FINAL

Uniform Federal Policy-Quality Assurance Project Plan Addendum

USAEC Per- and Polyfluoroalkyl Substances Preliminary Assessment/Site Inspection
Radford Army Ammunition Plant, Virginia

August 2020

Contract: W912DR-18-D-0004
Delivery Order: W912DR18F0685

Prepared For:

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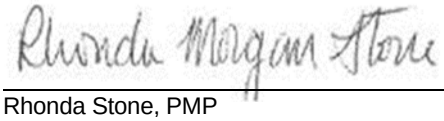

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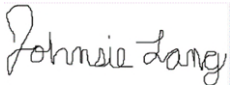

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Uniform Federal Policy-Quality Assurance Project Plan Addendum

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Arcadis Ref.:
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List of Acronyms and Abbreviations

%	percent
AFFF	aqueous film-forming foam
AMC	Army Materiel Command
amsl	above mean sea level
AOPI	area of potential interest
Arcadis	Arcadis U.S., Inc.
Army	United States Army
bgs	below ground surface
B.S.	Bachelor of Science
CAS	Chemical Abstract Service
CFR	Code of Federal Regulations
cm	centimeter
CPR	cardiopulmonary resuscitation
CSM	conceptual site model
DoD	Department of Defense
DOT	Department of Transportation
DQO	data quality objective
EB	equipment blank
FB	field blank
FD	field duplicate
GPS	global positioning system
HAZWOPER	Hazardous Waste Operations and Emergency Response
IDW	investigation-derived waste
installation	U.S. Army and Reserve installation
IRP	Installation Restoration Program
LOD	limit of detection
LOQ	limit of quantitation
mg/kg	milligram per kilogram
MMA	Main Manufacturing Area
MS	matrix spike
MSD	matrix spike duplicate
N	normal (parent sample)
N/A	not applicable
ng/L	nanogram per liter
NRU	New River Unit
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
PA	preliminary assessment
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
POC	point of contact
ppm	parts per million
PQAPP	Programmatic Uniform Federal Policy-Quality Assurance Project Plan

List of Acronyms and Abbreviations

PSL	project screening level
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QP	quality procedure
QSM	Quality Systems Manual
RFAAP	Radford Army Ammunition Plant
SB	source blank
SD	sediment
Shealy	Shealy Environmental Services, Inc.
SI	site inspection
SO	soil
SOP	standard operating procedure
SSHO	Site Safety and Health Officer
SSHP	Site Safety and Health Plan
SW	surface water
TBD	to be determined
TGI	technical guidance instructions
TOC	total organic carbon
U.S.	United States
UCMR3	Third Unregulated Contaminant Monitoring Rule
UFP-QAPP	Uniform Federal Policy-Quality Assurance Project Plan
USACE	United States Army Corps of Engineers
USAEC	United States Army Environmental Command
USEPA	United States Environmental Protection Agency

INTRODUCTION

A Programmatic Uniform Federal Policy-Quality Assurance Project Plan (PQAPP; Arcadis U.S., Inc. [Arcadis] 2019) was developed and submitted as final in October 2019. The PQAPP addresses the per- and polyfluoroalkyl substances (PFAS) preliminary assessment (PA) and site inspection (SI)-phase sampling at active United States (U.S.) Army (Army) installations (installations) within the U.S. Perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanesulfonic acid (PFBS) are three of the most abundant PFAS and are recognized by the U.S. Environmental Protection Agency (USEPA) as contaminants of emerging concern that present potentially unacceptable human health and environmental impacts. The purpose of this site-specific Quality Assurance Project Plan (QAPP) Addendum is to supplement the PQAPP, detail the planning processes for collecting data, and describe the implementation of the quality assurance (QA) and quality control (QC) activities developed for the PA/SI sampling planned at Radford Army Ammunition Plant (RFAAP) in Radford, Virginia. The objectives of the PQAPP and this QAPP Addendum are to generate project data that are technically defensible and useful in meeting the Army's PFAS PA/SI project goals. Project goals include determining the presence or absence of PFOS, PFOA, and PFBS at areas of potential interest (AOPIs), identifying the presence or absence and the nature of other PFAS, and updating AOPI conceptual site models (CSMs), which will be detailed in a PA/SI Report. Criteria for determining presence or absence is included in **Worksheet #15**.

This QAPP Addendum addresses three primary elements:

- Project management
- General CSM description
- Site-specific investigation design and data acquisition.

The site-specific worksheets in this QAPP Addendum for RFAAP supplement the general programmatic information provided in the PQAPP. A crosswalk between the PQAPP and the RFAAP QAPP Addendum is presented in **Table 1**. Site-specific details provided in this QAPP Addendum include sampling locations, media, methodologies, and procedures. Should site conditions warrant deviation from the prescribed procedures in this QAPP Addendum, the stakeholders defined in **Worksheet #4** of this QAPP Addendum will be consulted following the specific communication pathways described in Worksheet #6 of the PQAPP before changes to the sampling plan are made. Additionally, a non-conformance report summarizing the sampling deviations will be issued and attached as an appendix to the PA/SI report, if necessary (i.e., if data quality objectives [DQOs] are affected and corrective action is needed).

Table 1. Crosswalk: PQAPP to Radford Army Ammunition Plant QAPP Addendum

Optimized UFP-QAPP Worksheets		PQAPP	RFAAP QAPP Addendum
1 & 2	Title and Approval Page	✓	✓
3 & 5	Project Organization and QAPP Distribution	✓	
4, 7 & 8	Personnel Qualifications and Sign-off Sheet	✓	✓
6	Communication Pathways	✓	
9	Project Planning Session Summary	✓	✓
10	CSM	✓	✓
11	Project/DQOs	✓	✓
12	Measurement Performance Criteria	✓	
13	Secondary Data Uses and Limitations	✓	✓
14 & 16	Project Tasks & Schedule	✓	✓
15	Project Action Limits and Laboratory-Specific Detection / Quantitation Limits	✓	✓
17	Sampling Design and Rationale	✓	✓
18	Sampling Locations and Methods	✓	✓
19 & 30	Sample Containers, Preservation, and Hold Times	✓	
20	Field QC	✓	✓
21	Field Standard Operating Procedures (SOPs)	✓	✓
22	Field Equipment Calibration, Maintenance, Testing, and Inspection	✓	✓
23	Analytical SOPs	✓	
24	Analytical Instrument Calibration	✓	
25	Analytical Instrument and Equipment Maintenance, Testing, and Inspection	✓	
26 & 27	Sample Handling, Custody, and Disposal	✓	
28	Analytical QC and Corrective Action	✓	
29	Project Documents and Records	✓	
31, 32 & 33	Assessments and Corrective Action	✓	
34	Data Verification and Validation Inputs	✓	
35	Data Verification Procedures	✓	
36	Data Validation Procedures	✓	
37	Data Usability Assessment	✓	

QAPP ADDENDUM WORKSHEET #1 & #2: TITLE AND APPROVAL PAGE

(Uniform Federal Policy-Quality Assurance Project Plan [UFP-QAPP] Manual Section 2.1)
(USEPA 2106-G-05 Section 2.2.1)

1. Project Identifying Information:
    a. Site name/project name: U.S. Army Environmental Command (USAEC) PFAS PA/SI
    b. Site location/number: RFAAP, Radford, Virginia
    c. Contract/work assignment number: W912DR-18-D-0004/W912DR18F0685
2. Lead Organizations: U.S. Army Corps of Engineers (USACE), USAEC, and RFAAP
    a. USACE Regional Point of Contact (POC), Northeast District

    _____

    Nicole Walworth Date
    b. Army Materiel Command (AMC) Environmental Program Coordinator

    _____

    Bridgett Lyons Date
    c. RFAAP USAEC Environmental Support Manager

    _____

    Mary Ellen Maly Date
    d. RFAAP Installation Restoration Program (IRP) Manager

    _____

    James McKenna Date

3. List plans and reports from previous investigations relevant to this project:

Author/Title	Date
Arcadis. Final Programmatic Uniform Federal Policy-Quality Assurance Project Plan, USAEC PFAS PA/SI, Active Army Installations, Nationwide, USA	October 2019

QAPP ADDENDUM WORKSHEET #4, #7, & #8: PERSONNEL QUALIFICATIONS AND SIGN-OFF SHEET

(UFP-QAPP Manual Sections 2.3.2 – 2.3.4)
(USEPA 2106-G-05 Sections 2.2.1 and 2.2.7)

This worksheet is used to identify key site-specific personnel for each organization performing tasks defined in this QAPP Addendum.

LEAD ORGANIZATIONS: USACE, USAEC, and RFAAP

Name	Agency	Project Title/Role	Signature[1] (check box)
Nicole Walworth	USACE	Regional POC	☐
Mary Ellen Maly	USAEC	Environmental Support Manager	☐
Bridgett Lyons	AMC	Environmental Program Coordinator	☐
James McKenna	RFAAP	IRP Manager	☐

[1] Signature check boxes indicate personnel have read and agree to implement this QAPP Addendum as written

ORGANIZATION: Arcadis

Name	Project Title/Role[1]	Education/Experience	Specialized Training/Certifications	Signature[2] (check box)
Jason Artrip	SI Project Manager	Associate of Applied Science Environmental Science (Engineering Technology), Bachelor of Science (B.S.) Geography (Environmental Studies), Master of Business Administration (Project Management), 15 years of experience in environmental consulting, including site characterization and investigation (drilling oversight/well installations), remediation (source removal, long term and short term), emergency response, waste management, and project management.	• Occupational Safety and Health Administration (OSHA): Initial 40-Hour Hazardous Waste Operations and Emergency Response (HAZWOPER) • OSHA: HAZWOPER 8-Hour Refresher 29 Code of Federal Regulation (CFR) 1910.120(e)(8) • OSHA: Site Supervisor • OSHA: 10-Hour Construction Safety • First Aid/Cardiopulmonary Resuscitation (CPR)/Blood Borne Pathogens	☐
Johnsie Lang	Technical Lead	B.S. Environmental Engineering, Master of Science Environmental Engineering, Doctor of Philosophy Civil Engineering. 5 years of experience. Numerous publications on fate and transport of PFAS.	• Engineer in Training	☐
Lauren Henderson	Task Manager	B.S. Biological Engineering. 7.5 years of experience. Comprehensive Environmental Response, Compensation, and Liability Act reporting; IRP/ Military Munitions Response Program project coordination; environmental remediation, Army liabilities quality review and reporting; task management and region oversight for PFAS PAs; subcontractor oversight and coordination; project management for SIs.	• OSHA: Initial 40-Hour HAZWOPER • OSHA: HAZWOPER 8-Hour Refresher 29 CFR 1910.120(e)(8)	☐
Dakota Valle	Field Sampling Staff	B.S. Geology. One year of experience. This experience includes environmental remediation	• OSHA: Initial 40-Hour HAZWOPER • Geologist in Training	☐

Name	Project Title/Role[1]	Education/Experience	Specialized Training/Certifications	Signature[2] (check box)
		field work, and report writing for various industrial and federal remediation and compliance projects.	• Department of Transportation (DOT) Hazmat #1: DOT/ International Air Transport Association Shipping and Transportation • First Aid/CPR	
Justin Radford	Site Safety and Health Officer (SSHO)/Field Sampling Staff	B.S. Geology. 8 years of experience. This experience includes environmental remediation and geotechnical field work, task management, and report writing for various industrial and federal remediation and compliance projects.	• OSHA: Initial 40-Hour HAZWOPER • OSHA: HAZWOPER 8-Hour Refresher • OSHA: 30-Hour Construction Safety • OSHA: Site Supervisor • DOT Hazmat #1: DOT/ International Air Transport Association Shipping and Transportation • First Aid/CPR	☐

[1] Field sampling personnel may be subject to change based on staff availability.
[2] Signature check boxes indicate personnel have read and agree to implement this QAPP Addendum as written.

QAPP ADDENDUM WORKSHEET #9: PROJECT PLANNING SESSION SUMMARY

(UFP-QAPP Manual Section 2.5.1 and Figures 9-12)
(USEPA 2106-G-05 Section 2.2.5)

Programmatic Project Planning Session Summaries are provided in Worksheet #9 of the PQAPP. The Project Planning Session Summaries presented below are those specific to the USAEC PFAS PA/SI activities at RFAAP. Meeting minutes to summarize Planning Sessions are provided in **Attachment 1**.

Participants: The key participants who have been involved in the RFAAP SI Planning Sessions are listed below.

Name	Initials	Organization	Title/Role	Email
Cliff Opdyke	CO	USACE	Technical Lead	Clifford.a.opdyke@usace.army.mil
Nicole Walworth	NW	USACE	Regional POC	Nicole.u.walworth@usace.army.mil
Mary Ellen Maly	MM	USAEC	Environmental Support Manager	mary.e.maly.civ@mail.mil
James McKenna	JM	RFAAP	IRP Manager	James.j.mckenna16.civ@mail.mil
Melissa Lincoln	ML	BAE Systems	Environmental Specialist (on-site contractor)	Melissa.lincoln@baesystems.com
Lauren Henderson	LH	Arcadis	Task Manager	Lauren.henderson@arcadis.com
Johnsie Lang	JL	Arcadis	Technical Lead	Johnsie.lang@arcadis.com
Jason Artrip	JA	Arcadis	Project Manager	Jason.artrip@arcadis.com
Courtney Ingersoll	CI	Arcadis	Region Lead	Courtney.ingersoll@arcadis.com
Rhonda Stone	RS	Arcadis	Program Manager	Rhonda.stone@arcadis.com
Kimmie Schrupp	KS	Arcadis	Deputy Program Manager	Kimmie.schrupp@arcadis.com

Date of Planning Session: 04 February 2020
Location: Teleconference
Purpose: RFAAP SI Kickoff and Scoping Teleconference
Participant Initials: CO, NW, MM, JM, ML, LH, JL, JA, CI, RS, KS

Summary of discussion topics: Arcadis introduced the SI project management team, presented the preliminary SI schedule, discussed the general field work logistics, and discussed the planned SI scope for each AOPI to complete the SI at RFAAP. See **Attachment 1** for meeting minutes summarizing the SI Kickoff and Scoping Teleconference discussion topics.

