PRELIMINARY ASSESSMENT OF PER- AND POLYFLUOROALKYL SUBSTANCES AT RIVERBANK ARMY AMMUNITION PLANT RIVERBANK, CALIFORNIA

Prepared for:

U.S. ARMY

ODCS, G-9, ISE BRAC

Final

August 2023

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LIST OF ACRONYMS AND ABBREVIATIONS

AFFF	Aqueous Film-Forming Foam
ALCOA	Aluminum Corporation of America
AOPI	Area of Potential Interest
Army	U.S. Army
AST	Aboveground Storage Tank
ATSDR	Agency for Toxic Substances and Disease Registry
BRAC	Base Realignment and Closure
bgs	Below Ground Surface
CA EPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COI	Constituent of Interest
CSM	Conceptual Site Model
DERP	Defense Environmental Restoration Program
DoD	U.S. Department of Defense
DTSC	Department of Toxic Substances Control
E/P	Evaporation/Percolation
EDC	Economic Development Conveyance
EDR	Environmental Data Resources, Inc.
FOSET	Finding of Suitability for Early Transfer
FTA	Fire Training Area
GOCO	Government-Owned/Contractor-Operated
GWTS	Groundwater Treatment System
HA	Health Advisory
Hazmat	Hazardous Materials
HFPO-DA	Hexafluoropropylene Oxide Dimer Acid (aka GenX)
HQ	Hazard Quotient
HRS	Hazard Ranking System
IPaC	Information for Planning and Consultation
IWTP	Industrial Wastewater Treatment Plant
LHA	Lifetime Health Advisory
LUC	Land Use Control
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
NWI	National Wetlands Inventory
OID	Oakland Irrigation District
OSD	Office of the Secretary of Defense
PA	Preliminary Assessment
PAL	Project Action Limit
PFAS	Per- and Polyfluoroalkyl Substances
PFBS	Perfluorobutane Sulfonate
PFHpA	Perfluoroheptanoic Acid
PFHxS	Perfluorohexane Sulfonate
PFNA	Perfluorononanoic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
RBAAP	Riverbank Army Ammunition Plant
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

RI	Remedial Investigation
RLRA	Riverbank Land Redevelopment Authority
ROD	Record of Decision
RSL	Regional Screening Level
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	Site Inspection
SWMU	Solid Waste Management Unit
T&E	Threatened and Endangered
TTLC	Total Threshold Limit Concentration
U.S.C.	United States Code
UCMR3	Third Unregulated Contaminant Monitoring Rule
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WDR	Waste Discharge Requirement
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

The objective of a Preliminary Assessment (PA) is to identify areas of potential interest (AOPIs) based on whether use, storage, or disposal of potential per- and polyfluoroalkyl substances (PFAS)-containing materials, including aqueous film-forming foam (AFFF), occurred in accordance with the 2018 U.S. Army (Army) *Guidance for Addressing Releases of Per- and Polyfluoroalkyl Substances* (U.S. Army 2018a). A PA for PFAS-containing materials with a focus on perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorobutane sulfonate (PFBS), perfluorononanoic acid (PFNA), perfluorohexane sulfonate (PFHxS), and hexafluoropropylene oxide dimer acid (HFPO-DA) and its ammonium salt ("GenX" chemicals) was completed for the Base Realignment and Closure (BRAC) property at the Former Riverbank Army Ammunition Plant (RBAAP) to assess potential PFAS release areas and exposure pathways. The entire former RBAAP, which is in Riverbank, California, was selected for closure under BRAC. The completion of this PA included the execution of the following tasks:

- Conducted a kickoff meeting with the BRAC Office and U.S. Army Corps of Engineers (USACE) on August 18, 2021, to present all parties' preliminary knowledge of the former RBAAP to provide information to guide the PA and site visit.
- Reviewed available records (e.g., aerial photography, historical maps, technical reports, previous studies, investigations) from online sources (i.e., Internet-based searches), environmental investigations and/or regulatory programs (e.g., the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]), and internal Army documents from the Administrative Record. In addition, an Environmental Data Resources, Inc. (EDR) Report was generated for the former RBAAP and included any listed sites within and up to a 2-mile search distance.
- Conducted a 2-day site visit on October 26 and 27, 2021, to identify potential sources of PFAS and gather information for developing conceptual site models (CSMs) at AOPIs.
- Interviewed individuals with historical and present-day knowledge of operations on the BRAC property.
- Identified AOPIs and developed preliminary CSMs for pathways of potential PFAS in soil, groundwater, surface water, and sediment.

In conducting the PA of the BRAC property at the former RBAAP, six AOPIs were identified where a potential for release of PFAS exists resulting from site operational history. AOPIs were identified at potential PFAS-release locations on the BRAC property only.

Based on the potential PFAS releases at the AOPIs, the potential for exposure to PFAS contamination in soil exists. In addition, the potential for off-post exposure in groundwater exists, as on-post groundwater could influence downgradient drinking water sources. Given the findings of this PA, the AOPIs presented warrant further evaluation in a Site Inspection (SI).

1. INTRODUCTION

The Army conducted this Preliminary Assessment (PA) to investigate the potential presence of per-and polyfluoroalkyl substances (PFAS) at the former Riverbank Army Ammunition Plant (RBAAP), Riverbank, California, in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, 42 United States Code [U.S.C.] §9601 et seq.); the Defense Environmental Restoration Program (DERP, 10 U.S.C. §2701 et seq.); the National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 40 Code of Federal Regulations [CFR] Part 300); and guidance documents developed by the U.S. Environmental Protection Agency (USEPA) and the Department of the Army. The former RBAAP is on the National Priorities List (NPL), and the U.S. Army (Army) is responsible for compliance with CERCLA in accordance with Executive Order 12580, as amended.

The purpose of this PFAS PA is to identify locations that are areas of potential interest (AOPIs) on the former RBAAP based on the use, storage, and/or disposal of potential PFAS-containing materials, in accordance with the *Army Guidance for Addressing Releases of Per-and Polyfluoroalkyl Substances* (U.S. Army 2018a). The PA was conducted in general accordance with 40 CFR §300.420(b), the USEPA *Guidance for Performing Preliminary Assessments Under CERCLA* (USEPA 1991), and the Army *Guidance for Addressing Releases of Per- and Polyfluoroalkyl Substances* (U.S. Army 2018a). This report presents findings from research conducted to assess past use of materials containing PFAS and identify areas where these materials were stored, handled, used, or disposed of at the former RBAAP.

The entire former RBAAP property was evaluated, including Army-owned property as well as property that has been previously transferred. RBAAP is located in Riverbank, Stanislaus County, California, as shown in Figure 1-1.

1.1 PFAS BACKGROUND INFORMATION

PFAS are a group of synthetic compounds that have been manufactured and used extensively worldwide since the 1950s for a variety of purposes. PFAS are stable, man-made fluorinated organic chemicals that repel oil, grease, and water. Common industrial uses of PFAS include paints, varnishes, sealants, hydraulic fluid, surfactants, and firefighting foams. PFAS include both per- and polyfluorinated compounds. Perfluorinated compounds, such as perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), perfluorobutanesulfonic acid (PFBS), perfluorononanoic acid (PFNA), perfluorohexane sulfonate (PFHxS), and hexafluoropropylene oxide dimer acid (HFPO-DA or Gen X) are a subset of PFAS with completely fluorinated carbon chains, while polyfluorinated compounds have at least one carbon chain atom that is not fully fluorinated. These six PFAS together, and for the purposes of this PA, are referred to in this report as “Target PFAS.”

RBAAP was evaluated for all potential use, storage, and/or disposal of PFAS-containing materials. A variety of PFAS-containing materials are used in relation to current and historical Army operations. However, the use, storage, and/or disposal of aqueous film-forming foam (AFFF) is the most common potential source of PFAS at U.S. Department of Defense (DoD) facilities. As such, this section is organized to summarize the AFFF-related sources first followed by all of the remaining potential PFAS-containing materials. AFFF is used as a firefighting agent to suppress petroleum hydrocarbon fires and vapors. Firefighting foams like AFFF were developed in the 1960s (ITRC 2020a), but AFFF did not see widespread DoD use until the early 1970s. Older fire training facilities often were unlined and not constructed to prevent infiltration of firefighting foams and combustion products leaching into the subsurface. Large quantities of AFFF may have been released into the environment as a result of fire training exercises, fire responses, fire suppression system activations, and tank and pipeline leaks/spills.

Other potential PFAS sources considered include installation storage warehouses, some pesticide use, automobile maintenance shops, photographic processing facilities, laundry/waterproofing facilities, car washes, stormwater or sanitary sewer components, and biosolid application areas.

Many PFAS are highly soluble in water and have low volatility due to their ionic nature. The specific gravity/relative density for PFOS and PFOA is 1.8 (ITRC 2020c). Long-chain perfluorinated compounds have low vapor pressure and are expected to persist in aquatic environments. These compounds do not readily degrade by most natural processes. They are thermally, chemically, and biologically stable, and are resistant to biodegradation, atmospheric photooxidation, direct photolysis, and hydrolysis. The structure of these compounds increase their resistance to degradation; the carbon-fluorine bond is one of the strongest in nature, and the fluorine atoms shield the carbon backbone.

When PFAS are released to the environment, they can readily migrate into soil, groundwater, surface water, and sediment. Once in the environment, the compounds are persistent and may continue to migrate through airborne transport, surface water, groundwater, and/or biologic uptake. The amount of PFAS entering the environment depends on the type and amount of the PFAS material that may have been released, where and when it was used, the type of soil, and other factors. If private or public wells are located nearby, they potentially could be affected by PFAS. Similarly, surface water features may be impacted and may convey PFAS to downgradient receptors.

Of the thousands of PFAS, some are considered precursor compounds (typically polyfluoroalkyl substances). Precursor compounds can abiotically or biotically transform into PFOS and PFOA. PFOS and PFOA are referred to as terminal PFAS, meaning no further degradation products will form from them (ITRC 2020b).

1.2 PURPOSE AND OBJECTIVES

The purpose of a PA under the NCP is to 1) eliminate from further consideration those sites that pose no threat to public health or the environment; 2) determine if any potential need for removal action exists; 3) set priorities for Site Inspections (SIs); and 4) gather existing data to facilitate evaluation for the release pursuant to the Hazard Ranking System, if warranted (40 CFR §300.420(b)(1)).

The primary objective of the PA is to identify locations at RBAAP where PFAS-containing materials were used, stored, or disposed of, resulting in a potential release of PFAS to the environment, and conduct an initial assessment of possible migration pathways of potential contamination. This PA also includes development of a preliminary conceptual site model (CSM) for AOPIs related to PFAS.

1.3 PFAS REGULATORY OVERVIEW AND SCREENING CRITERIA

In May 2016, USEPA issued lifetime health advisories (LHAs) for PFOA and PFOS under the Safe Drinking Water Act (SDWA). To provide Americans, including the most sensitive populations, with a margin of protection from a lifetime of exposure to PFOS and PFOA in drinking water, USEPA established a health advisory (HA) level for PFOS and PFOA (individually or combined) of 70 ng/L (USEPA 2016).

In October 2019, the Office of the Assistant Secretary of Defense (OSD) issued guidance on investigating PFOS, PFOA, and PFBS at DoD restoration sites. The OSD guidance provided risk screening levels for PFOS, PFOA, and PFBS in groundwater, tap water, and soil, based on the USEPA regional screening level (RSL) calculator for residential and industrial reuse and using the oral reference dose of 2E-05 mg/kg-day. These screening levels are used during an SI to determine if further investigation in a Remedial Investigation (RI) is warranted.

In April 2021, USEPA issued an updated toxicity assessment for PFBS. USEPA developed chronic (0.0003 mg/kg-day) and subchronic (0.001 mg/kg-day) oral reference doses (RfDs) for PFBS as part of USEPA's toxicity assessment. The RSL for PFBS was previously calculated using the RfD of 0.02 mg/kg day. New toxicity values resulted in revisions to the RSLs for PFBS in May 2021 (USEPA 2021a).

In September 2021, OSD issued a revision to *Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program* (DoD 2021). The revised memorandum accounts for the updated PFBS screening levels attributable to USEPA's reassessment of PFBS toxicity in 2021. Based on USEPA research, the RSLs for PFOS and PFOA are calculated using an RfD of 2E-05 mg/kg-day. The RSL for PFBS is calculated using an RfD of 3E-04 mg/kg-day. When multiple PFAS are encountered at a site, a 0.1 factor is applied to the screening level when it is based on noncarcinogenic endpoints.

In May 2022, based on continued evaluation of Target PFAS by the Agency for Toxic Substances and Disease Registry (ATSDR) and the USEPA Office of Water, USEPA provided new screening levels for PFOA, PFOS, PFNA, PFHxS, and HFPO-DA.

In July 2022, OSD issued a policy memorandum adopting these new screening levels to be used during the SI phase to determine whether further investigation in an RI is warranted. The screening levels for Target PFAS are listed in Table 1-1. This revised guidance is in effect as of July 2022 and is applicable to investigating PFOS, PFOA, PFBS, PFNA, PFHxS, and HFPO-DA at DoD restoration sites, including Base Realignment and Closure (BRAC) sites (DoD 2022). Currently, no legally enforceable Federal standards exist for PFAS in groundwater, surface water, soil, or sediment.

Table 1-1. Project Action Limits from the 2022 OSD Memorandum

Chemical	Residential Tap Water HQ = 0.1 (ng/L or ppt)	Residential Soil HQ = 0.1 (µg/kg or ppb)
HFPO-DA (GenX)	6	23
PFBS	601	1,900
PFHxS	39	130
PFNA	6	19
PFOA	6	19
PFOS	4	13

Note: The Residential Tap Water PALs are used to evaluate groundwater and surface water data. The Residential Soil PALs are used to evaluate soil and sediment data.

The Army's strategy is to continue to assess and investigate potential releases and implement necessary response actions in accordance with CERCLA to ensure that no human health-based exposures are above the CERCLA risk-based values in drinking water. Therefore, sites where human exposure to contaminated drinking water exists will be addressed first and as quickly as possible to eliminate the exposure, and then other sites will be subsequently prioritized and sequenced to conduct the investigations and response actions necessary to characterize and, if necessary, remediate the source of PFAS contamination (U.S. Army 2018a).

