investigation
pCi/g	picocuries per gram
QA	quality assurance
QC	quality control
QSM	Quality Systems Manual
RPDs	relative percent differences
SAP	Sampling and Analysis Plan
Scan MDC	scanning minimum detectable concentrations
SI	Site Investigation
TENORM	technologically enhanced naturally occurring radioactive material
TNT	trinitrotoluene
USACE	United States Army Corps of Engineers
VP X	Vicinity Property X
WDD	Western Drainage Ditch
WWTP	wastewater treatment plant
μR/hr	microroentgen per hour
%R	percent recovery

Part I: Field Sampling Plan

1.0 Introduction

The following Field Sampling Plan applies to U.S. Army Corps of Engineers (USACE) field activities planned for the preliminary assessment/site inspection (PA/SI) of the Niagara Falls Storage Site (NFSS) Vicinity Property X (VP X) located in the towns of Lewiston and Porter, in Niagara County, New York. VP X is situated within the original boundary of the former Lake Ontario Ordnance Works (LOOW), where the USACE Manhattan Engineer District (MED) and the U.S. Atomic Energy Commission (AEC) stored radioactive materials during the 1940s and 1950s and is part of the Formerly Utilized Sites Remedial Action Program (FUSRAP).

In 1984 and 1986, the U.S. Department of Energy (DOE) investigated and remediated VP X under FUSRAP and in 1991, the DOE certified that radiological conditions on the property met cleanup guidelines for unrestricted use.

In 1997, Congress authorized USACE to become the lead federal agency for FUSRAP, under which newly identified or previously remediated sites are referred by the DOE for investigation and, if necessary, further remediation. Radiological data collected in 2011 on site by USACE while performing the Phase IV Remedial Investigation/Feasibility Study of the LOOW under the Defense Environmental Restoration Program for Formerly Used Defense Sites (DERP-FUDS) (USACE 2011) and safety hazard mitigation of the former LOOW wastewater treatment plant in 2012 under the Office of Economic Adjustment (OEA) (USACE 2012) showed a potential uncharacterized exceedance of DOE cleanup guidelines. Based on this information, the DOE referred VP X to USACE in 2014 for further assessment and, if needed, remediation. A preliminary assessment and site inspection (SI) consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, 42 United States Code (U.S.C.) 9601 et seq., as amended, and the National Oil and Hazardous Substances Pollution Contingency Plan as directed by Congress in the Energy and Water Appropriation Act for Fiscal Year 1999 and 2000 (Pub. L. 105-245 and 106-60) 10 U.S.C. 2701 is to be completed to determine if there are potential threats to human health or the environment at the site that need to be addressed under FUSRAP.

As part of the PA/SI, USACE is self-performing gamma radiation walkover surveys (GWS) over areas of past activities or remediation at VP X. The gamma walkover survey results will be used to identify candidate areas of potentially elevated radioactivity to be sampled over 100 square meters (m^2) (1076 square feet [ft^2]). Analytical results for representative composite soil samples will then be screened and characterized against the DOE remediation criteria.

2.0 Purpose and Site Background

VP X is located in the Towns of Lewiston and Porter, New York (Figures 1 and 2). The Town of Lewiston has owned VP X since 1974, when it acquired the property from the federal government. The site is approximately 9 hectares (22 acres) in size and roughly rectangular in shape, with dimensions of 223 meters by 404 meters (732 feet by 1,326 feet). It is bound by the federally owned Niagara Falls Storage Site to the south; Chemical Waste Management, LLC, to the north and east; and a National Grid easement to the west. The West Drainage Ditch (WDD), constructed during the 1940s to accommodate surface water runoff, drains predominantly north across the eastern portion of the site. North of VP X, the WDD flows into the Central Drainage Ditch and ultimately into Four Mile Creek and Lake Ontario.

There are currently structural remnants of a former wastewater treatment plant (WWTP) on VP X (Figure 2). The WWTP was constructed as part of the LOOW facility that manufactured trinitrotoluene (TNT) between 1942 and 1943 in support of World War II; production lasted less than a year due to an oversupply of TNT. The WWTP treated wastewater from LOOW operations, which included sanitary, acid, and liquid TNT process wastewater. Since the WWTP ceased operation in 1979, the following structures have been partially and/or completely demolished to mitigate public safety hazards:

- The mixing house was deconstructed and removed.
- TNT waste lines, which terminated at the mixing house, were partially removed, and the interiors cleaned during an interim removal action.
- The pump house was removed, and only below grade portions of the northern concrete wall and concrete floor remain.
- The acid neutralization building with attached dilution sump/weir was partially deconstructed, along with asbestos abatement and debris removal, and only a below ground portion remains; a chain-link fence surrounds the structure.

The venturi vault was completely removed. Several structures in addition to those associated with the WWTP were located on VP X to support LOOW. They included an electric shop, tool house, and paint shop west of the WWTP along the West Patrol Road, and two railroad loading platforms in the southwest corner of the property. Previously, railroad tracks trended north-south through the shops area. During the 1950s, wastes were received at the railroad platforms and stored in the buildings before being moved to the NFSS.

The land is currently zoned light industrial by the Town of Lewiston, which includes uses such as manufacturing, processing, and wholesale/warehousing. Town of Porter zoning indicates M-2 General Industrial, which allows for heavier manufacturing and processing facilities, offices, and research and service establishments where compatible industries are co-located to ensure efficient and compatible development of industrial use with adjacent districts.

There is no evidence of contaminated waste burial on VP X, but past radiological surveys performed by the DOE found areas in the WDD and on soil in the southern portion of the property and near WWTP structures that exhibited signs of contamination. Runoff from residues stored on the NFSS was believed to be the source of contamination in the WDD, and operations near the former railroad loading platforms were thought to have caused the elevated radiation levels in soil in the southern portion of the property. The site was remediated under FUSRAP by the DOE in 1984 (DOE 1984, 1986) and certified for unrestricted future use in 1992 (DOE 1992).

3.0 USACE Sampling History

Radiological data collected on VP X by USACE during the Phase IV Remedial Investigation/Feasibility Study of the LOOW under DERP-FUDS in 2011 (USACE 2011) and during safety hazard mitigation of the former LOOW wastewater treatment plant under OEA in 2012 (USACE 2012) showed potentially uncharacterized radioactivity in site soil, specifically one localized (~1 m^2) area near the northwest corner of the former acid neutralization basin requiring further evaluation.

USACE began an initial evaluation in 2019 to determine whether these elevated radioactivity observations are attributable to slag or MED/AEC activities by performing a localized GWS in the vicinity of the acid neutralization building. This 2019 survey subsequently identified additional spotty areas of potential residual radioactivity not previously characterized by the DOE. A follow-up GWS was performed in the WWTP area in 2020 to better understand the scope of required PA/SI activities. Based on site history and these initial surveys, this Sampling and Analysis Plan (SAP) covers further GWS expansion over areas of previous remediation and/or historic site activities and subsequent soil/sediment sampling, as necessary, to determine the extent to which uncharacterized residual radioactivity exceeding DOE remediation criteria, if any, may be present on VP X.

Groundwater in the southern portion of the site was also identified as requiring additional evaluation and was sampled in 2019 as part of the Niagara Falls Storage Site Environmental Surveillance Program. Six pre-existing groundwater monitoring wells, including three in the southern portion of the site near the former railroad loading areas and three near the former WWTP, were sampled for total uranium and radium-226 using a low flow purge. Analytical results of the 2019 groundwater sampling will be included in the PA/SI report.

4.0 General Approach

This SAP is intended to address soil and sediment in areas of the site potentially containing elevated residual radioactivity. This includes areas associated with the former WWTP, areas near the former railroad loading platforms in the southern portion of the site, and the WDD which received runoff from residues stored at the NFSS.

Characterization of these areas will be performed in two stages to determine if unassessed radiological contamination exceeding previous DOE cleanup guidelines remains on site (DOE 2014). First additional gamma walkover surveys will be conducted over the remaining areas shown in Figure 3 and incorporated into a total aggregate GWS dataset. If elevated readings are identified during the surveys and/or during processing of the data, targeted soil samples will be taken and submitted to a contracted Environmental Laboratory Accreditation Program (ELAP)-accredited laboratory for radiological analysis of FUSRAP-related contaminants: radium-226, radium-228, thorium-228, thorium-230, thorium-232, uranium-234, uranium-235, and uranium-238. Analytical results will be used to determine whether the previous remedial actions at the site were sufficient, or if uncharacterized releases of MED/AEC contamination remaining poses a threat to human health or the environment warranting further action under FUSRAP, consistent with CERCLA.

VP X was remediated by the DOE to unrestricted release (DOE 1986) and followed up by confirmation surveys (DOE 1989, 1992). For the sake of the PA/SI, uncharacterized releases of FUSRAP material will be defined as residual radioactivity exceeding the DOE release criteria. Therefore, the radiological screening criteria to be applied to soil and sediment sample results (Table 1) are based primarily on generic criteria established in 40 CFR 192, which were the basis for the previous DOE cleanup at the site. These criteria for isotopic radium and thorium apply to radioactivity distributed over 100 square meters (m^2) (1076 square feet [ft^2]).

Table 1 – Screening Levels for Site Soils and Sediments in picocuries per gram (pCi/g)

Radionuclide	Media	Screening Level (pCi/g)	Reference
Radium-226 (Ra-226)	Surface soil (0-15 cm)*	5	DOE 1987
	Subsurface soil (> 15 cm)*	15	DOE 1987
	Western Drainage Ditch**	20	DOE 1986a
Radium-228 (Ra-228)	Surface soil (0-15 cm)*	5	DOE 1987
	Subsurface soil (> 15 cm)*	15	DOE 1987
Thorium-228 (Th-228)	Surface soil (0-15 cm)*	5	DOE 1987
	Subsurface soil (> 15 cm)*	15	DOE 1987
Thorium-230 (Th-230)	Surface soil (0-15 cm)*	5	DOE 1987
	Subsurface soil (> 15 cm)*	15	DOE 1987
Thorium-232 (Th-232)	Surface soil (0-15 cm)*	5	DOE 1987
	Subsurface soil (> 15 cm)*	15	DOE 1987
Uranium-234 (U-234)	All soil	44	ANL 1988
Uranium-235 (U-235)	All soil	2	ANL 1988
Uranium-238 (U-238)	All soil	44	ANL 1988
Cesium-137 (Cs-137)***	All soil	30	ANL 1988

* The listed screening level applies over an area of 100 square meters (m^2) (1076 square feet [ft^2]).

** The listed screening level was developed for the Central Drainage Ditch.

*** Cesium-137 is associated with legacy operations independent of FUSRAP activities. The radionuclide is included because DOE remediated the site to the listed activity concentration.

5.0 Field Sampling Plan

The investigation will advance in two phases: the radiological gamma walkover survey over areas of past site activities and remediation, followed by composite soil and sediment sampling over targeted areas identified in the GWS for analytical screening.

5.1 Health and Safety

All field investigation activities are planned in accordance with the health and safety specifications in Engineering Manual (EM)-385-1-1 (USACE 2014) as well as the site- and task-specific hazards identified in the Activity Hazards Analyses (Appendix A). Throughout the course of the investigation, daily quality assurance (QA) reports will document daily progress, newly identified hazard potential, and any other health and safety concerns.

5.2 Investigation Location Rationales

As summarized in Section 3.0, preliminary gamma walkover surveys were completed by USACE in August 2019 and August 2020 to evaluate the observations made during DERP-FUDS (USACE 2011) and OEA (USACE 2012) activities on site. During these initial surveys, additional localized areas were identified suggesting further uncharacterized residual radioactivity warranting investigation. Therefore, the surveys covered in this SAP are planned to expand coverage across all accessible areas associated with the WWTP and the railroad loading platforms, and the entirety of the WDD. Figure 3 depicts the planned survey areas. A global positioning system (GPS) unit will be utilized to locate and document these survey locations.

Data quality issues associated with poor post-processing GPS accuracy may be encountered, especially around heavily vegetated areas near the railroad platforms and the WDD. Targeted composite sampling locations will be determined primarily based on elevated radioactivity in the aggregate post-processed survey data and secondarily based on elevated in-field observations during the GWS in the event of poor spatial accuracy.

5.3 Field Investigation Procedures

5.3.1 Gamma Walkover Survey

USACE will perform a GWS over accessible areas identified in Figure 3 such that the aggregate of all surveys capture the former WWTP, the former railroad loading platforms, and WDD with a primary focus on the areas of past activities or remediation. The survey will be performed with a high-efficiency gamma ray scintillation detector (e.g., 2"x2" sodium iodide [NaI], Ludlum Model 44-10, Eberline SPA-3, or equivalent), paired with a count rate meter/scaler (e.g. Ludlum Model 2221 or equivalent). Gamma radiation count rates data will be transferred to a GPS unit to associate observed activity with a geospatial location. The position and associated information will be recorded at one-second intervals using GPS equipment such as a survey grade (±1 meter) Geo7 X and external antenna (e.g., Zephyr). The GPS unit will be configured to collect data using North American Datum 1983 CORS 96 - New York State Plane West Coordinates (3103) in U.S. Survey Feet. All collected GPS data will be post-processed using Trimble GPS Pathfinder Office (or equivalent).

