

**Field Sampling Plan
for the
Remedial Investigation of Vicinity Property H Prime
Niagara Falls Storage Site
Lewiston, Niagara County, New York**

October 2018



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Buffalo District
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**Submitted to:
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Buffalo District
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Contract No. W912QR-17-R-0061

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for the Remedial Investigation of Vicinity
Property H Prime
Niagara Falls Storage Site (NFSS)**

Contract Number: W912QR-17-R-0061

FSP APPROVALS

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Acronyms and Abbreviations

AAA	ARS Aleut Analytical, LLC
AAR	ARS Aleut Remediation, LLC
AEC	(US) Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ASTM	American Society for Testing and Materials
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act.
CF	correction factor
CHP	Certified Health Physicist
CMSA	Consolidated Material Storage Area
CPM	counts per minute
CPM/ μ R/hr	counts per minute per microRoentgen per hour
CQCSM	Contractor Quality Control Systems Manager
CWM	Chemical Waste Management, Inc. (now Waste Management, Inc.)
cm	centimeter(s)
DERP-FUDS	Defense Environmental Restoration Program for Formerly Used Defense Sites
DOD	(US) Department of Defense
DOD ELAP	Department of Defense Environmental Laboratory Accreditation Program
DOE	(US) Department of Energy
DOECAP	Department of Energy's Consolidated Audit Program
DOP	dilution of precision
DOT	(US) Department of Transportation
DQO	Data Quality Objectives
$^{\circ}$ C	degrees Celsius
ENG	Engineering
eV	electron volts
FRER	Fluence Rate to Exposure Rate
FUSRAP	Formerly Utilized Sites Remedial Action Program
ft.	foot (feet)
FSP	Field Sampling Plan
GWS	Gamma Walkover Survey
g	gram(s)
g/cc	gram per cubic centimeter
GPS	global positioning system
HPT	AAR Health Physics Technician
ID	Identification
IDW	investigation derived waste
ITR	Independent Technical Reviewer
IWCS	Interim Waste Containment Structure
KAPL	Knolls Atomic Power Laboratory
keV	kilo-electron volts
km	kilometer
LAW	large area wipes
L _c	Critical Level
LOOW	Lake Ontario Ordnance Works
MARSSIM	Multi Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
m	meter
MED	Manhattan Engineering District

mi	mile(s)
NAD	North American Datum
NaI	sodium iodide
NELAP	National Environmental Laboratory Accreditation Program
NFSS	Niagara Falls Storage Site
NYSDEC	New York State Department of Environmental Conservation
ORAU	Oak Ridge Associated Universities
PCB	polychlorinated biphenyls
pCi, pCi/g	picoCurie(s), picoCurie(s) per gram
PID	Photoionization Detector
PM	Project Manager
POCs	points of contact
POTW	Publicly-Owned Treatment Works
PPE	personal protective equipment
ppm	parts per million
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QC	Quality Control
QCP	Quality Control Plan
QCR	Quality Control Report
ORAU	Oak Ridge Associated Universities
QSM	Quality Systems Manual
Ra-226	Radium-226
Ra-228	Radium-228
RCA	Radiologically Controlled Area
RDR	Relative Detector Response
RI	Remedial Investigation
RSO	AAR Site Radiation Safety Officer
RSP	AAR Radiation Safety Plan
SAP	Sampling and Analysis Plan
SM	Site Manager
SOP	Standard Operating Procedure
SOW(s)	scope(s) of work
SS	Site Superintendent
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
TDS	total dissolved solids
Th-230	Thorium-230
Th-232	Thorium-232
TNT	trinitrotoluene
U-234	Uranium-234
U-235	Uranium-235
U-238	Uranium-238
U.S.	United States
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
USDOD	U.S. Department of Defense
USEPA	U.S. Environmental Protection Agency
UXO	Unexploded Ordnance Activities
VOC	volatile organic compounds
VP	Vicinity Property
VP H'	Vicinity Property H-Prime

VP-X	Vicinity Property X (former LOOW/NFSS sewage treatment plant)
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

1.1 Purpose and Approach

ARS Aleut Remediation, LLC (AAR) has been selected by the United States Army Corps of Engineers (USACE) – Buffalo District under Contract Number W912QR-17-R-0061 to perform a remedial investigation of the Vicinity Property H-Prime (VP H') and to dispose of legacy investigation derived wastes (IDW) located at the Niagara Falls Storage Site (NFSS). VP H' is a vicinity property of the NFSS. The NFSS and surrounding vicinity properties constitute the former Lake Ontario Ordnance Works (LOOW). The LOOW produced explosives for military purposes and was also used for temporary and permanent storage and incineration of radioactive waste beginning in 1944 by the Manhattan Engineer District (MED) and subsequently the Atomic Energy Commission (AEC). Historical wastes stored at LOOW include residues from uranium ore processing (primary waste type), contaminated rubble and scrap from decommissioning activities, biological and miscellaneous waste from the University of Rochester, and low-level fission-product waste from contaminated liquid evaporators at the Knolls Atomic Power Laboratory (KAPL). The LOOW stopped accepting radioactive waste in 1954. Cleanup activities were conducted, and the vicinity properties were sold to various private, commercial, and governmental agencies. VP H' is currently owned by CWM Chemical Services, LLC (CWM) and the NFSS remains in federal ownership. Previous investigations at VP H' include:

- 1973: Radiation Survey and Decontamination Report of the LOOW Site prepared AEC. Grid based sampling of gamma readings at the VP H' resulted in the removal of soils over an area of 35,000 square feet at depths ranging from one (1) foot to three (3) feet. This area was not backfilled.
- 1983: Comprehensive Radiological Survey, Off-Site Property H', NFSS, Lewiston, New York prepared by DOE. Soil samples showed elevated readings of radium-226 and uranium-238 and approximately 2,000 cubic yards of soil required remediation.
- 1986: Verification of 1983 and 1984 Remedial Actions NFSS Vicinity Properties Lewiston, New York, prepared by Oak Ridge Associated Universities (ORAU). Confirmation sampling verified that the remaining concentration of select radionuclides were within prescribed regulatory guidelines at VP H'.
- 2004: After Action Report Unexploded Ordnance Activities (UXO) at the Waste Water Treatment Plant (WWTP) at the Former LOOW Site 2003, prepared by USACE. USACE used the southeastern corner of VP H' as a contaminated materials storage area (CMSA) for another project, making a pad from layers of stone, geotextile, and high-density polyethylene. The CMSA was removed after project completion and sampling was performed, including a gamma walkover survey. Results found elevated levels of radium-226 and uranium-238. The area was covered with geotextile (extent unknown), backfilled with approximately six (6) inches of clean soil, and re-seeded.

A complete list of previous investigations can be found in the VP H' preliminary assessment report published by USACE in 2016 (USACE, 2016).

This remedial investigation is being completed under USACE's Formerly Utilized Sites Remedial Action Program (FUSRAP), which was established to identify, investigate and clean up or control properties previously used by the MED and AEC. VP H' has been identified as containing various concentrations of residual radioactive material in soil and debris from previous operations. Radiological constituents of potential concern to be investigated include: radium-226, radium-228, uranium-234, uranium-235, uranium-238, thorium-228, thorium-230, and thorium-232.

The primary objectives of the activity described herein are (1) determine the magnitude and extent of radiological contamination at VP H' and (2) the successful disposal of newly generated IDW from the VP

H' investigation and IDW currently stored at NFSS. The USACE will complete a Remedial Investigation Report based on the data provided by this activity.

Site characterization, waste characterization, waste packaging, and waste shipping will be conducted in a manner that provides a level of protection to the public and investigation field personnel that is consistent with applicable radiation exposure guidelines and with the objective of achieving as low as reasonably achievable (ALARA) exposure levels.

This Field Sampling Plan (FSP), which is Part I of the project Sampling and Analysis Plan (SAP), describes and presents procedures and protocols for project-specific field radiological surveys, sampling, and laboratory analyses.

Part II of the SAP is a project-specific *Quality Assurance Project Plan* (QAPP).

1.2 Plan Organization

This FSP consists of the following sections:

1. Introduction to present the purpose and organization of the report;
2. Site Description that includes a physical description of the vicinity property and potential contaminants;
3. Organization and Responsibilities that lists the parties involved in radiological survey and sampling activities and explains the general responsibilities of each party;
4. Scope and Objectives that presents data quality objectives (DQOs) and criteria for field screening and sampling;
5. Field Screening to explain the methods used to conduct field screening for radiological contaminants in soil and on equipment and personnel;
6. Field Sampling to present the methods and procedures for collecting soil, water, and oil samples for laboratory analysis;
7. Field Quality Control that includes the processes and procedures for maintaining adequate quality control of field activities;
8. Laboratory Analysis that lists the analytical methods for soil and water samples collected;
9. Reporting that presents an overview of the basic information included in final field investigation report; and
10. References with report citations.

2.0 SITE DESCRIPTION

2.1 Site History

VP H' is a rectangular parcel of land, approximately 590 feet by 295 feet, located in western New York State, in the Town of Porter. The property is part of the former LOOW. The LOOW, which consists of the NFSS and all vicinity properties, was utilized, by the MED and its later successor, the AEC for storage of radioactive wastes. These wastes primarily originated from uranium processing operations however there are reports of additional materials being stored on the property including: contaminated building materials from decommissioning activities, biological and miscellaneous wastes from the University of Rochester, and low-level fission product wastes from KAPL. The LOOW ceased receipt of wastes in 1954, after which the former operations contractor, Hooker Chemical Company, conducted cleanup operations. Some 1,297 acres of the original 1,512 acres that comprised the NFSS and the vicinity properties were sold by the General Services Administration as surplus following the cleanup. The following excerpts from the Preliminary Assessment Report conducted by USACE in 2016 provide additional detail.

From 1970 to 1971 and again from 1981 to 1984, contractors for the AEC and Department of Energy (DOE) conducted radiological surveys of the 525 hectares (1,297 acres) comprising the vicinity (off-site) properties, identified as Vicinity Properties A, H', L, M, N/N' South, Q, R, S, U, V, and X. The Oak Ridge Associated Universities (ORAU) performed surveys at the DOE's request to determine if any of these properties contained residual contamination above current federal guideline levels. Battelle Columbus Laboratories also conducted surveys in 1979 and 1980 and identified extensive contamination in the western and central drainage ditches of the vicinity properties. This investigation is focused on VP H', currently owned by Chemical Waste Management, Inc. (CWM). Figure 2 shows the location of VP H' in relation to the Town of Lewiston and Town of Porter boundary and also includes individual parcel boundaries of the surrounding properties and site drainage features.

The VP H' property is rectangular in shape and occupies an area of approximately 1.6 hectares (4 acres). It is bounded on three sides by roads – Wesson Road on the west, M Street on the south, and 5th Street on the east. The northern boundary is an out-of-service railroad track. The property is restricted by CWM. There are no buildings on the site, but there are several small concrete pads or foundations on the eastern section. A portion of an unused railroad spur crosses the northern corner of the property. The VP and surrounding area are generally flat. Most of the site is overgrown with pasture grass and northern shrub. Maple, ash, and oak trees dominate the wooded areas. Cattail-marsh grass is dominant within drainage swales and low-lying areas with standing surface water. A variety of mammals, amphibians, reptiles, fish, and bird species utilize the area within 1.6 km (0.5 mile) radius of the site.

Surface soil consists of generally dry, clayey silt with some fine sand that had been graded during past Department of Defense (DoD) operations. VP H' is underlain by approximately 9 to 18m (30 to 60ft) of unconsolidated glacial deposits that over lie shale bedrock of the Queenston formation. There are eight distinct stratigraphic layers under the LOOW: fill material, alluvium, upper glacial till (or brown clay till), middle silt till, glaciolacustrine clay, glaciofluvial sand and gravel, red lodgment till, and Queenston shale bedrock. Groundwater in the near-surface stratigraphy occurs in low-permeability unconsolidated deposits, and the water-table surface generally conforms to the local topography. Groundwater at the site occurs at approximately 1.5 to 3 m (5 to 10 ft.) below ground surface (bgs). Regional groundwater flow is primarily to the northwest toward the Niagara River, although creeks and drainage ditches influence localized

groundwater flow patterns. The discontinuous nature of saturated lenses restricts lateral groundwater flow.

Before SCA Chemical Services, Inc., (site owner prior to CWM) acquired the VP H' land, as excessed property, the New York State Commissioner of Health prepared a letter outlining the land-use restrictions that would apply to the property for the state to approve the land transfer (DOE, 1982b). The state imposed restrictions with the objective of protecting public health and safety and to "minimize danger to life and property from radiation hazards." The restrictions indicate that the property cannot be used for residential purposes, schools, or hospitals, but it can be used for industrial or commercial activities. If the New York State Department of Health deemed it appropriate, these restrictions could be lifted.

The NFSS proper and associated VPs occupy approximately 607 hectares (1,500 acres) of the original 3,035 hectares (7,500 acres) LOOW, the former trinitrotoluene (TNT) manufacturing facility built during the 1940s. In 1944, the MED took over the LOOW to store radioactive residues and materials leftover from the development of the atomic bomb. By 1948, the federal government had sold 2,428 hectares (6,000 acres) of the original 3,035 hectares (7,500 acres), leaving 611 hectares (1,511 acres) under newly formed AEC control. The DoD determined that all but 86 hectares (212 acres) of the 611 hectare (1511 acre) site were excess beginning in 1955. The GSA later disposed of the excess acreage at various times. In 1974, the Town of Lewiston acquired an additional area of approximately 9 hectares (22 acres), including the original sewage treatment plant facilities (VP-X), leaving the NFSS the remaining 77 hectares (191 acres).

In 1974, FUSRAP was initiated to address contamination at sites formerly used for MED and early AEC operations that were not addressed by other programs. In the 1980s, the DOE and its contractor, Bechtel National, Inc., performed remedial actions at the NFSS and its vicinity properties. The NFSS vicinity properties are radioactively contaminated areas adjacent to or near the NFSS that were once part of the former LOOW and designated by the DOE as radiologically impacted by past government activities. The interim waste containment structure (IWCS) is the dominant site feature, occupying approximately 4 hectares (10 acres) in the southwest portion of the NFSS; the DOE built it on the location of the former fresh water treatment plant and the R-10 pile (uranium extraction residues). During the 1980s, the DOE consolidated radioactive wastes and contaminated materials from the NFSS and its vicinity properties into the IWCS, which it engineered to retard radon emissions, infiltration from precipitation, and migration of contamination to groundwater.

The DOE completed remediation of 23 of the 26 designated VPs before Congress transferred cleanup responsibilities under FUSRAP to the U.S. Army Corps of Engineers in 1997. The USACE, Buffalo District, is responsible for remediating the remaining three VPs (E, E', and G) and the NFSS proper under FUSRAP. Additionally, USACE received a letter from the DOE in 2014 referring both VP-X and VP H' to USACE for assessment and, if needed, remediation under FUSRAP. The characterization of VP H' outlined in this FSP provides data to support remedial action decision making.

With regard to climate, the climate in the vicinity of the NFSS FUSRAP Site is strongly influenced by Lake Erie and Lake Ontario. West to northerly winds blowing off Lake Erie tend to lower daily high temperatures in summer and raise temperatures in winter. The mean annual temperature is 8.8 degrees Celsius (°C) (48 degrees Fahrenheit (°F)) with mean seasonal temperatures ranging between -3.9°C and 24.4°C (25°F and 76°F). Mean annual precipitation is approximately 74 cm (29 inches (in)), distributed

evenly throughout the year. Snowfall, predominantly falling between November and March, averages approximately 130 centimeters (cm) (51 inches (in)) per year (USACE, 2016).

2.2 Radiological History

Beginning in the 1970's, numerous investigations of the NFSS and vicinity properties were conducted to provide information on the identity and concentrations of radionuclides present. The results of these investigations documented widespread radiological contamination as a result of legacy waste operations. AEC and its predecessor the DOE undertook remedial action as a result of these investigations, resulting in the excavation contaminated soils and demolition of contaminated structures at the NFSS and vicinity properties. The operational history of VP H' is provided in detail in the 2016 Preliminary Assessment Report (USACE, 2016) and included in the following paragraphs.

There is no evidence of contaminated waste burial on VP H', through documentation review or site investigation. Although, the DOE suspects that before 1954, radioactive material was stored on this property and that waste incineration operations were performed on a pad in the eastern portion of the site. A 1958 aerial photograph of VP H' is provided in Figure 4. There are reports that incineration of the combustible portion of KAPL waste occurred on VP H' on a pad along the east boundary adjacent to VP-E' (DOE,2013). A report titled "Background and Resurvey Recommendations for the Atomic Energy Commission Portion of the Lake Ontario Ordnance Works" presents the most comprehensive overview of the NFSS VPs' operating history and land use (DOE,1982b). This document states that the Hooker Electrochemical Company, under instructions from the AEC, incinerated KAPL material on a concrete pad. An excerpt from the report is as follows:

Based on studies and experimental contaminated-waste burning conducted on an open cement pad at the Lake Ontario Ordnance Works it was discovered that significant volume reduction of combustible wastes could be attained ...The Atomic Energy Commission instructed Hooker Electrochemical Company to burn low-level (5 milli-roentgens/hour or less) crates and barrel the ashes for shipment to Oak Ridge... The burning was to be done on cement pad or in the incinerator (Building 419) Hooker suggested using loose cinder block concrete outdoor fireplace erected on an existing concrete pad metal backstop used for indoor pistol practice was modified to contain fan-operated water scrubbing arrangement to remove particulate matter that might be carried up the stack... It is possible that the pad used for burning the combustible wastes was the change house south of the locomotive shop on Castle Garden Road where Oak Ridge National Laboratory discovered cesium-137 in the soil... No plutonium-bearing waste or unmarked waste was to be burned. Ashes in crates sent from the Knolls Atomic Power Laboratory were to be buried on-site [sic] because they were uncontaminated. It is not clear why this uncontaminated waste was sent to the Ordnance Works...

The eastern half of this plot was decontaminated in 1972 through the removal of scrap from a concrete pad. The plot had several areas with radiation levels between 20 and 40 microroentgens/hour in the eastern half... There is no evidence of contaminated scrap burial. However, the concrete pad is suspected to be the site of waste incineration operations...

Flyover surveys conducted by DOE in 1978 did not indicate any elevated gamma radiation levels on VP H'. Preliminary and follow-up characterization efforts by DOE conducted in the early 1980's revealed the presence of cobalt-60, cesium-137, strontium-90, radium-226, plutonium-239, and uranium-238 at levels in excess of background. Results for cesium, strontium, and plutonium were less than DOE

established guidelines. Subsequent biased sampling conducted following a gamma walkover survey revealed numerous locations with radium-226 concentrations exceeding 5 pCi/g. Several samples also had uranium-238 results exceeding established cleanup criteria. DOE subsequently remediated the VP H' property. Post-remediation verification surveys conducted by a DOE contractor found elevated readings in an area with suspected incineration wastes. A sample of the material found radium-226 at 220 pCi/g and uranium-238 at 37 pCi/g. DOE performed additional remediation, after which, the VP H' area was deemed to meet established FUSRAP cleanup criteria. Additional information provided by DOE concluded that KAPL related radionuclides (i.e. fission products and plutonium-239) at the VP H' property were remediated to levels that do not exceed regulatory thresholds (USACE, 2016).

