FINAL PRELIMINARY ASSESSMENT AND SITE INSPECTION OF PER- AND POLYFLUOROALKYL SUBSTANCES

Former Indiana Army Ammunition Plant, Indiana

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Preliminary Assessment and Site Inspection of Per- and Polyfluoroalkyl Substances

Former Indiana Army Ammunition Plant, Indiana

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EXECUTIVE SUMMARY

The United States Army (Army) 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 perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanesulfonic acid (PFBS), perfluorononanoic acid (PFNA), perfluorohexane sulfonate (PFHxS), and hexafluoropropylene oxide dimer acid (HFPO-DA) at Army installations nationwide. The PA identifies areas of potential interest (AOPIs) where PFAS-containing materials were used, stored, and/or disposed, or areas where known or suspected releases to the environment occurred. The SI includes multi-media sampling at AOPIs 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. This former Indiana Army Ammunition Plant (INAAP) PA/SI was completed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), National Oil and Hazardous Substances Pollution Contingency Plan, and Army/Department of Defense (DoD) policy and guidance.

Former INAAP comprised an area of approximately 10,851 acres and is located in the towns of Jeffersonville and Charlestown in southern Indiana, approximately 10 miles from Louisville, Kentucky, across the Ohio River. The area in the vicinity of former INAAP is a sparsely populated residential area (USAEC 2002).

The former INAAP PA identified five AOPIs for investigation during the SI phase. SI sampling results from the five AOPIs were compared to risk-based screening levels calculated by the Office of the Secretary of Defense (OSD) for PFOS, PFOA, PFBS, PFNA, and PFHxS. Of the six PFAS compounds presented in the 06 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 former INAAP because HFPO-DA is generally not a component of military specification 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. PFOS, PFOA, PFBS, PFNA, and/or PFHxS were detected in soil and/or groundwater at all five of the AOPIs; one of the AOPIs had PFOS, PFOA, PFBS, PFNA, and/or PFHxS present at concentrations greater than the risk-based screening levels. The former INAAP PA/SI identified the need for further study in a CERCLA remedial investigation. **Table ES-1** below summarizes the PA/SI sampling results and provides recommendations for further study in a remedial investigation or no action at this time at each AOPI.

Table ES-1. Summary of AOPIs Identified during the PA, PFOS, PFOA, PFBS, PFNA, and PFHxS Sampling at Former INAAP, and Recommendations

AOPI Name	PFOS, PFOA, PFBS, PFNA, and/or PFHxS detected greater than OSD Risk Screening Levels? (Yes/No/ND/NS)		Recommendation
	GW	SO	
Cooling Tower Fire Area	Yes	ND	Further study in a remedial investigation
Building 709-1 – P&E Area Fire Station	No	No	No action at this time
Building 709-4 – P&E Area Fire Station Foam General Storage	NS*	ND	No action at this time
Building 2521 – Fire Station for Area 1500	No	NS	No action at this time
Fire Training Area at Area 1500	ND	NS	No action at this time

Notes:

* – Groundwater sampling was attempted but not reached at 50 feet below ground surface (bgs). Depth to water was expected at 35 feet bgs. Surface water was collected from a proximal spring, which was representative of groundwater in the area.

Light gray shading – detection greater than the OSD risk screening level

GW – groundwater

ND – non-detect

NS – not sampled

SO – soil

1 INTRODUCTION

The United States (U.S.) Army (Army) 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 perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanesulfonic acid (PFBS), perfluorononanoic acid (PFNA), perfluorohexane sulfonate (PFHxS), and hexafluoropropylene oxide dimer acid (HFPO-DA) at Army installations (installations) nationwide. The Army is the lead agency under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Executive Order 12580 and is conducting the PA/SI consistent with its authority under CERCLA, 42 United States Code §§ 9600, et seq. (as amended), and the Defense Environmental Restoration Program, 10 United States Code §§ 2701, et seq. The PFAS PA/SI included two distinct efforts. The PA identified locations that are areas of potential interest (AOPIs) at former Indiana Army Ammunition Plant (INAAP) based on the use, storage and/or disposal of PFAS-containing materials, in accordance with the 2018 Army Guidance for Addressing Releases of Per-and Polyfluoroalkyl Substances (Army 2018). The SI included multi-media sampling at AOPIs to determine whether or not a release has occurred, and the analytical results were compared to the Office of the Secretary of Defense (OSD) PFOS, PFOA, PFBS, PFNA, and PFHxS risk screening levels to determine whether further investigation is warranted. HFPO-DA was not in the suite of PFAS compounds analyzed during the SI; therefore, there are no HFPO-DA SI analytical results to screen against the OSD risk screening levels. This report provides the PA/SI for former INAAP and was completed in accordance with CERCLA and The National Oil and Hazardous Substances Pollution Contingency Plan.

1.1 Project Background

PFAS are a class of compounds that have been used in a wide range of industrial applications and commercial products due to their unique surface tension/leveling properties. Due to industry and regulatory concerns about the potential health effects and adverse environmental impacts, there has been a reduction in the manufacture and use of PFAS worldwide. In the U.S., significant reductions in the production, importation, and use of PFOS and PFOA (two individual compounds in the PFAS class) occurred between 2001 and 2015 (Interstate Technology Regulatory Council 2017). PFBS replaced PFOS in some applications and is currently used and manufactured in the U.S.

In 2016, the United States Environmental Protection Agency (USEPA) established a lifetime health advisory of 70 nanograms per liter (ng/L) in drinking water for PFOS or PFOA and for the sum of PFOS and PFOA when both are present (USEPA 2016). On 15 October 2019, the OSD provided guidance on the investigation of PFOS, PFOA, and PFBS at Department of Defense (DoD) restoration sites (OSD 2019). The DoD guidance provides risk screening levels for PFOS, PFOA, and PFBS in tap water and soil, calculated using the USEPA's Regional Screening Level (RSL) calculator for residential and industrial/commercial worker receptor scenarios. Following the issuance of the 2019 OSD memo, on 08 April 2021, USEPA published an updated toxicity assessment for PFBS (USEPA 2021). Based on the updated toxicity assessment for PFBS, the OSD issued a memorandum on 15 September 2021 to include updated PFBS risk screening levels (OSD 2021). On 18 May 2022, the USEPA published an update to the RSLs table. The May 2022 RSL table included six PFAS constituents: PFOS, PFOA, PFBS, PFNA, PFHxS, and HFPO-DA (USEPA 2022). On 06 July 2022, the OSD issued a memorandum to include

revised risk screening levels based on the May 2022 USEPA RSLs (OSD 2022). The July 2022 Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program is provided for reference as **Appendix A**. These screening criteria are discussed further in **Section 6.5**.

1.2 PA/SI Objectives

This PA/SI was conducted consecutively because the results of the PA yielded AOPIs that necessitated continuing onto the SI phase in accordance with CERCLA. Consequently, this report provides the combined objectives of both PA and SI reports.

1.2.1 PA Objectives

During the PA, investigators collect readily available information and conduct site reconnaissance. This PA will evaluate and document areas where PFAS-containing materials were used, stored, and/or disposed, so the Army can distinguish between sites that pose little or no threat to human health and the environment and sites that require further investigation.

1.2.2 SI Objectives

An SI is conducted when the PA determines an AOPI exists based on probable use, storage, and/or disposal of PFAS-containing materials. The SI includes multi-media sampling at AOPIs 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.

Installation-specific data quality objectives (DQOs) and the sampling design and rationale are summarized in **Sections 6.1** and **6.2**.

1.3 PA/SI Process Description

For former INAAP, PA/SI development followed the process as described below. **Section 3** provides a summary of the PA activities completed, and **Section 6** provides a summary of the SI activities completed for former INAAP. The PA and SI processes are documented in the PA/SI Quality Control Checklist included as **Appendix B**.

1.3.1 Pre-Site Visit

First, an installation kickoff teleconference was held between applicable points of contact from United States Army Environmental Command (USAEC), United States Army Corps of Engineers (USACE), former INAAP, and Arcadis U.S., Inc. (Arcadis). The kickoff call occurred on 10 February 2021 to discuss the goals and scope of the PA, project scheduling, installation access, timeline for the site visit (if a site visit were to occur), and access to installation-specific databases, and to request available records.

A records review was conducted to obtain electronically available documents from the installation and external sources for review. The purpose of the records research was to identify any area on the

installation that may have been a location where PFAS-containing materials were used, stored, and/or disposed, as well as to gather information on the physical setting and site history at former INAAP.

A research summary report (RSR) was prepared to document and summarize all information regarding the current and historical use, storage, and/or disposal of PFAS-containing materials obtained during the research activities conducted from February through July 2021. This report included the following:

- A list of interviewed personnel, affiliation, roles, and contact information
- Interview logs detailing all interviews that took place during the PA
- A list of the data sources collected and reviewed
- A table of sites identified during research with description and relevance
- An operations timeline
- A site figure with potential AOPIs

1.3.2 Preliminary Assessment Site Visit

The installation is not active, and is now operated by contractors, and some buildings and/or facilities of interest are abandoned or are reported to have been demolished. Therefore, a site visit was not conducted.

1.3.3 Post Research

After the RSR was submitted, a teleconference was scheduled to discuss the preliminary findings and finalize the list of any potential AOPIs. The post-RSR teleconference took place 01 February 2022 and determined that SI phase sampling was warranted. The information collected during the PA research was compiled to develop the installation-specific PA portion of the PA/SI report (**Section 3**). Site data obtained during the PA were used to develop preliminary conceptual site models (CSMs) for each AOPI, which serve as the basis for developing the SI scope of work presented in an installation-specific Quality Assurance Project Plan (QAPP) Addendum.

1.3.4 Site Inspection Planning and Field Work

The SI process was initiated at the installation to evaluate PFOS, PFOA, PFBS, PFNA, and PFHxS presence or absence at each AOPI and determine whether further investigation is warranted. First, an SI kickoff and scoping teleconference was held on 17 May 2022 between USACE, USAEC, former INAAP, and Arcadis.

The objectives of the SI kickoff and scoping teleconference were to:

- discuss the AOPIs selected for sampling and the proposed sampling plan for each AOPI
- gauge regulatory involvement requirements or preferences
- identify overlapping unexploded ordnance or cultural resource areas
- confirm the plan for investigation-derived waste (IDW) handling and disposal

- identify specific installation access requirements and potential schedule conflicts
- discuss general SI deliverable and field work schedule information and logistics

A Programmatic Uniform Federal Policy-Quality Assurance Project Plan (PQAPP) was developed and finalized in October 2019 for the USAEC PFAS PA/SI (Arcadis 2019). The PQAPP details general planning processes for collecting data and describes the implementation of quality assurance (QA) and quality control (QC) activities for the SI portion for Army installations nationwide. Additionally, an installation-specific QAPP Addendum was developed to define the DQOs, present the sampling design and rationale, and provide qualifications for project personnel. The SI field work was completed in accordance with the PQAPP (Arcadis 2019) and the approved installation-specific QAPP Addendum. A Site Safety and Health Plan (SSHP) was also developed as an attachment to the QAPP Addendum to identify specific health and safety hazards that may be encountered at the installation during sampling. The SSHP was designed to supplement the Accident Prevention Plan (Arcadis 2018), which was developed for Army installations nationwide. The QAPP Addendum and SSHP were submitted to the installation and finalized before commencement of field work.

The DQOs, sampling design and rationale, and field methods employed for the SI are summarized from the QAPP Addendum developed for former INAAP (Arcadis 2022) in **Sections 6.1** through **6.3**.

After finalization of the QAPP Addendum and SSHP, field planning and coordination with the installation and subcontractors was completed. Once the schedule was determined, field teams mobilized to the installation to complete the scope of work defined in the QAPP Addendum.

1.3.5 Data Analysis, Validation, and Reporting

Environmental samples collected during the SI were submitted to a laboratory which is DoD Environmental Laboratory Accreditation Program (ELAP)-accredited for PFOS, PFOA, PFBS, PFNA, and PFHxS analysis by liquid chromatography with tandem mass spectrometry and compliant with the DoD Quality Systems Manual (QSM) 5.4 (DoD and Department of Energy 2021), Table B-15. Laboratory analytical results were then validated and verified by a project chemist to assess the usability of the data collected. Validated analytical results were summarized in the context of OSD risk screening levels (defined in **Section 6.5**).

2 INSTALLATION OVERVIEW

The following subsections provide general information about former INAAP, including the location and layout, the installation mission(s) over time, a brief site history, current and projected land use, climate, topography, geology, hydrogeology, surface water hydrology, potable wells within a 5-mile radius of the installation, and applicable ecological receptors.

2.1 Site Location

Former INAAP is located in the towns of Jeffersonville and Charlestown in southern Indiana, approximately 10 miles from Louisville, Kentucky, across the Ohio River (**Figures 2-1 and 2-2**). The former installation area of approximately 10,851 acres is bordered by Indiana State Highway 62 to the west and the Ohio River to the east. The area in the vicinity of former INAAP is sparsely populated residential area (USAEC 2002).

2.2 Mission and Brief Site History

The former INAAP, constructed in the early 1940s, originally consisted of three separate facilities, including the Indiana Ordnance Works Plant 1 (Propellant and Explosives [P&E] Area), where smokeless powder was manufactured; the Hoosier Ordnance Works (Load Assemble Package [LAP] Area); and the Indiana Ordnance Works Plant 2 (Double-Base Rocket Propellant Plant). The three facilities were consolidated into the Indiana Arsenal in 1945. The Indiana Arsenal was redesignated as the Indiana Ordnance Plant in 1961; in August 1963, it was redesignated again as the Indiana Army Ammunition Plant (USAEC 2002).

Partial closure of former INAAP under the 1988 Base Realignment and Closure (BRAC) plan transferred an approximately 859-acre portion situated at the northeastern terminus of installation, leaving the total acreage at 9,790 acres. On 16 August 1993, the Army made the 859-acre transfer to the U.S. Department of the Interior thereby completing the BRAC mandated “partial closure”. The official closure date of the 1988 BRAC parcel was 31 August 1993. The U.S. Department of the Interior subsequently transferred the parcel to the Indiana Department of Natural Resources for use as a state park (USACE 2020).

The non-BRAC portion of former INAAP had been placed into modified caretaker status in 1992 and was operated by ICI Americas, Inc. as an industrial park. Starting in 1995, Congress began to pass a series of special legislations that approved the transfer of the property to the State of Indiana and the local reuse authority. In 1998, the Army made a determination of excess making the remaining land available for reuse (USACE 2020).

On 03 December 2001, the Vice Chief of Staff for the U.S. Army directed an Industrial Base Program Review in support of Army Transformation requirements. In October 2002, this review resulted in the transfer of 13 non-BRAC excess industrial installations (including the remaining former INAAP property) from Army Materiel Command to Assistant Chief of Staff for Installation Management (now known as Deputy Chief of Staff for Installations) for divesture, and the BRAC Division was assigned the mission of managing conveyance for these non-BRAC excess installations (USACE 2020). The Army transferred oversight responsibility for environmental cleanup and property conveyance from the Army Materiel

Command to the Assistant Chief of Staff for Installation Management (now known as Deputy Chief of Staff for Installations) BRAC Division. There is no caretaker staff onsite (Army 2019).

2.3 Current and Projected Land Use

Property conveyance began in October 2004 and as of August 2016, 100 percent (%) of the former INAAP property had been conveyed. Parcel recipients include Charlestown State Park and River Ridge Redevelopment Authority. Charlestown State Park consists of 5,100 acres and attracts nearly 200,000 recreational visitors annually. The park offers hiking trails, picnic areas, fishing, boating, playground equipment, and campgrounds (Indiana Department of Natural Resources 2022). The remaining acreage was redeveloped by River Ridge Redevelopment Authority to create the River Ridge Commerce Center. River Ridge Commerce Center hosts more than 60 companies including aerospace, automotive, food and beverage, information technology, life sciences and logistics. In 2019, the River Ridge Development Authority invested in capital improvement projects to lay the groundwork for new development. Capital improvement/infrastructure projects included expanding the River Ridge roadway network to allow better traffic circulation and access to developable sites; improving water utilities; removing abandoned Army structures that remained on the site; and clearing debris from sites to make them attractive for development. At the time of this report, nearly 1,000 abandoned Army structures remain at River Ridge Commerce Center (River Ridge Development Authority 2022).

2.4 Climate

The climate in the vicinity of former INAAP is of the continental type and is categorized as mild and moderate with hot summers and moderately cold winters. The proximity of former INAAP to Louisville suggests that the data for Louisville are representative of the former INAAP.

The average temperature ranges from approximately 29.4 to 45.6 degrees Fahrenheit (^{o}F) in the winter to approximately 67.8 to 86.6 ^{o}F in the summer. The average annual precipitation is approximately 48.12 inches with the lowest amount in February, averaging 3.27 inches, and the highest amount in May, averaging approximately 5.16 inches (National Weather Service 2020).

Floods occur in some parts of Indiana nearly every year and have occurred in every month of the year. The months of greatest flood frequency are from December through April. The primary cause of floods is prolonged periods of heavy rain, although rain falling on snow and frozen ground is a contributing factor. Flooding of the Ohio River has been a problem on the floodplain and stream valleys at former INAAP. At flood stage, the Ohio River can overflow the floodplain and cause the tributary streams to back up through the valleys. Severe storms that damage property and cause loss of life are most frequent in the spring. Indiana has an annual average of 11 days with tornadoes (U.S. Army Toxic and Hazardous Materials Agency 1990).

2.5 Topography

The topography, proceeding successively from the Ohio River westward, traverses a relatively flat river flood plain, with an elevation of approximately 450 feet to climb a steep escarpment to an elevation of approximately 550 feet, which parallels the river and extends laterally along the major drainage-ways (**Figure 2-3**). The uplands are moderately dissected with slopes ranging from relatively level to 30%. The

northern part (Fourteen Mile Creek area) of the plant is extremely rough and broken, being more deeply dissected by Fourteen Mile creek and its tributaries, with less land suitable for row cropping and more suitable for woodlands and wildlife. The middle and southern parts of former INAAP west of the steep escarpment has more level to gently rolling land (USACE 1999).

2.6 Geology

The geology at former INAAP generally consists of unconsolidated sediments overlying carbonate bedrock. The Uplands Areas consist of glacial and residual weathered bedrock materials while the Terrace/Floodplain Area consists of fluvial silts and clays or terrace sands and gravels.

Most of the installation is located in the Upland Areas. The ground surface is gently rolling to nearly flat, except where surface water drainage has eroded the unconsolidated surficial deposits and cut into the limestone strata, forming steep-sided valleys. Numerous sinkholes, springs, and solution caverns are present. Surficial deposits in the Upland Areas consist of glacial till and residuum. The glacial deposits, where present, are primarily fine-grained sediments consisting of clay, silt, and sand. The residuum underlying the reported glacial material consists of layers of insoluble bedrock material of varying thickness, primarily residual clays and chert fragments that remained in place after erosion removed the soluble components.

The terrace/floodplain deposits along the east side of former INAAP are part of the Alluvial-Valley Aquifer-Stream System. The aquifer-stream system formed as melt waters from glacial events eroding a deep valley in the bedrock (i.e., the Ohio River Valley). During later stages of glaciation, the valley was filled with sand and gravel deposits from glacial melt waters (i.e., the terrace deposits). As the glaciers retreated, the sediment load in the glacial melt water decreased; as a result, clay, silt, and fine sand (i.e., floodplain deposits) was deposited on top of the coarser sands and gravels (USACE 1999).

The bedrock surface beneath former INAAP consists of limestone and shale of the Ordovician, Silurian, and Devonian systems. The youngest, and stratigraphically highest, rock formation beneath former INAAP is the New Albany shale. which is dark gray-to-black and relatively impervious. The uneroded formation is approximately 60 to 140 feet thick and highly jointed in many areas. Because this formation is exposed at the surface at former INAAP, erosion has reduced its thickness to the point where development of sinkholes is common. In some locations, lenses of sandstone and sandy shale have been noted near the base of the formation.

Beneath the New Albany shale are limestone units of Middle Devonian age. Successively older units are the Beechwood limestone, the Silver Creek limestone, and the Jeffersonville limestone. The Beechwood limestone is a hard, massive, coarse crystalline crinoidal limestone, approximately 3 feet thick. The Silver Creek limestone is fine-grained, thinly bedded, clayey limestone, averaging approximately 16 feet in thickness. The Jeffersonville limestone is the basal member of the Middle Devonian rocks, composed of an upper shaley fossiliferous limestone, a middle white to blue-gray, hard, massive limestone, with a total thickness of approximately 10 feet. The aggregate thickness of the Middle Devonian units is approximately 50 feet.

Silurian Age formations underlying the Jeffersonville limestone outcrop along the Ohio River and tributary valleys at former INAAP. The Louisville limestone, Walden shale, Laurel limestone, Osgood formation, and Brassfield limestone comprise the Silurian sequence at the installation. The Louisville limestone is

the uppermost Silurian formation consisting of light gray-to-yellowish or buff, massive magnesian limestone. The Walden shale lies unconformably below the Louisville limestone, is relatively impermeable, and is approximately 10 feet thick in most areas. The Laurel limestone is an evenly bedded, hard, white limestone, approximately 40 to 50 feet thick. It usually occurs in even-bedded layers, and chert is frequently present. The Osgood formation is approximately 20 feet thick and consists of layers of limestone and shale. The Brassfield limestone is a coarse crystalline, mottled pinkish limestone, approximately 1 to 16 feet thick. This formation is unconformable with the overlying Osgood formation and the underlying Ordovician rocks.

The oldest outcropping rock at the former INAAP is limestone and shale of the Ordovician Maquoketa Group that underlie the Brassfield limestone. These rocks outcrop along Fourteen Mile Creek at the north end of the installation (USACE 1992a).

2.7 Hydrogeology

Groundwater is found in the bedrock underlying the former INAAP and in the sand and gravel deposits of the Ohio River floodplain terraces. The underlying aquifer is recharged through soil infiltration, inflow through sinkholes, and seepage from water courses. The sand and gravel aquifer receives a majority of its recharge from the Ohio River (USACE 1992b).