The GPS external antenna will be positioned at a fixed height to accurately capture consistent detector locations throughout the survey. Additionally, the detector itself will be maintained at a fixed distance of approximately 10 centimeters (4 inches) above the ground surface during the walkover survey. Appendix B provides justification that the detector scan speed and detector height have been selected to adequately meet the project objectives and to observe the potential FUSRAP-related radionuclides of interest at the screening criteria, if present. These instrument minimum detectable count rates (MDCR) and corresponding scanning minimum detectable concentrations (Scan MDC) will be verified on site to confirm the selected instruments are capable of detecting contamination with the required sensitivity. The detection sensitivity during the survey should, at a minimum, be within the DOE remediation guidelines used as soil screening criteria.

The ambient radiation is expected to be approximately 7 microroentgen per hour (μR/hr), consistent with previous investigations on site and on adjacent properties. Heterogeneity is anticipated based on variable soil types and differences between native soils and fill from previous remediation efforts across the VP; however, the majority of VP is assumed to be within DOE unrestricted release criteria until evidence suggests otherwise. Therefore, post-processed data will be evaluated in the context of variability from the sitewide mean. Ultimately GWS data will binned by standard deviations of the sitewide mean.

The post-processed action level will be initially defined as contiguous clusters of technically legitimate results (i.e., attributable to actual site soil or sediment conditions rather than anomalous instrument responses or clear technologically enhanced naturally occurring radioactive material [TENORM] influence such as slag) exceeding two standard deviations of the mean. Observed count rates above the post-processing action level or the instrument MDCR in the field do not necessarily indicate that contamination is present, but rather indicate areas for further evaluation. Because TENORM (i.e., slag and slag-like material) has been thoroughly documented (DOE 1984, 1986) within the NFSS and vicinity properties, these flagged areas will also be investigated for contributing TENORM point sources.

5.3.2 Composite Soil Sampling

Composite soil samples will be collected across 100 m^2 (1076 ft^2). areas exhibiting elevated GWS measurements. Samples will be homogenized and submitted for radiochemistry analysis of FUSRAP-related contaminants at a contracted ELAP-accredited laboratory. Well-homogenized composite samples are considered more representative surrogates of the mean radioactivity concentration over each area than the population mean of discrete samples. Incremental activity contributions are intrinsically weighted per area based on the number of increments and compositing minimizes the overrepresentation of uniquely high or low activities in a discrete sample. This approach provides a more efficient means of evaluating residual radioactivity per 100 m^2 (1076 ft^2) areas for direct evaluation against the DOE remediation criteria used as site screening criteria.

5.3.2.1 Composite Sample Delineation

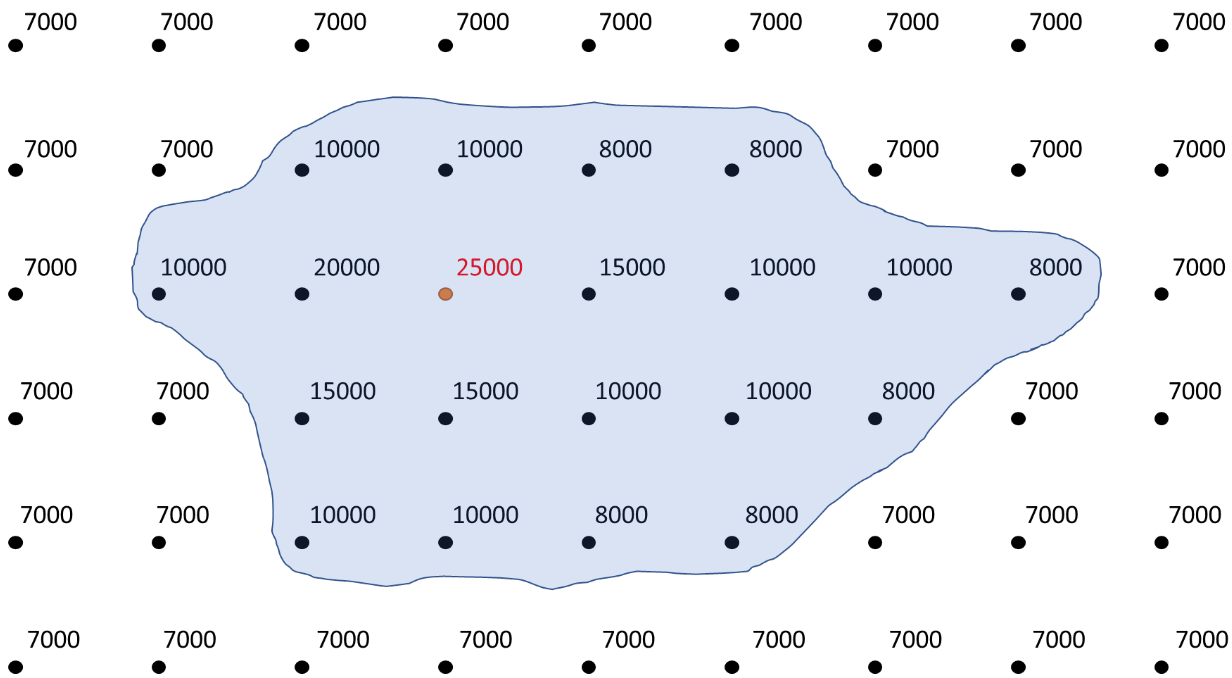
Areas identified in the GWS suggesting potentially uncharacterized residual radioactivity will be bounded into contiguous 100 m^2 (1076 ft^2) decision units (DU) defined by maximum anticipated interior radioactivity. Decision units in this context represent the most fundamental area upon which screening decisions are made in the PA/SI to maintain the area-weighted component of the DOE release criteria for direct comparison. These areas will primarily be distinguished during post-processing of the GWS data and secondarily by field observations if subsets of the data contain poor spatial accuracy.

For example, if a distinct definable feature is identifiable during the GWS then the area will be scaled outward by initially centering the 100 m^2 (1076 ft^2)decision unit on the maximally observed count rate, with the location of the centroid adjusted as necessary in order to fully encompass the area exceeding the action level. If the exceeding area is greater than 100 m^2 (1076 ft^2), the initial decision unit will be centered on the maximally observed count rate and the remaining area will be subdivided into additional decision units, as necessary, for composite sampling such that each unit comprises 100 m^2 (1076 ft^2). If multiple unique yet adjacent features are definable then they will be mutually incorporated into a common decision unit.

In order to satisfy competing interests of capturing the maximum discrete interior activity and maximum spatial coverage, the representative composite sample from each decision unit will consist of systematically located gridded increments with a starting location defined by the greatest individual GWS count rate. If portions of the completed GWS contain flagged or otherwise definable features but are characterized by poor geospatial accuracy, the decision unit boundaries will be defined manually in the field with individually noted boundary coordinates based on the post-processed action level.

The figure below demonstrates a conceptual DU designation and increment collection scheme for composite sampling based on observable gamma count rates in a GWS. Note that the boundaries are biased to incorporate the maximally anticipated interior activity.

Conceptual Illustration of DU Definition per GWS Count Rate (counts per minute)



Conceptual DU in blue for composite sampling, not to scale

5.3.2.2 Composite Sample Collection

Each composite sample will consist of incremental grabs collected over distinct 15 centimeter (cm) (6 inch) vertical intervals throughout the decision unit. This will consist of a surface interval (0 to 15 cm [0 to 6 in]) and a subsurface interval (15 to 30 cm [6 to 12 in]). Samples will be collected over these intervals for direct evaluation against the screening levels in Table 1. The number of increments per sample is determined primarily by the need to adequately represent the overall variance within the DU without over- or under-representing any particular local activity concentration. Overall, 20 increments are planned to be collected per sample; however, more or less may be considered depending on the observable variance of gamma count rates in the GWS.

Soil increments will be collected using a hand operated coring device that ensures reproducible masses and volumes per increment. Each increment location will be geolocated in the field using a GPS device and flagged for sampling. Any relocations or adjustments due to physical obstruction or poor soil recovery will be noted and the new offset coordinates will be recorded.

All increments will be placed into a clean, dedicated sampling receptacle for homogenization. The composite sample will be screened or sieved to remove organics (i.e., grass and roots) and non-soil-like materials (i.e., rocks, slag, gravel, etc.). The overall sample will be weighed to ensure adequate soil mass for laboratory analysis. Approximately 1,000 to 2,000 grams is desired. If this overall sample mass cannot be obtained (i.e., obstructions or poor recovery), the number of increments may be increased. Homogenized samples will be placed in Ziplock-type bags for processing and shipment to the contracted ELAP-accredited laboratory.

5.3.2.3 Sample Identification

Soil samples collected will be recorded on a sampling log and chain of custody formatted specifically for the field investigative activities at the site (Appendix C). Samples will be identified as prescribed in Table 2 to ensure the necessary identifiers are maintained from sample collection through laboratory result interpretation.

Table 2 – Composite Soil Sample Naming Scheme

Sample ID Component	Sample ID Description	Sample ID Notation
Site Code	Vicinity Property X	VPX
Matrix Code	Soil	SO
Location Code	Hot Spot	HS
Numerical Sequence Identifier (e.g. 01, 02, 03, etc.)		##
Vertical Depth Interval (in inches)		##-##
Duplicate sample (if applicable)		D

Examples:
VPX-SO-HS01-0-6 = Surface soil sample obtained from hot spot #1 at the site between 0-6 inches.
VPX-SO-HS01-6-12-D = Duplicate subsurface sample from hotspot #1 between 6-12 inches.

5.3.2.4 Decontamination

All reusable sampling equipment (i.e., core sampler, bowls, mixing tools, etc.) will be decontaminated prior to use, between samples, and following on-site activities. Disposable sampling equipment or materials used during the decontamination process (i.e., paper towels, rags, etc.) will be radiologically screened to determine the appropriate disposal route.

Decontamination will be performed in the following order:

1. Dry wipe to remove bulk media
2. Distilled water rinse
3. Scrub with laboratory-grade detergent (i.e., Alconox® or equivalent)
4. Distilled water rinse
5. Isopropyl alcohol or acetone rinse
6. Air dry

Decontaminated equipment will be radiologically screened prior to reuse.

5.4 Alternative Procedures for Limited Survey Coverage or Poor Spatial Accuracy

If site conditions such as extensive vegetative or canopy cover, flooding, or snowfall limit the physical gamma walkover survey coverage or negatively impact the spatial accuracy of the GPS, systematic composite sampling may alternatively be performed over the area(s) intended to be surveyed, only if adjacent survey data, historical data, or the conceptual site model indicates a likelihood of impacts over a particular area. For example, if significant flooding is encountered in the WDD such that the GWS can either not be safely performed or the resulting source-to-detector configuration is insufficient to meet the desired detection sensitivities outlined in Appendix B, then composite samples may be systematically collected over 100 m^2 (1076 ft^2) areas down the ditch.

Data quality issues associated with localized poor post-processing GPS accuracy due to vegetative cover may also present issues, especially around sections near the railroad platforms and the WDD with heavy vegetation cover. In these instances, a field investigation level will be defined as the observable instrument response that triggers further investigation of the surveyed area through additional scanning, static measurements, and/or composite sampling. For this site inspection, the field investigation level will be 1.5x the ambient count rate (i.e., sitewide or local mean) and/or judgmental, as necessary, based on surveyor observations to maintain conservatism. Any alternative procedures or general deviations from the procedures described in this SAP will be documented.

5.5 Electronic data

The GPS data (coordinates) and GWS readings will be recorded electronically during field activities. The coordinates and GWS data will be exported as a Microsoft Excel file and saved with other project files.

Part II: Quality Assurance Project Plan

6.0 Data Quality Objectives

Data quality objectives (DQOs) are meant to ensure the quality and integrity of samples, the accuracy and precision of analyses, and the representativeness, comparability and completeness of results to meet project objectives. The DQOs are dependent on the data requirements and intended uses of the collected data. They can be expressed in terms of objectives for precision, accuracy, representativeness, completeness, comparability, and sensitivity.

6.1 DQO Process

The DQO process is comprised of seven steps designed specifically for data collection and analysis which supports informed decision making.

The seven-step DQO process includes:

1. **State the Problem** – Site history consulted during the PA/SI process demonstrates that most of the historic data from previous investigations and remedial actions are below DOE unrestricted release criteria following remediation, but radiological observations made during DERP-FUDS (USACE 2011) and OEA (USACE 2012) activities on site prompted further evaluation for groundwater and localized soils. Site groundwater was sampled from pre-existing wells in 2019 and preliminary field evaluations performed by USACE in 2019 and 2020 identified potential additional instances of uncharacterized residual radioactivity, prompting the expanded scope of this SAP. The principal DQOs of this investigation and the following PA/SI have been established:
    - Determine if radiological contamination resulting from MED/AEC activities is present in concentrations which may constitute a threat to human health or the environment; and
    - Provide sufficient characterization data to enable completion of the subsequent PA/SI document.
2. **Identify the Goals of the Study** – The overall goal of the study is to determine whether potential MED/AEC-related material present at VP X warrants the advancement of further CERCLA action (i.e., remedial investigation or removal of critically impacted media). Specifically, the remaining tasks will be addressed in two actions:
    - Complete a gamma walkover survey over areas of previous site activities and remediation (i.e., the former wastewater treatment plant area, the former railroad loading areas, and the Western Drainage Ditch) to identify potential instances of uncharacterized residual radioactivity, and
    - Characterize identified radioactivity through composite sampling for direct evaluation against the site screening levels outlined in Table 1.
3. **Identify the Information Inputs** – Inputs include data types and information required to make informed decisions. The first decision input is the identification of distinguishable radiation in the GWS exceeding the post-processed action level or field investigation level, prompting composite sampling. The analytical results of the composite samples will then serve as the primary screening metric for the subsequent SI.