1.4 PA METHODOLOGY

The PA for RBAAP included a site visit, aerial photographic analysis, records review, and interviews that were conducted in accordance with the methods detailed in the Programmatic PA Work Plan (Leidos 2021). The Programmatic PA Work Plan outlines the approach and methodology for conducting the PFAS PA. As detailed in the Programmatic PA Work Plan, the PA activities focused on ascertaining and documenting the following information regarding PFAS history and use, storage, or disposal at RBAAP:

- On-post fire training activities
- Use of PFAS-based AFFF in fire suppression systems or other systems
- AFFF stored, used, and/or disposed of at buildings and crash sites
- Activities or use of materials that are likely to contain PFAS, such as metal plating operations
- Wastewater treatment plants (WWTPs) and landfills that may have received PFAS-containing materials
- Studies conducted to assess environmental impacts at the facility
- Potential PFAS use at parcels post transfer
- Potential off-post sources that may impact RBAAP

The data gathered during PA activities are summarized in Section 3.

1.5 REPORT ORGANIZATION

The contents of this PA Report are summarized below:

- ***Section 2. Site Background***—This section presents site-specific information related to operational history and discusses the environmental setting. Demographics, land use, topography, geology, hydrogeology, hydrology, groundwater, potable wells, ecological receptors, and climate are described.
- ***Section 3. PA Analysis***—This section provides observations and results from the PA site visit, aerial photographic analysis, records review, and interviews.
- ***Section 4. Summary of PA Data***—This section provides an overview of the data collected during the PA for the different potential PFAS sources.
- ***Section 5. Summary of PA Results***—This section synthesizes all of the data gathered during the PA activities and determines whether each area evaluated during the PA is an AOPI or was not retained as an AOPI.
- ***Section 6. Conclusions***—This section presents conclusions of the PA.
- ***Section 7. References—***This section lists the references that were used in the preparation of this report.
- ***Appendices***—Appendices A through F include data from field activities or related assessments:
  - Appendix A. Final RBAAP Installation Kickoff Meeting Minutes
  - Appendix B. Documents/Sources Reviewed During PA
  - Appendix C. Aerial Photographs
  - Appendix D. Site Visit Photographs
  - Appendix E. Questionnaire Responses and Interview Notes
  - Appendix F. Environmental Data Resources, Inc. (EDR) Report.

2. SITE BACKGROUND

2.1 SITE LOCATION

RBAAP is located at 5300 Claus Road, Riverbank, Stanislaus County, California. It is located 1 mile south of the Stanislaus-San Joaquin County border and approximately 5 miles northeast of the city of Modesto (Figure 1-1). While in operation, RBAAP was approximately 168 total acres and is composed of two non-contiguous tracts of property: the main installation (139.2 acres) and the evaporation/percolation (E/P) ponds (28.8 acres) (U.S. Army 2017a). Townsend Avenue and railroad tracks bound the main installation to the north, Claribel Road bounds the site to the south, and Claus Road borders the main installation to the west. The four E/P ponds are located approximately 1.5 miles to the north of the main installation along the Stanislaus River. Figure 2-1 depicts the RBAAP site features.

2.2 SITE OPERATIONAL HISTORY

The Defense Plant Corporation purchased RBAAP in 1942. Under the authority of the Defense Plant Corporation, Aluminum Corporation of America (ALCOA) constructed the plant as an aluminum reduction plant. The land and plant ownership were transferred to the Army in 1948. The Army purchased the E/P ponds property in 1948.

In 1949, the title was transferred from the Defense Plant Corporation to the Federal Works Administration. The Ordnance Corps decided to convert to the manufacture of steel cartridge cases for joint Army and Navy use in 1951. RBAAP was assigned to the Army on June 1, 1951, and became a Government-Owned/Contractor-Operated (GOCO) industrial installation under the jurisdiction of the Army Joint Munitions Command. Industrial wastewaters, including phosphate, nitrate, sulfate, chloride, zinc, iron, lead, copper, manganese, chromium, nickel, mercury, cyanide, sulfuric acid, and chromic acid, have resulted from these processes (CH2M Hill 2006).

Norris Thermador Corporation (later changed to Norris Industries, Inc. then to NI Industries) was awarded a contract for the conversion and operation of RBAAP on January 30, 1952. Seven production lines were constructed. Lines 1, 2, 3, and 4 produced 105mm cartridge cases. Lines 5 and 6 produced 3-inch/59, 5-inch/38, and 5-inch/54 naval cartridge cases. Line 7 supplied additional 105mm cases. Full production started on September 17, 1952, and continued until May 1954, when the plant was placed on a limited-production schedule. The manufacture of 105mm cartridge cases continued until 1958. Production ceased following the Korean War, and the plant was placed on layaway status until 1963. The General Services Administration attempted to sell the property. The property was removed from the sales market and placed on standby status until 1966.

The facility was reactivated to support requirements for the Vietnam War. The Army Ammunition Procurement and Supply Agency issued Norris Thermador Corporation a contract on June 30, 1966, to provide for reactivation of existing facilities to produce 105mm cartridge cases and the acquisition and installation of necessary facilities to concurrently produce 60mm and 81mm mortar projectiles. Final production of 81mm mortar projectiles was completed in September 1975. Activities at the facility from September 1975 through 1976 were limited to modernization and expansion of Line 1, layaway of idle facilities, limited manufacturing and technology updates, maintenance, and protection of the facility. From 1977 to 1990, only grenade casing and mortar casing production lines were operational. Grenade casing production ceased in June 1990. Production of 5-inch and 105mm artillery casing continued until base closure in 2009.

In 1990, RBAAP was proposed for inclusion on the NPL with a Hazard Ranking System (HRS) score of 63.94 and was officially named to the NPL on February 16, 1990. Subsequently, an Interagency Agreement (Federal Facility Agreement) was signed by the Army, USEPA Region 9, California Environmental Protection Agency (CA EPA) Department of Toxic Substances Control (DTSC), and California Regional

Water Quality Control Board. The Interagency Agreement became effective in June 1990. A Record of Decision (ROD) for site soils and groundwater was finalized in March 1994, and construction of the Groundwater Treatment System (GWTS) expansion was completed in September 1997 (CH2M Hill 2006).

RBAAP was recommended for closure by the 2005 BRAC Commission and was formally closed on March 31, 2010.

2.3 DEMOGRAPHICS, PROPERTY TRANSFER, AND LAND USE

The RBAAP main installation area is bounded by residential areas and farmland. In 2019, the U.S. census reported a population of 24,881 for the city of Riverbank, California (U.S. Census Bureau 2019).

RBAAP is broken into the following six parcels on the main installation (A, B, 1, 1a, 2, and 2a) and Parcel 4 (E/P ponds), as shown in Figure 2-2. On October 17, 2017, Parcel B (24.42 acres) was transferred to the Riverbank Local Redevelopment Authority (RLRA) for use as a new green industry park via a no-cost Economic Development Conveyance (EDC). The remaining acreage on the main installation is leased by RLRA, which then subleases the facilities for manufacturing, light industrial use, storage, and repair facilities (U.S. Army 2020). The Army plans to transfer Parcel A (77.8 acres) and the Northwest Stormwater Reservoir (3.3 acres) via a no-cost EDC to RLRA. The remaining parcels will be put up for sale (U.S. Army 2020).

No land use controls (LUCs) are currently in place for any parcels at RBAAP. A second Explanation of Significant Differences recommending groundwater use restrictions for areas impacted by groundwater contamination, unrelated to PFAS, has been prepared by the Army and is currently in regulatory review.

2.4 TOPOGRAPHY

RBAAP is located between the Stanislaus River and Dry Creek on the northeastern side of the San Joaquin Valley within the Great Valley geomorphic province. Topography of RBAAP is flat, featureless valley land. The ground surface elevation of RBAAP is 135 feet above mean sea level and slopes southwestwardly at a rate of 25 feet per mile (USACE 2013).

2.5 GEOLOGY

RBAAP is located within the San Joaquin Valley, part of the Great Valley Providence, a deep, northwest-southeast trending structural trough. It is bounded on the east by the Sierra Nevada Mountains, which consist of tilted fault blocks of igneous and metamorphic crystalline rock, with a relatively gradual westward slope forming the eastern boundary of the valley. The valley is filled with Cretaceous, Tertiary, and Quaternary aged sediments (Weston 1991).

The sediments underlying the valley floor are part of the Great Valley sequence. The older valley fill deposits were formed under marine conditions, derived from the erosion of the ancestral Sierra Nevada range as it rose in the east. During the Tertiary age, the coastal ranges formed along the western margin of the Great Valley, eventually making it a closed basin. This resulted in increased deposition of sediments along the eastern and western margins. Vast quantities of unconsolidated sediment were deposited under continental conditions as alluvial fans built out into the valley (Weston 1991).

The main installation at RBAAP is located in an area of low alluvial plains and fans less than 2 miles south of the Stanislaus River. The surficial geology at RBAAP consists of unconsolidated Pleistocene non-marine sedimentary deposits, locally referred to as the Riverbank Formation and Aromas Red Sands. They consist of gray to brown and yellow to red cross-bedded sands. These sands also contain minor amounts of clay and silt with some pebbles (CH2M Hill 2008).

The fluvial depositional environment has resulted in the shallow subsurface geology being similar to the surficial geology; however, the fluvial deposits are hundreds of feet of interbedded sands, clays, and gravels, with some clay layers being substantially thick (CH2M Hill 2008).

Geological conditions at the E/P ponds are similar to the main installation, and fluvial deposits are present below the E/P ponds. Industrial wastewater treatment plant (IWTP) effluent discharges into the E/P ponds. Sediment is present in the effluent deposits on the bottom of the E/P ponds and is predominantly composed of silts and clays.

The top of bedrock at RBAAP has not been intercepted with any of the monitoring or production wells around the facility. The California Geological Survey Geologic Map of California published in 2010 (Jennings et al. 2010) identifies the bedrock as “basement crystalline rock units,” and the available bedrock geology maps of the area indicate the bedrock may be 1,000 feet below ground surface (bgs).

2.6 HYDROGEOLOGY

The hydrostratigraphy of RBAAP has been defined through several RI phases and subsequent remedial design phases. The presence of discontinuous fine-grained sediment layers creates a complex groundwater flow pattern in the vicinity of RBAAP. Five zones of relatively coarse-grained sediments, separated by inter-beds of finer-grained material, have been identified at RBAAP (Weston 1991) and confirmed with recent in situ well installations (Ahtna 2015). These stratigraphic zones vary in continuity, thickness, and depth at RBAAP:

- Zone A: Sand and silty sand; ~10 feet thick, extends from ~30 to 40 feet bgs
- Interzone A/A’: Clay and silt, ~25 feet thick, extends from ~40 to 65 feet bgs
- Zone A’: Sand and silty sand with clay lenses, ~20 feet thick, extends from ~65 to 85 feet bgs
- Interzone A’/B: Clayey silt and clayey sand interbedded with the A’-Zone, ~10 feet thick, extends from ~80 to 90 feet bgs
- Zone B: Well-graded and poorly graded sand, ~20 feet thick, extends from ~90 to 110 feet bgs
- Interzone B/C: Clay/silty clay with isolated areas of sandy silt, ~10 feet thick, extends from ~110 to 110 feet bgs
- Zone C: Sand and silty sand with isolated areas of silt and clay, ~25 feet thick, extends from ~120 to 145 feet bgs
- Interzone C/D: Silt and clay, ~50 feet thick, extends from ~145 to 195 feet bgs
- Zone D: Gravel and clayey gravel, >45 feet thick, top of unit ~195 feet bgs.

The shallow and deep aquifer zones were determined to be hydraulically interconnected. The presence of discontinuous fine-grained sediment layers creates a complex flow pattern in the subsurface. Groundwater flows generally toward the southwest. Regionally, the groundwater table is lowering, and the Zone A aquifer is essentially dry. Only the lower portion of Zone A becomes saturated during the late fall and winter (CH2M Hill 2008).

2.7 SURFACE WATER HYDROLOGY

RBAAP is located within the San Joaquin River watershed, specifically within the North Stanislaus minor subarea of the East Valley Floor Subarea of the Lower San Joaquin River Watershed. RBAAP has minimal relief and slopes downward gently approximately 20 feet per mile toward the southwest. The surface water features present at RBAAP are shown in Figure 2-1.

2.8 WATER USAGE

Stormwater runoff at the Main Production Area is diverted to a drainage system that collects water into two large evaporatory storm reservoirs; the Southeast Stormwater Reservoir and the Northwest Stormwater Reservoir. The Southeast Stormwater Reservoir, with a capacity of approximately 400,000 gallons, receives runoff from the southeastern part of the main installation (southern portion of Parcel A), and the collected stormwater is then pumped to the Northwest Stormwater Reservoir. The Northwest Stormwater Reservoir has a capacity of 2.5 million gallons and receives stormwater runoff from most of the main installation as well as from the Southeast Stormwater Reservoir. The storm system could hold a 24-hour rainfall event of approximately 1.78 inches. If the main stormwater reservoir exceeds the maximum capacity, the excess rainwater would flow into the Oakland Irrigation District (OID) canal. While flooding events have occurred in the past after heavy rainfall, the probability of a 24-hour rainfall event at 2.00 inches is low (USACE 2009).

RBAAP operates a non-transient, non-community water system that provides potable water for the facilities at the main installation. Once a total of six wells, the Army has abandoned wells 02, 03, and 04. The primary water is obtained from two wells (Production Wells 05 and 06) located on the plant property. Production well 01 is held in reserve. The production wells can cumulatively produce 2,600 gallons per minute (USACE 2009).

Well records indicate that production well 01 draws water from 158 to 170 feet bgs. Production wells 05 and 06 were installed with several intervals of perforated casing and can draw from multiple depths from 104 to 677 feet bgs (production well 05) or 120 to 600 feet bgs (production well 06). The system operates under a State of California Domestic Water Supply Permit and is treated at the wellheads by gas chlorination. Production well 01 was placed on standby in 2005 and is available for emergency use only. Production well 01 lies within the designated Environmental Condition of Property Category 5 area of the property, where release, disposal, and/or migration of hazardous substances has occurred but remediation is incomplete. Production wells 05 and 06 are located in the southern portion of RBAAP in an area designated as Category 3 in the Environmental Condition of Property Phase I Report; groundwater contamination was present but has been below the cleanup standards in this area. Contamination in Zone C or deeper has not been previously detected in this area (Figure 2-1).