Radiological constituents of potential concern to be investigated for nature and extent include: radium-226, radium-228, uranium-234, uranium-235, uranium-238, thorium-228, thorium-230, and thorium-232. Soil and water samples collected as part of this investigation also will be analyzed for KAPL radionuclides, cesium-137, strontium-90, and isotopic plutonium, for the purpose of characterization of investigation-derived wastes only, i.e., this investigation will not evaluate the nature and extent or the potential risks from KAPL radionuclides. Furthermore, KAPL contamination that is not comingled with FUSRAP-related contamination will not be remediated under FUSRAP. The remediation of KAPL wastes is the responsibility of the DOE Office of Environmental Management.

2.3 Recent Site Characterization

Characterization and remediation of VP H' has been conducted since the 1970's. As a result, there is a significant amount of material available for review. The Preliminary Assessment Report provides a thorough description of these activities. The narrative describing the most recent characterization effort, conducted in 2004, has been included below since it is the initiator for this remedial investigation (USACE, 2016):

The contaminated material storage area (CMSA) pad was a storage pad (approximately 175ft x 175 ft.) on the southeast corner of VP H' that consisted of compacted stone on top of a geotextile liner; USACE constructed it in 2000 as part of a removal action of TNT-contaminated pipelines. The CMSA pad was designed to securely hold TNT-contaminated material awaiting disposal; it was no longer needed once the waste material was removed. In turn, USACE began its scheduled removal of the CMSA pad at the beginning of November 2004. The USACE conducted this field work to remove the CMSA pad under the Defense Environmental Restoration Program for Formerly Used Defense Sites (DERP-FUDS) program to address environmental impacts due to government activities on the LOOW property. The contractor for USACE completed the CMSA pad removal in 2004. During the removal, the contractor removed both the compacted stone and the liner under the pad. After removing the stone and geotextile, the contractor collected six (6) grab samples of soil using dedicated sample equipment for each specific location. The contractor disposed of the CMSA pad stone as approved by the Corps of Engineers team and the New York State Department of Environmental Conservation (NYSDEC).

The Corps performed radiological monitoring for health, safety, and disposal purposes during the CMSA pad removal. As part of the health and safety monitoring during the CMSA pad excavation process, USACE performed gamma walk-over surveys and identified a small area of subsurface soil below the former pad exhibiting radiological readings above background. The gamma walk-over, conducted with a 2x2 sodium iodide detector, did not identify the need to adjust health and safety procedures, but the Corps conducted limited soil sampling for confirmation purposes.

In turn, the Corps' contractor collected two (2) biased soil samples and confirmed the results of the gamma walk-overs with Ra-226 concentrations of 16 pCi/g and 836 pCi/g with total U concentrations of 46 pCi/g (estimated) and 88.2 pCi/g, respectively. It collected and analyzed a third bias sample as representative of radiologically unimpacted soil. A 2005 CMSA fact sheet, included in Appendix C, summarizes the soil sample results (USACE, 2005). Figure 11 shows the location of soil samples the Corps' contractor collected under DERP-FUDS during the CMSA pad removal and the location of the only groundwater well located on VP H'. Tables 1 and 2 contain the data from soil samples collected at the CMSA pad during its removal in 2004.

After the CMSA pad stone and original geo-textile liners were removed, the site was restored with clean backfill from a local vendor, and the site was reseeded. The areas USACE identified as exhibiting elevated gamma walk-over and radiological sample results had a new geo-textile liner placed on top prior to backfilling and reseeded. In 2005, USACE communicated the radiological findings to the DOE.

It should be noted the historic sampling indicated heterogeneously distributed contamination over the property with values ranging from background to several times the historic cleanup criteria. Measured background concentrations and data from the recent biased samples collected in the CMSA storage pad area at VP H' are included in *Table 2-1*. This data is provided in the Preliminary Assessment Report (USACE, 2016). The CMSA data provides a bounding estimate for residual radioactivity concentrations at VP H' that may be encountered during investigation activities. It is included to support the initial assessment of radiological hazards anticipated during work activities and to provide preliminary information to the laboratory on the radioactivity concentrations they may receive during the investigation.

Table 2-1. Summary of Radionuclide Concentrations Most Recently Measured at VP H'			
Parameter	Background	Maximum Value from CMSA Samples	Units
Radium-226	0.79	836	pCi/g
Thorium-232	0.90	15.0	pCi/g
Uranium-238	0.82	42.3	pCi/g

2.4 NFSS Legacy Investigation Derived Waste (IDW)

In addition to conducting the characterization of VP H', USACE has also requested that AAR dispose of several legacy IDW waste streams currently stored at the NFSS. These include:

- Ten drums of soil and solid wastes from a recent piezometer installation at NFSS;
- Approximately 200 gallons of residual water from sampling and development of wells at NFSS stored in large poly tanks;
- Residual sediment from sampling and development of wells at NFSS present in the bottoms of large poly tanks;
- Four 1500-gallon poly tanks, one 500-gallon poly tank, and one 425-gallon poly tank; and
- Four drums of waste hydraulic and/or motor oil.

Process history information and characterization data for the NFSS IDW is limited, however, the radionuclides expected are consistent with those present at the NFSS. The source of the NFSS radiological contaminants is predominantly the processing of uranium ores. Prior to disposal, a comprehensive characterization of these wastes will be conducted to ensure adequate data is available to support packaging and disposal decisions.

3.0 ORGANIZATION AND RESPONSIBILITIES

This section describes the project organization and responsibilities for the functional roles during remedial investigation. The project-specific organization chart is provided as **Figure 3-1**.

3.1 USACE Responsibilities

USACE personnel within the organizational structure hold overall management responsibility for the entire project. USACE Buffalo District's Project Manager (PM) will be the primary point of contact (POC) with property owners and New York State Department of Environmental Conservation (NYSDEC). For purposes of quality assurance, USACE personnel will be responsible for overall project direction and decisions concerning technical issues and strategies. Project direction has been provided in the project Scope of Work (USACE, 2017) and support documents referenced in the scope. Additional direction may be provided by the PM or designee throughout the project.

3.2 AAR Responsibilities and Personnel

3.2.1 Project Manager

AAR's PM for this effort will be [REDACTED] is responsible for evaluating the appropriateness 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 Contractor Quality Control Systems Manager (CQCSM) during implementation of the field program. Specific responsibilities include:

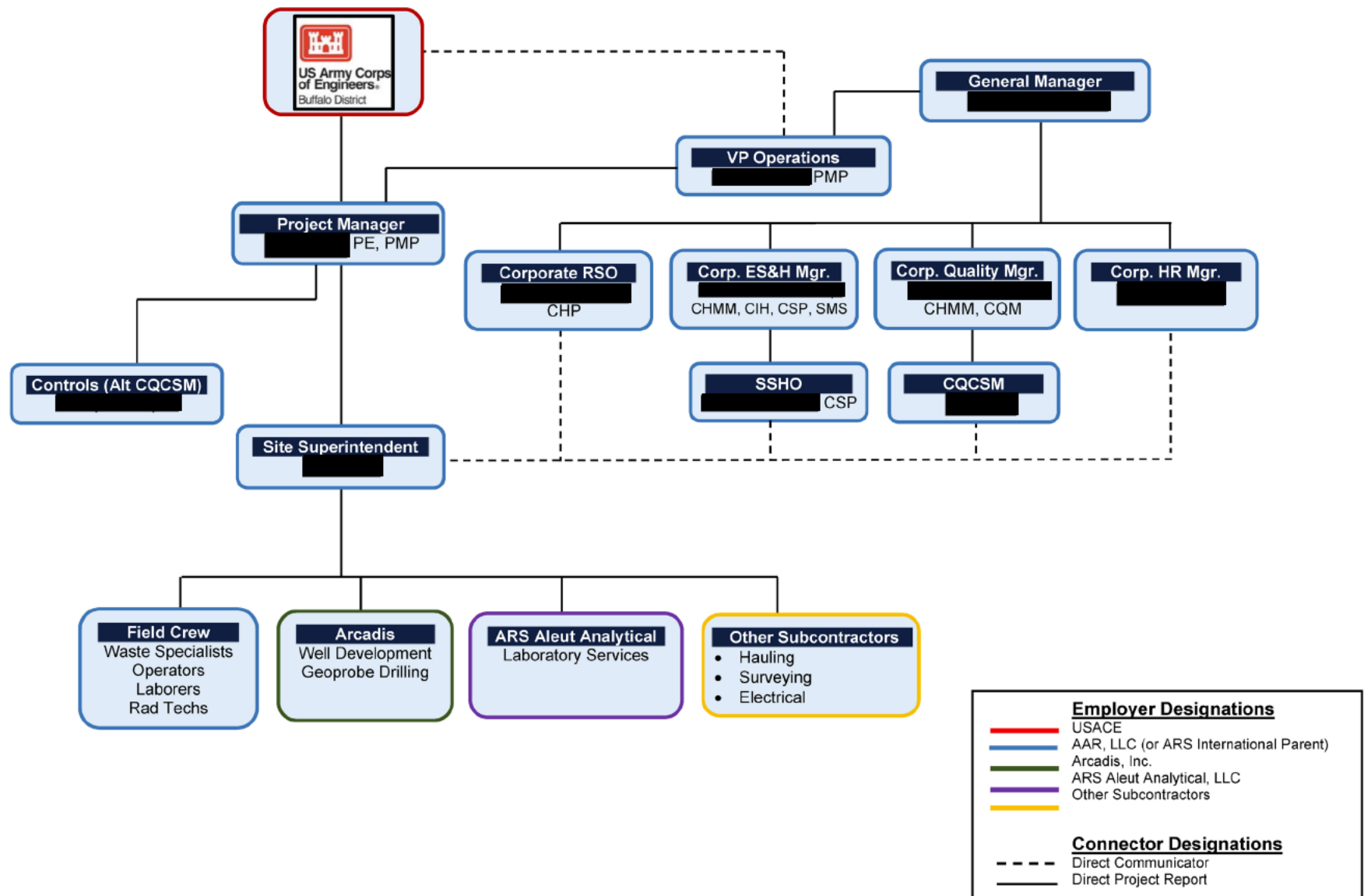
- Initiating project planning and directing project activities;
- Ensuring that qualified technical personnel are assigned to various tasks, including subcontractors;
- Identifying and fulfilling equipment and other resource requirements;
- Monitoring project activities to ensure compliance with established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

AAR's PM and CQCSM have overall responsibility for ensuring that all activities are performed in accordance with USACE and NYSDEC requirements, as well as this FSP and other project work plans.

3.2.2 Site Superintendent/CQCSM

As Site Superintendent and CQCSM (SS/CQCSM), [REDACTED] is responsible not only for the overall direction and management of field tasks, but also for the quality of AAR's work. This includes oversight of field staff and subcontractors and ensuring that procedures for field activities are executed in the proper manner, activities are properly documented, the prescribed scopes of work (SOWs) are completed, and communication protocols are followed. [REDACTED] 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 AAR PM, Technical Specialists, and Independent Technical Reviewers (ITRs). [REDACTED] will monitor work progress and schedule, advise the PM of variances, and assist in the preparation of work progress schedules, project reports, drawings, and required compliance submittals.

Figure 3-1. Project Organization Chart



The SS/CQCSM is responsible for directing, planning, implementing and tracking QC activities and maintaining internal communication on QC matters. He, or a designee, may conduct periodic site and project audits as part of this process. He may conduct periodic audits of on-site procedures, including safety procedures. 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 satisfies the project objectives as defined in the project Contractor Quality Control Plan.

3.2.3 Corporate/Site Radiation Safety Officer

██████████, CHP and Corporate Radiation Safety Officer (RSO) for AAR, will be responsible for oversight and review of all AAR radiological activities and data. ██████████ 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 / Site RSO 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 PM, Site Safety and Health Officer (SSHO), and in concert with project Health Physics Technicians (HPTs) to ensure that the Radiation Safety Plan (RSP) and SAP are properly implemented and followed.

3.2.4 Site Safety and Health Officer

As the project SSHO, ██████████, reports directly to AAR's Corporate Health & Safety Manager. The SSHO communicates and coordinates with the PM and SS/CQCSM. The SSHO is responsible for verifying the Site Safety and Health Plan (SSHP) is followed and that project personnel are appropriately trained in its provisions. The SSHO has authority to issue stop work orders on-site tasks that he believes may be unsafe. When stopped, work will not recommence until the Corporate Health & Safety Manager, Corporate / Site RSO, and PM approve the restart.

The SSHO is also responsible for maintaining personnel training certificates, medical monitoring files (as needed), and preparing accident investigation forms (USACE Form ENG 3394) in accordance with the accident avoidance and reporting procedures of the SSHP.

3.2.5 Field Team Members

AAR Field Team Members are responsible for performing field activities as stipulated in this plan and will report directly to the SS/CQCSM. In addition to the personnel listed above, the field team members and responsibilities will consist of:

- Arcadis, Inc. - Responsible for performing civil and utilities surveys, push-probe sampling, monitoring well development and sampling, topographic surveying, and geographic information system (GIS) cartography support. Ben Girard will serve as the Arcadis PM. The Arcadis PM is accountable to the AAR PM throughout the duration of the project. The PM may delegate authority to expedite and facilitate the implementation of the project plan. The Arcadis PM is responsible for work conducted by Arcadis. The Arcadis PM is responsible for ensuring adequate resources are available to conduct the work safely and according to the project schedule.
- Craft Labor and Other On-Site Subcontractors – Equipment Operators and Laborers will be present on-site throughout project and will conduct clearing, mowing, waste packaging and handling, downsizing, and general support.
- HPTs – Health Physics Technician(s) will perform periodic instrument checks, perform radiological surveys (e.g., scans of waste containment bags (containment sacks), debris and remediation equipment), and collect and prepare soil samples for laboratory analysis. The HPTs

will also maintain radiological zones and controls, perform surveys of personnel and equipment, and complete instrument and data records with oversight by the Project RPM.

3.2.6 *Subcontract Off-Site Analytical Laboratory*

ARS Aleut Analytical, LLC (AAA) of Port Allen, LA will provide off-site radiological and chemical laboratory analytical services during the project. ARS is an ISO 17025, NELAP, DOD ELAP and DOECAP audited laboratory and is fully qualified and licensed to provide a full range of analytical services.

4.0 SCOPE AND OBJECTIVES

In general, investigatory activities performed during project characterization and waste management will consist of: (a) walkover surveys and field screening, and (b) sampling for off-site radiological and chemical laboratory analyses. This section summarizes the scope and objectives of these investigatory activities; detailed descriptions of radiological surveys and field screening and sampling are presented in Sections 5.0 and 6.0, respectively. Off-site laboratory analyses performed in support of characterization are described in the QAPP - Part II of the SAP.

The project DQOs of this remedial investigation are to collect data of sufficient quality and quantity to:

- Investigate and identify the nature and extent of radioactive contaminants in soil and water for remedial planning (remedial investigation/feasibility study).
- Develop a groundwater contaminant fate and transport model, if required.
- Prepare a baseline human health and screening level ecological risk assessment.
- Characterize IDW for purposes of disposal.
- Support requirements of a future Final Status Survey for site closure in accordance with Multi-agency Radiation Survey and Site Investigation Manual (MARSSIM).

Characterization and waste management at the VP H' and NFSS locations includes the following activities:

1. Mobilization, including baseline surveys of potentially impacted field equipment. Layout of field trailers and waste areas is shown in **Figure 4-1**.
2. Contamination control surveys of equipment and items moving out of Radiologically Controlled Areas (RCAs).
3. Clearing and mowing the vicinity property to allow access to the survey units.
4. Performance of a gamma walkover survey (GWS) of each of the five survey units to identify areas of elevated radioactivity.
5. Performance of a civil survey to establish property boundaries and the 77 pre-determined, systematic boring locations.
6. Performance of geophysical surveys for utility and obstruction clearance prior to soil boring.
7. Processing of gamma walkover data to identify up to ten additional locations with elevated activity for collection of judgmental borings/sampling.
8. Use of push-probe sampling techniques to collect 261 soil samples from 87 locations.
9. Field screening of soil cores for elevated radioactivity and volatile organic compounds (VOCs).
10. Performance of a post-sampling civil survey of the 77 systematic boring locations and the ten judgmental boring locations.
11. Collection of up to 13 standing water samples from some five previously identified low lying areas.
12. Development of three (3) pre-existing shallow groundwater wells and collection of three (3) groundwater samples.
13. Containerization of newly generated IDW and sampling for waste disposal.
14. Survey and sampling of legacy IDW at NFSS to include soil, water, sediment, and hydraulic/motor oil.
15. Downsizing and containerization of legacy IDW.
16. Development of waste profiles and disposal of IDW waste streams.
17. Demobilization, including free release surveys of equipment.

Figure 4-1. VP H' Site Layout

The following summary and the descriptions of field screening and sampling efforts included in sections 5.0 and 6.0, respectively, refer to the project specific Radiation Safety Plan and various AAR and Arcadis Operating Procedures listed in **Table 4-1** below. The Operating Procedures are included in the QAPP.

Table 4-1. Applicable Procedures

Procedure No.	Procedure Title
<i>RSP-AAR-HP</i>	<i>Radiation Protection Plan for the Remedial Investigation of Vicinity Property H-Prime and Disposal of IDW</i>
RSP-102	Radiation Protection Program Overview
RSP-103	Radiation Protection Audits, Assessments, and Oversight
RSP-104	Radiation Protection Surveys and Inspections
RSP-105	Radiation Protection Training and Qualification
RSP-107	Operation of Portable Radiological Survey Instruments
RSP-108	Calibration and Quality Control of Portable Radiological Survey Instruments
RSP-110	Radiological Surveys
RSP-113	Radiological Posting and Labeling
RSP-114	Access to Radiological Areas
RSP-115	Sealed Source Accountability and Leak Checks
RSP-119	Shipping and Transportation of Radioactive Materials
N/A	SOP - Monitoring Well Integrity Survey

Table 4-1. Applicable Procedures

Procedure No.	Procedure Title
N/A	TGI – Investigation Derived Waste Handling and Storage
N/A	TGI – Groundwater and Soil Sampling Equipment Decontamination
N/A	TGI – Low Flow Groundwater Surging and Sampling Procedures for Monitoring Wells
N/A	TGI – Monitoring Well Development
ARCHSFS019	Utility Location and Clearance

4.1 Site Clearing and Utility Clearance Activities

In order to prepare the property for the GWS and other work, AAR will perform clearing and mowing over the VP H' property. The goal of this effort is to remove excessive vegetation, overburden, brush, and small trees in order to improve accessibility of surveyors during the GWS. The GWS has a goal of surveying 100% of accessible areas. Clearing and mowing will also facilitate the civil survey, locating of sampling points, and accessibility of the push-probe sampling rig.