Regionally, groundwater flow direction at the former INAAP tends to follow surface drainage patterns toward the Ohio River to the east (**Figure 2-2**). However, groundwater flow varies greatly at the local level due to the heavily karstified subsurface geology. The groundwater flow tends to follow surface drainage patterns toward the Ohio River to the east; however, groundwater flow varies in the areas of karst terrain. The exact discharge points are not easily predictable due to fractured bedrock (USACE 1992b). In 1950 grease and oil from a vehicle wash rack in the southwest corner of the installation reportedly appeared in a spring off government property, southwest of the facility in question. Dye tests performed at the wash rack confirmed the subsurface connection. In another instance, a dye test was performed in a sinkhole within the P&E area. This test indicated a northwestward-to-northward subsurface flow. Several springheads are reportedly on the installation. The flow from one of the largest spring heads is, judging by the topography, probably from an easterly direction. These data confirm that variable groundwater flow patterns exist at former INAAP (USACE 1992a).

Bedrock aquifers are not considered a significant water supply in Clark County. Former INAAP does not obtain potable or industrial water supplies from bedrock formations. Groundwater productivity varies with geography and with elevation, being governed mainly by structural discontinuities and/or bedding orientation of the rock. Wells in this region generally extend to depths of 100 to 200 feet, into Silurian dolomite or the alternating limestone and shales of the Ordovician age. Small yields can be obtained by dug wells. No potable or industrial water supplies are obtained from the bedrock aquifer at former INAAP, but bedrock groundwater is a source of water for livestock through spring discharges (USACE 1992a).

The Ohio River and the terrace/floodplain aquifer are in hydraulic connection, and water levels in the aquifer respond to changes in river stage as well as other factors, such as changes in barometric pressure and precipitation. The sand and gravel also receive some recharge from upland areas as shallow groundwater flows toward the Ohio River. However, this amount is very small compared to the amount of recharge from the Ohio River (URS 2003).

Any individual domestic wells located outside the former INAAP boundaries are unlikely to be affected by possible groundwater contamination from former INAAP. These wells are most likely fracture-flow wells. It was reported that more than 50 dye-trace studies on fracture-flow wells (sustained flow less than 25 gallons per minute) in Mississippian-age limestone in Kentucky indicate that recharge is from local epikarst (Ray 2001). No positive dye-trace results from a source more than 800 feet from a well was detected (URS 2003).

2.8 Surface Water Hydrology

The principal drainage channels at the former INAAP are Fourteen Mile Creek; Battle Creek; Little Battle Creek; East, West, and Central Lentzier Creeks; Lick Creek; and Jenny Lind Run. There are 13 National Pollutant Discharge Elimination System (NPDES)-permitted outfalls at the former INAAP (NPDES Permit IN0001163) (USACE 1992b).

All the surface streams serving the former INAAP are tributaries of the Ohio River, and all originate within the former INAAP, except for Fourteen Mile Creek. Fourteen Mile Creek enters INAAP at the northeast corner as a continuous stream and flows southeast to the Ohio River. This stream and its principal tributary, Lick Creek, drain the northern portion of the facility (USACE 1992b).

Surface water on former INAAP all drains into the Ohio River. There is fishing in the Jenny Lind Pond and Fourteen Mile Creek; however, that is the extent of former INAAP surface water use. Jenny Lind Run has shown moderate levels of lead contamination in sediment and low levels in the surface water (USACE 1992a).

All streams on the installation drain into the Ohio River, which has an average flow rate in Louisville, Kentucky, of 98,433 cubic feet per second. Louisville is the only municipality within 15 miles downstream to use the Ohio River as a drinking water source. The intakes for the Louisville water system are 9 miles downstream from the confluence with Jenny Lind Run (USACE 1992a).

2.9 Relevant Utility Infrastructure

The following subsections provide general information regarding the installation's stormwater and wastewater management systems, as well as information on how the utility infrastructures may influence the fate and transport of PFAS constituents at former INAAP.

2.9.1 Sewer and Stormwater Management System Description

Former INAAP had five sewage treatment plants. These are the P&E, River Ridge North and South, LAP, and Black Powder Plants. Also, process wastewater was historically discharged to several creeks, ponds, and holding basins at the facility, including Jenny Lind Run/Flume, Jenny Lind Pond, Aniline Pond, Process Waste Settling Basin, and North and South Ash Settling Basins (USACE 1999).

Originally, sewer and process wastewater had outfalls to a large ditch leading to Jenny Lind Run and subsequently to the Process Waste Settling Basin. When former INAAP began operations, two-thirds of the wastewater entered rock crevices and disappeared underground. The wastewater resurfaced more than 4,000 feet away. Vitreous clay pipes were laid in the creek to carry the water, and refractory brick

headwalls were constructed. A large-diameter lead-lined culvert was installed in the creek bed (USACE 1999).

The P&E Plant was upgraded in 1973 by the addition of secondary treatment facilities. In 1972, the River Ridge Package Plants replaced three septic tanks that discharged directly to the Ohio River. The plants were upgraded in 1976 by the addition of phosphorus removal systems. The Black Powder Package Plant is a physical-chemical system (USACE 1999).

The environmental baseline survey, dated August 1998, prepared by Plexus Scientific Corporation states that the sanitary sewer lines in the P&E Area are interconnected with the storm sewer lines and industrial lines, several of which are plugged with nitrocellulose. In 1981, 20,000 feet of the original vitreous clay sewer pipes were slip-lined with polyethylene pipe to reduce infiltration (USACE 1999).

2.10 Potable Water Supply and Drinking Water Receptors

The water supply for the former INAAP was built during World War II to support the manufacture of smokeless gunpowder and rocket propellant. The original water supply system consisted of a series of seven high-capacity Ranney horizontal collector wells constructed in the prolific alluvial aquifer along the Ohio River. A portion of the former INAAP land was transferred to the State of Indiana to expand Charlestown State Park, which included the land along the Ohio River with the collector wells and pipelines. Between 2009 and 2011, the State of Indiana invested in the construction of a new water supply system for the Charlestown State Park and the River Ridge Commerce Center. The supply system consists of a well field, treatment plant, transmission pipelines, storage tank and booster pump station with a capacity of approximately 2.0 million gallons per day. The alluvial aquifer has the potential for sustainable production of over 75 million gallons per day for use as a regional water supply in Southeastern Indiana (INTERA, Inc. 2020).

The current source of supply is the Charlestown State Park Well Field, with three production wells in the southeast portion of the installation, located near the treatment plant in a line parallel to the Ohio River. The wells produce groundwater from the Ohio River Alluvium, a highly productive glacial outwash aquifer composed of permeable sand and gravel deposits. The deposits fill a pre-glacial bedrock valley along the Ohio River. The aquifer is limited in extent, with a saturated thickness of less than 100 feet. Perpendicular to the river, the aquifer pinches out where the bedrock crops out along a line of bluffs ranging from 400 to 1,000 feet from the river. The Ohio River is incised into the aquifer and is connected through a layer of silt and organic material lying along the riverbed. The hydraulic connection to the Ohio River supports high yields from the aquifer and is the primary control on groundwater levels. Static water levels in the aquifer are determined by river stage, which is controlled downstream of the well field by the McAlpine Locks and Dam in Louisville. Analysis of daily data from a United States Geological Survey monitoring well at the well field indicates that the minimum, median, and 90th percentile groundwater levels are 419, 420, and 425 feet, respectively. The ground elevation in the well field is approximately 449 feet. The existing treatment facility is located adjacent to the well field. The plant is designed for iron and manganese removal and includes aeration and detention, filtration, chemical treatment, backwash recycling, and high service pumping (INTERA, Inc. 2020).

An Environmental Data Resources, Inc. (EDR) report includes search results from a variety of environmental, state, city, and other publicly available databases for a referenced property. An EDR

report was generated for former INAAP, which along with state and county geographic information system data provided by the installation identified several off-post public and private wells within 5 miles of the installation boundary (**Figure 2-4**). The EDR report providing well search results is provided as **Appendix C**.

2.11 Ecological Receptors

The PA team collected information regarding ecological receptors that was available in the installation documents. The following information is provided for future reference should the Army decide to evaluate exposure pathways relevant to the ecological receptors.

Federal

The U.S. Fish and Wildlife Service, Bloomington, Indiana field office conducted a bat survey in 1997 and concluded that there is a maternity colony of the endangered gray bat at former INAAP, probably located in the upper portion of the Jenny Lind Run drainage. Data collected again in 1998 further supported this conclusion. Assuming the presence of a maternity colony of gray bats on former INAAP, this indicates that there is a cave on the installation, which meets the narrow requirements of the species. The exact location of the maternity colony was unable to be determined because of the general difficulty associated with radio tracking, the many openings to the cave system and safety concerns limiting the ability to explore the cave system. Protection of gray bats at former INAAP will involve protection of the karst features and protection of forested stream corridors used by the bats.

Other threatened or endangered species which could inhabit the installation include the Indiana Bat and the Fat Pocketbook mussel. Any action that would disturb these species must comply with the Endangered Species Act.

State of Indiana

Endangered plant species include the Leavenworthia, Wild Cherry, and Great Plains Lakies' Tresses. Threatened plant species include the Large-leaved phlox, Eastern broadleaf, Wallrue spleenwort, Two-seeded mercury, Slender Heliotrop, and Allegheny Stonecrop. Rare plant species include the Adder's-tongue Fern, Ebony sedge, Illinois Woodsorrel, Crested Coral Root Orchid, and Groved Yellow Flax. Watch List plant species include the Alumroot, Carolina buckeye, American Mistletoe, Yellow Buckeye, and Eastern Milk Pea. Plant species of concern include the Ohio Sullivantia and Large Passionflower.

Endangered vertebrates include the Eastern hellbender and threatened vertebrates include the Henslow sparrow and Kirtland's snake.

2.12 Previous PFAS Investigations

Previous (i.e., pre-PA) PFAS investigations relative to former INAAP, including both those conducted and not conducted by the Army, are summarized to provide full context of available PFAS data for former INAAP. However, only data collected by the Army will be used to make recommendations for further investigation. Available results are included in **Table 2-1** and a summary is included below.

2.12.1 Off-post

Historical sampling for select PFAS in drinking water was conducted in 2013 per the Third Unregulated Contaminant Monitoring Rule. Two drinking water source locations were sampled per the 2013 Third Unregulated Contaminant Monitoring Rule. One location was directly across the Ohio River from the southeastern corner of the installation, located in Prospect, Kentucky, at the Louisville Water Company's B.E. Payne Water Treatment Plant. The second location was over 5 miles down the Ohio River from the installation border, located in Louisville, Kentucky, at the Louisville Water Company's Crescent Hill Filter Plant. PFOA was detected at a concentration of 20 ng/L at both locations (Kentucky Department of Environmental Protection 2019). All other select PFAS were non-detect at both locations.

In February 2021, Indiana Department of Environmental Management began facilitating PFAS monitoring at all Community Public Water Systems throughout the state of Indiana. Samples are being collected at all raw water (i.e., wells and intakes) and finished (after treatment) water points in a Community Public Water System's supply. Samples were collected in October 2021 from the well fields of the Rural Membership Water Corporation of Clark County suppliers, including the Stucker Fork Water well field north of the installation and the Sellersburg Water well field south of the installation. The October 2021 analytical data contained results for two samples but did not indicate which well field(s) the samples were associated with for confidentiality. One sample was non-detect for all of the 18 PFAS compounds that were analyzed, and the other sample showed detections of 3.3 ng/L or less in a list of 18 PFAS compounds. PFOA was detected at 3.3 ng/L, PFOS was detected at 2.5 ng/L, and PFBS was detected at 2.7 ng/L (Indiana Department of Environmental Management 2022).

2.12.2 On-post

Louisville Water Company performed additional testing in December 2019. The lab analysis was performed on a mix of raw water from Well 1 and Well 3 of the Charlestown State Park Well Field. The wells were operating together at the time of sample collection and PFOA was detected at a level of 4.5 ng/L in the combined sample collected from Well 1 and Well 3 (INTERA, Inc. 2020). INTERA, Inc. collected samples for analysis of PFOA, PFOS, and PFHxA in January 2020 from the three production wells (Well 1, Well 2, and Well 3) of the Charlestown State Park Well Field. The highest concentrations for each well were for PFOA, with 6.9 ng/L being the highest in Well 3 (INTERA, Inc. 2020).

As part of the same monitoring at all Indiana Community Public Water Systems by the Indiana Department of Environmental Management mentioned in **Section 2.12.1**, samples were collected in June 2021 from the Charlestown State Park supply system, which is the well field for the Indiana American Water Company. Analytical data showed detections of 6.5 ng/L or less in a list of 18 PFAS compounds. PFOA was detected in two samples at 6.5 ng/L, and other detections included PFHxA and PFOS (Indiana Department of Environmental Management 2022).

3 SUMMARY OF PA ACTIVITIES

To document areas where any potential current and/or historical PFAS-containing materials were used, stored and/or disposed at former INAAP, data was collected from three principal sources of information and are described in the subsections below:

1. Records review
2. Personnel interviews

Preliminary locations of potential use, storage, and/or disposal of PFAS-containing materials were then evaluated in the PA (during records review, personnel interviews, and/or site reconnaissance) and were categorized as AOPIs or as areas not retained for further investigation at this time based on a combination of information collected (e.g., records reviewed, personnel interviews, internet searches). A summary of the observations made and data collected through records reviews (**Appendix D**) and installation personnel interviews (**Appendix E**) during the PA process for former INAAP is presented in **Section 4**. Further discussion regarding rationale for not retaining areas for further investigation is presented in **Section 5.1**, and further discussion regarding categorizing areas as AOPIs is presented in **Section 5.2**.

3.1 Records Review

The records reviewed for this PA included, but were not limited to, various Installation Restoration Program (IRP) administrative record documents, compliance documents, former INAAP fire department documents, former INAAP directorate of public works documents, and geographic information system files. Internet searches were also conducted to identify publicly available and other relevant information. A list of the specific documents reviewed for former INAAP is provided in **Appendix D**.

3.2 Personnel Interviews

The list of roles for the installation personnel interviewed during the PA process for former INAAP is presented below.

- Former INAAP Firefighter (Current Fire Chief of the Utica Township Fire Department)
- Charlestown Fire Department Records Administrator
- River Ridge Development Authority Director of Planning and Operations
- Charlestown Public Library Historian

The compiled interview logs are provided in **Appendix E**.

4 POTENTIAL PFAS USE, STORAGE, AND/OR DISPOSAL AREAS

Former INAAP was evaluated for all potential current and historical use, storage, and/or disposal of PFAS-containing materials. As such, this section is organized to summarize the aqueous film-forming foam (AFFF)-related uses first, and all remaining potential PFAS-containing materials in the subsequent section.

4.1 AFFF Use, Storage, and Disposal Areas

AFFF was developed in the mid-1960s in response to a need for firefighting foams better suited to extinguish Class B, fuel-based fires. AFFF formulations consist of water, an organic solvent, up to 5% hydrocarbon surfactants, and 1 to 3% PFAS (Interstate Technology Regulatory Council 2020). AFFF concentrate is designed to be diluted with water to become a 1, 3, or 6% foam. AFFF releases at DoD facilities may have occurred during firefighter training, emergency response actions, equipment testing, or accidental releases. The military still primarily uses AFFF for Class B fires; however, the current formulations of AFFF contain significantly lower amounts of PFOS, PFOA, and their precursors, and significant operational changes have been implemented to restrict uncontrolled releases and non-essential use of PFAS-containing foams. Army installations may still house AFFF, commonly stored in closed containers (e.g., 55-gallon drums, 5-gallon buckets), within designated storage buildings or at firehouses.

During the PA, several areas were identified as having the potential for use, storage, and/or disposal of AFFF. One area was identified as an emergency response to a fire that was suppressed with AFFF (Cooling Tower Fire Area), two areas were identified as fire stations in areas with known AFFF use and storage (Building 709-1 – P&E Area Fire Station and Building 2521 – Fire Station for Area 1500), one area was identified as a storage building for AFFF (709-4 – P&E Area Fire Station Foam General Storage), and one area was identified as a fire training area that used AFFF (Fire Training Area at Area 1500).

4.1.1 Former and Current Fire Stations

While former INAAP was active, the installation had two fire stations that both used AFFF for fire suppression. One fire station was responsible for the P&E Area, and one was responsible for Area 1500 and the area surrounding it. The Building 709-1 – P&E Area Fire Station was the fire station for the P&E Area, which had known uses of AFFF (e.g., emergency response to fires) and was associated with a foam storage building (Building 709-4) that is approximately 0.2 mile to the south-southeast. Building 709-4 – P&E Area Fire Station Foam General Storage housed foam for the associated fire station at Building 709-1, and likely stored AFFF. The Building 2521 – Fire Station for Area 1500 was the fire station for Area 1500, which had known uses of AFFF (e.g., fire training) and stored 5-gallon buckets of AFFF. The building also had a fire-fighting equipment storage shed attached to the back.

During the PA, two interviewees were able to provide information regarding fire response coverage at the former INAAP. According to an interview with a former INAAP firefighter and current Fire Chief at the Volunteer Utica Township Fire Department, the Charlestown and Utica fire departments split the

responsibility of emergency response at the former INAAP property. According to an interview with a Charlestown Fire Department employee, the Charlestown and Jeffersonville fire departments currently split the responsibility of the former INAAP property. This employee also mentioned that the Charlestown Fire Department has not used AFFF at the former INAAP property.

4.1.2 Other AFFF-Related Areas

In 1988 or 1989, a fire occurred near the cooling tower, and firefighters from the P&E Area fire station used AFFF in the efforts to suppress the fire. It is unknown how much AFFF was used during the firefighting process or exactly where the AFFF was sprayed. However, based on the historical and current aerials, a woodland area has and still exists on the north side of the building that would likely force the AFFF to be sprayed from the west, south, and east sides of the building.

The Fire Training Area at Area 1500 was used for fire training that consisted of burning cars and diesel fuel to simulate a burning diesel tank from approximately 1990 until 1993. Based on the historical aerials, there appeared to be three targets approximately 50 feet apart from each other.

4.2 Other PFAS Use, Storage, and/or Disposal Areas

Following document research, personnel interviews, and site reconnaissance at former INAAP, two sewage treatment plants and two landfills were also identified as preliminary locations for use, storage, and/or disposal of PFAS-containing materials. A summary of information gathered in the PA for each of these preliminary locations is described below. Specific discussion regarding areas not retained for further investigation is presented in **Section 5.1** and specific discussion regarding areas retained as AOPIs is presented in **Section 5.2**.

4.2.1 Sewage Treatment Plants

The P&E Area Sewage Treatment Plant (INAAP-10) was identified as a potential receptacle for PFAS-containing materials. This plant is situated on about 2 acres and has been used since 1941 to treat sewage from the P&E Area. Treatment processes include primary settling, trickling filter, final clarifier, digesters, and chlorination. The plant is operational at the time of this report, with effluent discharging to the P&E flume under a NPDES permit. Waste sludge is placed in drying beds, which consist of a concrete retaining wall and filter media, prior to disposal (USAEC 2002).

The LAP Area Sewage Treatment Plant (INAAP-13) was also identified as a potential receptacle for PFAS-containing materials. This plant is situated on about 2 acres and has been used since 1942 to treat sewage from the LAP and Inert areas. Treatment processes included primary and intermediate settling, aeration, trickling filter, final clarifier, and chlorination. Effluent discharges to the Ohio River under a NPDES permit. Waste sludge is placed in drying beds, which consist of a concrete retaining wall, filter media, and a leachate collection system, prior to disposal. Leachate discharges to the Central Branch of Lentzier Creek (USAEC 2002).

4.2.2 Landfills

The Old Landfill (INAAP-01) occupies about 20 acres and is separated into east and west sections by Landfill Road. The landfill was active from 1969 to 1974. Prior to 1969 the area was reportedly used as a burning ground for domestic waste. The landfill reportedly contains general refuse, construction debris, nitrocellulose waste, and possibly polychlorinated biphenyls. The landfill is unlined and soil covered. Various types of debris are visible, including debris north of the landfill in an area that is now part of Charlestown State Park (USAEC 2002).

The New Landfill (INAAP-02A and INAAP-02B) occupies about 45 acres. This landfill has two parts: 2A is the Solid Waste Landfill, and 2B is the hazardous waste cells and fill within the Solid Waste Landfill. The Solid Waste Area was used until 1993. The Hazardous Waste Area was used until 1982. The landfill originally received industrial and household waste from facility operations containing general refuse, sewage treatment sludge, dispensary wastes, and construction debris. Wastes were buried in the northern and western parts of the landfill that were later determined to be hazardous and included lead-lined bags, cadmium paint shavings, propellant-contaminated wastes, and asbestos debris. The landfill is unlined and soil covered. Surface debris is not visible. Approximately 28,000 cubic yards of wastes were deposited in the landfill each year (USAEC 2002).

4.3 Readily Identifiable Off-Post PFAS Sources

An exhaustive search to identify all potential off-post PFAS sources (i.e., not related to operations at former INAAP) is not part of the PA/SI. However, potential off-post PFAS sources within a 5-mile radius of the installation that were identified during the PA research are described below.

At the time of this report, an aerospace systems manufacturer facility is located 350 feet northwest of the Building 2521 – Fire Station for Area 1500 AOPI and an automobile manufacturer facility is located 0.4 mile northeast of the Building 2521 – Fire Station for Area 1500 AOPI. Information was not available to determine if these facilities were actively manufacturing or for administrative purposes.

Additionally, nearby fire departments or stations within close proximity of former INAAP could potentially be off-post PFAS sources if they use, store, or dispose AFFF. Approximately 15 fire stations or fire departments appear to be within 5 miles from the installation boundary.

5 SUMMARY AND DISCUSSION OF PA RESULTS

The preliminary locations evaluated for potential use, storage, and/or disposal of PFAS-containing materials at former INAAP were further refined during the PA process and identified either as an area not retained for further investigation or as an AOPI. In accordance with the established process for the PA/SI, five areas have been identified as AOPIs. The process used for refining these areas is presented on **Figure 5-1**, below.