The city of Riverbank provides water within the city limits of Riverbank and the immediately surrounding areas to the east, north, and west of RBAAP. Riverbank's water is sourced entirely from nine active and one inactive production wells (Kjeldsen, Sinnock & Neudeck, Inc. 2021). The city of Modesto provides water within the city limits of Modesto and the immediately surrounding area to the south of RBAAP. Modesto uses both surface water from the Tuolumne River and 75 groundwater wells as sources for its water supply. The Tuolumne River is located more than 6 miles to the south of RBAAP. Water demands in the outlying service area of Modesto are met entirely by groundwater, while areas within the city limits are met with a combination of surface water and groundwater (West Yost 2021). In 1992, the Army completed a response action to protect residents from potential exposure to groundwater contaminated with chromium and cyanide migrating downgradient from RBAAP to the west (USAEC 1994). The response action included extending the city of Riverbank's public water supply system into the residential areas west of Riverbank. In addition, the Army drilled deeper wells for a small number of residents that still wanted to use wells for irrigation purposes (U.S. Army 2006).

An EDR report generated in 2021 for RBAAP was reviewed to obtain off-post well information. The EDR report identified 109 well records located within 1 mile of the main installation of RBAAP, which includes monitoring, residential, and commercial wells. Data in the EDR report were verified using the California Department of Water Resources database of well completion reports (CA DWR 2001). The Department of Water Resources database was also used to include a 1-mile radius around the E/P ponds, bringing the total number of permitted wells retrieved between both resources to 200 wells. Figure 2-3 displays the locations of water supply well information within a 1-mile radius of RBAAP (excluding monitoring and remediation wells) and includes agricultural, domestic, unknown, and public water supply wells. A review of Department of Water Resources records between a 1- and 4-mile radius of RBAAP identified 792 additional wells. These wells are not shown in Figure 2-3 because the records provided by the Department of Water Resources includes only centroid coordinates for the Public Land Survey System where the wells are located, increasing the uncertainty of well locations and status. In ongoing efforts to meet concerns raised by the regulators during the Five-Year Review process, the Army conducted a Well Survey Public Outreach in 2021. Preliminary results of the well survey, conducted over a ¼ mile downgradient buffer of the 50 µg/L dissolved chromium plume at RBAAP, identified 54 well records to be surveyed. The survey included the use of a mailed questionnaire and door-to-door reconnaissance. The survey confirmed that eight properties within the search area had a well for domestic use or were suspected of having a domestic use well. Ten properties contained inactive wells or wells used for irrigation purposes only. Eleven additional properties contained a well; however, the use could not be determined. The remaining well records were either determined to be located outside the buffer area or no information could be obtained (Ahtna 2022).

2.9 ECOLOGICAL PROFILE

RBAAP is approximately 168 total acres and is composed of two noncontiguous properties: the main installation (139.2 acres) and the E/P ponds (28.8 acres). Most of the main installation area is developed, and the ground has either been paved or is covered by other hardscape and structures. Most of the E/P area is undeveloped and has open field or crushed gravel. What little vegetation occurs in the developed areas of RBAAP is characterized by nonnative species that provide little habitat value to wildlife species. Areas that have not been developed are characterized by five vegetation types: ruderal grassland, irrigated pasture, emergent marsh, riparian woodland, and wetlands. The grassland is predominantly along the southern periphery of the main installation in the area that was a former parking lot and is dominated by nonnative plant species, including yellow starthistle (*Centaurea solstitialis*), wild oat (*Avena fatua*), soft chess (*Bromus hordeaceus*), and dove weed (*Eremocarpus setigerus*). Irrigated pastures occur in areas on the main installation that were formerly annual grassland but have been irrigated to provide year-round forage for livestock. Common plant species found in irrigated pastures include Dallis grass (*Paspalum dilatum*), bird's-foot trefoil (*Lotus corniculatus*), curly dock (*Rumex crispus*), and a few sedge species (*Carex* sp.). Emergent marshes on the main installation property occur within a stormwater ditch located in the southeastern portion of the site and in water detention basins located in the northwestern portion of the site. Emergent marshes are dominated by plant species that are adapted to inundation or saturation year round, including cattails (*Typha latifolia*) and arrowhead (*Sagittaria cuneata*).

The E/P ponds were constructed along the banks of the Stanislaus River. Mature riparian woodland forest remains along the bank and typically consists of tall, dense, deciduous broadleaf trees, including Fremont cottonwood (*Populus fremontii*), California box elder (*Acer negundo* ssp. *californicum*), black willow (*Salix gooddingi*i), western sycamore (*Planatus racemosa*), and valley oak (*Quercus lobata*). The National Wetlands Inventory (NWI) mapping indicates the wetlands along the bank of the Stanislaus River in the E/P ponds area is an approximately 18-acre freshwater forested/scrub wetland complex (NWI 2023). Based on the 1970s imagery, wetlands present in the main installation are limited to the ditches to the north, south, and east (NWI 2023). The NWI mapping describes these ditches as semipermanently flooded, manmade, riverine wetlands. Although the reservoirs are not depicted as wetlands on the NWI mapping, the Southeast and Northwest Stormwater Reservoirs contain water or are moist most of the rainy season (U.S. Army 2018b).

The developed areas at RBAAP provide little habitat value to most wildlife species; wildlife on the property is typically composed of common species that are adapted to residential or urban settings. Wildlife that may be present in the ruderal grassland, irrigated pastures, and emergent marsh in the main installation include species such as deer mouse (*Peromyscus maniculatus*), black-tailed jackrabbit (*Lepus californicus*), mourning dove (*Zenaida macroura*), killdeer (*Charadrius vociferus*), red-tailed hawk (*Buteo jamaicensis*), red-winged blackbird (*Agelaius phoeniceus*), great blue heron (*Ardea herodias*), bullfrog (*Rana catesbeiana*), western fence lizard (*Sceloporus occidentalis*), and gopher snake (*Pituophis catenifer*)

(USACE 2009). Wildlife that may be present in the riparian forests of the E/P ponds area include mammalian species such as Western harvest mouse (*Reithrodontomys megalotis*), California vole (*Microtus californicus*), Virginia opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and mule deer (*Odocoileus hemionus*), as well as various species of raptors, songbirds, and waterfowl (USACE 2009).

The U.S. Fish and Wildlife Service (USFWS) Environmental Conservation Online System Information for Planning and Consultation (IPaC) tool identified four federally listed threatened and endangered (T&E) species as potentially occurring (i.e., known or expected to be on or near) at RBAAP (USFWS 2023). The federally listed T&E species included the threatened California tiger salamander (*Ambysoma californiense*), threatened valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), threatened vernal pool fairy shrimp (*Branchinecta lynchi*), and endangered vernal pool tadpole shrimp (*Lepidurus packardi*). One candidate species, the monarch butterfly (*Danaus plexippus*), was identified by IPaC as potentially occurring at RBAAP (USFWS 2023). The potential for these T&E and candidate species to occur does not mean the species are present at RBAAP. For example, there is no suitable habitat (vernal pools, ephemeral stock ponds, small ponds, lakes or vernal pools in grassland and oak woodlands for larvae) for the California tiger salamander, vernal pool fairy shrimp, or vernal pool tadpole shrimp, and these species are unlikely to occur at RBAAP. The Valley elderberry longhorn beetle requires riparian and oak savanna habitats with elderberry shrubs. The beetle may be present in the elderberry shrubs surrounding the wastewater ponds (USACE 2009).

Ten migratory birds of particular concern are identified by the IPaC tool as potentially occurring on RBAAP. These birds include species such as the bald eagle (*Haliaeetus leucocephalus*), Bullock's oriole (*Icterus bullockii*), Nuttall's woodpecker (*Picoides nuttallii*), and yellow-billed magpie (*Pica nuttalli*) (USFWS 2023).

2.10 CLIMATE

The average temperature at RBAAP is 61.7°F, which is slightly higher than the California average temperature of 61.2°F and the national average temperature of 54.5°F. The annual rainfall amount is 14.60 inches, with 34.03 days of 0.1 inches or more of precipitation. The annual snowfall amount is 0.00 inches, with 0.00 days of 1 inch or more of snow. Average wind speed for the area is 16.33 miles per hour (USA.com 2021).

3. PA ANALYSIS

The primary components of the PA are records reviews, analysis of aerial photographs, a site visit, and interviews. The following sections summarize the methods used and activities conducted for the RBAAP PA. The reference to "on-post" refers to property that has been or still is owned by the Army. Any references to "off-post" refers to areas that have never been owned by the Army.

3.1 RECORDS REVIEW

Prior to the records review, site visit, and interviews, a kickoff meeting was held between BRAC Environmental Program, the U.S. Army Corps of Engineers (USACE), and Leidos on August 18, 2021. The purpose of the kickoff meeting was to present all parties' preliminary knowledge of RBAAP to inform the PA and site visit. The final kickoff meeting minutes are presented in Appendix A.

Preliminary research was conducted prior to the site visit to determine the potential for use, storage, or disposal of PFAS-containing materials, including if any of the following activities were conducted at RBAAP:

- On-post fire training
- Use of PFAS-based AFFF in fire suppression systems or other systems
- AFFF used, stored, or disposed of at buildings and emergency response sites
- Activities or materials used that are likely to include PFAS-containing materials
- Studies conducted to assess the environmental impacts of PFAS-containing materials
- Review of potential off-post sources.

The records review included a combination of internet-based searches and reviews of aerial photography, historical maps, technical reports, previous studies, and investigations available online. In addition, an EDR search of state and Federal environmental databases for RBAAP and any listed sites within a 1-mile search distance was conducted (EDR 2021).

A search was conducted of the California Water Board Geotracker website (https://geotracker.waterboards.ca.gov), which provides digital copies of cleanup action reports, regulatory activities, environmental data, maps, and other documents. The records review also evaluated available environmental investigations conducted under CERCLA and Resource Conservation and Recovery Act (RCRA) regulatory programs. Additional documents were discovered in the Administrative Record managed by RLRA, which included hard copies of installation maps, photographs, inspection reports, and regulatory correspondence. Table 3-1 lists the documents reviewed that are relevant to the evaluation of AOPIs in this PA. A complete list of documents reviewed is included in Appendix B.

Table 3-1. Summary of Relevant Records Reviewed

Document Title	Author	Date	Relevance
Riverbank Army Ammunition Plant Riverbank, California RCRA Facility Assessment Preliminary Review Report	PRC Environmental Management, Inc.	October 1990	Information on AOPIs Background Information
Remedial Investigation Reports Riverbank Army Ammunition Plant	Roy F. Weston, Inc.	July 1991	Information for AOPIs History and Summary of RBAAP
RCRA Facility Investigation Current Conditions Report	CH2M Hill	October 2002	Information on AOPIs
US Army BRAC 2005 Environmental Condition of Property Phase I Report Riverbank Army Ammunition Plant	CH2M Hill	November 2006	Information for AOPIs

Table 3-1. Summary of Relevant Records Reviewed (Continued)

Document Title	Author	Date	Relevance
Second Five Year Review Report at Riverbank Army Ammunition Plant– Final	Department of the Army	September 2006	Information for AOPIs Background Information
Final Site Investigation Report – Riverbank Army Ammunition Plant	CH2M Hill	March 2008	Information for AOPIs History and Summary of RBAAP
Environmental Assessment for BRAC 05 Disposal and Reuse of the Riverbank AAP, CA	USACE – Mobile District	March 2009	Physical setting (topography, geology, surface hydrology)
Third Five Year Review Report Riverbank Army Ammunition Plant	USACE – Sacramento District	July 2011	Information for AOPIs Background Information
Draft Final EDC Property and Sale Parcels 2 and 2A – Soil Investigation Report, Riverbank Army Ammunition Plant, Riverbank, CA	USACE – Sacramento District	June 2013	Land parcels, LUCs, deed restrictions
Closure Certification Report HWMU #4 Chromium Reduction Unit – Continuous Process, Riverbank Army Ammunition Plant	USACE – Sacramento District	January 2016	Identification of areas where chromium plating process wastes were treated/stored
Closure Certification Report HWMU #3 Chromium Reduction Unit – Continuous Process, Riverbank Army Ammunition Plant	USACE – Sacramento District	January 2016	Identification of areas where chromium plating process wastes were treated/stored
Update of the Environmental Condition of Property Phase I Report	U.S. Army	March 2017	Background information and facility updates on restoration site status
Finding of Suitability for Early Transfer (FOSET) Riverbank Army Ammunition Plant Parcel A, Northwest Stormwater Reservoir and Parcel 2A	U.S. Army	December 2019	Land parcels, LUCs, deed restrictions
Riverbank Army Ammunition Plant, CA Conveyance Report	Headquarters, Department of the Army	October 2020	Land parcels, LUCs, deed restrictions
Endangered Species, Find Endangered Species	USFWS	Accessed December 23, 2021	Ecological profile information
Stanislaus County, California Weather	USA.com	Accessed December 23, 2021	Climate information
City of Riverbank, Stanislaus County, California Census Data	U.S. Census Bureau	Accessed December 23, 2021	Demographics information

Information gathered during the records reviews helped identify data gaps and enabled elimination of several areas based on their historical use. Data gaps associated with facility operations; PFAS-containing material use, storage, or disposal; and current exposure receptors at RBAAP contributed to a conservative approach for identifying AOPIs. However, areas with little potential to result in a PFAS release, such as residential buildings, hospitals, cafeterias, and recreational areas, were eliminated from further evaluation early in the PA process.

Areas identified to have potentially used, stored or disposed of, or had recorded the potential for a release of PFAS-containing materials, including AFFF, were further evaluated.