AAR personnel will clear and cut trees less than approximately two (2) inches (< 2") in diameter, brush, and overburden from the VP H' property. Additionally, when field personnel determine that it will not harm the integrity of the tree, AAR will remove lower tree branches up to 1.5 inches in diameter and foliage from remaining trees up to breast/shoulder height to allow easy access of personnel and survey equipment. All tree limbs, vegetation, and other cleared materials will be staged on property adjacent to VP H' as directed by USACE and CWM.

Once the clearing and grubbing is complete, a local State of New York licensed Surveyor will conduct a civil survey to establish the baseline elevations for the property, property boundaries, and to locate and mark the locations of USACE delineated sampling locations. A post-sampling civil survey will also be performed to record the final locations of all borings. This information will be included in the final report.

Prior to beginning any intrusive work, geophysical surveys will be conducted within a 15-ft radius around all profile boring and monitoring well locations to locate utilities, if any. If anomalies are encountered near the edge of the radius, the boundary of the survey area will be extended. Aboveground utilities within the work area will also be identified. Proposed boring/well locations will be field adjusted, as necessary, based on the results of these surveys.

4.2 Field Screening Activities

Field screening activities will consist of using field instruments and detectors to identify the possible presence and degree of contamination as well as scanning, surveying, and free releasing equipment and materials from RCAs. Field screening on this project will include:

- Mobilization radiological surveys of specific areas and items (e.g., roadways, location of temporary decontamination pad, temporary waste storage areas, office and support trailers, vehicles, and equipment) to define baseline conditions;
- Gamma walkover surveys of VP H' to identify locations for judgmental sampling;
- Periodic radiological surveys of specific areas (e.g., roads, equipment, waste storage areas, office and worker break/meeting trailers) during the project to ensure radiological contamination is not

spread to uncontaminated areas of the property, to minimize worker exposure and take interim measures as appropriate to modify work practices to ensure radiological contamination is not spread to uncontaminated areas;

- Radiological surveys of poly tanks at NFSS for free release;
- Utilization of a photoionization detector (PID) for screening of soil cores collected at VP H' to confirm that VOCs are not likely to be present at elevated concentrations that could either pose a health and safety concern to remediation field personnel or be of concern from an off-site disposal standpoint;
- Radiological surveys of soil cores collected at VP H' to identify the presence of elevated radioactivity;
- Radiological surveys of the exterior of waste containers prior to moving them from the work area and RCA to verify that removable surface contamination is not present prior to the containers being transferred to the temporary on-site waste storage area;
- Radiation "frisking" of personnel before exiting RCAs;
- Radiological surveys of potentially impacted equipment and materials immediately prior to removal from property during demobilization to verify that release criteria are not exceeded.

Decontamination will be performed if radiological surveys indicate contamination above release limits, and decontaminated areas/equipment will subsequently be re-surveyed. The USACE will be notified of any areas/equipment that report contamination above release limits or baseline levels. The limits for release are specified in the project specific RSP.

Direct-read radiological instruments and detectors will be used throughout field operations for scanning and surveying of personnel, equipment, materials, and areas. The instruments and detectors will be operated and maintained by HPTs, and will undergo daily performance checks per AAR procedure. Any additional equipment used on-site, including the PID, will be maintained and operated by the HPTs, the Corporate/Site RSO, Arcadis, and the SSHO. Proposed types of instruments, detectors, and equipment (or their equivalents) to be used on-site during field screening are listed in *Table 4-2*.

Table 4-2. Field Screening and Sampling Equipment		
Instrument	Detector	Parameters/Usage
Ludlum Model 2224, or equivalent	e.g., Ludlum Model 43-89, 100 cm ² Scintillator	Portable scaler/ratemeter (alpha/beta)
Ludlum Model 2221, or equivalent	e.g., Ludlum Model 44-10, 2x2 NaI Scintillator	Portable scaler/ratemeter (high energy gamma)
Ludlum Model 2929, or equivalent	Ludlum Model 43-10-1	Smear/air sample filter counter (alpha/beta)
Ludlum Model 19 , or equivalent	--	Portable low-level dose rate meter (gamma)
Ludlum Model 3, or equivalent	Ludlum Model 44-9 Pancake Frisker	General purpose survey meter (beta/gamma)
Mini RAE PID, or equivalent	11.7eV lamp	Photoionization detector / organic vapor analyzer.
Trimble GeoExplorer, or equivalent, GPS unit with range pole and interface for Ludlum 2221		GPS position information and data logging of count rates from gamma survey instrument (Ludlum 2221 w/ 44-10)

4.3 Remedial Investigation Sampling Activities

Field sampling on this project will consist of collecting samples of environmental media for off-site laboratory analysis. The following types of field samples will be collected for the purposes identified:

- Soil samples from push-probe collected cores to a depth of five (5) feet below ground surface (bgs); one sample from the top 6-inches (15 centimeters) of soil; one (1) sample from a one-foot interval immediately below the surface sample; one (1) sample from a one-foot interval below 18-inches that exhibits the highest radiological scan measurement on the soil core; if there are no elevated radiological measurements below 18 inches, the third sample shall be collected from the interval immediately below 18 inches. Additional material from zero to six (6) inches may be hand dug as necessary to achieve adequate sample volumes. Soil sample analytes are included in **Table 8-1**.
- Standing water samples from five previously identified low lying areas will be collected. Up to 13 samples will be collected from areas with standing water. Standing water analytes are included in **Table 8-1**.
- Groundwater samples will be collected at least 72 hours following the development of three (3) shallow groundwater wells at VP H'. One (1) sample from each well will be collected for analysis. Groundwater analytes are included in **Table 8-1**.
- Additional samples to support quality assurance and control will be collected at predefined rates. For instance, field duplicates will be collected at a rate of 1:10 or 10%. Per the DOE/DOD Quality Systems Manual (QSM) for Environmental Laboratories, version 5.1, Section 1.7.2.3, matrix spikes are not required for radiochemical analysis if an isotopic tracer or chemical carrier is used to determine chemical recovery or yield during the separation and mounting process. Matrix spikes are also not required for gross alpha/beta and gamma analysis. In consultation with the off-site laboratory, tracers and carriers will be utilized for all analytes except those analyzed by gamma spectroscopy and gross alpha/beta. As such, samples for matrix spikes and matrix spike duplicates will not be collected per the QSM.
- Analytes are provided in **Table 8-1**; minimum sample quantities, containers, preservation, and holding times are summarized in **Table 8-3** (see Section 8.0).

4.4 Investigation-Derived Waste Sampling Activities

Field sampling of IDW will consist of collecting samples of various waste streams for off-site laboratory analysis. In addition, four drums of used oil (at the NFSS) will be sampled for disposal.

Characterization parameters have been specified based on the waste acceptance criteria of the anticipated USACE-approved disposal facility for each waste stream. Final off-site disposal options will be determined based on characterization data. The following types of field samples will be collected for the purposes identified:

- Soil samples will be collected from investigation derived solid waste generated from borings. It is estimated that up to five (5) sample will be collected from segregated containers for waste characterization. Analytes for newly generated, soil sampling IDW are found in **Table 8-1**.
- Newly generated water from decontamination activities (decon water) will be sampled for a variety of analytes to support disposal. Disposal options include discharge via a local publically owned treatment works (POTW). As such, analytes include those required to demonstrate compliance with the POTW waste acceptance criteria. Up to four (4) samples of decon water will be collected. The amount of decon water to be generated is unknown at this time and will depend on-site conditions encountered during the project. Analytes for newly generated decon water are found in **Table 8-1**.

- Newly generated water from well development will be sampled for a variety of analytes to support disposal. Disposal options include discharge via a local POTW. As such, analytes include those required to demonstrate compliance with the POTW waste acceptance criteria. Up to 165 gallons (55 gallons from each of three wells) may be generated. Up to three (3) samples of well development water will be collected. Analytes for newly generated development water are found in **Table 8-1**.
- Samples from ten 55-gallon drums of legacy soil and solid IDW from a piezometer installation project at NFSS will also be sampled for disposal. A total of ten samples will be collected to ensure representativeness. Analytes for these legacy soil samples are provided in **Table 8-1**.
- Samples from legacy wastewaters containerized at NFSS will be sampled for disposal. Disposal options include discharge via a local POTW. As such, analytes include those required to demonstrate compliance with the POTW waste acceptance criteria. Approximately 200 gallons of water from legacy well installation and more recent well sampling is stored in one or more poly tanks. This water will be consolidated prior to sampling. One (1) sample will be collected. Analytes for this legacy wastewater sample are provided in **Table 8-1**.
- Samples of sediment found in the poly-tanks stored at NFSS will also be sampled for disposal. This sediment originated from water storage associated with past investigations, including well installation and sampling. Sediments will be consolidated prior to sampling. One (1) sample will be collected. Analytes for this sample are provided in **Table 8-1**.
- Four 55-gallon containers of used hydraulic/motor oil located at NFSS will be sampled for disposal. The oil was used in various heavy and motorized equipment at the NFSS. Disposal options, including recycling, are being pursued. Up to four (4) samples will be collected. Up to three (3) samples of oil known to be non-contaminated will also be sampled for comparison. The samples will be analyzed for gross alpha and gross beta; if gross alpha/beta indicates levels of radioactivity that is above background, the samples will be analyzed for additional analytes that are listed in **Table 8-1**.
- Additional samples to support quality assurance and control will be collected at predefined rates. For instance, field duplicates will be collected at a rate of 1:10 or 10%. Field and trip blanks will be collected at a rate of 1:20 or 5% for VOC and metals samples.

Sampling and laboratory analysis requirements are summarized in **Table 8-1**; minimum sample quantities, containers, preservation, and holding times are summarized in **Table 8-3** (see Section 8.0).

5.0 FIELD SCREENING AND TESTING ACTIVITIES

Procedures and activities for radiological surveys of soil, equipment, facilities, and personnel are described below. Screening procedures for detecting organic vapors in soil cores are also presented. AAR and Operating Procedures referred to in the text are included in the QAPP. Activities in direct support of the remedial investigation are denoted in the individual section headers.

5.1 Remedial Investigation Gamma Walkover Survey

Following property mowing and clearing, a GWS will be conducted of the open areas at the VP H' property. The property will be civil surveyed in support of the walkover and layout lines demarcated to guide the walkover. A Trimble global positioning system (GPS) will be utilized in conjunction with a Ludlum 2221 with 44-10 2-inch by 2-inch (2x2") thallium doped, sodium iodide (NaI) scintillation probe. The 44-10 provides good sensitivity to gamma rays emitted by radium-226, uranium-235, and uranium-238 daughters (i.e. protactinium-234m and thorium-234). The detector will be utilized in a traditional, single pass survey method, with a surveyor swinging the detector in a one (1) meter (39.4 inches) wide serpentine pattern while maintaining the detector approximately four (4) inches (10 centimeters) above the ground surface. The surveyor will advance at a rate of no more than 0.5 meters per second. The Ludlum 2221's will be configured to transmit count rate data to the datalogger at one (1) second intervals. The GWS will address 100% of accessible portions of each of the five (5) survey units at VP H'. 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.

AAR will attempt to conduct GWS in marshy areas, or those with standing water, by placing the detector in a sealed polyvinyl chloride (PVC) tube for moisture protection. The gamma attenuation, albeit small, as a result of the PVC tube must be assessed. AAR will coordinate with USACE to gain access to the Army National Guard Training Site in order to recollect background data at each established location in order to assess the impact of the protective tube.

If during initial mobilization activities it is discovered that the detector background is significantly in excess of those shown in the following section, a lead shield will be affixed to the detector. The lead shield will attenuate the ambient background to acceptable levels in order to meet project DQOs for sensitivity and minimum detectable concentration. If a lead shield is used, AAR will coordinate with USACE to gain access to the Training Site in order to collect revised background data at each established location.

5.1.1 Established Reference Backgrounds

USACE has pre-established background gamma radiation levels for the VP H' investigation. Results were obtained on various surfaces and environmental media at the Army National Guard Weekend Training Site just north of Balmer Road and directly north of NFSS. The Training Site has been deemed an appropriate reference location for the property as there is no documented history of MED or AEC-related activity. Surfaces at the Training Site are similar to those to be encountered at VP H'. Backgrounds were established using a Ludlum 2221 with 44-10 detector similar to that which will be utilized for the GWS. **Table 5-1** provides these established background values.

Table 5-1. Established Background Count Rates for Various Surfaces	
Surface Type	NaI 2x2 Average Count Rate (counts per minute (cpm))
Soil	9,000
Slag	15,900
Gravel	8,000
Concrete	5,700
Asphalt (original)	11,000
Asphalt (paved over)	6,206

5.1.2 Estimate of Scan Minimum Detectable Concentrations

The typical scan minimum detectable concentration (MDC) for a 2x2 NaI detector used as designed in this plan is calculated below using methodology found in the Multi-Agency Radiation Site Survey and Investigation Manual (MARSSIM) and NUREG-1507. The scan MDC is calculated for radium-226, thorium-232, and natural uranium (uranium-234, -235, -238). Calculation of the scan MDC for natural uranium provides a conservative estimate when compared to uranium-238 alone. Scan MDCs were compared to historic cleanup values and background radioactivity levels in order to judge their appropriateness.

Scan MDCs were derived using standard MARSSIM/NUREG-1507 methodologies and assumptions. 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. These values are summarized in *Table 5-2*. Additional details on the derivation of these values is included in Appendix A.

Table 5-2. Typical Detector Scan MDCs for Common Radiological Contaminants		
<i>Gamma Scan with a 2"x2" NaI detector for:</i>	<i>Background Count Rate (cpm)</i>	<i>Scan MDC (pCi/g)</i>
Ra-226	10000	2.8
U-natural	10000	80
Th-232	10000	1.8

These values compare favorably to established backgrounds and historic cleanup criteria from previous FUSRAP projects. This demonstrates the appropriateness of the survey design. The survey report will calculate actual scan MDC ranges based on the collected field data.

5.1.3 Site Specific Investigation Levels

The USACE established investigation levels for various surfaces shown in *Table 5-3* below. These investigation levels, provided in the SOW, are based on the reference background count rates for various materials. Per USACE, investigation levels were set at approximately 1.5 times background except for soil which was adjusted to 1.7 times background. This is based on previous activity and concentration correlations from other Buffalo Area FUSRAP projects (USACE, 2017). These values will be used during the GWS and subsequent analysis as an indication of elevated residual radioactivity or "hotspot". These areas will be denoted on survey maps. Per the OSW, ten (10) locations with the highest count rate will be flagged for soil sampling.

Table 5-3. Investigation Levels for VP H' GWS

Surface Type	Investigation Level Count Rate (counts per minute)
Soil	16,001
Slag	23,851
Gravel	12,001
Concrete	8,501
Asphalt (original)	15,571
Asphalt (paved over)	NA

5.1.4 Gamma Walkover Survey Data Collection

The data collected by the Trimble GPS unit, after post-processing, will have a sub-meter mean accuracy when in ideal conditions and using an external antenna. The GPS unit will be configured to collect data using North American Datum (NAD) 1983 CORS 96 – New York State Plane West Coordinates (3103) in US Survey Feet. All collected data will be post-processed using Trimble Pathfinder Office. Corrected and uncorrected files will be provided to the USACE. A range pole (or equivalent) will be used to ensure that the external antenna is located at a fixed distance above the detector to ensure accurate position data is collected for each measurement.

Results from the GWS will be presented graphically and in electronic tabular format. Graphical results will be displayed as an overlay on a property drawing and geo-referenced aerial photograph using ArcView or equivalent. Various surface types will be demarcated. AAR will establish a graduated color scheme in order to display the count rate data results, differentiating those values in excess of the established project specific investigation levels. Inaccessible areas due to the presence of debris or vegetation exceeding the criteria for clearing (i.e. two (2) inches in diameter) will be demarcated on the survey maps. Tabular form data will include counts per minute (cpm), northing and easting (x, y), dilution of precision (PDOP), date, and time.

5.1.5 Daily Instrument Performance Checks

AAR Health Physics personnel will perform daily performance checks on the Ludlum 2221 with 44-10 detector to ensure proper functionality. During project mobilization, reference source and local background ranges will be established for determining acceptable performance. Ranges will be established in accordance with AAR procedure RSP-108, *Calibration and Quality Control of Portable Radiological Survey Instruments*. Performance checks will be conducted daily prior to conducting surveys and will be verified at the end of the workday. Results of performance checks will be documented. Performance tests will also be repeated if health physics personnel suspect that an instrument has malfunctioned or is providing anomalous results.

In addition, to ensure reproducible count rate and GPS positioning data, AAR will establish three (3) local reference points just beyond the VP H' property boundary. These locations will be civil surveyed to establish accurate positioning. Prior to the start of daily GWS activities, health physics personnel will position each detector at these local reference locations and allow the instrumentation to log count rates and position data for a minimum of five (5) minutes which is equivalent to 300 measurements considering the instruments will transmit data at one (1) second intervals. The results of these daily reproducibility tests will be saved individually by instrument and day. Count rate data will be reviewed periodically by the Corporate / Site RSO or designee to ensure the generation of quality GWS data.

5.2 Radiological Survey of Waste Containers

Based on historic data, there is limited potential for the spread of contamination during sampling. HPTs will be present during push probe sampling and will perform in-process surveys to ensure contamination control is maintained. After the soil cores are examined, surveyed, and sampled, residual material will be placed into 55-gallon drums (or equivalent) for disposal. It is unlikely that drum exteriors will become contaminated during this packaging activity. However, as a preventative measure, drums will be lined with a four (4) to six (6) mil poly liners which will extend beyond the top of the containers and folded over the sides. Drums will also be placed on plastic in the work area to ensure they are not in contact with the soil surface. When filled, the liner will be folded into the drum and the lid sealed.

HPTs will perform a radiological survey of the drum exterior prior to moving to the staging area to ensure it is free of radiological contamination. The survey will consist of collecting large-area wipes (LAWs). LAWs will be obtained using standard oil-impregnated masslin cloth. LAWs will be obtained over areas larger than 100 cm². At least two (2) wipes will be collected from each drum to assess the top, sides, and bottom of the container.

LAWs will be screened using a Ludlum 2360 with 43-89 alpha/beta probe (or equivalent). If screening results indicate contamination in excess of the instrument MDC, the HPT will pull swipes to quantify level of removable contamination per 100 centimeters squared (cm²). Swipes will be collected using dry, cotton swipes. Swipes will be counted either using the Ludlum 2360 with 43-89 probe (or equivalent) or using a Ludlum 2929 swipe counter with 43-10-1 alpha beta detector.