4. **Define the Boundaries of the Study** – This investigation is bounded by the physical extent of the vicinity property; however, the primary focus will be the areas of historic use and past remediation efforts (i.e., the former wastewater treatment plant, the railroad loading areas, and the Western Drainage Ditch). It is expected that uncharacterized residual radioactivity, if present, will be surficial or near-surficial based on previous DOE remediation (DOE 1984, 1986). Therefore, the physical collection of surface (0-15 cm [0-6 inches]) and subsurface (15-30 cm [6-12 inches]) soil/sediment samples will likely be achievable with hand borings. In the event that additional subsurface samples are desired or required, such as if legacy utilities are suspected to be impacted, this approach may be reconsidered.
5. **Develop the Analytical Approach** – All environmental samples will be analyzed in a DOD-ELAP accredited laboratory according to the prescribed methods presented in Table 3. Analytical results will be compared to the site screening levels established in Table 1.

Table 3 – Soil Analysis and Analytical Methods

Parameter(s)	Method
Radium-226 and Radium-228	EPA 901.1, Gamma spectroscopy
Isotopic Thorium (Thorium-228, -230, and -232)	DOE EML HASL-300m, Alpha spectroscopy
Isotopic Uranium (Uranium-234, -235, and -238)	DOE EML HASL-300m, Alpha spectroscopy

6. **Specify Performance and Acceptance Criteria** – Decision-error tolerances are established to limit (i.e., control) the degree of uncertainty with which the decision is made, and avoid, to the extent possible, the consequences of making an incorrect decision. Potential sources of error must be identified and evaluated for the likelihood that an incorrect decision may result such that the ultimate decisions are made based on known, reliable, and reproducible data. Establishing acceptable decision-error tolerances minimizes the three types of error listed below:
    - *Sampling design error*, which occurs when the sampling design and surveyor judgment does not account for the natural variability in the true state of the environment (i.e., does not produce representative data).
    - *Measurement error*, which occurs from random and systematic errors that are inherent in each step of the data production process, including sample collection, preparation and analysis, and data reduction, handling, and reporting.
    - *Total study error*, which is a function of both sampling design and measurement error combined. Therefore, both the field investigation and the analytical laboratory must be held to strict quality assurance (QA) standards to meet the quantification and quality control (QC) limits specified by the Department of Defense (DoD) and DOE Consolidated Quality Systems Manual (QSM) for Environmental Laboratories Version 5.3 (DOD and DOE 2021).
7. **Develop the Plan for Obtaining Data** – This SAP was developed based on the needs of the project and to obtain sufficient quality data to address the project objectives.

6.2 Field Equipment Data Quality

All field instruments will be calibrated prior to field mobilization and will be evaluated throughout the work to ensure reliable comparativeness. Additionally, the gamma walkover survey will be performed according to the prescribed methodology in Appendix B such that the anticipated sensitivities (i.e., ScanMDCs) are within the site screening levels presented in Table 1.

6.2.1 Instrument Calibration

All field instruments will be calibrated prior to field mobilization. Current calibration and/or maintenance records will be kept on site for review and inspection for all instruments used during the survey.

The records will include, at a minimum, the following:

- Name of the equipment
- Equipment identification (model and serial number)
- Manufacturer
- Data of Calibration (i.e., efficiencies per energy)
- Calibration Due Date

Instrumentation shall be maintained and calibrated to manufacturer specifications to ensure that required traceability, sensitivity, accuracy, and precision of the equipment/instruments is maintained.

6.2.2 Instrument Checks

The operator will perform a pre-operational check on all instruments before use. A quality control measurement with a check source will be performed at the beginning of each survey day and, at a minimum if used for data collection, at the end of the survey day to verify consistency throughout the day. The following routine checks will be performed on all instruments:

- Pre-Operational Checks:
  - Perform battery check.
  - Check for broken, frayed, damaged, or different length cables.
- Perform Instrument Response Checks
  - Collect background reading and ensure it is within QC chart parameters.
  - Perform quality control check on meters utilizing a source that emits the same radiation and approximate energy as that of the primary isotope(s) of interest.

6.2.3 Quality Control Tracking

A QC tracking chart is created by obtaining up to 30 measurements of an ambient background area and with check sources that emit the same radiation or approximate energy as that of the primary radiological contaminants of interest. The mean and standard deviations for the instrument response will be calculated and plotted where the mean is assumed to be the "true" value. The values for the warning limits and control limits are then calculated as 2σ and 3σ of the mean value, respectively. The graph will be used to plot the daily operability checks for survey meters operated in the survey. Trend analysis will also be evaluated for each instrument to monitor any potential drift throughout the survey.

If daily operability checks fall outside the warning limits, the operability check should be repeated up to three times. If the instrument continues to fall outside the warning limits but inside the control limits; the surveyor will investigate causes and may permit continued use with justification. An instrument may be removed from service if the operability check falls outside the control limits and cannot be attributed to site conditions such as radon progeny fluctuations (i.e., in soils/sediment), humidity, or temperature inversion. The instrument will be returned to service with a new QC chart after it is either repaired, recalibrated, or the cause for the faulty reading is identified. Instruments may also be removed from service and recalibrated if a malfunction is suspected.

All daily operability checks (including any outside the warning or control limits) will be recorded in the instrument QA/QC files.

6.3 Analytical Data Quality

The overall quality assurance objective defined in the SAP is to develop and implement procedures for the gamma walkover survey and subsequent composite sampling, chain of custody, laboratory analysis, and reporting which will result in sound data that are scientifically valid and achieve standards that meet the specific DQOs for the site. Additionally, the laboratory analytical methods and results for all environmental samples collected from VP X will be evaluated against prescribed measurement quality objectives (MQOs) to ensure sufficiency to satisfy the DQOs. These MQOs evaluate key data quality indicators (DQIs) such as precision, accuracy, representativeness comparability, completeness, and sensitivity as established in the DoD/DOE QSM (DOD and DOE 2021) and the Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) (EPA 2004), where applicable.

6.3.1 Measurement Quality Objectives

The MQO objectives are accuracy, precisions, completeness, representativeness and comparability which are defined as follows:

1. **Accuracy**: the closeness of agreement between an observed value and an accepted reference value. The difference between the observed value and the reference value includes components of both systematic error (bias) and random error. Accuracy will be ensured through the adherence to all field instrument calibration procedures, sample handling, preservation, and holding time requirements. The laboratory will assess the overall accuracy of their instruments and analytical methods (independent of sample or matrix effects) through the measurement of "standards," materials of accepted reference value. Accuracy may vary from analysis to analysis because of individual sample and matrix effects. Laboratory accuracy requirements are presented in the DoD/DOE QSM (DOD and DOE 2021). Accuracy within each individual analysis will be measured in terms of blank results, the percent recovery (%R) of surrogate compounds in organic analyses, or %R of spiked compounds in matrix spikes (MSs), matrix spike duplicates (MSDs), and/or laboratory control samples (LCSs). This gives an indication of expected recovery for analytes tending to chemically behave like the spike or surrogate compounds.
2. **Precision**: the agreement among a set of replicate measurements without consideration of the "true" or accurate value (i.e., variability between measurements of the same material for the same analyte). Precision is measured in a variety of ways including statistically, such as calculating variance or standard deviation among replicate samples. The resulting information will be used to assess analytical variability. Precision in the field will be assessed through the analyses of field replicate samples (i.e., Table 6). Precision in the laboratory will be assessed through the analyses

of matrix spike/matrix spike duplicate (MS/MSD) samples. MS/MSDs will be chosen at random by the laboratory from the batch of samples and analyzed per the analytical method. Precision in the laboratory will be measured through the calculation of relative percent differences (RPDs).

3. **Completeness**: is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. "Normal conditions" are defined as the conditions expected if the sampling plan was implemented as planned. Completeness is a measure of the number of valid measurements obtained from all the measurements taken in the project and valid samples collected. The field completeness objective is greater than 90 percent. The laboratory completeness objective is greater than 95 percent.
4. **Representativeness**: a qualitative parameter that expresses the degree to which data accurately and precisely represents either a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition within a defined spatial and/or temporal boundary. To ensure representativeness, composite samples from each decision unit will consist of systematically located gridded increments with a starting location defined by the greatest individual GWS count rate, or as close as possible, to capturing the maximum perceived interior activity. Representativeness is further dependent upon proper design of the sampling plan and ensuring that the SAP is followed. This will be semi-quantitatively contextualized in terms of field duplicates (i.e., Section 6.3.2).
5. **Comparability**: expresses the confidence with which one data set can be compared to another. Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the SAP is followed. Comparability is dependent on the use of recognized EPA or equivalent analytical methods and the reporting of data in standardized units. Analytical laboratory data will be reported in picocuries per gram (pCi/g).
6. **Sensitivity**: the ability of a method or instrument to discriminate between responses representing different concentrations of the analyte of interest. This is represented as a detection limit.

Tables 4 and 5 define the DQI acceptance metrics for the laboratory analyses of soil and/or sediment matrices considered in this investigation.

Table 4 – Alpha Spectrometry Performance Criteria

Method	DQI	MQO	QC Sample and/or Activity Used to Assess Performance
DOE EML HASL-300m	Precision	$\lvert ZDup \rvert \leq 3$. Investigate recurrent results with $\lvert ZDup \rvert \geq 2$ (MARLAP 18.4.1) *or* The Duplicate Error Ratio (DER) between the sample and the duplicate is < 3; or the Relative Percent Difference (RPD) is < 25%	Laboratory Sample Duplicate

Method	DQI	MQO	QC Sample and/or Activity Used to Assess Performance
	Sensitivity	|ZBlank | ≤ 3. Investigate recurrent results with |ZBlank| ≥ 2 (MARLAP 18.4.1)	Method Blank
	Accuracy	|ZLCS | ≤ 3. Investigate recurrent results with |ZLCS| | ≥ 2 (MARLAP 18.4.3)	Laboratory Control Spike (LCS)
	Accuracy	Isotopic yield within 30- 110%. Full-width half maximum (FWHM) < 100 kiloelectron volts (keV) and peak energy within ± 40 keV of known peak energy.	Tracer Recovery
	Completeness	>95% laboratory analysis	Data Completeness

Table 5 – Gamma Spectroscopy Performance Criteria

Method	DQI	MQO	QC Sample and/or Activity Used to Assess Performance
EPA 901.1	Precision	|ZDup | ≤ 3. Investigate recurrent results with |ZDup| ≥ 2 (MARLAP 18.4.1) *or* The DER between the sample and the duplicate is < 3; or the RPD is < 25%	Laboratory Sample Duplicate
	Sensitivity	|ZBlank | ≤ 3. Investigate recurrent results with |ZBlank| ≥ 2 (MARLAP 18.4.1)	Method Blank
	Accuracy	|ZLCS | ≤ 3. Investigate recurrent results with |ZLCS| | ≥ 2 (MARLAP 18.4.3)	LCS
	Completeness	>95% laboratory analysis	Data Completeness

6.3.2 Field Quality Indicators

Field duplicates will be collected when extensive DU variability is known or suspected (i.e., from GWS observations) to best quantify the true mean and/or with a regular frequency to evaluate and contextualize internal representativeness within composite sampling DUs. Overall, duplicates will be collected from each sampling strata with an approximate frequency of at least 10%. If the total sample size is less than ten per strata, then at least one duplicate will be collected.

Field duplicates will be collected using the same procedure as for the primary sample (i.e. obtaining gridded increments across the decision unit); however, since the primary sample is biased based on the maximally observable count rate, the starting point of the duplicate will be offset from that of the primary sample. For this reason, discrepancies between the primary and duplicate samples effectively quantify the degree of internal heterogeneity within a DU. When field duplicates are collected, this internal heterogeneity will be contextualized between duplicates using a normalized absolute difference (NAD):

$$NAD = \frac{|Sample - Duplicate|}{\sqrt{\sigma_{Sample}^2 + \sigma_{Duplicate}^2}}$$

Where σ is the analytical uncertainty per sample. The heterogeneity will be interpreted according to Table 6.

Table 6 – Field Duplicate Representativeness

NAD	Heterogeneity Assumption
≤ 1.96	Fairly homogenous
1.96 > NAD ≤ 2.58	Moderately heterogeneous
> 2.58	Fairly heterogeneous

To maintain conservatism, the greatest of the field replicates will be assumed representative of the concentration per area to maintain conservatism for direct screening.

7.0 Sample Handling, Preservation, and Holding Times

If necessary, the sampling containers and coolers will be provided by the analytical laboratory. All samples will be placed in appropriate sample containers and labeled with sample location, date, time, unique sample ID, and analyses required. The samples will be packed in coolers with ice sufficient to maintain the samples at 4º C for 24 hours using proper Chain-of-Custody (COC) procedures. The coolers will be sealed using proper security procedures and shipped via overnight delivery to the analytical laboratory. Each sample shipment will be accompanied by a COC record identifying its contents. This record will be used to document sample custody transfer from the sampler to either other sampling team members (if necessary) or the courier, and finally to the analytical laboratory. The COC record ensures that samples can be traced from the time of field collection until they are received and analyzed by the analytical laboratory. The original custody record is shipped along with the samples, while the initiator of the record retains a copy. The information required for the COC includes:

- Type of sample (grab or composite) and matrix;
- Analytical method numbers and parameter names;
- Sample container size and type, and number of containers per parameter;
- Preservatives, if any;
- Sample identification (ID);
- Printed name and signature of sampler;
- Date and time of sample collection;
- Project name, location and address; and

- Signatures of persons involved in the chain of possession.