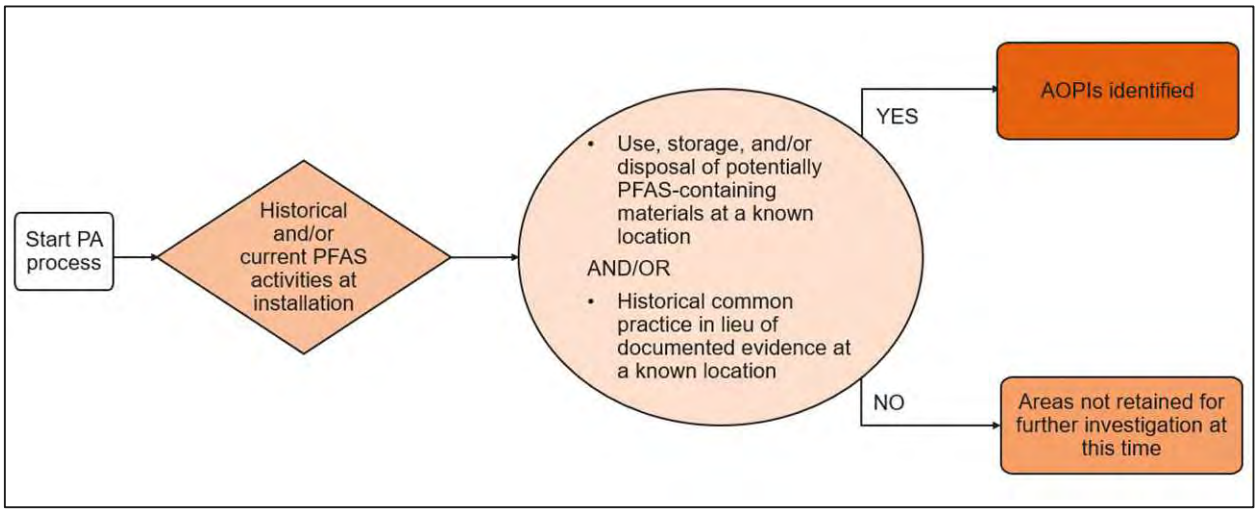


Figure 5-1: AOPI Decision Flowchart

The areas not retained for further investigation are presented in **Section 5.1**. The areas retained as AOPIs are presented in **Section 5.2**.

Data limitations for this PA/SI at former INAAP are presented in **Section 8**.

5.1 Areas Not Retained for Further Investigation

Through the evaluation of information obtained during records review, personnel interviews, and/or site reconnaissance, the areas described below were categorized as areas not retained for further investigation at this time.

A brief site history and rationale for areas not retained for further investigation are presented in **Table 5-1**, below.

Table 5-1. Installation Areas Not Retained for Further Investigation

Area Description	Dates of Operation	Relevant Site History	Rationale
LAP Sewage Treatment Plant (INAAP-13)	1942 to Current	The LAP Area Sewage Treatment Plant is situated on about 2 acres and has been used since 1942 to treat sewage from the LAP and Inert areas. Effluent discharges to the Ohio River under a NPDES permit. Waste sludge is placed in drying beds prior to disposal.	There is no evidence of PFAS-containing materials being used, stored or disposed of at this location. There is no evidence that any wastewater entering this facility contained PFAS.
P&E Sewage Treatment Plant (INAAP-10)	1941 to Current	The P&E Area Sewage Treatment Plant is situated on about 2 acres and has been used since 1941 to treat sewage from the P&E Area. The plant is currently operational, with effluent discharging to the P&E Flume under a NPDES permit. Waste sludge is placed in drying beds prior to disposal.	There is no evidence of PFAS-containing materials being used, stored or disposed of at this location. There is no evidence that any wastewater entering this facility contained PFAS.
New Landfill (INAAP-02A and INAAP-2B)	Unknown to 1993	The New Landfill is unlined, soil covered, and occupies about 45 acres. This landfill has two parts: 2A is the Solid Waste Landfill, and 2B is the Hazardous waste cells and fill within the Solid Waste Landfill. The Solid Waste Area was used until 1993. The Hazardous Waste Area was used until 1982. The landfill originally received industrial and household waste from facility operations containing general refuse, sewage treatment sludge, dispensary wastes, and construction debris.	There is no evidence of PFAS-containing materials being used, stored or disposed of at this location. There is no evidence that the sludge contained PFAS.
Old Landfill (INAAP-01)	1969 to 1974	The Old Landfill is unlined, soil covered, occupies about 20 acres, and is separated into east and west sections by Landfill Road. Prior to 1969 the area was reportedly used as a burning ground for domestic waste.	There is no evidence of PFAS-containing materials being used, stored or disposed of at this location. There is no evidence that the sludge contained PFAS or that AFFF was being used during the time the area was used as a burning ground.

5.2 AOPIs

Overviews for each AOPI identified during the PA process are presented in this section. None of the AOPIs overlap with former INAAP IRP sites and/or Headquarters Army Environmental System sites (**Figure 5-2**). At the time of this PA, none of the former INAAP IRP sites have historically been investigated or are currently being investigated for the possible presence of PFAS.

The AOPI locations are shown on **Figure 5-2**. Aerial photographs of each AOPI are presented on **Figures 5-3 through 5-7**.

5.2.1 Cooling Tower Fire Area

The Cooling Tower Fire Area is identified as an AOPI following records research and personnel interviews due to the discharge of AFFF at this location (**Figure 5-3**). In 1988 or 1989, a fire occurred near the cooling tower, which is located in the P&E Area. AFFF was used in the fire-fighting efforts to suppress the fire. Between October 2018 and June 2020, the cooling tower was completely removed from the AOPI. The square-shaped footprint of the main structure is most visible, and the original footprint is illustrated on **Figure 5-3**. The area to the west, south, and east of the cooling tower footprint consists of dirt from the removal of the building structure (where grass has not grown back), and the area to the north of the footprint is a woodland area with trees. During the sampling event, a spring was discovered adjacent to the northwest portion of the cooling tower footprint that was sampled in place of a spring to the northeast of the AOPI that was not present during the sampling event. Additionally, there is a small stream flowing northeast that appears to begin near the spring that was discovered. Groundwater flows to the east-southeast toward the Ohio River.

5.2.2 Building 709-1 – P&E Area Fire Station

Building 709-1 – P&E Area Fire Station is identified as an AOPI following records research and personnel interviews due to use and/or potential storage of AFFF (**Figure 5-4**). Building 709-1 was the fire station for the P&E Area, which had known uses of AFFF (e.g., the Cooling Tower Fire Area) and was associated with a foam storage building (Building 709-4) that is approximately 0.2 mile to the south-southeast. The area surrounding the building comprises a mix of gravel, pavement, and grass, as well as a set of train tracks to the east. There are no surface water bodies at or near this AOPI. Groundwater flows to the east-southeast toward the Ohio River.

5.2.3 Building 709-4 – P&E Area Fire Station Foam General Storage

Building 709-4 – P&E Area Fire Station Foam General Storage is identified as an AOPI following records research and personnel interviews due to suspected storage of AFFF (**Figure 5-5**). AFFF was used at the P&E Area and this building possibly housed AFFF for the associated fire station at Building 709-1, which is approximately 0.2 mile to the north-northeast. The area surrounding the building consists of grass before reaching a paved road. There are no surface water bodies at or near this AOPI. Groundwater flows to the east-southeast toward the Ohio River.

5.2.4 Building 2521 – Fire Station for Area 1500

Building 2521 – Fire Station for Area 1500 is identified as an AOPI following records research and personnel interviews due to use and storage of AFFF (**Figure 5-6**). Building 2521 was the fire station for

Area 1500, which had known uses of AFFF (e.g., a fire training area) and stored 5-gallon buckets of AFFF. The building also had a fire-fighting equipment storage shed attached to the back. The building was demolished between September 2014 and February 2016, and a new building and parking lot were constructed over the historical footprint between October 2018 and June 2020. A stream flowing southeast exists approximately 0.2 mile south of the AOPI. Groundwater flows to the east-southeast toward the Ohio River.

5.2.5 Fire Training Area at Area 1500

The Fire Training Area at Area 1500 is identified as an AOPI following records research and personnel interviews due to the use of AFFF (**Figure 5-7**). This AOPI was used for fire training that consisted of burning cars and diesel fuel to simulate a burning diesel tank from approximately 1990 until 1993. A building and parking lot were constructed over the historical footprint between June 2020 and March 2022. A stream flowing southeast exists approximately 300 feet west of the AOPI. Groundwater flows to the east-southeast toward the Ohio River.

6 SUMMARY OF SI ACTIVITIES

Based on the results of the PA at former INAAP, an SI for PFOS, PFOA, PFBS, PFNA, and PFHxS was conducted in accordance with CERCLA. SI sampling was completed at former INAAP at all five AOPIs to evaluate presence or absence of PFOS, PFOA, PFBS, PFNA, and PFHxS in comparison with the OSD risk screening levels. As such, an installation-specific QAPP Addendum (Arcadis 2022) was developed to supplement the general information provided in the PQAPP (Arcadis 2019) and to detail the site-specific proposed scopes of work for the SI. A preliminary CSM was prepared for each of the installation's AOPIs in accordance with the USACE Engineer Manual on Conceptual Site Models, EM 200-1-12 (USACE 2012). The preliminary CSMs identified potential human receptors and chemical exposure pathways based on current and/or reasonably anticipated future land uses. The preliminary CSMs identified 17 soil, groundwater, surface water, and/or sediment pathways as potentially complete which guided the SI sampling. The QAPP Addendum details the sampling design and rationale based on each AOPI's preliminary CSM. The SI scope of work was completed in March 2023 through the collection of field data and analytical samples.

The SI field work was completed in accordance with the standard operating procedures (SOPs), technical guidance instructions (TGIs), sampling design, and QA/QC requirements as detailed in the QAPP Addendum (Arcadis 2022) and PQAPP (Arcadis 2019). The subsections below summarize the DQOs, sampling design and rationale, sampling activities and methods, and data analyses procedures for the SI phase at former INAAP. Analytical results obtained through SI field activities are summarized in **Section 7**.

6.1 Data Quality Objectives

As identified during the DQO process and outlined in the site-specific QAPP Addendum (Arcadis 2022), the objective of the SI is to identify whether there has been a release to the environment at the AOPIs identified in the PA and to determine if further investigation is warranted. This SI evaluated groundwater, soil, and surface water for PFOS, PFOA, PFBS, PFNA, and PFHxS presence or absence at each of the sampled AOPIs.

6.2 Sampling Design and Rationale

The rationale for sampling at each AOPI is illustrated in **Figure 6-1** below.

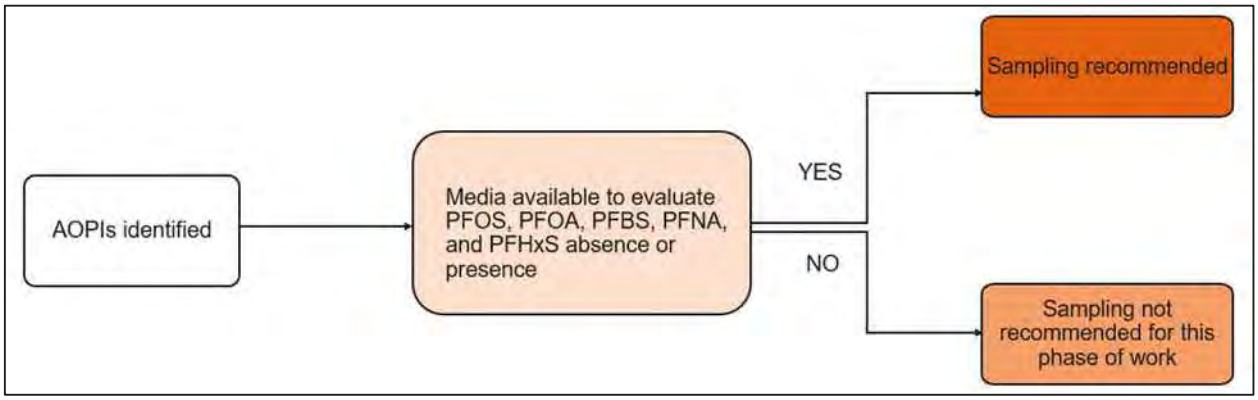


Figure 6-1: AOPI Sampling Decision Tree

The sampling design for SI sampling activities at former INAAP is detailed in Worksheet #17 of the QAPP Addendum (Arcadis 2022). Briefly, groundwater samples were collected to determine the presence or absence of PFOS, PFOA, PFBS, PFNA, and PFHxS, and to update the individual AOPI CSMs. Soil samples were collected to evaluate PFOS, PFOA, PFBS, PFNA, and PFHxS presence or absence, to evaluate the potential for those areas to be sources to surface water and groundwater as an influence to drinking water, and to update the individual AOPI CSMs. Surface water samples were collected to inform the presence or absence of PFOS, PFOA, PFBS, PFNA, and PFHxS at potential release areas or adjacent surface water bodies.

6.3 Sampling Methods and Procedures

Environmental data were collected and analyzed in accordance with the PQAPP (Arcadis 2019), the SOPs and TGIs included as Appendix A to the PQAPP, the QA/QC requirements identified in Worksheet #20 of the PQAPP, the approved scope and sampling methods outlined in the site-specific QAPP Addendum (Arcadis 2022), and the safety procedures specified in the Accident Prevention Plan (Arcadis 2018) and SSHP (Arcadis 2022). The sampling methods described in the SOPs and TGIs establish equipment requirements, procedures for preparing equipment and containers before sampling, sampling procedures under various conditions, and procedures for storing samples to ensure that sample contamination does not occur during collection and transport. In general, sampling techniques used in the SI were consistent with conventional sampling techniques used in the environmental industry, but special considerations were made regarding PFAS-containing materials and equipment and cross-contamination potential.

The sampling methods employed during the SI are detailed in the PQAPP (Arcadis 2019) and QAPP Addendum (Arcadis 2022). The subsections below provide a summary of the field methods and procedures utilized to complete the SI scope of work. Field notes and field forms (i.e., soil boring logs, groundwater purging logs, equipment calibration forms, tailgate health and safety forms, and sample collection logs) documenting the SI sampling activities are included in **Appendices F and G**, respectively.

6.3.1 Field Methods

Groundwater samples were collected following the installation of temporary monitoring wells via sonic drilling. Shallow (first encountered) groundwater was sampled but when groundwater was not encountered immediately, a temporary well was set to recharge for up to 24 hours. The field staff returned to collect samples and obtain field parameters if groundwater was available. If groundwater did not recharge, a groundwater sample was not collected. Groundwater samples were analyzed for select PFAS, and field parameters were measured during purging and allowed to stabilize or purge for a maximum of 20 minutes, whichever came sooner, to ensure a representative sample is collected and, potentially, to inform the interpretation of analytical data. If low-flow purging was not possible, a bailer was used to collect the groundwater sample. Coordinates for each borehole's groundwater sampling location were recorded using a handheld global positioning system (GPS; approximately 10-ft accuracy).

Composite shallow subsurface soil samples (less than 6 feet below ground surface [bgs]) were collected via hand auger from native soil. Soil samples were analyzed for select PFAS. Total organic carbon (TOC), pH, and grain size were analyzed in one soil sample per AOPI. Soil lithological descriptions were logged and documented. Coordinates for each soil sampling location were recorded using a GPS.

Surface water samples were collected if water was present at the time of sampling and were analyzed for select PFAS. Field parameters were measured during surface water sampling to potentially inform the interpretation of analytical data. Coordinates for each surface water sampling location were recorded using a GPS.

Decontamination procedures for non-dedicated equipment used during sampling are described in **Section 6.3.4**.

6.3.2 Quality Assurance/Quality Control

QA/QC samples, including field duplicates, matrix spike/matrix spike duplicates, equipment blanks (EBs), source blanks for water used in the initial decontamination step for drill tooling, and field blanks for laboratory-supplied water used in the final decontamination step, were collected at the frequencies specified in the QAPP Addendum (Arcadis 2022), typically at a rate of 1 per 20 parent samples. Field duplicates and matrix spike/matrix spike duplicate samples were collected for media sampled for PFOS, PFOA, PFBS, PFNA, and PFHxS, and TOC only. EBs were collected for media sampled for PFOS, PFOA, PFBS, PFNA, and PFHxS, at a frequency of one per piece of relevant equipment for each sampling event, as specified in the QAPP Addendum (Arcadis 2022). The decontaminated reusable equipment from which EBs were collected include hand augers, drill casing, water-level meters, groundwater pumps, and bailers as applicable to the sampled media. A source blank was collected from the water used to pressure-wash drill tooling. Analytical results for blank samples are discussed in **Section 7.8**.

6.3.3 Field Change Reports

In some cases, clarifications to the established scope of work were needed but do not necessarily constitute a non-conformance from the sampling plans described in the QAPP Addendum. Minor modifications from and clarifications for the procedures and scope of work detailed in the QAPP

Addendum and PQAPP and that did not affect DQOs are documented in Field Change Reports (FCRs) included as **Appendix H** and are summarized below:

FCR-INAAP-01

- The surface water sample INAAP-CTFA-1-SW was moved closer to the Cooling Tower Fire Area AOPI. During the sampling event, it was discovered that there was a spring at the AOPI, directly adjacent to the cooling tower. Additionally, the spring that was originally proposed either did not exist or did not have water present at the time of the SI sampling event.

FCR-INAAP-02

- Field duplicate, matrix spike, and matrix spike duplicate soil samples were collected at INAAP-B709-4-1-SO instead of INAAP-CTFA-1-SO.

FCR-INAAP-03

- A surface water sample (INAAP-PE-1-SW) was added to the scope and the planned groundwater sample (INAAP-B709-4-1-GW) at the Building 709-4 – P&E Area Fire Station Foam General Storage AOPI was not able to be collected due to the depth to groundwater.

6.3.4 Decontamination

Non-dedicated reusable sampling equipment (e.g., hand augers, drill cutting shoes and casing, and water-level meters) that came into direct contact with sampling media was decontaminated before first use, between sampling locations/intervals, and before demobilization in accordance with P-09, TGI - Groundwater and Soil Sampling Equipment Decontamination (Arcadis 2019, Appendix A).

6.3.5 Investigation-Derived Waste

IDW, including groundwater and decontamination fluids, were collected and placed in Department of Transportation-approved 55-gallon drums, labeled as non-hazardous, and transported to a staging area pending analysis. Equipment IDW was collected in bags and disposed in municipal waste receptacles. Equipment IDW includes personal protective equipment and other disposable materials (e.g., gloves, plastic sheeting, and high-density polyethylene and silicon tubing) that may have come in contact with sampling media. Analytical results for IDW samples collected during the SI are discussed in **Section 7.6**.

6.4 Data Analysis

The subsections below summarize the laboratory analytical methods and the methodology used to evaluate data collected during the SI through data verification and usability assessments (as completed by a project chemist, independent of the project team).

6.4.1 Laboratory Analytical Methods

Analytical samples collected during the SI were submitted to Pace South Carolina (formerly Shealy Environmental Services, Inc.), an ELAP-accredited laboratory for PFAS analysis, including PFOS, PFOA, PFBS, PFNA, and PFHxS, by liquid chromatography with tandem mass spectrometry. Laboratory

analyses associated with the SI were completed in accordance with Worksheets #12.1 through #12.5 in the PQAPP (Arcadis 2019). Eighteen PFAS-related compounds, including PFOS, PFOA, PFBS, PFNA, and PFHxS, were analyzed in groundwater, soil, and surface water samples using an analytical method that is ELAP-accredited and compliant with QSM 5.4 (DoD and Department of Energy 2021), Table B-15.

Additionally, the following general chemistry and physical characteristic analyses were completed for select soil samples in accordance with Worksheet #18 of the QAPP Addendum (Arcadis 2022) by the analytical method noted:

- TOC by Solid Waste Test Method 846 9060A
- Grain size analysis by American Society for Testing and Materials D422-63
- pH by Solid Waste Test Method 846 9045D.

These data are collected as they may be useful in future fate and transport studies.

The laboratory limit of detection (LOD) is defined as “the lowest concentration for reliable reporting of a non-detect of a specific analyte in a specific matrix with a specific method at 99 percent confidence. At the LOD, the false negative rate (Type II error) is 1%. A LOD may be used as the lowest concentration for reliably reporting a non-detect of a specific analyte in a specific matrix with a specific method at 99% confidence.” (DoD 2021). The lowest concentration of a substance that produces a quantitative result within specified limits of precision and bias and for DoD/DOE projects, the LOQ shall be set at or above the concentration of the lowest initial calibration standard and within the calibration range is known as the limit of quantitation (LOQ; DoD 2021). Concentrations detected between the LOD and LOQ, therefore, are considered estimates and are qualified as such on laboratory analytical reports. Instrument-specific detection limits (e.g., the smallest analyte concentration that can be demonstrated to be different from zero or a blank concentration with 99% confidence; DoD 2021), as provided for each analyte by the laboratory, are reported along with the LODs and LOQs in the laboratory analytical reports included in the Data Usability Summary Report (DUSR) (**Appendix I**).

6.4.2 Data Validation

All analytical data generated during the SI, except grain size and data generated from IDW profiling, were verified and validated in accordance with the data verification procedures described in Worksheets #34 through #36 of the PQAPP (Arcadis 2019). Each laboratory data package/sample delivery group underwent Stage 3 data validation in accordance with DoD QSM 5.4 (DoD and Department of Energy 2021), Table B-15. Additionally, 10% of the data underwent Stage 4 data validation. Copies of the data validation reports for each sample delivery group are included as attachments to the DUSR in **Appendix I**. The Level IV analytical reports are included within **Appendix I** in the final electronic deliverable only.

6.4.3 Data Usability Assessment and Summary

A data usability assessment was completed for all analytical data associated with SI sampling at former INAAP. Documentation generated during the data usability assessments, which was compiled into a DUSR (**Appendix I**), was prepared in accordance with the USACE Engineer Manual 200-1-10 (USACE 2005), the Final DoD General Data Validation Guidelines (DoD 2019) and the Final DoD Data Validation

Guidelines Module 3: Data Validation Procedure for Per-and Polyfluoroalkyl Substances Analysis by QSM Table B-15 (DoD 2020), that reviewed precision, accuracy, completeness, representativeness, comparability, and sensitivity. A statement of overall data usability is included in the DUSR.

Based on the final data usability assessment, the environmental data collected at former INAAP during the SI were found to be acceptable and usable for this SI evaluation with the qualifications documented in the DUSR and its associated data validation reports (**Appendix I**), and as indicated in the full analytical tables (**Appendix J**) provided for the SI results. These data are of sufficient quality to meet the objectives and requirements of the PQAPP (Arcadis 2019) and former INAAP QAPP Addendum (Arcadis 2022). Data qualifiers applied to laboratory analytical results for samples collected during the SI at former INAAP are provided in the data tables, data validation reports, and the Data Usability Summary Table located at the end of DUSR. Qualifiers for data shown on figures are defined in the notes of figures.