In addition to the collection of LAWs (and potentially swipes), the HPT will perform scans and static measurements to document the level of total contamination on the container. Static measurements will be obtained using a Ludlum 2360 with 43-89 alpha/beta probe (or equivalent). A minimum of one (1) static measurement for total alpha and total beta contamination will be documented per item. Measurement locations will be determined based on the results of scanning. The HPT will collect the static measurement at the location exhibiting the highest level of radioactivity as determined during the scan. If no area of elevated radioactivity is detected during the scan, the HPT will collect the static measurement at the location deemed most likely to be contaminated (e.g. container bottom)

Radiological surveys will be conducted and documented in accordance with AAR procedures including: RSP-110, *Radiological Surveys* and RSP-108, *Calibration and Quality Control of Portable Radiation Protection Instrumentation*.

5.3 Free Release Surveys of Tools and Equipment

Prior to release from the property, tools and equipment that were utilized in the impacted areas at VP H' and at NFSS for waste packaging will be surveyed for free release. Some examples of tools and equipment which may be subject to survey include:

- Skid steer and attachments
- Push probe rig
- Vehicles/Trucks
- Portable tanks and containers
- Generators
- Pumps
- Power tools
- Hand tools such as shovels

Equipment that is covered in mud, dirt, or grease will be decontaminated prior to survey. Decontamination may consist of scraping, sweeping, wiping with cloth rags, low volume pressure washing, and the use of non-solvent based degreasers. Expendable or disposal items will be packaged for transport and characterized with other IDW. Water and wastes associated with decontamination will be collected and managed as IDW.

A radiological survey will be performed for free release of this equipment and tools prior to leaving the project area. LAWs will be utilized to rapidly assess the radiological condition of equipment in a manner similar to surveys of waste containers discussed in Section 5.2.

LAWs will be screened using a Ludlum 2360 with 43-89 alpha/beta probe (or equivalent). If screening results indicate contamination in excess of the instrument MDC, the HPT will pull swipes to quantify level of removable contamination per 100 cm². Swipes will be collected using dry, cotton swipes. Swipes will be counted either using the Ludlum 2360 with 43-89 probe (or equivalent) or using a Ludlum 2929 swipe counter with 43-10-1 alpha beta detector.

In addition to the collection of LAWs (and potentially swipes), the HPT will perform scans and static measurements to document the level of total contamination on the item. Static measurements will be obtained using a Ludlum 2360 with 43-89 alpha/beta probe (or equivalent). A minimum of one (1) static measurement for total alpha and total beta contamination will be documented per item. Measurement locations will be determined based on the results of scanning. The HPT will collect the static measurement at the location exhibiting the highest level of radioactivity as determined during the scan. If no area of elevated radioactivity is detected during the scan, the HPT will collect the static measurement at the location deemed most likely to be contaminated (e.g. tracks, tires, blades).

Results will be compared to established free-release criteria found in the project specific Radiation Safety Plan. Radiological surveys will be conducted and documented in accordance with AAR procedures including: RSP-110, *Radiological Surveys* and RSP-108, *Calibration and Quality Control of Portable Radiation Protection Instrumentation*.

5.4 Job Coverage Radiological Surveys

Job coverage radiological surveys will be performed to assess radiological conditions at various work locations and phases. These surveys include:

- Baseline surveys of material, equipment, and trailers
- Periodic surveys of office, break, and storage trailers.
- Periodic surveys of waste storage areas
- Periodic dose rate survey of the work and support areas.

Baseline surveys will be conducted on large equipment and trailers in order to document their pre-use radiological condition. Baseline surveys will focus on both removable and total contamination and will consist of both the collection of LAWs and static measurements. Scanning will be used to determine the location of static measurements. At least one static measurement for total alpha and total beta contamination will be collected from each item undergoing baseline survey.

Periodic surveys of office, break, storage trailers, and waste areas will initially be conducted weekly during periods of active work to ensure that any contamination has not spread to uncontaminated areas and to ensure radiological exposures to field personnel remains ALARA. Periodic surveys of other support areas will be conducted at the discretion of the Corporate / Site RSO. These surveys will focus on removable contamination by using LAWs. At least one LAW will be collected from each location.

The Corporate / Site RSO may adjust the frequency of periodic surveys based on survey results and site conditions.

LAWs will be screened using a Ludlum 2360 with 43-89 alpha/beta probe (or equivalent). If screening results indicate contamination in excess of the instrument MDC, the HPT will pull swipes to quantify level of removable contamination per 100 cm². Swipes will be collected using dry, cotton swipes. Swipes will be counted either using the Ludlum 2360 with 43-89 probe (or equivalent) or using a Ludlum 2929 swipe counter with 43-10-1 alpha beta detector.

In addition to the collection of LAWs (and potentially swipes), the HPT will perform scans and static measurements to document the level of total contamination on the item. Static measurements will be obtained using a Ludlum 2360 with 43-89 alpha/beta probe (or equivalent). A minimum of one (1) static measurement for total alpha and total beta contamination will be documented per item. Measurement locations will be determined based on the results of scanning. The HPT will collect the static measurement at the location exhibiting the highest level of radioactivity as determined during the scan. If no area of elevated radioactivity is detected during the scan, the HPT will collect the static measurement at the location deemed most likely to be contaminated (e.g. tracks, tires, blades).

Radiological surveys will be conducted and documented in accordance with AAR procedures including: RSP-104, *Radiation Protection Surveys and Inspections*, RSP-110, *Radiological Surveys*, and RSP-108, *Calibration and Quality Control of Portable Radiation Protection Instrumentation*.

In addition to surveys for contamination, HPTs will perform periodic dose rate monitoring in the work and support areas. As described in the Radiation Safety Plan, it has been determined that anticipated radiological conditions, based on historic data, will not lead to a worker effective dose equivalent (EDE) in excess of monitoring thresholds (i.e. 500 mrem/yr). HPTs will perform a baseline dose rate survey of the work area and support area using a Ludlum Model 19 dose ratemeter. Additional surveys will be conducted at the discretion of the Corporate / Site RSO if, based on GWS or contamination data, radiological conditions have changed in a manner which may increase the ambient gamma dose rate. Radiological surveys will be conducted and documented in accordance with AAR procedures including: RSP-104, *Radiation Protection Surveys and Inspections*, RSP-110, *Radiological Surveys*, and RSP-108, *Calibration and Quality Control of Portable Radiation Protection Instrumentation*.

5.5 Radiological Screening of Soil Cores to Support Remedial Investigation Sampling

Soil cores in their liner shall be removed from the boreholes. The sample table plastic sheeting, sampling tools, and the outside of the sleeve will be verified free of loose radioactive contamination. Sampling tools, plastic sheeting and external surfaces of 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 HPT. Soil cores in their sleeve will be placed on the table in a low-background area for scanning and visual inspections. A low background area is defined as one with ambient radiation levels that produce less than 100 cpm on the pancake Geiger-Mueller probe and less than 10,000 cpm with the 2x2 NaI. Lead shielding may also be used to lower background levels and increase the sensitivity of the 2x2 NaI. The outside of the sleeve shall be wiped down to remove any possible moisture and to allow for visual inspections of the core soil. The HPT will scan the entire core with a Ludlum Model 2221 with Model 44-10 2x2 NaI detector followed by localized scanning with a Ludlum Model 3 with Model 44-9 pancake Geiger-Mueller alpha/beta/gamma probe. HPT will also use a Ludlum 2360 with Model 43-89 alpha/beta scintillation probe to further assess elevated readings discovered with the 44-9 or 44-10 probes. The HPT will scan one (1) foot above and one (1) foot below the core section exhibiting the highest gamma radiation reading with the pancake Geiger-Mueller probe. All radiation scan cpm ranges for each core will be documented on the core log sheet. One minute static counts for alpha, beta, and gamma cpm will be documented from the location with the highest gamma scan readings and the position of those

readings. Instruments will be calibrated and performance checked in accordance with AAR procedure RSP-108, *Calibration and Quality Control of Portable Radiation Protection Instrumentation*.

5.6 Radiological Surveys of Wastes for Free Release

Solid waste materials with no potential for volumetric contamination such as the poly tanks at NFSS, will be scanned for free release in order to attempt disposal at a local solid waste landfill.

Items that are covered in mud, dirt, or grease will be decontaminated prior to survey. Decontamination may consist of scraping, sweeping, wiping with cloth rags, low volume pressure washing, and the use of non-solvent based degreasers. Expendable or disposable items will be packaged for transport and characterized with other IDW. Water and wastes associated with decontamination will be collected and managed as IDW with potential volumetric contamination subject to sampling.

A radiological survey will be performed for free release of these wastes prior to packaging. LAWs will be utilized to rapidly assess the radiological condition of equipment in a manner similar to surveys discussed in previous sections. While the mechanics of the survey process may be similar to other surveys, the limits for release are not. For wastes destined for non-radiological, local disposal, the USACE has specified that “indistinguishable from background” will be utilized as the release criteria. As such, free release survey results for waste materials will be compared to the instrument’s Critical Level (L_c), which is the statistical value below which any residual radioactivity is indistinguishable from background. Typically, this value is approximately one-half ($1/2$) of the static MDC for any particular instrument. The L_c for instruments used to conduct free release surveys of wastes will be determined during instrument setup and will be based on a one (1) minute background count and a one (1) minute sample count.

LAWs will be screened using a Ludlum 2360 with 43-89 alpha/beta probe (or equivalent). If screening results indicate contamination in excess of the L_c , the HPT will pull swipes to quantify level of removable contamination per 100 cm². Swipes will be collected using dry, cotton swipes. Swipes will be counted either using the Ludlum 2360 with 43-89 probe (or equivalent) or using a Ludlum 2929 swipe counter with 43-10-1 alpha beta detector.

In addition to the collection of LAWs (and potentially swipes), the HPT will perform scans and static measurements to document the level of total contamination on the item. Static measurements will be obtained using a Ludlum 2360 with 43-89 alpha/beta probe (or equivalent). A minimum of one (1) static measurement for total alpha and total beta contamination will be documented per item. Measurement locations will be determined based on the results of scanning. The HPT will collect the static measurement at the location exhibiting the highest level of radioactivity as determined during the scan. If no area of elevated radioactivity is detected during the scan, the HPT will collect the static measurement at the location deemed most likely to be contaminated (e.g. stains, rust, surface imperfections).

The survey results will be reviewed by USACE prior to final packaging for shipment. USACE will obtain the concurrence of NYSDEC prior to disposal. Radiological surveys will be conducted and documented in accordance with AAR procedures including RSP-110, *Radiological Surveys* and RSP-108, *Calibration and Quality Control of Portable Radiation Protection Instrumentation*.

5.7 Frisking of Personnel Egressing Radiologically Controlled Areas

The Corporate / Site RSO may post RCAs at either VP H’ or NFSS based on-site radiological conditions as described in the project specific RSP. Field personnel performing tasks in RCAs will be governed by a radiological work authorization or radiation work permit (RWP) and will be required to wear personal protective equipment (PPE). Site personnel will doff disposable PPE and remove dirt, mud, and dust

from work boots on each occasion prior to leaving RCAs. Site personnel will then scan the exterior of boots, hands, and clothing as appropriate using a Ludlum Model 3 ratemeter equipped with a Ludlum 44-9, beta-gamma pancake Geiger-Mueller probe prior to leaving RCAs. Frisking will be performed by slowly moving the referenced probe over the surfaces being scanned in accordance with RSP-110, *Radiological Surveys* and RSP-108, *Calibration and Quality Control of Portable Radiation Protection Instrumentation*.

5.8 Organic Vapor Screening of Soil Cores

After soil cores have been removed, wiped down with a damp cloth to remove loose debris, and radiologically surveyed, field personnel will screen the soil core for organic vapors. The sleeved core will be placed on a firm, horizontal surface and the sleeve will be cut away. The core will then be examined by the geologist and screened for VOCs using a PID such as a RAE Systems MiniRAE. Photographs of the core may also be taken. Samples for laboratory analysis will immediately be removed and placed into appropriate containers using a decontaminated stainless steel spoon or scoop (or equivalent) as prescribed in subsequent sections. The maximum PID measurement, in parts per million (ppm), will be recorded on the core log sheet along with the location that measurement was obtained. IDW from bore holes with PID readings in excess of 5 ppm will be segregated for VOC sampling prior to disposal.

The PID will be calibrated in accordance with the manufacturer's procedures at the beginning of each work day when excavation and soil handling activities are performed. Additional calibration may be completed at the discretion of the instrument operator if significant weather variations occur during the course of the day. Sample collection, logging, and screening for VOCs will be conducted in accordance with Arcadis' procedure, *Sample Drilling and Collection*.

In many instances, soil cores can be produced faster than they can be opened, logged, screened and sampled by field personnel. In those instances, when a backlog of cores is being generated, care must be made to protect the cores from direct sunlight, excessive ambient temperatures, and rain. These conditions may have an adverse effect on highly sensitive volatile organics within the core or the instruments used for screening. The cores will be labeled so that the up/down orientation is not lost. Field screening will proceed carefully but quickly. If necessary, soils will be logged for lithology information after sample collection.

6.0 FIELD SAMPLING ACTIVITIES

This section of the FSP describes sampling and analyses to be performed by the off-site laboratories. The quantitative analytical data that are generated as a result of these activities will be sufficient in type, quantity, and quality such that project DQOs (discussed in section 4.0 and the project QAPP) are met, radiation exposure to on-site field personnel is minimized, and the potential for migration or dispersion of radioactive materials as a result of the field activities is minimized. Field sampling will be performed for soil/debris/sediment, standing water, groundwater, and wastewater samples, as described below. Those activities in direct support of the remedial investigation are noted in the individual section heading. Likewise, sampling activities in support of IDW characterization and disposal are also noted in the individual section headings.

Section 8.0 provides an overview of the analytical activities to be performed by the off-site laboratory. Specific sampling parameters, analytes, and numbers of samples are summarized in **Table 8-1**. **Table 8-2** provides the list of VOCs to be analyzed. **Table 8-3** summarizes analysis methods, sample volume, preservation, and holding times. Additional information is found in the QAPP.

6.1 Soil Samples

Four (4) types of soil samples may be collected on this project:

- Soil and concrete from core samples collected at VP H' with a push-probe sample rig;
- Soil IDW from elevated VOC core samples at VP H';
- Soil/debris from drummed IDW at NFSS;
- Soil/sediment residue from poly tanks at NFSS.

6.1.1 Soil and Concrete from VP H' Remedial Investigation Core Samples

6.1.1.1 Sampling Objective

The objective of this activity is to perform a survey and sampling activity that is consistent with MARSSIM protocols. Personnel will collect soil from each Class 1 survey unit and Class 2 survey unit, to a depth of five (5) feet, for the purpose of determining the magnitude and extent of any remaining soil contamination at VP H'. The sampling is intended to be of sufficient quality and rigor such that the data can be used to support a CERCLA remedial investigation report.

6.1.1.2 Sample Type and Location

Systematic soil samples will be collected from pre-established grid points in each of four (4) Class 1 survey units and the Class 2 survey unit. A total of 77 systematic sampling locations have been specified by USACE, including two (2) of which are under the concrete slab on the southeast corner of VP H'. In addition, ten (10) biased sample locations will be determined based on GWS results. **Figure 6-1** (provided by USACE) provides a representation of the survey units and the sample locations. Sample locations, in NAD 1983 NY-West State Plane coordinates, are shown in **Table 6-1**. Samples locations will be established by an NY licensed surveyor prior to collection. Sample locations offset due to obstructions will be resurveyed after sampling completion and denoted in the project report. Offsets will be minimized to the extent possible.

Concrete will also be collected from two (2) borings from locations on the concrete pad in the southeast portion of VP H'. The soil under the concrete will also be sampled at these locations.

Figure 6-1. Survey Units and Planned Soil Sample Locations (USACE, 2017)

