FINAL
Site Inspection Report
Tulsa Army Aviation Support Facility #2, Oklahoma

Site Inspection for Perfluorooctanoic acid (PFOA), Perfluorooctanesulfonic acid (PFOS), Perfluorohexanesulfonic acid (PFHxS), Perfluorononanoic acid (PFNA), Hexafluoropropylene oxide dimer acid (HFPO-DA), and Perfluorobutanesulfonic acid (PFBS) at ARNG Installations, Nationwide

May 2023

Prepared for:

Army National Guard Bureau
111 S. George Mason Drive
Arlington, VA 22204

UNCLASSIFIED

THIS PAGE INTENTIONALLY BLANK

Table of Contents

Appendices

Figures

Tables

THIS PAGE INTENTIONALLY BLANK

Acronyms and Abbreviations

%	percent
°C	degrees Celsius
°F	degrees Fahrenheit
µg/kg	micrograms per kilogram
AASF	Army Aviation Support Facility
AECOM	AECOM Technical Services, Inc.
AFFF	aqueous film-forming foam
amsl	above mean sea level
ANGB	Air National Guard Base
AOI	Area of Interest
ARNG	Army National Guard
ASTM	American Society for Testing and Materials
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CoC	chain of custody
CSM	conceptual site model
DA	Department of the Army
DoD	Department of Defense
DOT	Department of Transportation
DQO	data quality objective
DUA	data usability assessment
ELAP	Environmental Laboratory Accreditation Program
EM	Engineer Manual
FedEx	Federal Express
FTA	Fire Training Area
GPRS	Ground Penetrating Radar Systems
HDPE	high-density polyethylene
HEMTT	heavy expanded mobile tactical truck
HFPO-DA	hexafluoropropylene oxide dimer acid
IDW	investigation-derived waste
ITRC	Interstate Technology Regulatory Council
LC/MS/MS	liquid chromatography with tandem mass spectrometry
MIL-SPEC	military specification
MS	matrix spike
MSD	matrix spike duplicate
NELAP	National Environmental Laboratory Accreditation Program
ng/L	nanograms per liter
OKARNG	Oklahoma Army National Guard
OKIE811	Oklahoma 811
OSD	Office of the Secretary of Defense
OWS	oil water separator
PA	Preliminary Assessment
PFAS	per- and polyfluoroalkyl substances

PFBS	perfluorobutanesulfonic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PID	photoionization detector
PQAPP	Programmatic UFP-QAPP
PVC	polyvinyl chloride
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
SI	Site Inspection
SL	screening level
SOP	standard operating procedure
RI	Remedial Investigation
TOC	total organic carbon
TPP	Technical Project Planning
UFP	Uniform Federal Policy
US	United States
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WWTP	wastewater treatment plant

Executive Summary

The Army National Guard (ARNG) G9 is performing Preliminary Assessments (PAs) and Site Inspections (SIs) on the current or potential historical use of per- and polyfluoroalkyl substances (PFAS) with a focus on the six compounds presented in the memorandum from the Office of the Secretary of Defense (OSD) dated 6 July 2022 (Assistant Secretary of Defense, 2022). The six compounds listed in the OSD memorandum include perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), perfluorohexanesulfonic acid (PFHxS), hexafluoropropylene oxide dimer acid (HFPO-DA)[1], and perfluorobutanesulfonic acid (PFBS). These compounds are collectively referred to as “relevant compounds” throughout the document, and the applicable screening levels (SLs) are provided in **Table ES-1**.

The PA identified three Areas of Interest (AOIs) where PFAS-containing materials may have been used, stored, disposed, or released historically (see **Table ES-2** for AOI locations). The objective of the SI is to identify whether there has been a release to the environment from the AOIs identified in the PA and determine whether further investigation is warranted, a removal action is required to address immediate threats, or no further action is required based on screening levels for relevant compounds. This SI was completed at Tulsa Army Aviation Support Facility (AASF) #2 in Tulsa, Oklahoma and determined further investigation is warranted for AOI 1: Eastern Release Area and AOI 2: Western Fire Training Areas (FTAs). No further evaluation is warranted for AOI 3: Heavy Expanded Mobility Tactical Truck (HEMTT) Storage at this time. Tulsa AASF #2 will also be referred to as the “facility” throughout this document.

Tulsa AASF #2 is located at 4220 North Mingo County Expressway, approximately 9 miles northeast of downtown Tulsa, Tulsa County, Oklahoma. The approximately 42-acre facility is situated at the junction of US Highway 169 and Oklahoma Highway 266 and is northeast of Tulsa International Airport, one mile east of Tulsa Air National Guard Base. Tulsa AASF #2 was built in 1987, and the Oklahoma ARNG moved into the facility in 1989. Prior to construction, the land was previously agricultural or undeveloped land (AECOM Technical Services, Inc., 2020). The mission of AASF #2 is to support aviation equipment and machinery, as well as maintain properly trained and equipped units for mobilization. AASF #2 includes a storage hangar, maintenance hangar, HEMTT storage area, and an armory.

The PA identified three AOIs for investigation during the SI phase. SI sampling results from the three AOIs were compared to OSD SLs. **Table ES-2** summarizes the SI results for each AOI. Based on the results of this SI, further evaluation under CERCLA is warranted in a Remedial Investigation for AOI 1 and AOI 2.

[1] Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the conceptual site model (CSM) developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of military specification (MIL-SPEC) aqueous film forming foam (AFFF) and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

Table ES-1: Screening Levels (Soil and Groundwater)

Analyte[b]	Residential (Soil) (µg/kg)[a] 0-2 feet bgs	Industrial/ Commercial Composite Worker (Soil) (µg/kg)[a] 2-15 feet bgs	Tap Water (Groundwater) (ng/L)[a]
PFOA	19	250	6
PFOS	13	160	4
PFBS	1,900	25,000	601
PFHxS	130	1,600	39
PFNA	19	250	6

Notes:
bgs = below ground surface; µg/kg = micrograms per kilogram; ng/L = nanograms per liter

a.) Assistant Secretary of Defense, 2022. Risk Based Screening Levels in Groundwater and Soil using United States Environmental Protection Agency's (USEPA's) Regional Screening Level Calculator. Hazard Quotient (HQ) = 0.1. 6 July 2022.

b.) Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the CSM developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of MIL-SPEC AFFF and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

Table ES-2: Summary of Site Inspection Findings and Recommendations

AOI	Potential Release Area	Soil – Source Area	Groundwater – Source Area	Future Action
1	Eastern Release Areas	◐	●	Proceed to RI
2	Western FTAs	◐	●	Proceed to RI
3	HEMTT Storage	◐	N/A	No further action

Legend:
N/A = not applicable
● = detected; exceedance of the screening levels
◐ = detected; no exceedance of the screening levels
○ = not detected

1. Introduction

1.1 Project Authorization

The Army National Guard (ARNG) G9 is the lead agency in performing Preliminary Assessments (PAs) and Site Inspections (SIs) on the current or potential historical use of per- and polyfluoroalkyl substances (PFAS) with a focus on the six compounds presented in the memorandum from the Office of the Secretary of Defense (OSD) dated 6 July 2022 (Assistant Secretary of Defense, 2022). The six compounds listed in the OSD memorandum will be referred to as "relevant compounds" throughout this document and include perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perfluorohexanesulfonic acid (PFHxS), perfluorononanoic acid (PFNA), hexafluoropropylene oxide dimer acid (HFPO-DA)[1], and perfluorobutanesulfonic acid (PFBS) at ARNG facilities nationwide. The ARNG performed this SI at Tulsa Army Aviation Support Facility (AASF) #2 in Tulsa, Oklahoma. Tulsa AASF #2 is also referred to as the "facility" throughout this document.

The SI project elements were performed in compliance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; United States [US] Environmental Protection Agency [USEPA], 1980), as amended, the National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations Part 300; USEPA, 1994), and in compliance with US Department of the Army (DA) requirements and guidance for field investigations.

1.2 SI Purpose

A PA was performed at Tulsa AASF #2 (AECOM Technical Services, Inc. [AECOM], 2020) that identified three Areas of Interest (AOIs) where PFAS-containing materials may have been used, stored, disposed, or released historically. The objective of the SI is to identify whether there has been a release to the environment from the AOIs identified in the PA and determine whether further investigation is warranted, a removal action is required to address immediate threats, or no further action is required based on screening levels (SLs) for the relevant compounds.

[1] Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the conceptual site model (CSM) developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of military specification (MIL-SPEC) aqueous film forming foam (AFFF) and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

THIS PAGE INTENTIONALLY BLANK

2. Facility Background

2.1 Facility Location and Description

Tulsa AASF #2 is located at 4220 North Mingo County Expressway, Tulsa, Tulsa County, Oklahoma, approximately 9 miles northeast of downtown Tulsa. Tulsa AASF #2 encompasses approximately 47 acres of land situated at the junction of US Highway 169 and Oklahoma Highway 266. The facility is northeast of Tulsa International Airport, one mile east of the Tulsa Air National Guard Base (ANGB), across Mingo Creek (**Figure 2-1**). Tulsa AASF #2 was built in 1987, and the Oklahoma ARNG (OKARNG) moved into the facility in 1989. Prior to construction, the land was previously agricultural or undeveloped land.

The mission of AASF #2 is to support aviation equipment and machinery and maintain properly trained and equipped units ready for mobilization. The AASF includes a storage hangar, maintenance hangar, flight ramp and helicopter autorotation lane, heavy expanded mobility tactical truck (HEMTT) storage area, an armory, and support facilities (AECOM, 2020). The facility is entirely developed, with paved surfaces covering the majority of the AASF #2 footprint; however, some grassy areas surround the buildings and airfield.

2.2 Facility Environmental Setting

AASF #2 is within the geomorphic province of Claremore Cuesta Plains, which is characterized by westward dipping Pennsylvanian-aged sandstones and limestones that form cuestas between broad shale plains (Tyrl et al., 2007). The topography at the facility is relatively flat, sloping gently to the west towards Mingo Creek, with surface elevations ranging from about 600 to 610 feet above mean sea level (amsl). Mingo Creek sits roughly 20 to 30 feet lower in elevation than AASF #2 and gentle hills rises to the east (**Figure 2-2**).

The area surrounding AASF #2 is primarily commercial and industrial use, with large areas of undeveloped land abutting those properties. Several large stone quarries, one of which has been converted to use as a landfill, are located to the east of the facility. The Tulsa ANGB and Tulsa International Airport, and commercial/industrial properties associated with the airport, occupy much of the nearest developed land located 1-mile west of AASF #2. The nearest residential properties are just under 1 mile southeast of the facility.

2.2.1 Geology

The geology in the vicinity of AASF #2 is characterized by Pennsylvanian-aged rock, which dips to the west, overlain by Quaternary-aged alluvial deposits within the valleys and floodplains (Miller and Stanley, 2006; Tyrl et al., 2007). Thin alluvial deposits are present near the facility along Mingo Creek; however, the Oologah Formation is the surficial unit present at AASF #2 and is the predominant surficial unit in the region east of Mingo Creek (Miller and Stanley, 2006). The Oologah Formation is a Pennsylvanian-aged grayish limestone, with intervals of sandstone or fossiliferous shale ranging up to 110 feet-thick (Miller and Stanley, 2006). As the surficial unit beneath the facility, the Oologah Formation is shallow, within 5 to 10 feet of the ground surface. The unconsolidated material present at the ground surface on AASF #2 is made up of mostly fill, brought onsite during construction of the facility, as noted by AASF personnel, or the uppermost weathered section of the Oologah.

The Labette Formation underlies the Oologah Formation and is composed of shale and thin laminations of sandstone and limestone. The thickness of the Labette Formation in the Tulsa region ranges from 220 to 260 feet thick (Miller and Stanley, 2006). The Labette Formation is buried beneath the entire thickness of the Oologah at AASF #2, but daylights on the faces of the bluffs along Bird Creek and the Verdigris River, approximately 3 to 4 miles up-dip from the facility. The Fort Scott and Senora Formations, and older Pennsylvanian units, underlie the Labette (Miller and Stanley, 2006). Geologic units present at AASF #2 and the surrounding region are displayed on **Figure 2-3**.

Direct push borings advanced during the SI generally ranged in depth from 8 to 17 feet below ground surface (bgs), with the exception of TUL-MW002, which was advanced to a depth of 70 feet bgs. The dominant lithology of the shallow borings consisted of clay and silt. Lean clay and silt were encountered from the surface to depths ranging between 6 to 15 feet bgs. Fat clay was encountered in two borings, AOI02-01 and TUL-MW003, just above the contact with the limestone bedrock. Bedrock was encountered in all borings, at depths between 7 to 15 feet bgs. Bedrock logged at TUL-MW002 consisted of well-cemented, hard, and fossiliferous limestone from 10 feet bgs to a depth of approximately 47 feet bgs, followed by shale/wackestone and a thin interbedded sandstone to a depth of 54 feet bgs. Well-cemented, hard, and fossiliferous limestone was observed from 54 to 58 feet bgs, followed by poorly cemented wackestone from 58 to 60 feet bgs, and then the same well-cemented limestone to the terminal depth of the boring at 70 feet bgs. The shallow clayey and silty soils appear consistent with the understood presence of fill brought in to grade the facility for construction. The deeper unconsolidated material, particularly the clays, are more representative of weathered limestone. The underlying fossiliferous limestone with intervals of sandstone, wackestone, and shale is characteristic the Pennsylvanian-aged Oologah Formation known to be present beneath AASF #2. The fine-grained soils and well-cemented bedrock encountered in the subsurface below the facility may limit the transmissivity of PFAS into the deeper subsurface. Boring logs are presented in **Appendix E**.

Samples for grain size analyses were collected at three locations; AOI01-01, TUL-MW002, and AOI01-01, and analyzed via American Society for Testing and Materials (ASTM) Method D-422. The samples were collected between the surface and 6 feet bgs, which is the interval most likely to contain fill material. The results indicate that the soil samples are comprised primarily of silt (58.43 percent [%] to 72.47%), clay (9.90% to 18.05%), and fine sand (6.27% to 18.80%). Grain size results are presented in **Appendix F**.

2.2.2 Hydrogeology

There is no principal aquifer in the Tulsa area (Johnson, 1983). While groundwater exists in the Pennsylvanian rocks found at the facility, it is not ideal for groundwater resources, with most wells yielding an estimated rate of 0.5 gallons per minute. The Oologah Formation, which is stratigraphically the uppermost unit at the facility, yields small quantities of fair to poor quality water (Marcher and Bingham, 1971).

Subsurface investigative work completed at the C&D landfill, located approximately 1 mile east of the facility, indicated groundwater depths vary but are typically at the contact of the Oologah and Labette formations or the first 10 feet of the Labette Formation. The boring logs of this work indicate the contact between limestone and shale occurs around 532 to 565 feet amsl (E&E Engineering and Associates, LLC, 2018). An SI completed in 2018 at the adjacent Tulsa ANGB, located approximately 1 mile west of the facility, reported groundwater levels in soil borings and monitoring wells that ranged from 4.78 to 25 feet bgs, within the alluvial deposits present west of Mingo Creek (Leidos, 2018). Based on the findings from these previous nearby investigations and the elevation and flow patterns of nearby surface water features, the inferred groundwater flow direction at the facility is northwest.

Depths to groundwater measured in April 2021 during the SI ranged from 1.24 to 11.18 feet bgs; however, groundwater was not observed in three of the seven borings advanced, including TUL-MW002, which was advanced deep into the bedrock. No groundwater was observed in TUL-

MW002 above bedrock; therefore, drilling proceeded incrementally with the objective of identifying a transmissive zone within the bedrock where a monitoring well could be installed. Several facies changes were observed within the predominately well-cemented limestone boring, but no groundwater was encountered at the anticipated depth between 20 to 40 feet bgs, or down to the terminal depth at 70 feet bgs.

While mobilized in the field, available geologic and hydrogeologic information for the area was reevaluated by the project team along with real-time SI findings. As noted previously, the Oologah Formation is known to produce little to no groundwater. Additional sources, including the C&D landfill investigation, suggested that the first available groundwater would not likely be encountered until the underlying shale Labette Formation (E&E Engineering and Associates, LLC, 2018). Boring log data from the C&D Landfill investigation indicated the elevation of the top of the Labette Formation was projected west toward AASF #2. The data suggested the Labette Formation would be encountered at the facility at an elevation between 482 to 498 feet amsl (110 to 130 feet bgs), approximately 40 to 50 feet below the terminal depth of TUL-MW002. As discussed later in **Section 5.8**, drilling further into bedrock in order to encounter sufficient groundwater production (110 to 130 feet bgs) would not provide relevant data that are representative of impacts due to on-facility conditions. Therefore, deeper bedrock drilling was not pursued.

Groundwater elevations in the shallow borings that produced groundwater were calculated using depth to groundwater measurements and surveyed well casing elevations. Groundwater elevations were generally higher in the southern portion of the facility and lower to the north-northwest. As a result, the SI findings show an overall northwesterly groundwater flow direction (**Figure 2-4**). Groundwater availability was limited during sampling, and groundwater depths were generally observed to be approximately 1 to 2 feet above the bedrock and/or fat clay layers encountered within the soil borings. This observation suggests that the shallow groundwater flow at the facility is localized and may depend on the grade of the bedrock surface or less permeable clay units rather than regionally influenced. The availability of groundwater appeared to correlate to where the unconsolidated material was less compacted and had higher silt content that allowed some degree of infiltration for shallow groundwater production. In less permeable areas, surface water disposition is likely dominated by runoff rather than infiltration.

Within a 2.5-mile radius of the facility, there are three domestic wells whose total depths range from 21 to 197 feet bgs. Additionally, there are numerous monitoring wells at the landfills east of the facility and Tulsa ANBG to the west. Most of these monitoring wells have total depths ranging from 10 to 60 feet bgs (Oklahoma Water Resource Board, 2020). Groundwater features surrounding the facility are shown in **Figure 2-3**. The facility's drinking water is supplied by the City of Tulsa, which is sourced from surface water as described in **Section 2.2.3** below.

2.2.3 Hydrology

Surface water near AASF #2 includes Mingo Creek, located immediately to the west at an elevation approximately 20 to 30 feet below the ground surface elevation at the facility. Mingo Creek flows northward into Bird Creek, which is a tributary of the Verdigris River. The inferred surface water flow direction at the facility is northwest, eventually draining into Mingo Creek. A drainpipe leading to Mingo Creek was observed along the western facility boundary, approximately 300 feet west of AOI 1. Surface water features surrounding the facility are shown in **Figure 2-5**.

The facility's drinking water is supplied by the City of Tulsa, which acquires its water from Lake Spavinaw, Lake Eucha, and Oologah Lake. Lakes Spavinaw and Eucha are located approximately 46 and 52 miles east of the facility, respectively; Oologah Lake is about 7.5 miles northeast of the facility, on the Verdigris River upstream from its confluence from Bird Creek.

2.2.4 Climate

Climate in eastern Oklahoma is classified as humid subtropical (Oklahoma Climatological Survey, 2011). The average temperature of Tulsa is 60.7 degrees Fahrenheit (°F). Seasonally, temperatures vary from a summer average monthly high of 93 °F to a winter average monthly low of 28 °F. Average precipitation in rain Tulsa is 40.91 inches, and average snowfall is 10 inches (World Climate, 2022).