6.5 Office of the Secretary of Defense Risk Screening Levels

The OSD risk screening levels for PFOS, PFOA, PFBS, PFNA, PFHxS, and HFPO-DA in groundwater (tap water) and soil were calculated using the USEPA's RSL calculator for residential and industrial/ commercial worker receptor scenarios and current toxicity values. These risk screening levels are shown in **Table 6-1**.

Table 6-1 OSD Risk Screening Levels Calculated for PFOS, PFOA, PFBS, PFNA, PFHxS, and HFPO-DA in Tap Water and Soil Using USEPA's Regional Screening Level Calculator

Chemical	Residential Scenario Risk Screening Levels Calculated Using USEPA RSL Calculator		Industrial/Commercial Scenario Risk Screening Levels Calculated Using USEPA RSL Calculator
	Tap Water (ng/L or ppt) [1]	Soil (mg/kg or ppm) [1,2]	Soil (mg/kg or ppm) [1,2]
PFOS	4	0.013	0.16
PFOA	6	0.019	0.25
PFBS	601	1.9	25
PFNA	6	0.019	0.25
PFHxS	39	0.13	1.6
HFPO-DA[3]	6	0.023	0.35

Notes:
1. Risk screening levels for tap water and soil provided by the OSD. 2022. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. July 06 (**Appendix A**).
2. All soil data will be screened against both the Residential Scenario and Industrial/Commercial risk screening levels (if collected from less than 2 feet bgs), regardless of the current and projected land use of the AOPI.
3. Of the six PFAS compounds presented in the 06 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 former INAAP 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.
activities at former INAAP.
mg/kg = milligram per kilogram
ng/L = nanograms per liter
ppm = parts per million
ppt = parts per trillion

The OSD residential tap water risk screening levels will be used to compare all groundwater and surface water data due to the surface water being an expression of groundwater (i.e., springs/seeps) for this Army PFAS PA/SI. While the current and reasonably anticipated future land uses of the AOPIs at former INAAP are industrial/commercial, both residential and industrial/commercial soil risk screening levels for PFOS, PFOA, PFBS, PFNA, and PFHxS will be used to evaluate detected soil concentrations. The data from the SI sampling event are compared to the OSD risk screening levels in **Section 7**. If concentrations of PFOS, PFOA, PFBS, PFNA, or PFHxS are detected greater than the applicable OSD risk screening levels, further study in a remedial investigation is recommended in **Section 8**.

7 SUMMARY AND DISCUSSION OF SI RESULTS

This section summarizes the analytical results obtained from samples collected during the SI at former INAAP (field duplicate results are provided in the associated tables). Sampled media and QA/QC samples were analyzed for the constituents prescribed per Worksheet #18 of the QAPP Addendum (Arcadis 2022). The sample results discussion below focuses on the PFOS, PFOA, PFBS, PFNA, and PFHxS analytical results because they have OSD risk screening levels. The Army will make subsequent investigation decisions based on these constituents' concentrations relative to the OSD risk screening levels.

Tables 7-1 through 7-3 provide a summary of the groundwater, soil, and surface water analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS. **Table 7-4** summarizes AOPIs and whether their SI results exceed the OSD risk screening levels. **Appendix J** includes the full suite of analytical results for these media, as well as for the QA/QC samples. An overview of AOPIs at former INAAP with OSD risk screening level exceedances is depicted on **Figure 7-1**. **Figures 7-2 through 7-6** show the PFOS, PFOA, PFBS, PFNA, and PFHxS analytical results in groundwater, soil, and surface water for each AOPI. Non-detected results are reported as less than the LOQ. Detections of PFOS, PFOA, PFBS, PFNA, and/or PFHxS greater than the applicable OSD risk screening levels are highlighted in summary tables and on figures. Final qualifiers applied to the data by the laboratory and the project chemist (as defined in **Section 6.4.3**) are presented on the analytical tables. Groundwater and surface water data collected during the SI are reported in ng/L, or parts per trillion, and soil and sediment data are reported in mg/kg, or parts per million.

Field parameters measured for groundwater during low-flow purging and sample collection and for surface water during sample collection are provided on the field forms in **Appendix G**. Soil descriptions are provided on the field forms in **Appendix G**. The results of the SI are grouped by AOPI and discussed for each medium as applicable. Groundwater was generally first encountered at depths of approximately 6 to 16.5 feet bgs in the southern portion of the installation at the Building 2521 – Fire Station for Area 1500 and Fire Training Area at Area 1500 AOPIs and approximately 26 to 30 feet bgs in the northern portion of the installation at the Cooling Tower Fire Area and Building 709-1 – P&E Area Fire Station AOPIs.

Table 7-4 AOPIs and OSD Risk Screening Level Exceedances

AOPI Name	OSD Exceedances (Yes/No)
Cooling Tower Fire Area	Yes
Building 709-1 – P&E Area Fire Station	No
Building 709-4 – P&E Area Fire Station Foam General Storage	No
Building 2521 – Fire Station for Area 1500	No
Fire Training Area at Area 1500	No

7.1 Cooling Tower Fire Area

The subsections below summarize the soil, groundwater, and surface water PFOS, PFOA, PFBS, PFNA, and PFHxS analytical results associated with the Cooling Tower Fire Area AOPI (**Figure 7-2**).

7.1.1 Groundwater

One groundwater sample was collected from a temporary well via sonic drilling at first encountered groundwater at the Cooling Tower Fire Area AOPI (INAAP-CFTA-1-GW). The groundwater analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-2** and **Table 7-1**, and are summarized below:

- PFOS was not detected in the groundwater sample collected.
- PFOA was detected at a concentration greater than the OSD risk screening level of 6 ng/L at INAAP-CFTA-1-GW at 11 ng/L.
- PFBS was detected at a concentration less than the OSD risk screening level of 601 ng/L at INAAP-CFTA-1-GW at 4.8 ng/L.
- PFNA was detected at a concentration less than the OSD risk screening level of 6 ng/L at INAAP-CFTA-1-GW at 2.4 J (J qualifier indicates that the analyte was positively identified, however the result is an estimated concentration only) ng/L.
- PFHxS was detected at a concentration less than the OSD risk screening level of 39 ng/L at INAAP-CFTA-1-GW at 3.8 J ng/L.

7.1.2 Soil

Five soil samples were collected via hand auger at the Cooling Tower Fire Area AOPI (INAAP-CFTA-1-SO, INAAP-CFTA-2-SO, INAAP-CFTA-3-SO, INAAP-CFTA-4-SO, INAAP-CFTA-5-SO). The soil analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-2** and **Table 7-2**, and are summarized below:

- PFOS, PFOA, PFBS, PFNA, and PFHxS were not detected in the soil samples collected.

7.1.3 Surface Water

One surface water sample was collected from a spring via grab sample at the Cooling Tower Fire Area AOPI (INAAP-CFTA-1-SW) and was compared to the OSD risk screening levels, as it was an expression of groundwater. The surface water analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-2** and **Table 7-3**, and are summarized below:

- PFOS was not detected in the surface water sample collected.
- PFOA was detected at a concentration less than the OSD risk screening level of 6 ng/L at INAAP-CFTA-1-SW at 3.0 J ng/L.
- PFBS was detected at a concentration less than the OSD risk screening level of 601 ng/L at INAAP-CFTA-1-SW at 2.4 J ng/L.

- PFNA was not detected in the surface water sample collected.
- PFHxS was not detected in the surface water sample collected.

7.2 Building 709-1 – P&E Area Fire Station

The subsections below summarize the soil and groundwater PFOS, PFOA, PFBS, PFNA, and PFHxS analytical results associated with the Building 709-1 – P&E Area Fire Station AOPI (**Figure 7-3**).

7.2.1 Groundwater

One groundwater sample was collected from a temporary well via sonic drilling at first encountered groundwater at the Building 709-1 – P&E Area Fire Station AOPI (INAAP-B709-1-1-GW). The groundwater analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-3** and **Table 7-1**, and are summarized below:

- PFOS, PFBS, PFNA, and PFHxS were not detected in the groundwater sample collected.
- PFOA was detected at a concentration less than the OSD risk screening level of 6 ng/L at INAAP-B709-1-1-GW at 2.6 J ng/L.

7.2.2 Soil

Four soil samples were collected via hand auger at the Building 709-1 – P&E Area Fire Station AOPI (INAAP-B709-1-1-SO, INAAP-B709-1-2-SO, INAAP-B709-1-3-SO, INAAP-B709-1-4-SO). The soil analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-3** and **Table 7-2**, and are summarized below:

- PFOS was detected at a concentration less than the OSD risk screening level of 0.013 mg/kg at INAAP-B709-1-1-SO, INAAP-B709-1-2-SO, INAAP-B709-1-3-SO, and INAAP-B709-1-4-SO at 0.00061 J mg/kg, 0.00055 J mg/kg, 0.0023 mg/kg, and 0.001 J mg/kg, respectively.
- PFOA, PFBS, PFNA, and PFHxS were not detected in the soil samples collected.

7.3 Building 709-4 – P&E Area Fire Station Foam General Storage

The subsections below summarize the soil and surface water PFOS, PFOA, PFBS, PFNA, and PFHxS analytical results associated with the Building 709-4 – P&E Area Fire Station Foam General Storage AOPI (**Figure 7-4**). Groundwater was not able to be sampled due to the absence of existing, proximal monitoring wells and depth of the water table. The water table was expected to be present at approximately 35 feet bgs or shallower. Four soil samples were able to be collected as planned, and an additional surface water sample from a proximal spring representative of groundwater was added to the scope (**Section 6.3.3**).

7.3.1 Soil

Four soil samples were collected via hand auger at the Building 709-4 – P&E Area Fire Station Foam General Storage AOPI (INAAP-709-4-1-SO, INAAP-709-4-2-SO, INAAP-709-4-3-SO, INAAP-709-4-4-

SO). The soil analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-4** and **Table 7-2**, and are summarized below:

PFOS, PFOA, PFBS, PFNA, and PFHxS were not detected in the soil samples collected.

7.3.2 Surface Water

One surface water sample was collected from a spring via grab sample at the Building 709-4 – P&E Area Fire Station Foam General Storage AOPI (INAAP-PE-1-SW) and was compared to the OSD risk screening levels, as it was an expression of groundwater. The surface water analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-4** and **Table 7-3**, and are summarized below:

- PFOS, PFOA, PFNA, and PFHxS were not detected in the surface water sample collected.
- PFBS was detected at a concentration less than the OSD risk screening level of 601 ng/L at INAAP-PE-1-SW at 2.8 J ng/L.

7.4 Building 2521 – Fire Station for Area 1500

The subsections below summarize the groundwater PFOS, PFOA, PFBS, PFNA, and PFHxS analytical results associated with the Building 2521 – Fire Station for Area 1500 AOPI (**Figure 7-5**).

7.4.1 Groundwater

One groundwater sample was collected from a temporary well via sonic drilling at first encountered groundwater at the Building 2521 – Fire Station for Area 1500 AOPI (INAAP-A1500-2-GW). The groundwater analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-5** and **Table 7-1**, and are summarized below:

- PFOS was detected at a concentration less than the OSD risk screening level of 4 ng/L at INAAP-A1500-2-GW at 2.3 J ng/L.
- PFOA was detected at a concentration less than the OSD risk screening level of 6 ng/L at INAAP-A1500-2-GW at 2.7 J ng/L.
- PFBS was detected at a concentration less than the OSD risk screening level of 601 ng/L at INAAP-A1500-2-GW at 2.1 J ng/L.
- PFNA was detected at a concentration less than the OSD risk screening level of 6 ng/L at INAAP-A1500-2-GW at 2.4 J ng/L.
- PFHxS was detected at a concentration less than the OSD risk screening level of 39 ng/L at INAAP-A1500-2-GW at 2.0 J ng/L.

7.5 Fire Training Area at Area 1500

The subsections below summarize the groundwater and surface water PFOS, PFOA, PFBS, PFNA, and PFHxS analytical results associated with the Fire Training Area at Area 1500 AOPI (**Figure 7-6**).

7.5.1 Groundwater

One groundwater sample was collected from a temporary well via sonic drilling at first encountered groundwater at the Fire Training Area at Area 1500 AOPI (INAAP-A1500-1-GW). The groundwater analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-6** and **Table 7-1**, and are summarized below:

- PFOS, PFOA, PFBS, PFNA, and PFHxS were not detected in the groundwater sample collected.

7.5.2 Surface Water

One surface water sample was collected from a stream via grab sample at the Fire Training Area at Area 1500 AOPI (INAAP-A1500-1-SW). This sample was not compared to the OSD risk screening levels, as it was not an expression of groundwater. The surface water analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS are shown on **Figure 7-6** and **Table 7-3**, and are summarized below:

- PFOS was detected at INAAP-A1500-1-SW at 5.3 ng/L.
- PFOA was not detected in the surface water sample collected.
- PFBS was detected at INAAP-709-4-1-SW at 2.6 J ng/L.
- PFNA was not detected in the surface water sample collected.
- PFHxS was detected at INAAP-709-4-1-SW at 2.7 J ng/L.

7.6 Investigation-Derived Waste

A composite sample of the purge and decontamination wastewater was collected from the 55-gallon drums currently in storage at the Building 709-1 – P&E Area Fire Station AOPI. The analytical results from the wastewater indicated that there were no detections of PFOS, PFOA, PFBS, PFNA, or PFHxS (**Appendix J**). The IDW will be discharged at the installation in accordance with state regulations or at a nearby wastewater treatment facility, as agreed upon by the installation. The full analytical results (i.e., for all constituents analyzed) for IDW samples collected during the SI are included in **Appendix J**.

7.7 TOC, pH, and Grain Size

In addition to sampling soil for PFOS, PFOA, PFBS, PFNA, and PFHxS, one soil sample per AOPI was analyzed for TOC, pH, and grain size data as they may be useful in future fate and transport studies. The TOC in the soil samples ranged from 1,070 to 30,400 mg/kg. The TOC at this installation was within range of TOC levels typically observed in desert (less than 5,000 mg/kg) and topsoil (5,000 to 30,000 mg/kg). The combined percentage of fines (i.e., silt and clay) in soils at former INAAP ranged from 8.4 to 88.4% with an average of 44.6%. In general, PFAS constituents tend to be more mobile in soils with less than 20% fines (silt and clay) and lower TOC. The pH of the soil was slightly acidic to slightly alkaline (5.5 to 7.8 standard units). Based on these geochemical and physical soil characteristics (i.e., low percentage of fines and TOC) observed underlying the installation during the SI, PFAS constituents are expected to be relatively more mobile at former INAAP than in soils with greater percentages of fines and TOC.

7.8 Blank Samples

Detections of PFOS, PFOA, PFBS, PFNA, and PFHxS constituents are summarized below for blank samples. Other than those noted below, concentrations of PFOS, PFOA, PFBS, PFNA, and PFHxS in all other blank samples were not detected. The source blank (INAAP-SB-1) analytical results indicated there were no detections of PFBS, PFNA, and PFHxS, but there was a detection of PFOS at 2.1 ng/L J, which is less than the OSD risk screening level of 4 ng/L, and there was a detection of PFOA at 3.2 J ng/L, which is less than the OSD risk screening level of 6 ng/L. These analytical results did not affect the interpretation of other results or the conclusions of this report.

The full analytical results for blank samples collected during the SI are included in **Appendix J**.

7.9 Conceptual Site Models

The preliminary CSMs presented in the QAPP Addendum (Arcadis 2022) were re-evaluated and updated, if necessary, based on the SI sampling results. The CSMs presented on **Figures 7-7 through 7-9** and in this section therefore represent the current understanding of the potential for human exposure. For some AOPIs, the CSM is the same and thus shown on the same figure.

Many of the PFAS constituents found in AFFF are surfactants (which do not volatilize) and are found in a charged or ionic state at environmentally relevant pH (i.e., pH 5 to 9 standard units). PFOS, PFOA, PFBS, PFNA, and PFHxS are each negatively charged at environmentally relevant pH. The media potentially affected by PFOS, PFOA, PFBS, PFNA, and PFHxS releases at Army installations are soil, groundwater, surface water, and sediment. Once released to the environment, a primary factor that inhibits the movement of PFAS constituents is the presence of organic matter and organic co-constituents in soils and sediments. Generally, PFAS constituents are mobile in the potentially affected media, and they are not known to be fully broken down by natural processes.

Based on the historical use, storage, and/or disposal of PFAS-containing materials (e.g., AFFF) at the AOPIs, affected media are likely to consist of soil and groundwater, and could include downgradient surface water and sediment. Release and transport mechanisms include dissolution/desorption from soil to groundwater, discharge from shallow groundwater to surface water, and adsorption/desorption between surface water and sediment. Generic categories of potential human receptors and their associated exposure scenarios that are typically evaluated in a CERCLA human health risk assessment were considered and include on-installation site workers (e.g., industrial/commercial workers, utility workers, or future construction workers who could be exposed to chemicals in soil at an AOPI or to chemicals in tap water in an industrial/commercial building), on-installation residents (e.g., adults and children who could be exposed to chemicals in tap water in a residence), and on-installation recreational users (e.g., hikers or hunters who could be exposed to chemicals in waterways at an installation). Off-installation receptor types could include drinking water receptors (i.e., commercial/industrial workers or residents) and recreational users.

Human exposure pathways are shown as “complete”, “potentially complete”, or “incomplete” on the CSM figures. A complete exposure pathway consists of a constituent source and release mechanism, a transport or retention medium, an exposure point where human contact with the contaminated medium could occur, and an exposure route at the exposure point. If any element is missing, the exposure pathway is incomplete. Pathways are “potentially complete” where data are insufficient to conclude the

pathway is either “complete” or “incomplete”. Additionally, the CSMs do not include ecological receptors and exposure pathways. The potential for ecological exposures to PFOS, PFOA, PFBS, PFNA, and PFHxS may be evaluated at a future date if those pathways warrant further consideration.

CSMs were developed for each individual AOPI and were combined where source media, potential migration pathways and exposure media, and human exposure pathway determinations are congruent. The following exposure pathway determinations apply to all CSMs:

- There are no residents on the former installation grounds, and future residential development of the AOPIs is not likely to occur. Therefore, all exposure pathways for on-site residents are incomplete.
- PFOS, PFOA, PFBS, PFNA, and/or PFHxS were detected in groundwater samples from temporary well points or in surface water samples (from springs or a stream) at all AOPIs. Drinking water within the former installation boundary is supplied from four groundwater wells from one well field located in Charlestown, Indiana, hydraulically upgradient of the former INAAP, that is owned and operated by Indiana American Water (Indiana American Water 2020). Though the existing drinking water wells are upgradient of the former INAAP, the groundwater exposure pathway (via drinking water ingestion and dermal contact) for on-site workers is potentially complete to account for possible future use of groundwater downgradient of the AOPIs as a potable water source.
- Recreational users (if present) are not likely to contact groundwater during outdoor recreational activities. Therefore, the groundwater exposure pathway for on-site recreational users is incomplete.
- Shallow groundwater originating at the AOPIs may discharge to on-site streams which ultimately flow to the Ohio River. Wells located along the Ohio River floodplain terrace are the major water source for the former INAAP and surrounding communities. Therefore, the groundwater exposure pathway for off-site drinking water receptors is potentially complete.
- Recreational users could contact constituents in downgradient streams within the boundaries of the former INAAP or the Ohio River. Therefore, the surface water and sediment exposure pathways for on-site and off-site recreational users are potentially complete.

Additional exposure pathway descriptions for each CSM are listed below by figure.

Figure 7-7 shows the CSM for the Cooling Tower Fire Area and Building 709-4 P&E Area Fire Station Foam General Storage AOPIs. These AOPIs have the potential for PFAS presence due to the historical use or storage of AFFF. The AOPIs are in areas that were transferred to Charlestown State Park, which consists of 5,100 acres and attracts nearly 200,000 recreational visitors annually. The park offers hiking trails, picnic areas, fishing, boating, playground equipment, and campgrounds (Indiana Department of Natural Resources 2022).

- PFOS, PFOA, PFBS, PFNA, and PFHxS were not detected in soil samples from these AOPIs. Based on the SI sample results, the soil exposure pathways are incomplete.
- PFOA and PFBS were detected in a surface water sample that was collected from a spring at the Cooling Tower Fire Area AOPI. PFOA was detected in a surface water sample collected from a

spring at the Building 709-4 – P&E Area Fire Station Foam General Storage AOPI. On-site workers could contact constituents in surface water and sediment (via incidental ingestion and dermal contact) in downgradient streams within the boundaries of the former INAAP. Therefore, the surface water and sediment exposure pathways for on-site workers are potentially complete.

Figure 7-8 shows the CSM for Building 709-1 P&E Area Fire Station AOPI, which has the potential for PFAS presence due to the historical use or storage of AFFF. The AOPI is in an area that was transferred to Charlestown State Park.

- PFOS was detected in soil at this AOPI. On-site workers and recreational users could contact constituents in soil via incidental ingestion, dermal contact, and inhalation of dust. Therefore, these soil exposure pathways are complete.
- Off-site receptors are not expected to contact soil at the site (i.e., each AOPI). Therefore, the soil exposure pathway for off-site receptors is incomplete.
- PFOA was detected in groundwater at this AOPI, and groundwater could discharge to nearby surface water. On-site workers could contact constituents in surface water and sediment (via incidental ingestion and dermal contact) in downgradient streams within the boundaries of the former INAAP. Therefore, the surface water and sediment exposure pathways for on-site workers are potentially complete.

Figure 7-9 shows the CSM for two AOPIs that were transferred to River Ridge Redevelopment Authority: Building 2521 - Fire Station for Area 1500 and Fire Training Area at Area 1500. These AOPIs have the potential for PFAS presence due to the historical storage or use of AFFF. River Ridge Commerce Center hosts more than 60 companies including aerospace, automotive, food and beverage, information technology, life sciences and logistics (River Ridge Development Authority 2022).