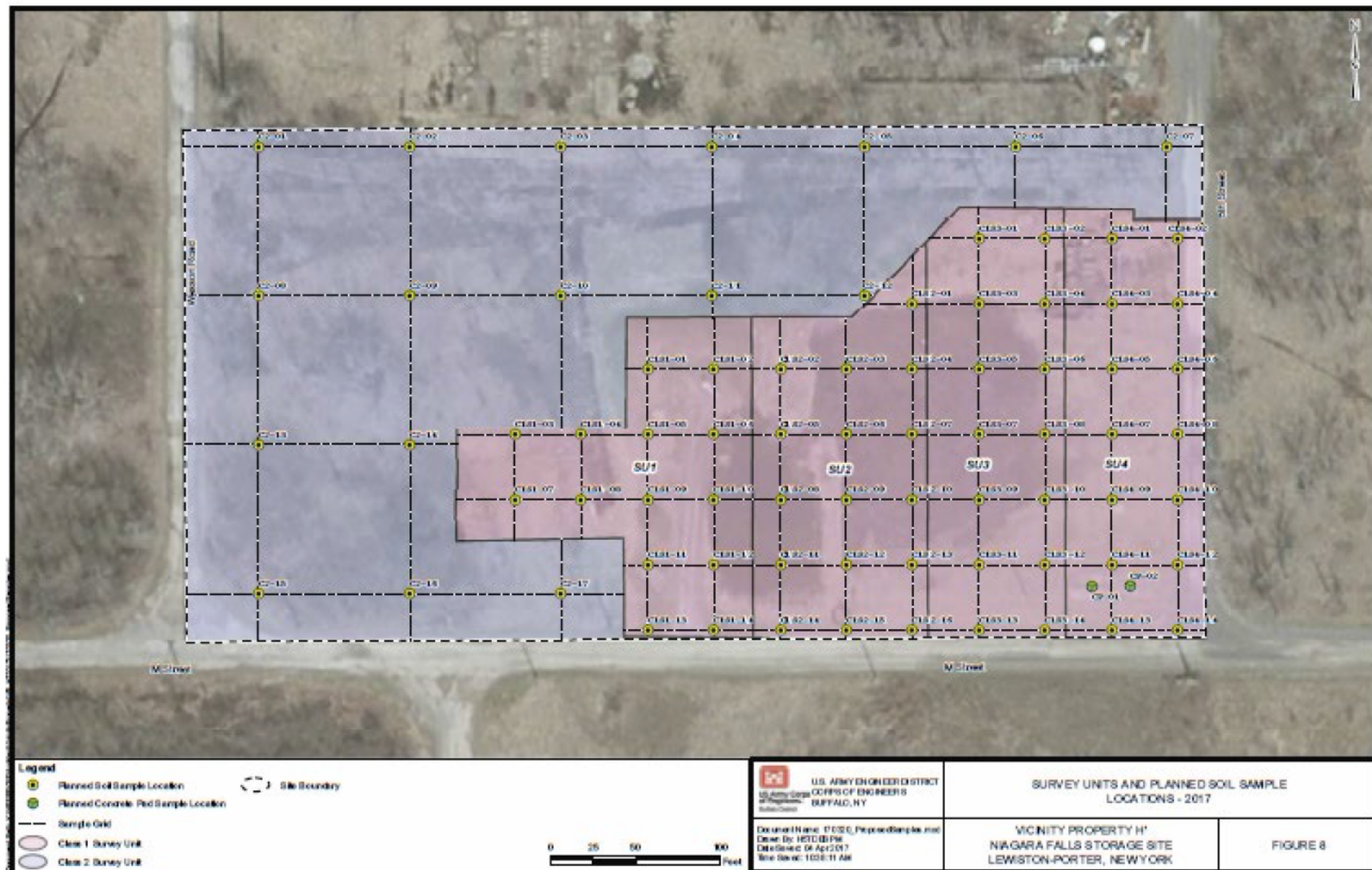


Table 6-1. Coordinates for Proposed Sample Locations

Location ID	Northing	Easting
C1S1-01	1174740.586	1041636.819
C1S1-02	1174740.586	1041675.819
C1S1-03	1174701.586	1041558.819
C1S1-04	1174701.586	1041597.819
C1S1-05	1174701.586	1041636.819
C1S1-06	1174701.586	1041675.819
C1S1-07	1174662.586	1041558.819
C1S1-08	1174662.586	1041597.819
C1S1-09	1174662.586	1041636.819
C1S1-10	1174662.586	1041675.819
C1S1-11	1174623.586	1041636.819
C1S1-12	1174623.586	1041675.819
C1S1-13	1174584.586	1041636.819
C1S1-14	1174584.586	1041675.819
C1S2-01	1174779.587	1041792.819
C1S2-02	1174740.586	1041714.819
C1S2-03	1174740.586	1041753.819
C1S2-04	1174740.586	1041792.819
C1S2-05	1174701.586	1041714.819
C1S2-06	1174701.586	1041753.819
C1S2-07	1174701.586	1041792.819
C1S2-08	1174662.586	1041714.819
C1S2-09	1174662.586	1041753.819
C1S2-10	1174662.586	1041792.819
C1S2-11	1174623.586	1041714.819
C1S2-12	1174623.586	1041753.819
C1S2-13	1174623.586	1041792.819
C1S2-14	1174584.586	1041714.819
C1S2-15	1174584.586	1041753.819
C1S2-16	1174584.586	1041792.819
C1S3-01	1174818.586	1041831.819
C1S3-02	1174818.586	1041870.819
C1S3-03	1174779.587	1041831.819
C1S3-04	1174779.587	1041870.819
C1S3-05	1174740.586	1041831.819
C1S3-06	1174740.586	1041870.819
C1S3-07	1174701.586	1041831.819
C1S3-08	1174701.586	1041870.819
C1S3-09	1174662.586	1041831.819
C1S3-10	1174662.586	1041870.819
C1S3-11	1174623.586	1041831.819
C1S3-12	1174623.586	1041870.819
C1S3-13	1174584.586	1041831.819
C1S3-14	1174584.586	1041870.819
C1S4-01	1174818.586	1041909.819
C1S4-02	1174818.586	1041948.819
C1S4-03	1174779.587	1041909.819

Table 6-1. Coordinates for Proposed Sample Locations

Location ID	Northing	Easting
C1S4-04	1174779.587	1041948.819
C1S4-05	1174740.586	1041909.819
C1S4-06	1174740.586	1041948.819
C1S4-07	1174701.586	1041909.819
C1S4-08	1174701.586	1041948.819
C1S4-09	1174662.586	1041909.819
C1S4-10	1174662.586	1041948.819
C1S4-11	1174623.586	1041909.819
C1S4-12	1174623.586	1041948.819
C1S4-13	1174584.586	1041909.819
C1S4-14	1174584.586	1041948.819
C2-01	1174873.35	1041407.984
C2-02	1174873.35	1041496.984
C2-03	1174873.35	1041585.984
C2-04	1174873.35	1041674.984
C2-05	1174873.35	1041763.984
C2-06	1174873.35	1041852.984
C2-07	1174873.35	1041941.984
C2-08	1174784.35	1041407.984
C2-09	1174784.35	1041496.984
C2-10	1174784.35	1041585.984
C2-11	1174784.35	1041674.984
C2-12	1174784.35	1041763.984
C2-13	1174695.35	1041407.984
C2-14	1174695.35	1041496.984
C2-15	1174606.35	1041407.984
C2-16	1174606.35	1041496.984
C2-17	1174606.35	1041585.984
CP-01	1174610.62	1041898.198
CP-02	1174611.116	1041920.792
NAD 1983 State Plane New York West FIPS 3103 Feet		

6.1.1.3 Sampling Frequency

At each location, AAR and its subcontractor Arcadis, will collect a 2.75 inch diameter soil core to a depth of five (5) feet bgs. Arcadis will utilize a direct push rig with a 3.5 inch single tube tool. Each core will be placed on a sturdy worktable, the exterior wiped to remove gross soil and contamination, and the sleeve removed. Three (3) samples will be collected from each core. One (1) sample from the top 6-inches (15 centimeters) of soil; one (1) sample from a one-foot interval immediately below the surface sample; and one (1) sample from a one-foot interval below 18-inches that exhibits the highest radiological scan measurement on the soil core. If there are no elevated radiological measurements below 18 inches, the third sample shall be collected from the interval immediately below 18 inches. A total of 77 soil cores will be collected from the systematic locations, including two (2) which will require concrete removal prior to soil coring. These locations will generate 231 soil samples. Additionally, ten (10) biased locations will be cored and sampled based on the GWS survey data. These ten (10) locations will yield thirty (30) additional soil samples. Methodology for sample collection is discussed below.

Two (2) sample locations are located on the southeast concrete pad at VP H'. The concrete at these locations will be removed using mechanical cutting so that the soil beneath can be accessed for push-

probe sampling similar to other locations. A sample of the concrete will be obtained for laboratory analysis at each of these locations.

6.1.1.4 Sampling Methods

Following survey and locating of proposed sample points, AAR subcontractor Arcadis will utilize a push-probe rig with 3.5 inch single tube sampler to collect 2.75 inch diameter sample cores to a depth of five (5) feet bgs. Cores will be extracted from the collection apparatus, wiped to remove gross soil and potential contamination, and placed on a plastic draped, sturdy worktable for evaluation.

The HPT will perform a LAW survey of the tube exterior using a masslin cloth or similar prior to removing the lining. If contamination in excess of the levels specified in the RSP is encountered, the HPT will pause work and implement additional administrative controls to mitigate the spread of contamination to the work area and team members.

After the HPT has determined the radiological condition of the core exterior, the geologist or designee will remove the sleeves. The core will be scanned for VOCs and radioactivity as described in Section 5. If elevated VOC readings are encountered, IDW from the boring will be segregated along with other IDW from borings exhibiting elevated VOCs. If elevated radioactivity is encountered, the HPT will determine if additional controls are warranted.

Following scanning, the geologist will conduct observations of the core and log accordingly. The observations will include descriptions of ASTM classification (ASTM method D2488-06), consistency, moisture content, and color. Boring logs will include the minimum information specified on Engineering Form 5056 – HRTW Drilling Log. In addition, drilling logs will show the depth of the water table (if encountered), each geologic formation, and all results of PID and scan measurements.

Three (3) soil samples will be collected from each boring at the following intervals:

- One (1) sample from the top six (6) inches of the core;
- One (1) sample from the 6 to 18-inch depth (i.e. one (1) foot interval below top six (6) inches); and,
- One (1) sample from a one-foot interval below 18-inches that exhibits the highest radiological scan measurement on the soil core. If there are no elevated radiological measurements below 18 inches, the third sample shall be collected from the interval immediately below 18 inches.

If the core does not produce adequate volume for the top six (6) inch sample (i.e. surface soil), additional material may be hand dug from around the boring to add additional volume.

At locations identified as requiring a duplicate sample, a second core will be collected immediately adjacent to the primary borehole.

Media from each location that will constitute the sample will be placed into a bowl and homogenized prior to placement in sample containers. Gravel and large organic debris (e.g., wood) will be removed from the media prior to placement in containers.

Sample duplicates will be collected at a ratio of 1:10 (i.e. 10%), beginning with the first sample. A duplicate will also be collected from the last sample. Per the DOE/DOD Quality Systems Manual (QSM) for Environmental Laboratories, version 5.1, Section 1.7.2.3, matrix spikes are not required for radiochemical analysis if an isotopic tracer or chemical carrier is used to determine chemical recovery or yield during the separation and mounting process. Matrix spikes are also not required for gamma analysis. In consultation with the off-site laboratory, tracers and carriers will be utilized for all analytes

except those analyzed by gamma spectroscopy. As such, samples for matrix spikes and matrix spike duplicates will not be collected per the QSM.

At the two (2) locations on the concrete pad, AAR/Arcadis will remove the concrete using mechanical means (e.g. concrete saw cutting) so that the area beneath can be accessed for soil sampling. A sample of the concrete at these locations will be collected and sent to the laboratory for analysis.

Per Section 6.4, sampling equipment (e.g., stainless steel trowels, scoops, bowls, sample tubes) will be decontaminated prior to the first use on-site, between borings, and following the last use on-site. HPTs will survey equipment after decontamination to ensure equipment is free of contamination.

Samples will be placed into laboratory-prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. The samples will be transported in coolers via overnight delivery service under Chain-of-Custody control to the off-site laboratory for analysis. The sample containers will be swipe surveyed for removable radioactivity in accordance with the procedure identified in Section 6.5 prior to transport to the off-site laboratory. USACE representatives will review and approve the sample shipment (USACE, 2017). **Table 8-3** identifies container types and preservation methods that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in **Table 8-3**.

Residual soil and other allowed IDW will be packaged and characterized for disposal. Boreholes will be backfilled with grout (bentonite) and the area restored to its original condition. Concrete removed from the two (2) locations on the pad will be placed back in its original location. Boring locations will be marked using temporary means to facilitate subsequent civil survey of sample locations by New York State licensed Surveyor.

Non-soil IDW that does not exhibit detectable radioactivity, such as plastic, PPE, wipes, and disposable items will be placed into standard trash bags and stored pending disposal. Non-soil IDW that does exhibit detectable radioactivity will be segregated and stored in radioactive material bags pending disposal as low level wastes. All PPE will be rendered unusable prior to disposal.

Soil sample collection, preservation, and Chain-of-Custody control will be performed in accordance with Arcadis Standard Operating Procedure *Soil Drilling and Sampling* and USACE guidance provided in Appendix C of EM 200-1-3.

6.1.1.5 Laboratory Analysis Methods

Soil samples will be submitted for off-site laboratory analysis of the parameters specified in **Table 8-1**. Laboratory analytical methods for these parameters are identified in **Table 8-2** and discussed in the QAPP.

6.1.2 Soil Investigation Derived Waste from Boreholes

6.1.2.1 Sampling Objectives

Soil IDW generated during sampling will be placed in 55-gallon drums open head, DOT-rated drums (or equivalent) and stored. After sampling is completed, the segregated drum(s) will be sampled for select radionuclides, VOCs and metals in order to characterize the wastes for shipping and proper disposal. Radiological concentrations will be determined by association with soil samples collected from the boreholes.

6.1.2.2 Sample Type and Location

Soil from individual drums will be collected. Drums will be staged on the waste storage pad. Soil will be obtained by hand using scoops, augers, or tube samplers depending on the volume and compaction of soil in the containers.

6.1.2.3 Sampling Frequency

One sample per drum will be collected for analytes specified in **Table 8-1**. Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectively. A duplicate and a field blank will be collected with the last sample collected.

6.1.2.4 Sampling Methods

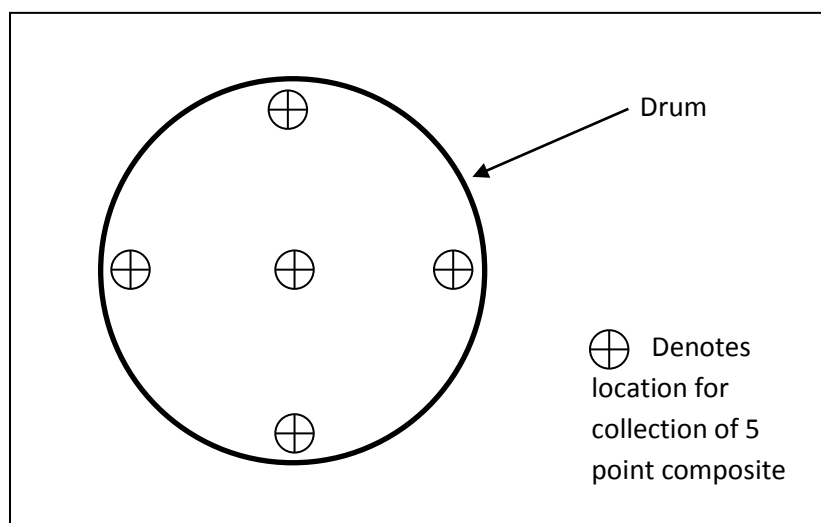
Each drum will be placed on plastic or equivalent to prevent contamination of the waste storage pad during sampling. Drum lids will be opened. The PID will be used to measure VOC content in the drum headspace to ensure worker safety. HPTs will perform a survey of the drum interior to determine appropriate administrative controls and PPE to mitigate the spread of contamination to the work area and team members.

A sample may be collected from the drum using a variety of methods depending on the amount of material in the drum. In drums with less than one (1) foot of non-compacted material, a traditional scoop or trowel may be used to homogenize the soil and collect a representative sample. Gravel and large organic debris (e.g., wood) will be removed from the sample. For ease of handling, sample media may be placed into a bowl prior to placement in containers.

For drums with more than one (1) foot of material, an auger or core sampler (or equivalent) will be utilized. The auger or core sampler will be used to collect a five (5) point, full-vertical profile, composite sample will be collected from each drum. Sample media from individual cores will be placed in a bowl and homogenized. Gravel and large organic debris (e.g., wood) will be removed from the sample.

Figure 6-2 provides a graphical representation of sample locations.

Figure 6-2. Composite Sampling Layout for Drums



VOC sample containers will be filled immediately after soil mixing is complete. Residual material will be placed back into the drum and the drum sealed following sample collection.

Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. A duplicate and a field blank will be collected with the last sample collected.

Per Section 6.4, sampling equipment (e.g., stainless steel trowels, scoops, bowls, augers) will be decontaminated prior to the first use on-site, between samples, and following the last use on-site. HPTs will survey equipment after decontamination to ensure equipment is free of contamination.

Samples will be placed into laboratory-prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. VOC samples will be stored at less than six (6) degrees Celsius (<6°C) prior to shipment. The samples will be transported in coolers with ice packs, using an overnight delivery service under Chain-of-Custody control, to the off-site laboratory for analysis. The sample containers will be swipe surveyed for removable radioactivity in accordance with the procedure identified in Section 6.5 prior to transport to the off-site laboratory. USACE representatives will review and approve the sample shipment (USACE, 2017). **Table 8-3** identifies container types and preservation methods that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in **Table 8-3**.

Non-soil IDW that does not exhibit detectable radioactivity, such as plastic, PPE, wipes, and disposable items will be placed into standard trash bags and stored pending disposal. Non-soil IDW that does exhibit detectable radioactivity will be segregated and stored in radioactive material bags pending disposal as low level wastes. All PPE will be rendered unusable prior to disposal.

Soil sample collection, preservation, and Chain-of-Custody control will be performed in accordance with Arcadis' Standard Operating Procedure *Soil Drilling and Sampling* and USACE guidance provided in Appendix C of EM 200-1-3.

6.1.2.5 Laboratory Analysis

Samples will be submitted to the off-site laboratory for analysis of parameters found in **Table 8-1**. Laboratory analytical methods for these parameters are identified in **Table 8-3** and discussed in the QAPP.

6.1.3 Drummed Soil Investigation Derived Waste Located at NFSS

6.1.3.1 Sampling Objective

Samples of drummed soil and solids IDW at the NFSS will be collected to ensure proper shipping and disposal.

6.1.3.2 Sample Type and Location

Ten (10) 55-gallon drums of soil are staged at NFSS. It is assumed that these drums are full. A representative soil sample will be obtained from each drum. A core sample or auger (or equivalent) will be used to collect composite samples from each drum. Drums that contain less than one (1) foot of soil may be sampled using a traditional scoop, homogenizing the material in the drum prior to collection.

6.1.3.3 Sampling Frequency

One (1) sample per drum will be collected for analytes specified in **Table 8-1**. Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. A duplicate and a field blank will be collected with the last sample collected.

6.1.3.4 Sampling Methods

Each drum will be placed on plastic or equivalent to prevent contamination of the waste storage pad during sampling. Drum lids will be opened. The PID will be used to measure VOC content in the drum headspace to ensure worker safety. HPTs will perform a survey of the drum interior to determine appropriate administrative controls and PPE to mitigate the spread of contamination to the work area and team members.

A sample may be collected from the drum using a variety of methods depending on the amount of material in the drum. In drums with less than one (1) foot of non-compacted material, a traditional scoop or trowel may be used to homogenize the soil and collect a representative sample. Gravel and large organic debris (e.g., wood) will be removed from the sample. For ease of handling, sample media may be placed into a bowl prior to placement in containers.

For drums with more than one (1) foot of material, an auger or core sampler (or equivalent) will be utilized. The auger or core sampler will be used to collect a five (5) point, full-vertical profile, composite sample will be collected from each drum. Sample media from individual cores will be placed in a bowl and homogenized. Gravel and large organic debris (e.g., wood) will be removed from the sample.

Figure 6-2 provides a graphical representation of sample locations. Residual material will be placed back into the drum and the drum sealed following sample collection.

Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. A duplicate and a field blank will be collected with the last sample collected.

Sample containers for VOCs will be filled first and capped prior to filling other containers.

Per Section 6.4, sampling equipment (e.g., stainless steel trowels, scoops, bowls, augers) will be decontaminated prior to the first use on-site, between samples, and following the last use on-site. HPTs will survey equipment after decontamination to ensure equipment is free of contamination.

Samples will be placed into laboratory-prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. VOC samples will be stored at less than six (6) degrees Celsius ($<6^{\circ}\text{C}$) prior to shipment. The samples will be transported in coolers with ice packs, using an overnight delivery service under Chain-of-Custody control, to the off-site laboratory for analysis. The sample containers will be swipe surveyed for removable radioactivity in accordance with the procedure identified in Section 6.5 prior to transport to the off-site laboratory. USACE representatives will review and approve the sample shipment (USACE, 2017). **Table 8-3** identifies container types and preservation methods that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in **Table 8-3**.

Non-soil sampling IDW that does not exhibit detectable radioactivity, such as plastic, PPE, wipes, and disposable items will be placed into standard trash bags and stored pending disposal. Non-soil IDW that does exhibit detectable radioactivity will be segregated and stored in radioactive material bags pending disposal as low level wastes. All PPE will be rendered unusable prior to disposal.