2.2.5 Current and Future Land Use

Tulsa AASF #2 encompasses approximately 47 acres of land in northeast Oklahoma, approximately 9 miles northeast of downtown Tulsa. The facility is bounded to the west by Mingo Creek and wooded land, to the east and south by commercial and industrial facilities, and to the north by undeveloped land. The facility currently includes a storage hangar, maintenance hangar, flight ramp and helicopter autorotation lane, HEMTT storage area, an armory, and support facilities. The mission of the facility is to support aviation equipment and machinery and maintain properly trained and equipped units ready for mobilization. Reasonably anticipated future land use is not expected to change from the current land use.

2.2.6 Sensitive Habitat and Threatened/ Endangered Species

The following birds, fish, insects, mammals, and reptiles are federally endangered, threatened, proposed, and/ or are listed as candidate species in Tulsa County, Oklahoma (US Fish and Wildlife Service [USFWS], 2022).

- **Birds:** Red knot, *Calidris canutus rufa* (threatened); Piping Plover, *Charadrius melodus* (threatened)
- **Fish:** Peppered chub, *Macrhybopsis tetranema* (endangered)
- **Insects:** Monarch butterfly, *Danaus plexippus* (candidate); American burying beetle, *Nicrophorus americanus* (threatened)
- **Mammals:** Tricolored bat, *Perimyotis subflavus* (under review); Little brown bat, *Myotis lucifugus* (under review); Northern long-eared bat, *Myotis septentrionalis* (threatened)
- **Reptiles:** Alligator snapping turtle, *Macrochelys temminckii* (proposed threatened)

2.3 History of PFAS Use

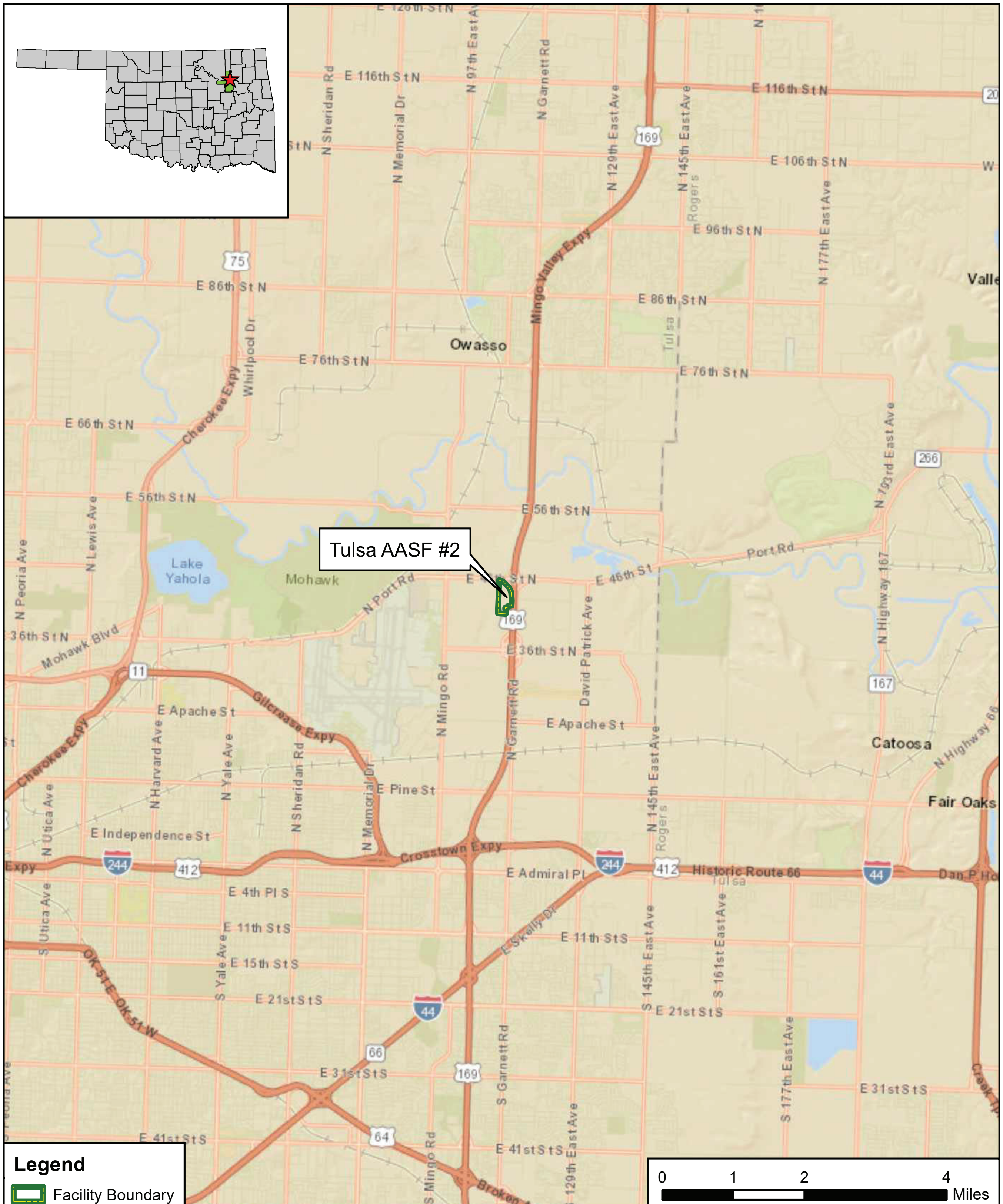
Nine potential release areas were identified at the Tulsa AASF #2 during the PA where AFFF may have been used or released historically: Tri-Max Training Area 1, Storage Hangar, Maintenance Hangar, Wash Rack, Evaporator, Building 100, Tri-Max Training Area 2, Tri-Max Training Area 3, and HEMTT Storage (AECOM, 2020).

Tulsa AASF #2 includes three fire training areas (FTAs) (Tri-Max Training Areas 1 to 3) where Tri-Max™ extinguishers were used for fire training activities from as early as the 1990s up until the early 2000s. Additionally, Tulsa AASF #2 includes two hangars, the Storage Hangar and Maintenance Hangar. In 2014, a fire suppression system was installed in the hangars. The fire suppression system conveys Buckeye Hi-Ex foam to three overhead sprayers in the Storage Hangar and two overhead sprayers in the Maintenance Hangar. The system was tested twice in 2014 after installation and resulted in PFAS draining from the Storage and Maintenance Hangars via the trench drain. In August 2014, the fire suppression system was accidentally triggered, resulting in a release of Buckeye Hi-Ex foam out of the buildings onto the ramp and grassy areas.

The Wash Rack was used to wash the Buckeye Hi-Ex foam off the helicopters after the accidental fire suppression release event. The Wash Rack effluent drains to an oil-water separator (OWS) and is then conveyed to a holding tank. Water in the holding tank is reused by the facility to wash aircraft. The excess water is burned off at the Evaporator. AFFF storage was noted at Building 100 and the HEMTT Storage.

The potential release areas were grouped into three AOIs based on proximity to one another and presumed groundwater flow. A description of each AOI is presented in **Section 3**.

THIS PAGE INTENTIONALLY BLANK



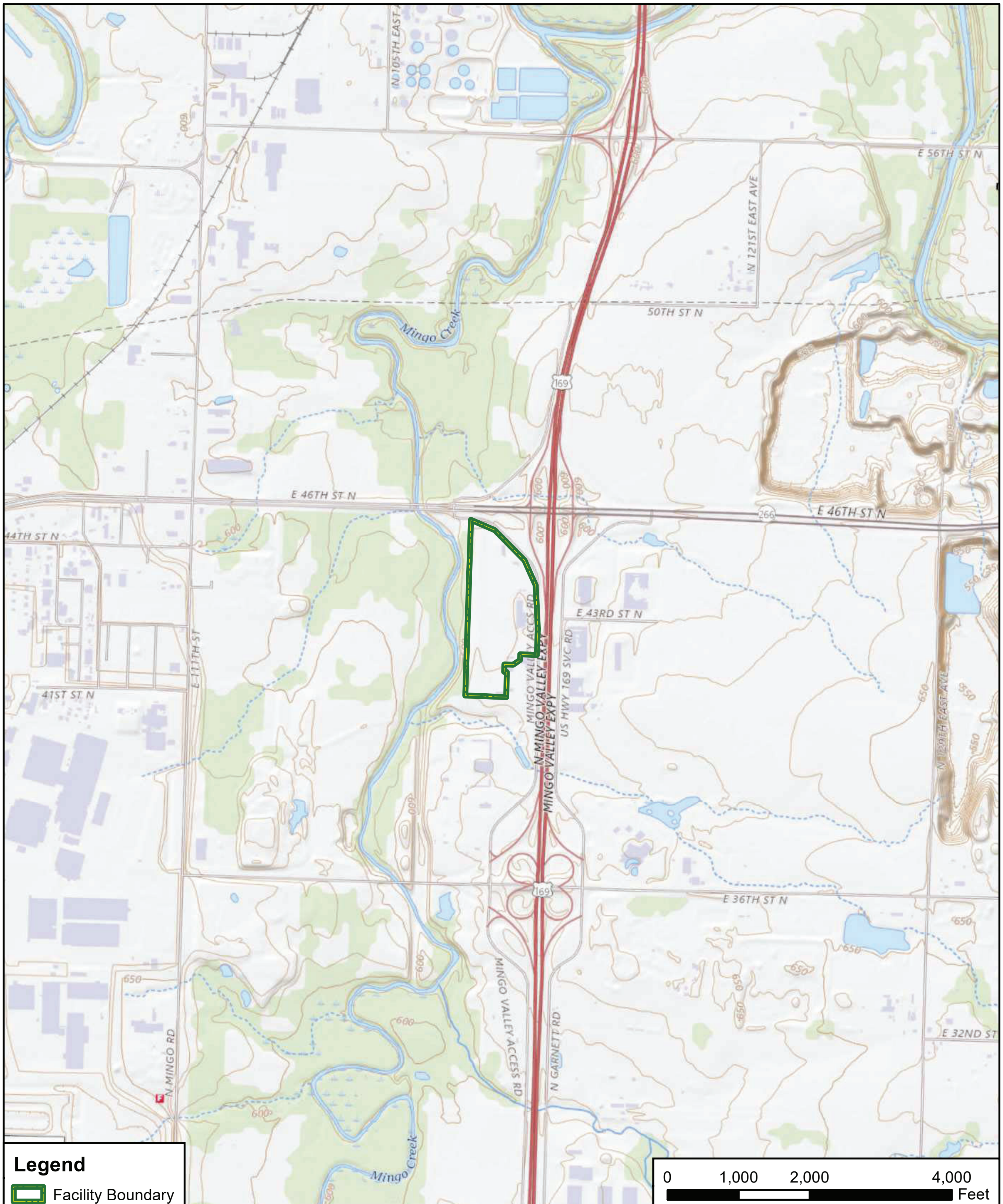
CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	9/12/2022	GIS BY	MS	9/12/2022
SCALE	1:126,720	CHK BY	VG	9/12/2022
Base Map: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI,		PM	CM	9/12/2022

N

Facility Location

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-1

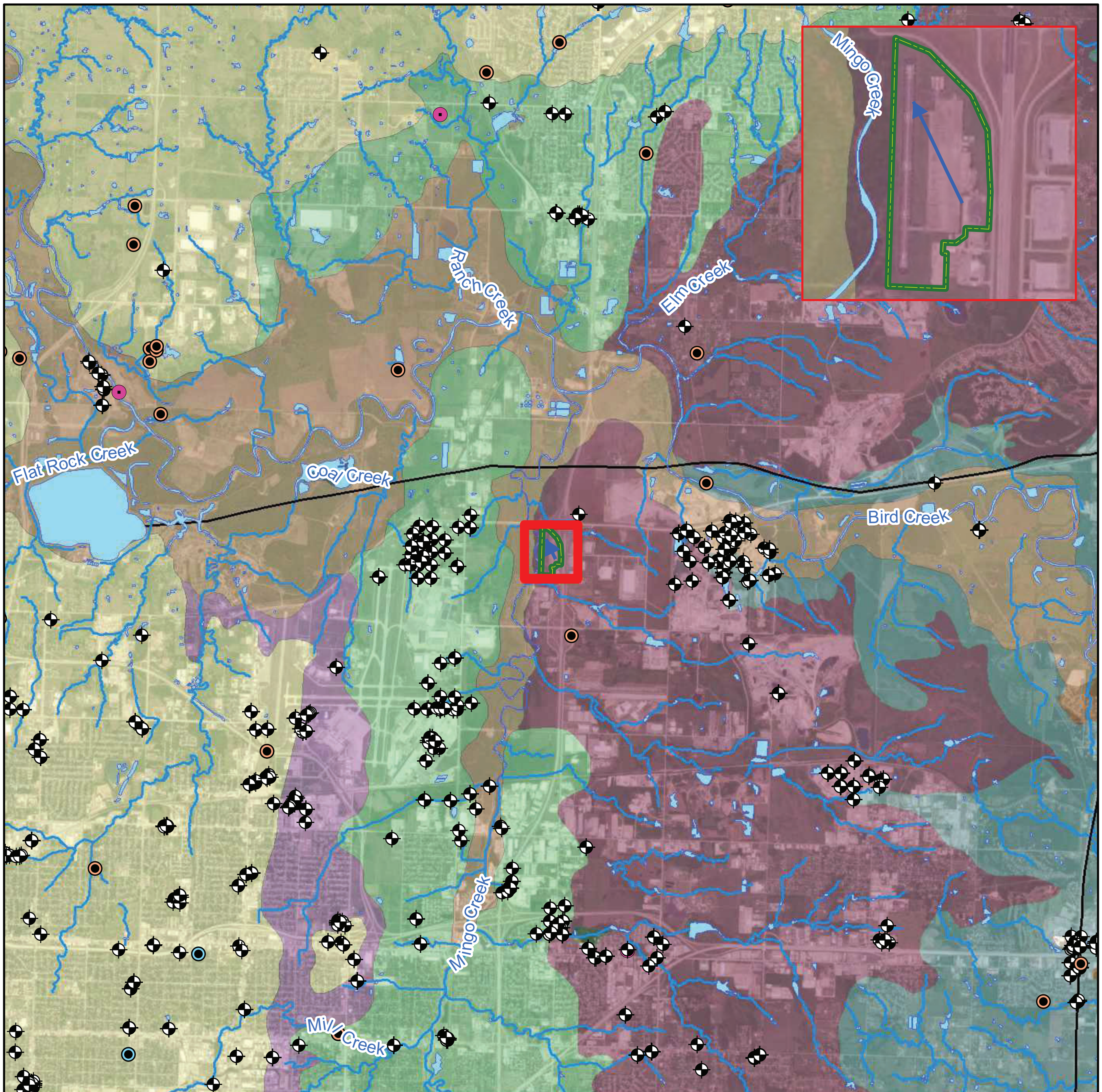


CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	9/12/2022	GIS BY	MS	9/12/2022
SCALE	1:24,000	CHK BY	VG	9/12/2022
Base Map: USGS The National Map: National Boundaries Dataset, 3DEP Elevation Program,		PM	CM	9/12/2022

Facility Topography

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-2



Facility Boundary
River/Stream
Pipeline
Water Body
Wetland
Groundwater Flow Direction

Geology
- Alluvium
- Seminole Formation
- Holdenville and Lenapah Formations
- Nowata Formation
- Oologah Formation
- Labette Formation
- Senora Formation

Wells
- Agriculture Well
- Commercial
- Domestic Well
- Observation/Monitoring Well

0 0.75 1.5 3 Miles

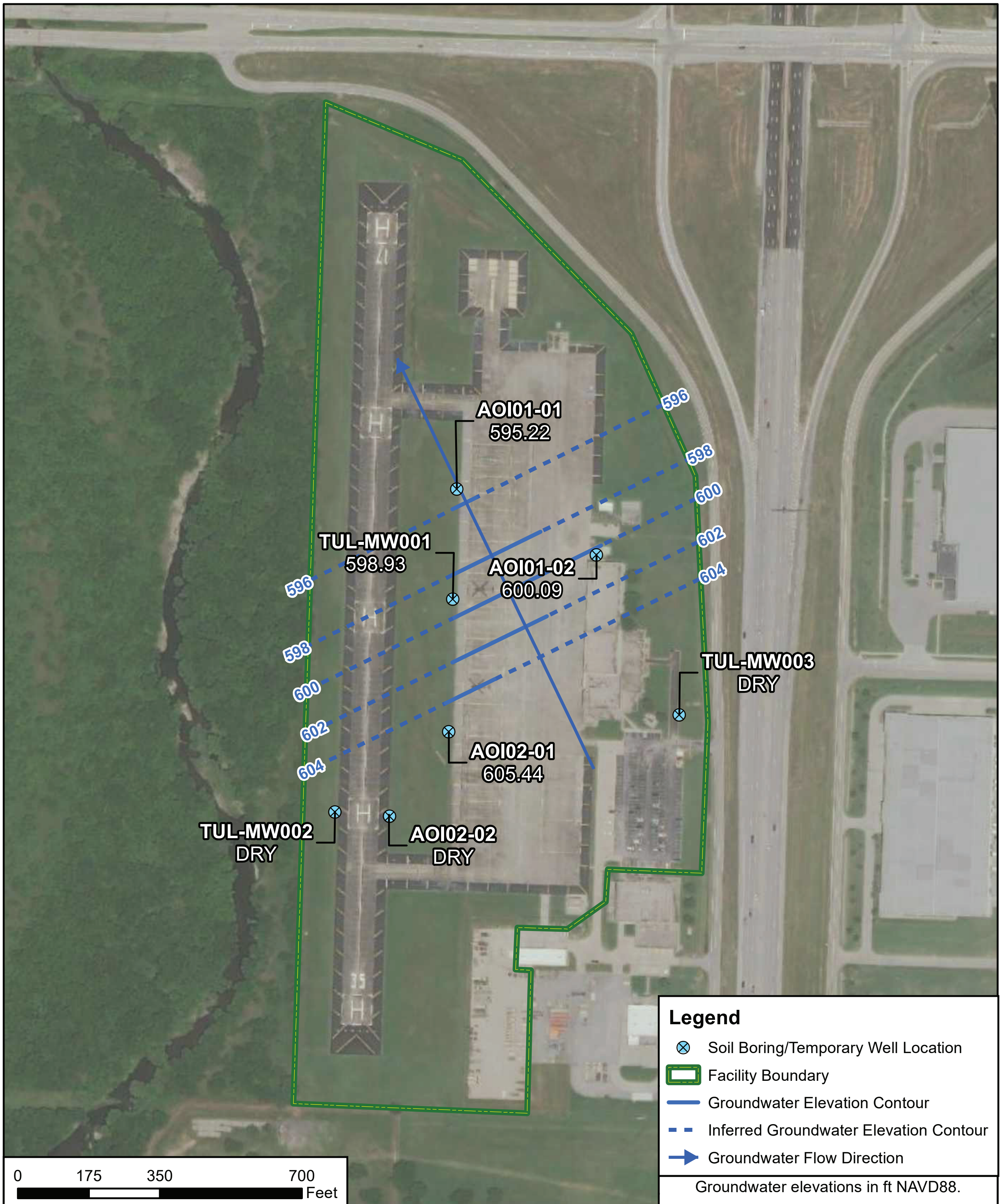
N

CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	10/10/2022	GIS BY	MS	10/10/2022
SCALE	1:95,040	CHK BY	VG	10/10/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	10/10/2022