8.0 Field Reports

Information pertinent to field activities including field instrument calibration data will be recorded in daily field reports. Photographs will be taken to document representative field procedures and areas of known or suspected residual contamination. When a photograph is taken, the date, time, weather conditions (if applicable), subject, purpose for the photograph, and photograph number will be recorded in the daily field reports.

9.0 Analytical Data Review

Data reports received from the analytical laboratory will be reviewed by the USACE chemist. The review will verify compliance with requested testing, completeness of the analytical report, and confirm the receipt of all requested deliverables. In addition, the data will be validated to identify method, batch, or individual sample results which may have limitations or be unacceptable.

10.0 Non-Conformance and Adaptations

During the course of the project, it is the responsibility of the field team members to ensure that measurement procedures are followed as specified, and that measurement data meet the prescribed criteria. It is imperative that prompt action be taken to correct the problem in the event that such a problem arises. Re-sampling will be performed, if necessary, to correct the discrepancy.

11.0 References

ANL 1988. *Derivation of a Uranium and Cesium-137 Residual Radioactive Material Guidelines for the Niagara Falls Storage Site,* Argonne National Laboratory, Chicago, Illinois, August.

Department of Defense (DOD) and Department of Energy (DOE) 2021. *Consolidated Systems Manual (QSM) for Environmental Laboratories, Version 5.4*. October.

DOE 1984. *Comprehensive Radiological Survey, Off-Site Property X, Niagara Falls Storage Site, Lewiston, New York.* May.

DOE 1986. *Post-Remedial Action Report for the NFSS Vicinity Properties 1983 and 1984.* December.

DOE 1986a. *Development of a Supplemental Residual Contamination Guideline for the NFSS Central Drainage Ditch*, December.

DOE 1987. *U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites*, Revision 2. March.

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DOE 1992. *Certification Docket for the Remedial Action Performed at the Niagara Falls Storage Site Vicinity Properties in Lewiston, New York, From 1983 through 1986.* July.

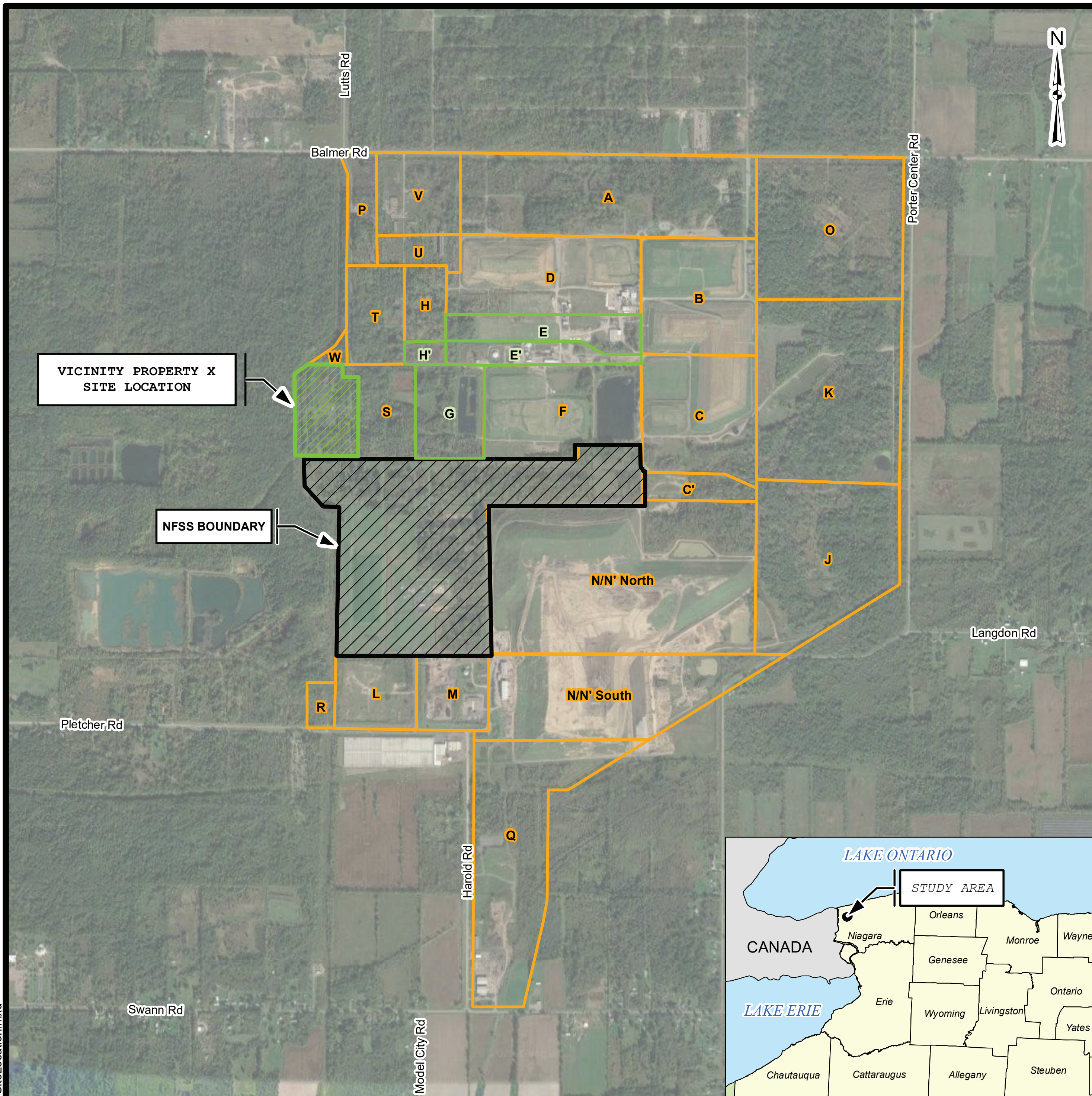
Environmental Protection Agency (EPA) 2004. *Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)*. (EPA 402-B-04-001A, NUREG-1576). July.

U.S. Army Corps of Engineers (USACE) 2011. *Final Remedial Investigation Report for Phase IV Remedial Investigation/Feasibility Study at Formerly Used Defense Site the Former Lake Ontario Ordnance Works, Niagara County, New York.* April.

USACE 2012. *Completion Report for Mitigation of Safety Hazards at the Lake Ontario Ordnance Works, Office of Economic Adjustment, Wastewater Treatment Plant.* March.

USACE 2014. *EM 385-1-1, Safety and Health Requirements Manual*. November.

FIGURES



Legend

Open Vicinity Property

Closed Vicinity Property

0 1,000 2,000 4,000 Feet

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

US Army Corps of Engineers Buffalo District

VICINITY PROPERTY X
SITE LOCATION

Document Name: 220425_SiteLocation.mxd
Drawn By: H5TDESPM
Date Saved: 25 Apr 2022
Time Saved: 11:26:29 AM

NIAGARA FALLS STORAGE SITE
LEWISTON, NEW YORK

FIGURE 1

Document Path: D:_Projects\C19\GIS\ArcMap\NFSS\VPX\2022\220425_SiteLocation.mxd

Document Path: K:\NFSSP\GIS\ArcMap\VicinityProperty\VP_X\2017\170822_F2_SiteFeatures.mxd

Legend

- Monitoring Well
- Drainage Feature
- Structures
- Site Feature
- Roads
- Railroads
- Removed Site Feature
- Fire, Drinking, Process and Cooling Water Lines
- Acid Waste Sewer Lines
- Sanitary Lines
- Wastewater Lines
- Acid Waste Sewer Lines
- TNT Waste Line (Has Undergone Cleaning and Interim Removal Action)
- 30-Inch Outfall Line
- Site Boundary
- Parcel Boundary (2010 Niagara County)
- Town Boundary

0 60 120 240 Feet

U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS BUFFALO, NY	VICINITY PROPERTY X AND ITS CURRENT SITE FEATURES	
Document Name: 170822_F2_SiteFeatures.mxd Drawn By: H5TDESPM Date Saved: 22 Aug 2017 Time Saved: 2:27:50 PM	VICINITY PROPERTY X NIAGARA FALLS STORAGE SITE LEWISTON-PORTER, NEW YORK	FIGURE 2

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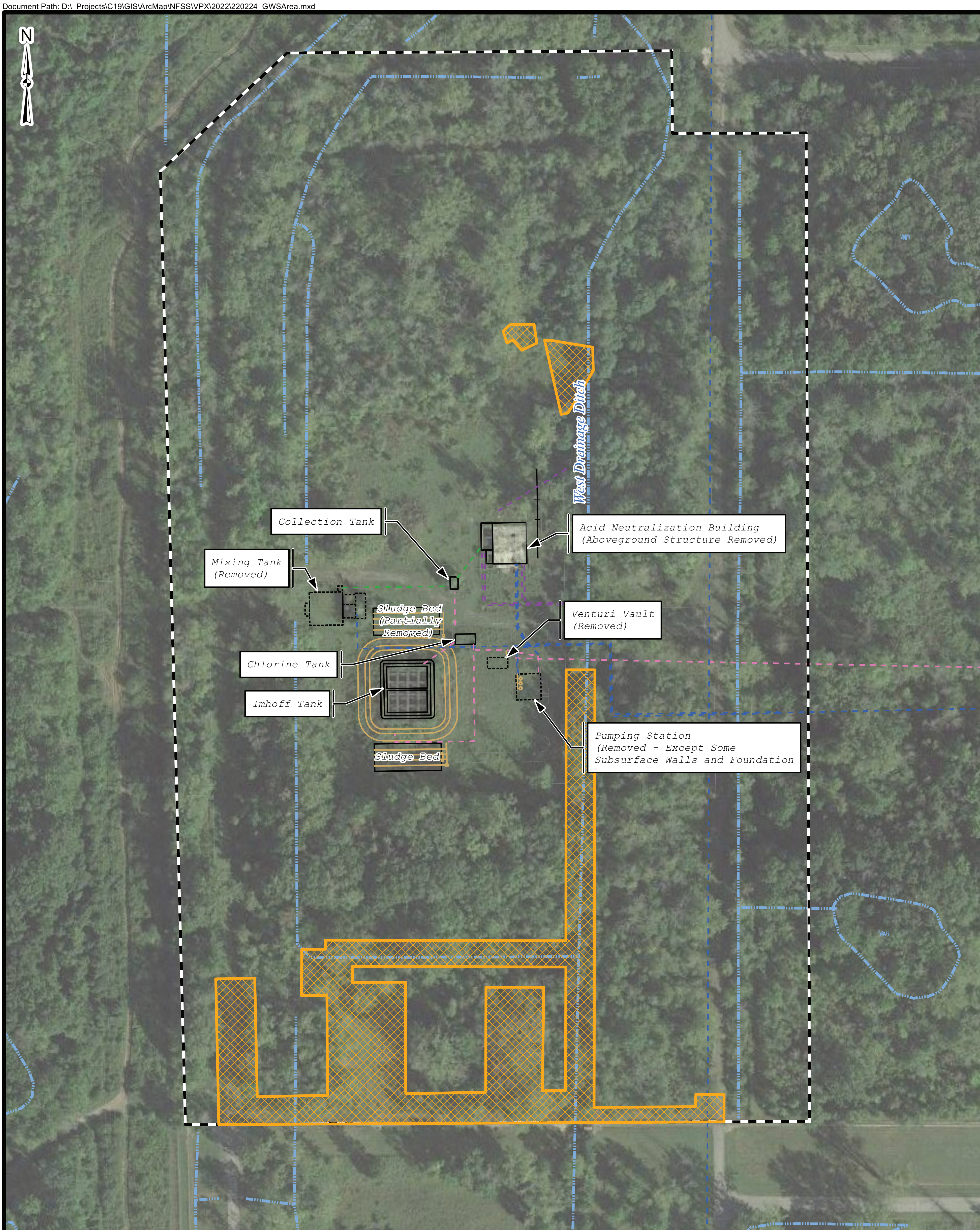

Legend

- Planned GWS Resurvey Area
- Drainage Feature
- Site Boundary

0 60 120 240 Feet

US Army Corps of Engineers
Buffalo District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

PLANNED GAMMA WALKOVER RESURVEY AREAS (2022)

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Drawn By: H5TDESPM
Date Saved: 24 Feb 2022
Time Saved: 8:27:58 AM