Soil sample collection, preservation, and Chain-of-Custody control will be performed in accordance with Arcadis' Standard Operating Procedure *Soil Drilling and Sampling* and USACE guidance provided in Appendix C of EM 200-1-3.

6.1.3.5 Laboratory Analysis

Samples will be shipped to the off-site laboratory for analysis of parameters found in **Table 8-1**. Laboratory analytical methods for these parameters are identified in **Table 8-3** and discussed in the QAPP.

6.1.4 Soil/Sediment Investigation Derived Waste from Poly Tanks at NFSS

6.1.4.1 Sampling Objective

Residual soil and sediment located in NFSS poly tanks will be consolidated prior to sampling. Sampling will be performed to ensure proper shipping and disposal of waste materials.

6.1.4.2 Sample Type, Location, and Frequency

Soils and sediment will be removed from the poly tanks at NFSS and consolidated into a DOT-rated waste container(s) of appropriate volume. One (1) sample per container will be collected. Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. A duplicate and a field blank will be collected with the last sample collected.

6.1.4.3 Sampling Methods

Each container will be placed on plastic or equivalent to prevent contamination of the waste storage pad during sampling. Container lids will be opened. The PID will be used to measure VOC content in the headspace to ensure worker safety. HPTs will perform a survey of the container interior to determine appropriate administrative controls and PPE to mitigate the spread of contamination to the work area and team members.

A sample will be collected from the container using a traditional scoop or trowel to homogenize the soil and collect a representative sample. Sample media will be placed into a bowl and mixed prior to placement in containers. Gravel and large organic debris (e.g., wood) will be removed from the sample. Residual material will be placed back into the drum and the drum sealed following sample collection.

Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. As only one sample is anticipated due to the limited amount of material available, a duplicate and a field blank will be collected with the last sample collected. If insufficient material is available for a duplicate, the deviation will be noted in the project report.

VOC sample containers will be filled and capped first before filling any other sample containers.

Per Section 6.4, sampling equipment (e.g., stainless steel trowels, scoops, bowls, augers) will be decontaminated prior to the first use on-site, between samples, and following the last use on-site. HPTs will survey equipment after decontamination to ensure equipment is free of contamination.

Samples will be placed into laboratory-prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. VOC samples will be stored at less than six (6) degrees Celsius (<6°C) prior to shipment. The samples will be transported in coolers with ice packs, using an overnight delivery service under Chain-of-Custody control, to the off-site laboratory for analysis. The sample containers will be swipe surveyed for removable radioactivity in accordance with the procedure identified in Section 6.5 prior to transport to the off-site laboratory. USACE representatives will review and approve the sample shipment (USACE, 2017). **Table 8-3** identifies container types and preservation methods that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in **Table 8-3**.

Non-soil sampling IDW that does not exhibit detectable radioactivity, such as plastic, PPE, wipes, and disposable items will be placed into standard trash bags and stored pending disposal. Non-soil IDW that does exhibit detectable radioactivity will be segregated and stored in radioactive material bags pending disposal as low level wastes. All PPE will be rendered unusable prior to disposal.

Soil sample collection, preservation, and Chain-of-Custody control will be performed in accordance with Arcadis' Standard Operating Procedure *Soil Drilling and Sampling* and USACE guidance provided in Appendix C of EM 200-1-3.

6.1.4.4 Laboratory Analysis

Samples will be shipped to the off-site laboratory for analysis of parameters found in **Table 8-1**. Laboratory analytical methods for these parameters are identified in **Table 8-3** and discussed in the QAPP.

6.2 Water Samples

Three (3) distinct types of water samples will be collected from this project. These include the following:

- Remedial investigation standing water samples from low lying areas at VP H'
- Remedial investigation groundwater samples from three (3) wells to be developed at VP H'
- IDW wastewaters
 - Well development water from VP H'
 - Decon water from VP H'
 - Legacy sampling and well water from NFSS poly tank(s)

Consistent with Section 6.1, samples in direct support of the remedial investigation will be denoted as such in the individual section headings. Likewise, samples supporting IDW characterization and disposal will be similarly denoted.

6.2.1 Standing Water Remedial Investigation Samples

6.2.1.1 Sampling Objective

Standing water from multiple low lying areas at VP H' will be sampled to assess the magnitude and extent of impacts to the water and the potential for impact to surrounding ditches and groundwater from legacy contamination.

Figure 6-3. VP H' Low Lying Areas of Standing Water Sample Locations (USACE, 2017)

6.2.1.2 Sample Type and Location

AAR/Arcadis will collect up to thirteen (13) water samples from low lying areas identified by USACE. Samples shall be grabs using a peristaltic pump. **Figure 6-3**, provided by USACE (USACE, 2017) denotes the low-lying areas and sample locations. If standing water is present in these locations at the time of the project, a sample will be collected. If all thirteen (13) locations identified in the SOW do not have standing water but other locations with standing water are available, sample locations will be shifted with the concurrence of USACE. Any deviations will be noted in the project report.

6.2.1.3 Sampling Frequency

Up to thirteen (13) samples will be collected at low-lying areas as shown in **Figure 6-3**. Analytes are provided in **Table 8-1**. Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. A duplicate and a field blank will be collected with the last sample collected.

6.2.1.4 Sampling Methods

A peristaltic pump with polyethylene tubing will be used to collect the water samples. The tubing will be placed just below the surface at each location so as to prevent the disturbance and intrusion of organic material. Clean polyethylene tubing will be used for each sample. Flow rates will be regulated to between 200 and 500 milliliters per minute (mL/min).

In order to prepare filtered samples, AAR will: install an in-line, disposable 0.45-micron particle filter on the pump discharge tubing after the appropriate unfiltered groundwater sample has been collected; continue to run the pump until an initial volume of “flush” water has been run through the filter in accordance with the manufacturer’s directions (generally 100 to 300 mL); and, collect the filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample containers.

All sample containers shall be full prior to installing appropriate lids.

HPTs will perform a survey of the work area prior to sampling in order to determine appropriate administrative controls and PPE to mitigate the spread of contamination to the work area and team members.

Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. A duplicate and a field blank will be collected with the last sample collected.

Per Section 6.4, sampling equipment will be decontaminated prior to the first use on-site, between samples, and following the last use on-site. HPTs will survey equipment after decontamination to ensure equipment is free of contamination.

Samples will be placed into prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. Samples will be stored at less than six (6) degrees Celsius (<6°C) prior to shipment. The samples will be transported in coolers with ice packs, using an overnight delivery service under Chain-of-Custody control, to the off-site laboratory for analysis. The sample containers will be swipe surveyed for removable radioactivity in accordance with the procedure identified in Section 6.5 prior to transport to the off-site laboratory. USACE representatives will review and approve the sample shipment (USACE, 2017). **Table 8-3** identifies container types and preservation methods that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in **Table 8-3**.

Sampling IDW that does not exhibit detectable radioactivity, such as plastic, PPE, wipes, and disposable items will be placed into standard trash bags and stored pending disposal. IDW that does exhibit detectable radioactivity will be segregated and stored in radioactive material bags pending disposal as low level wastes. All PPE will be rendered unusable prior to disposal.

Sample collection, preservation, and Chain-of-Custody control will be performed in accordance with USACE guidance provided in Appendix C of EM 200-1-3.

6.2.1.5 Laboratory Analysis

Samples will be shipped to the off-site laboratory for analysis of parameters found in **Table 8-1**. Laboratory analytical methods for these parameters are identified in **Table 8-3** and discussed in the QAPP.

6.2.2 Groundwater Remedial Investigation Samples

6.2.2.1 Sampling Objective

Groundwater from three (3) wells to be developed at VP H' will be sampled to assess the impact to the shallow groundwater aquifer from legacy radioactive contamination.

6.2.2.2 Sample Type and Location

AAR/Arcadis will collect three (3) groundwater samples following development of wells identified by USACE. Samples will be grabs collected directly from the well using low flow methods. Wells are depicted in **Figure 6-4**, provided by USACE (USACE, 2017). Any deviation will be noted in the project report.

6.2.2.3 Sampling Frequency

Three (3) samples will be collected for analytes specified in **Table 8-1**. Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. Due to the limited number of samples, one duplicate and one field blank will be collected at the discretion of the sample team.

6.2.2.4 Sampling Methods

Per USACE, in order for wells to stabilize, samples will not be collected within 72 hours of development. Arcadis procedures specifies at least a 1 week waiting period. A variety of low-flow methods, including peristaltic pumps, bladder pumps, and submersible pumps, maybe used to collect water samples, at the discretion of the sampler based on observed well conditions. Pump flow rates will be maintained in the 200-500 mL/min range.

Prior to purging, wells caps will be removed and a PID used to measure the amount of VOC vapor present in the well headspace. Readings will be recorded.

Wells will be purged prior to sampling and the water quality monitored and recorded. Following purging and recovery, samples will be collected directly from the pump discharge. Samples will not be collected from the discharge of the water quality meter. Samples will be collected in the following order: alkalinity, total dissolved solids (TDS), anions, and radionuclides.

Sampling equipment will be decontaminated between samples. If using polyethylene tubing, tubing will be replaced between samples.

In order to prepare filtered samples, AAR will: install an in-line, disposable 0.45-micron particle filter on the pump discharge tubing after the appropriate unfiltered groundwater sample has been collected; continue to run the pump until an initial volume of "flush" water has been run through the filter in accordance with the manufacturer's directions (generally 100 to 300 mL); and, collect the filtered groundwater sample by diverting flow out of the filter into the appropriately labeled sample containers.

HPTs will perform a survey of the work area prior to sampling in order to determine appropriate administrative controls and PPE to mitigate the spread of contamination to the work area and team members.

Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. Due to the limited number of samples, one duplicate and one field blank will be collected at the discretion of the sample team.

Per Section 6.4, sampling equipment will be decontaminated prior to the first use on-site, between samples, and following the last use on-site. HPTs will survey equipment after decontamination to ensure equipment is free of contamination.

Samples will be placed into prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. Samples will be stored at less than six (6) degrees Celsius (<6°C) prior to shipment. The samples will be transported in coolers with ice packs, using an overnight delivery service under Chain-of-Custody control, to the off-site laboratory for analysis. The sample containers will be swipe surveyed for removable radioactivity in accordance with the procedure identified in Section 6.5 prior to transport to the off-site laboratory. USACE representatives will review and approve the sample shipment (USACE, 2017). **Table 8-3** identifies container types and preservation methods that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in **Table 8-3**.

Sampling IDW that does not exhibit detectable radioactivity, such as plastic, PPE, wipes, and disposable items will be placed into standard trash bags and stored pending disposal. IDW that does exhibit detectable radioactivity will be segregated and stored in radioactive material bags pending disposal as low level wastes. All PPE will be rendered unusable prior to disposal.

Sample collection, preservation, and Chain-of-Custody control will be performed in accordance with Arcadis' procedure *Low Flow Groundwater Purging and Sampling Procedures for Monitoring Wells* and USACE guidance provided in Appendix C of EM 200-1-3.

6.2.2.5 Laboratory Analysis

Samples will be shipped to the off-site laboratory for analysis of parameters found in **Table 8-1**. Laboratory analytical methods for these parameters are identified in **Table 8-3** and discussed in the QAPP.

6.2.3 Investigation Derived Wastewater Samples

6.2.3.1 Sampling Objective

IDW wastewater will be sampled in order to characterize the material for proper shipping and disposal. IDW wastewater include the following:

- Well and sampling purge development waste from VP H'
- Decon water from VP H'
- Legacy sampling and well water from NFSS poly tank(s)

6.2.3.2 Sample Type and Location

AAR will collect samples from each distinct type of IDW wastewater in order to properly characterize the material for disposal. Wastewater samples will be collected from storage containers in order to accurately represent the material. In the event that two (2) phases are discovered, a sample of each phase will be collected.

6.2.3.3 Sampling Frequency

Samples will be collected from each distinct waste stream.

- Well and sampling purge development water – one sample from development water from each well. The USACE has specified that no more than 55 gallons will be generated during development, therefore one (1) drum from each well is assumed.
- Decon water – Decon water will be minimized to the extent possible. It is estimated that no more than four (4) containers will be generated. Each container will be sampled.
- Legacy sampling and well water at NFSS – Water present in the poly tanks will be consolidated and sampled. One sample will be collected.
- Duplicates and field blanks will be collected at ratios of 1:10 (10%) and 1:20 (5%), respectfully. Due to the limited number of samples, one (1) duplicate and one (1) field blank will be collected at the discretion of the sample team from each waste stream.

6.2.3.4 Sampling Methods

Containers will be placed on plastic or equivalent. Spill pads and pigs will be available. Field personnel will open drum bungs and use a PID to assess the presence of VOCs in the drum headspace. Results will be recorded. Field Personnel will then use a drum thief or equivalent to collect sample from the full vertical profile of the drum. Field personnel will withdraw and observe the drum thief to detect if more than one phase is present. If more than 1 phase is present in the drum, an additional sample(s) will be collect to represent each phase. Field personnel will utilize the drum thief to fill prepared sample containers. Samples will be collected in the following order: VOCs, pH, BOD, alkalinity, total dissolved solids (TDS), total suspended solids (TSS), metals, phosphorous, cyanide, and radionuclides.

Water will be placed directly into prepared sample containers.

Residual material will be placed back into the containers. Sampling supplies will be wiped clean and disposed of as IDW solid waste.

Per Section 6.4, sampling equipment will be decontaminated prior to the first use on-site, between samples, and following the last use on-site. HPTs will survey equipment after decontamination to ensure equipment is free of contamination.

Samples will be placed into laboratory-prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. Samples will be stored at less than six (6) degrees Celsius (<6°C) prior to shipment. The samples will be transported in coolers with ice packs, using an overnight delivery service under Chain-of-Custody control, to the off-site laboratory for analysis. The sample containers will be swipe surveyed for removable radioactivity in accordance with the procedure identified in Section 6.5 prior to transport to the off-site laboratory. USACE representatives will review and approve the sample shipment (USACE, 2017). **Table 8-3** identifies container types and preservation methods that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in **Table 8-3**.

Sampling IDW that does not exhibit detectable radioactivity, such as plastic, PPE, wipes, and disposable items will be placed into standard trash bags and stored pending disposal. IDW that does exhibit detectable radioactivity will be segregated and stored in radioactive material bags pending disposal as low level wastes. All PPE will be rendered unusable prior to disposal.

Sample collection, preservation, and Chain-of-Custody control will be performed in accordance with Arcadis' procedure *TGI - Investigation-Derived Waste Handling and Storage* and USACE guidance provided in Appendix C of EM 200-1-3.

6.2.3.5 Laboratory Analysis

Samples will be shipped to the off-site laboratory for analysis of parameters found in **Table 8-1**. Laboratory analytical methods for these parameters are identified in **Table 8-3** and discussed in the QAPP.

6.2.4 Used Hydraulic and Motor Oil at NFSS

6.2.4.1 Sampling Objective

Used hydraulic and motor oil from heavy equipment at NFSS will be sampled and characterized for off-site disposal. Analysis will be sufficient to demonstrate oil is non-impacted by NFSS radionuclides with a goal of free-release to a local recycler. USACE has stated that the oil does **NOT** contain polychlorinated biphenyls (PCBs).

6.2.3.2 Sample Type and Location

AAR will collect samples from each of four (4) 55-gallon drums of oil stored at NFSS in order to characterize for disposal. Oil will be sampled directly in the drums through the lid bung. In the event the oil is stratified in the drum, a representative sample of each drum will be collected using a drum thief or similar device.

6.2.3.3 Sampling Frequency

Four (4) samples will be collected for gross alpha/beta analysis and comparison to an established reference background. If elevated activity is detected, samples will be collected for NFSS specific radioisotopes. Duplicates will be collected at ratios of 1:10 (10%). Due to the limited number of samples, one duplicate will be collected at the discretion of the sample team. In addition, up to three (3) samples of hydraulic/motor oil known to have not been impacted by NFSS operations will be sampled to establish a reference background.

6.2.3.4 Sampling Methods

Containers will be placed on plastic or equivalent. Spill pads and pigs will be available. Field personnel will open drum bungs and allow any accumulated vapor to escape the area. Field personnel will then use a drum thief or equivalent to collect a sample from the full vertical profile of the drum. Field personnel will withdraw and observe the drum thief to detect if more than one phase is present. If more than 1 phase is present in the drum, an additional sample(s) will be collect to represent each phase. Field personnel will utilize the drum thief to fill prepared sample containers. Samples will be collected for radionuclides only.

Oil will be placed directly into prepared sample containers.

Residual material will be placed back into the containers.

Per Section 6.4, sampling equipment will be decontaminated prior to the first use on-site, between samples, and following the last use on-site. HPTs will survey equipment after decontamination to ensure equipment is free of contamination.

Samples will be placed into laboratory-prepared containers immediately following collection and caps and labels promptly affixed to the sample containers. The samples will be transported in coolers using an overnight delivery service under Chain-of-Custody control, to the off-site laboratory for analysis. The

sample containers will be swipe surveyed for removable radioactivity in accordance with the procedure identified in Section 6.5 prior to transport to the off-site laboratory. USACE representatives will review and approve the sample shipment (USACE, 2017). **Table 8-3** identifies container types and preservation methods that will be used for collection of these samples. Minimum sample quantities required for laboratory analysis are also identified in **Table 8-3**.

Sampling waste that does not exhibit detectable radioactivity, such as plastic, PPE, wipes, and disposable items will be placed into standard trash bags and stored pending disposal. Waste that does exhibit detectable radioactivity will be segregated and stored in radioactive material bags pending disposal as low level wastes. All PPE will be rendered unusable prior to disposal.

Sample collection, preservation, and Chain-of-Custody control will be performed in accordance with Arcadis' procedure *TGI - Investigation-Derived Waste Handling and Storage* and USACE guidance provided in Appendix C of EM 200-1-3.

6.2.2.5 Laboratory Analysis

Samples will be shipped to the off-site laboratory for analysis of parameters found in **Table 8-1**. Laboratory analytical methods for these parameters are identified in **Table 8-3** and discussed in the QAPP.

6.4 Equipment Decontamination Procedures

Disposable sampling equipment will be used wherever possible to minimize decontamination requirements. When reusable equipment is used, such equipment will be decontaminated both prior to sampling in the field and between uses. The following decontamination steps will be performed for reusable equipment, in the following order as necessary:

- 1) Potable water rinse
- 2) Wash with laboratory-grade detergent (Alconox®, Liquinox®, or equivalent)
- 3) Deionized or distilled water rinse
- 4) Acetone rinse
- 5) Deionized or distilled water rinse
- 6) Air drying

Steps four (4) and five (5) may be omitted if equipment will not be used to sample VOCs. A field nitric acid rinse and an additional deionized/distilled water rinse will be performed between steps three (3) and four (4) (above) for equipment used to collect samples submitted for metals analysis. Equipment used for radiological sampling will be scanned by the HPT to confirm successful decontamination.