Groundwater Features

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-3

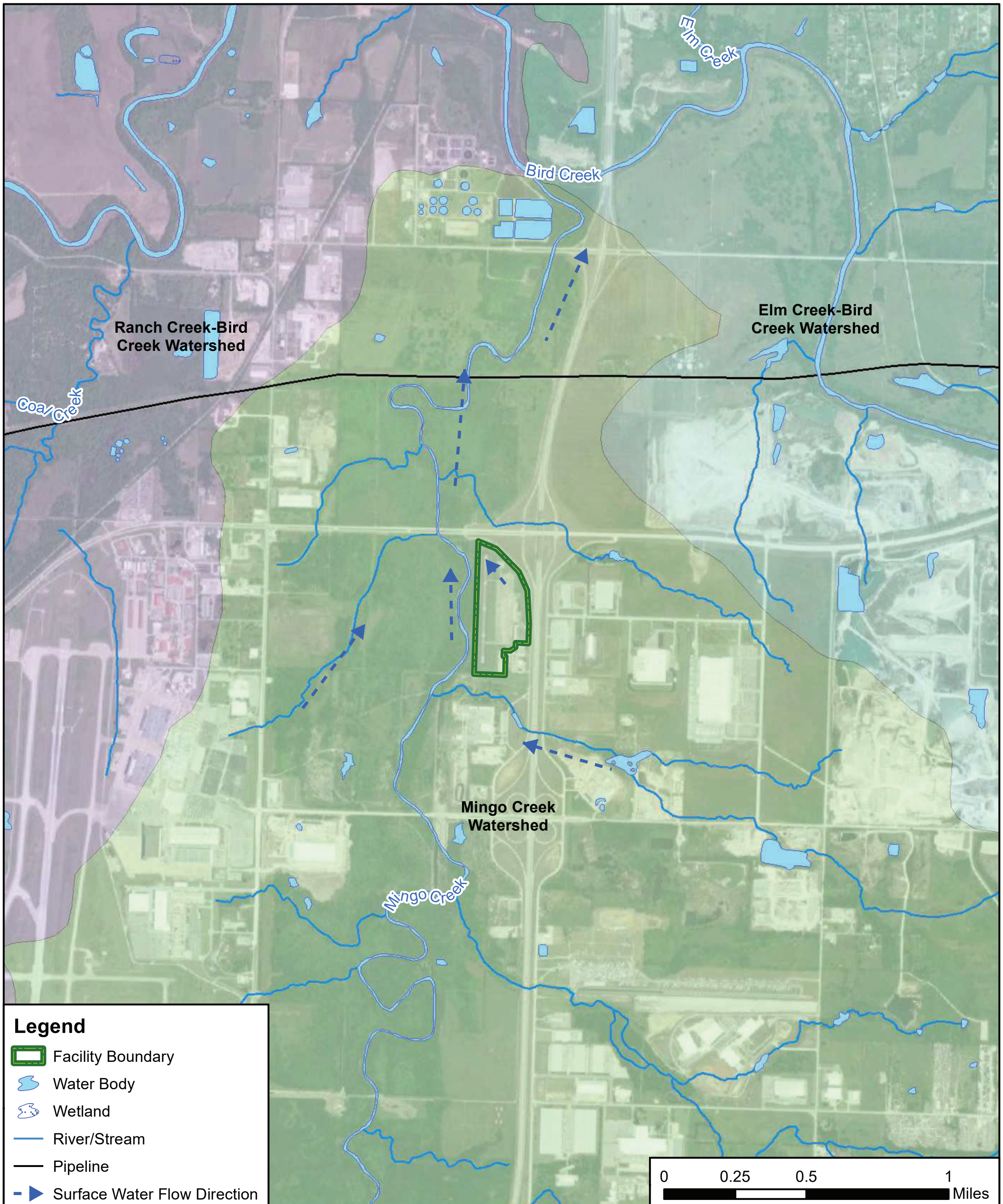


CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	10/20/2022	GIS BY	MS	10/20/2022
SCALE	1:4,200	CHK BY	VG	10/20/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	10/20/2022

Groundwater Elevations, April 2022

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-4



CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	9/12/2022	GIS BY	MS	9/12/2022
SCALE	1:31,680	CHK BY	VG	9/12/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	9/12/2022

Surface Water Features

AECOM

12420 Milestone Center Drive
Germantown, MD 20876

Figure 2-5

THIS PAGE INTENTIONALLY BLANK

3. Summary of Areas of Interest

The PA evaluated areas where PFAS-containing materials may have been used, stored, disposed, or released historically. Based on the PA findings, nine potential release areas were identified at Tulsa AASF #2 and grouped into three AOIs (AECOM, 2020). The potential release areas are shown on **Figure 3-1**.

3.1 AOI 1 Eastern Release Areas

AOI 1 consists of six potential release areas, as described below. Releases at AOI 1 have occurred on both paved areas and grassy surfaces. Some releases may have occurred directly onto surface soil but may also have infiltrated to the subsurface soil via cracks in pavement or joints between areas that are paved with different materials.

3.1.1 Tri-Max Training Area 1

Tri-Max Training Area 1 is located west of the Storage Hangar. Between the 1990s and the early 2000s, Tri-Max™ extinguishers were used for fire training activities at these locations. One training activity occurred at this location and involved the use of one extinguisher. No information was provided regarding the dates of the training events. The Tri-Max™ extinguishers were subsequently removed from use in the early 2000s.

3.1.2 Storage Hangar

The Storage Hangar is located between the Maintenance Hangar and the Evaporator. The Storage Hangar houses two 300-gallon foam tanks, located along the northern wall, and three 36-gallon manual AFFF tanks that were obtained in 2013 and are located along the north, east, and south walls. The 300-gallon foam tanks are filled with 2.2% Buckeye Hi-Ex foam. Foam is replaced by contractors. No information was provided on the disposal of AFFF and Buckeye Hi-Ex after it leaves the facility or when this occurred.

In 2014, a fire suppression system was installed that conveys Buckeye Hi-Ex foam to three overhead sprayers in the Storage Hangar and two overhead sprayers in the Maintenance Hangar; the system was tested twice after installation. During both tests, plastic was placed around both the Storage Hangar and the Maintenance Hangar to prevent foam from leaving the hangars. The first test failed because not enough foam was produced by the system, and only a small area of hangars was filled with foam. No information was provided on the type of foam used in the first test. Consequently, 2.2% Buckeye Hi-Ex foam was acquired, and a second test was conducted. The second test was successful, and the hangars filled up with 8 or 9 feet of foam. Only an estimated 5-10 gallons of Buckeye Hi-Ex foam were released during the second test. After both tests, the facility personnel let the foam settle and pushed it down to the trench drain, which transports wastewater to an OWS, then to the City of Tulsa sanitary sewer, and, eventually, to the Northside Wastewater Treatment Plant (WWTP).

In August 2014, the fire suppression system was accidentally triggered, and one of the 300-gallon foam tanks released into the Storage Hangar. Buckeye Hi-Ex foam spilled out through the Storage Hangar doors into the Maintenance Hangar and onto the ramp. Videos of the aftermath show up to around 4 feet of foam, which spread approximately 300 feet northward on the ramp and into the grassy area just north of the Storage Hangar and approximately 350 feet westward into the grassy area between the ramp and the runway. Facility personnel allowed the foam to settle and evaporate. The helicopters on the ramp that were covered by foam were washed at the Wash Rack. It is estimated that 300 gallons of Buckeye Hi-Ex foam were released during the accidental triggering of the fire suppression system.

3.1.3 Maintenance Hangar

The Maintenance Hangar is located south of the Storage Hangar and north of the Maintenance Room. Two 36-gallon AFFF tanks were obtained in 2013 and are stored in the Maintenance Hangar, one on the north side of the hangar, and one on the south side. Buckeye Hi-Ex foam filled the Maintenance Hangar to 8 or 9 feet during the second testing of the fire suppression system. Only an estimated 5-10 gallons of foam were released during the second test. Additionally, an unknown amount of Buckeye Hi-Ex foam spilled into the Maintenance Hangar during the August 2014 accidental fire suppression system release event. Any releases in the Maintenance Hangar would flow to the trench drain, then to the OWS and, eventually, to the Northside WWTP via the sanitary sewer.

3.1.4 Wash Rack

The Wash Rack is located 50 feet northwest of the Storage Hangar and west of the Evaporator. The Wash Rack was used to wash the Buckeye Hi-Ex foam off the helicopters after the accidental fire suppression release event. The Wash Rack effluent drains to an OWS and is then conveyed to a holding tank. Water in the holding tank is reused by the facility to wash aircraft. The excess water is burned off at the evaporator.

Multiple types of OWS have been used at the facility. The previous OWS system included a defoamer that conveyed the wastewater to Mingo Creek and a system that had a filter in the Petroleum, Oil, and Lubricant Storage building with an underground plate system. The current OWS is a recycle system with an evaporator and was installed in 2010. A valve on the system allows water to be discharged to nearby Mingo Creek, but this only occurs after a large rain event and once the water has been checked for a sheen. However, prior to 2010, water was discharged to the creek more frequently.

3.1.5 Evaporator

The Evaporator is located just north of the Storage Hangar. The Wash Rack effluent drains to an OWS and then to a holding tank. Any excess water is burned off at the Water Maze® Evaporator, which was installed in 2010. AFFF or Buckeye Hi-Ex foam discharged at the Wash Rack could be conveyed to the Evaporator. Solids from the wash water evaporation process are removed and disposed of by a contractor on routine basis. No information was available regarding the offsite disposal of the solid waste.

3.1.6 Building 100

Building 100 is located east of the ramp and approximately 100 feet northeast of the evaporator. Historically, 25 5-gallon buckets of AFFF were stored at this location. The buckets were donated to a local fire station at an unknown date. No information was available on the concentration or type of AFFF stored in the buckets. No leaks or spills were reported. No AFFF is currently stored in Building 100.

3.2 AOI 2 Western FTAs

AOI 2 consists of two potential release areas, as described below. Releases at AOI 2 occurred on paved surfaces and may have flowed northwestward, off the pavement, toward Mingo Creek, and potentially impacted surface soil. Additionally, AFFF may also have infiltrated subsurface soil via cracks in pavement or joints between areas that are paved with different materials

3.2.1 Tri-Max Training Areas 2 and 3

Tri-Max Training Area 2 and Tri-Max Training Area 3 are located along the ramp and landing pad. Between the 1990s and the early 2000s, Tri-Max™ extinguishers were used for fire training activities at these locations. One training activity occurred at each location and involved the use of one extinguisher. No information was provided regarding the dates of the training events. The Tri-Max™ extinguishers were subsequently removed from use in the early 2000s.

3.3 AOI 3 HEMTT Storage

AOI 3 consists of one potential release area, as described below. Any AFFF releases would have occurred on paved areas and grassy surfaces. AFFF released to the pavement could have infiltrated subsurface soil via cracks in pavement or joints between areas that are paved with different materials.

3.3.1 HEMTT Storage

HEMTT Storage is a concrete-covered area that is located north of the flight ramp. Tri-Max™ extinguishers were located at the HEMTT Storage from the 1990s to the early 2000s when the extinguishers were removed from the facility. No known or recorded leaks or spills occurred at AOI 3.

3.4 Adjacent Sources

Three potential off-facility sources of PFAS located near AASF #2, not under the control of the OKARNG, were identified during the PA and are described below. The potential adjacent sources are shown on **Figure 3-1**.

3.4.1 WWTP Sludge Spreading Area

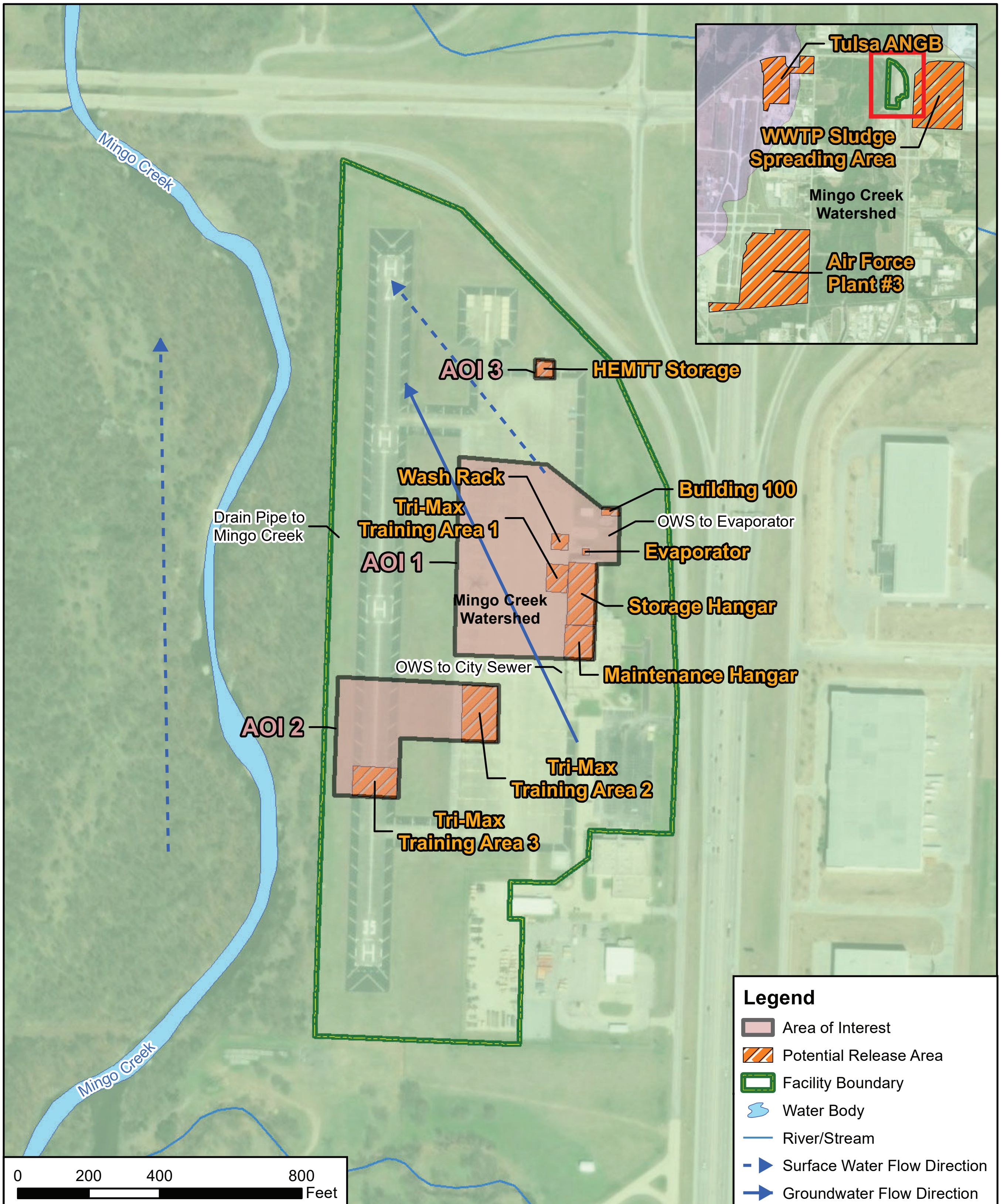
The WTTP Sludge Spreading Area is located to the east, directly across Mingo Valley Expressway. The Northside WWTP historically spread sludge at the WWTP Sludge Spreading Area. Information on when the sludge spreading practice began is unclear, but development of the area began around 2012; therefore, spreading may have ceased prior to 2012.

3.4.2 Tulsa ANGB

The Tulsa ANGB is less than 1 mile to the west of the facility. An SI report dated November 2018 identified multiple areas where AFFF was discharged. PFOA, PFOS, PFBS, PFHxS, and PFNA were detected in the soil and groundwater. In groundwater, PFOA, PFOS, PFBS, PFHxS, and PFNA were detected at maximum concentrations of 4,000 J nanograms per liter (ng/L), 44,000 J ng/L, 7,600 J ng/L, 69,000 ng/L. and 640 J ng/L, respectively (Leidos, 2018). Groundwater flow at the Tulsa ANGB was reported to be multi-directional, with both northwest and east/northeast flow directions (Leidos, 2018).

3.4.3 Air Force Plant #3

The Air Force Plant #3 is approximately 1.5 miles to the southwest of the facility, near the Tulsa International Airport. An August 2018 SI report for the Air Force Plant #3 indicated that PFOA, PFOS, PFBS, and PFHxS were detected in soil and groundwater. In groundwater, PFOA, PFOS, PFBS, and PFHxS were detected at maximum concentrations of 410 ng/L, 64 ng/L, 580 ng/L, and 11,000 ng/L, respectively (Oneida Total Integrated Enterprises, 2018). Groundwater flow direction at Air Force Plant #3 was reported to the east and southeast (Oneida Total Integrated Enterprises, 2018).



CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	3/1/2023	GIS BY	MS	3/1/2023
SCALE	1:4,800	CHK BY	VG	3/1/2023
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	3/1/2023

N

Areas of Interest

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 3-1

THIS PAGE INTENTIONALLY BLANK

4. Project Data Quality Objectives

As identified during the Data Quality Objective (DQO) process and outlined in the SI Quality Assurance Project Plan (QAPP) Addendum (AECOM, 2021), the objective of the SI is to identify whether there has been a release to the environment at the AOIs identified in the PA. For each AOI, ARNG determines if further investigation is warranted, a removal action is required to address immediate threats, or whether no further action is warranted. This SI evaluated groundwater and soil for presence or absence of relevant compounds at each of the sampled AOIs.

4.1 Problem Statement

ARNG will recommend an AOI for Remedial Investigation (RI) if related soil and groundwater samples have concentrations of the relevant compounds above the OSD risk-based SLs. The SLs are presented in **Section 6.1** of this report.

4.2 Information Inputs

Primary information inputs included:

- The PA for Tulsa AASF #2 (AECOM, 2020);
- Analytical data from groundwater and soil samples collected as part of this SI in accordance with the site-specific Uniform Federal Policy (UFP)-QAPP Addendum (AECOM, 2021); and
- Field data collected during the SI, including groundwater elevation and water quality parameters measured at the time of sampling.

4.3 Study Boundaries

The scope of the SI was bounded by the property limits of the facility (**Figure 2-2**). Off-facility sampling was not included in the scope of this SI. If future off-facility sampling is required, the proper stakeholders will be notified, and necessary rights of entry will be obtained by ARNG with property owner(s). The SI scope was bounded vertically by the observed depths of the surficial groundwater table and shallow bedrock. Temporal boundaries of the study were limited by seasonal conditions present during the Spring 2022 field work.

4.4 Analytical Approach

Samples were analyzed by Pace Analytical Gulf Coast, accredited under the Department of Defense (DoD) Environmental Laboratory Accreditation Program (ELAP; Accreditation Number 74960) and the National Environmental Laboratory Accreditation Program (NELAP; Certificate Number 01955). Data were compared to applicable SLs within this document and decision rules as defined in the SI QAPP Addendum (AECOM, 2021).

4.5 Data Usability Assessment

The Data Usability Assessment (DUA), which is provided in **Appendix A**, is an evaluation at the conclusion of data collection activities that uses the results of both data verification and validation in the context of the overall project decisions or objectives. Using both quantitative and qualitative methods, the assessment determines whether project execution and the resulting data have met installation-specific DQOs. Both sampling and analytical activities are considered to assess whether the collected data are of the right type, quality, and quantity to support the decision-making (DoD, 2019a; DoD, 2019b; USEPA, 2017).