Documented Changes since Planning Session: Surface water samples were added to the scope along the New River where the New River enters and exits the installation on the installation side of the river. This change was discussed during the scoping teleconference. Discussion notes are presented in **Attachment 1**.

The meeting minutes in **Attachment 1** discuss the CSMs related to drinking-water only receptors. The Army's goal has changed to include more than drinking water CSMs, and CSMs include all media and exposure mechanisms.

Date of Planning Session: 17 June 2020
Location: Teleconference
Purpose: RFAAP SI Scoping Changes Teleconference
Participant Initials: NW, MM, JM, ML, LH, JL, JA, CI

Summary of discussion topics: Arcadis proposed sampling revisions based on Draft QAPP Addendum comments. Historical documents were used to investigate groundwater flow directions, and groundwater or spring samples were recommended where groundwater flow could be determined based on the available groundwater characterization information at each AOPI. Additionally, USAEC made a programmatic decision to include all AFFF storage locations as an AOPI; therefore, the Current Fire Station and Current Storage Shed, which were previously listed as non-AOPIs, were added to the AOPI list and SI sampling scope.

The following decisions were reached:

- Teflon Coating Facility AOPI: Add three direct-push technology (DPT) borings to sample groundwater. Shallow groundwater is expected at less than 25 feet bgs and flows toward Stroubles Creek.
- Old Fire Station: Current Ladder Shed, and Old Ladder Shed AOPIs area: Groundwater is expected to be greater than 100 feet deep and within the bedrock at these sites. Shallow groundwater is expected to flow west toward the New River based on a dye trace study; therefore, a spring sample was proposed west of the area if the spring can be located during the SI fieldwork.
- Old Fire Station 2: Groundwater is expected to be greater than 100 feet deep and within the bedrock at this site. Shallow groundwater is expected to flow west; therefore, a well sample was proposed west of the site if the well is confirmed to be active during the SI fieldwork.
- River Warehouse: No changes to original scope
- Current Fire Station: Shallow groundwater is expected to flow with topography to the northwest; therefore, a spring sample was proposed northwest of the site if the spring can be located during the SI fieldwork.

Documented Changes since Planning Session: During backcheck of the Draft QAPP Addendum response to comments submitted by Arcadis on 10 July 2020, the OPSEC reviewer (Charles Saks) noticed the Old Ladder Shed and Old Fire Station 1 locations were incorrect. Arcadis revised Figure 5 to include the correct locations and moved soil samples to surface runoff locations of these buildings.

QAPP ADDENDUM WORKSHEET #10: CONCEPTUAL SITE MODEL

(UFP-QAPP Manual Section 2.5.2)
(USEPA 2106-G-05 Section 2.2.5)

Preliminary CSMs for RFAAP AOPIs included in the PA/SI sampling scope of work are presented below. Data collected during the completion of the PA/SI sampling scope of work within this QAPP Addendum will be used to further develop CSMs for each AOPI in the PA/SI Report for RFAAP.

Background Information

RFAAP is a 6,600-acre government-owned, contractor-operated industrial military installation supplier of solvent and solvent-less propellants and explosives in southwest Virginia Pulaski and Montgomery Counties (**Figure 1**). The installation is owned by the U.S. Department of the Army and was operated under contract with Hercules, Inc., from 1941 to 1995. Alliant Techsystems, Inc. operated the facility from 1995 to 2011 (IT Corporation 2001). Since 2011, BAE Systems, Inc. manages, operates, and maintains the facility and currently employs approximately 2,500 people (Malyasov 2019). The adjacent city of Radford, Virginia has an estimated population of 18,339 residents according to the most recent U.S. census estimates. Radford, Virginia is the 29th largest city in Virginia based on official 2018 estimates (U.S. Census Bureau 2019).

RFAAP consists of two noncontiguous units, the Main Manufacturing Area (MMA) and the New River Unit (NRU). The MMA encompasses approximately 4,800 acres and is located approximately 5 miles northeast of the city of Radford, approximately 10 miles west of Blacksburg, and 37 miles southwest of Roanoke. The MMA lies in one of a series of narrow valleys typical of the eastern range of the Appalachian Mountain region. The valley is oriented in a northeast-southwest direction and is approximately 25 miles long, 8 miles in width at the southwest end, and narrowing to 2 miles in width at the northeast end. The MMA lies along the New River in the relatively narrow northeastern corner of the valley. The New River divides the MMA into two sections, the northern section (known as the "Horseshoe Area") within the meander of the river, and the southern section, which is the main post area (IT Corporation 2001).

The NRU is noncontiguous with the MMA and encompasses approximately 1,800 acres about 6 miles southwest of the MMA near the town of Dublin in Pulaski County. The NRU facility is in the southern portion of the Appalachian Mountain region and sits approximately 1.5 miles north of Claytor Lake and 2 miles northwest of Claytor Lake Dam (IT Corporation 2001). The NRU is a storage facility and has had no suspected uses or releases of any PFAS-containing material and therefore will not be included further in this QAPP Addendum. The MMA is the main area of concern and will be referred to as RFAAP throughout the QAPP Addendum.

Physical Setting

Topography and Climate

Topography within the MMA of RFAAP can vary from relatively flat floodplain to elevated uplands in the southeast section. The New River forms the RFAAP boundary to the north at approximately 1,675 feet above mean sea level (amsl). The eastern boundary represents a transition from a floodplain elevation of 1,680 feet amsl to an upland elevation of 1,900 feet amsl. The southern boundary of RFAAP traverses terrain consisting of creek bottoms and sharply rising summits. The western boundary follows the bluff line

overlooking the New River to a point where Norfolk and Western Railroad crosses the western portion of the Horseshoe Area (IT Corporation 2001).

In winter the average temperature is 32 degrees Fahrenheit, and in summer the average temperature is 69 degrees Fahrenheit. The total average rainfall is 40 inches, of which 53 percent (%) occurs from April through September. The average annual snowfall is 28 inches, and the prevailing wind is from the west (USATHAMA 1987).

Hydrology

All of RFAAP is in the Upper New River drainage basin. Because of a prominent meander in the New River at the RFAAP location, water in the river first flows east in the southern section of RFAAP and then abruptly flows west in the northern section of the RFAAP. Stroubles Creek is a significant tributary of the New River in that it drains approximately one-third of the RFAAP MMA. Stroubles Creek located in the eastern section of the MMA flows northerly and enters the New River near the east central portion of the installation.

The New River is a drinking water and production water resource for RFAAP. The active RFAAP surface water intake is located along the New River upstream of the AOPIs. A second RFAAP surface water intake is located further downstream along the New River; however, this second surface water intake is no longer operational, and RFAAP does not plan to use it in the future.

Figure 1 shows off-installation public water systems and potential private wells identified by a public information survey (Environmental Data Resources, Inc. 2018). Additional private wells may exist within the shallow or deep aquifers surrounding RFAAP. Specifically, Montgomery County, which lies to the east of the New River in the RFAAP area sources water from rivers, lakes, streams, ponds, reservoirs, springs, and wells (Montgomery County Public Service Authority 2019). Specific locations of drinking water sources are not public information and, therefore, are unknown at this time. Other local off-installation usage of the New River includes crop irrigation, boating, and sport fishing (USATHAMA 1987).

Geology and Hydrogeology

RFAAP is within the Valley and Ridge physiographic province of the Appalachian Highland Region. The Valley and Ridge physiographic province is made up of elongated, narrow, flat topped ridges of resistant sandstone or metamorphosed sandstone (quartzite) and valleys that are composed of less resistant limestone and shale (USATHAMA 1987). Present day landforms within the vicinity of the RFAAP are the result of complex sequence of faulting and folding, occurring over the last 100 million years. The Pulaski Thrust fault caused Cambrian limestone formations (The Elbrook and the Rome Formations) to overlie younger Mississippian sandstone and shale formations (McCrady/Price Formations). The carbonate formations exposed at the surface through faulting have undergone extensive chemical weathering. The weathering of these carbonate formations results in karst relatively shallow subsurface landforms (sinkholes, caves, and solution cavities) which are found in the vicinity of the site.

The RFAAP is underlain by a complex sequence of both unconsolidated deposits and consolidated bedrock. The unconsolidated deposits consist of residual soils, river alluvium, and terrace deposits. The residual soil, which consists of reddish brown to pale yellow silty sand and gravel lenses or yellowish brown to brown silty loam containing sand and rock fragments, is caused by weathering of the limestone, dolomite, shale, and terrace deposits. River alluvium which lies along the stream valleys, consists primarily of clay, silt, and sand with pebble and cobble lenses. Well logs of monitoring wells drilled in the area indicate that the alluvial deposits can be up to 30 feet thick. Terrace deposits, which mantle much of the RFAAP area, consist of

poorly sorted, well rounded, brown to reddish brown cobbles (known locally as “River Jack”) entrenched in a matrix of sand, silt, and clay. These deposits, which may be over 50 feet thick, were deposited by the New River between later Tertiary and early Pleistocene. The cobbles, which consist of vein quartz, metaquartzite, and feldsparthic sandstone, originate from the Blue Ridge Mountains.

The bedrock that underlies the unconsolidated material consists of the Elbrook Formation, the Rome Formation, and the McCrady/Price Formation. The Elbrook Formation with thickness from 1,400 to 2,000 feet is composed of thickly bedded, blue gray dolomite, interbedded with blue gray to white limestone and with some shale. The Rome Formation with thickness from 1,000 to 2,000 feet is composed of red and green shale, sandstone, dolomite, and pure limestone. A distinctive red shale unit marks the base of the Rome Formation. The McCrady/Price Formation outcrops in a fenster (window) east of the RFAAP (MMA), this formation consists of fossiliferous shale and sandstone.

Groundwater in the vicinity of RFAAP is found in both unconsolidated and consolidated aquifers. Between 0 and 50 feet below ground surface (bgs), water bearing characteristics are considered poor and function primarily to recharge lower aquifers. The movement of groundwater through the upper unconsolidated aquifers (alluvium deposits and terrace deposits) is through pore spaces that lie between the particles making up these deposits. The movement of groundwater through the lower consolidated aquifers (Limestone and Dolomite bedrock) is through a complex system of solution cavities produced by solution of bedrock caused by rapid movement of groundwater through rock fractures (USATHAMA 1987).

Generally, in the vicinity of RFAAP, groundwater flows from topographically higher elevations to topographically lower regions; however, the presence of karst features at RFAAP may affect the flow of groundwater, therefore, groundwater beneath a site may not be representative of contamination caused by a release at that site (USEPA EPIC 1992).

Surficial groundwater ultimately discharges into the New River or New River surface water tributaries. Although this statement is generally true much of the year, it may not be true in periods when the New River is in a flood stage. Although no data exists to prove this, it is likely that water from the New River, which has a higher elevation during flood stage than adjacent groundwater formations, will enter these formations and cause a temporary reversal of gradient. Normal groundwater flows resume after flood waters recede (USATHAMA 1987).

Known or Suspected Contaminants and Sources

Teflon-coating operations and aqueous film-forming foam (AFFF) usage are the known sources of potential PFAS contamination onsite. Soil, sediment, surface water, and groundwater are potentially affected media, and the main drinking water receptor is the New River and its surface water tributaries. Specific releases have been identified and are related to Teflon-coating procedures and fire department practices including AFFF storage, nozzle testing, and training. No accidental releases of AFFF or fires suppressed with AFFF were reported during the PA.

Seven AOPIs were identified at RFAAP during the PA. The seven AOPIs include sources from historic Teflon-coating operations and general AFFF usage. All seven AOPIs are recommended for SI sampling due to the potential presence of PFOS/PFOA and will be the focus of the sampling outlined in this QAPP Addendum (**Table 1**). AOPI locations and historical AFFF/PFAS use are summarized in **Table 2**.

Table 2. Summary of PFAS Relevance at AOPIs

AOPI Description	Site History
The Teflon-Coating Facility	This facility was used from the 1940s to 1990s in varying capacities for Teflon spray coating of materials. Teflon-containing particles were vented into the atmosphere via a large air stack, and residual Teflon solids were washed into floor drains from water screen/curtains located behind the spray booth in the building. The building drains are piped to a discharge located on Stroubles Creek, which merges with the New River. There is a known release of Teflon constituents which may potentially contain PFASs at this location.
Old Fire Station 1	This former fire station was used from the 1940s to 1990s. One of two fire engines parked here was known to contain an AFFF reservoir. AFFF use, nozzle testing, training, and other fire department practices at this facility are unknown. This building was demolished in the late-1990s. AFFF has not been used at this AOPI since 1998. The location is currently a gravel lot used for temporary construction headquarters trailers. There are data gaps associated with AFFF use and potential releases, so this AOPI is considered a potential source area.
Old Ladder Shed	The Old Ladder Shed was used from the 1940s to 1990s in conjunction with Old Fire Station 1. It is located near the Old Fire Station 1. One of its uses was historical AFFF storage; therefore, AFFF filling potentially occurred near this building. Historical spills and AFFF handling are unknownThis building was demolished in the late-1990s. The location is currently a gravel lot. There are data gaps associated with AFFF use and potential releases, so this AOPI is considered a potential source area.
Old Fire Station 2	This former fire station was used from the 1940s to 1990s. It is unknown if fire engines or AFFF were stored at this location. AFFF use, nozzle testing, and training are unknown prior to 1998.AFFF has not been used at this AOPI since 1998. This building is still in place and is used as an office building. There are data gaps associated with AFFF use and storage, so this AOPI is considered a potential source area. Potential nozzle testing or flushing areas are identified as areas in the immediate surface runoff flow pathway from fire station aprons.
River Warehouse	This location has been used for driver/operator fire department training in approximately 2004 and potentially used prior. Fire department personnel stated in the PA site visit interview that personnel from all three shifts trained once per year but were unsure how many years this training occurred. The dirt road adjacent to the fence line at the River Warehouse area was utilized to drive fire engines while AFFF was sprayed into the grassy areas between the road and warehouse multiple times a year for unknown years. There are known PFAS releases at this AOPI.