3.2 AERIAL PHOTOGRAPHIC ANALYSIS

The PA included review of 32 historical aerial photographs spanning from 1937 to 2021, as presented in the EDR 2021 report, historicaerials.com, and Google Earth. The aerial photographs were analyzed to identify potential activities or developments that may suggest the potential use, storage, or disposal of PFAS-containing materials, including AFFF (e.g., evidence of fire training activities, such as fire pits or burn scars). Analysis of the historical aerial photographs did not identify evidence of fire training activities at RBAAP. Aerial photographs are included in Appendix C. The aerial photographic analysis is summarized as follows:

- 1937 – The 1937 aerial photograph shows the RBAAP property as agricultural. Roads, farm fields, and the aqueduct are shown on the aerial photograph. The only structures observed on the aerial photograph appear to be barns and a residence in the southwestern corner of the property. The 1937 aerial photograph shows the presence of a stream channel trending southwest to northeast across the southern section of the facility.
- 1950 – The production area of the facility has been constructed as well as Buildings 9 and 10. The construction of the production area has covered the stream channel. In the northern portion of the facility, the Northwest Stormwater Reservoir has been constructed with disturbed ground adjacent to the reservoir. RBAAP has on-post sanitary sewage; three of the sewage beds have been constructed in this photograph. Railroad tracks have been built going into the facility. The main line splits into three spurs once on the property: central, western, and eastern sides. The eastern spur splits again into six lines. The IWTP is not present; however, the land is cleared and one aboveground storage tank (AST) is located on the eastern side. Land use around the facility continues to be primarily agricultural.
- 1957 – Many buildings have been constructed, including Buildings 120, 121, and 122. Building 122 houses the center railroad spur. Clearing of the land is visible at the North and South Landfill areas. Two ASTs have been constructed northeast of Building 122, and one AST has been constructed on the southeastern corner of the property. Sets of horizontal ASTs are visible north of Building 122. Land use surrounding the facility continues to be agricultural.
- 1963 – The ground surface at the North and South Landfills continues to be disturbed. Land use surrounding the facility continues to be primarily agricultural.
- 1972 – This photograph is low-quality black and white. Five sewage beds are visible in the north-central section of the property. Structures within the IWTP have been constructed. A rectangular feature is north of the horizontal ASTs.
- 1976 – This photograph is low-quality black and white. Many new features are present in the IWTP area. When comparing the aerial photograph to the site features map, it appears the IWTP is fully constructed. Several residences have been added along the western side of the facility, but the primary land use continues to be agricultural.
- 1985 – The sewage beds and Northwest Stormwater Reservoir appear to be dry. A dark-colored feature similar to saturated surface soils is present at the southwestern corner of the property.
- 1993 – The rectangular feature first observed on the 1972 photograph is now a building. A new building (Building 181) has been constructed in the southeast. The sewage beds continue to look dry. Significant residential construction has occurred off-post, adjacent to the northwestern corner of the facility.
- 2002 – The northern parking lot is now being used for recreational vehicle storage. Excavating activities are occurring at the fifth sewage bed. Treatment and holding tanks are still visible in the IWTP. A gravel or dirt-covered road has been built trending west to east across the south of the facility. The eastern portion of the road connects to a small building to the south of the AST.

- 2006 – A small building has been built north of the landfill with automobile tracks circling it. The building north of the ASTs has been expanded.
- 2009 – The driving area and building on the northeastern corner are no longer present. A dark feature present at the location may represent excavation, demolition, or burning.
- 2010 to 2016 – No significant observations were made.
- 2016 – The most significant observation is the removal of the IWTP structures, except for two small buildings. Along the southern side of the property, dark images are present that appear to be unknown stockpiled material. The area appears to be saturated, and excavation activities are also occurring in this area.
- 2017 – The stockpiled material is still present, and the aerial photograph shows the presence of trucks driving around the stockpile area.
- 2019 – The stockpiled material has been removed in the south. The area continues to be bare ground, and the road has been removed.
- 2021 – The ground surface in the south is still bare, with no vegetation. The road that traversed the southern side is visible again, trending toward the structure in the southeast.

3.3 PA SITE VISIT

The RBAAP site visit was conducted on October 26 and 27, 2001. The site visit was conducted on foot and included visual inspection of all readily accessible areas at RBAAP to identify potential sources of PFAS and gather information for developing CSMs at AOPIs. In addition, access routes were assessed in consideration for SI sampling at AOPIs. Appendix D contains photographs from the PA site visit.

Prior to the site visit, the PA team corresponded with RLRA to request historical documents, site knowledge, and information for potential interviewees. RLRA provided access to available site records and security escorts.

3.4 SUMMARY OF INTERVIEWS

Prior to the site visit, the PA team developed and distributed a PFAS PA Questionnaire for gathering information related to PFAS usage at RBAAP from key personnel. Two individuals responded to the questionnaire; the questionnaire responses are presented in Appendix E. The primary goal of the questionnaire was to identify whether PFAS-containing materials and AFFF were used on-post, where they were used, how much was used, how much remains, and whether any releases may have occurred.

As part of this PA, interviews were conducted with employees of San Joaquin Engineering Solutions and former employees of NI Industries. Table 3-2 summarizes the interview conducted and relevant information of PFAS usage.

Table 3-2. Interviews Conducted for PA

Title	Date	Information Provided
San Joaquin Engineering Solutions, Maintenance Supervisor (2010 to present) NI Industries, IWTP Operator, Hazmat, RCRA Inspections (1983 to 2010)	October 27, 2021	Individual confirmed that AFFF was not stored or used at the facility. Two fires occurred during his employment, which were extinguished with water. Metal plating activities were performed in Line 1 and stopped around 1992. Metal plating activities began in Line 6 during the 2000s. All wastewater from the industrial processes at the facility were treated at the IWTP. Sludge from plating activities were drummed and sent for disposal at an off-post disposal facility.

Table 3-2. Interviews Conducted for PA (Continued)

Title	Date	Information Provided
San Joaquin Engineering Solutions, Operations Manager (2011 to present)	October 26, 2021	Individual confirmed that either the Riverbank Fire Department or Stanislaus Consolidated Fire Protection Services responded to fire calls if needed. AFFF has not been stored or used at the facility during his employment.
NI Industries, Fire Department Captain (1978 to 2010)	November 4, 2021	Individual confirmed AFFF was not stored or used by the facility fire department. On-post fire training exercises were limited to the use of hand-held fire extinguishers. All firefighting systems were water based, and water was supplied by the water wells at the facility.
NI Industries, Security and Emergency Response Supervisor, Production Quality Control (1967 to 2010)	November 5, 2021	Individual confirmed that AFFF was not stored or used at the facility. Metal plating and electrostatic painting was conducted at the facility. Chromic acid was used for washing of shell casings during the electrostatic painting process.

The information obtained from interviews and questionnaires confirmed that AFFF was not stored or used at the facility. Fire training exercises were limited to hand-held fire extinguishers. Metal plating and electrostatic painting, which involved chromic acid washes, was conducted in the main production area of RBAAP. Based on the dates of the metal plating operations, PFAS containing mist suppressants may have been used; however, none of the individuals interviewed could recall if such suppressants were part of the processes at RBAAP.

4. SUMMARY OF PA DATA

4.1 PREVIOUS PFAS INVESTIGATIONS

In 2012, USEPA published the Third Unregulated Contaminant Monitoring Rule (UCMR3), which required nationwide public water systems to sample for a list of 30 unregulated contaminants, including 6 chemicals of concern relevant to this PA (i.e., PFOS, PFOA, PFBS, PFNA, perfluoroheptanoic acid [PFHpA], and PFHxS). The city of Riverbank participated in the UCMR3 evaluation by sampling the six PFAS from 2013 to 2014; the PFAS were not detected (USEPA 2021b).

In October 2017, the Army collected an on-post drinking water sample at RBAAP and analyzed it for PFOS, PFOA, PFBS, PFNA, PFHpA, and PFHxS. No PFAS were detected in the RBAAP drinking water source sample (U.S. Army 2017b).

4.2 EVALUATED SITES

During the PA records reviews, interviews, aerial photographic analysis, and site reconnaissance, available documentation and physical evidence were examined for areas having a potential historical PFAS release. The sites evaluated include fire stations; fire training areas (FTAs); landfills; plating operations; WWTPs; pesticide facilities; vehicle maintenance shops, which used car washes and engine lubricants; paint shops; and photographic processing facilities, as shown in Figure 4-1 and described in the following sections.

4.2.1 AFFF Use, Storage, and Disposal

Documentation specifying the use of AFFF at RBAAP was not identified during the records reviews, interviews, aerial photographic analysis, nor site visit conducted as part of this PA. Two fire stations were operated at RBAAP. Building 10C was used as a fire station until approximately 1975. After 1975 and until plant closure, the fire station was located in Building 172. The on-post fire department would respond first to emergencies and contact the city of Riverbank fire department if needed. Based on interviews with RBAAP personnel, AFFF was not used or stored at RBAAP.

Fire training exercises were conducted at various places on the facility; however, training included only the use of dry chemical and carbon dioxide type fire extinguishers. AFFF was not used during training.

4.2.2 Metal Plating Operations

Metal plating operations were conducted at RBAAP with production activities including electroplating, cleaning, and metal finishing processes that generated wastewater potentially containing PFAS used as mist suppressants in the production line. Manufacturing Lines 1 and 6 contained metal plating operations involving both zinc and chromium plating. Prior to 1978, hexavalent chromium wastes from the zinc chromate solution on the production lines did not receive pretreatment prior to conveyance to the IWTP. In 1978, chromium reduction units were installed at Buildings 180 (solid waste management unit [SWMU] 6 adjacent to Building/Line 1) and Building 13 (SWMU 5 near Building/Line 6). Each unit consisted of a 1,200-gallon stainless steel tank. Sodium metabisulfide was added to chromic acid solution to reduce its chromium to a trivalent state in batch process. No evidence was found that any releases occurred from these units (CH2M Hill 2002). The wastewater was then piped to the IWTP for further treatment.

In May 1990, an industrial waste pipe leak (SWMU 24) in the chrome waste line between Building 13 and the main production area of Building/Line 6 was discovered. This pipe received overflow, process, and cleaning fluids from the batch chromium treatment system and zinc phosphate dip tank in the southeastern corner of Building 13 to the IWTP. The soil in the area was excavated to repair the break and then sampled to determine if residual contamination existed as a result of the leak. Sample results indicated that elevated levels of inorganics did not exist in this area. Therefore, no known contamination exists at the location of the industrial waste pipe leak, and no further action was pursued (CH2M Hill 2006).

Information collected during personnel interviews indicated Manufacturing Line 1, included plating operations, was shut down in 1992. Closure plan actions of the batch process reduction unit at Building 180 (HWMU #3) were initiated in 2012 and completed in 2015. Activities include demolition of the tank and secondary containment structure. One soil boring was advanced and soil samples were collected at 5-foot increments from the ground surface to the top of first groundwater (approximately 65 feet bgs). Zinc and total chromium concentrations of deeper (>15 feet bgs) samples were below soil screening (Ahtna 2016a).

According to the RCRA permit, a 1,000-gallon polyethylene continuous process chromium reduction unit was located within the Building/Line 6 plating operation until it was removed in 2010. The tank location and Line 6 operation were surrounded by two trench systems. Each trench was 2 feet wide, 2 feet deep, and lead to 4-foot-deep sumps on the northern side of the Line 6 plating operation. Both trenches were reportedly used for handling of the process water to the IWTP. Closure plan actions, including demolition and excavation of the trenches at Building 6 (HWMU #4), were initiated in 2012 and completed in 2015. Soil samples collected at 5-foot increments from the ground surface to the top of first groundwater (approximately 65 feet bgs) were below background levels for zinc and total chromium (Ahtna 2016b).

4.2.3 Wastewater Treatment Plants

The sanitary sewer system at RBAAP included five settling ponds located in the north-central area of the facility. The settling ponds received sanitary wastewater from the on-post sewage treatment plant and were composed of backfilled sand. The on-post sanitary sewage system was in operation from 1944 to 1980 when RBAAP was connected to the city of Riverbank sewage system.

The IWTP treated industrial wastewater generated at the facility from electroplating, cleaning, and metal finishing processes. The IWTP was located north of the main installation (Figure 4-1). The IWTP was a system of tanks, sumps, filters, pipes, and other related equipment. It was designed to treat facility wastewater and included equipment for coagulation, flocculation, clarification, sludge thickening, and sludge/liquid separation. The treated effluent water was discharged via underground pipe primarily to the E/P ponds. Limited amounts of effluent from RBAAP's IWTP were discharged to the OID canal under Waste Discharge Requirement (WDR) permits issued in 1994, until updated WDR permits in 2001 no longer permitted OID discharge of IWTP effluent (USACE 2009). Construction of the IWTP began in 1951, and configuration has remained nearly unchanged since the start up in 1952 until 1972. Zinc-cyanide solution tanks were added in 1952 to treat the wastewater produced from the zinc plating of the naval shells produced on Manufacturing Line 6 in 1955 and continued to be used until 1958 (CH2M Hill 2002). From 1973 to 1980, the IWTP was upgraded. The IWTP is identified as SWMU 1 and operated under a RCRA Part B Permit 05-SAC-06. The IWTP was decommissioned in 2013 (U.S. Army 2017a).

Previous investigations determined the use of redwood ASTs in the IWTP were a significant source of hexavalent chromium contamination (CH2M Hill 2008). When the redwood ASTs were not in use, the wood dried out and shrank, allowing gaps in the walls to form. When the tanks were refilled, waste would leak out of these gaps until the wood rehydrated and expanded. These tanks were demolished and replaced with concrete tanks in 1980. The IWTP also included a network of underground piping and surface ditches that transported wastes to the IWTP. Conditions beneath these pipes and ditches may have also contributed to hexavalent chromium contamination.

The E/P ponds were constructed in 1952 for the disposal of treated effluent generated by the RBAAP IWTP. The four unlined ponds are located approximately 1.5 miles north of the main installation along the Stanislaus River. The treated water from the IWTP was discharged through a force main into a 21-inch-diameter clay pipe. The effluent was then distributed to the four ponds. The ponds operated independently; once the first pond was full, the flow was diverted to the second pond and so forth. The effluent discharged to the ponds evaporated and/or percolated through the sediment into the groundwater (CH2M Hill 2002). The E/P ponds are referred to as SWMU 23. In 1993, a removal action was completed to address zinc-contaminated soil. The ROD documented the removal action and concluded no further action was required at the ponds (USAEC 1994).

In 1972, a break occurred in the effluent sewer line that conveyed treated water to the E/P ponds, referred to as SWMU 12 the IWTP Sewer Line Break Area (Effluent Force Main) (CH2M Hill 2002). The break was discovered approximately 7 days after the line ruptured in the northeastern corner of the property near the Hetch-Hetchy Aqueduct (Figure 2-1). It is unknown how much liquid was lost through the leak; however, during that period, the IWTP was processing approximately 1,000,000 gallons per day. Soil samples at the location were analyzed for inorganic substances listed in Title 22, Article 11 Section 66699 (in effect in 1990). Groundwater samples collected from monitoring wells in the area were analyzed for total chromium, free and total cyanide, Target Analyte List metals, phosphate, nitrate, and hexavalent chromium. During the RI conducted in 1990 and 1991, the soil sample results were compared to background soil analytical results. It was determined that none of the results exceeded the Total Threshold Limit Concentration (TTLC) levels, and only zinc and thallium were detected above the TTLC but not more than three times; therefore, the soil was not considered to be contaminated (Weston 1991). Remedial action at SWMU 12 was not necessary, as determined in the ROD (USAEC 1994).