Based on the DUA, the environmental data collected during the SI were found to be acceptable and usable for this SI evaluation with the qualifications documented in the DUA and its associated data validation reports. These data are of sufficient quality to meet the objectives and requirements of the SI QAPP Addendum (AECOM, 2021).

5. Site Inspection Activities

This section describes the environmental investigation and sampling activities that occurred as part of the SI. The SI sampling approach was based on the findings of the PA and implemented in accordance with the following approved documents:

- *Final Site Inspection Programmatic Uniform Federal Policy-Quality Assurance Project Plan (PQAPP)* dated March 2018 (AECOM, 2018a);
- *Final Programmatic Accident Prevention Plan* dated July 2018 (AECOM, 2018b);
- *Final Preliminary Assessment Report, Tulsa Army Aviation Support Facility #2, Tulsa, Oklahoma* dated October 2020 (AECOM, 2020);
- *Final Site Inspection Uniform Federal Policy-Quality Assurance Project Plan Addendum, Army Aviation Support Facility #2, Tulsa, Oklahoma* dated September 2021 (AECOM, 2021); and
- *Final Site Safety and Health Plan, Army Aviation Support Facility, Tulsa, Oklahoma* dated March 2022 (AECOM, 2022).

The SI field activities were conducted from 4 to 14 April 2022 and consisted of utility clearance, sonic drilling, soil sample collection, temporary monitoring well installation, grab groundwater sample collection, and land surveying. Field activities were conducted in accordance with the SI QAPP Addendum (AECOM, 2021), except as noted in **Section 5.8**.

The following samples were collected during the SI and analyzed for a subset of 18 compounds by liquid chromatography with tandem mass spectrometry (LC/MS/MS) compliant with Quality Systems Manual (QSM) 5.3 Table B-15 to fulfill the project DQOs:

- Twenty-six (26) soil samples from thirteen (13) locations;
- Four (4) grab groundwater samples from four (4) of six (6) temporary wells; and
- Sixteen (16) quality assurance (QA)/quality control (QC) samples.

Figure 5-1 provides the sample locations for all media across the facility. **Table 5-1** presents the list of samples collected for each media. Field documentation is provided in **Appendix B**. A Log of Daily Notice of Field Activity was completed throughout the SI field activities, which is provided in **Appendix B1**. Sampling forms are provided in **Appendix B2**, a Field Change Request Form is provided in **Appendix B3**, and land survey data are provided in **Appendix B4**. Additionally, a photographic log of field activities is provided in **Appendix C**.

5.1 Pre-Investigation Activities

In preparation for the SI field activities, project team members participated in Technical Project Planning (TPP) meetings, performed utility clearance, and sampled decontamination source water. Details for each of these activities are presented below.

5.1.1 Technical Project Planning

The US Army Corps of Engineers (USACE) TPP Process, Engineer Manual (EM) 200-1-2 (USACE, 2016) defines four phases to project planning: 1.) defining the project phase; 2.) determining data needs; 3.) developing data collection strategies; and 4.) finalizing the data collection plan. The process encourages stakeholder involvement in the SI, beginning with defining overall project objectives, including DQOs, and formulating a sampling approach to address the AOIs identified in the PA.

A combined TPP Meeting 1 and 2 was held on 18 August 2021, prior to SI field activities. The combined TPP Meeting 1 and 2 was conducted in general accordance with EM 200-1-2. The stakeholders for this SI include the ARNG, OKARNG, USACE, and Oklahoma Department of Environmental Quality. Stakeholders were provided the opportunity to make comments on the technical sampling approach and methods at the combined TPP Meeting 1 and 2. The outcome of the combined TPP Meeting 1 and 2 was memorialized in the SI QAPP Addendum (AECOM, 2021).

A TPP Meeting 3 was held on 3 April 2023 to discuss the results of the SI. Meeting minutes for TPP 3 are included in **Appendix D** of this report. Future TPP meetings will provide an opportunity to discuss the results and findings, and future actions, where warranted.

5.1.2 Utility Clearance

Both AECOM and their drilling subcontractor, Environmental Works, Inc., contacted Oklahoma 811 (OKIE811) one-call utility clearance contractor prior to mobilization to notify them of intrusive work. Because OKIE811 locators do not locate private utilities, such as those belonging to Tulsa AASF #2, AECOM contracted Ground Penetrating Radar Systems, LLC. (GPRS) to perform utility clearance for private utilities at all boring locations. GPRS performed the utility clearance under the oversight of the AECOM field team on 4 April 2022 using industry standard methods in addition to ground-penetrating radar. Additionally, the first 5 feet of each boring were pre-cleared using a hand auger to verify utility clearance in shallow subsurface where utilities would typically be encountered.

5.1.3 Source Water and Sampling Equipment Acceptability

Two potable water source samples at Tulsa AASF #2 were sampled on 26 October 2021 to assess usability for use prior to the start of field activities. Results of the samples confirmed the sources to be acceptable for use in this investigation. Specifically, the samples were analyzed by LC/MS/MS compliant with QSM 5.3 Table B-15. The results of the decontamination water samples during the SI are provided in **Appendix F**. A discussion of the results is presented in the DUA (**Appendix A**).

Materials that were used within the sampling zone were confirmed as acceptable for use in the sampling environment. The checklist of acceptable materials for use in the sampling environment was provided in the Standard Operating Procedures (SOPs) appendix to the SI QAPP Addendum (AECOM, 2021). Prior to the start of field work each day, a Sampling Checklist was completed as an additional layer of control. The checklist served as a daily reminder to each field team member regarding the allowable materials within the sampling environment.

5.2 Soil Borings and Soil Sampling

Soil samples were collected via rotary sonic (sonic) drilling technology, in accordance with the SI QAPP Addendum (AECOM, 2021). At all boring locations, with the exception of AOI02-02, a Boart Longyear™ LS™250 Minisonic™ sampling system was used to collect continuous soil cores to the target depth. A Geoprobe® 8150LS sonic sampling system replaced the original sonic rig towards the end of the SI and was used at AOI02-02 to collect continuous soil cores to the target depth. A hand auger was used to collect soil from the top 5 feet of the boring, in accordance with AECOM utility clearance procedures. The soil boring locations are shown on **Figure 5-1**, and depths are provided **Table 5-1**.

In general, three discrete soil samples were collected from the vadose zone for chemical analysis from each soil boring: one surface soil sample (0 to 2 feet bgs), one subsurface soil sample approximately 2 feet above the observed saturated soil or bedrock, and one subsurface soil sample at the mid-point between the surface and the saturated soil or bedrock. To supplement the drilled boring locations, additional surface soil samples were collected at other locations using a hand auger.

The soil cores were continuously logged for lithological descriptions by an AECOM field geologist using the Unified Soil Classification System (USCS). Rock cores, which do not have a system similar to USCS, were logged using industry accepted descriptions of rock types and characteristics. A photoionization detector (PID) was used to screen the breathing zone during boring activities as part of personal safety requirements. Observations and measurements were recorded on boring logs and in a non-treated field logbook (i.e., composition notebook). Depth interval, recovery thickness, PID concentrations, moisture, relative density, color (using a Munsell soil color chart), and texture (using the USCS) were recorded. The boring logs are provided in **Appendix E**.

Sonic borings advanced during the SI generally ranged in depth from 8 to 17 feet bgs, with the exception of TUL-MW002, which was advanced to a depth of 70 feet bgs. The dominant lithology of the borings consisted of clay and silt. Lean clay and silt were encountered from the surface to depths ranging between 6 to 15 feet bgs. Fat clay was encountered in two borings, AOI02-01 and TUL-MW003, just above the limestone bedrock contact. Bedrock was encountered in all borings below the unconsolidated soils. The geologist noted that in the deep boring at TUL-MW002, the bedrock consisted of well-cemented, hard, and fossiliferous limestone to a depth of approximately 47 feet bgs, followed by shale/wackestone, and a thin interbedded sandstone to a depth of 54 feet bgs. Well-cemented, hard, and fossiliferous limestone was observed from 54 to 58 feet bgs, followed by poorly cemented wackestone from 58 to 60 feet bgs, and then the same well-cemented, fossiliferous limestone to the terminal depth of the boring at 70 feet bgs. The shallow surface clay and silt are likely fill material used to grade the facility. The deeper unconsolidated material, particularly the clays, are likely weathered limestone. The underlying fossiliferous limestone with intervals of sandstone, wackestone, and shale are characteristic of the Pennsylvanian-aged Oologah Formation.

Each soil sample was collected into laboratory-supplied PFAS-free high-density polyethylene (HDPE) bottles and labeled using a PFAS-free marker or pen. Samples were packaged on ice and transported via Federal Express (FedEx) under standard chain of custody (CoC) procedures to the laboratory and analyzed by LC/MS/MS compliant with QSM 5.3 Table B-15, total organic carbon (TOC) (USEPA Method 9060A), pH (USEPA Method 9045D), and grain size (ASTM Method D-422) in accordance with the SI QAPP Addendum (AECOM, 2021).

Field duplicate samples were collected at a rate of 10% and analyzed for the same parameters as the accompanying samples. Matrix spike (MS)/MS duplicates (MSDs) were collected at a rate of 5% and analyzed for the same parameters as the accompanying samples. In instances when non-dedicated sampling equipment was used, such as a hand auger for the shallow soil samples, equipment rinsate blanks were collected at a rate of 5% and analyzed for the same parameters as the soil samples. A temperature blank was placed in each cooler to ensure that samples were preserved at or below 6 degrees Celsius (°C) during shipment.

The boreholes were converted to temporary wells, which were subsequently abandoned in accordance with the SI QAPP Addendum (AECOM, 2021) using bentonite chips at completion of sampling activities. Borings were installed in grass areas to avoid disturbing concrete or asphalt surfaces.

5.3 Temporary Well Installation and Groundwater Grab Sampling

Temporary wells were installed using Boart Longyear™ LS™250 Minisonic™ and Geoprobe® 8150LS sonic drill rigs. Once the borehole was advanced to the desired depth, a temporary well was constructed of a 10-foot section of 1-inch Schedule 40 poly-vinyl chloride (PVC) screen with sufficient casing to reach ground surface. The temporary wells were installed within the open borehole without the use of a sand filter pack or well seal. New PVC pipe and screen were used to avoid cross contamination between locations. The screen intervals for the temporary wells are provided in **Table 5-2**.

The temporary wells were left in place after installation to allow for groundwater infiltration before collection of groundwater samples. After the recharge period, groundwater samples were collected using a peristaltic pump with PFAS-free HDPE tubing. The temporary wells were purged at a rate determined in the field to reduce turbidity and draw down prior to sampling. Water quality parameters (e.g., temperature, specific conductance, pH, dissolved oxygen, and oxidation-reduction potential were measured using a water quality meter and recorded on the field sampling form (**Appendix B2**) before each grab sample was collected. Each sample was collected into laboratory-supplied PFAS-free HDPE bottles and labeled using a PFAS-free marker or pen. Additionally, a subsample of each groundwater sample was collected in a separate container, and a shaker test was completed to identify if there were any foaming. Light foaming was noted in the groundwater subsample collected from AOI01-01. Samples were packaged on ice and transported via FedEx under standard CoC procedures to the laboratory and analyzed by LC/MS/MS compliant with QSM 5.3 Table B-15 in accordance with the SI QAPP Addendum (AECOM, 2021). As described in detail in **Section 5.8**, several locations did not produce groundwater during the SI and, as a result, were unable to be sampled.

Field duplicate samples were collected at a rate of 10% and analyzed for the same parameters as the accompanying samples. MS/MSDs were collected at a rate of 5% and analyzed for the same parameters as the accompanying samples. One field reagent blank was collected in accordance with the PQAPP (AECOM, 2018a). A temperature blank was placed in each cooler to ensure that samples were preserved at or below 6°C during shipment.

Temporary wells were abandoned in accordance with the SI QAPP Addendum (AECOM, 2021) by removing the PVC and backfilling the hole with bentonite chips. Temporary wells were installed in grass areas to avoid disturbing concrete or asphalt.

5.4 Synoptic Water Level Measurements

A synoptic groundwater gauging event was performed on 13 April 2022. Groundwater elevations were measured in the six new temporary monitoring wells. Two wells were observed to be dry during gauging. Groundwater was measured between 1.24 to 11.18 feet bgs. A groundwater flow contour map is provided in **Figure 2-4**. Groundwater elevation data are provided in **Table 5-2**.

5.5 Surveying

The northern side of each well casing was surveyed by Oklahoma-licensed land surveyors following guidelines provided in the SOPs provided in the SI QAPP Addendum (AECOM, 2021). Survey data from the newly installed wells on the facility were collected on 13 April 2022 in the applicable Universal Transverse Mercator zone projection with World Geodetic System 84 datum (horizontal) and North American Vertical Datum 1988 (vertical). The surveyed well data are provided in **Appendix B4**.

5.6 Investigation-Derived Waste

As of the date of this report, the disposal of investigation-derived waste (IDW) is not regulated federally. IDW generated during the SI is considered non-hazardous waste and was managed in accordance with the SI QAPP Addendum (AECOM, 2021) and with the DA Guidance for Addressing Releases of PFAS, Q18 (DA, 2018).

Solid IDW (i.e., soil and rock cuttings) was generated during the SI activities from the seven boring locations. No soil IDW was generated at the surface soil sample locations. Solid IDW were containerized into four labeled 55-gallon Department of Transportation (DOT)-approved steel drums and stored in the northeast portion of the facility in the Conex box storage area, pending laboratory analysis. IDW. The soil IDW was not sampled and assumes the PFAS characteristics of the associated soil samples collected from that source location. ARNG will coordinate the transportation and disposal of the solid IDW in accordance with the Army Guidance for Addressing Releases of PFAS, Q18 (DA, 2018).

Liquid IDW generated during SI activities (i.e., purge water and decontamination fluids) were containerized in a labeled 55-gallon DOT-approved steel drums. Due to the minimal amount of IDW generated, liquid IDW from all locations was consolidated into one drum. Additionally, liquid slurry IDW (i.e., drilling fluids and soil) were containerized in a labeled 55-gallon drum. The drums were stored next to the solid IDW drums. The liquid and liquid slurry IDW were not sampled and will assume the characteristics of the associated soil samples. Based on laboratory results, containerized liquid IDW will be managed and disposed by ARNG (either by offsite disposal or onsite disposal, with treatment as appropriate) under a separate contract in accordance with *SOP No. 042A for Treating Liquid Investigation-Derived Material (Purge water, drilling water, and decontamination fluids)* (EA Engineering, Science, and Technology, Inc., 2021). ARNG will further coordinate to ensure proper disposal in accordance with state requirements and the Army Guidance for Addressing Releases of PFAS, Q18 (DA, 2018).

Other solids such as spent personal protective equipment, plastic sheeting, tubing, rope, unused monitoring well construction materials, and other environmental media generated during the field activities were disposed of at a licensed solid waste landfill.

5.7 Laboratory Analytical Methods

Samples were analyzed by LC/MS/MS compliant with QSM 5.3 Table B-15 at Pace Analytical Gulf Coast in Baton Rouge, Louisiana, a DoD ELAP and NELAP certified laboratory. Soil samples were also analyzed for TOC using USEPA Method 9060A and pH by USEPA Method 9045D.

5.8 Deviations from SI QAPP Addendum

Two deviations from the SI QAPP Addendum were identified during review of the field documentation. The deviations are noted below and are documented in Field Change Request Forms (**Appendix B3**):

- At the first borehole drilled (TUL-MW002), clay with little moisture was encountered from the surface to bedrock interface at 10 feet bgs. Bedrock cores showed a well-cemented, hard, fossiliferous limestone consistent with the Oologah Formation to 47 feet bgs, where a 3- to 4-foot-thick section of interbedded wackestone and sandstone was encountered. The hole was left open overnight at 55 feet bgs, and no groundwater infiltration was observed the following morning. The boring was then drilled to 70 feet bgs and encountered wackestone within the limestone from 58 feet bgs to 60 feet bgs. The 70-foot-deep boring was pumped dry to remove all drilling water introduced during sonic coring and left overnight. Groundwater infiltration was not observed the following day. Geologic information for the area was reevaluated along with real-time SI findings. The information suggested that groundwater was not available within the Oologah at the AASF, and that the first available groundwater would likely not be encountered until at or within the underlying shale Labette Formation, expected at a depth of around 110 to 130 feet bgs. The team concluded that groundwater at these depths would not be representative of on-facility conditions for the following reasons: 1) the unconsolidated clay and thick section of competent limestone make surface infiltration to this groundwater unlikely, and 2) the westward dipping bedrock suggests that groundwater recharge at this depth comes from areas well east of the facility, the nearest recharge likely occurring 1.5 miles east of AASF #2 in a stone quarry now operating as a landfill.

No monitoring well was installed at TUL-MW002, and the borehole was sealed with grout. The project team decided to proceed by drilling at the temporary well locations to determine if shallow groundwater was available above the bedrock elsewhere at the facility. Each location was drilled without the use of water to the bedrock contact and a temporary well casing installed. Groundwater was observed in wells AOI02-01 and AOI01-02 within several hours after installation. Based on these findings, similar temporary wells were installed at all remaining proposed well locations: TUL-MW001, TUL-MW003, and AOI02-02. Location AOI02-02 was originally a surface soil sample location but was used as a substitute well location for TUL-MW002 because of concerns for drill water or grout intrusion near the original TUL-MW002 location. AOI02-02 is considered comparable because it is located at the same release area, approximately 125 feet upgradient from TUL-MW002, across the helicopter autorotation lane.

Six shallow temporary wells were installed instead of the mix of permanent and temporary wells. Groundwater samples were collected from four locations: AOI01-01, AOI02-02, TUL-MW001, and AOI02-01. Groundwater samples were not collected where it was not observed; at AOI02-02 and background location TUL-MW003. These actions are documented in a Field Change Request form provided in **Appendix B3**.

- Borings advanced during the SI found predominantly stiff, well-compacted clayey soils with varying amounts of silt. These observations are consistent with the clay top-fill and grading activities noted by facility personnel to have been conducted during the construction of AASF #2. Groundwater availability was intermittent within this shallow unconsolidated zone above bedrock. As stated in FCR001, locations that were less compacted and had higher silt content likely allow a greater degree of infiltration for shallow groundwater production. In less permeable areas, surface water disposition is likely dominated by runoff. PFAS-containing materials released directly to the ground surface is likely to flow overland rather than infiltrate. Thus, PFAS may be more likely encountered in surface materials than in groundwater. Where infiltration is significantly limited at AASF #2, materials released directly to the ground surface likely flow overland and could concentrate in low-lying areas or flow off facility. On impervious surfaces, such as the flight ramp, runoff not captured by surface drains flows off hard surfaces to low-lying grassy areas. Ponded water on the facility then either slowly infiltrates or, more likely, eventually evaporates.

  To adapt to the evolved understanding of the conceptual site model and evaluate the possibility of PFAS concentrating in these low-lying areas within AASF #2, several surface soil samples were added to the SI sample inventory. The added samples were collected from the lowest parts of the grassy median located between the AASF helicopter autorotation lane and the flight ramp. Two of the additional samples, identified as AOI01-05 and AOI01-06, were sampled in the northern half of the median, west of the potential release areas making up AOI 1. The third sample added, AOI02-03, was collected in the low point of the swale near the two Tri-Max training areas making up AOI 2. These actions were documented in a Field Change Request form provided in Appendix B3. These actions were documented in a Field Change Request form provided in **Appendix B3**, and the sample locations are shown on **Figure 5-1**.