AOPI Description	Site History
Current Fire Station	This fire station replaced Old Fire Station 1 and 2 in the late-1990s. Nozzle testing has never occurred at this fire station. AFFF has been filled in engine reservoirs at least once with a pump, and no leaks were reported. AFFF is not currently stored at this fire station, but fire department personnel reported during the PA site visit that AFFF containers were stored in the bays for a short period at least once. This AOPI is considered a potential source area due to data gaps associated with AFFF use and potential release.
Current Storage Shed	Two Ansulite AFFF foam trailers (265 gallons each) are stored in this facility in case of a fire at the solvent recovery facility. The fire response system has never been used. Storage area also contains 5-gallon buckets of Ansulite AFFF (112 buckets during PA site visit). Storage area is clean with no evidence of AFFF spills. No refilling of AFFF reservoirs occurs in this building. There is no drain in this building. While AFFF storage was verified at this location, there are no known releases; this AOPI is considered a potential source area due to the AFFF storage.

Potential Receptors and Contaminant Exposure Pathways

Potential receptors and contaminant exposure pathways for each of the installation's AOPIs are presented in the CSMs on **Figure 2 and Figure 3**. Based on the historical use of AFFF and Teflon coating at the AOPIs, affected media are likely to consist of soil, groundwater, surface water, and sediment. Release and transport mechanisms include dissolution/desorption from soil to groundwater, transport via sediment carried in and dissolution to stormwater and surface water, discharge/recharge between groundwater and surface water and adsorption/desorption between surface water and sediment. Human exposure pathways are shown as "potentially complete" or "incomplete" on the CSM figures. A potentially complete exposure pathway consists of a constituent source and release mechanism, a transport or retention medium, an exposure point where human contact with the contaminated medium could occur, and an exposure route at the exposure point. If any of these elements is missing, the exposure pathway is incomplete.

The major surface water features at RFAAP are the New River and Stroubles Creek. RFAAP has its own drinking water plant that provides all drinking water on the installation; the intake is along the New River upstream of the AOPIs. The RFAAP drinking water plant intake was sampled for PFOA/PFOS in 2017 with results being non-detect (Tetrahedron 2018).

The drinking water intakes from the New River for the Pulaski County, the City of Radford, the Town of Blacksburg, the Town of Christianburg, and the VPI Water Authority are all located off-post, upstream from the installation (New River Valley Planning District Commission, 2011 and Town of Blacksburg, 2011). The Third Unregulated Contaminant Monitoring Rule Three (UCMR3) data reports for the City of Radford and The Town of Blacksburg demonstrated non-detects for PFOA and PFOS (USEPA 2016).

There are groundwater public supply wells within a 5-mile radius of RFAAP. Due to the karst geology in the area, it is unclear the potential directions for groundwater migration, but generally in the RFAAP vicinity the

groundwater flow is from higher elevation to lower elevation, which is toward the New River and/or its tributary (Stroubles Creek).

Figure 2 shows the CSM for the AOPI related to the application of Teflon (i.e. Teflon-Coating Facility). The Teflon-Coating Facility is located on the east edge of the MMA and just west of Stroubles Creek. The facility was a large-scale Teflon-coating operation operated from the 1940s through the 1990s. A Teflon primer was sprayed on various items, sometimes in multiple coatings, and items would then be heated. Forced air blowers in the ceiling vented fumes to the atmosphere causing Teflon particulates to settle into the local soil. A water screen/curtain behind the spray booth dropped Teflon solids from residual spraying into floor drains. The eastern side of the facility contains a drain that is piped approximately 300 meters to a discharge on Stroubles Creek. Waste line utility records show this as the only drain conveyance from the building.

Figure 3 shows the CSM for the AOPIs related to AFFF use (i.e. Old Fire Station 1, Old Ladder Shed, Current Storage Shed, Old Fire Station 2, River Warehouse, and Current Fire Station). These AOPIs have historical usage and/or storage of AFFF, which could have led to releases of AFFF to soil. There is also surface runoff to the New River or other tributaries on the installation from potential source areas.

Below is a list of CSM exposure pathways of PFAS for the listed AOPIs. While the source media varies, all AOPIs at RFAAP have the same exposure pathways:

- There are no residents on the installation; therefore, all receptor pathways for on-installation residents are incomplete.
- On-installation site workers could contact constituents in soil from AOPIs via incidental ingestion, dermal contact, and inhalation of dust; as such, the soil exposure pathway for on-installation site workers is potentially complete. On-installation recreational (i.e. permitted hunters) users do not have access to areas of the installation where AOPIs are located due to enhanced security restrictions; therefore, the soil exposure pathway for on-installation recreational users is incomplete, and for off-installation receptors the soil exposure pathway is also incomplete.
- RFAAP has no on-installation potable wells or drinking water supply wells; therefore, the groundwater exposure pathways via drinking water ingestion and dermal contact for on-installation site workers and recreational users is incomplete.
- Additionally, there is potential due to karst geology in the area for the groundwater to move in unexpected pathways to off-installation receptors. There are two known water supply wells in Giles County near the downstream flow path for the New River within five miles of the installation (i.e. Blue Ridge Christian Camp and New River Junction Campground) with potential for other unknown private wells; therefore, the groundwater exposure pathway for off-installation receptors is potentially complete.
- The AOPIs are within a 5-mile proximity of the on-installation New River surface water intake used for on-site drinking water. Due to complex karst geology and potential (undocumented) spring discharges into the New River upstream of the drinking water plant, the surface water exposure pathways via drinking water ingestion and dermal contact for on-installation site workers and recreational users are potentially complete.
- There are additional surface water drinking water intakes off the installation (shown in **Figure 1**). Due to the karst geology and the local fault zone in the vicinity of RFAAP, groundwater originating at these AOPIs may have potential to discharge to surface water via local springs into the adjacent Stroubles Creek and/or New River, which flows off-post.. There are surface water intakes downstream of the installation potentially used for off-installation drinking water. Therefore, the surface water exposure

pathway via drinking water ingestion and sediment through incidental ingestion and dermal contact for off-installation receptors is potentially complete.

The preliminary CSMs will be further detailed in the PA/SI report for RFAAP and will be updated if necessary, based on the results of the SI.

Data Gaps

Presence or absence of PFAS in surface water, groundwater, sediment, and shallow soil at seven AOPIs have not been determined and will be investigated as part of this PA/SI. **Figures 4 through 9** shows the sampling locations for groundwater, surface water, sediment, and shallow soil. **Worksheet #17** of this QAPP Addendum provides the rationale and sampling design for the PA/SI sampling scope of work to address the above data gaps. **Worksheets #18 and #20** of this QAPP Addendum list the planned sample identifications and required QC samples for each medium.

QAPP ADDENDUM WORKSHEET #11: PROJECT/DATA QUALITY OBJECTIVES

(UFP-QAPP Manual Section 2.6.1)
(USEPA 2106-G-05 Section 2.2.6)

This worksheet states the problem, identifies the goal of the study, identifies information inputs, defines boundaries of the sampling, develops the analytical approach, specifies performance or acceptance criteria, and identifies the developed plan for obtaining data in accordance with USEPA's 7-step DQO process, *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA 2006). This QAPP Addendum presents the selected investigation design and rationale in **Worksheet #17**, and the sampling summary in **Worksheet #18** and **Worksheet #20**.

Step 1: State the Problem:
PFOS, PFOA, and PFBS are recognized as PFAS that present potentially unacceptable human health impacts if ingested via drinking water. Initial findings of a PA have identified seven AOPIs at which PFAS may have been released to the environment at RFAAP. These potential releases are primarily related to the use of AFFF or historic Teflon-coating operations. The presence, types, and concentrations of potential PFAS at these AOPIs, the potential for human receptors (i.e., residential or industrial/commercial receptors) to contact PFAS-containing media via ingestion, dermal contact, or inhalation have not been determined.
Step 2: Identify the Goal of the Study:
The primary goals of the sampling activities are to confirm PFAS absence or presence at individual AOPIs on the installation and refine the AOPI CSMs. The sampling activities as part of this PA/SI for RFAAP will be conducted in conformance with the 2018 Army Guidance for Addressing Releases of Per-and Polyfluoroalkyl Substances (Army 2018), the Department of Defense (DoD) instructions 4715.07 (DoD 2013) and 4715.18 (DoD 2019) and the DoD Manual 4715.20 (DoD 2012); the DoD Instructions 4715.18 requires DoD components to respond to emerging contaminants like PFOS, PFOA, and PFBS.

Step 3: Identify Information Inputs:

The data needed to accomplish the goals of the sampling activities for this project are as follows:

- All information reviewed to date as part of the PA to identify the AOPIs, including historical use and personnel's accounts of historical activities, spill records, previous remedial actions completed, previous analytical data and validation packages
- Observations made during the site reconnaissance and conference calls after site visits, and during the investigation
- New analytical data from sampled media applicable to each AOPI, which may include soil, groundwater, surface water, and/or sediment, and which may be accomplished through sampling of soil boring advancement or grab sample collection
- Soil boring description logs that include detailed descriptions where soil borings are advanced.

Sampling will be limited to areas where AFFF (which contained PFAS, including PFOS, PFOA, and PFBS) use is documented or areas that may have received PFAS-containing material. Parameters and analytical methods are identified in Worksheet #19 & #30 of the PQAPP. Field sample collection methods are summarized in **Worksheet #17** of this QAPP Addendum and in Worksheet #21 of the PQAPP.

Step 4: Define the Boundaries of the Sampling:

Analytical sample collection at RFAPP will be completed within or near seven AOPIs: Teflon-Coating Facility, Old Fire Station 1, Old Ladder Shed, Current Storage Shed, Old Fire Station 2, River Warehouse, and Current Fire Station. Six of these AOPIs are located in the center of the installation to the south of the New River. One of the old fire stations is located on the western side horseshoe area of the installation bound by the New River. Surface water samples will also be collected at two locations on the New River at the entrance and exit of the installation. Tentative sample identifications for each medium and location to be sampled are listed in **Worksheet #18** of this QAPP Addendum.

Shallow soil boring locations will be advanced via hand auger at each AOPI and a composite sample will be collected from 0 to 2 feet bgs for the analysis of the PFAS constituents listed on **Worksheet #15** and total organic carbon (TOC), grain size, and pH where applicable. This target sampling depth interval is anticipated to be well above the water table, unless perched groundwater is encountered.

Step 5: Develop the Analytic Approach:

Samples will be collected in accordance with the technical guidance instructions (TGI) and SOP documents included as Appendix A to the PQAPP (Arcadis 2019). The samples will be submitted for analysis to Shealy Environmental Services, Inc. (Shealy, which has been recently acquired by Pace Analytical). Liquid chromatography/tandem mass spectrometry will be used to analyze samples for PFAS; **Worksheet #15** of this QAPP Addendum identifies the laboratory limits of detection (LOD)s for PFAS. The LOD is defined as "the lowest concentration for reliable reporting of a non-detect of a specific analyte in a specific medium with a specific method at 99 percent confidence" (DoD 2017) and will be used as the project screening levels (PSLs) for this PA/SI. PSLs will only be used to identify presence or absence of PFAS (i.e., PSLs are not utilized for risk-based comparisons which may relate to future remedial decisions). On 15 October 2019, the Office of the Secretary of Defense (OSD) distributed guidance that provides risk screening levels (calculated using the USEPA's risk screening level calculator) for PFOA, PFOS, and PFBS in groundwater (tap water) and soil for residential and industrial/commercial worker receptor scenarios (**Attachment 3**). The OSD guidance provides two risk screening levels with a lower risk screening level in the presence of "multiple PFAS". Multiple PFAS will be defined as more than one PFAS compound of the 18 PFAS compounds analyzed for in this study.

- If PFAS concentrations are less than the PSLs, then no further action will be recommended at this time.
- If PFAS concentrations are greater or equal to than the PSLs (i.e., the laboratory LODs), PFAS are present.
- If PFOS/PFOA/PFBS concentrations are greater than the PSLs but less than the OSD risk screening levels (OSD 2019), then no further action will be recommended at this time.
- If PFOS/PFOA/PFBS concentrations are greater than the OSD risk screening levels (OSD 2019), further investigation will be recommended.

The final waste characterization and disposal plan for investigation-derived waste (IDW) will be conducted in accordance with Army guidance and state/local regulations. Disposition of IDW is discussed in **Worksheet #17** of this QAPP Addendum.

Step 6: Specify Performance or Acceptance Criteria:

Controls on precision, reporting, and accuracy are provided in Worksheets #12 and #28 of the PQAPP. Field monitoring and detection equipment will be routinely calibrated, as detailed in Worksheet #22 of the PQAPP, to confirm that equipment used is of the proper type, range, accuracy, and precision to provide data compatible with the specified requirements and desired results.

Step 7: Develop the Plan for Obtaining Data:

The detailed sampling plan and rationale for this PA/SI is presented in **Worksheet #17** of this QAPP Addendum. Sampling plans may be revised based on field conditions or site planning meetings.