- Soil samples were not collected at these AOPIs. PFOS, PFOA, PFBS, PFNA, and/or PFHxS were detected in groundwater or surface water samples collected at these AOPIs. If PFOS, PFOA, PFBS, PFNA, and/or PFHxS are also present in soil, on-site workers could contact constituents in soil via incidental ingestion, dermal contact, and inhalation of dust. Therefore, the soil exposure pathway for on-site workers is potentially complete.
- Recreational use of the AOPIs is not likely; therefore, the soil exposure pathway for on-site recreational users is incomplete.
- Off-site receptors are not expected to contact soil at the site (i.e., each AOPI). Therefore, the soil exposure pathway for off-site receptors is incomplete.
- On-site workers associated with the commercial/industrial properties could contact constituents in surface water and sediment (via incidental ingestion and dermal contact) of waterbodies downgradient of the AOPIs. Therefore, the surface water and sediment exposure pathways (via incidental ingestion and dermal contact) for on-site workers are potentially complete.

Following the SI sampling, all five AOPIs were considered to have complete or potentially complete exposure pathways. Although the CSMs indicate complete or potentially complete exposure pathways may exist, the recommendation for remedial investigation is based on the comparison of analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS to the OSD risk screening levels (**Table 6-1**).

8 CONCLUSIONS AND RECOMMENDATIONS

The PFAS PA/SI included two distinct efforts. The PA identified AOPIs at former INAAP based on the use, storage, and/or disposal of PFAS-containing materials, in accordance with the 2018 Army Guidance for Addressing Releases of Per-and Polyfluoroalkyl Substances (Army 2018). The SI included multi-media sampling at AOPIs to determine whether or not a release of PFOS, PFOA, PFBS, PFNA, and PFHxS to the environment occurred.

OSD provided residential risk screening levels based on the USEPA oral reference dose for PFOS, PFOA, PFBS, PFNA, and PFHxS in soil and groundwater (tap water) and industrial/commercial risk screening levels for PFOS, PFOA, PFBS, PFNA, and PFHxS in soil (**Appendix A**). A combination of document review, internet searches, and interviews with installation personnel were used to identify specific areas of suspected PFOS, PFOA, PFBS, PFNA, and PFHxS use, storage, and/or disposal at former INAAP. Following the evaluation, five AOPIs were identified.

The current source of water supply is the Charlestown State Park Well Field, with three production wells in the southeast portion of the installation, located near the treatment plant in a line parallel to the Ohio River. The wells produce groundwater from the Ohio River Alluvium, a highly productive glacial outwash aquifer composed of permeable sand and gravel deposits. The existing treatment facility is located adjacent to the well field.

Louisville Water Company conducted testing in December 2019 on a mix of raw water from Well 1 and Well 3 of the Charlestown State Park Well Field. The wells were operating together at the time of sample collection and PFOA was detected at a level of 4.5 ng/L in the combined sample collected from Well 1 and Well 3. INTERA, Inc. collected samples for analysis of PFOA, PFOS, and PFHxA in January 2020 from the three production wells (Well 1, Well 2, and Well 3) of the Charlestown State Park Well Field. The highest concentrations for each well were for PFOA, with 6.9 ng/L being the highest in Well 3. As part of the same monitoring at all Indiana Community Public Water Systems by the Indiana Department of Environmental Management, samples were collected in June 2021 from the Charlestown State Park supply system, which is the well field for the Indiana American Water Company. Analytical data showed detections of 6.5 ng/L or less in a list of 18 PFAS compounds. PFOA was detected in two samples at 6.5 ng/L, and other detections included PFHxA and PFOS.

All AOPIs were sampled (details on sampling activities at each AOPI provided below) during the SI at former INAAP to identify presence or absence of PFOS, PFOA, PFBS, PFNA, and PFHxS at each AOPI. Of the six PFAS compounds presented in the 06 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 former INAAP because HFPO-DA is generally not a component of military specification 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 SI scope of work was completed in accordance with the Final PQAPP (Arcadis 2019) and the former INAAP QAPP Addendum (Arcadis 2022).

Groundwater samples were collected at four AOPIs. The presence of PFOS, PFOA, PFBS, PFNA, and/or PFHxS was identified in groundwater samples from three AOPIs. Due to the absence of existing, proximal monitoring wells and depth to groundwater, samples were not collected at one AOPI. The only PFOS

detection in groundwater was from the Building 2521 – Fire Station for Area 1500 AOPI at 2.3 J ng/L. The highest PFOA, PFBS, PFNA, and PFHxS concentrations detected in groundwater samples were from the Cooling Tower Fire Area AOPI, at 11 ng/L, 4.8 ng/L, 2.4 J ng/L, and 3.8 J ng/L, respectively. The PFOA detection exceeded the OSD risk screening level of 6 ng/L. In total, one AOPI had concentrations of PFOS, PFOA, PFBS, PFNA, and/or PFHxS in groundwater that exceeded OSD risk screening levels.

Soil samples were collected at three AOPIs. The presence of PFOS, PFOA, PFBS, PFNA, and/or PFHxS was identified in soil samples from one AOPI. The only PFOS concentrations in soil were in samples from the Building 709-1 – P&E Area Fire Station AOPI, with the highest concentration at 0.0023 mg/kg, which is below the residential OSD risk screening level of 0.013 mg/kg. PFOA, PFBS, PFNA, and PFHxS were not detected in any soil samples.

Surface water samples were collected at three AOPIs. The presence of PFOS, PFOA, PFBS, PFNA, and/or PFHxS was identified in surface water samples from all three AOPIs. Surface water sample results at one of these three AOPIs (Fire Training Area at Area 1500 AOPI) was not compared to OSD risk screening levels, because the surface water sampled is not considered representative of groundwater. The only PFOS detection in surface water was in the sample from the Fire Training Area at Area 1500 AOPI, with the highest concentration at 5.3 ng/L. The only PFOA detection in surface water was in the sample from the Cooling Tower Fire Area AOPI, with the highest concentration at 3.0 J ng/L, which is below the residential OSD risk screening level of 6 ng/L. The highest PFBS concentrations detected in surface water samples were from the Building 709-4 – P&E Area Fire Station Foam General Storage AOPI, at 2.8 J ng/L. PFNA and PFHxS were not detected in any surface water samples.

Following the SI sampling, all five AOPIs with confirmed PFOS, PFOA, PFBS, PFNA, and/or PFHxS presence were considered to have complete or potentially complete exposure pathways. Soil exposure pathways for on-site workers and recreational users are complete at one AOPI. The soil exposure pathways for on-site workers are potentially complete at two AOPIs where soil samples were not collected but PFOS, PFOA, PFBS, PFNA, and/or PFHxS were detected in groundwater or surface water. Though the existing drinking water wells are upgradient of the former INAAP, the groundwater exposure pathways (via drinking water ingestion and dermal contact) for on-site workers are potentially complete at all five AOPIs to account for possible future use of groundwater downgradient of the AOPIs as a potable water source. Wells located along the Ohio River floodplain terrace are the major water source for the former INAAP and surrounding communities. Therefore, the groundwater exposure pathways for off-installation drinking water receptors are also potentially complete for all five AOPIs. On-site workers and recreational users (on-site and off-site) could contact constituents in surface water and sediment in downgradient streams within the boundaries of the former INAAP or the Ohio River. Therefore, the surface water and sediment exposure pathways are potentially complete for all five AOPIs.

Although the CSMs indicate complete or potentially complete exposure pathways may exist, the recommendation for further study in a remedial investigation based on the comparison of the SI analytical results for PFOS, PFOA, PFBS, PFNA, and PFHxS to the OSD risk screening levels (**Table 6-1**). **Table 8-1** below summarizes the AOPIs identified at former INAAP and PFOS, PFOA, PFBS, PFNA, and PFHxS sampling and recommendations for each AOPI. Further investigation is warranted at former INAAP in the Cooling Tower Fire Area. In accordance with CERCLA, site-specific risk will be assessed during a future phase to evaluate whether remedial actions are required.

Table 8-1 Summary of AOPIs Identified during the PA, PFOS, PFOA, PFBS, PFNA, and PFHxS Sampling at Former INAAP, and Recommendations

AOPI Name	PFOS, PFOA, PFBS, PFNA, and/or PFHxS detected greater than OSD Risk Screening Levels? (Yes/No/NS/ND)		Recommendation
	GW	SO	
Cooling Tower Fire Area	Yes	ND	Further study in a remedial investigation
Building 709-1 – P&E Area Fire Station	No	No	No action at this time
Building 709-4 – P&E Area Fire Station Foam General Storage	NS*	ND	No action at this time
Building 2521 – Fire Station for Area 1500	No	NS	No action at this time
Fire Training Area at Area 1500	ND	NS	No action at this time

Notes:
* – Groundwater sampling was attempted but not reached at 50 feet below ground surface (bgs). Depth to water was expected at 35 feet bgs. Surface water was collected from a proximal spring, which was representative of groundwater in the area.
Light gray shading – detection greater than the OSD risk screening level
GW – groundwater
ND – non-detect
NS – not sampled
SO – soil

Data collected during the PA (**Sections 3 through 5**) and SI (**Sections 6 and 7**) were sufficient to draw the conclusions and recommendations summarized above. The data limitations relevant to the development of this PA/SI for PFOS, PFOA, PFBS, PFNA, and PFHxS at former INAAP are discussed below.

The installation is not active, is now operated by contractors, and some buildings and/or facilities of interest are abandoned or are reported to have been demolished. Therefore, a site visit was not conducted and site records are limited.

Records gathered for the use, storage and/or disposal of PFAS-containing materials were reviewed during the PA process. Documentation specific to AFFF may have been limited (e.g., each AFFF use; procurement records, documentation of AFFF used during crash responses or fire training activities) due to lack of recordkeeping requirements for the full timeline of common AFFF practices. Anecdotal accounts of AFFF use (and therefore likely PFOS, PFOA, PFBS, PFNA, and PFHxS use) were limited to available installation personnel, whose knowledge of AFFF use may have been restricted by their time spent at the installation or previous roles held that limited their relevant knowledge of potential AFFF (or other PFAS-containing material) use.

A comprehensive well survey was not completed as part of this PA; therefore, the information reviewed regarding off-post wells is limited to what is contained in the off-post well search results (**Appendix C**).

The searches for ecological receptors and off-post PFOS, PFOA, PFBS, PFNA, and PFHxS sources were not exhaustive and were limited to easily identifiable and readily available information evaluated during the relevant documents research, installation personnel interviews, and site reconnaissance.

Finally, the available PFOS, PFOA, PFBS, PFNA, and PFHxS analytical data is limited to groundwater samples from four of five AOPIs, soil samples from three of five AOPIs, and on-post drinking water results from 2019, 2020, and 2021. Available data, including PFOS, PFOA, PFBS, PFNA, and PFHxS, are listed in **Appendix J**. HFPO-DA was not in the suite of PFAS compounds analyzed during the SI at former INAAP; therefore, there are no HFPO-DA SI analytical results to screen against the 2022 OSD risk screening levels.

Results from this PA/SI indicate further study in a remedial investigation is warranted at former INAAP in accordance with the guidance provided by the OSD.

9 REFERENCES

Arcadis U.S., Inc. (Arcadis). 2018. Accident Prevention Plan: A-E Services, PFASs Contamination in the Cleanup/Restoration Programs at Active Army Installations – Nationwide. Prepared for USACE, Baltimore District. March.

Arcadis. 2019. Final Programmatic Uniform Federal Policy (UFP) Quality Assurance Project Plan (QAPP), USAEC PFAS PA/SI, Active Army Installations, Nationwide, USA. October.

Arcadis. 2022. Final UFP QAPP Addendum, Revision 0, USAEC PFAS PA/SI, Indiana Army Ammunition Plant, Indiana. March.

Army. 2018. Army Guidance for Addressing Releases of Per- and Polyfluoroalkyl Substances. September 4. Available online at: https://www.fedcenter.gov/admin/itemattachment.cfm?attachmentid=1150.

Army. 2019. Non-BRAC Excess Installations Conveyance Progress Reports. October.

Department of Defense (DoD). 2017. Fact Sheet: Detection and Quantitation – What Project Managers and Data Users Need to Know. October.

DoD. 2019. Environmental Data Quality Working Group: Final General Data Validation Guidelines. November 4.

DoD. 2020. Data Validation Guidelines Module 3: Data Validation Procedure for Per- and Polyfluoroalkyl Substances Analysis by QSM Table B-15. May 1.

DoD and Department of Energy. 2021. Consolidated Quality Systems Manual for Environmental Laboratories, Version 5.4

Indiana American Water. 2020. Annual Water Quality Report.

Indiana Department of Environmental Management. 2022. PFAS Sampling Project for Community Public Water Systems. Available online at: https://www.in.gov/idem/resources/nonrule-policies/per-and-polyfluoroalkyl-substances-pfas/

Indiana Department of Natural Resources. 2022. Charlestown State Park, Indiana.

INTERA, Inc. 2020. Charlestown State Park Water Supply Expansion Investigation and Recommendations. April.

Interstate Technology Regulatory Council. 2017. History and Use of Per-and Polyfluoroalkyl Substances (PFAS). November. Available online at: https://pfas-1.itrcweb.org/wp-content/uploads/2017/11/pfas_fact_sheet_history_and_use__11_13_17.pdf.

Interstate Technology Regulatory Council. 2020. Section 3.1 Firefighting Foams. Updated April 14. Available online at: https://pfas-1.itrcweb.org/3-firefighting-foams/#3_1

Kentucky Department of Environmental Protection. 2019. Evaluation of Kentucky Community Drinking Water for Per- & Poly-Fluoroalkyl Substances. November 18.

National Weather Service. 2020. Louisville Bowman, Kentucky Monthly/Seasonal/Annual Climatological Normals 1991-2020. Available online at: https://www.weather.gov/lmk/clisdf

Office of the Secretary of Defense (OSD). 2019. Memorandum: Investigating Per- and Polyfluoroalkyl

Substances within the Department of Defense Cleanup Program. October.

OSD. 2021. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. September.

OSD. 2022. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. July.

Ray, J.A. 2001. Spatial interpretation of karst drainage basins. In Geotechnical and Environmental Applications of Karst Geology and Hydrology, B.F. Beck and J.G. Herring, eds., Balkema, Rotterdam, Netherlands.

River Ridge Development Authority. 2022. About River Ridge Commerce Center. August. Available online at: https://www.riverridgecc.com/about/

URS. 2003. Installation Groundwater – Site 90 INAAP Phase II RCRA Facility Investigation. November.

USACE. 1992a. Preliminary Assessment of Indiana Army Ammunition Plant. February.

USACE. 1992b. Proposed Inactivation of the Indiana Army Ammunition Plant Charlestown, Indiana. July.

USACE. 1999. Environmental Assessment to Support a Lease in Furtherance of Conveyance to the Indiana Army Ammunition Plant (INAAP) Reuse Authority and the Disposal of INAAP. July 13.

USACE. 2005. Environmental Quality: Guidance for Evaluating Performance-Based Chemical Data, Engineer Manual 200-1-10, CEMP-RA/CECW-E, June 30.

USACE. 2012. Environmental Quality: Conceptual Site Models, Engineer Manual 200-1-12, CEMP-CE, December 28.

USACE. 2020. INAAP BRAC Property Disposal and Environmental History. March.

USAEC. 2002. Installation Action Plan for Indiana Army Ammunition Plant. March.

U.S. Army Toxic and Hazardous Materials Agency. 1990. Enhanced Preliminary Assessment Report for a Portion of Indiana Army Ammunition Plant. March.

USEPA. 2016. Lifetime Health Advisories and Health Effects Support Documents for Perfluorooctanoic Acid and Perfluorooctane Sulfonate. EPA-HQ-OW-2014-0138; FRL-9946-91-OW. Federal Register/ Vol. 81. No. 101. May 25. Available online at: https://www.govinfo.gov/content/pkg/FR-2016-05-25/pdf/2016-12361.pdf.

USEPA. 2021. Human Health Toxicity Values for Perfluorobutane Sulfonic Acid (CASRN 375-73-5) and Related Compound Potassium Perfluorobutane Sulfonate (CASRN 29420-49-3). EPA/600/R-20/345F. Center for Public Health and Environmental Assessment, Office of Research and Development, Washington DC. April.

USEPA. 2022. Regional Screening Levels (RSLs) – Generic Tables. Tables as of May 2022. Access online: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

ACRONYMS

º	degree
%	percent
AFFF	aqueous film-forming foam
AOPI	area of potential interest
Arcadis	Arcadis U.S., Inc.
Army	United States Army
bgs	below ground surface
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CSM	conceptual site model
DoD	Department of Defense
DQO	data quality objective
DUSR	Data Usability Summary Report
EB	equipment blank
EDR	Environmental Data Resources, Inc.
ELAP	Environmental Laboratory Accreditation Program
F	Fahrenheit
FCR	Field Change Report
GPS	global positioning system
GW	groundwater
HFPO-DA	hexafluoropropylene oxide dimer acid
IDW	investigation-derived waste
INAAP	Indiana Army Ammunition Plant
installation	United States Army or Reserve installation
IRP	Installation Restoration Program
LAP	Load Assemble Package
LOD	limit of detection
LOQ	limit of quantitation
mg/kg	milligrams per kilogram (parts per million)

ND	non-detect
ng/L	nanograms per liter (parts per trillion)
NPDES	National Pollutant Discharge Elimination System
NS	not sampled
OSD	Office of the Secretary of Defense
P&E	Propellant and Explosives
PA	preliminary assessment
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
ppm	parts per million
ppt	parts per trillion
PQAPP	Programmatic Uniform Federal Policy-Quality Assurance Project Plan
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
RSL	Regional Screening Level
RSR	research summary report
SI	site inspection
SO	soil
SOP	standard operating procedure
SSHP	Site Safety and Health Plan
TGI	technical guidance instruction
TOC	total organic carbon
U.S.	United States
USACE	United States Army Corps of Engineers
USAEC	United States Army Environmental Command

USEPA United States Environmental Protection Agency

TABLES

Table 2-1 Historical PFOS, PFOA, PFBS, PFNA, PFHxS, and HFPO-DA Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Indiana Army Ammunition Plant, Indiana

Location		BE Payne Water Treatment Plant	BE Payne Water Treatment Plant	BE Payne Water Treatment Plant	BE Payne Water Treatment Plant	Crescent Hill Filter Plant	Crescent Hill Filter Plant	Crescent Hill Filter Plant	Crescent Hill Filter Plant	Charlestown State Park Well Field	Charlestown State Park Well Field	Charlestown State Park Well Field	Charlestown State Park Well Field
Sample ID		2923645	2777914	2824355	2875582	2923627	2777925	2824405	2875568	Well 1 + Well 3	Well 1	Well 2	Well 3
Sample Date		11/1/2013	2/11/2013	5/13/2013	8/12/2013	11/1/2013	2/11/2013	5/13/2013	8/12/2013	12/11/2019	1/23/2020	1/23/2020	1/23/2020
Chemical name	OSD risk screening level* in ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
9-Chlorohexadecafluoro-3-Oxanone-1-Sulfonic Acid (9Cl-PF3ONS)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
Hexafluoropropylene oxide dimer acid (HFPO-DA or GenX)	6	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
Perfluorobutanesulfonic acid (PFBS)	601	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
Perfluorodecanoic acid (PFDA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
Perfluorododecanoic acid (PFDoA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
Perfluoroheptanoic acid (PFHpA)	N/A	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
Perfluorohexanesulfonic acid (PFHxS)	39	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
Perfluorohexanoic acid (PFHxA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	2.3	ND	2.1
Perfluorononanoic acid (PFNA)	6	ND	ND	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
Perfluorooctane sulfonate (PFOS)	4	ND	ND	ND	ND	ND	ND	ND	ND	NA	ND	2.1	2.0
Perfluorooctanoic acid (PFOA)	6	ND	20	ND	ND	ND	ND	ND	20	4.5	4.7	4.4	6.9
Perfluorotetradecanoic acid (PFTA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
Perfluorotridecanoic Acid (PFTrDA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA
Perfluoroundecanoic acid (PFUnA)	N/A	NS	NS	NS	NS	NS	NS	NS	NS	NA	NA	NA	NA

Table 2-1 Historical PFOS, PFOA, PFBS, PFNA, PFHxS, and HFPO-DA Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Indiana Army Ammunition Plant, Indiana

Location		Charlestown State Park Well Field	Charlestown State Park Well Field	Charlestown State Park Well Field	Charlestown State Park Well Field	Charlestown State Park Well Field	Rural Membership Water Corporation Of Clark County	Rural Membership Water Corporation Of Clark County
Sample ID		EP001	WL001	WL002	WL003	WL004	EP001	EP002
Sample Date		6/14/2021	6/14/2021	6/14/2021	6/14/2021	6/14/2021	9/22/2021	9/22/2021
Chemical name	OSD risk screening level* in ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L	ng/L
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	N/A	ND	ND	ND	ND	ND	ND	ND
9-Chlorohexadecafluoro-3-Oxanone-1-Sulfonic Acid (9Cl-PF3ONS)	N/A	ND	ND	ND	ND	ND	ND	ND
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	N/A	ND	ND	ND	ND	ND	ND	ND
Hexafluoropropylene oxide dimer acid (HFPO-DA or GenX)	6	ND	ND	ND	ND	ND	ND	ND
N-ethyl perfluorooctane sulfonamidoacetic acid (NEtFOSAA)	N/A	ND	ND	ND	ND	ND	ND	ND
N-methyl perfluorooctane sulfonamidoacetic acid (NMeFOSAA)	N/A	ND	ND	ND	ND	ND	ND	ND
Perfluorobutanesulfonic acid (PFBS)	601	ND	ND	ND	ND	ND	ND	2.7
Perfluorodecanoic acid (PFDA)	N/A	ND	ND	ND	ND	ND	ND	ND
Perfluorododecanoic acid (PFDoA)	N/A	ND	ND	ND	ND	ND	ND	ND
Perfluoroheptanoic acid (PFHpA)	N/A	ND	ND	ND	ND	ND	ND	ND
Perfluorohexanesulfonic acid (PFHxS)	39	ND	ND	ND	ND	ND	ND	ND
Perfluorohexanoic acid (PFHxA)	N/A	2.2	2.0	2.8	3.5	ND	ND	ND
Perfluorononanoic acid (PFNA)	6	6.3	6.5	5.1	6.5	ND	ND	ND
Perfluorooctane sulfonate (PFOS)	4	ND	ND	ND	2.3	ND	ND	2.5
Perfluorooctanoic acid (PFOA)	6	ND	ND	ND	ND	ND	ND	3.3
Perfluorotetradecanoic acid (PFTA)	N/A	ND	ND	ND	ND	ND	ND	ND
Perfluorotridecanoic Acid (PFTrDA)	N/A	ND	ND	ND	ND	ND	ND	ND
Perfluoroundecanoic acid (PFUnA)	N/A	ND	ND	ND	ND	ND	ND	ND

Notes and Acronyms:

Data from November 2013 were collected per the Third Unregulated Contaminant Monitoring Rule at Louisville Water Company plants

Data from December 2019 were collected by the Louisville Water Company

Data from January 2020 were collected by INTERA, Inc. at the Charlestown State Park well field

Data from June 2021 were collected per the Indiana Department of Environmental Management 2021 monitoring program at the Charlestown State Park well field

Data from September 2021 were collected per the Indiana Department of Environmental Management 2021 monitoring program at the Charlestown State Park well field

Units are provided in nanograms per liter (ng/L).