THIS PAGE INTENTIONALLY BLANK

Table 5-1
Site Inspection Samples by Medium
Site Inspection Report, Tulsa AASF, Oklahoma

Sample Identification	Sample Collection Date	Sample Depth (feet bgs)	LC/MS/MS QSM 5.3 Table B-15	TOC (USEPA Method 9060A)	pH (USEPA Method 9045D)	Grain Size (ASTM D-422)	Comments
Soil Samples							
AOI01-01-SB-00-02	4/5/2022	0-2	x				
AOI01-01-SB-05-06	4/8/2022	5-6	x			x	
AOI01-01-SB-8.5-9.5	4/8/2022	8.5-9.5	x				
AOI01-02-SB-00-02	4/5/2022	0-2	x				
AOI01-02-SB-00-02-D	4/5/2022	0-2	x				Duplicate
AOI01-02-SB-07-08	4/8/2022	7-8	x				
AOI01-02-SB-07-08-MS	4/8/2022	7-8	x				MS/MSD
AOI01-02-SB-07-08-MSD	4/8/2022	7-8	x				MS/MSD
AOI01-02-SB-14-15	4/8/2022	14-15	x				
AOI01-03-SB-00-02	4/5/2022	0-2	x	x	x		
AOI01-03-SB-00-02-D	4/5/2022	0-2		x	x		Duplicate
AOI01-04-SB-00-01	4/5/2022	0-1	x				
AOI01-05-SB-00-02	4/9/2022	0-2	x				
AOI01-06-SB-00-02	4/9/2022	0-2	x				
AOI02-01-SB-00-02	4/5/2022	0-2	x	x	x		
AOI02-01-SB-00-02-MS	4/5/2022	0-2		x	x		MS/MSD
AOI02-01-SB-00-02-MSD	4/5/2022	0-2		x	x		MS/MSD
AOI02-01-SB-03-04	4/8/2022	3-4	x				
AOI02-01-SB-05-06	4/8/2022	5-6	x				
AOI02-02-SB-00-02	4/4/2022	0-2	x				
AOI02-02-SB-05-06	4/13/2022	5-6	x				
AOI02-03-SB-00-02	4/9/2022	0-2	x				
AOI03-01-SB-00-02	4/5/2022	0-2	x	x	x	x	
AOI03-01-SB-00-02-D	4/5/2022	0-2	x				Duplicate
TUL-MW001-SB-00-02	4/5/2022	0-2	x				
TUL-MW001-SB-00-02-D	4/5/2022	0-2	x				Duplicate
TUL-MW001-SB-09-10	4/9/2022	9-10	x				
TUL-MW001-SB-05-06	4/9/2022	5-6	x				
TUL-MW002-SB-00-02	4/4/2022	0-2	x				
TUL-MW002-SB-00-02-MS	4/4/2022	0-2	x				MS/MSD
TUL-MW002-SB-00-02-MSD	4/4/2022	0-2	x				MS/MSD
TUL-MW002-SB-4-5	4/5/2022	4-5				x	
TUL-MW002-SB-5-6	4/5/2022	5-6	x				
TUL-MW002-SB-9-10	4/5/2022	9-10	x				
TUL-MW003-SB-00-02	4/5/2022	0-2	x				
TUL-MW003-SB-05-06	4/9/2022	5-6	x				
TUL-MW003-SB-8.5-9.5	4/9/2022	8.5-9.5	x				

Table 5-1
Site Inspection Samples by Medium
Site Inspection Report, Tulsa AASF, Oklahoma

Groundwater Samples							
AOI01-01-GW	4/10/2022	NA	x				light foam
AOI01-02-GW	4/9/2022	NA	x				
AOI02-01-GW	4/8/2022	NA	x				
AOI02-01-GW-D	4/8/2002	NA	x				Duplicate
AOI02-01-GW-MS	4/8/2022	NA	x				MS/MSD
AOI02-01-GW-MSD	4/8/2022	NA	x				MS/MSD
TUL-MW001-GW	4/10/2022	NA	x				
Blank Samples							
TUL-FRB-01	4/13/2022	NA	x				
TUL-ERB-01	4/5/2022	NA	x				Hand auger
TUL-ERB-02	4/13/2022	NA	x				Core head
TUL-DECON-01	10/26/2021	NA	x				
TUL-DECON-02	10/26/2021	NA	x				
TUL-DECON-03	4/13/2022	NA	x				

Notes:

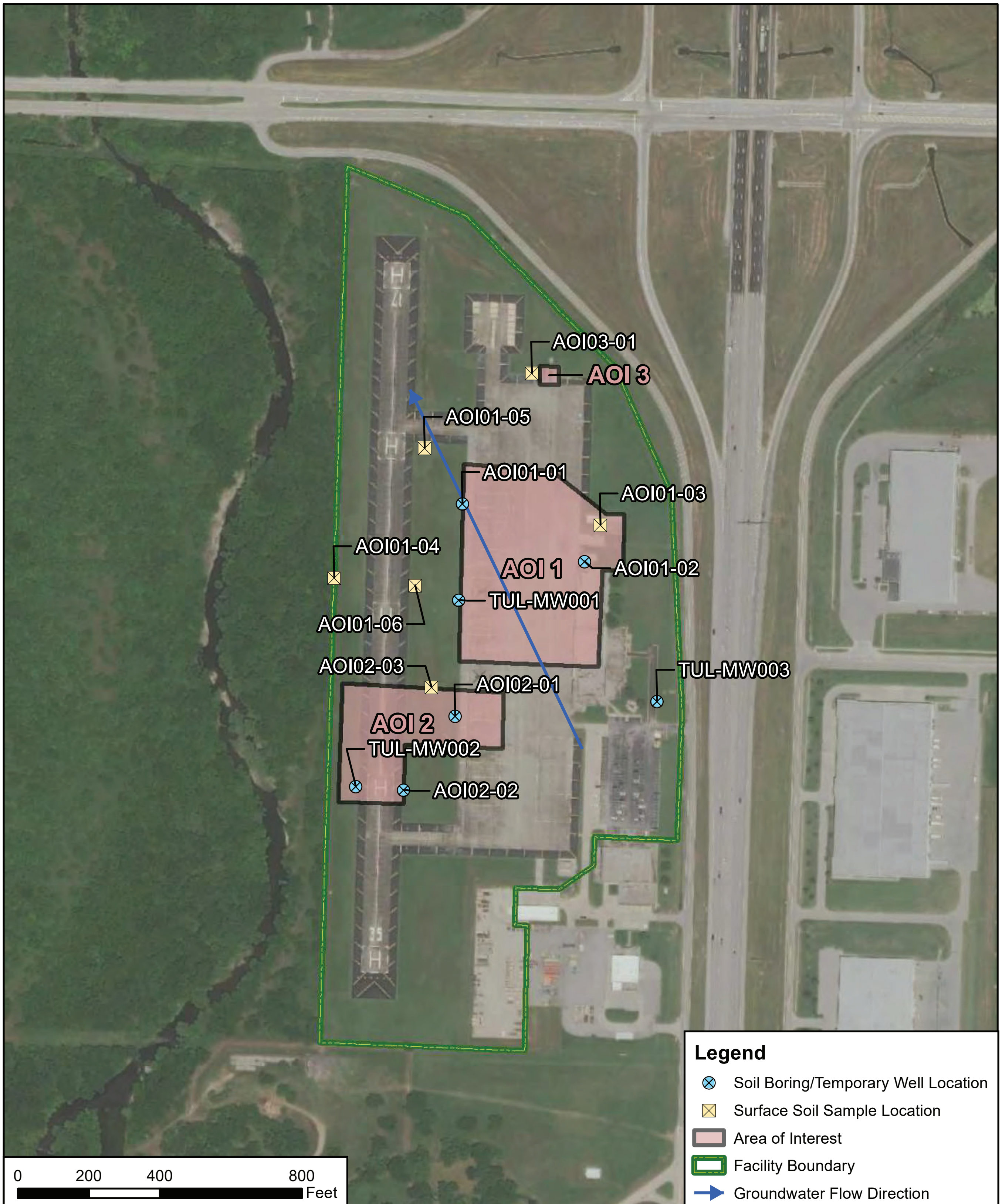
AASF = Army Aviation Support Facility
AOI = Area of Interest
bgs = below ground surface
D = duplicate
ERB - equipment blank
FRB - field reagent blank
MW = monitoring well
MS/MSD = matrix spike/matrix spike duplicate
pH = potential for hydrogen
SB = soil boring
TOC = total organic carbon
USEPA = United States Environmental Protection Agency

Table 5-2
Soil Boring Depths, Temporary Well Screen Intervals, and Groundwater Elevations
Site Inspection Report, Tulsa AASF #2, Tulsa, Oklahoma

Area of Interest	Boring Location	Soil Boring Depth (feet bgs)	Temporary Well Screen Interval (feet bgs)	Top of Casing Elevation (feet NAVD88)	Ground Surface Elevation (feet NAVD88)	Depth to Water (feet btoc)	Depth to Water (feet bgs)	Groundwater Elevation (feet NAVD88)
1	AOI01-01	11.5	1.5-11.5	607.63	606.40	12.41	11.18	595.22
	AOI01-02	17	7-17	612.11	610.68	12.02	10.59	600.09
	TUL-MW001	12	2-12	608.86	607.29	9.93	8.36	598.93
2	AOI02-01	9	0-9	607.72	606.68	2.28	1.24	605.44
	AOI02-02	8	0-8	N/A	607.93	Dry	Dry	Dry
	TUL-MW002	70	N/A	N/A	607.80	N/A	N/A	N/A
Sitewide	TUL-MW003	12	2-12	611.18	609.76	Dry	Dry	Dry

Notes:
bgs = below ground surface
btoc = below top of casing
NA = not applicable
NAVD88 = North American Vertical Datum 1988

THIS PAGE INTENTIONALLY BLANK



CLIENT	ARNG				**Site Inspection Sample Locations**
PROJECT	Site Inspection at Tulsa AASF #2, OK				
REVISED	10/10/2022	GIS BY	MS	10/10/2022	AECOM 12420 Milestone Center Drive Germantown, MD 20876 — **Figure 5-1**
SCALE	1:4,800	CHK BY	VG	10/10/2022	
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	10/10/2022	

THIS PAGE INTENTIONALLY BLANK

6. Site Inspection Results

This section presents the analytical results of the SI. The SLs used in this evaluation are presented in **Section 6.1**. A discussion of the results for each AOI is provided in **Section 6.3** through **Section 6.5**. **Table 6-2** through **Table 6-4** present results in soil or groundwater for the relevant compounds. Tables that contain all results are provided in **Appendix F**, and the laboratory reports are provided in **Appendix G**.

6.1 Screening Levels

The DoD has adopted a policy to retain facilities in the CERCLA process based on risk-based SLs for soil and groundwater, as described in a memorandum from the OSD dated 6 July 2022 (Assistant Secretary of Defense, 2022). The ARNG program under which this SI was performed follows this DoD policy. Should the maximum site concentration for sampled media exceed the SLs established in the OSD memorandum, the AOI will proceed to the next phase under CERCLA. The SLs established in the OSD memorandum apply to the five compounds presented on **Table 6-1** below.

Table 6-1: Screening Levels (Soil and Groundwater)

Analyte[b]	Residential (Soil) (µg/kg)[a] 0-2 feet bgs	Industrial/ Commercial Composite Worker (Soil) (µg/kg)[a] 2-15 feet bgs	Tap Water (Groundwater) (ng/L)[a]
PFOA	19	250	6
PFOS	13	160	4
PFBS	1,900	25,000	601
PFHxS	130	1,600	39
PFNA	19	250	6

Notes:
bgs = below ground surface; µg/kg = micrograms per kilogram; ng/L = nanograms per liter
a.) Assistant Secretary of Defense, 2022. Risk Based Screening Levels in Groundwater and Soil using United States Environmental Protection Agency's (USEPA's) Regional Screening Level Calculator. Hazard Quotient (HQ) = 0.1. 6 July 2022.
b.) Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the CSM developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of MIL-SPEC AFFF and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

The data in the subsequent sections are compared to the SLs presented in **Table 6-1**. The SLs for groundwater are based on direct ingestion. The SLs for soil are based on incidental ingestion and are applied to the depth intervals reasonably anticipated to be encountered by the receptors identified at the facility: the residential scenario is applied to surface soil results (0 to 2 feet bgs) and the industrial/commercial worker scenario is applied to shallow subsurface soil results (2 to 15 feet bgs). The SLs are not applied to deep subsurface soil results (>15 feet bgs) because 15 feet is the anticipated limit of construction activities.

6.2 Soil Physicochemical Analyses

To provide basic soil parameter information, select soil samples were analyzed for TOC, pH, and grain size, which are important for evaluating transport through the soil medium. **Appendix F** contains the results of the TOC, pH, and grain size analysis.

The data collected in this investigation will be used in subsequent investigations, where appropriate, to assess fate and transport. According to the Interstate Technology Regulatory Council (ITRC), several important partitioning mechanisms include hydrophobic and lipophobic effects, electrostatic interactions, and interfacial behaviors. At relevant environmental pH values, certain PFAS are present as organic anions and are therefore relatively mobile in groundwater (Xiao et al., 2015), but tend to associate with the organic carbon fraction that may be present in soil or sediment (Higgins and Luthy, 2006; Guelfo and Higgins, 2013). When sufficient organic carbon is present, organic carbon normalized distribution coefficients (K_{oc} values) can help in evaluating transport potential, though other geochemical factors (for example, pH and presence of polyvalent cations) may also affect PFAS sorption to solid phases (ITRC, 2018).

6.3 AOI 1

This section presents the analytical results for soil and groundwater in comparison to SLs for AOI 1: Eastern Release Areas. The soil and groundwater results are summarized on **Table 6-2** through **Table 6-4**. Soil and groundwater results are presented on **Figure 6-1** through **Figure 6-7**.

6.3.1 AOI 1 Soil Analytical Results

Surface soil was sampled from 0 to 2 feet bgs at boring locations AOI01-01 through AOI01-06, TUL-MW001, and TUL-MW003. Soil was also sampled from shallow subsurface soil (5 to 15 feet bgs) from boring locations AOI01-01, AOI01-02, TUL-MW001, and TUL-MW003. Deep subsurface samples (> 15 feet bgs) were not collected. **Figure 6-1** through **Figure 6-5** present the ranges of detections in soil. **Table 6-2** and **Table 6-3** summarize the soil results.

PFOA, PFOS, PFHxS, and PFNA were detected in the surface soil at concentrations below the SLs. The maximum detected concentration among the four compounds was PFOS at 12.1 micrograms per kilogram (µg/kg) at AOI01-02. PFBS was not detected.

PFOS, PFHxS, and PFNA were detected in the shallow subsurface soil at concentrations at least two orders of magnitude below the SLs and were detected at fewer locations than in surface soil. The maximum detected concentration among the three compounds was PFHxS at 0.835 J µg/kg at TUL-MW001. PFOA and PFBS were not detected.

6.3.2 AOI 1 Groundwater Analytical Results

Groundwater was sampled from temporary monitoring well AOI01-01, AOI01-02, and TUL-MW001. Groundwater was not observed at TUL-MW003. **Figure 6-6** and **Figure 6-7** present the ranges of detections in groundwater. **Table 6-4** summarizes the groundwater results.

In summary, PFOA, PFOS, and PFHxS were detected in groundwater above their SLs. PFBS and PFNA were detected below their SLs. Details are highlighted below.

- PFOA was detected above the 6 ng/L SL, at concentrations of 34.1 ng/L (AOI01-01) and 59.9 ng/L (TUL-MW001).
- PFOS was detected above the 4 ng/L SL, at concentrations of 51.6 ng/L (AOI01-01) and 267 ng/L (TUL-MW001).

- PFHxS was detected above the 39 ng/L SL, at concentrations of 939 ng/L (AOI01-01) and 3,100 ng/L (TUL-MW001).

PFBS and PFNA were detected at concentrations below their SLs. The maximum detected PFBS and PFNA concentrations were reported as 82.1 ng/L (TUL-MW001) and 2.30 J ng/L (AOI01-01), respectively.

6.3.3 AOI 1 Conclusions

Based on the results of the SI, PFOA, PFOS, PFHxS, and PFNA were detected in soil below their SLs. PFOA, PFOS, and PFHxS were detected in groundwater at concentrations above their SLs. Based on the exceedances of the SLs in groundwater, further evaluation at AOI 1 is warranted.

6.4 AOI 2

This section presents the analytical results for soil and groundwater in comparison to SLs for AOI 2: Western FTAs. The results in soil and groundwater are summarized on **Table 6-2** through **Table 6-4**. Soil and groundwater results are presented on **Figure 6-1** through **Figure 6-7**.

6.4.1 AOI 2 Soil Analytical Results

Surface soil was sampled from 0 to 2 feet bgs at boring locations AOI02-01 through AOI02-03 and TUL-MW002. Soil was also sampled from shallow subsurface soil (3 to 10 feet bgs) from boring locations AOI02-01, AOI02-02, and TUL-MW002. Deep subsurface samples were not collected. **Figure 6-1** through **Figure 6-5** present the ranges of detections in soil. **Table 6-2** through **Table 6-3** summarize the soil results.

PFOA, PFOS, PFHxS, and PFNA were detected in the surface soil, at concentrations below their SLs. The maximum detected concentration among the four compounds was PFOS, at 4.62 J+ µg/kg at AOI02-01. PFBS was not detected.

In the shallow subsurface soil, PFOS and PFHxS were detected at concentrations at least three orders of magnitude below their SLs. The maximum detected concentration among the two compounds was PFOS, at 0.149 J µg/kg at AOI02-01. PFOA, PFBS, and PFNA were not detected.

6.4.2 AOI 2 Groundwater Analytical Results

Groundwater was sampled from temporary monitoring well AOI02-01. Groundwater was not observed at AOI02-02 or TUL-MW002. **Figure 6-6** and **Figure 6-7** present the ranges of detections in groundwater. **Table 6-4** summarizes the groundwater results.

PFOA, PFOS, and PFHxS exceeded their SLs at AOI02-01, at concentrations of 8.79 ng/L, 141 J ng/L, and 382 ng/L, respectively. PFBS was detected at a concentration of 10.5 ng/L, below the SL. PFNA was not detected.

6.4.3 AOI 2 Conclusions

Based on the results of the SI, PFOA, PFOS, PFHxS, and PFNA were detected in soil below their SLs. PFOA, PFOS, and PFHxS were detected in groundwater at concentrations above their SLs. Based on the exceedances of the SLs in groundwater, further evaluation at AOI 2 is warranted.

6.5 AOI 3

This section presents the analytical results for soil in comparison to SLs for AOI 3: HEMTT Storage. The results in soil are presented in **Table 6-2**. Soil results are presented on **Figure 6-1** through **Figure 6-5**. Shallow and deep subsurface soil and groundwater were not sampled at AOI 3, consistent with the SI QAPP Addendum, based on the understanding that no known releases occurred at this location (AECOM, 2021).