VICINITY PROPERTY X
NIAGARA FALLS STORAGE SITE
LEWISTON-PORTER, NEW YORK

FIGURE 3

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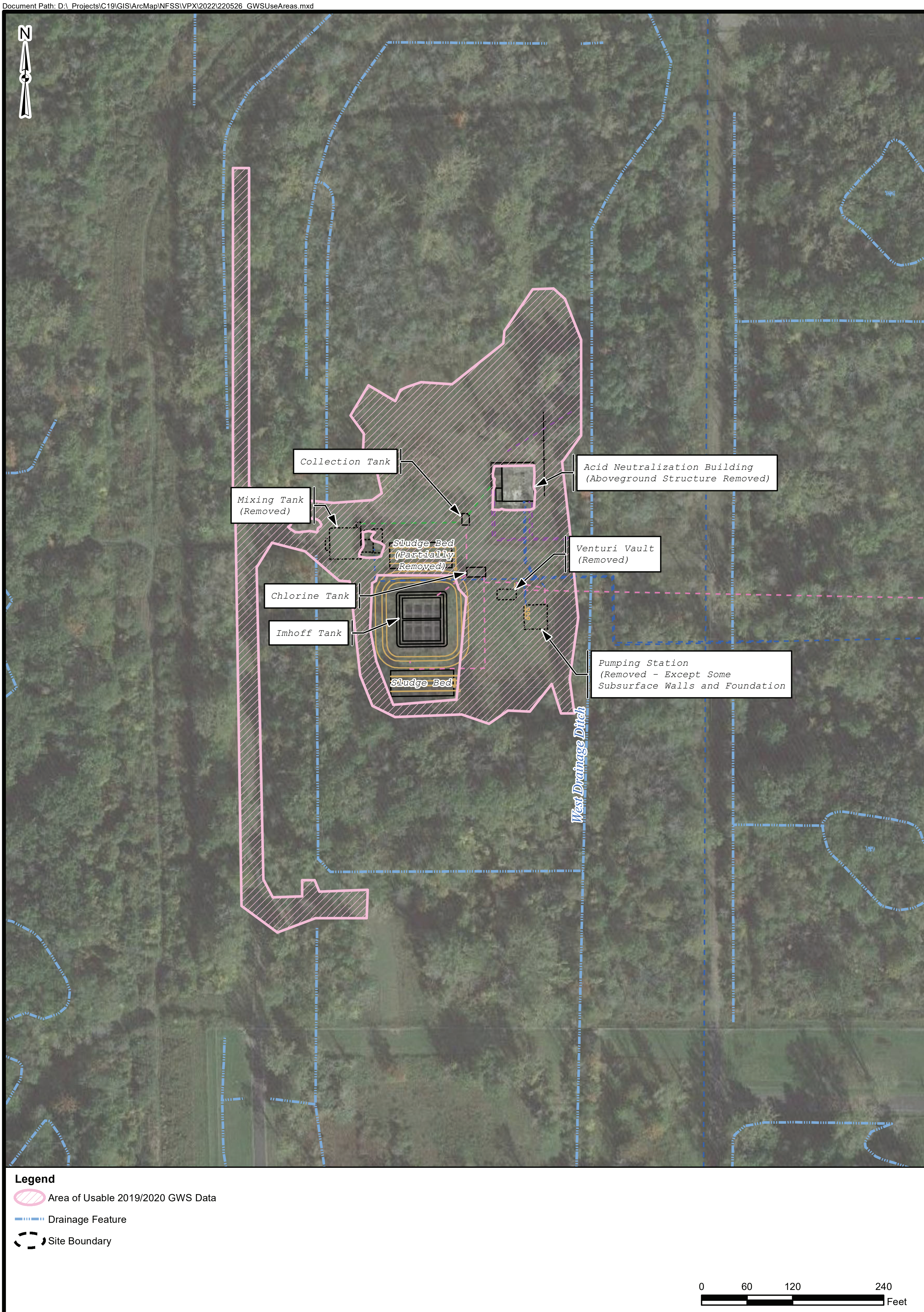

US Army Corps of Engineers Buffalo District

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NY

AREA OF USABLE 2019 & 2020
GAMMA WALKOVER SURVE DATA

Document Name: 220526_GWSUseAreas.mxd
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VICINITY PROPERTY X
NIAGARA FALLS STORAGE SITE
LEWISTON-PORTER, NEW YORK

FIGURE 4

APPENDIX A

ACTIVITY HAZARADS ANALYSIS

U.S. ARMY CORPS OF ENGINEERS, BUFFALO DISTRICT

ACTIVITY HAZARDS ANALYSIS (AHA)

For use of this form, see EM 385-1-1; the proponent agency is CELRB-SO.

DATE PREPARED: November 24, 2021	OVERALL RISK ASSESSMENT CODE (RAC) (Use Highest Code): L
ACTIVITY/WORK TASK: Environmental Field Sampling Activities	
ACTIVITY LOCATION: Niagara Falls Storage Site (NFSS), Lewiston, NY	
PREPARED BY: (*Name, Title*) Mat Masset, Chemist	
REVIEWED BY DISTRICT SOHO: (*Name, Title*) Vanessa Matheny, Safety Specialist	
RISK ACCEPTED BY: (*Name, Title*)	
PROJECT:	
CONTRACT NUMBER:	

RISK ASSESSMENT CODE (RAC) MATRIX

SEVERITY	PROBABILITY				
"Severity" is the outcome/degree if an incident, near miss, or accident did occur.	"Probability" is the likelihood to cause an incident, near miss, or accident.				
	FREQUENT	LIKELY	OCCASIONAL	SELDOM	UNLIKELY
CATASTROPHIC	E	E	H	H	M
CRITICAL	E	H	H	M	L
MARGINAL	H	M	M	L	L
NEGLIGIBLE	M	L	L	L	L

Step 1: Review each "Hazard" with identified safety "Controls" and determine RAC (See above)
Step 2: Identify the RAC for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.
Risk Code: E (Extremely High Risk), H (High Risk), M (Moderate Risk), or L (Low Risk)
Step 3: Identify any equipment, training, and inspection requirements.
Step 4: Identify the names of the Competent Person(CP)/Qualified Person(QP) required for a particular activity specified in EM 385-1-1/OSHA and provide proof of their competency/qualification.

NOTES:

Add Identified Hazards

	JOB STEPS	HAZARDS	Controls (Actions to Eliminate or Minimize Hazards)	RAC
X	Driving Motor Vehicle	Vehicle/Pedestrian Accident	Review "Driving Motor Vehicle For Work Related, AHA" for further details. Defensive Driver Training online course.	L
X	Site Access/Health and Safety Briefing	Inclement Weather, Project Specific Hazards	Evaluate weather conditions prior to travel to known locations. Ensure emergency supplies are on hand in the event you become stranded (e.g., first aid kit, flashlight, visibility triangles, blanket). Dress appropriate for the anticipated weather conditions. Employees must wear long pants and minimum short sleeve shirt. Wear appropriate PPE required by the Project (hard hat, high-vis vest, steel toed shoes, safety glasses/goggles, hearing protection if noise exposures above 85dbA., etc.).	L
X	Walking/Working	Slips/trips/falls	All individuals will be cognizant of the daily environmental conditions under which field work occurs, such as snow, ice, slippery surfaces, rough terrain, brushy/overgrown terrain, and uneven walking surfaces. First Aid kits will be available in each vehicle and for use in the field. Footwear with appropriate ankle support shall be used at all times. Footwear, including steel-toed and rubber boots, or hip waders, as appropriate, shall be available for all personnel. Avoid walking on ice that covers waters of unknown depths. Be aware of terrain consisting of muck soils or inundated surfaces.	L

ACTIVITY HAZARDS ANALYSIS (AHA)

For use of this form, see EM 385-1-1; the proponent agency is CELRB-SO.

	JOB STEPS	HAZARDS	Controls (Actions to Eliminate or Minimize Hazards)	RAC
X	Collection of Surface Water, Sediment, and Leachate Samples	Movement of Trucks and Equipment	1. Coordinate your visit with the COR and the site maintenance contractor so they know you are there. 2. Sign in/out at the contractors office building. 3. Be aware of the location and direction of contractors operating equipment.	L
X		Severe Weather	1. Seek shelter in vehicles during instances of high winds, extreme heat or cold, heavy snow, hail, freezing rain or thunderstorms. 2. 30 minute stand down from the last occurrence of thunder or lightning if within 10 miles. 3. Utilize canopies as needed.	L
X		Heat Stress	1. Rest in a shaded area if needed. 2. Consume large quantities of fresh, potable water. Dilute electrolytic replenishing beverages such as gatorade may be used as a secondary source of fluid replacement. 3. Utilize sun screen. Review LRB District Heat/Cold Stress program and training slides.	L
X		Cold Exposure	1. Wear many layers of relatively light clothing with an outer shell of windproof material. 2. Avoid exposure to humidity and contact with wet surfaces. 3. Use wind breaks to reduce wind chill factor. Review LRB District Heat/Cold Stress program and training slides.	L

U.S. ARMY CORPS OF ENGINEERS, BUFFALO DISTRICT

ACTIVITY HAZARDS ANALYSIS (AHA)

For use of this form, see EM 385-1-1; the proponent agency is CELRB-SO.

	JOB STEPS	HAZARDS	Controls (Actions to Eliminate or Minimize Hazards)	RAC
X		Animal or Insect Bites	1. Tuck in shirts and tape joints between pant legs and top of socks/boots to prevent insect infiltration under clothing. 2. Spray outer clothing with insect repellent containing DEET, permethrin or permanone. 3. Caution when opening well casings and well caps as bees nest in these areas. If a nest is observed use bee spray. Wasp nests are very common to find inside the metal well casings at NFSS and employees expect wasps to fly out when opening up the wells. Potential wasp hazards may have been focused on the the well casing and not the surrounding structures. USACE employees should check all structures that could potentially be disturbed for wasps and other hazards. In addition, each employee should carry wasp or bee spray. If an object or structure that needs to be disturbed is found to have a wasps nest, then employees should use the wasp spray and come back to the object once the wasps have been exterminated. In addition, employees should be encouraged or required to wear long sleeved shirts as necessary to reduce skin exposure to possible bits or stings. 4. Avoid all wild animals. 5. Do not touch chicken wing bones or debris dropped by seagulls from Modern Landfill.	L
X	Operating UTV	Accident	1. Observe 10 mph speed limit. 2. Drive on paved, gravel or hard packed surfaces. 2. Do not drive on slopes, surfaces that may be slippery, or through water. 3. Do not drive cars/trucks onto the cap. Only off-road vehicles permitted. 4. Use a spotter in areas of vegetation and when driving in/out of the screw building. 5. Make sure back-up alarm works properly on all off-road vehicles.	L
X	Collection of GW, Surface Water & Sediment Samples	Back Injuries	1. Use proper lifting techniques. 2. Get help or use lifting equipment when moving heavy, large or irregularly shaped objects. 3. Do not attempt to move near full carboys containing IDW waste water, alone. Transfer water using pump or have assistance from a second person.	L

U.S. ARMY CORPS OF ENGINEERS, BUFFALO DISTRICT

ACTIVITY HAZARDS ANALYSIS (AHA)

For use of this form, see EM 385-1-1; the proponent agency is CELRB-SO.

	JOB STEPS	HAZARDS	Controls (Actions to Eliminate or Minimize Hazards)	RAC
X		Chemical Exposure: Calibration Solutions and Sample Preservatives	1. SDS for each chemical utilized during sampling will be kept in the screw building and posted adjacent to the well location maps on the side of the control room. Also a map and directions to the nearest hospital will be maintained there. 2. Safety glasses and disposable gloves shall be utilized when handling all chemicals and open containers containing chemicals. When adding preservatives to sample containers from a bulk source, a face shield shall be utilized. 3. Portable eye wash bottles will be kept on top of the refrigerator in visible sight, unobstructed by other supplies. If there is skin contact with sample preservative chemicals, wash skin immediately and check SDS for medical directions. 4. Utilize good housekeeping practices for storage and containerization of chemicals in use. Refer to the SDS for storage requirements.	L
X		Contaminant Exposure	1. All wells and soils are to be handled as if contaminated. Disposable rubber gloves are to be worn during all sampling activities. Use tyvek suit if needed to prevent site water and soils from getting onto clothes. 2. Items that come into contact with site water and soils should be decontaminated or disposed of as IDW. 3. Wells that have been identified with a VOC/breathing zone hazard, are to be sampled with a full face respirator fitted with organic vapor cartridges. * Full adherence to LRB District Respiratory Protection Program which includes medical pre-clearance, annual fit testing and training shall be met as a prerequisite to donning respirators. 4. Ensure proper use and selection of PPE.	L

Add New Items

	EQUIPMENT	TRAINING REQUIREMENTS	INSPECTION REQUIREMENTS
X	Government Owned Vehicle (GOV)/Rental Vehicle	Defensive Driving Training (every 4 years)	Prior to use
X	Voluntary PPE: filtering facepiece respirator (protects against droplets and particles, not vapors)	Any persons wearing filtering facepiece respirator shall review voluntary use training and complete OSHA Appendix D form prior to use.	Daily or during each shift. Form must be signed and return to the Safety Office.

X	PPE (safety boots, safety glasses/goggles, hearing protection, gloves, high-vis vest, etc.)	PPE awareness	Prior to use
X	Sampling Equipment: 1. Water Level Probes 2. Water Quality Meters 3. Turbidity Meter 4. Peristaltic Pump 5. Post Hole Digger 6. PID	1. 40-Hour HAZWOPER/HTRW course. 2. Current 8-Hour Refresher course. 3. Radiation Awareness. 4. Pre-site safety and health briefing.	1. All equipment shall be inspected daily, prior to use 2. Water Quality Meters and PID shall be calibrated daily, prior to use.

PERSONNEL INVOLVED: (*Competent/Qualified Personnel, SSHO, CDSO, etc.*)

ACCEPTANCE AUTHORITY: (*digital signature*) ______________________________

U.S. ARMY CORPS OF ENGINEERS, BUFFALO DISTRICT

ACTIVITY HAZARDS ANALYSIS (AHA)

For use of this form, see EM 385-1-1; the proponent agency is CELRB-SO.