QAPP ADDENDUM WORKSHEET #13: SECONDARY DATA USES AND LIMITATIONS

(UFP-QAPP Manual Section 2.7)
(USEPA 2106-G-05 Chapter 3: QAPP Elements for Evaluating Existing Data)

This worksheet identifies sources of secondary data not generated for the specific purpose of this project, or data generated under a separate QAPP, and summarizes their uses for this project. A full list of references reviewed to complete the PA/SI at RFAAP will be provided in the PA/SI Report.

Data Type	Source	Data Uses Relative to Current Project	Factors Affecting the Reliability of Data and Limitations on Data Use
Aerial Imagery	ESRI, ArcGIS Online Aerial Imagery	Provided georeferenced aerial photos for figure backdrops.	There are no known limitations on aerial imagery.
Past Site Investigations	Tetrahedron, Inc. 2018. Updated Drinking Water Quality Assessment Related to Perfluorinated Compounds (PFCs) at U.S. Army Material Command Installations. January. IT Corporation. 2001. Radford Army Ammunition Plant, Virginia, Facility-Wide Background Study Report. Delivery Order No. 0008, Environmental Services, Program Support, DACA31-94-D-0064. December. USATHAMA. 1987. RCRA Facility Assessment of Radford Army Ammunition Plant.	Provided regional site conditions, historical site usage, historical contaminant identification and concentrations, and remedial actions.	Site usage histories may omit records of AFFF procurement and use. Limited PFAS data are available from previous investigations. It cannot be verified that historical sample collection or laboratory analysis for PFAS constituents was conducted in accordance with best practices (SOPs) for PFAS sampling in order to obtain technically defensible/usable data (i.e., not affected by sampling methods and procedures.]
Installation Personnel Interviews	Various	Provided anecdotal histories of site use, AFFF use, and remedial actions completed.	Several installation personnel who would have worked on site during the peak of AFFF use are retired or out of contact.

QAPP ADDENDUM WORKSHEET #14 & #16: PROJECT TASKS & SCHEDULE

(UFP-QAPP Manual Section 2.8.2)
(USEPA 2106-G-05 Section 2.2.4)

The project schedule is presented below for sampling activities planned at RFAAP as part of the PA/SI following completion of previous steps listed in Worksheet #14 & #16 of the PQAPP.

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
Installation site visits	Arcadis	Complete	Complete	Field notes (included in PA/SI Report)	Complete
Draft Final QAPP Addendum and Site Safety and Health Plan (SSHP, **Attachment 2** provided under separate cover)	Arcadis	Complete	April 2020	Draft Final QAPP Addendum and SSHP	April 2020
Final QAPP Addendum and SSHP	Arcadis	May 2020	June 2020	Final QAPP Addendum and SSHP	May 2020
Coordinating/permitting	Arcadis	May 2020	June 2020	Site permits	May 2020
Mobilization and set up	Arcadis and subcontractors	June 2020	June 2020	Field notes (included in PA/SI Report)	May 2020
Sample collection of surface water	Arcadis	June 2020	June 2020	Field notes and measurements (included in PA/SI Report)	Submitted in PA/SI Report
Soil boring advancement, sample collection of soil, and boring abandonment	Arcadis and subcontractors	June 2020	June 2020	Field notes and measurements (included in PA/SI Report)	Submitted in PA/SI Report
Sample Analysis	Shealy	June 2020	July 2020	Analytical data package and electronic data deliverable	Submitted in PA/SI Report

Activity	Responsible Party	Planned Start Date	Planned Completion Date	Deliverable(s)	Deliverable Due Date
Preliminary Data Review Teleconference (if requested)	Arcadis	July 2020	August 2020	Draft data figures and tables (if requested)	August 2020
Data Validation	Arcadis	August 2020	September 2020	Data validation report	Submitted in PA/SI Report
Draft PA/SI Report	Arcadis	July 2020	September 2020	Draft PA/SI Report	(90 days after data validation)
Final PA/SI Report	Arcadis	October 2020	December 2020	Final PA/SI Report	September 2020

QAPP ADDENDUM WORKSHEET #15: REFERENCE LIMITS AND EVALUATION TABLES

(UFP-QAPP Manual Section 2.6.2.3)
(USEPA 2106-G-05 Section 2.2.6)

This worksheet provides the laboratory-specific (Shealy) limits for the PFAS compounds that will be analyzed, including the typical limit of quantitation (LOQ) and LOD. The LOQs and LODs are what the laboratory can achieve and were supplied by the laboratory. The LOQ is "the smallest concentration that produces a quantitative result with known and recorded precision and bias," and the LOD is "the lowest concentration for reliable reporting of a non-detect of a specific analyte in a specific medium with a specific method at 99 percent confidence" (DoD 2017). For the purposes of this PA/SI, the PSLs are defined as the compound LODs. Because PSLs are equivalent to the LODs, PSLs will vary slightly depending on batch- or sample-specific LODs reported by the laboratory for each analyte. If PFAS are detected greater than the PSLs, PFAS are present. Concentrations detected between the LOD and LOQ are estimates, and therefore, will be qualified and indicated as such on laboratory analytical reports. All soil/sediment results are to be reported in dry weight.

Media: Groundwater/Surface Water		Analytical Group: PFAS (Shealy) per DoD Quality Systems Manual (QSM; DoD 2018) 5.1.1 (or later version) Table B-15		
Analyte	CAS Number	PSL (ng/L)	Laboratory-Specific Limits	
			LOQ (ng/L)	LOD (ng/L)
Perfluorobutanoic acid (PFBA)	375-22-4	2	4	2
Perfluoropentanoic acid (PFPA)	2706-90-3	2	4	2
Perfluorohexanoic acid (PFHxA)	307-24-4	2	4	2
Perfluoroheptanoic acid (PFHpA)	375-85-9	2	4	2
Perfluorooctanoic acid (PFOA)	335-67-1	2	4	2

Media: Groundwater/Surface Water		Analytical Group: PFAS (Shealy) per DoD Quality Systems Manual (QSM; DoD 2018) 5.1.1 (or later version) Table B-15		
Analyte	**CAS Number**	**PSL (ng/L)**	**Laboratory-Specific Limits**	
			LOQ (ng/L)	**LOD (ng/L)**
Perfluorononanoic acid (PFNA)	375-95-1	2	4	2
Perfluorodecanoic acid (PFDA)	335-76-2	2	4	2
Perfluoroundecanoic acid (PFUnA)	2058-94-8	2	4	2
Perfluorododecanoic acid (PFDoA)	307-55-1	2	4	2
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	2	4	2
Perfluorotetradecanoic acid (PFTA)	376-06-7	4	8	4
Perfluorobutanesulfonic acid (PFBS)	375-73-5	2	4	2
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	2	4	2
Perfluorooctane sulfonate (PFOS)	1763-23-1	2	4	2
N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	2991-50-6	4	8	4
N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	2355-31-9	4	8	4
6:2 Fluorotelomer sulfonate	27619-97-2	4	8	4
8:2 Fluorotelomer sulfonate	39108-34-4	4	8	4

Media: Soil/Sediment		Analytical Group: PFASs (Shealy) per DoD QSM 5.1.1 (or later version) Table B-15		
Analyte	CAS Number	PSL (mg/kg)	Laboratory-Specific Limits	
			LOQ (mg/kg)	LOD (mg/kg)
Perfluorobutanoic acid (PFBA)	375-22-4	0.0005	0.001	0.0005
Perfluoropentanoic acid (PFPA)	2706-90-3	0.0005	0.001	0.0005
Perfluorohexanoic acid (PFHxA)	307-24-4	0.0005	0.001	0.0005
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.0005	0.001	0.0005
Perfluorooctanoic acid (PFOA)	335-67-1	0.0005	0.001	0.0005
Perfluorononanoic acid (PFNA)	375-95-1	0.0005	0.001	0.0005
Perfluorodecanoic acid (PFDA)	335-76-2	0.0005	0.001	0.0005
Perfluoroundecanoic acid (PFUnA)	2058-94-8	0.0005	0.001	0.0005
Perfluorododecanoic acid (PFDoA)	307-55-1	0.0005	0.001	0.0005
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.0005	0.001	0.0005
Perfluorotetradecanoic acid (PFTA)	376-06-7	0.0005	0.001	0.0005
Perfluorobutanesulfonic acid (PFBS)	375-73-5	0.0005	0.001	0.0005
Perfluorohexanesulfonic acid (PFHxS)	355-46-4	0.0005	0.001	0.0005
Perfluorooctane sulfonate (PFOS)	1763-23-1	0.0005	0.001	0.0005
N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	2991-50-6	0.0005	0.001	0.0005
N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	2355-31-9	0.0005	0.001	0.0005

Media: Soil/Sediment		Analytical Group: PFASs (Shealy) per DoD QSM 5.1.1 (or later version) Table B-15		
Analyte	CAS Number	PSL (mg/kg)	Laboratory-Specific Limits	
			LOQ (mg/kg)	LOD (mg/kg)
6:2 Fluorotelomer sulfonate	27619-97-2	0.0006	0.002	0.0006
8:2 Fluorotelomer sulfonate	39108-34-4	0.0006	0.002	0.0006

Note:
CAS – Chemical Abstract Service
mg/kg – milligram per kilogram
ng/L – nanogram per liter

QAPP ADDENDUM WORKSHEET #17: SAMPLING DESIGN AND RATIONALE

UFP-QAPP, PFAS Sampling Activities

(UFP-QAPP Manual Section 3.1.1)
(USEPA 2106-G-05 Section 2.3.1)

The DQOs for the sampling are described in **Worksheet #11** of this QAPP Addendum. This worksheet provides the detailed rationale and approach for site-specific sampling at RFAAP. This QAPP Addendum has been developed to ensure the amount, type, and quality of data are sufficient to determine which areas and environmental media are impacted with detectable levels of PFAS and refine the CSMs for each AOPI.

The planned project schedule to complete the PA/SI for RFAAP is provided in **Worksheet #14 & 16** of this QAPP Addendum. The mobilization schedule will be determined upon the finalization of this QAPP Addendum. Necessary permits, forms, or other project documentation, subcontracts, or project equipment will be procured before mobilization. Prior to installation access, Arcadis personnel will attend a subcontractor meeting for fieldwork personnel to obtain an unescorted badge as required by RFAAP. Before conducting intrusive activities, the location of underground utilities will be determined. Utility companies and other responsible authorities will be contacted to locate and mark the locations. No required installation-specific training or additional requirements for installation access have been identified at this time.

Environmental data will be collected as presented within this QAPP Addendum and in accordance with the field SOPs provided in Appendix A to the PQAPP at the locations defined in **Worksheet #18** and on **Figures 4 through 9** of this QAPP Addendum, along with the QC sample requirements listed in **Worksheet #20** of this QAPP Addendum. Components of some SOPs may require modification or be superseded by the PFAS TGI (P-10 in Appendix A to the PQAPP) and/or PFAS Sampling and Analysis White Paper (Appendix B to the PQAPP) to accommodate PFAS-specific sampling requirements (Arcadis 2019). The sampling methods described in the SOPs establish equipment requirements; procedures for equipment and containers before sampling; sampling procedures under various conditions; equipment blank samples and field duplicate collection requirements; and requirements for storing samples to ensure that sample contamination does not occur during collection, transport, and analysis.

All field activities will be conducted in accordance with the approved Programmatic Accident Prevention Plan (Arcadis 2018) and SSHP. IDW (including soil cuttings, groundwater purged during sampling, and water from decontamination of drill tooling), which may potentially contain PFAS, will be containerized and temporarily stored at an on-post staging area approved by the installation. Confirmation samples will be sent to the lab to determine if PFAS or other site-specific contaminants of concern are present in IDW. Arcadis will procure a disposal contractor to dispose of IDW appropriately depending upon results of the confirmation sampling. The contract will dispose of IDW at an off-site location in accordance with local/state regulations. Non-IDW wastes will be removed from the AOPI immediately upon completion of each day's field activities. A post-activity inspection will be conducted by the field team lead/regional lead and SSHO identified in the this QAPP Addendum and the attached SSHP (**Attachment 2**, provided under separate cover) to ensure the location is left clean (i.e., borings filled, no trash left on-site, and/or site returned to

previous conditions to the extent possible). The investigation team will demobilize once field activities are complete.

The areas of focus for this SI were selected based on a review of historical documents and data and information obtained by conducting personal interviews during the PA; these information inputs were used to develop the preliminary CSMs provided in **Worksheet #10** and on **Figures 2 and 3** of this QAPP Addendum. Soil samples will be collected from 4 areas at the Teflon Coating Facility, Old Fire Station 1, Old Ladder Shed, Old Fire Station 2, River Warehouse, Current Fire Station, and Current Storage Shed. A sediment sample will be collected from one area at the Teflon Coating Facility near the Stroubles Creek outfall. Sediment and surface water samples will be collected from three areas at the Teflon Coating Facility and two locations on the New River. Groundwater samples will be collected from three areas at the Teflon Coating Facility and one area at Old Fire Station 2. Surface water, groundwater, and sediment will be sampled to identify PFAS presence, type (of the selected constituents as listed in **Worksheet #15** of this QAPP Addendum, including PFOS, PFOA, and PFBS), and concentrations. Soil will be sampled to identify PFAS presence, type (of the 18 selected constituents as listed in Worksheet #18 of the PQAPP, including PFOS, PFOA, and PFBS), and concentrations, as well as for TOC, pH, and grain size in one soil sample collected per AOPI. These data are collected as they may be useful in future fate and transport studies. These targeted sampling areas are believed to have the potential for the greatest PFAS concentrations closest to known releases of AFFF.