6.5.1 AOI 3 Soil Analytical Results

Surface soil was sampled from 0 to 2 feet bgs at boring location AOI03-01. Shallow and deep subsurface soil samples were not collected at AOI 3. **Figure 6-1** through **Figure 6-5** present the ranges of detections in soil. **Table 6-2** summarizes the soil results.

PFOA, PFOS, PFBS, PFHxS, and PFNA were detected in the surface soil, at concentrations below their SLs. The maximum detected concentration among the four compounds was PFOS, at 2.27 µg/kg at AOI03-01.

6.5.2 AOI 3 Conclusions

Based on the results of the SI, PFOA, PFOS, PFBS, PFHxS, and PFNA were detected in the surface soil, at concentrations below their SLs. Subsurface soil and groundwater were not sampled at AOI 3. Based on the findings below the SLs in soil, further evaluation at AOI 3 is not warranted.

Table 6-2
PFOA, PFOS, PFBS, PFNA, and PFHxS Results in Surface Soil
Site Inspection Report, Tulsa AASF

	Area of Interest	AOI01																			
	Sample ID	AOI01-01-SB-00-02		AOI01-02-SB-00-02		AOI01-02-SB-00-02-D		AOI01-03-SB-00-02		AOI01-04-SB-00-01		AOI01-05-SB-00-02		AOI01-06-SB-00-02		TUL-MW001-SB-00-02		TUL-MW001-SB-00-02-D		TUL-MW003-SB-00-02	
	Sample Date	04/05/2022		04/05/2022		04/05/2022		04/05/2022		04/05/2022		04/09/2022		04/09/2022		04/05/2022		04/05/2022		04/05/2022	
	Depth	0-2 ft		0-2 ft		0-2 ft		0-2 ft		0-1 ft		0-2 ft		0-2 ft		0-2 ft		0-2 ft		0-2 ft	
Analyte	**OSD Screening Level [a]**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
Soil, LCMSMS compliant with QSM 5.3 Table B-15 (µg/kg)																					
PFBS	1900	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U
PFHxS	130	0.196	J	1.67		1.55		0.038	J	0.121	J	0.554	J	0.736	J	0.611	J	0.959	J	0.209	J
PFNA	19	0.049	J	0.375	J	0.475	J	0.021	J	0.115	J	0.055	J	0.267	J	0.033	J	0.064	J	ND	U
PFOA	19	0.120	J	0.549	J	0.685	J	ND	U	ND	U	0.137	J	0.381	J	0.098	J	0.186	J	ND	U
PFOS	13	0.783	J	11.9		12.1		0.189	J	0.969	J	3.40		11.2		1.57		3.48		0.150	J

Grey Fill — Detected concentration exceeded OSD Screening Levels

References
a. Assistant Secretary of Defense, July 2022. Risk Based Screening Levels Calculated for PFOA, PFOS, PFBS, PFHxS, and PFNA in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1, May 2022. Soil screening levels based on residential scenario for incidental ingestion of contaminated soil.

Interpreted Qualifiers
J = Estimated concentration
J+ = Estimated concentration, biased high
U = The analyte was not detected at a level greater than or equal to the adjusted DL
UJ = The analyte was not detected at a level greater than or equal to the adjusted DL. However, the reported adjusted DL is approximate and may be inaccurate or imprecise.

Notes
ND = Analyte not detected above the LOD. LOD values are presented in Appendix F.

Chemical Abbreviations

PFBS	perfluorobutanesulfonic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
D	duplicate
DL	detection limit
ft	feet
HQ	hazard quotient
ID	identification
LCMSMS	liquid chromatography with tandem mass spectrometry
LOD	limit of detection
ND	analyte not detected above the LOD
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	interpreted qualifier
SB	soil boring
TUL	Tulsa
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram

Table 6-2
PFOA, PFOS, PFBS, PFNA, and PFHxS Results in Surface Soil
Site Inspection Report, Tulsa AASF

	Area of Interest	AOI02								AOI03			
	Sample ID	AOI02-01-SB-00-02		AOI02-02-SB-00-02		AOI02-03-SB-00-02		TUL-MW002-SB-00-02		AOI03-01-SB-00-02		AOI03-01-SB-00-02-D	
	Sample Date	04/05/2022		04/05/2022		04/09/2022		04/04/2022		04/05/2022		04/05/2022	
	Depth	0-2 ft		0-2 ft		0-2 ft		0-2 ft		0-2 ft		0-2 ft	
Analyte	OSD Screening Level [a]	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Soil, LCMSMS compliant with QSM 5.3 Table B-15 (µg/kg)													
PFBS	1900	ND	U	ND	U	ND	U	ND	U	0.026	J	ND	UJ
PFHxS	130	0.284	J	ND	U	0.481	J	ND	U	0.382	J	0.234	J
PFNA	19	0.066	J	0.071	J	0.045	J	ND	U	0.046	J	0.042	J
PFOA	19	0.219	J	0.115	J	0.093	J	ND	U	0.171	J	0.141	J
PFOS	13	4.62	J+	0.249	J	1.23		0.073	J	2.27		1.80	

Grey Fill — Detected concentration exceeded OSD Screening Levels

References
a. Assistant Secretary of Defense, July 2022. Risk Based Screening Levels Calculated for PFOA, PFOS, PFBS, PFHxS, and PFNA in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1, May 2022. Soil screening levels based on residential scenario for incidental ingestion of contaminated soil.

Interpreted Qualifiers
J = Estimated concentration
J+ = Estimated concentration, biased high
U = The analyte was not detected at a level greater than or equal to the adjusted DL
UJ = The analyte was not detected at a level greater than or equal to the adjusted DL. However, the reported adjusted DL is approximate and may be inaccurate or imprecise.

Notes
ND = Analyte not detected above the LOD. LOD values are presented in Appendix F.

Chemical Abbreviations

PFBS	perfluorobutanesulfonic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
D	duplicate
DL	detection limit
ft	feet
HQ	hazard quotient
ID	identification
LCMSMS	liquid chromatography with tandem mass spectrometry
LOD	limit of detection
ND	analyte not detected above the LOD
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	interpreted qualifier
SB	soil boring
TUL	Tulsa
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram

Table 6-3
PFOA, PFOS, PFBS, PFNA, and PFHxS Results in Shallow Subsurface Soil
Site Inspection Report, Tulsa AASF

	Area of Interest	AOI01																AOI02			
	Sample ID	AOI01-01-SB-05-06		AOI01-01-SB-8.5-9.5		AOI01-02-SB-07-08		AOI01-02-SB-14-15		TUL-MW001-SB-05-06		TUL-MW001-SB-09-10		TUL-MW003-SB-05-06		TUL-MW003-SB-8.5-9.5		AOI02-01-SB-03-04		AOI02-01-SB-05-06	
	Sample Date	04/08/2022		04/08/2022		04/08/2022		04/08/2022		04/09/2022		04/09/2022		04/09/2022		04/09/2022		04/08/2022		04/08/2022	
	Depth	5-6 ft		8.5-9.5 ft		7-8 ft		14-15 ft		5-6 ft		9-10 ft		5-6 ft		8.5-9.5 ft		3-4 ft		5-6 ft	
Analyte	OSD Screening Level [a]	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Soil, LCMSMS compliant with QSM 5.3 Table B-15 (µg/kg)																					
PFBS	25000	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U
PFHxS	1600	0.032	J	0.083	J	0.103	J	0.065	J	0.835	J	0.406	J	0.642	J	0.072	J	0.087	J	0.067	J
PFNA	250	ND	U	ND	U	ND	U	ND	U	ND	U	0.029	J	ND	U	ND	U	ND	U	ND	U
PFOA	250	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U	ND	U
PFOS	160	ND	U	ND	U	ND	U	ND	U	0.191	J	0.136	J	0.541	J	ND	U	0.149	J	0.084	J

Grey Fill — Detected concentration exceeded OSD Screening Levels

References
a. Assistant Secretary of Defense, July 2022. Risk Based Screening Levels Calculated for PFOA, PFOS, PFBS, PFHxS, and PFNA in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1, May 2022. Soil screening levels based on industrial/commercial composite worker scenario for incidental ingestion of contaminated soil.

Interpreted Qualifiers
J = Estimated concentration
U = The analyte was not detected at a level greater than or equal to the adjusted DL

Notes
ND = Analyte not detected above the LOD. LOD values are presented in Appendix F.

Chemical Abbreviations

PFBS	perfluorobutanesulfonic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
D	duplicate
DL	detection limit
ft	feet
HQ	hazard quotient
ID	identification
LCMSMS	liquid chromatography with tandem mass spectrometry
LOD	limit of detection
ND	analyte not detected above the LOD
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	interpreted qualifier
SB	soil boring
TUL	Tulsa
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram

Table 6-3
PFOA, PFOS, PFBS, PFNA, and PFHxS Results in Shallow Subsurface Soil
Site Inspection Report, Tulsa AASF

	Area of Interest	AOI02					
	Sample ID	AOI02-02-SB-05-06		TUL-MW002-SB-05-06		TUL-MW002-SB-09-10	
	Sample Date	04/13/2022		04/05/2022		04/05/2022	
	Depth	5-6 ft		5-6 ft		9-10 ft	
Analyte	**OSD Screening Level [a]**	**Result**	**Qual**	**Result**	**Qual**	**Result**	**Qual**
Soil, LCMSMS compliant with QSM 5.3 Table B-15 (µg/kg)							
PFBS	25000	ND	U	ND	U	ND	U
PFHxS	1600	ND	U	ND	U	ND	U
PFNA	250	ND	U	ND	U	ND	U
PFOA	250	ND	U	ND	U	ND	U
PFOS	160	ND	U	ND	U	ND	U

Grey Fill	Detected concentration exceeded OSD Screening Levels

References
a. Assistant Secretary of Defense, July 2022. Risk Based Screening Levels Calculated for PFOA, PFOS, PFBS, PFHxS, and PFNA in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1, May 2022. Soil screening levels based on industrial/commercial composite worker scenario for incidental ingestion of contaminated soil.

Interpreted Qualifiers
J = Estimated concentration
U = The analyte was not detected at a level greater than or equal to the adjusted DL

Notes
ND = Analyte not detected above the LOD. LOD values are presented in Appendix F.

Chemical Abbreviations

PFBS	perfluorobutanesulfonic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
D	duplicate
DL	detection limit
ft	feet
HQ	hazard quotient
ID	identification
LCMSMS	liquid chromatography with tandem mass spectrometry
LOD	limit of detection
ND	analyte not detected above the LOD
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	interpreted qualifier
SB	soil boring
TUL	Tulsa
USEPA	United States Environmental Protection Agency
µg/kg	micrograms per kilogram

Table 6-4
PFOA, PFOS, PFBS, PFNA, and PFHxS Results in Groundwater
Site Inspection Report, Tulsa AASF #2

	Area of Interest	AOI01						AOI02			
	Sample ID	AOI01-01-GW		AOI01-02-GW		TUL-MW001-GW		AOI02-01-GW		AOI02-01-GW-D	
	Sample Date	04/10/2022		04/09/2022		04/10/2022		04/08/2022		04/08/2022	
Analyte	OSD Screening Level [a]	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Water, LCMSMS compliant with QSM 5.3 Table B-15 (ng/l)											
PFBS	601	37.7		0.756	J	82.1		10.5		8.30	
PFHxS	39	939		11.1		3100		382		283	
PFNA	6	2.30	J	ND	U	ND	U	ND	U	ND	U
PFOA	6	34.1		1.03	J	59.9		8.79		6.51	
PFOS	4	51.6		ND	U	267		141	J	98.7	J

Grey Fill — Detected concentration exceeded OSD Screening Levels

References
a. Assistant Secretary of Defense, July 2022. Risk Based Screening Levels Calculated for PFOA, PFOS, PFBS, PFHxS, and PFNA in Groundwater or Soil using USEPA's Regional Screening Level Calculator. HQ=0.1, May 2022 Groundwater screening levels based on residential scenario for direct ingestion of groundwater.

Interpreted Qualifiers
J = Estimated concentration
U = The analyte was not detected at a level greater than or equal to the adjusted DL

Notes
ND = Analyte not detected above the LOD. LOD values are presented in Appendix F.

Chemical Abbreviations

PFBS	perfluorobutanesulfonic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid

Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AOI	Area of Interest
D	duplicate
DL	detection limit
GW	groundwater
HQ	hazard quotient
ID	identification
LCMSMS	liquid chromatography with tandem mass spectrometry
LOD	limit of detection
ND	analyte not detected above the LOD
OSD	Office of the Secretary of Defense
QSM	Quality Systems Manual
Qual	interpreted qualifier
TUL	Tulsa
USEPA	United States Environmental Protection Agency
ng/l	nanogram per liter

THIS PAGE INTENTIONALLY BLANK

CLIENT	ARNG				
PROJECT	Site Inspection at Tulsa AASF #2, OK				
REVISED	9/13/2022	GIS BY	MS	9/13/2022	
SCALE	1:4,800	CHK BY	VG	9/13/2022	
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	9/13/2022	

Legend

Facility Boundary

0 200 400 800 Feet

N

Exceedances of the OSD SL are depicted with a yellow halo.
Depth intervals shown represent respective sampling position within a given soil boring location.

PFOA Detections in Soil

AECOM 12420 Milestone Center Drive Germantown, MD 20876

Figure 6-1

CLIENT	ARNG		
PROJECT	Site Inspection at Tulsa AASF #2, OK		
REVISED	9/13/2022	GIS BY MS	9/13/2022
SCALE	1:4,800	CHK BY VG	9/13/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM CM	9/13/2022

Legend

Facility Boundary

0 200 400 800 Feet

N

Exceedances of the OSD SL are depicted with a yellow halo.
Depth intervals shown represent respective sampling position within a given soil boring location.

PFOS Detections in Soil

AECOM 12420 Milestone Center Drive Germantown, MD 20876

Figure 6-2

CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	9/13/2022	GIS BY	MS	9/13/2022
SCALE	1:4,800	CHK BY	VG	9/13/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	9/13/2022

Legend

Facility Boundary

0 200 400 800 Feet

N

Exceedances of the OSD SL are depicted with a yellow halo.
Depth intervals shown represent respective sampling position within a given soil boring location.

PFBS Detections in Soil

AECOM 12420 Milestone Center Drive Germantown, MD 20876

Figure 6-3

CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	9/13/2022	GIS BY	MS	9/13/2022
SCALE	1:4,800	CHK BY	VG	9/13/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	9/13/2022

Legend

Facility Boundary

0 200 400 800 Feet

N

Exceedances of the OSD SL are depicted with a yellow halo.
Depth intervals shown represent respective sampling position within a given soil boring location.

PFHxS Detections in Soil

AECOM 12420 Milestone Center Drive Germantown, MD 20876

Figure 6-4

CLIENT ARNG			
PROJECT Site Inspection at Tulsa AASF #2, OK			
REVISED 9/13/2022	GIS BY	MS	9/13/2022
SCALE 1:4,800	CHK BY	VG	9/13/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community	PM	CM	9/13/2022

Legend

Facility Boundary

0 200 400 800 Feet

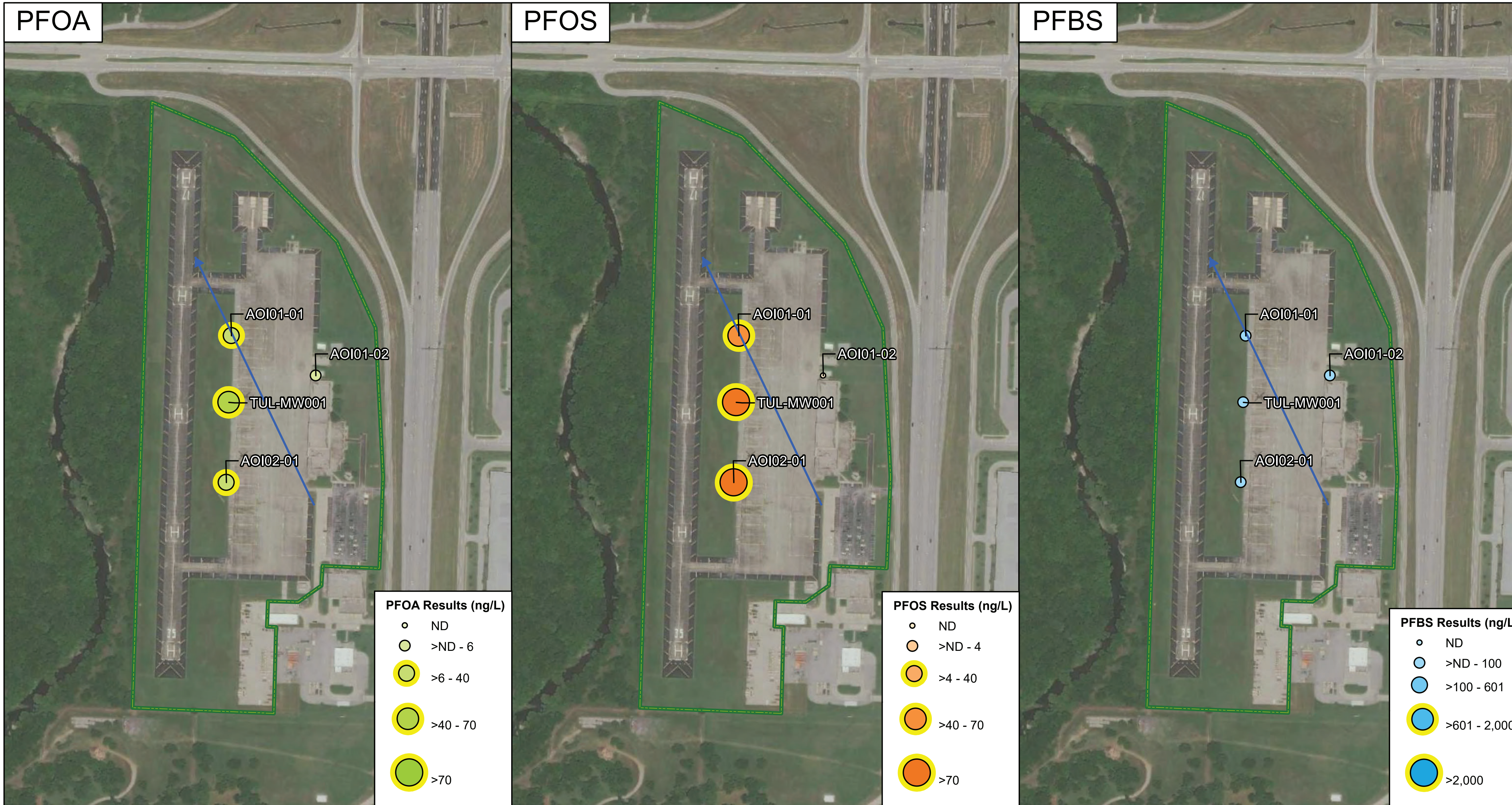
Exceedances of the OSD SL are depicted with a yellow halo.
Depth intervals shown represent respective sampling position within a given soil boring location.