DATE PREPARED: March 30, 2022	OVERALL RISK ASSESSMENT CODE (RAC) (Use Highest Code): L
ACTIVITY/WORK TASK: Gamma Walkover Surveys	
ACTIVITY LOCATION: Niagara Falls Storage Site and Vicinity Properties	
PREPARED BY: (*Name, Title*) Riley Carey, Health Physicist	
REVIEWED BY DISTRICT SOHO: (*Name, Title*)	
RISK ACCEPTED BY: (*Name, Title*)	
PROJECT:	
CONTRACT NUMBER:	

NOTES:

RISK ASSESSMENT CODE (RAC) MATRIX

SEVERITY	PROBABILITY				
"Severity" is the outcome/degree if an incident, near miss, or accident did occur.	"Probability" is the likelihood to cause an incident, near miss, or accident.				
	FREQUENT	LIKELY	OCCASIONAL	SELDOM	UNLIKELY
CATASTROPHIC	E	E	H	H	M
CRITICAL	E	H	H	M	L
MARGINAL	H	M	M	L	L
NEGLIGIBLE	M	L	L	L	L

Step 1: Review each "Hazard" with identified safety "Controls" and determine RAC (See above)
Step 2: Identify the RAC for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.
Risk Code: E (Extremely High Risk), H (High Risk), M (Moderate Risk), or L (Low Risk)
Step 3: Identify any equipment, training, and inspection requirements.
Step 4: Identify the names of the Competent Person(CP)/Qualified Person(QP) required for a particular activity specified in EM 385-1-1/OSHA and provide proof of their competency/qualification.

Add Identified Hazards

	JOB STEPS	HAZARDS	Controls (Actions to Eliminate or Minimize Hazards)	RAC
X	Perform instrument response checks	Radiation	Physically inspect instruments for damage (frayed cables, battery corrosion, water/humidity condensation, etc.), do not handle electroplated sources with bare hands (if applicable), properly store sources when not in use	L
X	Walking/Working	Slips/trips/falls	All individuals will be cognizant of the daily environmental conditions under which field work occurs, such as snow, ice, slippery surfaces, rough terrain, brushy/overgrown terrain, uneven walking surfaces, and unidentified hazards (i.e., holes, pits, metal, legacy infrastructure, etc.). Footwear, including steel-toed and rubber boots, or hip waders, as appropriate, with appropriate ankle support shall be used at all times. Avoid walking on ice that covers waters or in waters of unknown depths. Be aware of terrain consisting of muck soils or inundated surfaces.	L

U.S. ARMY CORPS OF ENGINEERS, BUFFALO DISTRICT

ACTIVITY HAZARDS ANALYSIS (AHA)

For use of this form, see EM 385-1-1; the proponent agency is CELRB-SO.

	JOB STEPS	HAZARDS	Controls (Actions to Eliminate or Minimize Hazards)	RAC
X		Severe Weather	Evaluate weather conditions prior to travel to known locations. Ensure emergency supplies are on hand in the event you become stranded (e.g., first aid kit, flashlight, visibility triangles, blanket). Dress appropriate for the anticipated weather conditions. Seek shelter indoors or in vehicles during instances of high winds, extreme heat or cold, heavy snow, hail, freezing rain or thunderstorms. Adhere to a 30 minute stand down from the last occurrence of thunder or lightning if within 10 miles.	L
X		Heat Exposure	1. Rest in a shaded area if needed. 2. Consume large quantities of fresh, potable water. Dilute electrolytic replenishing beverages such as gatorade may be used as a secondary source of fluid replacement. 3. Utilize sun screen. 4. Utilize work/rest cycles as necessary and appropriate to the specific exposures. Review LRB District Heat/Cold Stress program and training slides.	L
X		Cold Exposure	1. Wear many layers of relatively light clothing with an outer shell of windproof material. 2. Avoid exposure to humidity and contact with wet surfaces. 3. Use wind breaks to reduce wind chill factor. Review LRB District Heat/Cold Stress program and training slides.	L
X		Animal or Insect Bites, Irritative Plant Exposure (i.e., poison ivy)	1. Tuck in shirts and tape joints between pant legs and top of socks/boots to prevent insect infiltration under clothing. 2. Spray outer clothing with insect repellent containing DEET, permethrin or permanone. 3. Avoid all wild animals. 4. Be cognizant of irritative vegetation and how to identify them. Carry topical ointment (i.e., diphenhydramine) if necessary. 5. Perform a self check for ticks and other insects after work	L
X		Contaminant Exposure	1. All soils are to be respected and handled as if contaminated. Disposable rubber gloves are to be worn during all sampling activities. Use tyvek suit if needed to prevent site water and soils from getting onto clothing. 2. Items that come into contact with site water and soils should be decontaminated or disposed of as IDW. 3. Ensure proper use and selection of PPE, if necessary. 4. Minimize exposures as applicable	L

Add New Items

	EQUIPMENT	TRAINING REQUIREMENTS	INSPECTION REQUIREMENTS
X	PPE (safety boots, safety glasses/goggles, hearing protection, gloves, high-vis vest, etc.)	PPE Awareness	Prior to use
X	Radiation detection instrumentation	General familiarization and troubleshooting	Prior to and after use
X	GPS instrumentation	General familiarization and troubleshooting	Prior to and after use
X	Radiation dosimeter (if necessary)	40 Hour HAZWOPER training, LRB Radiation Safety Program	Prior to use

PERSONNEL INVOLVED: (*Competent/Qualified Personnel, SSHO, CDSO, etc.*)

ACCEPTANCE AUTHORITY: (*digital signature*) ____________________

APPENDIX B

ANTICIPATED GAMMA WALKOVER SURVEY SENSITIVITY

This appendix derives the anticipated *a priori* instrument sensitivity, or minimum detectable concentrations (Scan MDC), for the potential site contaminants. Surface scans are the primary method for identifying areas with potentially elevated activities for further investigation. Therefore, the Scan MDC for each potential site contaminant should ideally be sensitive enough to identify material at the accepted screening criteria with sufficient confidence. The following methodology used to determine the Scan MDCs is based on NUREG-1507, Revision 1, with a generic source term modeled using the information provided in the site Preliminary Assessment.

The overall approach is twofold: calculate a relationship between the expected instrument response and the source geometry, then determine the minimum detectable count rate of the surveyor. The relative fluence rate to exposure rate (FRER) is inversely proportional to the individual photon energies per contaminant and mass energy absorption of air, assuming the detector is in open air):

$$FRER_{E_i} \propto \dot{X}\frac{1}{E_i}\frac{1}{(\mu_{en}/\rho)_{air}}$$

where:

$\dot{X}$ = unit exposure rate (i.e., microroentgen per hour [uR/hr]),
E_i = individual photon energy (i.e., kiloelectronvolts [keV]), and
$(\mu_{en}/\rho)_{air}$ = mass energy absorption coefficient of air per photon energy (i.e., square centimeters per gram [cm^2/g]).

Next, the relative detector response (RDR) is calculated per energy as the product of the FRER and the probability, *P*, of the photon interacting with the detector crystal and producing a pulse:

$$RDR_{E_i} = FRER_{E_i}(P_{E_i})$$

This sodium iodide (NaI) crystal interaction probability, *P*, is calculated per energy as:

$$P_{E_i} = 1 - e^{-(\mu/\rho)_{NaI}(x)(\rho_{NaI})}$$

where:

$(\mu/\rho)_{NaI}$ = the mass attenuation coefficient of the NaI crystal per photon energy (i.e., cm^2/g),
x = the crystal thickness (i.e., centimeters), and
ρ_{NaI} = density of the NaI crystal (i.e., grams per cubic centimeter [g/cm^3]).

Because many instruments only specify the response to the standard 662 keV cesium-137 emission, the RDR is essential to determine the expected detector response across the energy spectrum for each potential site constituent. This is calculated using the energy-specific "count-rate-to-exposure-rate-ratio", CPMR:

$$CPMR_{E_i} = (CPMR_{662\ keV})\left(\frac{RDR_{E_i}}{RDR_{662\ keV}}\right)$$

where:

$CPMR_{662\ keV}$ = specified 662 keV response (i.e., counts per minute [cpm] per µR/hr) and
$RDR_{662\ keV}$ = the RDR for the cesium-137 662 keV gamma.

Next, the expected detector response must be calculated for a modeled source term representative of potential site conditions. The following scenario is assumed based on the information provided in the 2011 DERP-FUDS and 2012 OEA site activities:

- The impacted media is soil with as assumed density of 1.6 g/cm^3,
- Activity is uniformly distributed throughout a cylindrical source with a radius of 56 cm (1 square meter area) and thickness of 15 cm (6 inches),
- The source is covered by 15 cm (6 inches) of "cobbles, concrete, and brick" (assumed to be concrete for shielding purposes) with a density of 2.0 g/cm^3,
- Surveyor measurements are performed at 10 cm (4 inches) above the surface,
- Thirty-seven becquerel per kilogram (Bq/kg) (1 picocurie per gram [pCi/g]) for each potential contaminant (radium-226, thorium-232, and natural uranium) with expected progeny ingrowth over the duration of historical activities onsite.

The weighted instrument response for each photon energy, *WS*, of the modeled source is calculated as:

$$WS_{E_i} = \frac{R_{E_i}\left(CPMR_{E_i}\right)}{R_{Total}}$$

where:

R_{E_i} is the exposure rate at the detector per photon energy (i.e., uR/hr), and
R_{Total} is the total exposure rate at the detector from the source across all emissions (i.e., uR/hr).

The summation of all weighted, energy specific instrument responses then comprises the total weighted sensitivity of the instrument for each potential contaminant.

The minimum detectable count rate (MDCR) for a real (i.e., less-than-ideal) surveyor is dependent on the assumed decision error rates, scan speed, background count rate, and assumed surveyor efficiency, and is calculated as:

$$MDCR = \frac{\left(Z_{1-\alpha} + Z_{1-\beta}\right)\sqrt{60R_b/i}}{\sqrt{p}}$$

where:

$Z_{1-\varepsilon}$ = the z-score of Type I (α) and Type II (β) error rates,
R_b = the background count rate (i.e., cpm),
i = the observation interval (i.e., seconds), and
p = the surveyor efficiency (unitless).

Assuming all photon counts are solely a result of the modeled source, the minimum detectable exposure rate (MDER) is calculated as the ratio of the MDCR to the summation of all weighted instrument responses across the source spectrum:

$$MDER = \frac{MDCR}{\sum WS_{E_i}}$$

Finally, the Scan MDC per unit source activity is the ratio of the MDER to the expected exposure at the detector from the source, R_{Total}. The actual Scan MDC, accounting for the modeled source activity, *C*, considers the activity of all gamma-emitting progeny and is calculated as:

$$Scan\ MDC = C\left(\frac{MDER}{R_{Total}}\right)$$

APPENDIX B: ANTICIPATED GAMMA WALKOVER SURVEY SENSITIVITY

Radium-226 + C														
			μen/ρ									cpm/ur/h		Percent
Nuclide	Energy (keV)[a]	Intensity[a]	Air[b]	NaI[c]	Concrete[b]	FRER	P	RDR	Γ (uR/h/pCi @ 100 cm)[d]	Modeled pCi/g	Expected uR/hr	Effective	Weighted	Response Contribution
Pb210	46.5	0.041	5.06E-02	1.34E+01	2.06E-01	4.25E-01	1.00E+00	4.25E-01	2.52E-02	1.00E+00	5.76E-05	9754	0	*0.0*
Pb214	53.2	0.011	3.76E-02	9.20E+00	1.37E-01	5.00E-01	1.00E+00	5.00E-01	3.23E-02	1.00E+00	2.34E-04	11463	1	*0.1*
Ra226	186.2	0.033	2.62E-02	4.06E-01	2.88E-02	2.05E-01	1.00E+00	2.05E-01	1.21E-03	1.00E+00	1.66E-03	4692	1	*0.2*
Pb214	242	0.075	2.76E-02	2.60E-01	2.91E-02	1.50E-01	9.92E-01	1.49E-01	3.23E-02	1.00E+00	9.93E-02	3411	64	*7.2*
Pb214	258.8	0.006	2.79E-02	2.33E-01	2.93E-02	1.39E-01	9.87E-01	1.37E-01	3.23E-02	1.00E+00	7.89E-03	3135	5	*0.5*
Pb214	295.2	0.192	2.86E-02	1.74E-01	2.96E-02	1.18E-01	9.61E-01	1.14E-01	3.23E-02	1.00E+00	2.49E-01	2609	123	*13.7*
Pb214	351.9	0.372	2.91E-02	1.41E-01	3.00E-02	9.76E-02	9.28E-01	9.06E-02	3.23E-02	1.00E+00	4.75E-01	2076	188	*20.9*
Bi214	609.3	0.463	2.95E-02	8.14E-02	3.01E-02	5.56E-02	7.82E-01	4.35E-02	8.39E-02	1.00E+00	1.53E+00	998	289	*32.2*
Cs137	*662*		*2.93E-02*	*7.66E-02*		*5.15E-02*	*7.62E-01*	*3.93E-02*				*900*		*-*
Bi214	665.5	0.016	2.93E-02	7.64E-02	2.99E-02	5.13E-02	7.61E-01	3.90E-02	8.39E-02	1.00E+00	5.32E-02	894	9	*1.0*
Bi214	703.1	0.005	2.92E-02	7.39E-02	2.98E-02	4.88E-02	7.49E-01	3.65E-02	8.39E-02	1.00E+00	1.67E-02	838	3	*0.3*
Bi214	768.4	0.050	2.89E-02	6.96E-02	2.95E-02	4.50E-02	7.28E-01	3.28E-02	8.39E-02	1.00E+00	1.69E-01	751	24	*2.7*
Pb214	785.9	0.011	2.89E-02	6.84E-02	2.95E-02	4.41E-02	7.22E-01	3.18E-02	3.23E-02	1.00E+00	1.44E-02	730	2	*0.2*
Bi214	806.2	0.012	2.88E-02	6.72E-02	2.94E-02	4.31E-02	7.16E-01	3.08E-02	8.39E-02	1.00E+00	4.08E-02	707	5	*0.6*
Bi214	934.1	0.032	2.82E-02	6.17E-02	2.87E-02	3.80E-02	6.85E-01	2.60E-02	8.39E-02	1.00E+00	1.11E-01	596	13	*1.4*
Bi214	1120.3	0.151	2.73E-02	5.60E-02	2.78E-02	3.27E-02	6.49E-01	2.12E-02	8.39E-02	1.00E+00	5.46E-01	487	51	*5.6*
Bi214	1155.2	0.017	2.71E-02	5.51E-02	2.77E-02	3.19E-02	6.44E-01	2.05E-02	8.39E-02	1.00E+00	6.19E-02	471	6	*0.6*
Bi214	1207.7	0.005	2.69E-02	5.39E-02	2.74E-02	3.08E-02	6.35E-01	1.96E-02	8.39E-02	1.00E+00	1.84E-02	449	2	*0.2*
Bi214	1238.1	0.059	2.67E-02	5.32E-02	2.72E-02	3.02E-02	6.30E-01	1.90E-02	8.39E-02	1.00E+00	2.18E-01	437	18	*2.0*
Bi214	1281	0.015	2.65E-02	5.22E-02	2.70E-02	2.94E-02	6.23E-01	1.83E-02	8.39E-02	1.00E+00	5.60E-02	421	4	*0.5*
Bi214	1377.7	0.041	2.61E-02	4.99E-02	2.66E-02	2.79E-02	6.07E-01	1.69E-02	8.39E-02	1.00E+00	1.56E-01	388	12	*1.3*
Bi214	1385.3	0.008	2.60E-02	4.97E-02	2.65E-02	2.77E-02	6.06E-01	1.68E-02	8.39E-02	1.00E+00	3.05E-02	385	2	*0.2*
Bi214	1401.5	0.014	2.59E-02	4.93E-02	2.64E-02	2.75E-02	6.03E-01	1.66E-02	8.39E-02	1.00E+00	5.36E-02	380	4	*0.4*
Bi214	1509.2	0.022	2.54E-02	4.69E-02	2.59E-02	2.61E-02	5.84E-01	1.52E-02	8.39E-02	1.00E+00	8.60E-02	349	6	*0.6*
Bi214	1583.2	0.007	2.51E-02	4.61E-02	2.56E-02	2.51E-02	5.78E-01	1.45E-02	8.39E-02	1.00E+00	2.77E-02	333	2	*0.2*
Bi214	1661.3	0.012	2.48E-02	4.52E-02	2.53E-02	2.43E-02	5.71E-01	1.39E-02	8.39E-02	1.00E+00	4.81E-02	318	3	*0.3*
Bi214	1729.6	0.030	2.45E-02	4.45E-02	2.50E-02	2.36E-02	5.65E-01	1.33E-02	8.39E-02	1.00E+00	1.22E-01	305	7	*0.8*
Bi214	1764.5	0.158	2.44E-02	4.41E-02	2.49E-02	2.32E-02	5.62E-01	1.30E-02	8.39E-02	1.00E+00	6.44E-01	299	37	*4.1*
Bi214	1847.4	0.021	2.41E-02	4.32E-02	2.46E-02	2.25E-02	5.54E-01	1.25E-02	8.39E-02	1.00E+00	8.68E-02	286	5	*0.5*
Bi214	2118.6	0.012	2.31E-02	4.09E-02	2.36E-02	2.04E-02	5.35E-01	1.09E-02	8.39E-02	1.00E+00	5.15E-02	251	2	*0.3*
Bi214	2204.2	0.050	2.29E-02	4.05E-02	2.34E-02	1.98E-02	5.32E-01	1.06E-02	8.39E-02	1.00E+00	2.17E-01	242	10	*1.1*
Bi214	2447.9	0.016	2.22E-02	3.94E-02	2.27E-02	1.84E-02	5.22E-01	9.62E-03	8.39E-02	1.00E+00	7.13E-02	220	3	*0.3*
										Total:	5.26E+00	48673	900	*100*

Cesium-137 Response		
e.g., SPA-3	*1200*	*cpm/uR/h*
e.g., 22-40	*900*	*cpm/uR/h*
Assumed:	900	cpm/uR/h

Source Parameters		
Radius:	56.4	cm
Area:	1.00	m2
Thickness:	15	cm
Depth:	15	cm
Material Density		
Source:	1.6	g/cm3
Cover:	2.0	g/cm3

Surveyor Parameters		
Speed:	1	m/s
Interval:	1.1	s
Height:	10	cm
α:	0.05	
β:	0.05	
d':	3.29	
p surv.:	0.5	
NaI diameter:	2.00	inches
NaI diameter:	5.10	cm

References:

a. Oak Ridge Associated Universities (ORAU) 1989. *Nuclide identification catalog for gamma emitters and alpha emitters* . ORAU 88/K-32, Oak Ridge, TN.

b. National Institute of Standards and Technology (NIST) 1996. *Tables of X-Ray Mass Attenuation Coefficients and Mass Energy-Absorption Coefficients* . Hubbell, J.H. and Seltzer, S.M., Gaithersburg, MD, April.

c. National Institute of Standards and Technology (NIST) 1998. *XCOM: Photon Cross Sections Database*

d. Oak Ridge National Laboratory (ORNL) 1982. *Specific Gamma-Ray Dose Constants for Nuclides Important to Dosimetry and Radiological Assessment* . ORNL/RSIC-45/RI. Unger, L.M. and Trubey, D.K.

NOTE: Attenuation and absorption coefficients are linearly extrapolated per individual energy when references are listed at unit values

APPENDIX B: ANTICIPATED GAMMA WALKOVER SURVEY SENSITIVITY

Thorium-232 + C														
	Energy		μen/ρ						Γ (uR/h/pCi	Modeled	Expected	cpm/ur/h		Percent
Nuclide	(keV)[a]	Intensity[a]	Air[b]	NaI[c]	Concrete[b]	FRER	P	RDR	@ 100 cm)[d]	pCi/g	uR/hr	Effective	Weighted	*Response Contribution*
Ac228	57.8	0.005	3.27E-02	7.34E+00	1.09E-01	5.29E-01	1.00E+00	5.29E-01	8.44E-02	1.00E+00	3.03E-04	12118	0	*0.0*
Th228	84.4	0.012	2.39E-02	2.71E+00	4.74E-02	4.96E-01	1.00E+00	4.96E-01	7.93E-03	1.00E+00	7.28E-04	11372	1	*0.1*
Ac228	99.5	0.013	2.33E-02	1.70E+00	3.68E-02	4.32E-01	1.00E+00	4.32E-01	8.44E-02	1.00E+00	1.28E-02	9903	15	*1.7*
Pb212	115.2	0.006	2.38E-02	1.35E+00	3.42E-02	3.65E-01	1.00E+00	3.65E-01	2.73E-02	1.00E+00	2.13E-03	8373	2	*0.2*
Ac228	129.1	0.028	2.42E-02	1.05E+00	3.21E-02	3.19E-01	1.00E+00	3.19E-01	8.44E-02	1.00E+00	3.34E-02	7325	28	*3.3*
Ac228	154.2	0.009	2.58E-02	4.02E-01	2.89E-02	2.51E-01	9.99E-01	2.51E-01	8.44E-02	1.00E+00	1.22E-02	5759	8	*1.0*
Ac228	209.3	0.044	2.69E-02	3.13E-01	2.88E-02	1.78E-01	9.97E-01	1.77E-01	8.44E-02	1.00E+00	6.02E-02	4060	28	*3.3*
Pb212	238.6	0.450	2.75E-02	2.65E-01	2.91E-02	1.52E-01	9.93E-01	1.51E-01	2.73E-02	1.00E+00	1.97E-01	3471	79	*9.3*
Ra224	241	0.040	2.75E-02	2.62E-01	2.91E-02	1.51E-01	9.93E-01	1.50E-01	1.10E-03	1.00E+00	7.02E-04	3429	0	*0.0*
Tl208	252.6	0.008	2.78E-02	2.43E-01	2.92E-02	1.43E-01	9.89E-01	1.41E-01	1.70E-01	1.00E+00	2.17E-02	3234	8	*1.0*
Ac228	270.2	0.036	2.81E-02	2.14E-01	2.94E-02	1.32E-01	9.82E-01	1.29E-01	8.44E-02	1.00E+00	4.80E-02	2963	16	*1.9*
Tl208	277.4	0.068	2.83E-02	2.03E-01	2.95E-02	1.28E-01	9.77E-01	1.25E-01	1.70E-01	1.00E+00	1.83E-01	2858	60	*7.1*
Pb212	300.1	0.034	2.87E-02	1.66E-01	2.97E-02	1.16E-01	9.55E-01	1.11E-01	2.73E-02	1.00E+00	1.45E-02	2541	4	*0.5*
Ac228	327.6	0.032	2.89E-02	1.52E-01	2.98E-02	1.06E-01	9.42E-01	9.94E-02	8.44E-02	1.00E+00	4.19E-02	2280	11	*1.3*
Ac228	338.3	0.114	2.90E-02	1.47E-01	2.99E-02	1.02E-01	9.36E-01	9.54E-02	8.44E-02	1.00E+00	1.49E-01	2187	38	*4.4*
Ac228	409.5	0.021	2.95E-02	1.15E-01	3.02E-02	8.28E-02	8.84E-01	7.31E-02	8.44E-02	1.00E+00	2.70E-02	1677	5	*0.6*
Ac228	463	0.044	2.96E-02	1.03E-01	3.03E-02	7.30E-02	8.55E-01	6.24E-02	8.44E-02	1.00E+00	5.66E-02	1430	9	*1.1*
Ac228	509.6	0.005	2.96E-02	9.38E-02	3.03E-02	6.62E-02	8.27E-01	5.47E-02	8.44E-02	1.00E+00	6.42E-03	1255	1	*0.1*
Tl208	510.8	0.216	2.96E-02	9.36E-02	3.03E-02	6.60E-02	8.27E-01	5.46E-02	1.70E-01	1.00E+00	5.60E-01	1252	81	*9.5*
Ac228	562.3	0.009	2.96E-02	8.70E-02	3.02E-02	6.01E-02	8.04E-01	4.83E-02	8.44E-02	1.00E+00	1.16E-02	1108	1	*0.2*
Tl208	583.1	0.842	2.96E-02	8.44E-02	3.02E-02	5.80E-02	7.94E-01	4.61E-02	1.70E-01	1.00E+00	2.20E+00	1056	267	*31.4*
Cs137	*662*		*2.93E-02*	*7.66E-02*		*5.15E-02*	*7.62E-01*	*3.93E-02*				*900*		-
Ac228	727	0.008	2.91E-02	7.23E-02	2.97E-02	4.73E-02	7.42E-01	3.51E-02	8.44E-02	1.00E+00	1.05E-02	804	1	*0.1*
Bi212	727.2	0.118	2.91E-02	7.23E-02	2.97E-02	4.73E-02	7.42E-01	3.51E-02	1.95E-02	1.00E+00	3.59E-02	804	3	*0.4*
Ac228	755.2	0.011	2.90E-02	7.05E-02	2.96E-02	4.57E-02	7.33E-01	3.35E-02	8.44E-02	1.00E+00	1.46E-02	767	1	*0.2*
Tl208	763.1	0.016	2.90E-02	6.99E-02	2.95E-02	4.53E-02	7.30E-01	3.30E-02	1.70E-01	1.00E+00	4.28E-02	758	4	*0.4*
Ac228	772.2	0.016	2.89E-02	6.93E-02	2.95E-02	4.48E-02	7.27E-01	3.25E-02	8.44E-02	1.00E+00	2.12E-02	746	2	*0.2*
Ac228	782	0.005	2.89E-02	6.87E-02	2.95E-02	4.43E-02	7.24E-01	3.20E-02	8.44E-02	1.00E+00	6.65E-03	734	1	*0.1*
Bi212	785.5	0.020	2.89E-02	6.85E-02	2.95E-02	4.41E-02	7.22E-01	3.19E-02	1.95E-02	1.00E+00	6.14E-03	730	1	*0.1*
Ac228	794.7	0.046	2.88E-02	6.78E-02	2.94E-02	4.36E-02	7.19E-01	3.14E-02	8.44E-02	1.00E+00	6.13E-02	719	5	*0.6*
Ac228	830.5	0.006	2.87E-02	6.62E-02	2.93E-02	4.20E-02	7.10E-01	2.98E-02	8.44E-02	1.00E+00	8.05E-03	684	1	*0.1*
Ac228	835.5	0.018	2.87E-02	6.60E-02	2.92E-02	4.18E-02	7.09E-01	2.96E-02	8.44E-02	1.00E+00	2.42E-02	679	2	*0.2*
Ac228	840	0.009	2.86E-02	6.58E-02	2.92E-02	4.16E-02	7.08E-01	2.94E-02	8.44E-02	1.00E+00	1.21E-02	675	1	*0.1*
Tl208	860.4	0.125	2.85E-02	6.49E-02	2.91E-02	4.07E-02	7.03E-01	2.86E-02	1.70E-01	1.00E+00	3.40E-01	656	26	*3.0*
Bi212	893.4	0.007	2.84E-02	6.34E-02	2.89E-02	3.94E-02	6.95E-01	2.74E-02	1.95E-02	1.00E+00	2.19E-03	628	0	*0.0*
Ac228	904.5	0.008	2.83E-02	6.30E-02	2.89E-02	3.90E-02	6.92E-01	2.70E-02	8.44E-02	1.00E+00	1.09E-02	619	1	*0.1*
Ac228	911.1	0.277	2.83E-02	6.27E-02	2.89E-02	3.88E-02	6.91E-01	2.68E-02	8.44E-02	1.00E+00	3.77E-01	614	27	*3.1*
Ac228	964.6	0.052	2.81E-02	6.03E-02	2.86E-02	3.70E-02	6.77E-01	2.50E-02	8.44E-02	1.00E+00	7.16E-02	573	5	*0.6*
Ac228	969.1	0.166	2.80E-02	6.01E-02	2.86E-02	3.68E-02	6.76E-01	2.49E-02	8.44E-02	1.00E+00	2.29E-01	570	15	*1.8*
Bi212	1078.6	0.010	2.75E-02	5.69E-02	2.80E-02	3.37E-02	6.56E-01	2.21E-02	1.95E-02	1.00E+00	3.25E-03	507	0	*0.0*
Ac228	1264.4	0.005	2.66E-02	5.26E-02	2.71E-02	2.97E-02	6.26E-01	1.86E-02	8.44E-02	1.00E+00	7.31E-03	427	0	*0.0*
Ac228	1459.3	0.010	2.57E-02	4.80E-02	2.62E-02	2.67E-02	5.92E-01	1.58E-02	8.44E-02	1.00E+00	1.52E-02	363	1	*0.1*
Ac228	1495.8	0.010	2.55E-02	4.71E-02	2.60E-02	2.62E-02	5.86E-01	1.54E-02	8.44E-02	1.00E+00	1.53E-02	352	1	*0.1*