Results of the sampling will be compiled and analyzed by Arcadis and presented in a PA/SI Report. The report will summarize the field effort and present the validated sampling results, including QA/QC.

Groundwater Sampling

Groundwater samples will be collected to inform the interpretation of PFAS presence and update the individual AOPI CSMs.

- Grab groundwater samples will be collected via DPT from 3 discrete direct-push points at the Teflon Coating Facility Shallow (first encountered) groundwater will be sampled at each of these sampling points. DPT borings will be completed in accordance with the TGI for PFAS-Specific Drilling and Monitoring Well Installation (P-12 in Appendix A to the PQAPP [Arcadis 2019])
- A groundwater sample will be collected from the following existing monitoring wells: 31MW1 **Figure 6.** At existing wells monitoring wells, groundwater samples will be collected from approximately the center of the saturated screened interval. If the existing monitoring well planned to be sampled as part of the PFAS SI has dedicated, down-hole equipment, a dedicated equipment background (DEB) sample will be collected. The DEB will be used to evaluate if dedicated equipment is impacting PFAS results at the groundwater monitoring wells as it is unknown if the equipment has PFAS-containing components. However, it should be noted that if PFAS impacts are observed in the DEB, they may also be from PFAS impacts to groundwater which has become entrained in the sampling equipment. The DEB will be collected from the monitoring well when water is first produced during the initial purging of the equipment (i.e., before 1 equipment [pump and tubing] volume has been purged). The monitoring well will then be sampled for the normal parent groundwater sample via low-flow purge methods following stabilization of field parameters as described below. A lowflow peristaltic pumps will be used for purging.

Groundwater samples will be analyzed for select PFAS, and field parameters (temperature, pH, specific conductivity, dissolved oxygen, turbidity, and oxidation-reduction potential) will be measured during purging

and allowed to stabilize in accordance with the TGI for PFAS Sampling Procedures and Low-Flow Groundwater Purging for Monitoring Wells (P-11 in Appendix A to the PQAPP; Arcadis 2019) (or purged for a maximum of 20 minutes, whichever is sooner) before groundwater sampling to ensure a representative sample is collected and, potentially, to inform the interpretation of analytical data. Coordinates for each borehole's groundwater sampling location will be recorded using a handheld global positioning system (GPS). **Table 3** further describes the groundwater sampling points.

Soil Sampling

Soil samples will be collected to evaluate PFAS presence or absence at potential release areas, to evaluate the potential for those areas to be sources of PFAS to surface water and groundwater as an influence to drinking water, and to update the individual AOPI CSMs. Soil samples will be analyzed for select PFAS; TOC, pH, and grain size will be analyzed in one soil sample per AOPI (i.e., these analytes will not be analyzed for in every soil sample collected). Soil lithological descriptions will be continuously logged and will be documented on field forms. Soil samples will be collected via hand auger method in accordance with the TGI for PFAS Field Sampling (all media) (P-110 in Appendix A to the PQAPP [Arcadis 2019]) from 1 to 5 sampling points at each AOPI for a total of 22 total discrete points. (**Figures 4 through 8**). At each sampling point, the soil sample will be collected from the top 2 feet of native soil.

The soil sampling locations shown on **Figures 4 through 8** are tentative, and final coordinates will be dependent on field conditions and infrastructure (if present). Soil sampling locations will be adjusted in the field to avoid augering through concrete or asphalt, if possible. Coordinates for each soil sampling location will be recorded using a handheld global positioning system (GPS). **Table 3** further describes the soil sampling points at each AOPI.

Surface Water Sampling

Surface water samples will be collected to inform the presence or absence of PFAS in known or potential source areas. Grab surface water samples will be collected from three total locations: one at the Teflon-Coating Facility AOPI and two at the boundaries of the installation on the New River (**Figure 9**). All surface water samples will be analyzed for select PFAS, and field parameters (temperature, pH, specific conductivity, dissolved oxygen, turbidity, and oxidation-reduction potential) will be measured during surface water sampling to potentially inform the interpretation of analytical data. Coordinates for each surface water sampling location will be recorded using a handheld GPS. Where surface water samples are co-located with sediment sampling (Teflon-Coating Facility AOPI), the surface water sample will be collected before the sediment sample to reduce siltation. **Table 3** further describes the surface water sampling points.

Sediment Sampling

Sediment samples will be collected to evaluate PFAS presence or absence at known or potential release areas, to evaluate the potential for those areas to be sources of PFAS to surface water and groundwater as an influence to drinking water, and to update the individual AOPI CSMs. One sediment sample will be collected at the Teflon-Coating Facility AOPI (**Figure 4**). The sediment sample will be co-located with a surface water sample; therefore, the surface water sample will be collected first to reduce siltation. The sediment sample will be collected from the upper 10 centimeters (cms) using dedicated Lexan™ tubes or equivalent, and the sediment will be decanted before bottling for laboratory analysis of select PFAS only. Sediment descriptions will be documented on field forms. Coordinates for each sediment sampling location will be recorded using a handheld GPS. **Table 3** further describes the sediment sampling points

Table 33. Planned SI Sampling at Radford Army Ammunition Plant

AOPI Name	Planned SI Sampling
Teflon-Coating Facility **(Figure 4)**	• One shallow soil sampling point will be positioned around the Teflon-Coating Facility in upgradient of surface water flow from the AOPI. • Twogroundwater/soil sampling points will be positioned in the downgradient surface water and unconfined groundwater flow direction from the AOPI. • One additional groundwater/soil sampling location will be positioned at the Stroubles Creek outfall area for discharge of process water from the Teflon-Coating Facility. • A surface water sample will be co-located with a sediment sample at the Stroubles Creek outfall location.
Old Fire Station 1 **(Figure 5)**	• One soil sample will be collected from the top 2 feet of native soil in the center of the building footprint for the Old Fire Station 1 which has been demolished. • One soil sample will be collected at the edge of pavement in the apparent direction of surface runoff from the Old Fire Station 1. • One spring surface water sample will be collected in the downgradient groundwater flow direction from the AOPI.
Old Ladder Shed **(Figure 5)**	• One soil sample will be collected within the surface runoff flow direction of the building footprint for the Old Ladder Shed, which has been demolished. • One spring surface water sample will be collected in the downgradient groundwater flow direction from the AOPI.
Current Storage Shed **(Figure 5)**	• Two soil samples will be collected in the surface runoff flow direction from the shed. • One spring surface water sample will be collected in the downgradient groundwater flow direction from the AOPI.
Old Fire Station 2 **(Figure 6)**	• Three soil samples will be collected within potential nozzle testing or flushing areas and surface runoff flow areas. • One monitoring well sample will be collected from an existing monitoring well located near Old Fire Station 2.
River Warehouse **(Figure 7)**	• Four soil samples will be collected in the grassy area where AFFF was reported to have been sprayed near the River Warehouse

AOPI Name	Planned SI Sampling
Current Fire Station **(Figure 8)**	• Three soil samples will be collected at the edge of the pavement where fire trucks enter and exit the fire station. • One soil sample will be collected at the edge of pavement near the employee parking lot. • One spring sample will be collected from the outcrop located in the downgradient unconfined groundwater flow direction.
Installation-wide boundary sampling **(Figure 9)**	• One surface water sample will be collected at the first place where a sample can be safely collected on the New River where the river enters the installation. • One surface water sample will be collected at the installation boundary along the New River where the river exits the installation.

Laboratories

Shealy will be used for this study. PFAS analysis conducted in accordance with the DoD QSM 5.1.1 (or later version as the laboratory obtains updated certification), Table B-15 for the analytes listed in Worksheet #18 of the PQAPP and **Worksheet #15** of this QAPP Addendum. Arcadis will validate the data from the laboratory in accordance with Worksheets #34, #35, and #36 of the PQAPP. A Data Usability Summary Report will be prepared in accordance with the November 2019 Draft DoD General Data Validation Guidelines (DoD 2019b) that will review precision, accuracy, completeness, representativeness, comparability, and sensitivity of the analytical methods performed under the USACE PA/SI contract. This information will be included in a PA/SI Report.

QAPP ADDENDUM WORKSHEET #18: SAMPLING LOCATIONS AND METHODS

(UFP-QAPP Manual Section 3.1.1 and 3.1.2)
(USEPA 2106-G-05 Section 2.3.1 and 2.3.2)

The tentative sampling locations, identifications, and associated analytes and parameters are summarized below; sampling locations are depicted on **Figures 4 through 9**. Sample identifications will follow the following format:

- Parent samples: [Installation acronym]-[AOPI Name]-[sample number (out of how many samples in that medium are sampled at the AOPI)]-[medium type]-[sample depth interval if sampling groundwater or soil via hand auger in multiple intervals]-[MMDDYY].
- Field Duplicates: [Installation acronym]-FD-[Field Duplicate sample number for that medium]-[medium type]-[MMDDYY].
- Existing well: [Installation acronym]-[well name]-[MMDDYY].
- Blank QC samples: [Installation acronym]-[QC sample type]-[QC sample type number]-[MMDDYY].

The group of PFAS constituents (including PFOS, PFOA, and PFBS) noted for analysis for soil, surface water, and sediment samples in the table below is summarized for all media in **Worksheet #15** of this QAPP Addendum. **Worksheet #17** of this QAPP Addendum describes the rationale for the various sampling locations and media. Field activities and sampling procedures will be conducted in accordance with the TGI and SOP documents in Appendix A to the PQAPP (Arcadis 2019). Additional information on PFAS sampling is available in the PFAS Sampling and Analysis White Paper (Appendix B to the PQAPP; Arcadis 2019). The frequency requirements for QA/QC samples noted in Worksheet #20 of the PQAPP will be met. **Worksheet #20** of this QAPP Addendum lists the number and type of QA/QC samples anticipated for each medium based on the sampling plan presented herein; however, the final number and identifications of QA/QC samples listed in the table below are to be determined (TBD) based on progression of daily field activities.

Site Location	Medium	Sample ID	Depth Interval (Approximate)	Sample Method	Sample Type	Number of Samples	Analytes
Teflon-Coating Facility	Soil	RFAAP-TEF-SO-1	Top 2 feet of native soil	Grab	N	1	PFAS, TOC, pH, grain size
		RFAAP-TEF-SO-2	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-TEF-SO-3	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-TEF-SO-4	Top 2 feet of native soil	Grab	N	1	PFAS
	Groundwater	RFAAP-TEF-GW-1	First encountered groundwater	Grab	N, FD, MS, MSD	4	PFAS, field parameters[1]
		RFAAP-TEF-GW-2	First encountered groundwater	Grab	N	1	PFAS, field parameters[1]
		RFAAP-TEF-GW-3	First encountered groundwater	Grab	N	1	PFAS, field parameters[1]
	Surface Water	RFAAP-TEF-SW-1	Mid-Stream Depth	Grab	N, FD, MS, MSD	4	PFAS, field parameters[1]
	Sediment	RFAAP-TEF-SD-1	Upper 10 cm	Grab	N, FD, MS, MSD	4	PFAS
Old Fire Station 1, Old Ladder Shed, and Current Storage Shed	Soil	RFAAP-OFS1-SO-1	Top 2 feet of native soil	Grab	N	1	PFAS, TOC, pH, grain size
		RFAAP-OFS1-SO-2	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-OFS1-SO-3	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-OFS1-SO-4	Top 2 feet of native soil	Grab	N, FD, MS, MSD	4	PFAS
		RFAAP-OFS1-SO-5	Top 2 feet of native soil	Grab	N	1	PFAS
	Surface Water	RFAAP-OFS-SW-1	Mid-stream depth	Grab	N	1	PFAS, field parameters[1]

Old Fire Station 2	Soil	RFAAP-OFS2-SO-1	Top 2 feet of native soil	Grab	N	1	PFAS, TOC, pH, grain size
		RFAAP-OFS2-SO-2	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-OFS2-SO-3	Top 2 feet of native soil	Grab	N	1	PFAS
	Groundwater	RFAAP-31MW1	Mid-Saturated Screen	Grab	N, FD, MS, MSD	1	PFAS, field parameters
		RFAAP-OFS-DEB-1	Mid-Saturated Screen, first screen volume	Grab	N	1	PFAS
River Warehouse	Soil	RFAAP-RW-SO-1	Top 2 feet of native soil	Grab	N, FD, MS, MSD	4	PFAS, TOC, pH, grain size
		RFAAP-RW-SO-2	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-RW-SO-3	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-RW-SO-4	Top 2 feet of native soil	Grab	N	1	PFAS
Current Fire Station	Soil	RFAAP-CFS-SO-1	Top 2 feet of native soil	Grab	N	1	PFAS, TOC, pH, grain size
		RFAAP-CFS-SO-2	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-CFS-SO-3	Top 2 feet of native soil	Grab	N	1	PFAS
		RFAAP-CFS-SO-4	Top 2 feet of native soil	Grab	N	1	PFAS
	Surface Water	RFAAP-CFS-SW-1	Mid-stream Depth	Grab	N	1	PFAS, field parameters[1]
Boundary Sampling	Surface Water	RFAAP-NR-SW-1	Mid-Stream Depth	Grab	N	1	PFAS, field parameters[1]
		RFAAP-NR-SW-2	Mid-Stream Depth	Grab	N	1	PFAS, field parameters[1]

QA/QC	Equipment Blank	RFAAP-EB-1-MMDDYY	(Hand Auger)	N/A	EB	1	PFAS
		RFAAP-EB-2-MMDDYY	(Stainless Steel Putty Knife)			1	PFAS
	Field Blanks	RFAAP-FB-1-MMDDYY	N/A	N/A	FB	1	PFAS
	Source Blank	RFAAP-SB-1-MMDDYY	N/A	N/A	SB	1	PFAS

Notes:
1. Field parameters will be collected in the field and include temperature, pH, specific conductivity, dissolved oxygen, turbidity, oxidation-reduction potential.

cm = centimeter
EB = equipment blank
FB = field blank
FD = field duplicate
GW = groundwater
MS = matrix spike
MSD = matrix spike duplicate
N = normal (parent)
SB = source blank
SD = sediment
SO = soil
SW = surface water

QAPP ADDENDUM WORKSHEET #20: FIELD QC SUMMARY

(UFP-QAPP Section 3.1.1 and 3.1.2)
(USEPA 2106-G-05 Section 2.3.5)

Primary and QA/QC samples will be collected during field activities as noted below at the frequencies prescribed in Worksheet #20 of the PQAPP (Arcadis 2019). FBs will be collected at a frequency of 1 per 20 primary samples (not medium-specific). SBs will be collected from each source of water used for the initial decontamination step. EBs, FB and SBs will be analyzed for PFAS only (same analyte list for soil/sediment on **Worksheet #15** of this QAPP Addendum).