6.5 Field Scanning of Sample Containers for Radioactivity

Sample containers holding sample media obtained from the site will be scanned for radioactivity prior to packaging and shipment to the subcontract laboratory. The containers will be scanned for removable contamination in accordance with the field screening methods discussed in Section 5 and in accordance with site specific RSP and AAR procedure RSP-119, *Shipping and Transportation of Radioactive Materials*. Field scanning results will be recorded on Chain-of-Custody forms submitted to the laboratory along with the samples, as well as documented on field data sheets.

7.0 FIELD QUALITY CONTROL

Field QC will be maintained through the implementation of the project QCP, QAPP, and other work plans. AAR and Arcadis both maintain procedures relevant to the activities being conducted during this project. Personnel will be briefed on procedures that are applicable to these activities and will be implemented during this project. Controlled copies of pertinent plans and procedures will be available in the on-site office trailer for the duration of the project. AAR's CQCSM will be responsible for the execution of the project QC program, under the direction of the AAR General Manager.

AAR will maintain direct and daily contact/coordination with the USACE concerning field operations and scheduling field activities. The primary POCs for project communications will be Mr. Jeffery Rowley (PM) for USACE, and Mr. Greg Lord (PM) and Mr. Scott Ely (Site Superintendent/CQCSM) for AAR. The AAR PM, or designee, will participate in a weekly project meeting throughout the period of performance of the work.

7.1 Quality Control Reports (QCR)

AAR will submit a QCR to the USACE PM monthly during field work. The field QCR 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 QCR will include results of radiological field screening, identify samples collected, and present laboratory analysis results of off-site laboratory analyses. Copies of off-site laboratory analytical reports will be attached to QCRs. The QCR will be signed and dated by AAR's on-site CQCSM and will be submitted to the USACE PM or designee by the 5th of each month.

7.2 Corrective Actions

Non-conformance with established procedures presented in the project plans will be identified and corrected. AAR's PM will issue a non-conformance report for each non-conforming condition. Corrective actions will also 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; and
- Physical or documentation discrepancies with samples upon receipt at the laboratory.

AAR's PM will be notified in the event discrepancies are discovered by field personnel, during a desk or field audit, or during data evaluation. AAR's PM will 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. If necessary, re-surveying or re-sampling/analysis will be performed to correct the discrepancy. AAR's PM will notify the USACE PM of the identified problem, corrective action(s), and the impact on the overall project.

7.3 Field Documentation

7.3.1 Log Books and Field Data Sheets

Information pertinent to field activities will be recorded on field logbooks. The logbooks will be bound and the pages will be consecutively numbered. Sufficient information will be recorded in the logbooks to permit reconstruction of remedial investigation activities. Information recorded on official project documents (e.g., survey forms, Chains-of-Custody, etc.) will not be repeated in the log books except in summary form or cross reference notation where determined necessary. Field log books will be kept in

the possession of the appropriate field personnel, or in a secure place when not being utilized during field work. Logbooks will become part of the final project file upon completion of the field activities. Entries recorded in log books will be made in blue or black, indelible ink and may include, but not be limited to, the following information:

- Author, date, and times of arrival at and departure from the work location;
- Description of the field activity and summary of daily tasks;
- Names and responsibilities of field crew members;
- Sample collection method and number/volume of sample(s) collected;
- Information regarding activity changes and scheduling modifications;
- Field observations and weather conditions;
- Types of field instruments used and purpose of use, including calibration methods and results;
- Field measurements made;
- Scanning/surveying of equipment and materials;
- Number of and identification of waste containment bags; and
- Quantity of samples and waste scheduled for shipment.

Field data sheets and Radiological Survey forms may be used to record field information in addition to the use of log books. All field data sheets and forms will be maintained by the Corporate / Site RSO and CQCSM in the project office trailer.

7.3.2 *Photographs*

Photographs taken during the project will be noted in the field logbook. Photographs taken to document field conditions at a given point in time will include two or more permanent reference points within the photograph to facilitate relocating the point at a later date. A series of initial condition site photographs prior to full mobilization and startup of activities will be taken as required by USACE.

NOTE: Photography at NFSS is prohibited without authorization from USACE personnel.

7.3.3 *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 thumb drive or CD) and before processing or editing. This is an archive of the raw data and, once created, will not be altered. Electronic GPS data will be provided daily to off-site data processing specialists, as needed. All electronic files will be named according to a convention in which the file type/information included and generation date or revision date are included as part of the name. For example, a file of GWS survey data for Class 1 Survey Unit 4 might be called C1S4080118.xls. Daily quality control files will be called: DQC1080118.xls for example. If multiple instruments are used, the file designation will include an IA or IB to denote different instrument (C1S4080118IA.xls). An electronic log of files generated at the property will be created and maintained daily. The log file (a Microsoft Excel spreadsheet) will include the filename, author, subject, generation/revision date, and the date on which the file was transferred off-site and to whom.

7.4 *Sample Documentation*

7.4.1 *Sample Numbering System*

A unique sample numbering scheme will be used to identify each sample collected for off-site laboratory analysis. The purpose of this numbering scheme is to provide a tracking system for the retrieval of analytical and field data on each sample. Sample identification numbers will be recorded on sample labels or tags, field data sheets and/or logbooks, Chain-of-Custody records, and all other applicable documentation used during the project. Sample identification (ID) for this project will include a Project

Code, Sample Matrix Code, Location Code, Date Code (if needed to discern recurring samples), and Quality Control code (if applicable), in that sequence.

A summary of the components of the sample-numbering scheme to be used for the project is presented in **Table 7-1**. Examples of the Sample ID format and procedure are provided below. Sample IDs developed in the field will be recorded in the appropriate field logbook as described in Section 7.3.1.

HP-DW-H-04 Sample of IDW decon water at VP H', fourth container.

HP-Oil-NF-01-Dup Soil sample collected at NFSS, drum 1, duplicate

HP-SO-H-C1S301-A Soil sample collected from VP H' location C1S3-01, surface (A).

HP-SO-H-C1S301-B-DUP Soil sample collected from VP H' location C1S3-01, 6-18" sample, duplicate.

Table 7-1. Sample Identification Numbering Scheme		
Sample ID Component	Code	Description
Project Code	HP	Vicinity Property H' (and NFSS IDW)
Sample Matrix Code	SO	Soil or Sediment Sample
	GW	Groundwater Sample
	SW	Standing Water Sample
	WW	IDW Wastewater
	DW	IDW Decon Water
	ISO	IDW Soil
	OIL	Waste Oil
	OT	Other - Description to be recorded in logbook
	-FIL	Added to Matrix Code (e.g., GW-FIL) to denote filtered water samples.
Location Code	H or NF	H – VP H' NF - NFSS
	TEXT	Free form description used to describe equipment, location, area of smear/swipe sample, or a generic description of location not otherwise categorized
	CXSY-ZZ	For Soil Samples from Survey Units X - Survey Unit Class (1 or 2) Y - Class 1 Survey Unit Number (1-4) – Omitted for C2 area ZZ – Sample Location (1-17)
	A-B-C	Soil Sample Depth (A – 0-6", B - 6-18", C- Other)
Date Code	MMDDYY	Date of collection (if needed to discern recurring samples collected on different dates)
Quality Control Codes	DUP	Duplicate
	FB	Field Blank
	TB	Trip Blank

7.4.2 Sample Labels

Labels will be affixed to all sample containers during sampling activities. Information will be recorded on each sample container label at the time of sample collection. The information to be recorded on the labels will be as follows:

- Sample identification number;
- Sample type (discrete or composite);
- Site name and excavation area/location number;
- Analysis to be performed;
- Type of chemical preservative present in container;
- Date and time of sample collection; and
- Sample collector's name and initials.

7.4.3 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 a cooler receipt checklist utilized by the contract laboratory.

7.4.4 Chain-of-Custody Records

Chain-of-Custody procedures implemented for the project will provide documentation of the handling of each sample from the time of collection until completion of laboratory analysis. The chain-of-custody form serves as a legal record of possession of the sample. A sample is considered to be 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.

Custody will be documented throughout the project field sampling activities by a chain-of-custody form initiated each day during which samples are collected. The Chain-of-Custody will accompany the samples to the laboratory and will be returned to the laboratory coordinator with the final analytical report. Personnel with sample custody responsibilities will be required to sign, date, and note the time on a Chain-of-Custody form when relinquishing samples from their immediate custody (except in the case where samples are placed into designated secure areas for temporary storage prior to shipment). Bills of Lading or air bills will be used as custody documentation during times when the samples are being shipped to the laboratory, and will be retained as part of the permanent sample custody documentation.

Chain-of-Custody forms will be used to document the integrity of all samples collected. To maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory, Chain-of-Custody forms will be filled out for sample sets as determined appropriate during the course of fieldwork.

The individual responsible for shipping of the samples from the field to the laboratory will be responsible for completing the Chain-of-Custody form and noting the date and time of shipment. This individual will also inspect the form for completeness and accuracy. After the form has been inspected and determined to be satisfactorily completed, the responsible individual will sign, date, and note the time of transfer on the form. The Chain-of-Custody form will 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. The field copy of the form will be appropriately filed and kept on-site for the duration of the project activities. A copy of the Chain-of-Custody will be included in the QCR for that month's activity (see Section 7.1).

Chain-of-Custody seals will also be placed on each cooler used for sample transport. These seals will consist of a tamper-proof adhesive material placed across the lid and body of the coolers. The Chain-of-

Custody seals will be used to ensure that no sample tampering occurs between the time the samples are placed into the coolers and the time the coolers are opened for analysis at the laboratory. Cooler custody seals will be signed and dated by the individual responsible for completing the Chain-of-Custody form contained within the cooler.

7.4.5 Receipt of Sample Forms

The subcontract laboratory will document the receipt of environmental samples by accepting custody of the samples from the approved shipping company. In addition, the subcontract laboratory will document the condition of the environmental samples upon receipt.

7.4.6 Documentation Procedures

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

- Collect and place samples into laboratory sample containers;
- Complete sample container label information;
- Complete sample documentation information in the field logbook;
- Complete project and sampling information sections of the Chain-of-Custody form(s);
- Complete the air bill for the cooler to be shipped to off-site laboratory;
- Perform a completeness and accuracy check of the Chain-of-Custody form(s);
- Complete sample relinquishment section of form(s) and place the form(s) into cooler;
- Pack cooler with ice, as needed, for samples requiring preservation to 4° Celsius (C)
- Place Chain-of-Custody seals on the exterior of the cooler; and
- Package and ship the cooler to the laboratory.

The following steps will be made upon receipt of the cooler at the subcontract laboratory:

- Inspection of contents;
- Notify AAR's CQCSM or PM of discrepancies;
- Complete requested analyses; and
- Transmit original Chain-of-Custody form(s) with final analytical results from laboratory.

7.4.7 Corrections to Documentation

Original information and data in field logbooks, on sample labels, on Chain-of-Custody forms, and on any other project-related documentation will be recorded in blue or 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.

7.5 Sample Packaging and Shipping

Sample containers destined for off-site laboratory analysis will be stored on-site at <6°C prior to packaging in thermally insulated rigid-body coolers with ice packs for shipment. Custody of the samples will be maintained throughout the shipment process. While in AAR's position, samples will be secured. These samples will be packaged, classified, labeled, stored, shipped, and tracked in accordance with

current DOT regulations (e.g., 49 CFR 173 et. seq.) and AAR Procedure RSP-119, *Shipping and Transportation of Radioactive Materials*.

7.6 Management and Retention of Records

Original copies of field data, field records, analytical data, training records, and other project-specific documentation will be retained in the AAR project office in accordance with the project specific QCP and relinquished to the USACE as requested.

7.7 Sampling Wastes

Waste generated as a result of the field sampling activities will be managed as IDW and sampled according to this plan.

8.0 LABORATORY ANALYSIS

ARS Analytical Laboratories, LLC (AAA) in Port Allen, LA will perform radiological and chemical analysis of samples collected under the FSP. The off-site radiochemistry laboratory has prior FUSRAP and USACE experience capable of providing the analytical services required to meet the project objectives and is DOD-accredited.

Table 8-1 summarizes soil sampling and analysis requirements for the project. **Table 8-2** includes a complete list of VOCs to be quantified during analysis. **Table 8-3** summarizes sample collection, preservative, and holding time requirements for each applicable media on this project.

Per the DOE/DOD Quality Systems Manual (QSM) for Environmental Laboratories, version 5.1, Section 1.7.2.3, matrix spikes are not required for radiochemical analysis if an isotopic tracer or chemical carrier is used to determine chemical recovery or yield during the separation and mounting process. Matrix spikes are also not required for gross alpha/beta, and gamma analysis. In consultation with the off-site laboratory, tracers and carriers will be utilized for all analytes except those analyzed by gamma spectroscopy and gross alpha/beta. As such, samples for matrix spikes and matrix spike duplicates will not be collected per the QSM.

Field duplicates have been designated for all sample types and will be collected at 1:10 or 10%. Field blanks and trip blanks will be collected for VOC and metals samples at 1:20 or 5%.

Samples will be transported to the off-site laboratory for analyses in accordance with documented laboratory-specific standard methods. Specific sample and laboratory requirements are provided in the project QAPP.

Table 8-1. Sampling and Analytical Requirements					
Type	Max Field Samples	Field Duplicates	MS/MSD	Field Blanks	Analytes
Soil Samples	261	10%	NA	NA	Radium-226
					Radium-228
					Isotopic Uranium - 234, 235, 238
					Isotopic Thorium - 228, 230, 232
					Cesium-137
					Strontium-90
					Isotopic Plutonium -238, 239/240
Standing Water	13	10%	NA	NA	Isotopic U - Filtered (dissolved)
					Isotopic U - Non-Filtered (total)
					Radium 226 - Filtered (dissolved)
					Radium 226 - Non-Filtered (total)
					Radium 228 - Filtered (dissolved)
					Radium 228 - Non-Filtered (total)
					Isotopic Th - Filtered (dissolved)
					Isotopic Th - Non-Filtered (total)
					Cesium-137 – Filtered (dissolved)
					Cesium-137 – Non-Filtered (total)
					Strontium-90 – Filtered (dissolved)
					Strontium-90 – Non-Filtered (total)

Table 8-1. Sampling and Analytical Requirements

Type	Max Field Samples	Field Duplicates	MS/MSD	Field Blanks	Analytes
					Isotopic Plutonium -238, 239/240– Filtered (dissolved)
					Isotopic Plutonium -238, 239/240– Non-Filtered (total)
					Anions (Bromide, Chloride, Fluoride, Nitrate-N, Nitrate/Nitrite-combined, Nitrite, O-Phosphate, Sulfate)
					Total Dissolved Solids
					Alkalinity
Ground Water	3	10%	NA	NA	Isotopic U - Filtered (dissolved)
					Isotopic U - Non-Filtered (total)
					Radium 226 - Filtered (dissolved)
					Radium 226 - Non-Filtered (total)
					Radium 228 - Filtered (dissolved)
					Radium 228 - Non-Filtered (total)
					Isotopic Th - Filtered (dissolved)
					Isotopic Th - Non-Filtered (total)
					Cesium-137 – Filtered (dissolved)
					Cesium-137 – Non-Filtered (total)
					Strontium-90 – Filtered (dissolved)
					Strontium-90 – Non-Filtered (total)
					Isotopic Plutonium -238, 239/240– Filtered (dissolved)
					Isotopic Plutonium -238, 239/240– Non-Filtered (total)
					Anions (Bromide, Chloride, Fluoride, Nitrate-N, Nitrate/Nitrite-combined, Nitrite, O-Phosphate, Sulfate)
					Total Dissolved Solids
					Alkalinity
Soil IDW - New Gen	5	10%	NA	5%	VOCs
					Metals (Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, Zinc)
Soil IDW	10	10%	NA	5%	Cesium-137

Table 8-1. Sampling and Analytical Requirements

Type	Max Field Samples	Field Duplicates	MS/MSD	Field Blanks	Analytes
- NFSS legacy					Strontium-90
					Isotopic Plutonium -238, 239/240
					Radium-226
					Radium-228
					Isotopic Uranium - 234, 235, 238
					Isotopic Thorium - 228, 230, 232
					Metals (Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, Zinc)
					VOCs
Oil IDW - NFSS Legacy	7 (4 drums plus up to 3 non-impacted samples)	10%	NA	NA	Gross Alpha/Beta
					Cesium-137*
					Strontium-90*
					Isotopic Plutonium -238, 239/240*
					Radium-226*
					Radium-228*
					Isotopic Uranium - 234, 235, 238*
					Isotopic Thorium - 228, 230, 232*
					*denoted isotopes will be analyzed if gross alpha/beta indicates elevated radioactivity.
Water IDW - New Gen (Decon)	4	10%	NA	5%	Cesium-137 – Non-Filtered (total)
					Strontium-90 – Non-Filtered (total)
					Isotopic Plutonium -238, 239/240– Non-Filtered (total)
					Radium 226 - Non-Filtered (total)
					Radium 228 - Non-Filtered (total)
					Isotopic U - Non-Filtered (total)
					Isotopic Th - Non-Filtered (total)
					VOCs
					Metals (Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, Zinc)
					Phosphorous
					Cyanide
					pH
					Oil and Grease

Table 8-1.Sampling and Analytical Requirements

Type	Max Field Samples	Field Duplicates	MS/MSD	Field Blanks	Analytes
Water IDW - New Gen (Well Dev and Purge Water)	3	10%	NA	5%	Total Dissolved Solids
					Total Suspended Solids
					Biological Oxygen Demand
					Metals (Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, Zinc)
					VOCs
					Phosphorous
					Cyanide
					pH
					Oil and Grease
					Total Dissolved Solids
					Total Suspended Solids
					Biological Oxygen Demand
Water IDW - NFSS Legacy	1	10%	NA	5%	Cesium-137 – Non-Filtered (total)
					Strontium-90 – Non-Filtered (total)
					Isotopic Plutonium -238, 239/240– Non-Filtered (total)
					Radium 226 - Non-Filtered (total)
					Radium 228 - Non-Filtered (total)
					Isotopic U - Non-Filtered (total)
					Isotopic Th - Non-Filtered (total)
					VOCs
					Metals (Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Molybdenum, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, Zinc)
					Phosphorous
					Cyanide
					pH
					Oil and Grease
					Total Dissolved Solids
					Total Suspended Solids
					Biological Oxygen Demand
Sediment IDW - NFSS Legacy	1	10%	NA	5%	Cesium-137
					Strontium-90
					Isotopic Plutonium -238, 239/240