* = OSD risk screening level for tap water

ID - identification

N/A = not applicable

NA = not available

ND = not detected above the limit of detection

ng/L = nanogram per liter

NS = not sampled

OSD = Office of the Secretary of Defense

Table 7-1 - Groundwater PFOS, PFOA, PFBS, PFNA, and PFHxS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Indiana Army Ammunition Plant, Indiana

Location	Sample/ Duplicate ID	Sample Date	Analyte	PFOS (ng/L)		PFOA (ng/L)		PFBS (ng/L)		PFNA (ng/L)		PFHxS (ng/L)	
			OSD Tapwater Risk Screening Level	4		6		601		6		39	
			Sample Type	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
INAAP-A1500-1-GW	INAAP-A1500-1-GW-032123	03/21/2023	N	3.9	U	3.9	U	3.9	U	3.9	U	3.9	U
INAAP-A1500-2-GW	INAAP-A1500-2-GW-032223	03/22/2023	N	**2.3**	J	**2.7**	J	**2.1**	J	**2.4**	J	**2.0**	J
INAAP-B709-1-1-GW	INAAP-B709-1-1-GW-032323	03/23/2023	N	4.0	U	**2.6**	J	4.0	U	4.0	U	4.0	U
INAAP-CTFA-1-GW	INAAP-CTFA-1-GW-032323	03/23/2023	N	4.2	U	**11**		**4.8**		**2.4**	J	**3.8**	J
	INAAP-FD-1-GW-032323	03/23/2023	FD	4.0	U	**10**		**4.6**		**2.5**	J	**3.2**	J

Notes:
1. **Bolded** values indicate the result was detected greater than the limit of detection.
2. Gray shaded values indicate the result was detected greater than the 2022 Office of the Secretary of Defense (OSD) risk screening levels, (OSD. 2022. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. July).

Acronyms/Abbreviations:
AOPI = area of potential interest
FD = field duplicate sample
ID = identification
N = primary sample
ng/L = nanograms per liter (parts per trillion)
PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
PFNA = perfluorononanoic acid
PFHxS = perfluorohexane sulfonate
Qual = qualifier

Qualifier	Description
J	The analyte was positively identified; however the associated numerical value is an estimated concentration only.
U	The analyte was analyzed for but the result was not detected above the limit of quantitation (LOQ).

Table 7-2 Soil PFOS, PFOA, PFBS, PFNA, and PFHxS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Indiana Army Ammunition Plant, Indiana

Location	Sample ID / Duplicate ID	Sample Date	Analyte	PFOS (mg/kg)		PFOA (mg/kg)		PFBS (mg/kg)		PFNA (mg/kg)		PFHxS (mg/kg)	
			OSD Industrial/Commercial Risk Screening Level	0.16		0.25		25		0.25		1.6	
			OSD Residential Risk Screening Level	0.013		0.019		1.9		0.019		0.13	
			Sample Type	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
INAAP-B709-1-1-SO	INAAP-B709-1-1-SO-032223	03/22/2023	N	**0.00061**	J	0.0011	U	0.0011	U	0.0011	U	0.0011	U
INAAP-B709-1-2-SO	INAAP-B709-1-2-SO-032023	03/20/2023	N	**0.00055**	J	0.00096	U	0.00096	U	0.00096	U	0.00096	U
INAAP-B709-1-3-SO	INAAP-B709-1-3-SO-032023	03/20/2023	N	**0.0023**		0.00098	U	0.00098	U	0.00098	U	0.00098	U
INAAP-B709-1-4-SO	INAAP-B709-1-4-SO-032023	03/20/2023	N	**0.001**	J	0.0011	U	0.0011	U	0.0011	U	0.0011	U
INAAP-B709-4-1-SO	INAAP-B709-4-1-SO-032223	03/22/2023	N	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
	INAAP-FD-1-SO-032223	03/22/2023	FD	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
INAAP-B709-4-2-SO	INAAP-B709-4-2-SO-032023	03/20/2023	N	0.0011	U	0.0011	U	0.0011	U	0.0011	U	0.0011	U
INAAP-B709-4-3-SO	INAAP-B709-4-3-SO-032023	03/20/2023	N	0.0012	U	0.0012	U	0.0012	U	0.0012	U	0.0012	U
INAAP-B709-4-4-SO	INAAP-B709-4-4-SO-032023	03/20/2023	N	0.0012	U	0.0012	U	0.0012	U	0.0012	U	0.0012	U
INAAP-CTFA-1-SO	INAAP-CTFA-1-SO-032323	03/23/2023	N	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
INAAP-CTFA-2-SO	INAAP-CTFA-2-SO-032023	03/20/2023	N	0.0012	U	0.0012	U	0.0012	U	0.0012	U	0.0012	U
INAAP-CTFA-3-SO	INAAP-CTFA-3-SO-032023	03/20/2023	N	0.0012	U	0.0012	U	0.0012	U	0.0012	U	0.0012	U
INAAP-CTFA-4-SO	INAAP-CTFA-4-SO-032023	03/20/2023	N	0.0011	U	0.0011	U	0.0011	U	0.0011	U	0.0011	U
INAAP-CTFA-5-SO	INAAP-CTFA-5-SO-032023	03/20/2023	N	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U

Notes:
1. **Bolded** values indicate the result was detected greater than the limit of detection
2. Data are compared to the Office of the Secretary of Defense (OSD) risk screening levels for both the residential as well as the industrial/commercial scenarios (OSD. 2022. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. July).
3. Gray shaded values indicate the result was detected greater than the residential scenario risk screening levels (OSD 2022).
4. Gray shaded and italicized values indicate the result was detected greater than the industrial/commercial scenario (i.e., and therefore greater than the residential scenario) risk screening levels (OSD 2022).

Acronyms/Abbreviations:
-- = not applicable
AOPI = area of potential interest
FD = field duplicate sample
ID = identification
mg/kg = milligrams per kilogram (parts per million)
N = primary sample
PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
PFNA = perfluorononanoic acid
PFHxS = perfluorohexane sulfonate
Qual = qualifier

Qualifier	Description
J	The analyte was positively identified; however the associated numerical value is an estimated concentration only.
U	The analyte was analyzed for but the result was not detected above the limit of quantitation (LOQ).

Table 7-3 - Surface Water PFOS, PFOA, PFBS, PFNA, and PFHxS Analytical Results
USAEC PFAS Preliminary Assessment/Site Inspection
Indiana Army Ammunition Plant, Indiana

Location	Sample/ Duplicate ID	Sample Date	Analyte	PFOS (ng/L)		PFOA (ng/L)		PFBS (ng/L)		PFNA (ng/L)		PFHxS (ng/L)	
			OSD Tapwater Risk Screening Level	4		6		601		6		39	
			Sample Type	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
INAAP-A1500-1-SW[1]	INAAP-A1500-1-SW-032023	03/20/2023	N	**5.3**		3.7	U	**2.6**	J	3.7	U	**2.7**	J
	INAAP-FD-1-SW-032023	03/20/2023	FD	**5.7**		3.8	U	**3.0**	J	3.8	U	**2.9**	J
INAAP-CTFA-1-SW	INAAP-CTFA-1-SW-032323	03/23/2023	N	3.6	U	**3.0**	J	**2.4**	J	3.6	U	3.6	U
INAAP-PE-1-SW	INAAP-PE-1-SW-032323	03/23/2023	N	3.8	U	3.8	U	**2.8**	J	3.8	U	3.8	U

Notes:
1. The samples collected at INAAP-A1500-1-SW were not compared to the 2022 Office of the Secretary of Defense (OSD) risk screening levels, because they are not expressions of groundwater (OSD. 2022. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. July).
2. **Bolded** values indicate the result was detected greater than the limit of detection.
3. Gray shaded values indicate the result was detected greater than the 2022 Office of the Secretary of Defense (OSD) risk screening levels, (OSD. 2022. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. July).

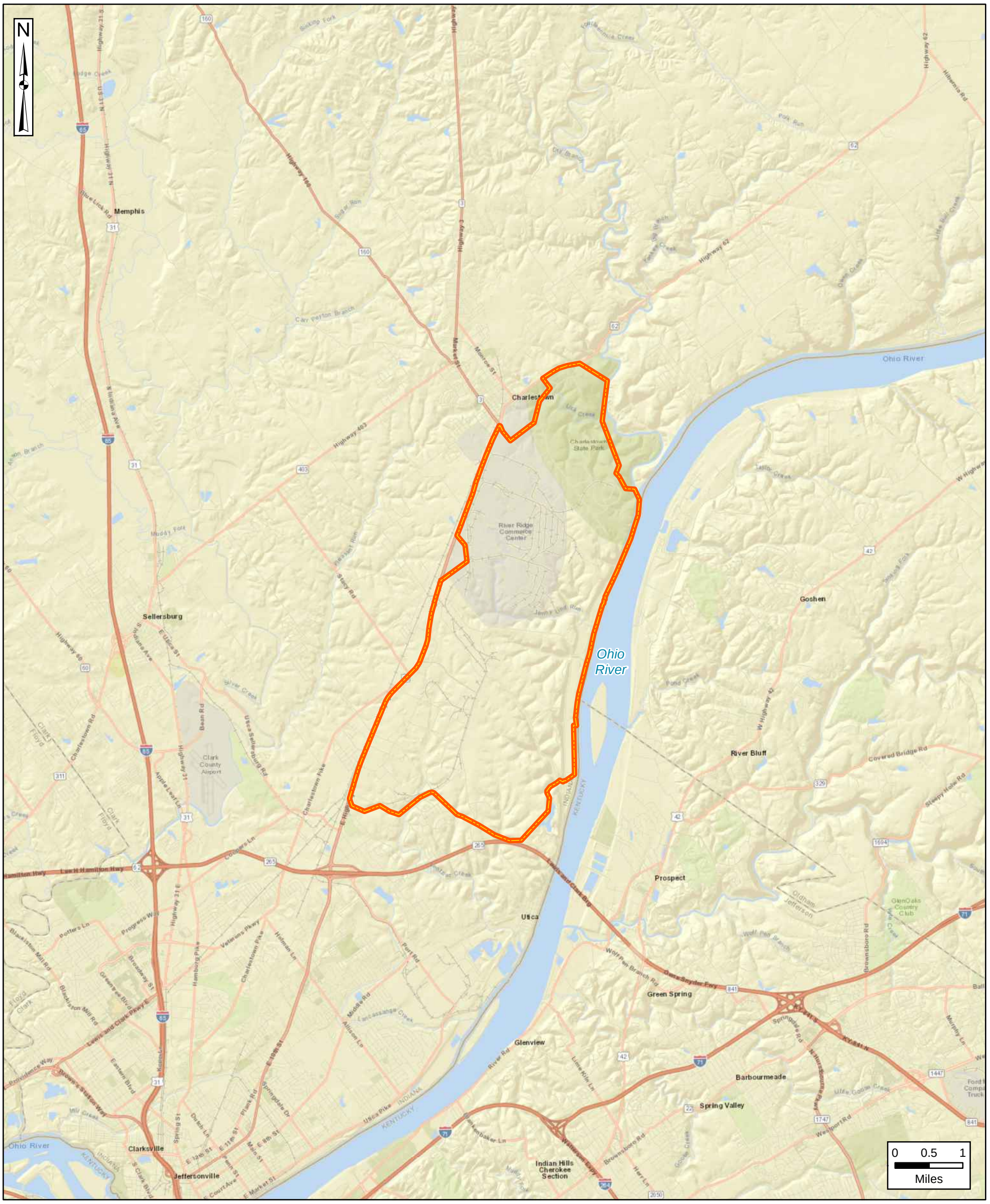
Acronyms/Abbreviations:
-- = not applicable
AOPI = area of potential interest
FD = field duplicate sample
ID = identification
N = primary sample
ng/L = nanograms per liter (parts per trillion)
PFAS = per- and polyfluoroalkyl substances
PFBS = perfluorobutanesulfonic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
PFNA = perfluorononanoic acid
PFHxS = perfluorohexane sulfonate
Qual = qualifier

Qualifier	Description
J	The analyte was positively identified; however the associated numerical value is an estimated concentration only.
U	The analyte was analyzed for but the result was not detected above the limit of quantitation (LOQ).

FIGURES

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 2-1
Site Location



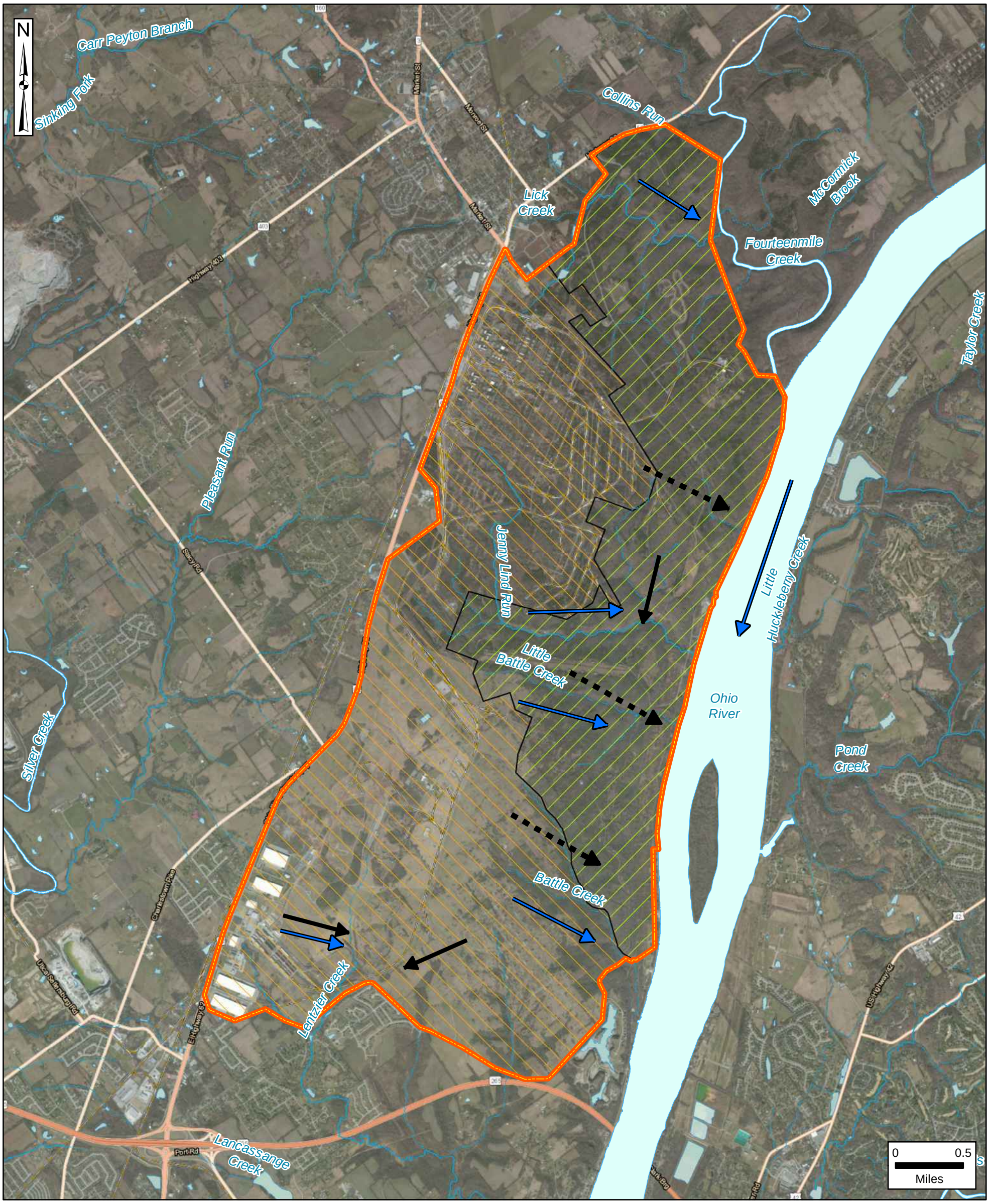
Former Installation Boundary

Data Sources:
ESRI, ArcGIS Online, Street Map Data

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 2-2
Site Layout



- Former Installation Boundary
- Charlestown State Park Property
- River Ridge Redevelopment Authority Property
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- Surface Water Flow Direction
- Local Groundwater Flow Direction
- Inferred Regional Groundwater Flow Direction

Data Sources:
USGS, NHD Data, 2021
ESRI, ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 2-3
Topographic Map

Former Installation Boundary

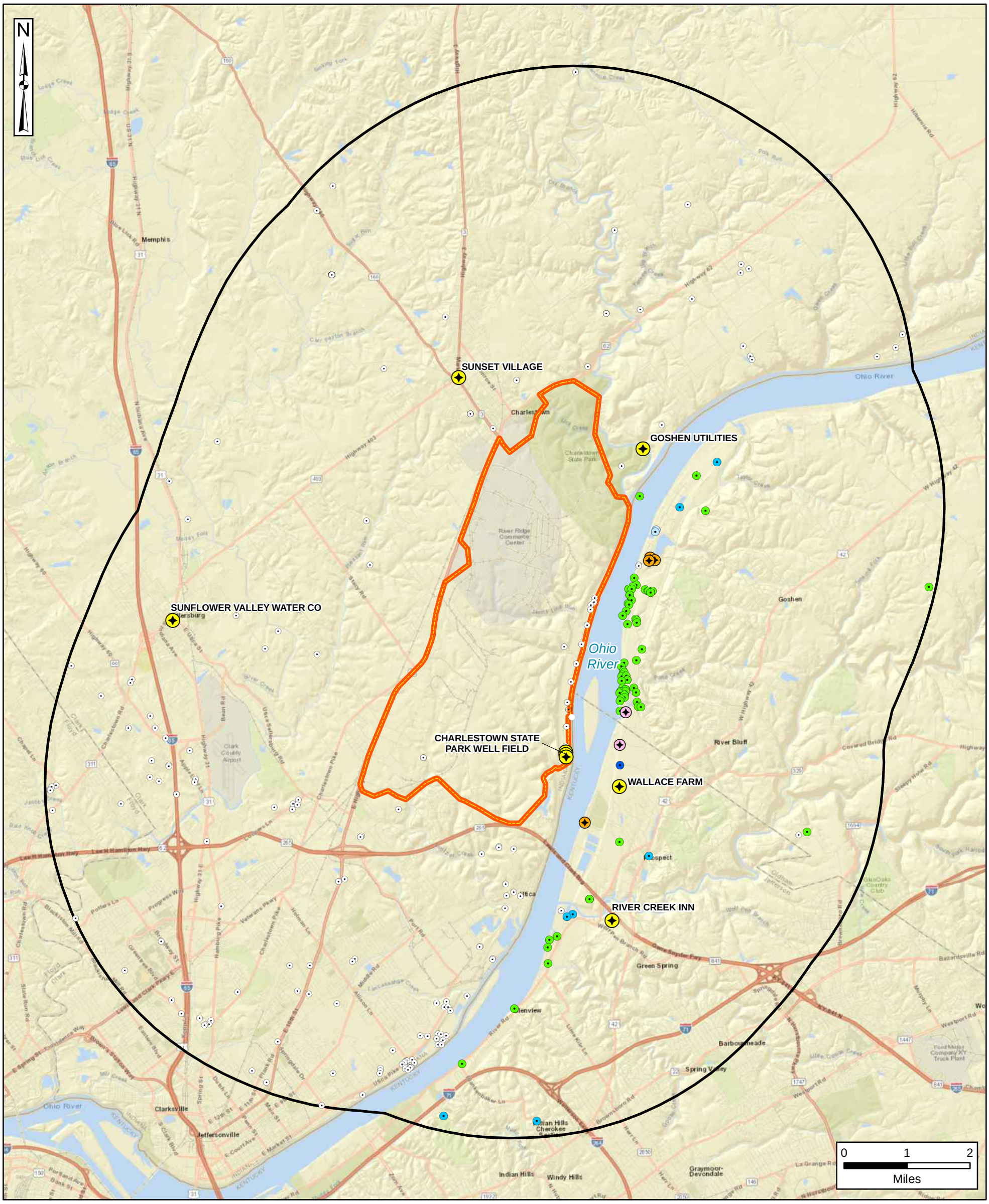
Elevation Contour (10 feet)

Data Sources:
ESRI, ArcGIS Online, USA Topo Map

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 2-4
Off-Post Potable Supply Wells