Matrix	Analyte/Analytical Group	Normal Samples	FD	MS	MSD	EB	FB	SB	Total # Analyses
Groundwater	PFAS	4	1	1	1	1 per piece of relevant equipment per sampling event	1 per 20 primary samples, not medium-specific	1 per each source of water used for the initial decontamination step	TBD
Soil	PFAS	20	2	2	2	1 per piece of relevant equipment per sampling event			TBD
	TOC	5	Not Applicable (N/A)	N/A	N/A	N/A			5
	pH	5	N/A	N/A	N/A	N/A			5
	Grain size	5	N/A	N/A	N/A	N/A			5
Surface Water	PFAS	5	1	1	1	N/A			8
Sediment	PFAS	1	1	1	1	N/A			4

QAPP ADDENDUM WORKSHEET #21: FIELD SOPS

(UFP-QAPP Section 3.1.2)
(USEPA 2106-G-05 Section 2.3.2)

SOP # or Reference[1]	Title, Revision, Date, and URL (if available)	Originating Organization	SOP Option or Equipment Type (if SOP provides different options)[2]	Modified for Project? Yes/No
P-01	Quality Procedure (QP)- Field Activities Documentation, Rev. C, November 2016	Arcadis	Applies to all Arcadis field personnel.	No
P-02	SOP – Sample Chain of Custody, Rev. 1, 23 May 2017	Arcadis	Applies to all Arcadis field personnel with 40-hour HAZWOPER and DOT HazMat #1 training.	No
P-03	Health and Safety Standard – Utility Location and Clearance, Rev. 16, 17 March 2017	Arcadis	Applies to all subsurface intrusive work.	No
P-04	QP – Calibration and Control of measuring and test equipment, Rev. C, November 2016	Arcadis	Applies to all Arcadis field personnel using equipment that is capable of calibration.	No
P-05	QP - Field Sampling, Measurement, and Observation, Rev. D, October 2017	Arcadis	Applies to all Arcadis field personnel completing field sampling, measurement, and observations.	No

SOP # or Reference[1]	Title, Revision, Date, and URL (if available)	Originating Organization	SOP Option or Equipment Type (if SOP provides different options)[2]	Modified for Project? Yes/No
P-06	TGI - Soil Description, Rev. 2, 16 Feb 2018	Arcadis	Applies to all Arcadis field personnel conducting soil logging.	No
P-09	TGI – Groundwater and Soil Sampling Equipment Decontamination, Rev. 0, 23 February 2017	Arcadis	Applies to soil sampling tools; groundwater, sediment, and surface-water sampling devices; water testing instruments; downhole instruments; and other activity-specific sampling equipment.	No
P-10	TGI - Poly- and Perfluorinated Alkyl Substances (PFAS) Field Sampling (all media) Guidance, Rev. 4, 26 March 2019	Arcadis	Applies to all Arcadis field personnel collecting environmental samples for PFAS analysis. See TGI for specific equipment needs.	Yes
P-12	PFAS-Specific Drilling and Monitoring Well Installation TGI, Rev. 2, 19 December 2019 (**Attachment 4**)	Arcadis	Applies to all Arcadis field personnel sampling soil or groundwater for PFAS via hand auger, drilling or installing monitoring wells for PFAS analysis. See TGI for specific equipment needs.	Yes
P-13	TGI – Equipment and Reagent Blank Sample Collection for PFAS Analysis, Rev. 0, October 2018	Arcadis	Applies to all Arcadis field personnel completing field sampling. See TGI for specific equipment needs.	Yes
P-15	TGI – Sediment, Surface Water, and Stormwater Sample Collection for PFAS Analysis, Rev. 1, 26 March 2019	Arcadis	Applies to all Arcadis field personnel collecting sediment, surface water, and stormwater samples. See TGI for specific equipment needs.	Yes

SOP # or Reference[1]	Title, Revision, Date, and URL (if available)	Originating Organization	SOP Option or Equipment Type (if SOP provides different options)[2]	Modified for Project? Yes/No
P-16	TGI – IDW Handling and Storage, Rev. 0, 23 February 2017	Arcadis	See TGI for specific equipment needs.	No

Note:

[1]Copies of the field SOPs are included in Appendix A of the PQAPP (Arcadis 2019).
[2]For all TGIs pertaining to the collection of samples for PFAS analysis, there is concern that sampling for PFAS using sampling equipment manufactured from fluoropolymers could result in sample contamination. The materials of construction of all downhole and surface sampling and monitoring equipment — including pumps, packers, transducers, tubing, liners, valves, and wiring — should be free from polytetrafluorethylene or ethylene tetrafluoroethylene to the maximum extent practicable. In addition, well drilling procedures and completion materials should avoid the use of fluorocarbon-based lubricants, O-rings and pipe thread pastes, tapes and sealants. If possible, a confirmation letter with analytical testing results should be obtained from a manufacturer or service provider certifying that the equipment (or supplies) are free of any PFAS.

QAPP ADDENDUM WORKSHEET #22: FIELD EQUIPMENT CALIBRATION, MAINTENANCE, TESTING, AND INSPECTION

(UFP-QAPP Section 3.1.2.4)
(USEPA 2016-G-05 Section 2.3.6)

Instrument or Equipment	Description	Field Calibration Procedure	Performance Criteria	Responsible Personnel
Water Quality Meter – YSI 6-Series Multi-Parameter Instrument or Equivalent	Multi-parameter tool designed for field use with battery operation. Ranges: 0 – 14 pH -999 to +999 millivolt Oxidation-Reduction Potential -5 to 50 °Celsius 0 to 50 mg/L Dissolved Oxygen 0 to 100 mS/cm Specific Conductivity 0 to 1,000 nephelometric turbidity unit Turbidity	The unit is factory calibrated. Unit responsiveness will be checked prior to use each day with appropriate standards provided by the supplier. Unit responsiveness is checked against the solution standards provided by each manufacturer.	+/- 10% of included standard solutions with meter	Sample Collection Personnel
Turbidimeter – Hach 2100P or Equivalent	Designed for field use with battery operation. Range: 0 to 1,000 nephelometric turbidity unit	Each day prior to use, the turbidimeter is calibrated against the standard solutions provided by each manufacturer.	+/- 10% of included standard solutions with turbidimeter	Sample Collection Personnel
4-Gas Meter – MultiRAE or Equivalent	Designed for field use with battery operation. Ranges: 0 to 100% Lower Explosive Limit 0 to 100 parts per million (ppm) H_2S 0 to 30% (by vol.) O_2 0 to 2,000 ppm CO 0 to 20,000 µRem/h Gamma 0.1 to 5,000 ppm VOC	Each day prior to use, the 4-Gas Meter is calibrated against clean (ambient) air and supplier-provided standard (mixed gas cannister).	+/- 10% of included standard gas value	Sample Collection Personnel

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Figures

Quality Assurance Project Plan Addendum
USAEC PFAS Preliminary Assessment / Site Inspection
Radford Army Ammunition Plant, VA