N

PFNA Detections in Soil

AECOM 12420 Milestone Center Drive Germantown, MD 20876

Figure 6-5



CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	10/10/2022	GIS BY	MS	10/10/2022
SCALE	1:4,800	CHK BY	VG	10/10/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	10/10/2022

Legend

Facility Boundary

Groundwater Flow Direction

0 200 400 800 Feet

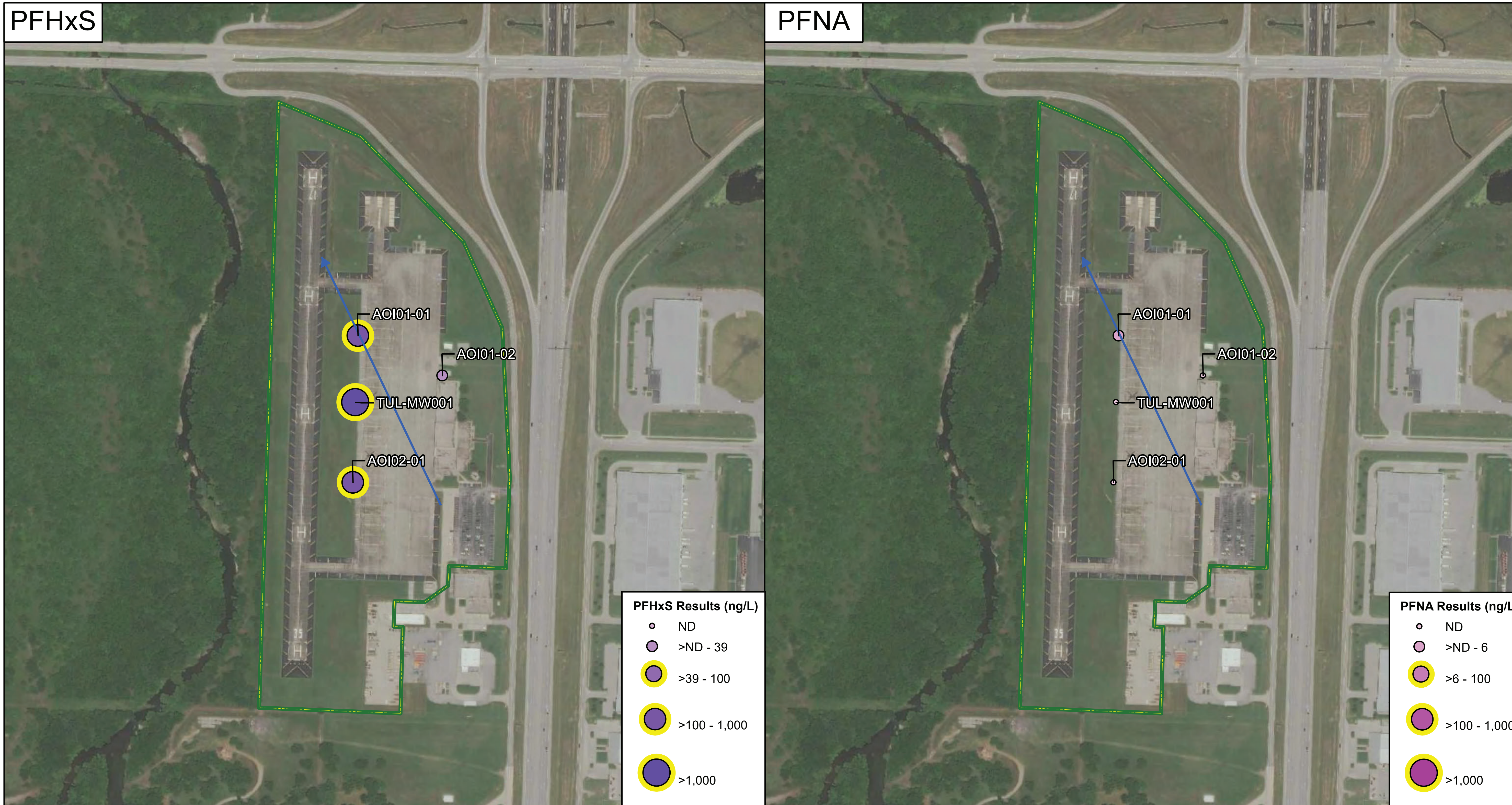
Exceedances of the OSD SL are depicted with a yellow halo.

N

PFOA, PFOS, and PFBS Detections in Groundwater

AECOM
12420 Milestone Center Drive
Germantown, MD 20876

Figure 6-6



CLIENT	ARNG			
PROJECT	Site Inspection at Tulsa AASF #2, OK			
REVISED	10/10/2022	GIS BY	MS	10/10/2022
SCALE	1:4,800	CHK BY	VG	10/10/2022
Base Map: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community		PM	CM	10/10/2022

Legend

- Facility Boundary
- Groundwater Flow Direction

0 200 400 800 Feet

N

Exceedances of the OSD SL are depicted with a yellow halo.

PFHxS and PFNA Detections in Groundwater

AECOM

12420 Milestone Center Drive
Germantown, MD 20876

Figure 6-7

THIS PAGE INTENTIONALLY BLANK

7. Exposure Pathways

The CSMs for each AOI, revised based on the SI findings, are presented on **Figure 7-1** through **Figure 7-3**. Please note that while the CSM discussion assists in determining if a receptor may be impacted, the decision to move from SI to RI or interim action is determined based upon exceedances of the SLs for the relevant compounds and whether the release is more likely attributable to the DoD. A CSM presents the current understanding of the site conditions with respect to known and suspected sources, potential transport mechanisms and migration pathways, and potentially exposed human receptors. A human exposure pathway is considered potentially complete when the following conditions are present:

1. Contaminant source;
2. Environmental fate and transport;
3. Exposure point;
4. Exposure route; and
5. Potentially exposed populations.

If any of these elements are missing, the pathway is incomplete. The CSM figures use an empty circle symbol to represent an incomplete exposure pathway. Areas with an incomplete pathway generally warrant no further action. However, the pathway is considered potentially complete if the relevant compounds are detected, in which case the CSM figure uses a half-filled circle symbol to represent a potentially complete exposure pathway. Additionally, a completely filled circle symbol is used to indicate when a potentially complete exposure pathway has detections of relevant compounds above the SLs. Areas with an identified potentially complete pathway that have detections of the relevant compounds above the SLs may warrant further investigation. Although the CSMs indicate whether potentially complete exposure pathways may exist, the recommendation for future study in an RI or no action at this time is based on the comparison of the SI analytical results for the relevant compounds to the SLs.

In general, the potential routes of exposure to the relevant compounds are ingestion and inhalation. Human exposure via the dermal contact pathway may occur, and current risk practice suggests it is an insignificant pathway compared to ingestion; however, exposure data for dermal pathways are sparse and continue to be the subject of toxicological study. The receptors evaluated are consistent with those listed in USEPA guidance for risk screening (USEPA, 2001). Receptors at the facility include site workers (e.g., facility staff and visiting soldiers), construction workers, trespassers, residents outside the facility boundary, and recreational users outside of the facility boundary.

7.1 Soil Exposure Pathway

The SI results in soil were used to determine whether a potentially complete pathway exists between the source and potential receptors at AOI 1, AOI 2, and AOI 3 based on the aforementioned criteria.

7.1.1 AOI 1

AOI 1 consists of the Eastern Release Areas, where controlled AFFF releases through fire training activities have occurred as early as the 1990s until the early 2000s, a wash rack with associated OWS and evaporator are located, two fire suppression system releases occurred in 2014, and bulk AFFF containers were stored. Releases at AOI 1 have occurred on both paved areas and grassy surfaces. Some PFAS releases may have occurred directly onto surface soil but may also have infiltrated to subsurface soil via cracks or joints in the pavement. Any releases that occurred in the hangars or wash rack would have drained to the OWS and evaporator or, as was the case prior to the evaporator installation in 2010, potentially discharged to the surface towards Mingo Creek.

PFOA, PFOS, PFHxS, and PFNA were detected below their SLs in surface soil at AOI 1. Site workers and future construction workers could contact constituents in surface soil via incidental ingestion and inhalation of dust. No ongoing construction was observed at the facility during the SI. Therefore, the surface soil exposure pathway for site workers and future construction workers are potentially complete. The facility is gated and there are no adjacent residential structures; therefore, the incidental ingestion and inhalation of dust exposure pathways for the trespasser, residential, and recreational user receptors are considered incomplete. PFOS, PFHxS, and PFNA were detected below their SLs in shallow subsurface soil at AOI 1. The construction worker exposure scenario assumes excavation occurs at depths at or above 15 feet bgs. Construction workers could contact constituents in subsurface soil via incidental ingestion; therefore, the subsurface soil exposure pathway for future construction workers is potentially complete. The CSM for AOI 1 is presented on **Figure 7-1**.

7.1.2 AOI 2

AOI 2 consists of the Western FTAs, where controlled AFFF releases through fire training activities have occurred as early as the 1990s until the early 2000s. Releases at AOI 2 occurred on paved surfaces and may have flowed westward, off the pavement, toward Mingo Creek, and potentially impacted surface soil. Additionally, AFFF may also have infiltrated to subsurface soil via cracks or joints in the pavement.

PFOA, PFOS, PFHxS, and PFNA were detected below their SLs in surface soil at AOI 2. Site workers and future construction workers could contact constituents in surface soil via incidental ingestion and inhalation of dust. Therefore, the surface soil exposure pathway for site workers and future construction workers are potentially complete. The incidental ingestion and inhalation of dust exposure pathways for the trespasser, residential, and recreational user receptors are considered incomplete for the same reasons established for AOI 1. PFOS and PFHxS were detected below the SLs in shallow subsurface soil at AOI 2. Construction workers could contact constituents in subsurface soil via incidental ingestion; therefore, the subsurface soil exposure pathway for future construction workers is potentially complete. The CSM for AOI 2 is presented on **Figure 7-2**.

7.1.3 AOI 3

AOI 3 is a former HEMTT Storage area where Tri-Max™ extinguishers stored from the 1990s to the early 2000s. No known AFFF releases occurred at AOI 3; however, any potential releases would have occurred on paved areas. AFFF released to the pavement could have infiltrated to subsurface soil via cracks or joints in the pavement or joints, or run off to nearby grassy surfaces.

PFOA, PFOS, PFBS, PFHxS, and PFNA were detected below the SLs in surface soil at AOI 3. Site workers and future construction workers could contact constituents in surface soil via incidental ingestion and inhalation of dust. Therefore, the surface soil exposure pathway for site workers and future construction workers are potentially complete. The incidental ingestion and inhalation of dust exposure pathways for the trespasser, residential, and recreational user receptors are considered incomplete for the same reasons as the other AOIs. The subsurface soil was not sampled at AOI 3; therefore, the pathways for subsurface soil ingestion for all receptors cannot be directly evaluated but are conservatively considered to be similar to AOI 1 and AOI 2 due to the presence of relevant compounds in surface soil. The CSM for AOI 3 is presented on **Figure 7-3**.

7.2 Groundwater Exposure Pathway

The SI results in groundwater were used to determine whether a potentially complete pathway exists between the source and potential receptors based on the aforementioned criteria.

7.2.1 AOI 1

PFOA, PFOS, and PFHxS were detected above their SLs in groundwater samples collected at AOI 1. Drinking water at the facility is provided by the City of Tulsa and is sourced from surface water upstream from the facility; therefore, the ingestion exposure pathway for site workers is considered incomplete. Three domestic wells are present within a 2.5-mile radius of the facility. Based on available information, the nearest of these wells is just under 1 mile to the southeast, in the observed upgradient direction from AASF #2, and has a depth of 24 feet bgs. The downgradient domestic well is shown as being 197 feet deep. Groundwater encountered during the SI was observed in the shallow unconsolidated soil. It is not anticipated that the groundwater evaluated during the SI interacts with these potential off-facility water sources. Therefore, the pathway for exposure to off-facility residents and recreation users via ingestion of groundwater is considered incomplete. Depths to water measured at AOI 1 in April 2022 during the SI ranged from 8.36 to 11.18 feet bgs. The construction worker exposure scenario assumes excavation occurs at depths at or above 15 feet bgs. Based on the shallow groundwater and constituents encountered at AOI 1, the ingestion exposure pathway for future construction workers is considered potentially complete. The CSM for AOI 1 is presented on **Figure 7-1**.

7.2.2 AOI 2

PFOA, PFOS, and PFHxS were detected above their SLs in groundwater samples collected at AOI 2. Drinking water is sourced from surface water upstream from the facility; therefore, the ingestion exposure pathway for site workers is considered incomplete via drinking water. Based on the understanding of groundwater conditions at the facility and location of identified wells in the vicinity, the pathway for exposure to off-facility residents and recreational users via ingestion of groundwater is considered incomplete. Depth to water measured at AOI 2 in April 2022 during the SI was 1.24 feet bgs; therefore, the incidental ingestion exposure pathway for future construction workers, and potentially site workers due to the shallow groundwater, is considered potentially complete. The CSM for AOI 2 is presented on **Figure 7-2**.

7.2.3 AOI 3

Groundwater samples were not collected at AOI 3. Because groundwater was not sampled at this AOI, the groundwater exposure pathway cannot be directly evaluated. The CSM for AOI 3 is presented on **Figure 7-3**.

7.3 Surface Water and Sediment Exposure Pathway

Surface water and sediment samples were not collected during the SI field mobilization at AASF #2. The SI results in soil and groundwater, in combination with knowledge of the fate and transport properties of PFAS, were used to determine whether a potentially complete pathway exists between the source and potential receptors.

7.3.1 AOI 1 and AOI 2

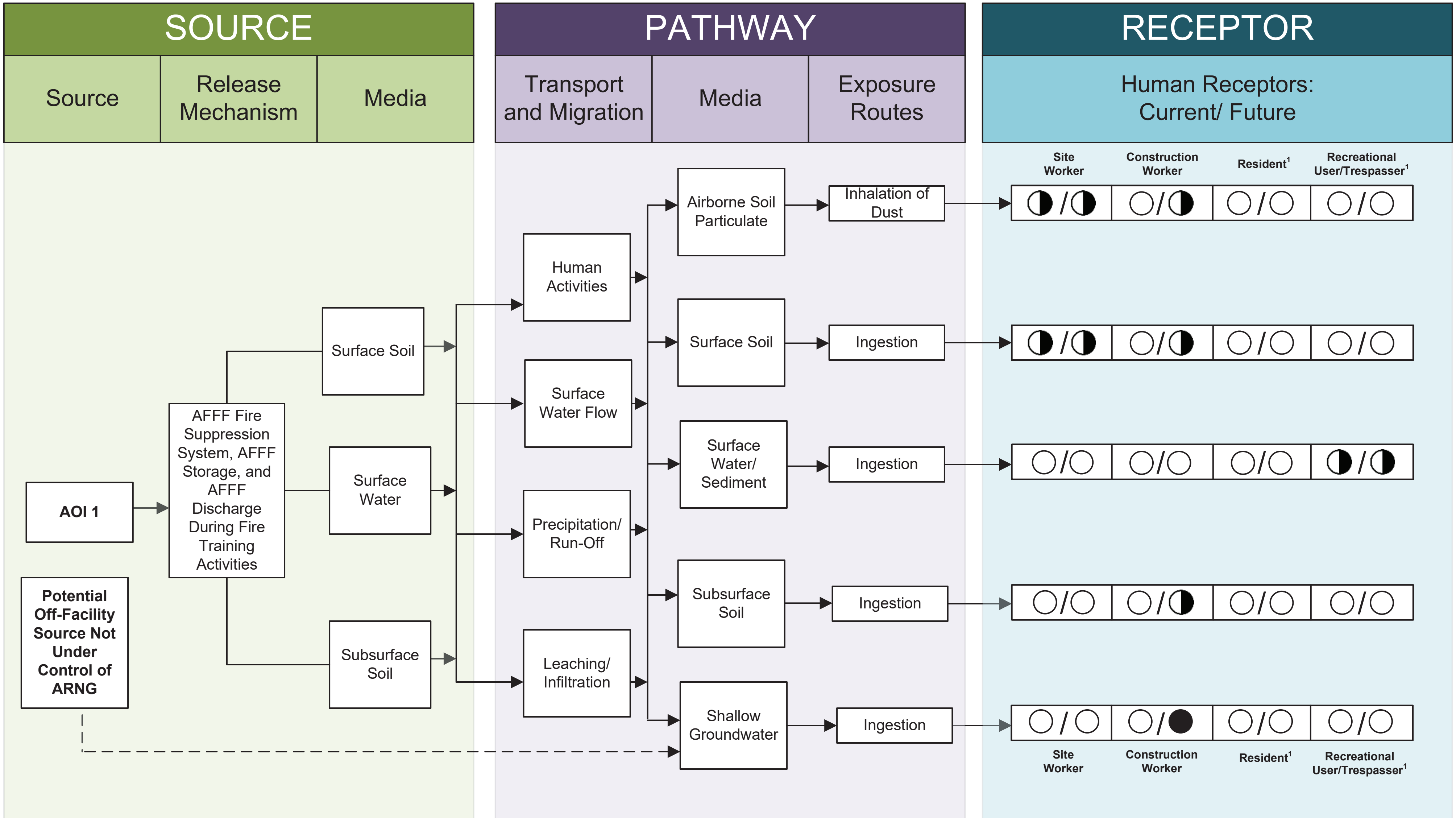
At AOI 1 and AOI 2, PFOA, PFOS, PFHxS, and PFNA were detected in soil, and PFOA, PFOS, and PFHxS were detected in groundwater. Concentrations of PFOS, PFNA, and PFHxS below 1 µg/kg were detected at location AOI01-04, the surface soil sample collected at the OWS surface discharge point at the facility boundary, upslope from Mingo Creek. Surface water features were not observed within the facility boundary during the SI; therefore, the surface water and sediment ingestion exposure pathway for site workers and future construction workers is considered incomplete.

PFAS are water soluble and can migrate readily from soil to surface water via leaching and run-off. It is possible that the compounds detected in soil may have migrated to Mingo Creek, located directly west of the facility and topographically downgradient of the facility. Additionally, exposed bedrock is apparent in the creek bed; therefore, based on the current understanding of shallow groundwater relative to the near-surface bedrock, the detected compounds in groundwater may migrate to Mingo Creek via shallow groundwater discharge. Consequently, the surface water and sediment ingestion exposure pathway for off-facility recreational users is also considered potentially complete. Drinking water for the City of Tulsa and surrounding area is provided by surface water sourced upstream from Mingo Creek. Therefore, the surface water exposure pathway for off-facility residents is considered incomplete. The CSMs for AOI 1 and AOI 2 are presented on **Figure 7-1** and **Figure 7-2**, respectively.

7.3.2 AOI 3

PFOA, PFOS, PFBS, PFHxS, and PFNA were detected in surface soil at AOI 3. Subsurface soil and groundwater were not sampled at this AOI during the SI. Surface water features were not observed within the facility boundary during the SI; therefore, the surface water and sediment ingestion exposure pathway for site workers and future construction workers is considered incomplete.

Due to the water-soluble property of PFAS, it is possible the compounds detected in the surface soil at AOI 3 may have migrated via shallow groundwater discharge or surface runoff to Mingo Creek. Therefore, the surface water and sediment ingestion exposure pathway for off-facility recreational users is also considered potentially complete. Surface water from Mingo Creek is not used as drinking water in the vicinity, so the surface water ingestion exposure pathway for off-facility residents is considered incomplete. The CSM for AOI 3 is presented on **Figure 7-3**.