Table 8-1.Sampling and Analytical Requirements					
Type	Max Field Samples	Field Duplicates	MS/MSD	Field Blanks	Analytes
					Radium-226
					Radium-228
					Isotopic Uranium - 234, 235, 238
					Isotopic Thorium - 228, 230, 232
					Metals (Aluminum, Antimony, Arsenic, Barium, Beryllium, Boron, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Lithium, Magnesium, Manganese, Mercury, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, Zinc)
					VOCs

Table 8-2. Specific List of Volatile Organic Compounds to be Analyzed for IDW Samples	
Chemical Name:	CAS #:
Acetone	67-64-1
Benzene	71-43-2
Bromodichloromethane	75-27-4
Bromochloromethane	74-97-5
Bromoform	75-25-2
Bromomethane	74-83-9
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chlorodibromomethane	124-48-1
Chloroethane	75-00-3
Chloroform	67-66-3
Chloromethane	74-87-3
1,2-Dibromo-3-chloropropane	96-12-8
1,2-Dibromoethane (Ethylene Dibromide)	106-93-4
1,2-Dichlorobenzene	95-50-1
1,3-Dichlorobenzene	541-73-1

Table 8-2. Specific List of Volatile Organic Compounds to be Analyzed for IDW Samples	
Chemical Name:	CAS #:
1,4-Dichlorobenzene	106-46-7
Dichlorodifluoromethane	75-71-8
1,1-Dichloroethane	75-34-3
1,2-Dichloroethane	107-06-2
1,1-Dichloroethene	75-35-4
cis-1,2-Dichloroethene	156-59-2
trans-1,2-Dichloroethene	156-60-5
1,2-Dichloropropane	78-87-5
cis-1,3-Dichloropropene	10061-01-5
trans-1,3-Dichloropropene	10061-02-6
Ethylbenzene	100-41-4
2-Hexanone	591-78-6
Isopropylbenzene	98-82-8
2-Butanone (MEK)	78-93-3
Methylene chloride	75-09-2
4-Methyl-2-pentanone	108-10-1
Methyl tert-butyl ether	1634-04-4
Styrene	100-42-5
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethene	127-18-4
Toluene	108-88-3
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
1,2,3-Trichlorobenzene	87-67-6
1,2,4-Trichlorobenzene	120-82-1
1,1,1-Trichloroethane	71-55-6
1,1,2-Trichloroethane	79-00-5
Trichloroethene	79-01-6
Trichlorofluoromethane	75-69-4

Table 8-2. Specific List of Volatile Organic Compounds to be Analyzed for IDW Samples	
Chemical Name:	CAS #:
1,2,4-Trimethylbenzene	95-63-6
Vinyl chloride	75-01-4
Xylenes (total)	1330-20-7

Table 8-3. Sample Preservation, Container, and Holding Time Requirements

Analytical Group	Matrix	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type) ¹	Preservation Requirements (chemical, temperature, light protected) ²	Maximum Holding Time (preparation/analysis) ³	Data Package Turnaround
RI Soil						
Cs-137	Soil/Sediment	EPA 901.1	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Sr-90	Soil/Sediment	EPA 905.0	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Isotopic Pu (Pu-238, Pu239/240)	Soil/Sediment	HASL 300m Alpha Spectrometry	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Ra-226	Soil	EPA 901.1	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days

Table 8-3. Sample Preservation, Container, and Holding Time Requirements

Analytical Group	Matrix	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type) ¹	Preservation Requirements (chemical, temperature, light protected) ²	Maximum Holding Time (preparation/analysis) ³	Data Package Turnaround
Ra-228	Soil	EPA 901.1	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Isotopic Uranium (U-234, U-235, U-238)	Soil	HASL 300m Alpha Spectrometry	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 days	35 calendar days
Isotopic Thorium (Th-228, Th-230, Th-232)	Soil	HASL 300m Alpha Spectrometry	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Soil/Sediment IDW						
VOCs	Soil/Sediment	SW846 8260C	2x125mL amber glass jar with Teflon®-lined lid	Cool to <6°C	14 Days	21 calendar days
Metals	Soil/Sediment	SW846 6010C/6020/7471A	1x125 poly jar	Cool to <6°C	Metals: 180 days Mercury: 28 days	21 calendar days

Table 8-3. Sample Preservation, Container, and Holding Time Requirements

Analytical Group	Matrix	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type) ¹	Preservation Requirements (chemical, temperature, light protected) ²	Maximum Holding Time (preparation/analysis) ³	Data Package Turnaround
Cs-137	Soil/Sediment	EPA 901.1	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Sr-90	Soil/Sediment	EPA 905.0	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Isotopic Pu (Pu-238, Pu239/240)	Soil/Sediment	HASL 300m Alpha Spectrometry	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Ra-226	Soil/Sediment	EPA 901.1	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days

Table 8-3. Sample Preservation, Container, and Holding Time Requirements

Analytical Group	Matrix	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type) ¹	Preservation Requirements (chemical, temperature, light protected) ²	Maximum Holding Time (preparation/analysis) ³	Data Package Turnaround
Ra-228	Soil/Sediment	EPA 901.1	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
Isotopic Uranium (U-234, U-235, U-238)	Soil/Sediment	HASL 300m Alpha Spectrometry	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 days	35 calendar days
Isotopic Thorium (Th-228, Th-230, Th-232)	Soil/Sediment	HASL 300m Alpha Spectrometry	1x500 milliliter (mL) widemouth poly bottle (only one required bottle for all RAD analytes) (1 gallon poly bag may also be used, minimum volume 500 mL)	None	180 Days	35 calendar days
RI Standing Water and Groundwater						
Ra-226	Standing Water/ Groundwater	EPA 903.1	1x1 L widemouth poly bottle (for each fraction)	Total: Nitric acid (HNO ₃) to pH ≤2 Filtered: None	180 Days	35 calendar days
Ra-228	Standing Water/ Groundwater	EPA 904.0	1x1 L widemouth poly bottle (for each fraction)	Total: HNO ₃ to pH ≤2 Filtered: None	180 Days	35 calendar days

Table 8-3. Sample Preservation, Container, and Holding Time Requirements

Analytical Group	Matrix	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type) ¹	Preservation Requirements (chemical, temperature, light protected) ²	Maximum Holding Time (preparation/analysis) ³	Data Package Turnaround
Isotopic Uranium	Standing Water/ Groundwater	HASL 300m Alpha Spectrometry	1x1 L widemouth poly bottle (for each fraction)	Total: HNO ₃ to pH ≤ 2 Filtered: None	180 days	35 calendar days
Isotopic Thorium	Standing Water/ Groundwater	HASL 300m Alpha Spectrometry	1x1 L widemouth poly bottle (for each fraction)	Total: HNO ₃ to pH ≤ 2 Filtered: None	180 Days	35 calendar days
Cs-137	Standing Water/ Groundwater	EPA 901.1	1x1 L widemouth poly bottle (for each fraction)	Total: HNO ₃ to pH ≤ 2 Filtered: None	180 Days	35 calendar days
Sr-90	Standing Water/ Groundwater	EPA 905.0	1x1 L widemouth poly bottle (for each fraction)	Total: HNO ₃ to pH ≤ 2 Filtered: None	180 Days	35 calendar days
Isotopic Pu (Pu-238, Pu239/240)	Standing Water/ Groundwater	HASL 300m Alpha Spectrometry	1x1 L widemouth poly bottle (for each fraction)	Total: HNO ₃ to pH ≤ 2 Filtered: None	180 Days	35 calendar days
Anions	Standing Water/ Groundwater	EPA 300.0 or SW846 9056	1x1 L poly bottle (only one bottle required for Anions, TDS, and Alkalinity)	Cool to <6°C	Bromide, chloride, fluoride, and sulfate: 28 days Nitrate-N, nitrite-N, and orthophosphate: 48 hours (Overnight ship on Tuesday or Wednesday)	21 calendar days
TDS	Standing Water/ Groundwater	SM2540C or EPA 160.1	1x1 L poly bottle (only one bottle required for Anions, TDS, and Alkalinity)	Cool to <6°C	7 days	21 calendar days

Table 8-3. Sample Preservation, Container, and Holding Time Requirements

Analytical Group	Matrix	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type) ¹	Preservation Requirements (chemical, temperature, light protected) ²	Maximum Holding Time (preparation/analysis) ³	Data Package Turnaround
Alkalinity	Standing Water/ Groundwater	SM2320B or EPA 310.1	1x1 L poly bottle (only one bottle required for Anions, TDS, and Alkalinity)	Cool to <6°C	14 days	21 calendar days
Used Oil						
Gross Alpha/Beta	Oil	EPA 900.0	2x40mL glass vials (only two vials required for all RAD analytes)	None	180 Days	35 calendar days
Cs-137	Oil	EPA 901.1	2x40mL glass vials (only two vials required for all RAD analytes)	None	180 Days	35 calendar days
Sr-90	Oil	EPA 905.0	2x40mL glass vials (only two vials required for all RAD analytes)	None	180 Days	35 calendar days
Isotopic Pu (Pu-238, Pu239/240)	Oil	HASL 300m, Alpha Spectroscopy	2x40mL glass vials (only two vials required for all RAD analytes)	None	180 Days	35 calendar days
Ra-226	Oil	EPA 901.1	2x40mL glass vials (only two vials required for all RAD analytes)	None	180 Days	35 calendar days
Ra-228	Oil	EPA 901.1	2x40mL glass vials (only two vials required for all RAD analytes)	None	180 Days	35 calendar days

Table 8-3. Sample Preservation, Container, and Holding Time Requirements

Analytical Group	Matrix	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type) ¹	Preservation Requirements (chemical, temperature, light protected) ²	Maximum Holding Time (preparation/analysis) ³	Data Package Turnaround
Isotopic Uranium (U-234, U-235, U-238)	Oil	HASL 300m Alpha Spectrometry	2x40mL glass vials (only two vials required for all RAD analytes)	None	180 days	35 calendar days
Isotopic Thorium (Th-228, Th-230, Th-232)	Oil	HASL 300m Alpha Spectrometry	2x40mL glass vials (only two vials required for all RAD analytes)	None	180 Days	35 calendar days
Water IDW						
Cs-137	Water	EPA 901.1	1x1 L widemouth poly bottle	HNO ₃ to pH ≤2	180 Days	35 calendar days
Sr-90	Water	EPA 905.0	1x1 L widemouth poly bottle	HNO ₃ to pH ≤2	180 Days	35 calendar days
Pu-239	Water	HASL 300m Alpha Spectroscopy	1x1 L widemouth poly bottle	HNO ₃ to pH ≤2	180 days	35 calendar days
Ra-226	Water	EPA 903.1	1x1 L widemouth poly bottle	HNO ₃ to pH ≤2	180 Days	35 calendar days
Ra-228	Water	EPA 904.0	1x1 L widemouth poly bottle	HNO ₃ to pH ≤2	180 Days	35 calendar days
Isotopic Uranium	Water	HASL 300m Alpha Spectrometry	1x1 L widemouth poly bottle	HNO ₃ to pH ≤2	180 days	35 calendar days
Isotopic Thorium	Water	HASL 300m Alpha Spectrometry	1x1 L widemouth poly bottle	HNO ₃ to pH ≤2	180 Days	35 calendar days
VOCs	Water	SW846 8260C	3x40 milliliter glass VOC vial	HCl to pH ≤2; Cool to <6°C	14 days	21 calendar days

Table 8-3. Sample Preservation, Container, and Holding Time Requirements

Analytical Group	Matrix	Analytical and Preparation Method/SOP Reference	Containers (number, size, and type) ¹	Preservation Requirements (chemical, temperature, light protected) ²	Maximum Holding Time (preparation/analysis) ³	Data Package Turnaround
Metals	Water	SW846 6010C/6020/7470A	1x1 L widemouth poly bottle	HNO ₃ to pH ≤2; Cool to <6°C	Metals: 180 days Mercury: 28 days	21 calendar days
Oil and Grease	Water	EPA 1664A	2x1 L amber glass bottles	HCl to pH <2°C; Cool to <6°C	28 days	21 calendar days
Cyanide	Water	SW846 9010/9012/9014/SM4500CN	1x250 mL poly	NaOH to pH>12; Cool to <6°C	14 days	21 calendar days
Phosphorous (Total)	Water	EPA 365.1/SM4500-P	1x1 L poly bottle (only one bottle required for phosphorous, pH, TDS, and TSS)	Cool to <6°C	28 days	21 calendar days
pH	Water	SW846 9040B	1x1 L poly bottle (only one bottle required for pH, TDS, and TSS)	Cool to <6°C	As soon as possible	21 calendar days
TDS	Water	SM2540C or EPA 160.1	1x1 L poly bottle (only one bottle required for pH, TDS, and TSS)	Cool to <6°C	7 days	21 calendar days
TSS	Water	SM2540D or EPA 160.2	1x1 L poly bottle (only one bottle required for pH, TDS, and TSS)	Cool to <6°C	7 days	21 calendar days
BOD	Water	SM5210D	1x1 gallon poly container	Cool to <6°C	48 hours (Overnight ship on Tuesday or Wednesday)	21 calendar days
Notes: 1 The laboratory should be consulted prior to sample collection, as it may be possible to combine sample volume for multiple analyses in one sample container. 2 Samples will be filtered in the field where possible and should be collected in preserved sample containers. 3 It is imperative that all samples are submitted to the laboratory with ample time for the analysis to be completed within the holding time.						

9.0 REPORTING

AAR will prepare a Project Completion Report following demobilization. The report will include a narrative description of key project activities, tabular summary of field results and data, laboratory analytical data, a summary of waste types and disposal quantities, and relevant project records (including records from subcontractors), including, but not limited to:

- Baseline surveys of equipment and areas that will be used for the temporary waste storage area;
- Off-site laboratory analysis data for disposal characterization and monitoring for IDW samples;
- Off-site laboratory analysis data for characterization of soil samples from VP H';
- Off-site laboratory analysis data for characterization of standing water samples from VP H';
- Off-site laboratory analysis data for characterization of groundwater samples from VP H';
- Field VOC screening of soil cores;
- Gamma walkover data from VP H' including property maps depicting measurement locations and locations of elevated readings;
- Radiological surveys of equipment and waste supporting free release;
- Periodic radiological surveys work and support areas to verify that radiological contamination is not being spread to uncontaminated areas of the property;
- Off-site shipping documents used for wastewater disposal; and
- Copies of QCRs.

The report will be submitted in three-ring binders, and labeled and indexed in accordance with the SOW (USACE, 2017). Draft and final versions of the document will be prepared, with comments on the draft addressed in the final iteration. Original files to be submitted will include working copies of any documents/data in the appropriate MS format (i.e., Microsoft® Word, Excel, etc.) as provided in the SOW (USACE, 2017). Laboratory data will be provided as electronic data deliverables in the format(s) specified by USACE in the SOW. Project documents/records and plans will also be submitted on CD-ROM in electronic formats in accordance with the SOP.

10.0 REFERENCES

- AAR, 2017, *Radiation Safety Plan for the Remedial Investigation of Vicinity Property H-Prime and Disposal of Investigation Derived Wastes at the Niagara Falls Storage Site*, August 2018.
- AAR, 2017, *Quality Assurance Project Plan for the Remedial Investigation of Vicinity Property H-Prime and Disposal of Investigation Derived Wastes at the Niagara Falls Storage Site*, August 2018.
- AAR, 2017, *Quality Control Plan for the Remedial Investigation of Vicinity Property H-Prime and Disposal of Investigation Derived Wastes at the Niagara Falls Storage Site*, August 2018.
- AAR, 2017, *Site Safety and Health Plan for the Remedial Investigation of Vicinity Property H-Prime and Disposal of Investigation Derived Wastes at the Niagara Falls Storage Site*, August 2018.
- DOT, US Department of Transportation, *Class 7 (Radioactive) Materials*, Title 49 Code of Federal Regulations, Chapter I, Part 171.
- EPA, 1991, *Management of Investigation-Derived Wastes During Site Inspections*, May 1991.
- NRC, 1997, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, NUREG-1507, December 1997.
- USACE, 1995, *Policies, Guidance, and Requirements for Geospatial Data and Systems*, September 1995.
- USACE, 2001, *Requirements of Sampling and Analysis Plans*, EM-200-1-3, February 2001.
- USACE, 2016, *Preliminary Assessment Report – Niagara Falls Storage Site – Vicinity Property H Prime, Niagara County, New York*, December 2016.
- USACE, 2017, *Scope of Work – Remedial Investigation of Vicinity Property H Prime – Niagara Falls Storage Site*, December 2017.
- USDOD, 2017, *Department of Defense – Department of Energy (DOE) Consolidated Quality Systems Manual for Environmental Laboratories*, Version 5.1, January 2017.
- USEPA, 1996, *Soil Screening Guidance*, EPA Office of Solid Waste and Emergency Response, EPA540/R-96/018, July, 1996.
- USEPA, 2000, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, EPA 402/R-97/016, Rev. 1, August 2000.
- USNRC, 2000, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*; NUREG-1575, Rev. 1; August 2000.
- Radiological Health Handbook, U.S. Department of HEW, 1970 Edition.

Appendix A

Calculation of Scanning Minimum Detectable Concentrations

The computer code Microshield was used to model the presence of normalized sources of the residual radioactivity and Potassium-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.

Table A-1 presents estimated MDC values for typical backgrounds 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.

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

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

Where:

- E_γ = energy of the gamma photon of concern, keV
 (μ_{en}/ρ) = the mass energy absorption coefficient for air, cm^2/g

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

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

Where:

- $(\mu/\rho)_{NaI}$ = 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

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:

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

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 Handbook, Revised Edition January 1970, pages 139 and 140.

FRER	=	0.0514
Energy $_\gamma$, keV	=	662
$(\mu_{en}/\rho)_{air}$, cm^2/g	=	0.0294
$(\mu/\rho)_{NaI}$, cm^2/g	=	0.0780
P	=	0.89

therefore:

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

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:

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

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

- There is a six (6) 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 (1) second at nine (9) inches above the ground surface (six (6) inches of compacted brush/cattails and a three (3) inch air gap);
- The average number of background counts in a one (1) 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:

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

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.

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. **Table A-1** below provide a summary of scan MDCs calculated for a background of 10,000 cpm which falls within the range of reference backgrounds provided.

Table A-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	10000	760	1.380	18	1069	1512	1.99	1.41	2.8
U-natural ^b	10000	3990	1.380	18	1069	1512	0.38	211	80
Th-232 ^a	10000	830	1.380	18	1069	1512	1.82	0.99	1.8

Notes:

B = background count rate (cpm)

MDCR_s = surveyor MDCR

cpm = counts per minute

MDC = minimum detectable concentration

i = scan time interval

CF = conversion factor (Microshield/NUREG-1507)

p = surveyor efficiency (ranges from 0.5 to 0.75)

ncpm = net counts per minute

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

pCi/g = pico-curies per gram

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

 μ R/h = micro- Roentgen per hour s_i = minimal number of net source counts^aIn Equilibrium with progeny

MDCR = minimum detectable count rate

^bSum of U-234, 235 and 238

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