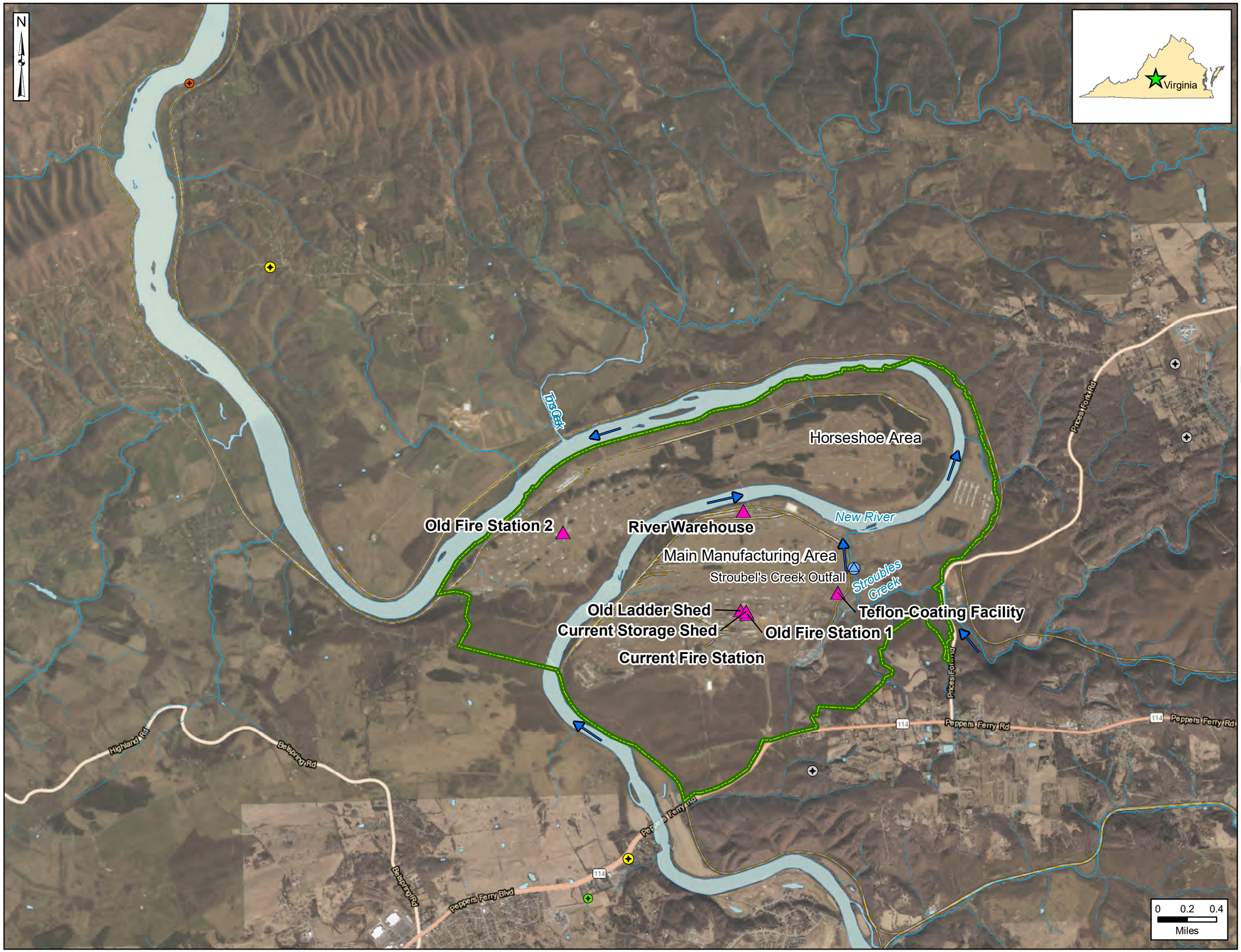


Figure 1
Radford Army Ammunition Plant
Installation Layout

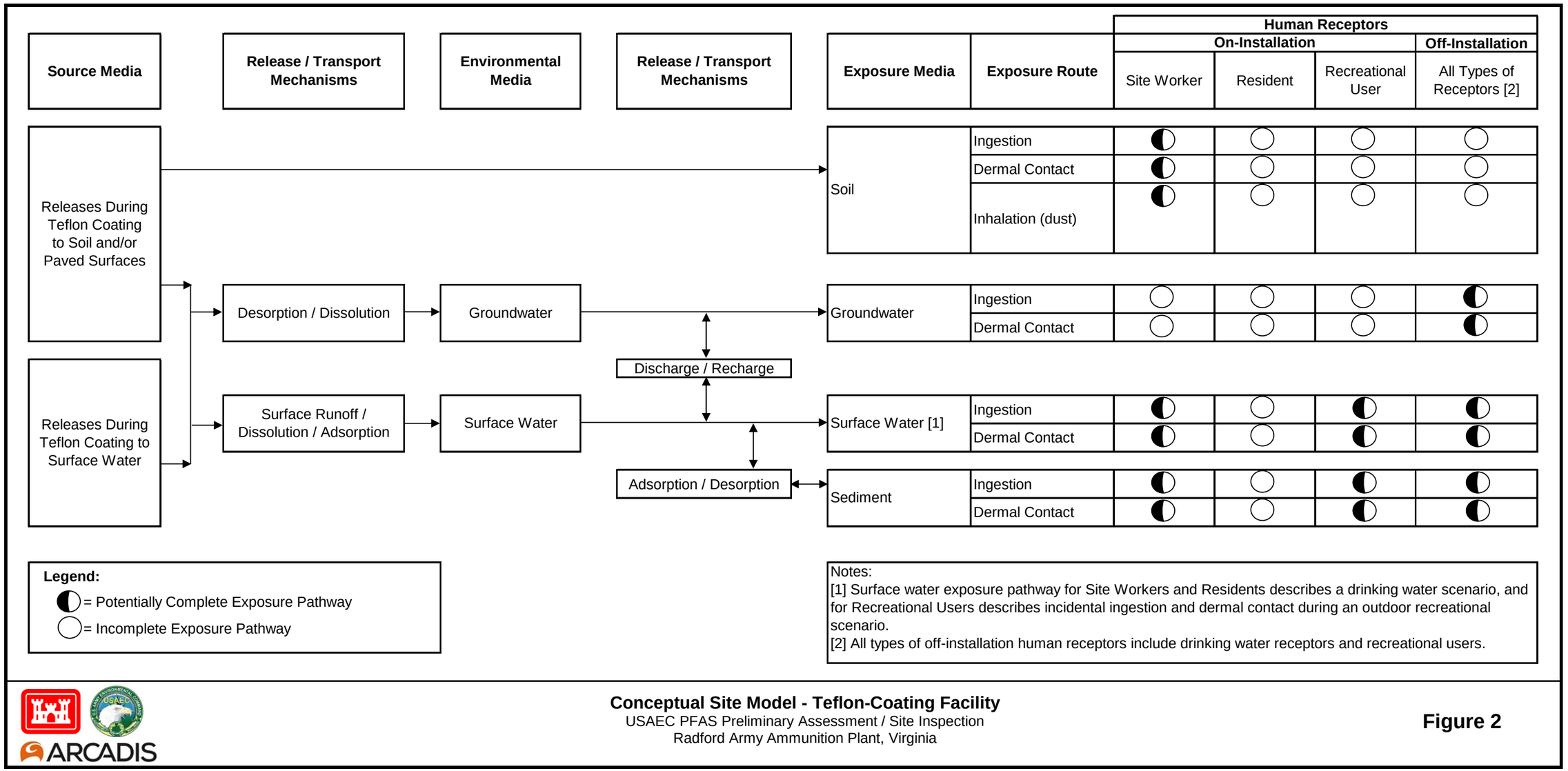
Legend

- Installation Boundary
- AOPI Location
- Surface Water Flow Direction
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- Stroubel's Creek Outfall
- Public Water Supply System Well
- Inactive Public Water System Supply Well
- State Water Well (Non-Community)
- Non-Community Water Supply System

AOPI - area of potential interest

Data Sources:
USGS, NHD Data, 2020
EDR, Well Data, 2019
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 17 North



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Conceptual Site Model - Teflon-Coating Facility
USAEC PFAS Preliminary Assessment / Site Inspection
Radford Army Ammunition Plant, Virginia

Figure 2

Source Media	Release / Transport Mechanisms	Environmental Media	Release / Transport Mechanisms	Exposure Media	Exposure Route	Human Receptors: On-Installation: Site Worker	On-Installation: Resident	On-Installation: Recreational User	Off-Installation: All Types of Receptors [2]
AFFF Releases to Soil and/or Paved Surfaces				Soil	Ingestion	◐	○	○	○
					Dermal Contact	◐	○	○	○
					Inhalation (dust)	◐	○	○	○
	Desorption / Dissolution	Groundwater		Groundwater	Ingestion	○	○	○	◐
					Dermal Contact	○	○	○	◐
			Discharge / Recharge						
	Surface Runoff / Dissolution / Adsorption	Surface Water		Surface Water [1]	Ingestion	◐	○	◐	◐
					Dermal Contact	◐	○	◐	◐
			Adsorption / Desorption	Sediment	Ingestion	◐	○	◐	◐
					Dermal Contact	◐	○	◐	◐

Legend:

◐ = Potentially Complete Exposure Pathway

○ = Incomplete Exposure Pathway

Notes:
[1] Surface water exposure pathway for Site Workers and Residents describes a drinking water scenario, and for Recreational Users describes incidental ingestion and dermal contact during an outdoor recreational scenario.
[2] All types of off-installation human receptors include drinking water receptors and recreational users.

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Conceptual Site Model - Old Fire Station 1, Old Ladder Shed, Current Storage Shed, Old Fire Station 2, River Warehouse and Current Fire Station

USAEC PFAS Preliminary Assessment / Site Inspection

Figure 3

Quality Assurance Project Plan Addendum
USAEC PFAS
Preliminary Assessment / Site Inspection
Radford Army Ammunition Plant, VA

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Figure 4
Proposed Sampling Locations for Teflon-Coating Facility AOPI

RFAAP-TEF-SW-1
RFAAP-TEF-SD-1
RFAAP-TEF-SO-1
RFAAP-TEF-GW-1
Stroubel's Creek Outfall
RFAAP-TEF-SO-3
RFAAP-TEF-GW-3
RFAAP-TEF-SO-2
RFAAP-TEF-GW-2
RFAAP-TEF-SO-4
Teflon-Coating Facility
Stroubles Creek
Price Station Rd
Radford AAP - Main Manufacturing
Pulaski
Montgomery
Peppers Ferry Rd

Legend

- Installation Boundary
- AOPI
- River/Stream (Perennial)
- Stream (Intermittent)
- Elevation Contour (feet)
- Surface Water Flow Direction
- Stroubel's Creek Outfall
- Proposed Soil Boring
- Proposed Soil/Groundwater Boring
- Proposed Surface Water / Sediment Sample Location

AOPI - area of potential interest

Note: Groundwater flow direction is inferred to be from topographically higher elevations to topographically lower regions; however, karst features may affect the groundwater flow, and the direction is not confirmed

0 25 50
Meters

Data Sources:
USGS, NHD Data, 2020
USGS, Elevation Data, 2020
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 17 North

Quality Assurance Project Plan Addendum
USAEC PFAS Preliminary Assessment / Site Inspection
Radford Army Ammunition Plant, VA

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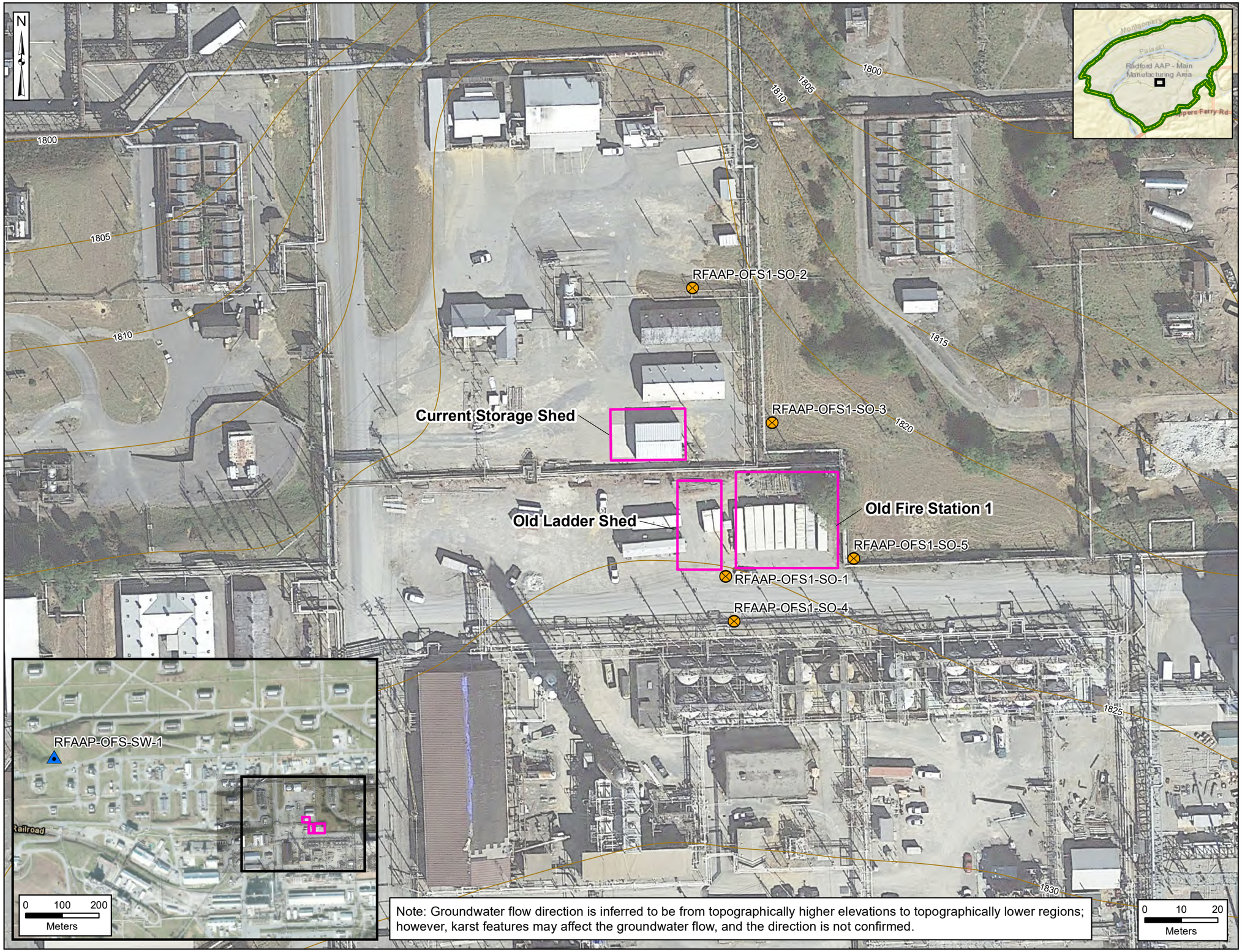
Figure 5
Proposed Sampling Locations for Old Fire Station 1, Old Ladder Shed, & Current Storage Shed AOPIs



Note: Groundwater flow direction is inferred to be from topographically higher elevations to topographically lower regions; however, karst features may affect the groundwater flow, and the direction is not confirmed.

Legend

- Installation Boundary
- AOPI
- Elevation Contour (feet)
- Proposed Soil Boring
- Proposed Surface Water Sampling Location (Spring)

AOPI - area of potential interest

Data Sources:
USGS, Elevation Data, 2020
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 17 North

Quality Assurance Project Plan Addendum
USAEC PFAS Preliminary Assessment / Site Inspection
Radford Army Ammunition Plant, VA

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Figure 6
Proposed Sampling Locations for Old Fire Station 2 AOPI

Legend

- Installation Boundary
- AOPI
- Water Body
- Elevation Contour (feet)
- Monitoring Well
- Proposed Soil Boring
- Proposed Groundwater Sampling Location (Existing Well)

AOPI - area of potential interest

Note: Groundwater flow direction is inferred to be from topographically higher elevations to topographically lower regions; however, karst features may affect the groundwater flow, and the direction is not confirmed

Data Sources:
USGS, Elevation Data, 2020
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 17 North

Quality Assurance Project Plan Addendum
USAEC PFAS Preliminary Assessment / Site Inspection
Radford Army Ammunition Plant, VA

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Figure 7
Proposed Sampling Locations for River Warehouse AOPI

Legend

- Installation Boundary
- AOPI
- Elevation Contour (feet)
- Surface Water Flow Direction
- Proposed Soil Boring

AOPI - area of potential interest

Note: Groundwater flow direction is inferred to be from topographically higher elevations to topographically lower regions; however, karst features may affect the groundwater flow, and the direction is not

Data Sources:
USGS, Elevation Data, 2020
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 17 North

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Radford Army Ammunition Plant, VA

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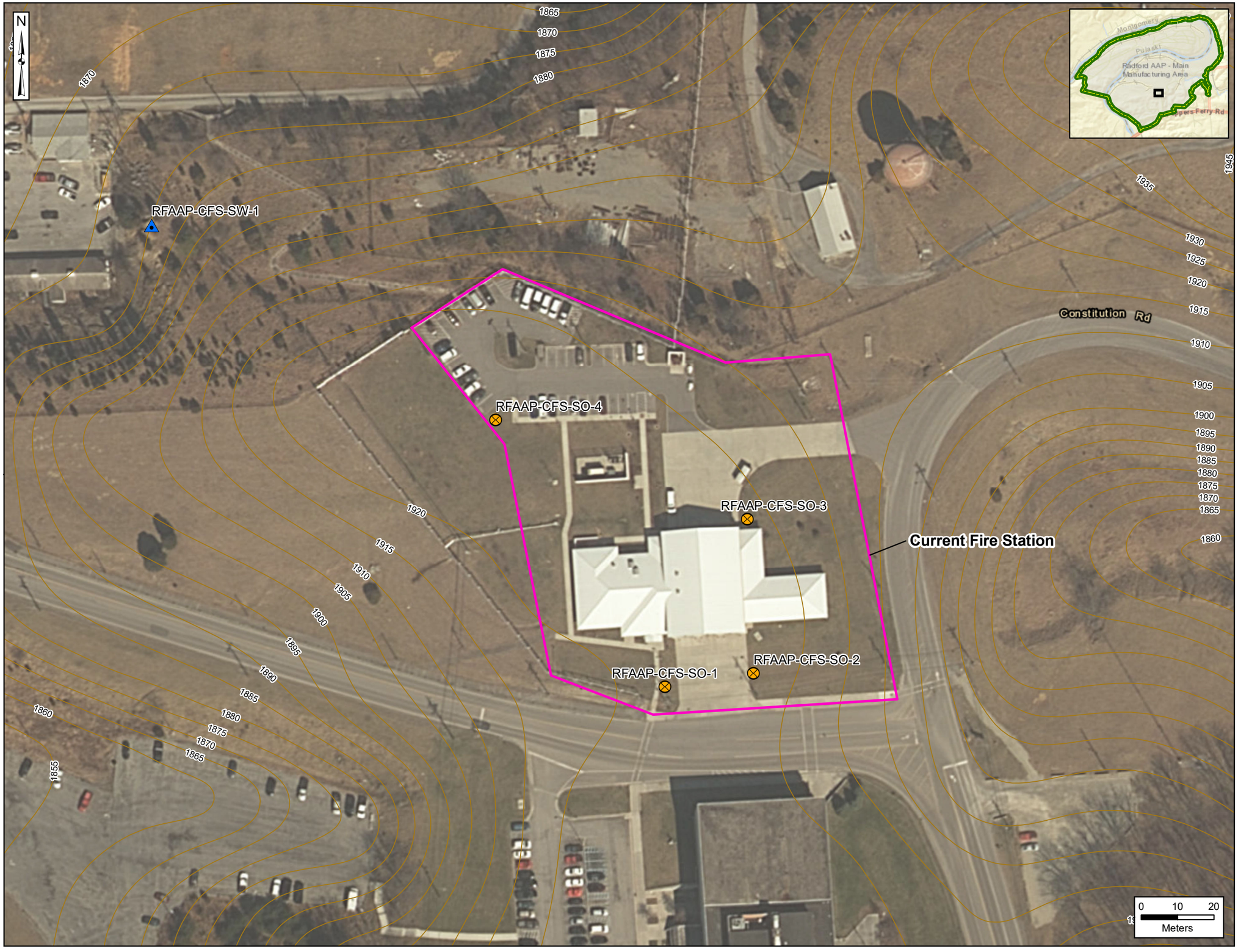
Figure 8
Proposed Sampling Locations for Current Fire Station AOPI