The Northwest Stormwater Reservoir and Southeast Stormwater Reservoir are shown in Figure 2-1. The Southeast Stormwater Reservoir receives stormwater and surface water runoff from the southeastern section of the facility. Collected stormwater is then pumped to the Northwest Stormwater Reservoir. The Northwest Stormwater Reservoir receives stormwater from most of the installation and is the discharge point for excess runoff from the Southeast Stormwater Reservoir. During Phase I of the RI, elevated concentrations of chromium were detected in sediment in the Northwest Stormwater Reservoir; however, the reservoir was not considered a source of groundwater contamination, In 1993, it was discovered that a cross-connection between the industrial sewer system and the stormwater sewer system was present in an in-line cistern leading to the Northwest Stormwater Reservoir. The cistern was pumped out and cleaned with a soap solution. No further action was required at the Northwest Stormwater Reservoir (2006a). In 2004, approximately 15 yd^3 were excavated from the Southeast Stormwater Reservoir and disposed of off-post to address PCB contamination in soil.

4.2.4 Landfills

Two landfill areas were present on the RBAAP facility. The area identified as the South Landfill was used from 1941 through 1952. Wastes were placed in trenches, and the trenches were filled with demolition debris, general refuse, and possible cyanide wastes. When the Army converted the plant to a cartridge and projectile manufacturing operation in 1952, the South Landfill closed and the Army constructed and operated the North Landfill. The Army used the North Landfill from 1952 through 1966. Historical documentation indicates the landfill consisted of eight pits. Typical wastes buried in the pits included construction debris, paper, oils, greases, solvents, hospital wastes, and industrial sludges, including zinc, chromium, phosphates, and nitrates. In 1966, the North landfill was closed and filled in with dirt and construction rubble. However, review of a 1967 aerial photograph noted a new trench in the central portion of the landfill (USAEC 1994). Since the North Landfill has been closed, private contractors have transported waste off the property (PRC 1990). The South Landfill and North Landfill are referred to as SWMU 10 and SWMU 11, respectively. A landfill cover system, consisting of a clay and topsoil cap, was constructed in 1995 that included both landfills, and no further action was required at SWMU 10 (South Landfill) and SWMU 11 (North Landfill) (CH2M Hill 2002).

4.2.5 Other Potential Sources of PFAS

In addition to AFFF-related PFAS sources, other potential sources of PFAS may be associated with the use of some types of pesticides, car washes, engine lubricants, paint shops, laundry or waterproofing facilities, and photographic processing facilities. Document research, site visit, and interviews resulted in identification of other potential PFAS sources at RBAAP. The following paragraphs describe potential non-AFFF PFAS sources at RBAAP. The locations are noted on Figure 4-1.

Small incinerators were present at Buildings 123 and 163 and are known as SWMU 13 and SWMU 14, respectively. The incinerator at Building 123 was in use from 1948 through 1972. The incinerator in Building 163 was in operation from 1974 up to plant closure. The incinerators were reportedly used to burn paper and small combustible material. Some infectious materials from the RBAAP dispensary may have been burned in these units. No documentation exists detailing what may have been incinerated.

A hazardous waste storage area was located in Building 174 that was used for storage of 55-gallon containers. The area measured 50 by 100 feet and had the capacity to store 300 drums. The area consisted of a concrete slab with three 400-gallon sumps. The drum storage area is known as SWMU 2, and no known spills occurred in this area (CH2M Hill 2006).

An empty drum storage area was located to the north of Building 11 that was used for staging and storage for empty product drums and scrap storage. The storage area was constructed in July 1953 and was a 27- by 200-foot concrete pad capable of holding 1,250 55-gallon drums. No known waste was stored in the area, and the results of RI sampling indicated that no further action was required (CH2M Hill 2006). This area is known as SWMU 3.

A temporary 90-day holding area used for drum staging was located in the southeastern corner of the IWTP and consisted of a 26- by 31-foot epoxy sealed concrete pad. Drums of various wastes were brought to this staging area from the main production area. Use of drum storage area began in 1990. No indication exists that spillage in this area penetrated the concrete pad. The area is known as SWMU 4, and no further action was determined to be necessary (CH2M Hill 2006).

A pesticide storage area was located west of Building 11 and is known as SWMU 15. The area consisted of a 9- by 15-foot aboveground bunker constructed of concrete. The exact dates of pesticide storage are unknown; however, the replacement storage area (Building 165) was constructed in July 1975. Visual inspection of the structure showed no signs of staining or structural deterioration of the building, and the area required no further action (CH2M Hill 2006).

Building 165 was a prefabricated metal building sitting on a concrete floor that was used for the storage of pesticides between 1975 and 1979. The building was surrounding by asphalt and bare ground. Pesticides were stored in their original containers, and no releases have been reported. This area is known as SWMU 16, and based on sampling results, no further action was determined to be necessary (CH2M Hill 2006).

Beginning in 1979, Building 170 was used for pesticide storage and mixing. The building was a 600-ft^2 steel building erected on a concrete pad and contained a steel-reinforced concrete sump. In 1982, the sump was taken offline and later removed in 1994. Visual inspection of the concrete sump did not reveal any holes, cracks, or deterioration of the walls or floor of the sump. Approximately 20 yards of soil were excavated for disposal during the removal. The area is known as SWMU 17, and no future action was determined to be necessary (CH2M Hill 2006).

Although a complete list of pesticides used, stored, or disposed of at RBAAP is not available, the use of fluorinated pesticides was infrequent until approximately the mid-2000s (Alexandrino et al. 2022). Given the operational period of RBAAP, the likelihood of PFAS impacts due to pesticide use, storage, or disposal is assumed to be low.

During the document research and site visit, no additional potential PFAS-containing material use, storage, or disposal were identified.

4.3 POTENTIAL OFF-POST PFAS SOURCES

The search to identify potential off-post PFAS sources (i.e., not related to operations at RBAAP), although not exhaustive, included review of significant potential contributors (i.e., airports, fire stations, solid waste landfills, WWTPs, car washes).

Potential off-post PFAS sources within a 5-mile radius of RBAAP are shown in Figure 4-2. Fourteen car washes, nine fire stations, and four landfills were identified. PFAS-containing materials may be used at the car washes and may have been disposed of at the landfills. It is unknown if the fire stations use AFFF for fire training and/or fire response.

5. SUMMARY OF PA RESULTS

The areas evaluated for potential PFAS use and/or storage at RBAAP were further refined during the PA process and categorized as an AOPI or not retained. Areas not retained as AOPIs are discussed in Section 5.1. AOPIs are discussed in Section 5.2.

5.1 AREAS NOT RETAINED AS AOPIs

Based on analysis of information obtained during this PA, the areas described below were not retained as AOPIs. These areas were previously identified as potential PFAS sources (e.g., AFFF storage, car washes, automobile maintenance, paint shops, photographic processing, pesticide use or storage, WWTPs, landfills) at RBAAP. However, PA research does not indicate that PFAS-containing material was used, stored, or disposed of at these areas. A brief site history and the rationale for eliminating the areas as AOPIs are presented in Table 5-1.

Table 5-1. Summary of Areas Not Retained as AOPIs at RBAAP

Area Description	Dates of Operation	Relevant Site History	Rationale
Building 10C Old Fire Station Building	Unknown to 1975	Building 10C was used as the RBAAP fire station until the new fire station at Building 172 was constructed. Based on interviews with RBAAP personnel, AFFF was not used or stored at the fire station or during response activities.	No evidence that PFAS-containing materials were used, stored, or disposed of.
Building 172 New Fire Station	1975 to 2010	Building 172 replaced Building 10C as the RBAAP fire station. Based on interviews with RBAAP personnel, AFFF was not used or stored at the fire station or during response activities.	No evidence that PFAS-containing materials were used, stored, or disposed of.
Northwest Stormwater Reservoir	1950s to present	The Northwest Stormwater Reservoir receives stormwater from the majority of RBAAP and the Southeast Stormwater Reservoir.	No known or suspected releases of PFAS-containing materials to surface water; however, evidence of PFAS from AOPIs to groundwater could also indicate contamination of stormwater conveyance lines and subsequent contamination of the stormwater reservoir.
Southeast Stormwater Reservoir	1950s to present	The Southeast Stormwater Reservoir receives stormwater and surface water runoff from the southeastern section of RBAAP. Collected stormwater is then pumped to the Northwest Stormwater Reservoir.	No known or suspected releases of PFAS-containing materials to surface water; however, evidence of PFAS from AOPIs to groundwater could also indicate contamination of stormwater conveyance lines and subsequent contamination of the stormwater reservoir.
Building 123 Incinerator	1948 to 1972	A small incinerator was present at Building 123. The incinerator reportedly burned paper and small combustible material. Some infectious materials from the RBAAP dispensary may have been burned in the unit.	No evidence that PFAS-containing materials were used, stored, or disposed of.

Table 5-1. Summary of Areas Not Retained as AOPIs at RBAAP (Continued)

Area Description	Dates of Operation	Relevant Site History	Rationale
Building 163 Incinerator	1974 to 2010	A small incinerator was present at Building 163. The incinerator reportedly burned paper and small combustible material. Some infectious materials from the RBAAP dispensary may have been burned in the unit.	No evidence that PFAS-containing materials were used, stored, or disposed of.
South Landfill	1943 to 1952	Wastes were placed in trenches, and the trenches were filled with demolition debris, general refuse, and possible cyanide wastes. The Army closed the landfill in 1952.	No evidence that PFAS-containing materials were used, stored, or disposed of.
Building 174 Hazardous Waste Storage Area	Unknown to 2010	Building 174 was used for storage of 55-gallon containers. The area measured 50 by 100 feet and had the capacity to store 300 drums. The area consisted of a concrete slab with three 400-gallon sumps. No known spills occurred in this area.	No evidence that PFAS-containing materials were used, stored, or disposed of.
Building 11 Empty Drum Storage Area	1953 to unknown	Area used for the staging of empty drums awaiting disposal. A 27- by 200-foot concrete pad capable of holding 1,250 55-gallon drums and located to the north of Building 11. No known waste was stored in the area.	No evidence that PFAS-containing materials were used, stored, or disposed of.
Pesticide Storage Area West of Building 11	Unknown to 1975	A pesticide storage area was located west of Building 11. The area consisted of a 9- by 15-foot aboveground bunker constructed of concrete. No signs of staining or structural deterioration of the building.	No evidence that PFAS-containing materials were used, stored, or disposed of. Pesticides are not suspected to contain PFAS because dates of pesticide use at the facility predate the use of fluorinated pesticides.
Building 165 Pesticide Storage Area	1975 to 1979	A prefabricated metal building sitting on a concrete floor. Pesticides were stored in their original containers, and no releases have been reported.	No evidence that PFAS-containing materials were used, stored, or disposed of. Pesticides are not suspected to contain PFAS because dates of pesticide use at the facility predate the use of fluorinated pesticides.
Building 170 Pesticide Storage Area	1979 to 2010	Building 170 was used for pesticide storage and mixing. The building was a 600-ft^2 steel building erected on a concrete pad and contained a steel-reinforced concrete sump. The sump was removed, and approximately 20 yards of soil were excavated for disposal during the removal.	No evidence that PFAS-containing materials were used, stored, or disposed of. Pesticides are not suspected to contain PFAS because dates of pesticide use at the facility predate the use of fluorinated pesticides.

5.2 AOPIs

Based on analysis of information obtained during document research, personnel interviews, and/or site reconnaissance, six areas were categorized as AOPIs and are presented in Table 5-2 and Figure 5-1. Site research conducted for this PA indicates that PFAS-containing material use, storage, or disposal is potentially suspected at these areas.

Table 5-2. Summary of AOPIs at RBAAP

Area Description	SWMU ID	Dates of Operation	Relevant Site History	Rationale
Metal Plating Operations Building/Line 1	None	Periodically from 1952 to 1992	Metal plating operations were conducted at Line 1 as part of the production of 105mm casings. Plating operations were typically located at the end of the manufacturing lines near the chromium reduction tanks. Site encompasses batch process chrome reduction tank in Building 180.	PFAS-containing surfactants were likely used as a mist suppressant during the plating process and may be present in the plating waste stream of chrome reduction systems.
Metal Plating Operations Building/Line 6	None	Periodically from 1952 to 2009	Metal plating operations were conducted at Line 6, which was historically used to produce the 5-inch casings. Site encompasses batch chrome reduction in Building 13, continuous chrome reduction in Building 6, industrial waste pipe leak, and waste lines/trenches conveying plating waste to the IWTP.	PFAS-containing surfactants were likely used as a mist suppressant during the plating process and may be present in the plating waste stream of chrome reduction systems.
IWTP	SWMU 1	1951 to 2013	The IWTP treated all of the industrial wastewater generated at RBAAP. Wastewater was directly associated with metal finishing operations of the production processes. The IWTP also received pretreated wastewater from the chromium reduction units.	PFAS-containing surfactants were likely used during the plating process. The IWTP was not designed to treat PFAS.
IWTP Sewer Line Break Area (Effluent Force Main)	SWMU 12	1951 to present	In 1972, a break occurred in the effluent sewer line that conveys treated water from the IWTP to the E/P ponds. The break occurred in the northeastern corner of the property near the Hetch-Hetchy Aqueduct.	PFAS-containing surfactants were likely used during the plating process. The underground pipe conveyed discharge water from the IWTP, which was not designed to treat PFAS.
E/P Ponds	SWMU 23	1951 to present	The E/P ponds were constructed in 1952 for the disposal of treated effluent generated by the RBAAP IWTP.	PFAS-containing surfactants were likely used during the plating process. The E/P ponds received water from the IWTP, which was not designed to treat PFAS.
North Landfill	SWMU 11	1952 to 1966	Typical wastes buried in the North Landfill included construction debris, paper, oils, greases, solvents, hospital wastes, and industrial sludges, including zinc, chromium, phosphates, and nitrates.	PFAS-containing surfactants were likely used during the plating process. The plating sludge may have been disposed of in the landfill.

5.2.1 Preliminary CSM

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) and USEPA guidance. 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 soil, groundwater, surface water, and sediment pathways as potentially complete.