LEGEND

Flow-Chart Stops

Flow-Chart Continues

Partial / Possible Flow

○ Incomplete Pathway

◐ Potentially Complete Pathway

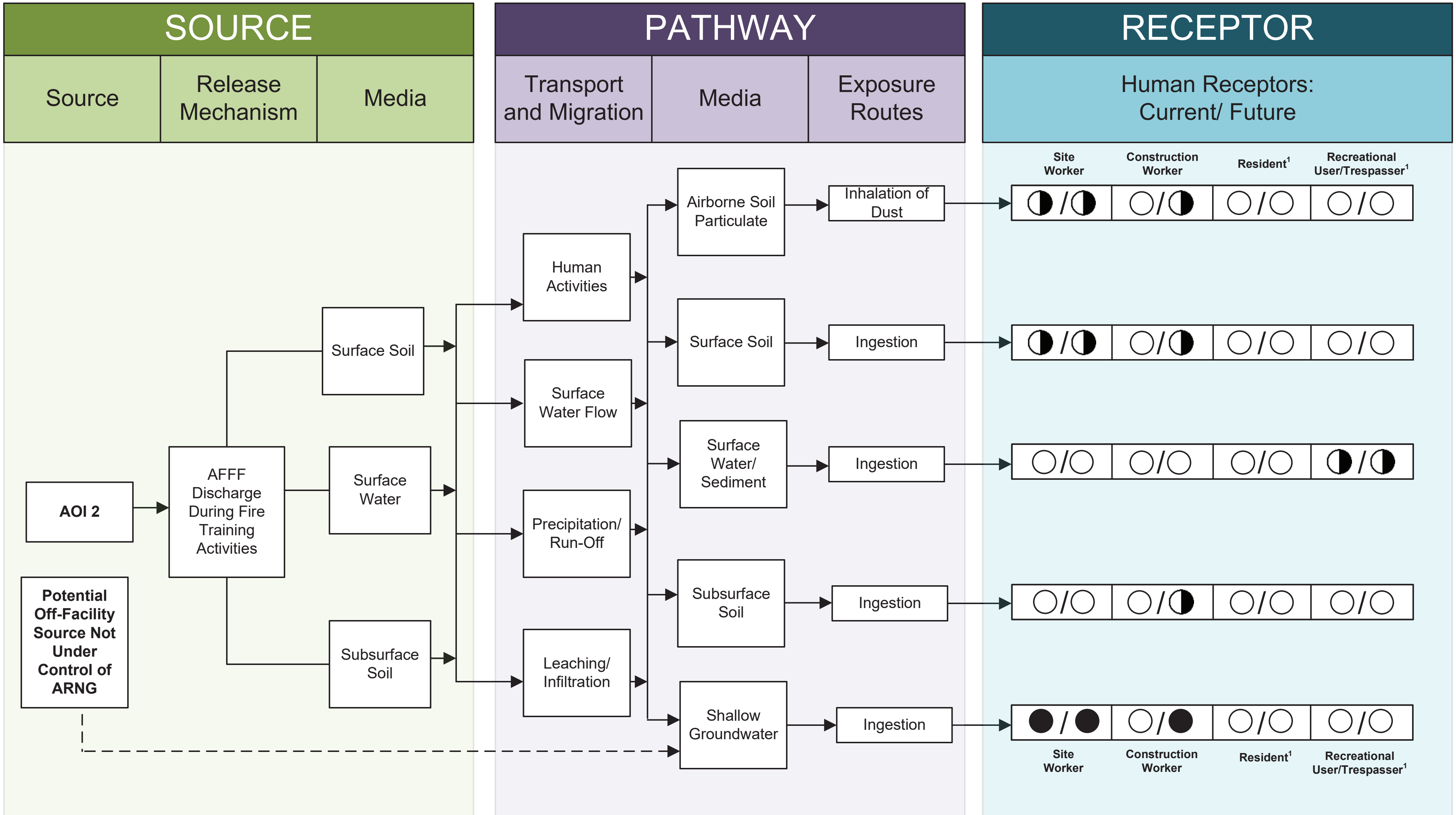
● Potentially Complete Pathway with Exceedance of SL

NOTES

1. The resident and recreational users refer to off-site receptors.

2. Construction was not observed during SI field activities.

Figure 7-1
Conceptual Site Model, AOI 1
Tulsa AASF #2, Tulsa, Oklahoma



LEGEND

Flow-Chart Stops

Flow-Chart Continues

Partial / Possible Flow

Incomplete Pathway

Potentially Complete Pathway

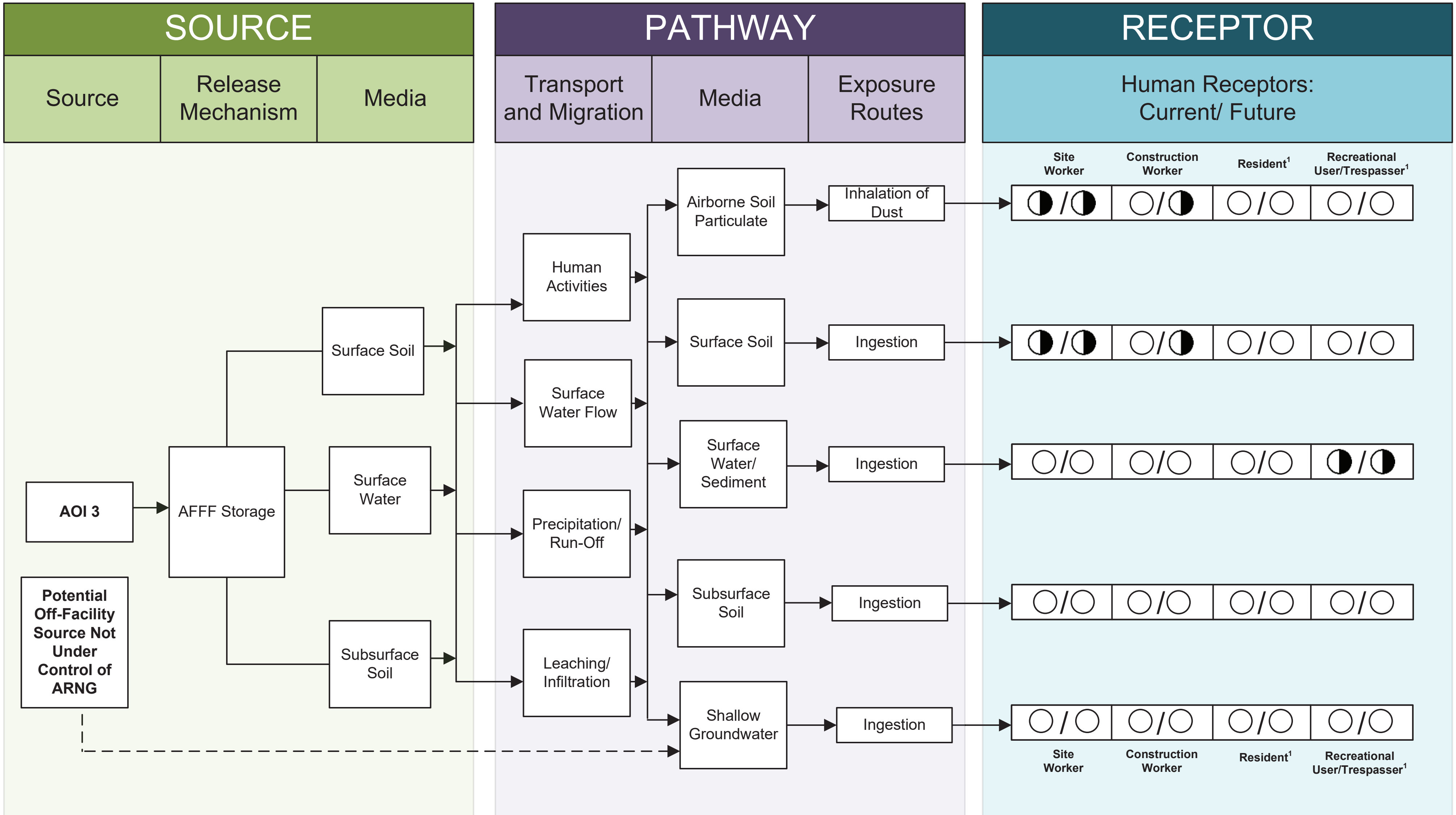
Potentially Complete Pathway with Exceedance of SL

NOTES

1. The resident and recreational users refer to off-site receptors.

2. Construction was not observed during SI field activities.

Figure 7-2
Conceptual Site Model, AOI 2
Tulsa AASF #2, Tulsa, Oklahoma



LEGEND

- Flow-Chart Stops
- Flow-Chart Continues
- Partial / Possible Flow
- Incomplete Pathway
- Potentially Complete Pathway
- Potentially Complete Pathway with Exceedance of SL

NOTES

1. The resident and recreational users refer to off-site receptors
2. Subsurface soil and groundwater was not sampled at AOI 3.
3. Construction was not observed during SI field activities.

Figure 7-3
Conceptual Site Model, AOI 3
Tulsa AASF #2, Tulsa, Oklahoma

THIS PAGE INTENTIONALLY BLANK

8. Summary and Outcome

This section summarizes SI activities and findings. The most significant findings are summarized in this section and are reproduced directly or abstracted from information contained in this report. The outcome provides general and comparative interpretations of the findings relative to the SLs.

8.1 SI Activities

The SI field activities were conducted from 4 to 14 April 2022 and consisted of utility clearance, sonic drilling, soil sample collection, temporary monitoring well installation, grab groundwater sample collection, and land surveying. Field activities were conducted in accordance with the SI QAPP Addendum (AECOM, 2021), except as noted in **Section 5.8**.

To fulfill the project DQOs set forth in the approved SI QAPP Addendum (AECOM, 2021), samples were collected and analyzed for a subset of 18 compounds by LC/MS/MS compliant with QSM 5.3 Table B-15 as follows.

- Twenty-six (26) soil samples from thirteen (13) locations;
- Four (4) grab groundwater samples from four (4) of six (6) temporary wells; and
- Sixteen (16) QA/QC samples.

An SI is conducted when the PA determines an AOI exists based on probable use, storage, and/or disposal of PFAS-containing materials. The SI includes multi-media sampling at AOIs to determine whether or not a release has occurred. The SI may conclude further investigation is warranted, a removal action is required to address immediate threats, or no further action is required. Additionally, the CSMs were refined to assess whether a potentially complete pathway exists between the source and potential receptors for potential exposure at the AOIs, which are described in **Section 7**.

8.2 Outcome

Based on the results of this SI, further evaluation is warranted in an RI for AOI 1: Eastern Release Area and AOI 2: Western FTAs. No further evaluation is warranted for AOI 3 at this time. Based on the CSMs developed and revised in light of the SI findings, there is no potential for exposure to drinking water receptors from sources on the facility resulting from historical DoD activities. Sample analytical concentrations collected during the SI were compared to the project SLs in soil and groundwater, as described in **Table 6-1**. A summary of the results of the SI data relative to the SLs is as follows:

- At AOI 1:
    - The detected concentrations of PFOA, PFOS, PFHxS, and PFNA in soil at AOI 1 were below their SLs. PFBS was not detected.
    - PFOA, PFOS, and PFHxS in groundwater exceeded their respective SLs. PFOA exceeded the 6 ng/L SL, with a maximum concentration of 59.9 ng/L at TUL-MW001. PFOS exceeded the 4 ng/L SL, with a maximum concentration of 267 ng/L at TUL-MW001. PFHxS exceeded the 39 ng/L SL, with a maximum concentration of 3,100 ng/L at TUL-MW001. PFBS and PFNA were below their SLs.
    - Based on the results of the SI, further evaluation of AOI 1 is warranted in the RI.

- At AOI 2:
    - The detected concentrations of PFOA, PFOS, PFHxS, and PFNA in soil at AOI 1 were below their SLs. PFBS was not detected.
    - At AOI02-01, PFOA exceeded the 6 ng/L SL, with a maximum concentration of 8.79 ng/L. PFOS exceeded the 4 ng/L SL, with a maximum concentration of 141 J ng/L. PFHxS exceeded the 39 ng/L SL, with a maximum concentration of at 382 ng/L. PFBS was detected below the SL. PFNA was not detected.
    - Based on the results of the SI, further evaluation of AOI 2 is warranted in the RI.
- At AOI 3:
    - The detected concentrations of PFOA, PFOS, PFBS, PFHxS, and PFNA in surface soil at AOI 1 were below their SLs.
    - Subsurface soil and groundwater were not sampled at AOI 3.

Groundwater availability was limited during the SI at the facility and several locations were unable to be sampled. Groundwater depths were generally observed to be approximately 1 to 2 feet above the bedrock and/or fat clay layers encountered within the soil borings. This suggests that the shallow groundwater flow at the facility is more locally rather than regionally influenced. The availability of groundwater appeared to correlate to where the unconsolidated material was less compacted and had higher silt content that allowed some degree of infiltration for shallow groundwater production. In less permeable areas, surface water disposition is likely dominated by runoff rather than infiltration. Groundwater was not observed in the well-cemented limestone bedrock, identified as the Oologah Formation, at Tulsa AASF #2. It is expected that the first available groundwater would not likely be encountered until at or within the underlying shale Labette Formation, expected at a depth of around 110 to 130 feet bgs.

Of the six PFAS compounds presented in the 6 July 2022 OSD memorandum, HFPO-DA (commonly referred to as GenX) was not included as an analyte at the time of this SI. Based on the CSM developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of MIL-SPEC AFFF and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS.

Table 8-1 summarizes the SI results for soil and groundwater used to determine if an AOI should be considered for further investigation under CERCLA and undergo an RI.

Table 8-1: Summary of Site Inspection Findings and Recommendations

AOI	Potential Release Area	Soil – Source Area	Groundwater – Source Area	Future Action
1	Eastern Release Areas	◐	●	Proceed to RI
2	Western FTAs	◐	●	Proceed to RI
3	HEMTT Storage	◐	N/A	No further action

Legend:
N/A = not applicable
● = detected; exceedance of the screening levels
◐ = detected; no exceedance of the screening levels
○ = not detected

9. References

AECOM. 2018a. *Final Site Inspection Programmatic Uniform Federal Policy-Quality Assurance Project Plan, Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) Impacted Sites ARNG Installations, Nationwide Contract No. W912DR-12-D-0014/ W912DR17F0192*. 9 March.

AECOM. 2018b. *Final Programmatic Accident Prevention Plan, Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) Impacted Sites ARNG Installations, Nationwide Contract No. W912DR-12-D-0014/W912DR17F0192.* July.

AECOM. 2020. *Final Preliminary Assessment Report, Tulsa Army Aviation Support Facility #2, Tulsa, Oklahoma*. October.

AECOM. 2021. *Final Site Inspection Uniform Federal Policy-Quality Assurance Project Plan Addendum, Army Aviation Support Facility #2, Tulsa, Oklahoma.* September.

AECOM. 2020. *Final Preliminary Assessment Report, Tulsa Army Aviation Support Facility, Oklahoma*. January.

AECOM. 2021. *Final Site Inspection Uniform Federal Policy-Quality Assurance Project Plan Addendum, Army Aviation Support Facility, Tulsa, Oklahoma, Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) Impacted Sites ARNG Installations, Nationwide.* September.

AECOM. 2022. *Final Site Safety and Health Plan, Army Aviation Support Facility, Tulsa, Oklahoma, Perfluorooctane Sulfonic Acid (PFOS) and Perfluorooctanoic Acid (PFOA) Impacted Sites ARNG Installations, Nationwide*. March.

Assistant Secretary of Defense. 2022. *Investigation Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program*. United States Department of Defense. 6 July.

DA. 2018. *Army Guidance for Addressing Releases of Per- and Polyfluoroalkyl Substances.* 4 September.

DoD. 2019a. *Department of Defense (DoD), Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.3*.

DoD. 2019b. *General Data Validation Guidelines. Environmental Data Quality Workgroup*. 4 November.

E&E Engineering and Associates, LLC. 2018. *Appendix F Groundwater Sampling and Analysis Plan. APAC East Quarry C&D Landfill, Tulsa County, Oklahoma, SW Permit No. 3572049.* June.

Guelfo, J.L. and Higgins, C.P. 2013. *Subsurface Transport Potential of Perfluoroalkyl Acids at Aqueous Film-Forming Foam (AFFF)-Impacted Sites.* Environmental Science and Technology 47(9): 4164-71.

Higgins, C.P., and Luthy, R.G. 2006. *Sorption of perfluorinated surfactants on sediments*. Environmental Science and Technology 40 (23): 7251-7256.

ITRC. 2018. *Environmental Fate and Transport for Per- and Polyfluoroalkyl Substances*. March.

Johnson, Kenneth S. 1983. *Maps Showing Principal Ground-water Resources and Recharge Areas in Oklahoma: Sheet 2 – Bedrock aquifers and Recharge Areas*. Oklahoma Geological Survey, Geologic Map 43.

Leidos. 2018. *Site Inspection Report for Perfluorooctane Sulfonate and Perfluorooctanoic Acid at Tulsa Air National Guard Base Tulsa, Oklahoma.* November.

Marcher, M.V., and Bingham, R.H. 1971. *Reconnaissance of the Water Resources of the Tulsa Quadrangle, Northeastern Oklahoma*. Oklahoma State Geological Survey, Hydrologic Atlas 2. 4 sheets.

Miller, G.W., and Stanley, T.M. 2006. *Geologic Map of the Mingo 7.5' Quadrangle, Rogers, Tulsa, and Wagoner Counties, Oklahoma*. Oklahoma Geological Survey, Oklahoma Geologic Quadrangle 70.

Oklahoma Climatological Survey. 2011. *Climate of* Oklahoma. Accessed 7 October 2022 at https://climate.ok.gov/index.php/site/page/climate_of_oklahoma.

Oklahoma Water Resource Board. 2020. *Groundwater Wells, Standards, and Protection in Oklahoma*. Accessed February 2020 at https://owrb.maps.arcgis.com/apps/webappviewer/index.html?id=ed61209c40ec4f53bc51d2ffd18aa39b

Oneida Total Integrated Enterprises. 2018. *Final Site Inspection Report, Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas, Environmental Programs Worldwide, Air Force Plant #3 Tulsa, Oklahoma*. August.

USACE. 2016. *Technical Project Planning Process*, EM-200-1-2. 26 February.

USEPA. 1980. *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*.

USEPA. 1994. *National Oil and Hazardous Substances Pollution Contingency Plan (Final Rule)*. 40 CFR Part 300; 59 Federal Register 47384. September.

USEPA. 2001. *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments)*. December.

USEPA. 2017. *National Functional Guidelines for Organic Superfund Data Review*. OLEM 9355.0-136, EPA-540-R-2017-002. Office of Superfund Remediation and Technology Innovation. January.

USFWS. 2022. *Species by County Report, County: Tulsa, Oklahoma.* Environmental Conservation Online System. Accessed 23 December 2022 at https://ecos.fws.gov/ecp/.

Tyrl, R.J., Bidwell, T.G., Masters, R.E., Elmore, R.D., and Weir, J.R. 2007. *Oklahoma's Native Vegetation Types*. Oklahoma State University. Oklahoma Cooperative Extension Service Publication No. E-993

World Climate. 2022. *Average Weather Data for Tulsa, Oklahoma.* Accessed 6 October 2022 at http://worldclimate.com/climate/us/oklahoma/tulsa.

Xiao, F., Simcik, M. F., Halbach, T. R., and Gulliver, J. S. 2015, *Perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) in soils and groundwater of a U.S. metropolitan area: Migration and implications for human exposure.* Water Research 72: 64-74.