Legend

- Installation Boundary
- AOPI
- Elevation Contour (feet)
- Proposed Soil Boring
- Proposed Surface Water Sampling Location (Spring)

AOPI - area of potential interest

Note: Groundwater flow direction is inferred to be from topographically higher elevations to topographically lower regions; however, karst features may affect the groundwater flow, and the direction is not

Data Sources:
USGS, Elevation Data, 2020
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 17 North

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Figure 9
Proposed Surface Water Sampling Locations

Legend

- Installation Boundary
- AOPI Location
- Surface Water Flow Direction
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- Stroubel's Creek Outfall
- Proposed Surface Water Sample Location

AOPI - area of potential interest

Data Sources:
USGS, NHD Data, 2020
ESRI ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 17 North

Attachment 1

Project Planning Session Summaries

RECORD OF MEETING

ARCADIS Design & Consultancy for natural and built assets

Subject:

KICK-OFF AND SCOPING CALL

PFAS Site Inspection

Radford Army Ammunition Plant, Virginia

Participants:

Jim McKenna, Radford
Mary Ellen Maly, USAEC
Melissa Lincoln, BAE Systems
Cliff Opdyke, USACE, Baltimore
Nicole Walworth, USACE, Baltimore

Lauren Henderson, Arcadis
Courtney Ingersoll, Arcadis
Johnsie Lang, Arcadis
Kimmie Schrupp/Rhonda Stone, Arcadis
Jason Artrip, Arcadis

Meeting Date:
04 February 2020

Issue Date:
20 February 2020

MEETING SUMMARY

GOALS AND SCOPE OF THE SITE INSPECTION

- Arcadis U.S., Inc. was contracted by the U.S. Army Corps of Engineers, Baltimore District, to conduct preliminary assessments (PAs) and site inspections (SIs) for the U.S. Army Environmental Command (USAEC) on the use of per- and polyfluoroalkyl substances (PFAS) at active U.S. Army and Reserve installations nationwide.
- Eighteen PFAS chemicals will be evaluated as part of the SI process. Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are the two main compounds of interest within the PFAS group of compounds.
- The SI will be conducted because the USAEC directed the completion of SI sampling for specific areas of potential interest (AOPIs) based on the results of the PA.
- The overall objective of the SI is to evaluate the AOPIs identified during the PA process where potential release of PFAS due to aqueous film-forming foam use, chromium plating operations, or other PFAS-related sources that pose a threat to drinking water warranted further investigation. The SI goals include:
  - Determine whether each AOPI identified in the PA process represents a significant source area or directly impacts a receptor.

- Update the AOPI conceptual site models (CSMs) for human exposure through drinking water pathways based on sampling results. While other likely affected media (i.e., soil or sediment) may be sampled for presence/absence of PFAS as part of the SI besides groundwater or surface water used for drinking water, direct ingestion of drinking water is the assumed exposure route and thus the Army's primary concern for human exposure. The potential for human exposures to PFAS through non-drinking water pathways has not yet been established and may be evaluated at a future date if it is determined that those pathways warrant further consideration.

- As part of the SI process, technically defensible and useful data will be compiled to determine whether media (soil, sediment, surface water, and groundwater) associated with individual AOPIs contains detectable levels of PFAS and to refine the AOPI drinking water CSM.

- The PA program is intended to provide a consistent product for the USAEC and U.S. Army Headquarters to support decision-making regarding PFOS/PFOA issues throughout the U.S. Army. No inspections, audits, or ratings will be conducted as part of the PA program. The PA program consists of a records search, personnel interviews, and site reconnaissance to identify areas where a PFOS/PFOA release could have occurred.

Site Inspection Components

The SI process follows the PA phase of the program and includes:

- Sampling at specific AOPIs identified during the PA process.
- Development of a scope of work based on the drinking water CSMs established during the PA process.
- Development of an installation-specific Quality Assurance Project Plan Addendum, which will include the drinking water CSMs and the proposed scope of work.
- Development of a Site Safety and Health Plan for each installation.

Meeting Agenda

- Review the preliminary assessment (PA) phase findings and schedule for the site inspection (SI) phase of work
- Review the list of areas of potential interest (AOPIs) identified during the PA
- Discuss the SI phase schedule and sampling scope

Discussion Points and Meeting Decisions

1. Ms. Ingersoll provided introductions and preliminary findings of the PA
2. Ms. Henderson provided an overview of the AOPIs, the geology in the area, Potential Drinking Water Receptors, SI Schedule

3. Ms. Maly noted the QAPP schedule is quite aggressive and asked how that will that work with Radford regulators. There was a discussion on regulator engagement. Arcadis indicated regulator involvement is a decision made by the installation and is site specific. Mr. McKenna indicated he would email VDEQ and ask if they want to participate. Mr. McKenna requested external scoping slides to share with regulators.
4. Ms. Henderson provided an overview of the sample scope for the Teflon Coating Facility. Ms. Maly asked about soil sample depth. Arcadis indicated all samples would be collected as a composite sample at 0-2 feet. Ms. Maly asked if there is a regulatory definition for surface soil in VA. Mr. Mckenna asked about composite sampling and the possibility of using discrete sample methods. Ms. Maly indicated the need for a separate sample marker for the soil location in the creek.
5. Ms. Henderson provided the sample scope for the old fire station and ladder shed. There was a discussion of sampling the existing monitoring wells to the northeast of this AOPI. The group decided not to sample the monitoring wells because they are a significant distance from any AOPIs and because the direction of groundwater flow is unknown.
6. Ms. Henderson provided the sample scope for Old Fire Station 2.
   There was additional discussion about soil sample depth. Mr. McKenna asked that Arcadis add a statement to the external scoping slides about sample depth.
7. Mr. Maly asked about collecting a surface water sample from the river downgradient of all AOPIs. Ms. Lang indicated a sample should be co-collected upstream if a downstream sample is collected. The group decided to collect surface water sample from the New River at the entrance and exit of Radford AAP.
8. Mr. Artrip led a discussion on field work coordination. Ms. Lincoln indicated all the areas are accessible without escort once you are badged into the facility. Mr. McKenna indicated IDW has to be drummed including soil cuttings. He will provide information on IDW storage when Arcadis comes to get badge access. Ms. Lincoln indicated Radford AAP can provide temporary storage for soil cuttings and water could be treated at WWTP onsite. Mr. McKenna indicated the Restoration Advisory Board is an additional stakeholder. He will provide them with external scoping slides Arcadis sends for their website. Ms. Stone indicated the project does not include a programmatic review with OPSEC, so it is up to the installation to engage them. The installation is responsible for engaging with PAO.

ACTION ITEMS

1. Arcadis will provide a version of the scoping slides to share externally with regulators. These slides will include information about soil sample depth and clarifications about sample markers at the Teflon Coating Facility. The existing GW monitoring wells will be removed from the slides and two surface water sample locations will be added on the New River.

Attachment 2

Site Safety and Health Plan (provided under separate cover).

Attachment 3

Office of the Secretary of Defense. 2019. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. October 15.

ASSISTANT SECRETARY OF DEFENSE
3500 DEFENSE PENTAGON
WASHINGTON, DC 20301-3500

OCT 15 2019

SUSTAINMENT

MEMORANDUM FOR ASSISTANT SECRETARY OF THE ARMY (INSTALLATIONS, ENERGY AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY (ENERGY, INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE (INSTALLATIONS, ENVIRONMENT AND ENERGY)
DIRECTOR, NATIONAL GUARD BUREAU (JOINT STAFF, J8)
DIRECTOR, DEFENSE LOGISTICS AGENCY (INSTALLATION SUPPORT)

SUBJECT: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program

The Department of Defense (DoD) conducts cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Defense Environmental Restoration Program (DERP). Our goal is protection of human health and the environment in a risk-based, fiscally-sound manner. This memorandum provides clarifying technical guidance on the investigation of perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanesulfonic acid (PFBS). This guidance is applicable to investigating PFOS, PFOA, and PFBS at Environmental Restoration Account-funded, Base Realignment and Closure Account-funded, and Operation and Maintenance accounts for the National Guard-funded sites.

PFOS, PFOA, and PFBS are part of a larger class of chemicals known as per- and polyfluoroalkyl substances (PFAS). PFAS shall be addressed in the same manner as other contaminants of concern within the DERP.

Under CERCLA, site-specific regional screening levels[1] (RSLs) for PFOS and PFOA are calculated using the Environmental Protection Agency (EPA) online calculator using the oral reference dose (RfD) of 2E-05 mg/kg-day. The RSL for PFBS is calculated using the EPA Provisional Peer Reviewed Toxicity Value (PPRTV) RfD of 2E-02 mg/kg-day, or it may be read off the tables available on the EPA RSL website. The values are provided in the attachment. These RSLs should be used for screening to determine if further investigation in the remedial investigation (RI) phase is warranted or if the site can proceed to site closeout. When multiple PFAS are encountered at a site, a 0.1 factor is applied to the screening level. For example, in cases where there are multiple PFAS, the screening level for PFOS and PFOA individually in tap water is 40 parts per trillion (ppt) (0.1 x 400 ppt = 40 ppt) and for PFBS it is 40 parts per billion (40,000 ppt).

[1] For sites on the National Priorities List, the DoD Components will use the EPA site specific screening levels, if provided.

During the RI phase, the RfDs for PFOS, PFOA, and PFBS and the oral cancer slope factor (CSF) for PFOA of 0.07 $(mg/kg\text{-}day)^{-1}$ will be used to conduct site specific risk assessments in accordance with Risk Assessment Guidance for Superfund Volume I, Part A (EPA/540/1-89/002, December 1989). Site-specific risk assessment results will be used to determine if any necessary remedial actions are required in accordance with CERCLA, DERP, and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

My point of contact for this matter is Ms. Deborah Morefield at 703-571-9067 or deborah.a.morefield.civ@mail.mil.

Robert H. McMahon

Attachment:
As stated

Attachment: Risk Screening Levels Calculated for PFOS, PFOA, PFBS in Groundwater or Soil Using EPA's RSL Calculator

Chemical	Carcinogenic Slope Factor - Oral (SF) $(mg/kg\text{-}day)^{-1}$	Non-Carcinogenic Reference Dose (RfD) (mg/kg-day)	Residential Scenario Screening Levels Calculated Using EPA RSL Calculator								Industrial/Commercial Composite Worker Screening Levels Calculated Using EPA RSL Calculator			
			Tap Water (µg/L or ppb)				Soil (mg/kg or ppm)				Soil (mg/kg or ppm)			
			HQ = 0.1	HQ = 1.0	ILCR = 1E-06	ILCR = 1E-04	HQ = 0.1	HQ = 1.0	ILCR = 1E-06	ILCR = 1E-04	HQ = 0.1	HQ = 1.0	ILCR = 1E-06	ILCR = 1E-04
PFOS	NA	2.00E-05	0.040	0.40	NA	NA	0.13	1.3	NA	NA	1.6	16	NA	NA
PFOA	7.00E-02	2.00E-05	0.040	0.40	1.1	111	0.13	1.3	7.8	775	1.6	16	33	3,280
PFBS	NA	2.00E-02	40	400	NA	NA	130	1300	NA	NA	1600	16000	NA	NA

HQ=Hazard Quotient
ILCR=Incremental Lifetime Cancer Risk
NA=Not available/applicable

NOTES:

- The table represents screening levels based on residential and industrial/commercial worker receptor scenarios for either direct ingestion of groundwater (residential scenario only) or incidental ingestion of contaminated soil (both residential and composite worker scenarios).
- All values were calculated using slope factors or reference doses for PFOS and PFOA published by EPA Office of Water in support of the LHA, and default exposure assumptions for each potential receptor scenario, contained in EPA's RSL Calculator on April 6, 2018.
- Peer reviewed toxicity values considered valid for risk assessment exist for PFBS, and the screening levels may be found in EPA's RSL table or EPA's RSL calculator used to develop them.
- Other potential receptor scenarios (e.g., recreational user, site trespasser, construction worker) are not included in the above table, but could be relevant receptors at a site potentially contaminated with PFOS, PFOA and/or PFBS. These receptors, and their associated exposure scenarios, should be further considered in the scoping phase and completion of the Baseline Human Health Risk Assessment typically completed during an RI.
- The shaded values represent conservative screening levels for PFOS and PFOA in groundwater or soil that when exceeded should be considered a contaminant of potential concern in the risk assessment process and calculations of site-specific risk posed.