Based on the documented or potential historical use, storage, or disposal of PFAS-containing materials at RBAAP, affected media are likely to consist of soil, groundwater, surface water, and sediment. Release and transport mechanisms include dissolution/desorption from soil to groundwater, runoff/dissolution/ adsorption with surface water or stormwater, and recharge to groundwater from surface water. While other potential exposure media (i.e., soil and sediment) besides drinking water sources (i.e., groundwater and/or surface water) may be impacted by PFAS, direct ingestion via drinking water is the most likely exposure route, and thus the Army's primary concern for human exposure. Therefore, the focus of the Army's PA program is on potential human exposures via drinking water ingestion. The potential for human exposures to PFAS through non-drinking water pathways has not yet been established and may be evaluated in the future if it is determined that those pathways warrant further consideration. The CSMs presented in this report focus on drinking water pathways via groundwater and surface water that are known to be used as a source of potable water.

The potable water at RBAAP is supplied by two active and one inactive on-post groundwater wells, as discussed in Section 2.8. Potable water was sampled in 2017, and PFAS were not detected (U.S. Army 2017b). Potable water in the area surrounding RBAAP is provided by either the city of Riverbank or the city of Modesto. Both Riverbank and Modesto use groundwater wells as a water supply source. Modesto supplements its water supply within the city limits using surface water from the Tuolumne River. EDR and California Natural Resources Agency database well records indicate that several agricultural, domestic, industrial, or unknown use wells are located within a 1-mile radius of RBAAP.

A groundwater exposure pathway is considered potentially complete where a constituent of interest (COI) could migrate from the AOPI source area to groundwater that is used for drinking water. Otherwise, the groundwater exposure pathway is considered incomplete. The following parameters are used to determine if an AOPI source area had a potentially complete groundwater exposure pathway:

- AOPIs located upgradient or in the vicinity of drinking water sources and that have the potential to influence groundwater associated with these potable sources are a potentially complete groundwater exposure pathway for drinking water receptors.
- AOPIs located outside the vicinity or downgradient from potable sources (drinking water wells) are considered to have an incomplete groundwater exposure pathway.

The soil exposure pathway is considered potentially complete where COIs could be present in soil. A surface water exposure pathway is considered potentially complete where COIs could be present in or migrate to a surface water body (e.g., a reservoir or large river) that serves as a potable water source. No on-post surface water features are used as a drinking water source. The city of Modesto sources a portion of its drinking water from the Tuolumne River, which is more than 6 miles to the south of RBAAP. Surface water from RBAAP does not discharge to the Tuolumne River.

Figure 5-1 presents the locations of the AOPIs. AOPI-specific CSM summaries are provided in Tables 5-3 through 5-8.

5.2.2 Metal Plating Operations Line 1 Rationale and CSM

The metal plating operations in Line 1 were identified as an AOPI following records reviews, interviews, aerial photograph review, and site reconnaissance. PFAS-containing mist suppressants were likely used during the plating process given the metal plating period of operation.

Production Line 1 produced 105mm cartridge cases from 1952 until 1954, and production was scaled back between 1954 and 1958. Production ceased following the Korean War and the plant was placed on layaway status until 1963. The facility was reactivated in 1966 to produce 105mm cartridge cases until 1976. After machine upgrades to Line 1, production of 105mm cartridge casings resumed and continued until approximately 1992. Production of the cartridge casings involved metal plating operations, batch process chromium reduction, and storage of plating wastes in Building 180.

The PA team conducted a visual inspection of the Line 1 metal plating area. None of the metal processing infrastructure remains in the building. Several small floor drains that feed underground piping, which led to the IWTP, were located running west to east along the line and appeared to be sealed. The floor in the interior of Line 1 is concrete. The exterior of Line 1 is either concrete or asphalt, and stormwater runoff is collected by the facility stormwater drain system, which leads to the Northwest Stormwater Reservoir.

Table 5-3. AOPI CSM Information Profile – Metal Plating Line 1

Profile Type	Information Needs	Preliminary Assessment Findings
Site Profile	AOPI site structures/description	Long rectangular warehouse. Steel structure constructed on concrete underlain by soil. Floor drains collected to the facility drainage system leading to the IWTP.
	Latitude, longitude	37.71418612, -120.9190854
	Size	0.86 acres
Land Use	Current/future land use	City/Industrial
CSM Profile	Source media	Floor drains, subsurface soil
	Migration routes/release mechanisms	Constituents released to subsurface soil through floor drain and subsurface drain lines could migrate to groundwater through release from subsurface drain lines and desorption from soil. Evidence of PFAS releases from AOPIs to groundwater could also indicate contamination of stormwater conveyance lines and subsequent contamination of the Northwest Stormwater Reservoir.
	Exposure pathways, media, and human receptors	Drinking water is supplied by both on-post facility wells and off-post domestic and water supply wells; therefore, a potential complete drinking water exposure pathway exists for on-post and off-post human receptors.

5.2.3 Metal Plating Operations Line 6 Rationale and CSM

The metal plating operations in Line 6 were identified as an AOPI following records reviews, interviews, aerial photograph review, and site reconnaissance. PFAS-containing mist suppressants were likely used during the plating process given the metal plating period of operation.

Metal Plating Line 6 produced 3-inch/59, 5-inch/38, and 5-inch/54 naval cartridge cases periodically from 1952 until 2009. Metal Plating Line 6 included an automated plater, continuous chromium reduction system in Building 6 and associated trenches, a batch process chromium reduction unit in the southeastern corner of Building 13, and a suspected industrial wastewater pipe leak between Buildings 6 and 13.

The PA team conducted a visual inspection of the Line 6 metal plating area. None of the metal processing infrastructure remains in the building. Several small floor drains that feed underground piping, which led to the IWTP, were located running west to east along the line and appeared to be sealed. The floor in the interior of Line 6 is concrete. The exterior of Line 6 is either concrete or asphalt, and stormwater runoff is collected by the facility stormwater drain system. Stormwater on the northern side of Line 6 leads to the Northwest Stormwater Reservoir, and stormwater on the southern side of Line 6 leads to the Southeast Stormwater Reservoir.

Table 5-4. AOPI CSM Information Profile – Metal Plating Line 6

Profile Type	Information Needs	Preliminary Assessment Findings
Site Profile	AOPI site structures/description	Long, rectangular warehouse. Steel structure constructed on concrete underlain by soil. Floor drains collected to the facility drainage system leading to the IWTP.
	Latitude, longitude	37.71281295, -120.9190777
	Size	0.86 acres
Land Use	Current/future land use	City/Industrial
CSM Profile	Source media	Floor drains, subsurface soil
	Migration routes/release mechanisms	Constituents released to subsurface soil through floor drain and subsurface drain lines could migrate to groundwater through release from subsurface drain lines and desorption from soil. Evidence of PFAS releases from AOPIs to groundwater could also indicate contamination of stormwater conveyance lines and subsequent contamination of the Northwest Stormwater Reservoir.
	Exposure pathways, media, and human receptors	Drinking water is supplied by both on-post facility and off-post domestic and water supply wells; therefore, a potential complete drinking water exposure pathway exists for on-post and off-post human receptors.

5.2.4 IWTP Rationale and CSM

The IWTP was identified as an AOPI following records reviews, interviews, aerial photograph review, and site reconnaissance. Given the metal plating period of operation, PFAS-containing mist suppressants were likely used and included in the waste stream processed at the IWTP.

The IWTP treated industrial wastewater generated at the facility from electroplating, cleaning, and metal finishing processes. It was designed to treat facility wastewater and included equipment for coagulation, flocculation, clarification, sludge thickening, and sludge/liquid separation. The treated effluent water was discharged via underground pipe to the E/P ponds. Construction of the IWTP began in 1951 and was operated until its decommission in 2013.

The PA team conducted a visual inspection of the IWTP area. None of the IWTP infrastructure remains, and the area has been covered with asphalt or gravel. Stormwater runoff is collected by the facility stormwater drain system, which leads to the Northwest Stormwater Reservoir.

Table 5-5. AOPI CSM Information Profile – IWTP

Profile Type	Information Needs	Preliminary Assessment Findings
Site Profile	AOPI site structures/description	Historical structures have been removed, and the area is neither paved asphalt or gravel. Stormwater collected by the facility drainage system leads to the Northwest Stormwater Reservoir.
	Latitude, longitude	37.71527904, -120.9183552
	Size	1.15 acres

Table 5-5. AOPI CSM Information Profile – IWTP (Continued)

Profile Type	Information Needs	Preliminary Assessment Findings
Land Use	Current/future land use	City/Industrial
CSM Profile	Source media	Soil, surface water
	Migration routes/release mechanisms	Constituents released from the IWTP potentially contaminate soil and surface water through effluent discharge. Constituents could migrate to groundwater through desorption from soil or migrate to groundwater from surface water recharge. Evidence of PFAS releases from AOPIs to groundwater could also indicate contamination of stormwater conveyance lines and subsequent contamination of the Southeast Stormwater Reservoir.
	Exposure pathways, media, and human receptors	On-post exposure to soil and surface water exists. In addition, drinking water is supplied by both on-post facility wells and off-post domestic and water supply wells; therefore, a potential complete drinking water exposure pathway exists for on-post and off-post human receptors.

5.2.5 IWTP Effluent Sewer Break (Force Main) Rationale and CSM

The underground pipe break, referred to as the IWTP Sewer Line Break Area in RCRA documents, was identified as an AOPI following records reviews, interviews, aerial photograph review, and site reconnaissance. Given the metal plating period of operation, PFAS-containing mist suppressants were likely used and included in the waste stream processed at the IWTP. The IWTP was not designed to treat PFAS; therefore, the discharge may have contained PFAS, which may have been released during the underground pipe break.

In 1972, a break occurred in the effluent sewer line that conveys treated water from the IWTP to the E/P ponds. The break occurred in the northeastern corner of the property near the Hetch-Hetchy Aqueduct. It is unknown how much liquid was lost through the leak; however, during that period, the IWTP was processing 3,785,000 liters per day. Soil samples at the location were tested for inorganic compounds but not organic compounds.

The PA team conducted a visual inspection of the underground pipe break area. The area is open meadow that is unused and located over the Hetch-Hetchy Aqueduct. Stormwater runoff drains naturally over the meadow, which is relatively flat.

Table 5-6. AOPI CSM Information Profile – IWTP Effluent Sewer Break

Profile Type	Information Needs	Preliminary Assessment Findings
Site Profile	AOPI site structures/description	Relatively flat and open meadow.
	Latitude, longitude	37.72121595, -120.9172841
	Size	0.05 acres
Land Use	Current/future land use	City/Industrial
CSM Profile	Source media	Subsurface soil
	Migration routes/release mechanisms	Constituents released to soil from the IWTP effluent sewer break could migrate to groundwater.
	Exposure pathways, media, and human receptors	Drinking water is supplied by both on-post facility groundwater wells and off-post domestic and water supply wells; therefore, a potential complete drinking water exposure pathway exists for on-post and off-post human receptors.

5.2.6 E/P Ponds Rationale and CSM

The E/P ponds were identified as an AOPI following records reviews, interviews, aerial photograph review, and site reconnaissance. Given the metal plating period of operation, PFAS-containing mist suppressants were likely used and included in the waste stream processed at the IWTP. The IWTP was not designed to treat PFAS; therefore, the discharge may have contained PFAS, which may have been released to the E/P ponds.

The E/P ponds were constructed in 1952 for the disposal of treated effluent generated by the RBAAP IWTP and consists of four unlined ponds, which are located approximately 1.5 miles north of the main installation along the Stanislaus River. The treated water from the IWTP is discharged through a force main into a 21-inch-diameter clay pipe. The effluent discharged to the ponds evaporates and/or percolates through the sediment into the groundwater (CH2M Hill 2002).

The E/P ponds are within a fenced and locked area, and the PA team was unable to access the area during the site visit. Aerial photography indicates that the area includes several berms with low vegetation. Stormwater captured by the E/P ponds would evaporate or drain naturally.

Table 5-7. AOPI CSM Information Profile – E/P Ponds

Profile Type	Information Needs	Preliminary Assessment Findings
Site Profile	AOPI site structures/description	Low-lying open area with soil berms and low vegetation.
	Latitude, longitude	37.74220333, -120.9200206
	Size	27.26 acres
Land Use	Current/future land use	General Agricultural
CSM Profile	Source media	Sediment and surface water
	Migration routes/release mechanisms	Constituents released into the ponds from the IWTP could migrate from sediment to groundwater via desorption and dissolution. Constituents in surface water could recharge to groundwater.
	Exposure pathways, media, and human receptors	Pathways exist for exposure to on-post sediment and surface water. Surface water contained within the E/P ponds drains naturally to the subsurface; therefore, a potential complete drinking water exposure pathway exists for off-post human receptors in groundwater used as a potable source.

5.2.7 North Landfill Rationale and CSM

The North Landfill was identified as an AOPI following records reviews, interviews, aerial photograph review, and site reconnaissance. The Army used the North Landfill from 1952 through 1966. Given the metal plating period of operation, PFAS-containing mist suppressants were likely used and included in the waste stream processed at the North Landfill. In 1966, the landfill was closed and filled in with dirt and construction rubble. Since the North Landfill has been closed, private contractors have transported waste off the property (PRC 1990).

The PA team conducted a visual inspection of the North Landfill area. The landfill is covered with well-maintained grass and surrounded by unimproved soil or asphalt roadway. Stormwater runoff is collected by the facility stormwater drain system, which leads to the Northwest Stormwater Reservoir.

Table 5-8. AOPI CSM Information Profile – North Landfill

Profile Type	Information Needs	Preliminary Assessment Findings
Site Profile	AOPI site structures/description	Well-maintained/grassy field. A soil cap is maintained as part of the landfill remedial measures. Stormwater is collected by the facility stormwater system leading to the Northwest Stormwater Reservoir.
	Latitude, longitude	37.71947894, -120.9174589
	Size	1.85 acres
Land Use	Current/future land use	City/Industrial
CSM Profile	Source media	Subsurface soil
	Migration routes/release mechanisms	Constituents released to soil from landfill material could migrate to groundwater via desorption and dissolution.
	Exposure pathways, media, and human receptors	Drinking water is supplied by both on-post facility wells and off-post domestic and water supply wells; therefore, a potential complete exposure pathway exists for on-post and off-post human receptors.

5.3 DATA LIMITATIONS

The data limitations relevant to the development of this PA for PFAS at RBAAP are discussed below.

A comprehensive well survey was not completed as part of this PA; therefore, the information reviewed regarding off-post wells is limited to an administrative search that resulted in numerous wells that could not be verified. The EDR well search report (Appendix F) and online databases (California Water Boards, CA DWR 2021) were referenced when identifying potential off-post drinking water receptors.