Cesium-137 Response		
e.g., SPA-3	*1200*	*cpm/uR/h*
e.g., 22-40	*900*	*cpm/uR/h*
Assumed:	900	cpm/uR/h

Source Parameters		
Radius:	56.4	cm
Area:	1.00	m2
Thickness:	15	cm
Depth:	15	cm
Material Density		
Source:	1.6	g/cm3
Cover:	2.0	g/cm3

Surveyor Parameters		
Speed:	1	m/s
Interval:	1.1	s
Height:	10	cm
α:	0.05	
β:	0.05	
d':	3.29	
p surv.:	0.5	
NaI diameter:	2.00	inches
NaI diameter:	5.10	cm

APPENDIX B: ANTICIPATED GAMMA WALKOVER SURVEY SENSITIVITY

Thorium-232 + C (continued)														
Nuclide	Energy (keV)[a]	Intensity[a]	μen/ρ			FRER	P	RDR	Γ (uR/h/pCi @ 100 cm)[d]	Modeled pCi/g	Expected uR/hr	cpm/ur/h		Percent Response Contribution
			Air[b]	NaI[c]	Concrete[b]							Effective	Weighted	
Ac228	1501.5	0.006	2.55E-02	4.70E-02	2.59E-02	2.62E-02	5.85E-01	1.53E-02	8.44E-02	1.00E+00	9.20E-03	351	0	*0.0*
Bi212	1512.8	0.006	2.54E-02	4.69E-02	2.59E-02	2.60E-02	5.84E-01	1.52E-02	1.95E-02	1.00E+00	2.13E-03	348	0	*0.0*
Ac228	1580.2	0.007	2.51E-02	4.61E-02	2.56E-02	2.52E-02	5.78E-01	1.46E-02	8.44E-02	1.00E+00	1.09E-02	334	0	*0.0*
Ac228	1588	0.035	2.51E-02	4.60E-02	2.56E-02	2.51E-02	5.78E-01	1.45E-02	8.44E-02	1.00E+00	5.45E-02	332	2	*0.2*
Bi212	1620.6	0.028	2.50E-02	4.57E-02	2.55E-02	2.47E-02	5.75E-01	1.42E-02	1.95E-02	1.00E+00	1.01E-02	325	0	*0.0*
Ac228	1630.4	0.019	2.49E-02	4.56E-02	2.54E-02	2.46E-02	5.74E-01	1.41E-02	8.44E-02	1.00E+00	2.98E-02	324	1	*0.1*
Ac228	1638	0.005	2.49E-02	4.55E-02	2.54E-02	2.45E-02	5.73E-01	1.40E-02	8.44E-02	1.00E+00	7.84E-03	322	0	*0.0*
Tl208	2614.7	1.000	2.17E-02	3.86E-02	2.23E-02	1.76E-02	5.15E-01	9.08E-03	1.70E-01	1.00E+00	3.60E+00	208	86	*10.1*
										Total:	8.67E+00	105608	851	*100*

References:

a. Oak Ridge Associated Universities (ORAU) 1989. *Nuclide identification catalog for gamma emitters and alpha emitters* . ORAU 88/K-32, Oak Ridge, TN.

b. National Institute of Standards and Technology (NIST) 1996. *Tables of X-Ray Mass Attenuation Coefficients and Mass Energy-Absorption Coefficients* . Hubbell, J.H. and Seltzer, S.M., Gaithersburg, MD, April.

c. National Institute of Standards and Technology (NIST) 1998. *XCOM: Photon Cross Sections Database*

d. Oak Ridge National Laboratory (ORNL) 1982. *Specific Gamma-Ray Dose Constants for Nuclides Important to Dosimetry and Radiological Assessment.* ORNL/RSIC-45/RI. Unger, L.M. and Trubey, D.K.

NOTE: Attenuation and absorption coefficients are linearly extrapolated per individual energy when references are listed at unit values

APPENDIX B: ANTICIPATED GAMMA WALKOVER SURVEY SENSITIVITY

Total Uranium														
Nuclide	Energy (keV)[a]	Intensity[a]	μen/ρ Air[b]	μen/ρ NaI[c]	μen/ρ Concrete[b]	FRER	P	RDR	Γ (uR/h/pCi @ 100 cm)[d]	Modeled pCi/g	Expected uR/hr	cpm/ur/h Effective	cpm/ur/h Weighted	*Percent Response Contribution*
Th231	25.6	0.147	3.23E-01	1.37E+01	1.48E+00	1.21E-01	1.00E+00	1.21E-01	5.45E-02	4.60E-02	6.50E-23	2771	0	*0.0*
Th231	58.6	0.005	3.19E-02	7.02E+00	1.04E-01	5.35E-01	1.00E+00	5.35E-01	5.45E-02	4.60E-02	2.76E-05	12270	5	*0.1*
Th234	63.3	0.038	2.94E-02	5.88E+00	8.81E-02	5.38E-01	1.00E+00	5.38E-01	7.54E-03	1.00E+00	1.15E-03	12336	227	*3.6*
Th231	81.2	0.009	2.40E-02	2.92E+00	4.97E-02	5.13E-01	1.00E+00	5.13E-01	5.45E-02	4.60E-02	4.04E-04	11755	76	*1.2*
Th231	84.2	0.064	2.39E-02	2.72E+00	4.76E-02	4.97E-01	1.00E+00	4.97E-01	5.45E-02	4.60E-02	3.13E-03	11395	567	*9.1*
Th231	90	0.009	2.35E-02	2.07E+00	4.07E-02	4.73E-01	1.00E+00	4.73E-01	5.45E-02	4.60E-02	5.78E-04	10843	100	*1.6*
Th234	92.6	0.054	2.36E-02	2.16E+00	4.17E-02	4.58E-01	1.00E+00	4.58E-01	7.54E-03	1.00E+00	1.00E-02	10513	1681	*26.9*
U235	109.1	0.015	2.36E-02	1.48E+00	3.51E-02	3.89E-01	1.00E+00	3.89E-01	3.39E-02	4.60E-02	7.49E-04	8920	106	*1.7*
U235	143.8	0.015	2.47E-02	7.42E-01	2.99E-02	2.81E-01	1.00E+00	2.81E-01	3.39E-02	4.60E-02	9.26E-04	6443	95	*1.5*
U235	163.4	0.047	2.54E-02	5.35E-01	2.89E-02	2.41E-01	1.00E+00	2.41E-01	3.39E-02	4.60E-02	3.02E-03	5517	266	*4.2*
U235	185.7	0.540	2.62E-02	4.09E-01	2.88E-02	2.05E-01	1.00E+00	2.05E-01	3.39E-02	4.60E-02	3.49E-02	4707	2617	*41.8*
U235	194.9	0.059	2.65E-02	3.57E-01	2.87E-02	1.93E-01	9.99E-01	1.93E-01	3.39E-02	4.60E-02	3.82E-03	4427	269	*4.3*
U235	202.1	0.010	2.68E-02	3.25E-01	2.87E-02	1.85E-01	9.98E-01	1.84E-01	3.39E-02	4.60E-02	6.48E-04	4230	44	*0.7*
U235	205.3	0.047	2.68E-02	3.19E-01	2.87E-02	1.82E-01	9.97E-01	1.81E-01	3.39E-02	4.60E-02	3.04E-03	4153	201	*3.2*
Cs137	*662*		*2.93E-02*	*7.66E-02*		*5.15E-02*	*7.62E-01*	*3.93E-02*				*900*	-	-
Pa234m	766.4	0.002	2.89E-02	6.97E-02	2.95E-02	4.51E-02	7.29E-01	3.29E-02	1.03E-03	1.00E+00	8.26E-05	753	1	*0.0*
Pa234m	1001	0.006	2.79E-02	5.88E-02	2.84E-02	3.58E-02	6.67E-01	2.39E-02	1.03E-03	1.00E+00	2.59E-04	548	2	*0.0*
										Total:	6.28E-02	110828	6258	*100.0*

Cesium-137 Response		
e.g., SPA-3	*1200*	*cpm/uR/h*
e.g., 22-40	*900*	*cpm/uR/h*
Assumed:	900	cpm/uR/h

Source Parameters		
Radius:	56.4	cm
Area:	1.00	m2
Thickness:	15	cm
Depth:	15	cm
Material Density		
Source:	1.6	g/cm3
Cover:	2.0	g/cm3

Surveyor Parameters		
Speed:	1	m/s
Interval:	1.1	s
Height:	10	cm
α:	0.05	
β:	0.05	
d':	3.29	
p surv.:	0.5	
NaI diameter:	2.00	inches
NaI diameter:	5.10	cm

Uranium Concentrations	
Abundance by Weight	
U238	0.9928
U235	0.0071
Relative Activity	
U238	1
U235	0.0460

References:

a. Oak Ridge Associated Universities (ORAU) 1989. *Nuclide identification catalog for gamma emitters and alpha emitters* . ORAU 88/K-32, Oak Ridge, TN.

b. National Institute of Standards and Technology (NIST) 1996. *Tables of X-Ray Mass Attenuation Coefficients and Mass Energy-Absorption Coefficients* . Hubbell, J.H. and Seltzer, S.M., Gaithersburg, MD, April.

c. National Institute of Standards and Technology (NIST) 1998. *XCOM: Photon Cross Sections Database*

d. Oak Ridge National Laboratory (ORNL) 1982. *Specific Gamma-Ray Dose Constants for Nuclides Important to Dosimetry and Radiological Assessment.* ORNL/RSIC-45/RI. Unger, L.M. and Trubey, D.K.

NOTE: Attenuation and absorption coefficients are linearly extrapolated per individual energy when references are listed at unit values

APPENDIX C

EXAMPLE SAMPLE LOG AND CHAIN OF CUSTODY

301 Fulling Mill Rd
Middletown, PA 17057
P. 717-944-5541
F.717-944-1430

CHAIN OF CUSTODY/ REQUEST FOR ANALYSIS

ALL SHADED AREAS MUST BE COMPLETED BY THE CLIENT / SAMPLER. INSTRUCTIONS ON THE BACK.

COC #: of

ALS Quote #:

Client Name:

Address:

Contact:

Phone#:

Project Name/#:

Bill To:

TAT
- ☐ Normal-Standard TAT is 10-12 business days.
- ☐ Rush-Subject to ALS approval and surcharges.

Date Required: Approved?

Email? ☐ -Y

Fax? ☐ -Y No.:

Container Type

Container Size

Perservative

ANALYSES/METHOD REQUESTED

Receipt Information (completed by Receiving Lab)

W.O. Temp: Therm ID:

Courier/Tracking #:

Purchase Order #:

Project Comments:

ALS Field Services: ☐ Pickup ☐ Labor ☐ Composite Sampling ☐ Rental Equipment

Other:

	Sample Description/Location (as it will appear on the lab report)	Date Collected mm/dd/yy	Time hh:mm	*G or C	**Matrix	Enter Number of Containers Per Sample or Field Results Below.										Sample/COC Comments
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

EXAMPLE

SAMPLED BY (Please Print):

Sampler Comments:

Relinquished By / Company Name	Date	Time	Received By / Company Name	Date	Time
1			2		
3			4		
5			6		
7			8		
9			10		

Data Deliverables
- ☐ Standard
- ☐ CLP-like
- ☐ USACE/DOD
- ☐

Special Processing
- USACE ☐
- Navy ☐
- ☐

State Samples Collected In
- ☐ NY
- ☐ NJ
- ☐ PA
- ☐ NC
- ☐ other

Reportable to PADEP? Yes ☐ No ☐

PWSID #

Sample Disposal
- Lab ☐
- Special ☐

EDDS: Format Type-