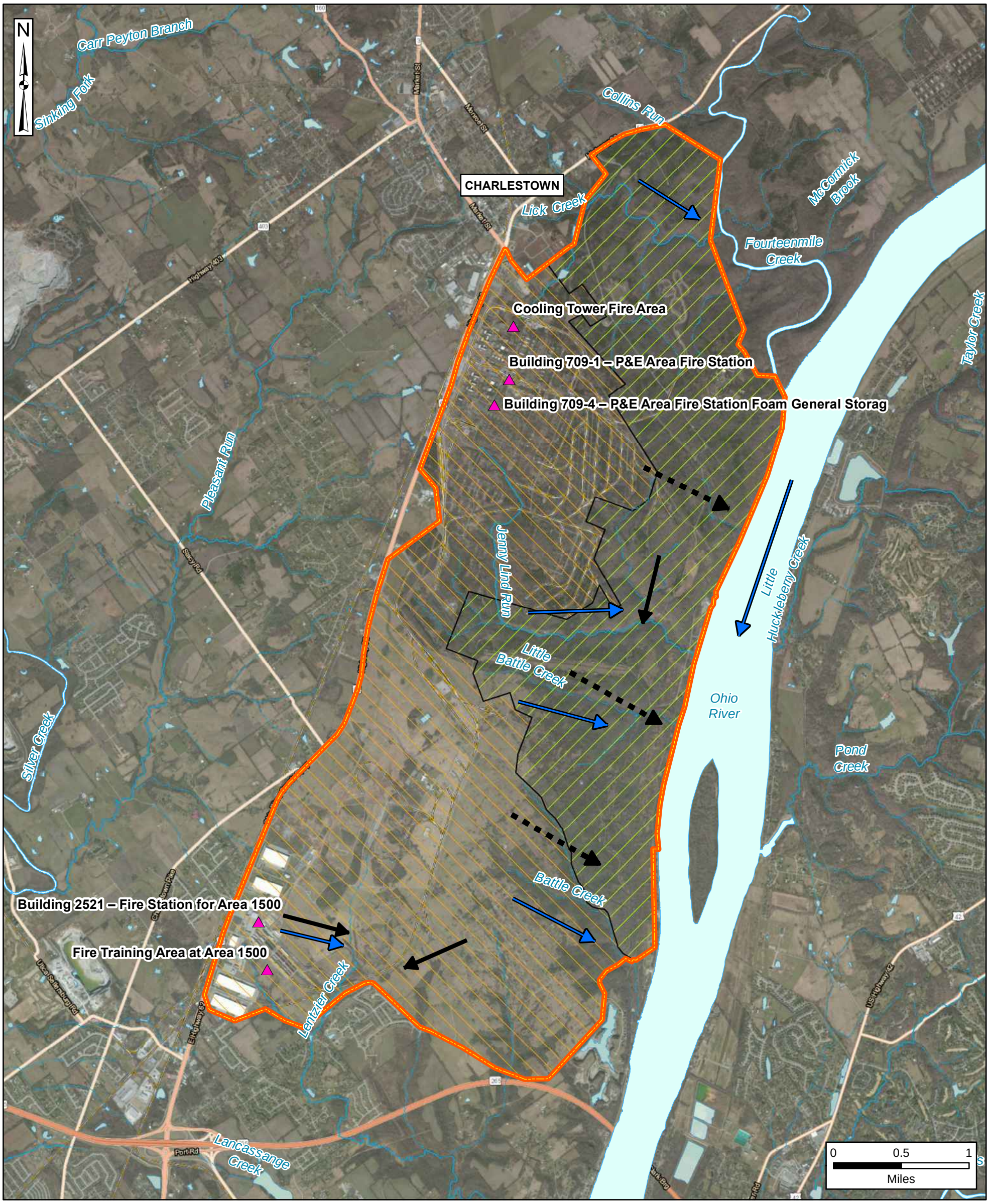
- Former Installation Boundary
- 5-Mile Radius
- Public Water Supply System Well
- Public - Community Well
- Public - Non-transient, Non-Community Well
- Agriculture - Livestock Watering Well
- Agriculture - Irrigation Well
- Commerical - Irrigation Well
- Domestic - Single Household Well
- Not Reported / Unknown Use Well

Data Sources:
EDR, Well Data, 2021
ESRI, ArcGIS Online, Street Map Data

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 5-2
AOPI Locations



- Former Installation Boundary
- Charlestown State Park Property
- River Ridge Redevelopment Authority Property
- AOPI Location
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- Surface Water Flow Direction
- Local Groundwater Flow Direction
- Inferred Regional Groundwater Flow Direction

AOPI = area of potential interest
INAAP = Indiana Army Ammunition Plant
P&E = Propellant and Explosives

Data Sources:
USGS, NHD Data, 2021
ESRI, ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 5-3
Aerial Photo of
Cooling Tower Fire Area AOPI

- Former Installation Boundary
- AOPI
- Historical Building Footprint
- Stream (Intermittent)
- Water Body (Pond)
- Surface Water Flow Direction
- Surface Water Runoff Direction
- Groundwater Flow Direction

AOPI = area of potential interest

Data Sources:
USGS, NHD Data, 2021
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 5-4
Aerial Photo of
Building 709-1 – P&E Area Fire Station AOPI

Former Installation Boundary
AOPI
Surface Water Runoff Direction
Groundwater Flow Direction

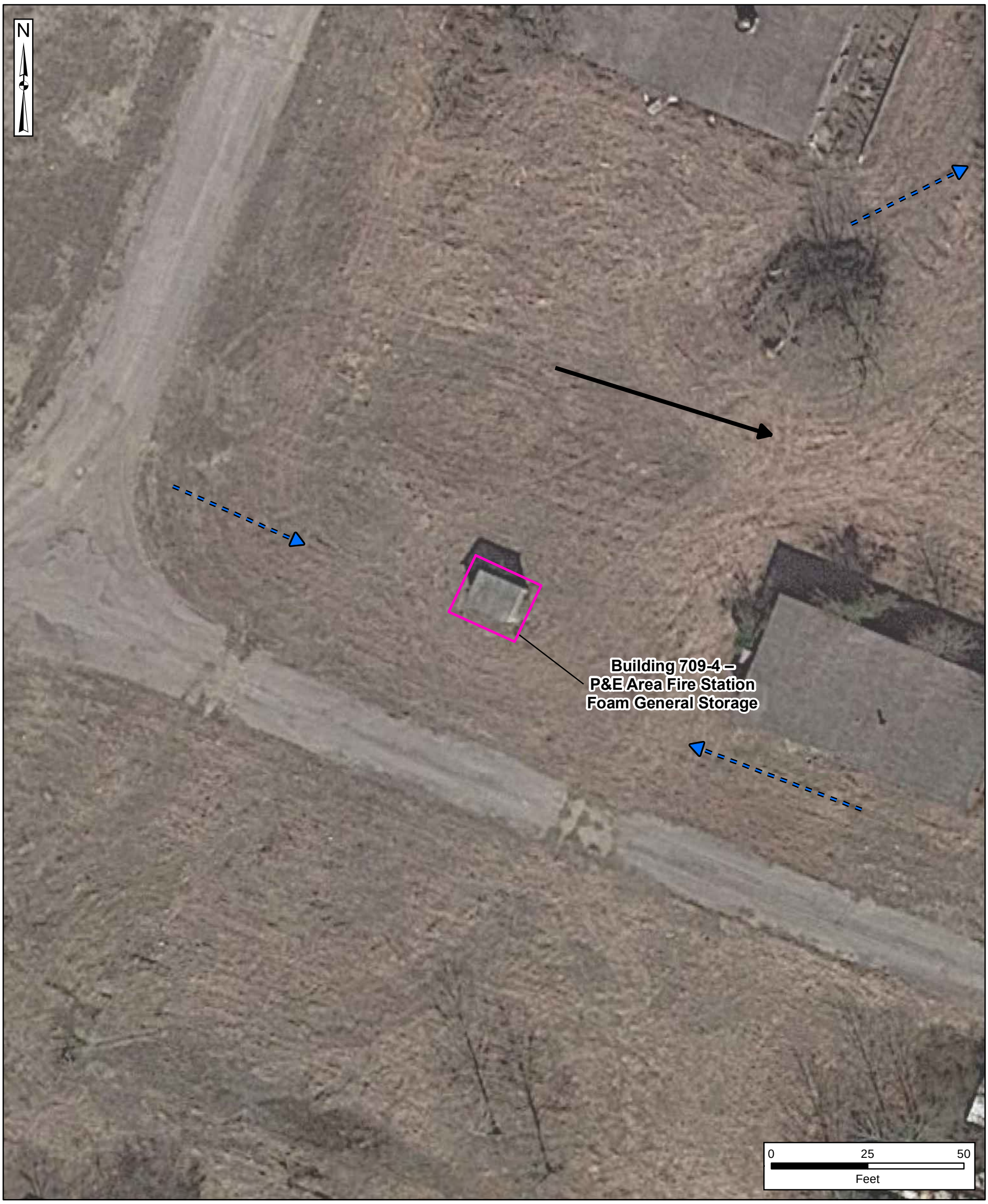
AOPI = area of potential interest
P&E = Propellant and Explosives

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 5-5
Aerial Photo of Building 709-4 –
P&E Area Fire Station Foam General Storage AOPI



Former Installation Boundary
AOPI
Surface Water Runoff Direction
Groundwater Flow Direction

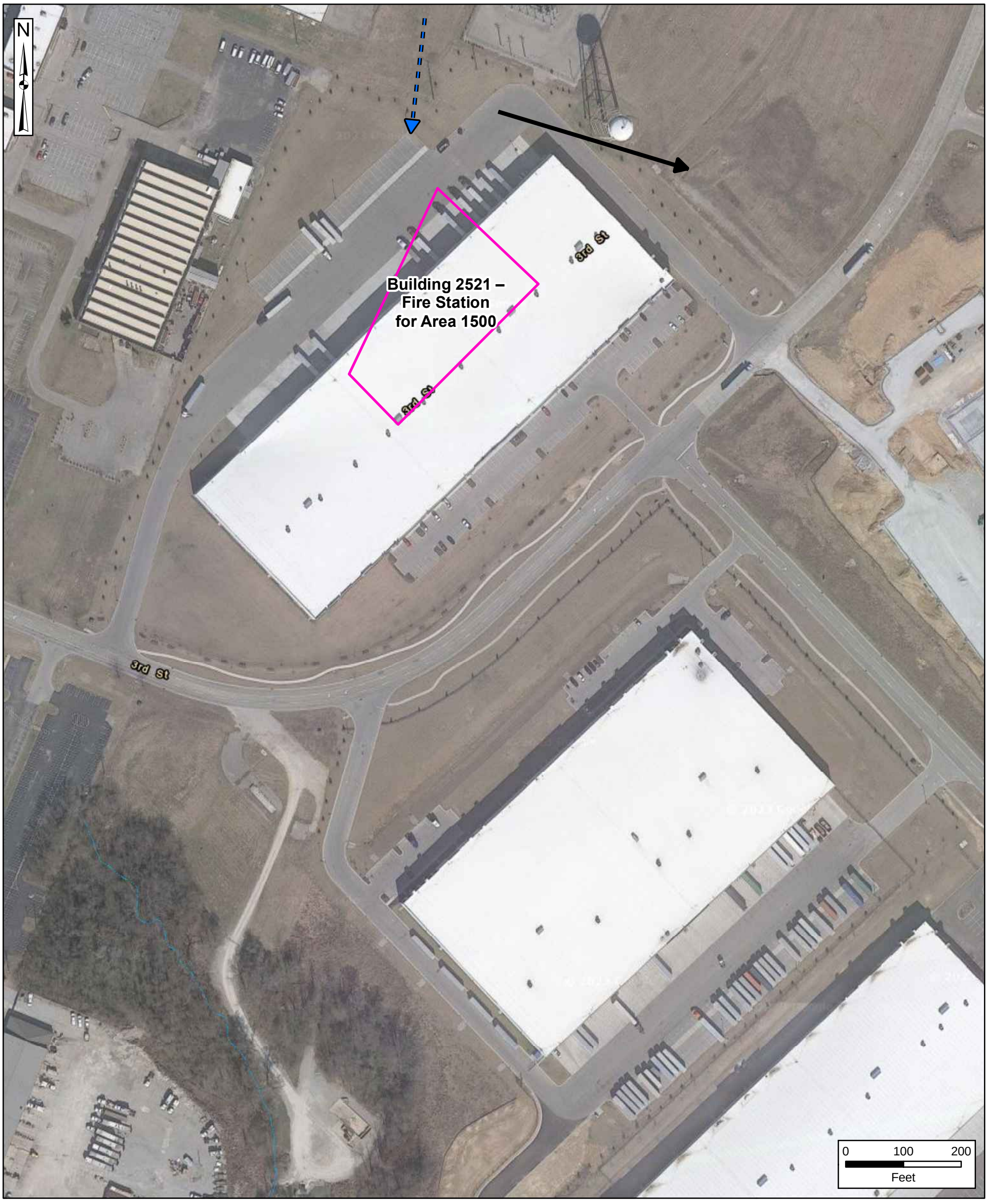
AOPI = area of potential interest
P&E = Propellant and Explosives

Data Sources:
USGS, NHD Data, 2021
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 5-6
Aerial Photo of
Building 2521 – Fire Station for Area 1500 AOPI



Former Installation Boundary
AOPI
Stream (Intermittent)
Surface Water Runoff Direction
Groundwater Flow Direction

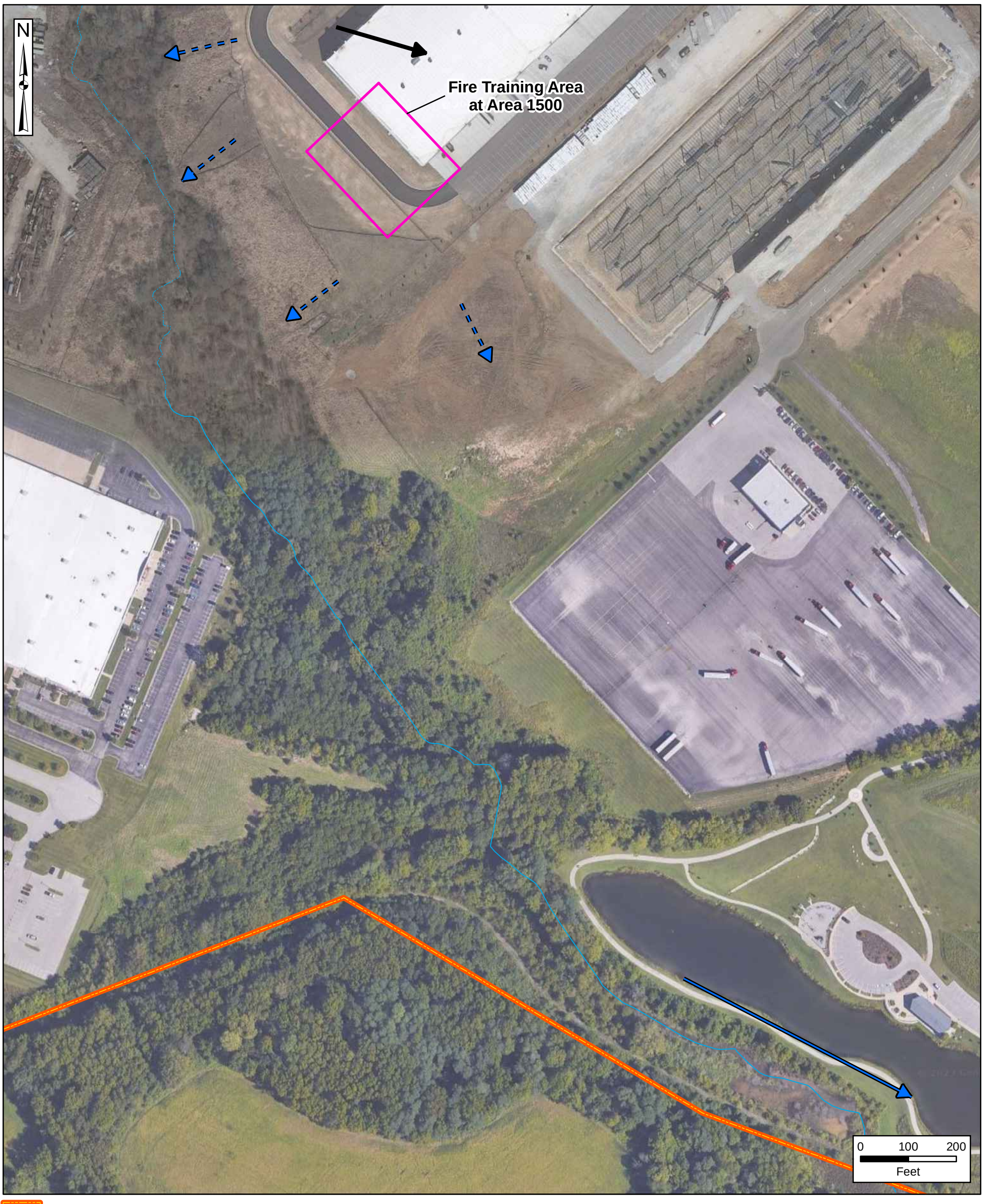
AOPI = area of potential interest

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 5-7
Aerial Photo of
Fire Training Area at Area 1500 AOPI



- Former Installation Boundary
- AOPI
- River/Stream (Perennial)
- Stream (Intermittent)
- Surface Water Flow Direction
- Surface Water Runoff Direction
- Groundwater Flow Direction

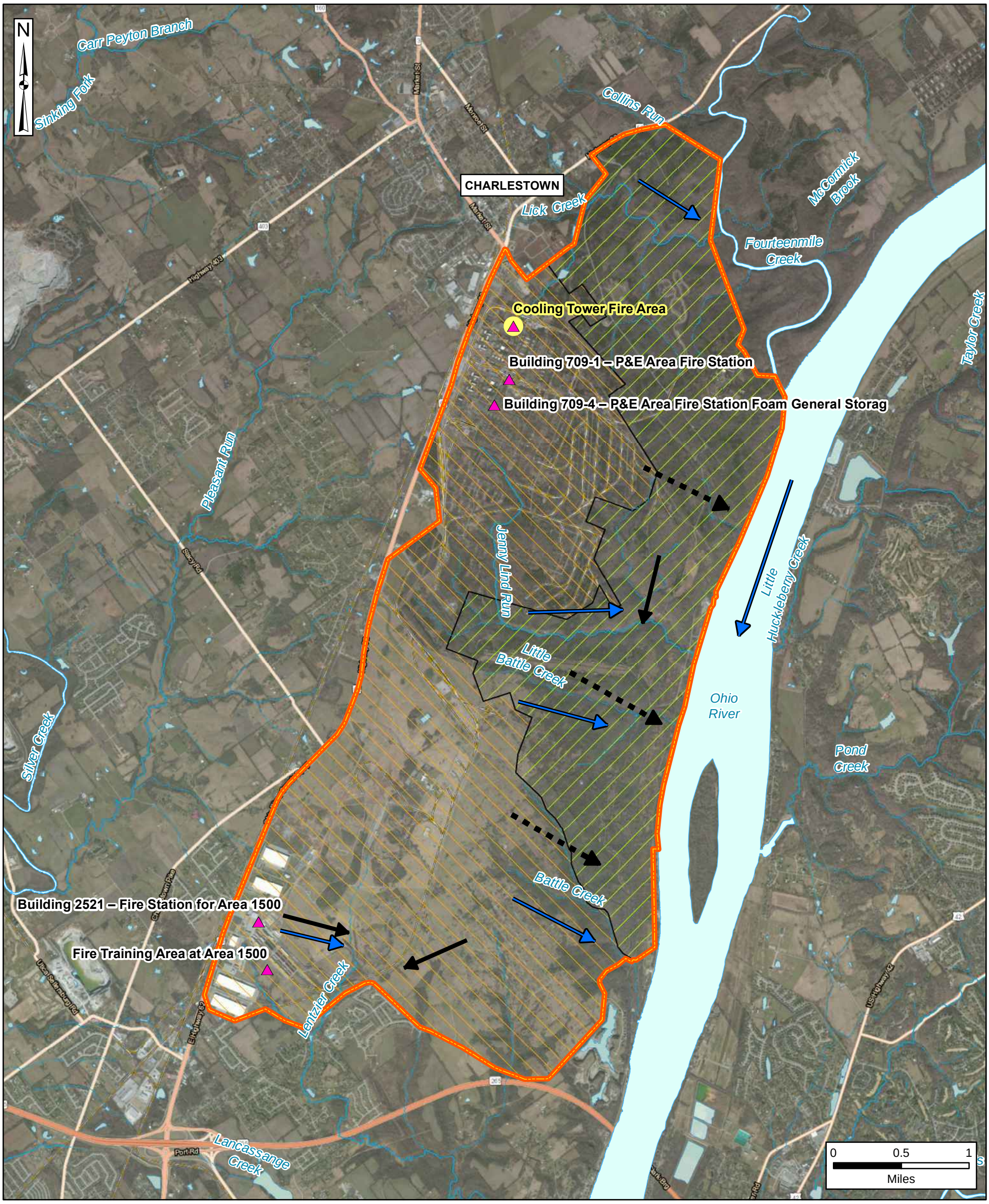
AOPI = area of potential interest

Data Sources:
USGS, NHD Data, 2021
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 7-1
AOPI Locations and
OSD Risk Screening Level Exceedances



- Former Installation Boundary
- Charlestown State Park Property
- River Ridge Redevelopment Authority Property
- AOPI Location
- AOPI with OSD Risk Screening Level Exceedance
- River/Stream (Perennial)
- Stream (Intermittent)
- Water Body
- Surface Water Flow Direction
- Local Groundwater Flow Direction
- Inferred Regional Groundwater Flow Direction

AOPI = area of potential interest
INAAP = Indiana Army Ammunition Plant
OSD = Office of the Secretary of Defense
P&E = Propellant and Explosives

Data Sources:
USGS, NHD Data, 2021
ESRI, ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 7-2
Cooling Tower Fire Area AOPI
PFOS, PFOA, PFBS, PFNA, and PFHxS Analytical Results

Chemical	Residential Scenario Risk Screening Level		Industrial/Commercial Scenario Risk Screening Level
	Tap Water (ng/L)	Soil (mg/kg)	Soil (mg/kg)
PFOS	4	0.013	0.16
PFOA	6	0.019	0.25
PFBS	601	1.9	25
PFNA	6	0.019	0.25
PFHxS	39	0.13	1.6

N

Government

Government

INAAP-CTFA-1-SW

Cooling Tower Fire Area

INAAP-CTFA-4-SO	
Date	3/20/2023
PFOS	0.0011 U
PFOA	0.0011 U
PFBS	0.0011 U
PFNA	0.0011 U
PFHxS	0.0011 U

INAAP-CTFA-1-SW	
Date	3/23/2023
PFOS	3.6 U
PFOA	**3.0 J**
PFBS	**2.4 J**
PFNA	3.6 U
PFHxS	3.6 U

INAAP-CTFA-3-SO	
Date	3/20/2023
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U
PFNA	0.0012 U
PFHxS	0.0012 U

INAAP-CTFA-5-SO	
Date	3/20/2023
PFOS	0.001 U
PFOA	0.001 U
PFBS	0.001 U
PFNA	0.001 U
PFHxS	0.001 U

INAAP-CTFA-2-SO	
Date	3/20/2023
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U
PFNA	0.0012 U
PFHxS	0.0012 U

INAAP-CTFA-1-SO	
Date	3/23/2023
PFOS	0.001 U
PFOA	0.001 U
PFBS	0.001 U
PFNA	0.001 U
PFHxS	0.001 U

INAAP-CTFA-1-GW	
Date	3/23/2023
PFOS	4.2 U [4.0 U]
PFOA	**11 [10]**
PFBS	**4.8 [4.6]**
PFNA	**2.4 J [2.5 J]**
PFHxS	**3.8 J [3.2 J]**

Notes:
1. Soil results are reported in milligrams per kilogram (mg/kg).
2. Groundwater and surface water results are reported in nanograms/liter (ng/L).
3. Duplicate sample results are shown in brackets.
4. Bolded results indicate detections.
5. Results that exceed Office of the Secretary of Defense (OSD) residential scenario risk screening levels (OSD 2022) are highlighted gray.