The searches for ecological receptors and off-post PFAS sources were limited to easily identifiable and readily available information. An online database was referenced when identifying the ecological profile for the site (USFWS 2021).

Records reviewed during the PA process were limited in information regarding PFAS-containing materials, including AFFF use, procurement records, and firefighter training records. Generally, interviews were crucial to understanding past practices and identifying the potential for use, storage, or disposal of PFAS-containing materials because records are often not available after installation closure. Interviews providing information regarding potential PFAS-containing material use were limited in quantity but inclusive of personnel knowledgeable of fire, emergency response, and industrial activities over the time frame from 1978 to the present.

The PA was conducted through observation of operational periods, site usage, aerial photographs, records reviews, anecdotal evidence, and personnel interviews to evaluate the use, storage, or disposal of PFAS-containing materials. Therefore, some conclusions and recommendations presented in this report are based on available information, professional judgment, and industry best practices.

6. CONCLUSIONS

This PA was conducted in accordance with DoD, Army, and USEPA guidance documents. Programmatically, the Army has focused its PFAS PA efforts on identifying locations where a potential for a release of PFAS exists (i.e., those locations where PFAS-containing materials were used, stored, or disposed of). Locations on Army installations with the greatest likelihood of releases of PFAS were evaluated as part of this PA, including FTAs, AFFF storage locations, aircraft crash sites, fuel farms, and sites associated with aviation assets. However, other potential sources of PFAS at the installation were considered and have been documented in this PA. A combination of document review, Internet searches, interviews with installation personnel, and an installation site visit were used to identify specific areas of suspected PFAS use and releases at RBAAP.

The entire former RBAAP installation was assessed; 22 preliminary areas were identified and evaluated for potential use, storage and/or disposal of PFAS-containing materials; and these areas were further refined during the PA process and then either identified either as an area not retained for further investigation or as an AOPI. In accordance with the established process for the PA, six of the preliminary areas have been identified as AOPIs.

The AOPIs identified during this this PA at RBAAP are listed below:

- Two metal plating operations areas (Line 1 and Line 6)
- IWTP
- IWTP effluent sewer line break between the IWTP and the E/P ponds
- E/P ponds
- North Landfill.

A site-specific CSM was developed for each AOPI based on an assessment of the potentially contaminated media, migration routes, site characteristics, and existing records. The CSMs developed for this PA identified that on-post and off-post drinking water receptors exist that could be potentially impacted by AOPIs at RBAAP.

Given the findings of this PA, the AOPIs presented warrant further evaluation in a SI (40 CFR 300.420(c)).

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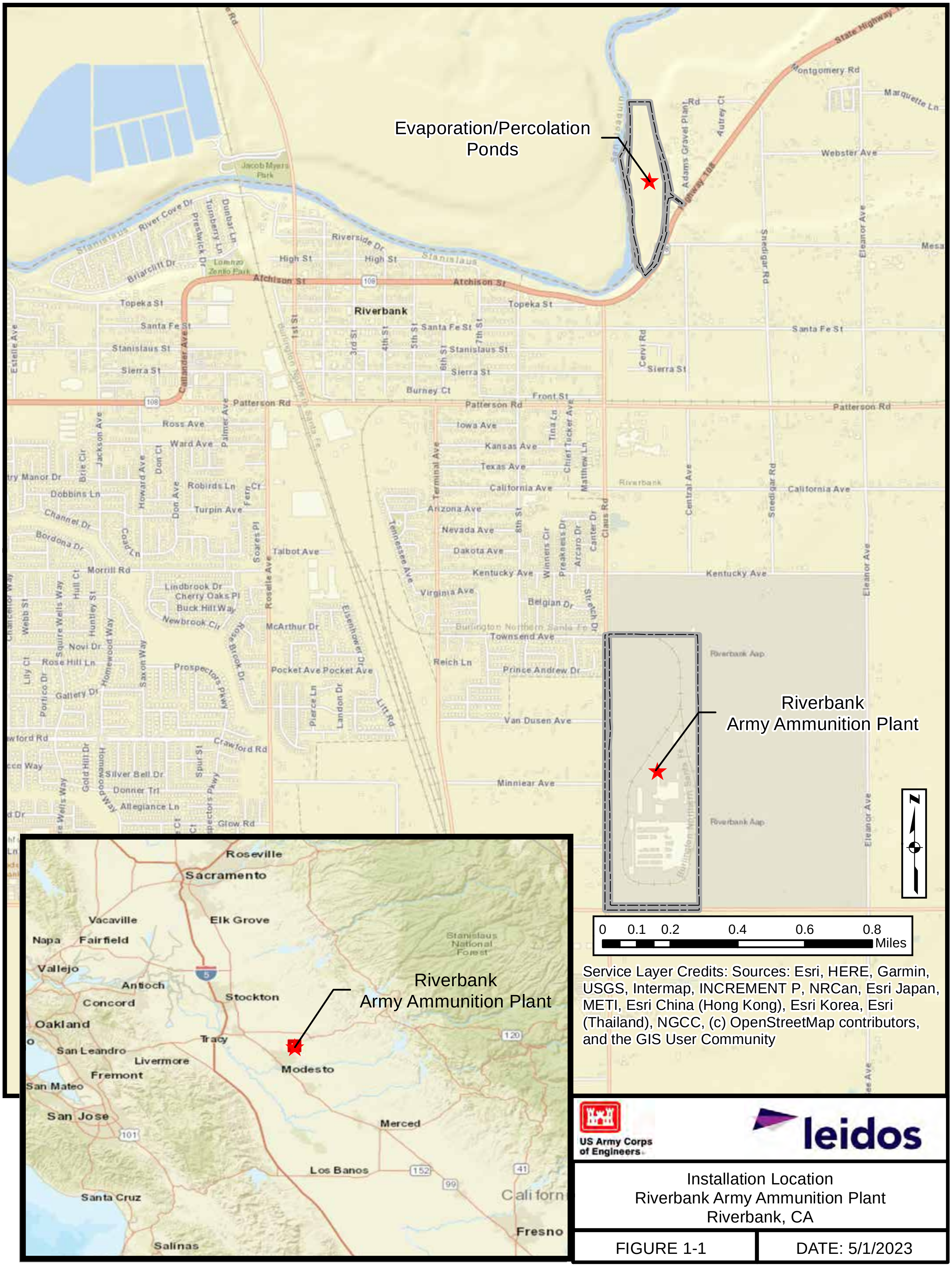
FIGURES


Evaporation/Percolation Ponds
Riverbank Army Ammunition Plant
Riverbank
Roseville
Sacramento
Vacaville
Elk Grove
Napa
Fairfield
Vallejo
Antioch
Concord
Stockton
Oakland
Tracy
San Leandro
Livermore
Fremont
Modesto
San Mateo
San Jose
Merced
Los Banos
Santa Cruz
Fresno
Salinas
Riverbank Army Ammunition Plant
0 0.1 0.2 0.4 0.6 0.8 Miles
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
US Army Corps of Engineers
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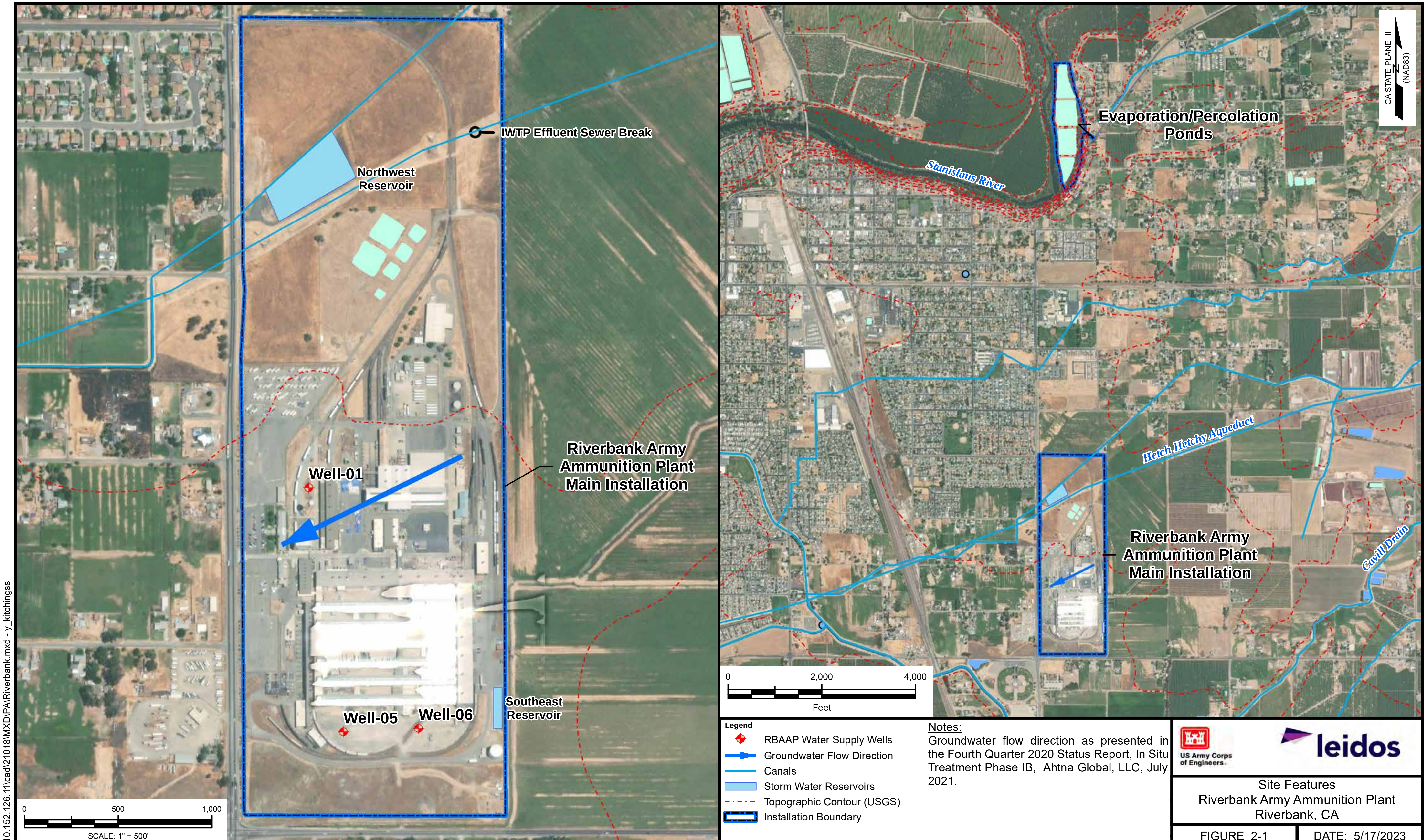
Installation Location
Riverbank Army Ammunition Plant
Riverbank, CA
FIGURE 1-1
DATE: 5/1/2023