Qualifiers:
J = The analyte was positively identified; however the associated numerical value is an estimated concentration only.
U = The analyte was analyzed for, but was not detected above the limit of quantitation (LOQ).

0 200
Feet

Former Installation Boundary
AOPI
Historical Building Footprint
Stream (Intermittent)
Water Body (Pond)

Surface Water Flow Direction
Surface Water Runoff Direction
Groundwater Flow Direction

Sampling Locations
Shallow Soil
Surface Water
Soil / Groundwater

AOPI = area of potential interest
PFBS = perfluorobutanesulfonic acid
PFHxS = perfluorohexane sulfonate
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
USGS, NHD Data, 2021
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 7-3
Building 709-1 – P&E Area Fire Station AOPI
PFOS, PFOA, PFBS, PFNA, and PFHxS Analytical Results

Chemical	Residential Scenario Risk Screening Level		Industrial/Commercial Scenario Risk Screening Level
	Tap Water (ng/L)	Soil (mg/kg)	Soil (mg/kg)
PFOS	4	0.013	0.16
PFOA	6	0.019	0.25
PFBS	601	1.9	25
PFNA	6	0.019	0.25
PFHxS	39	0.13	1.6

N

US Government

Building 709-1 – P&E Area Fire Station

INAAP-B709-1-4-SO	
Date	3/20/2023
PFOS	**0.001 J**
PFOA	0.0011 U
PFBS	0.0011 U
PFNA	0.0011 U
PFHxS	0.0011 U

INAAP-B709-1-3-SO	
Date	3/20/2023
PFOS	**0.0023**
PFOA	0.00098 U
PFBS	0.00098 U
PFNA	0.00098 U
PFHxS	0.00098 U

INAAP-B709-1-2-SO	
Date	3/20/2023
PFOS	**0.00055 J**
PFOA	0.00096 U
PFBS	0.00096 U
PFNA	0.00096 U
PFHxS	0.00096 U

INAAP-B709-1-1-SO	
Date	3/22/2023
PFOS	**0.00061 J**
PFOA	0.0011 U
PFBS	0.0011 U
PFNA	0.0011 U
PFHxS	0.0011 U

INAAP-B709-1-1-GW	
Date	3/23/2023
PFOS	4.0 U
PFOA	**2.6 J**
PFBS	4.0 U
PFNA	4.0 U
PFHxS	4.0 U

0 100
Feet

Notes:
1. Soil results are reported in milligrams per kilogram (mg/kg).
2. Groundwater results are reported in nanograms/liter (ng/L).
3. Bolded results indicate detections.

Qualifiers:
J = The analyte was positively identified; however the associated numerical value is an estimated concentration only.
U = The analyte was analyzed for, but was not detected above the limit of quantitation (LOQ).

Former Installation Boundary
AOPI
Surface Water Runoff Direction
Groundwater Flow Direction

Sampling Locations
Shallow Soil
Soil / Groundwater

AOPI = area of potential interest
PFBS = perfluorobutanesulfonic acid
PFHxS = perfluorohexane sulfonate
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
P&E = Propellant and Explosives

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 7-4
Building 709-4 – P&E Area Fire Station Foam General Storage AOPI
PFOS, PFOA, PFBS, PFNA, and PFHxS Analytical Results

Chemical	Residential Scenario Risk Screening Level		Industrial/Commercial Scenario Risk Screening Level
	Tap Water (ng/L)	Soil (mg/kg)	Soil (mg/kg)
PFOS	4	0.013	0.16
PFOA	6	0.019	0.25
PFBS	601	1.9	25
PFNA	6	0.019	0.25
PFHxS	39	0.13	1.6

N

Building 709-4 – P&E Area Fire Station Foam General Storag

INAAP-PE-1-SW	
Date	3/23/2023
PFOS	3.8 U
PFOA	3.8 U
PFBS	**2.8 J**
PFNA	3.8 U
PFHxS	3.8 U

0 100
Feet

Building 709-4 – P&E Area Fire Station Foam General Storage

INAAP-B709-4-4-SO	
Date	3/20/2023
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U
PFNA	0.0012 U
PFHxS	0.0012 U

INAAP-B709-4-3-SO	
Date	3/20/2023
PFOS	0.0012 U
PFOA	0.0012 U
PFBS	0.0012 U
PFNA	0.0012 U
PFHxS	0.0012 U

INAAP-B709-4-2-SO	
Date	3/20/2023
PFOS	0.0011 U
PFOA	0.0011 U
PFBS	0.0011 U
PFNA	0.0011 U
PFHxS	0.0011 U

INAAP-B709-4-1-GW*

INAAP-B709-4-1-SO	
Date	3/22/2023
PFOS	0.001 U [0.001 U]
PFOA	0.001 U [0.001 U]
PFBS	0.001 U [0.001 U]
PFNA	0.001 U [0.001 U]
PFHxS	0.001 U [0.001 U]

Notes:
1. Soil results are reported in milligrams per kilogram (mg/kg).
2. Surface water results are reported in nanograms/liter (ng/L).
3. Duplicate sample results are shown in brackets.

Qualifiers:
J = The analyte was positively identified; however the associated numerical value is an estimated concentration only.
U = The analyte was analyzed for, but was not detected above the limit of quantitation (LOQ).

0 50
Feet

Former Installation Boundary
AOPI
Surface Water Runoff Direction
Groundwater Flow Direction

Sampling Locations
Shallow Soil
Soil / Groundwater
Surface Water (Spring)
*Groundwater sample was not collected

AOPI = area of potential interest
PFBS = perfluorobutanesulfonic acid
PFHxS = perfluorohexane sulfonate
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
P&E = Propellant and Explosives

Data Sources:
USGS, NHD Data, 2021
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, IN

Figure 7-5
Building 2521 – Fire Station for Area 1500 AOPI
PFOS, PFOA, PFBS, PFNA, and PFHxS Analytical Results

Chemical	Residential Scenario Risk Screening Level Tap Water (ng/L)
PFOS	4
PFOA	6
PFBS	601
PFNA	6
PFHxS	39

N

Building 2521 – Fire Station for Area 1500

3rd St

INAAP-A1500-2-GW	
Date	3/22/2023
PFOS	**2.3 J**
PFOA	**2.7 J**
PFBS	**2.1 J**
PFNA	**2.4 J**
PFHxS	**2.0 J**

0 100
Feet

Notes:
1. Groundwater results are reported in nanograms/liter (ng/L).
2. Bolded results indicate detections.

Qualifiers:
J = The analyte was positively identified; however the associated numerical value is an estimated concentration only.

Former Installation Boundary
AOPI
Stream (Intermittent)
Surface Water Runoff Direction
Groundwater Flow Direction

Sampling Locations
Groundwater (Boring)

AOPI = area of potential interest
PFBS = perfluorobutanesulfonic acid
PFHxS = perfluorohexane sulfonate
PFNA = perfluorononanoic acid
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate

Data Sources:
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North

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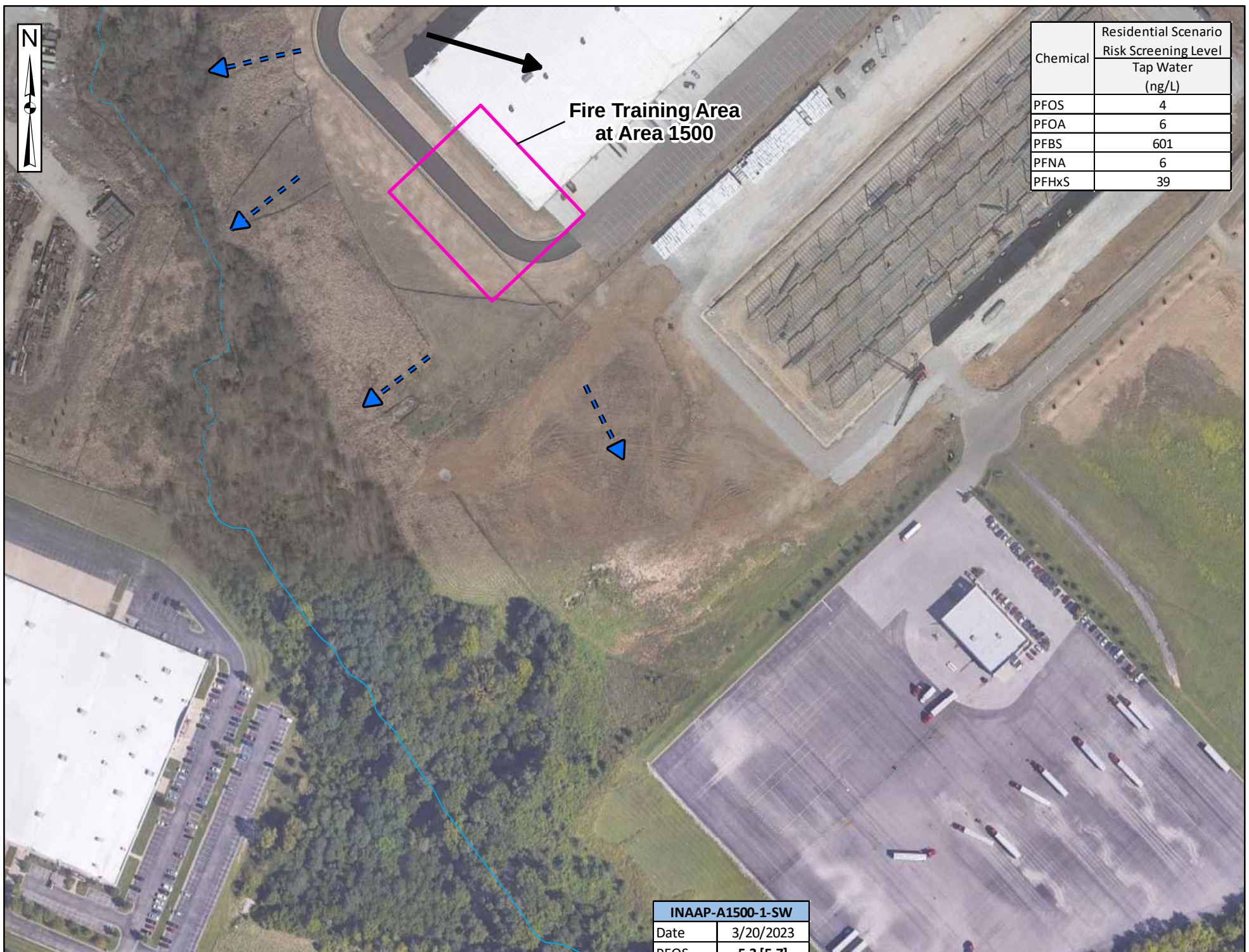
Figure 7-6
Fire Training Area at Area 1500 AOPI
PFOS, PFOA, PFBS, PFNA, and PFHxS Analytical Results



Chemical	Residential Scenario Risk Screening Level Tap Water (ng/L)
PFOS	4
PFOA	6
PFBS	601
PFNA	6
PFHxS	39

Notes:
1. Groundwater and surface water results are reported in nanograms/liter (ng/L).
2. Duplicate sample results are shown in brackets.
3. Bolded results indicate detections.
4. The samples collected at INAAP-A1500-1-SW were not compared to the 2022 OSD risk screening levels because they are not expressions of groundwater.

Qualifiers:
J = The analyte was positively identified; however the associated numerical value is an estimated concentration only.
U = The analyte was analyzed for, but was not detected above the limit of quantitation (LOQ).

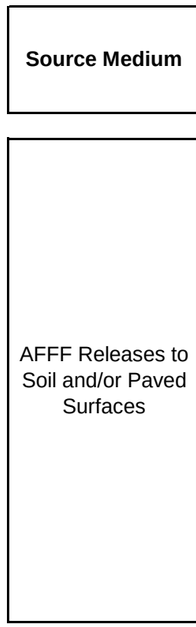
Former Installation Boundary
AOPI
River/Stream (Perennial)
Stream (Intermittent)
Surface Water Flow Direction
Surface Water Runoff Direction
Groundwater Flow Direction

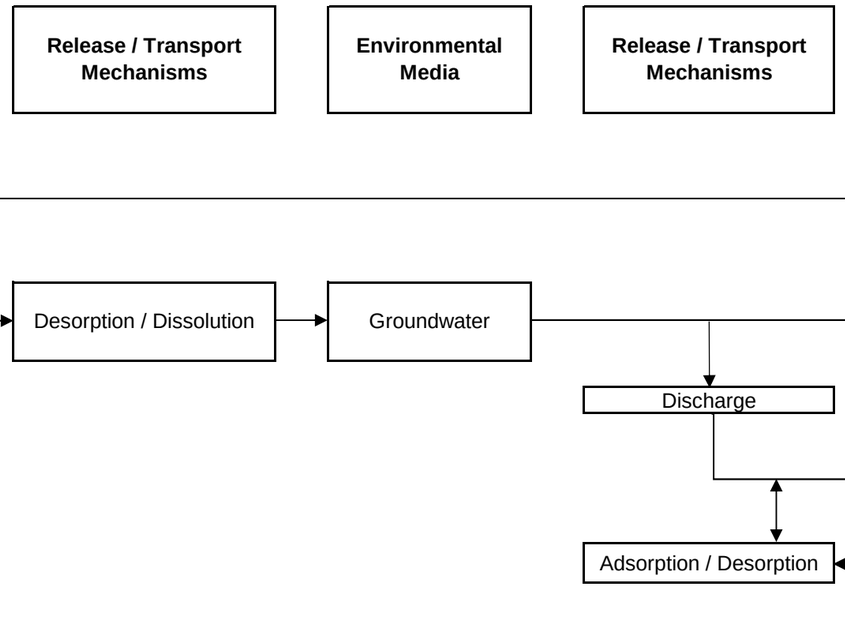
Sampling Locations
Groundwater (Boring)
Surface Water (Spring)

AOPI = area of potential interest

Data Sources:
USGS, NHD Data, 2021
Google Earth, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 16 North





Exposure Media	Exposure Route	Human Receptors: On-Site[2] Site Worker	On-Site[2] Resident	On-Site[2] Recreational User	Off-Site[2] All Types of Receptors [3]
Soil	Ingestion	◯	◯	◯	◯
	Dermal Contact	◯	◯	◯	◯
	Inhalation (dust)	◯	◯	◯	◯
Groundwater	Ingestion	◐	◯	◯	◐
	Dermal Contact	◐	◯	◯	◐
Surface Water [1]	Ingestion	◐	◯	◐	◐
	Dermal Contact	◐	◯	◐	◐
Sediment	Ingestion	◐	◯	◐	◐
	Dermal Contact	◐	◯	◐	◐

Legend:

◐ = Potentially Complete Exposure Pathway

◯ = Incomplete Exposure Pathway

Notes:
[1] Surface water and sediment pathways for on-site workers and recreational users describe incidental ingestion and dermal contact during outdoor work or recreational activities, respectively.
[2] "Site" refers to the bounds of the AOPI.
[3] All types of off-site receptors include drinking water receptors and recreational users.
AFFF = aqueous film-forming foam
AOPI = area of potential interest
P&E = propellant and explosives

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Conceptual Site Model for the Cooling Tower Fire Area and Building 709-4 P&E Area Fire Station Foam General Storage AOPIs
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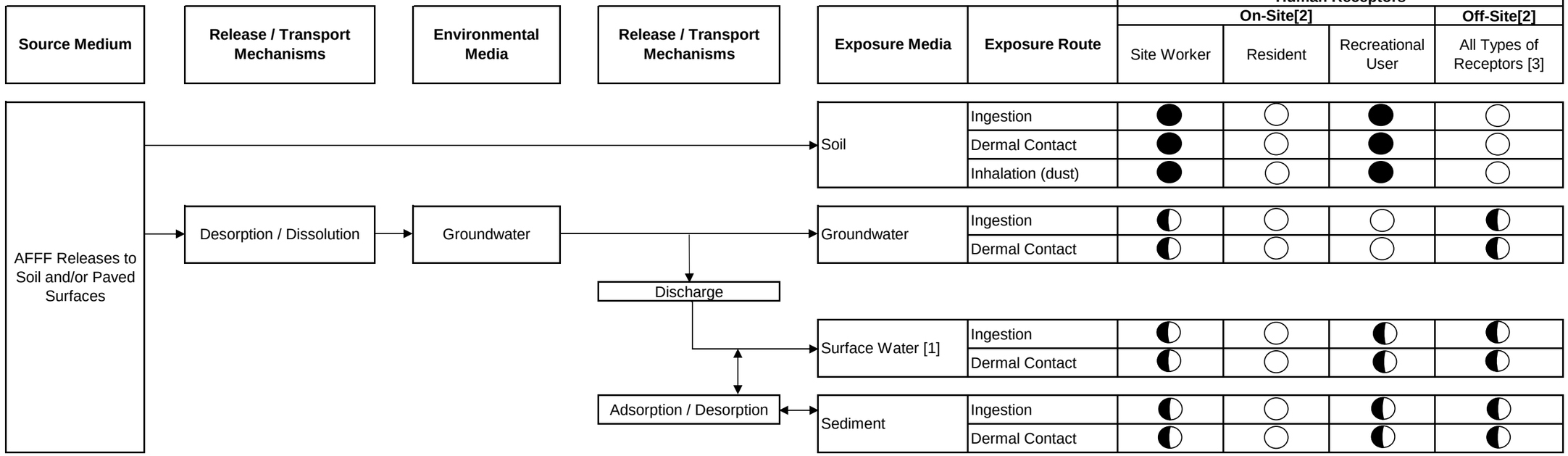
Figure 7-7



Legend:

● = Complete Exposure Pathway

◐ = Potentially Complete Exposure Pathway

○ = Incomplete Exposure Pathway

Notes:
[1] Surface water and sediment pathways for on-site workers and recreational users describe incidental ingestion and dermal contact during outdoor work or recreational activities, respectively.
[2] "Site" refers to the bounds of the AOPI.
[3] All types of off-site receptors include drinking water receptors and recreational users.
AFFF = aqueous film-forming foam
AOPI = area of potential interest
P&E = propellant and explosives

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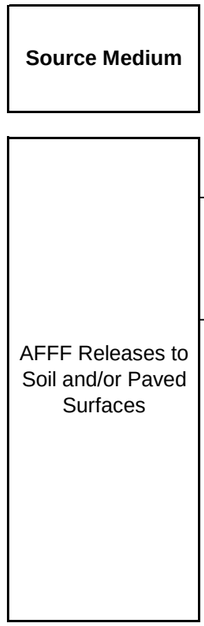
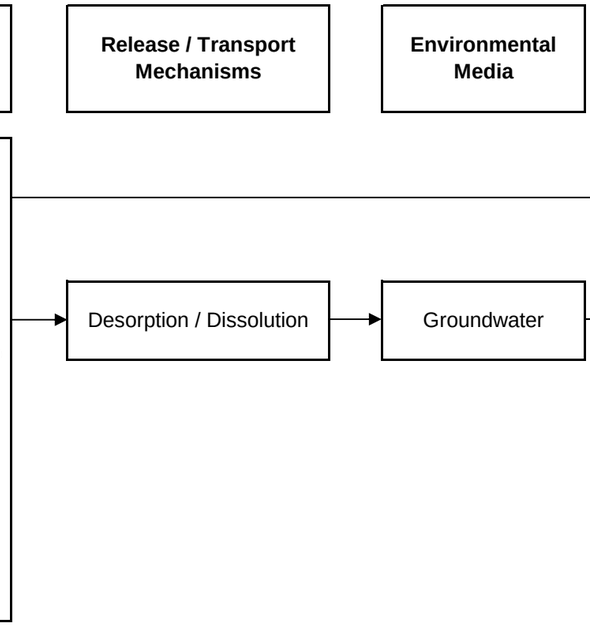
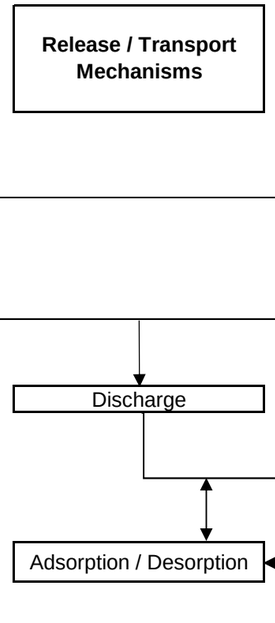
Conceptual Site Model for Building 709-1 P&E Area Fire Station AOPI
USAEC PFAS Preliminary Assessment / Site Inspection
Former Indiana Army Ammunition Plant, Indiana

Figure 7-8







Exposure Media	Exposure Route	Human Receptors: On-Site[2] Site Worker	On-Site[2] Resident	On-Site[2] Recreational User	Off-Site[2] All Types of Receptors [3]
Soil	Ingestion	◐	○	○	○
	Dermal Contact	◐	○	○	○
	Inhalation (dust)	◐	○	○	○
Groundwater	Ingestion	◐	○	○	◐
	Dermal Contact	◐	○	○	◐
Surface Water [1]	Ingestion	◐	○	◐	◐
	Dermal Contact	◐	○	◐	◐
Sediment	Ingestion	◐	○	◐	◐
	Dermal Contact	◐	○	◐	◐

Legend:

◐ = Potentially Complete Exposure Pathway

○ = Incomplete Exposure Pathway

Notes:
[1] Surface water and sediment pathways for on-site workers and recreational users describe incidental ingestion and dermal contact during outdoor work or recreational activities, respectively.
[2] "Site" refers to the bounds of the AOPI.
[3] All types of off-site receptors include drinking water receptors and recreational users.
AFFF = aqueous film-forming foam
AOPI = area of potential interest

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Conceptual Site Model for the Building 2521 - Fire Station for Area 1500 and Fire Training Area at Area 1500 AOPIs
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Former Indiana Army Ammunition Plant, Indiana

Figure 7-9

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