IWTP Effluent Sewer Break
Northwest Reservoir
Riverbank Army Ammunition Plant Main Installation
Well-01
Well-05
Well-06
Southeast Reservoir
0 500 1,000
SCALE: 1" = 500'
Evaporation/Percolation Ponds
Stanislaus River
Hetch Hetchy Aqueduct
Riverbank Army Ammunition Plant Main Installation
Cavill Drain
0 2,000 4,000
Feet
CA STATE PLANE III (NAD83)
N
Legend
RBAAP Water Supply Wells
Groundwater Flow Direction
Canals
Storm Water Reservoirs
Topographic Contour (USGS)
Installation Boundary
Notes:
Groundwater flow direction as presented in the Fourth Quarter 2020 Status Report, In Situ Treatment Phase IB, Ahtna Global, LLC, July 2021.
US Army Corps of Engineers
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Site Features
Riverbank Army Ammunition Plant
Riverbank, CA
FIGURE 2-1
DATE: 5/17/2023
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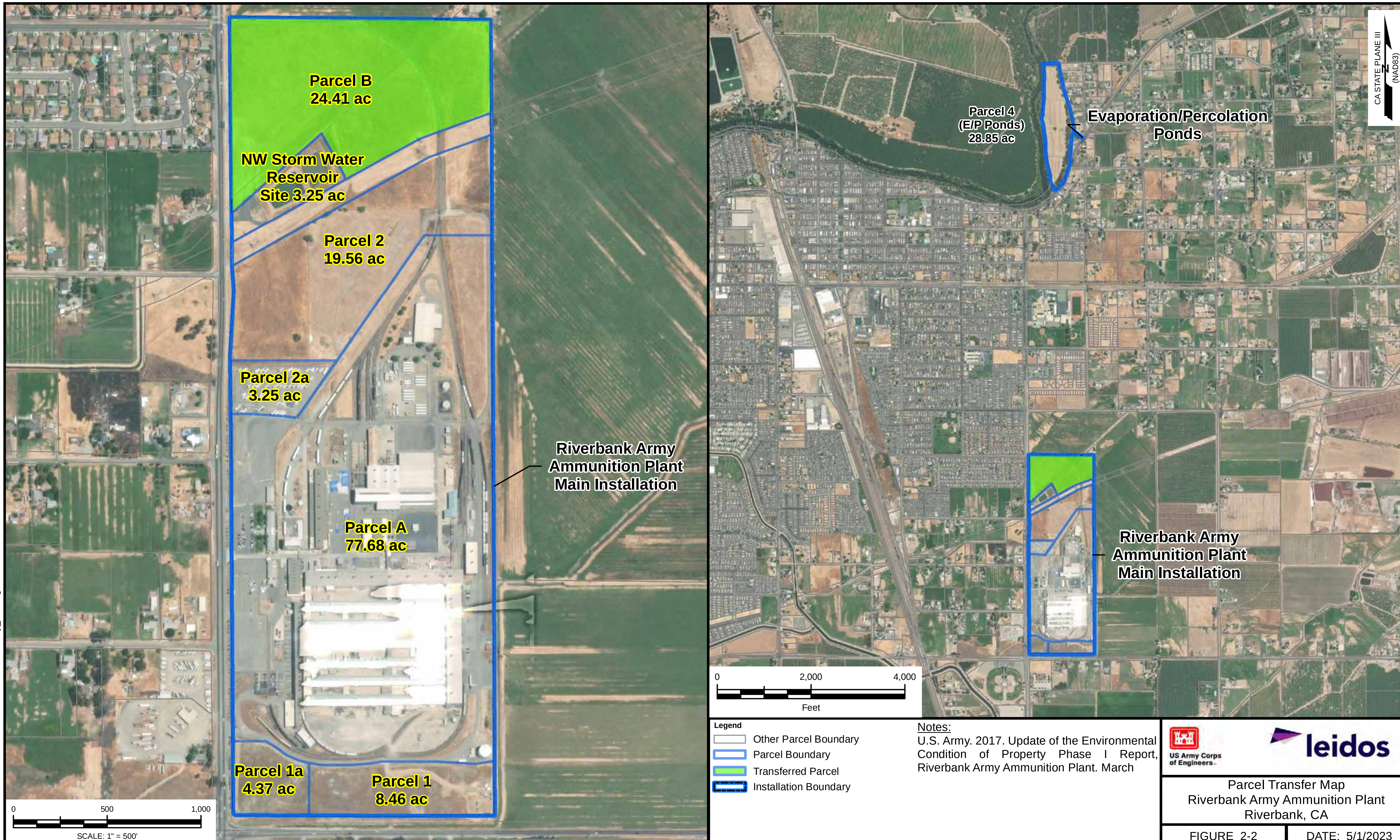
Parcel B
24.41 ac
NW Storm Water
Reservoir
Site 3.25 ac
Parcel 2
19.56 ac
Parcel 2a
3.25 ac
Parcel A
77.68 ac
Riverbank Army
Ammunition Plant
Main Installation
Parcel 1a
4.37 ac
Parcel 1
8.46 ac
0 500 1,000
SCALE: 1" = 500'
Parcel 4
(E/P Ponds)
28.85 ac
Evaporation/Percolation
Ponds
CA STATE PLANE III
N
(NAD83)
Riverbank Army
Ammunition Plant
Main Installation
0 2,000 4,000
Feet
Legend
Other Parcel Boundary
Parcel Boundary
Transferred Parcel
Installation Boundary
Notes:
U.S. Army. 2017. Update of the Environmental Condition of Property Phase I Report, Riverbank Army Ammunition Plant. March
US Army Corps of Engineers
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Parcel Transfer Map
Riverbank Army Ammunition Plant
Riverbank, CA
FIGURE 2-2
DATE: 5/1/2023
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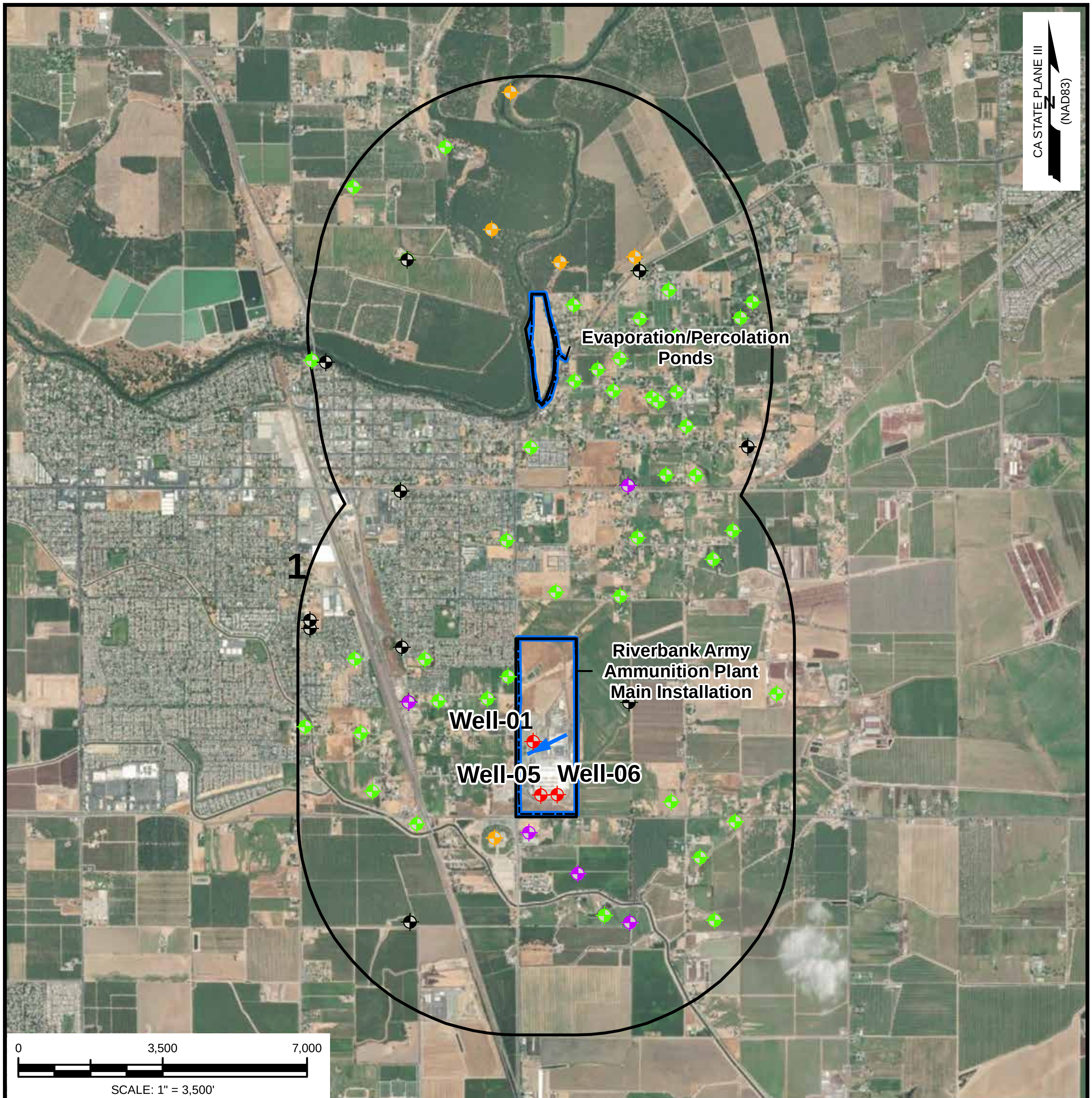

Legend

- RBAAP Water Supply Wells
- Agriculture
- Water Supply Public
- Domestic
- Unknown
- Groundwater Flow Direction
- 1-mile radius line
- Installation Boundary

Notes:
California Department of Water Resources. 2021. Well Completion Report Database https://water.ca.gov/Programs/Groundwater-Management/Wells/Well-Completion-Reports. Accessed December 13.

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Potable Wells Within a 1-Mile Radius
Riverbank Army Ammunition Plant
Riverbank, CA

FIGURE 2-3 | DATE: 5/17/2023

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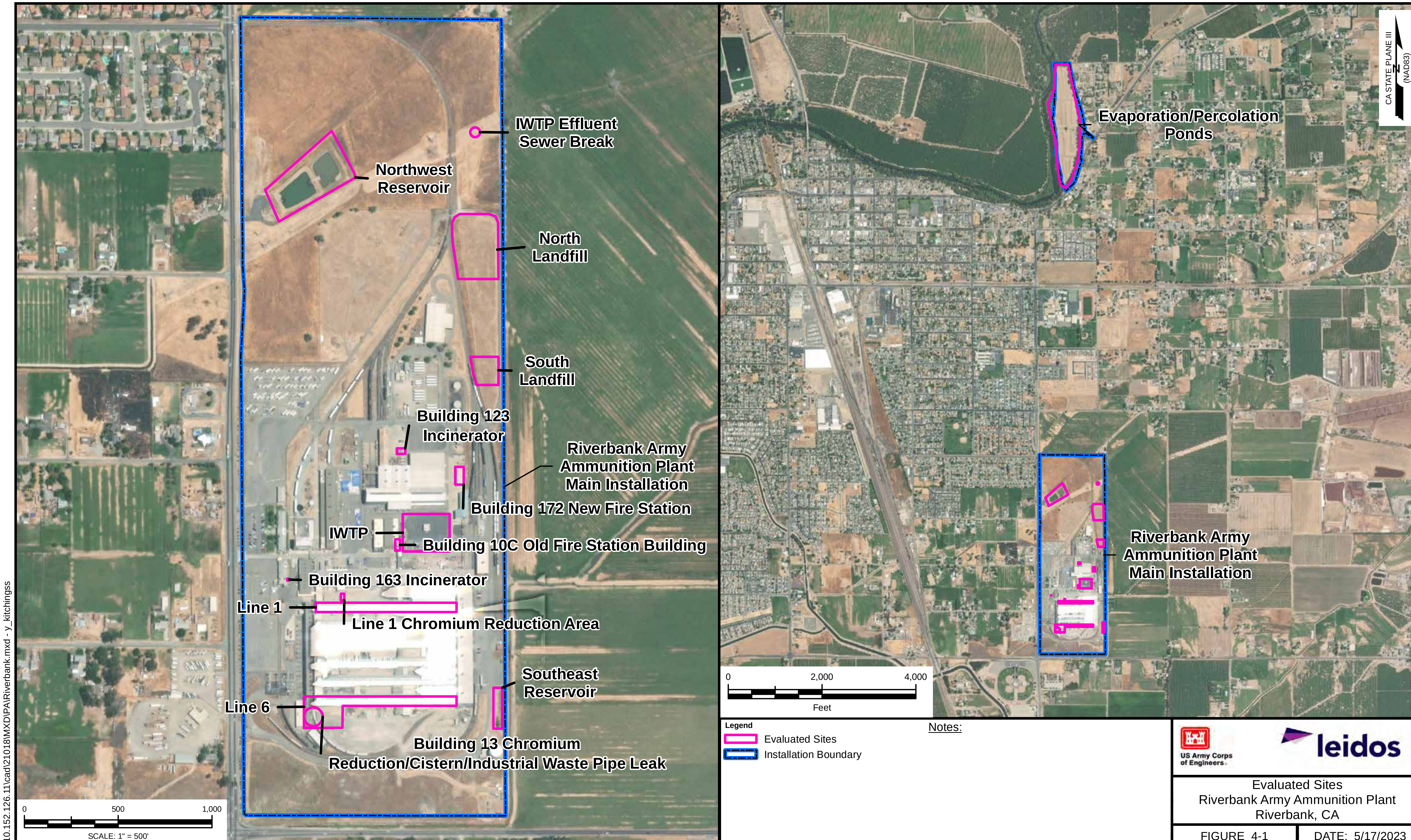
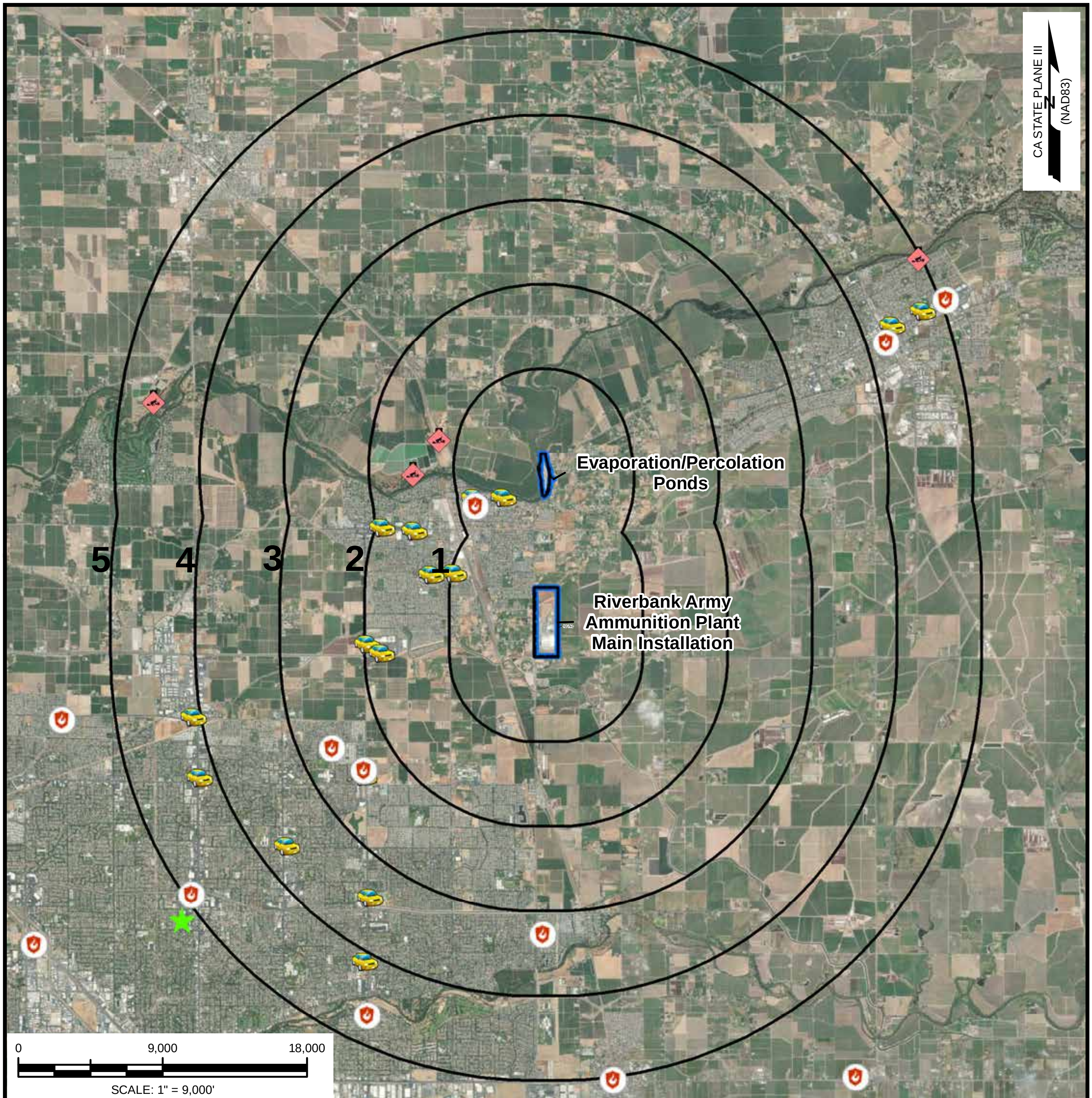


Evaluated Sites
Riverbank Army Ammunition Plant
Riverbank, CA

FIGURE 4-1 | DATE: 5/17/2023



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Legend

- Airport/Helipads (FAA)
- Fire Stations
- Car Wash
- Solid Waste Landfill
- Distance Rings
- Installation Boundary

Notes:
Airports and Helipads FAA (https://services6.arcgis.com)
Fire Stations Stan County (https://gis2.stancounty.com)
California State GeoPortal (https://gis.data.ca.gov)
Car wash facilities (Google 2023)

US Army Corps of Engineers

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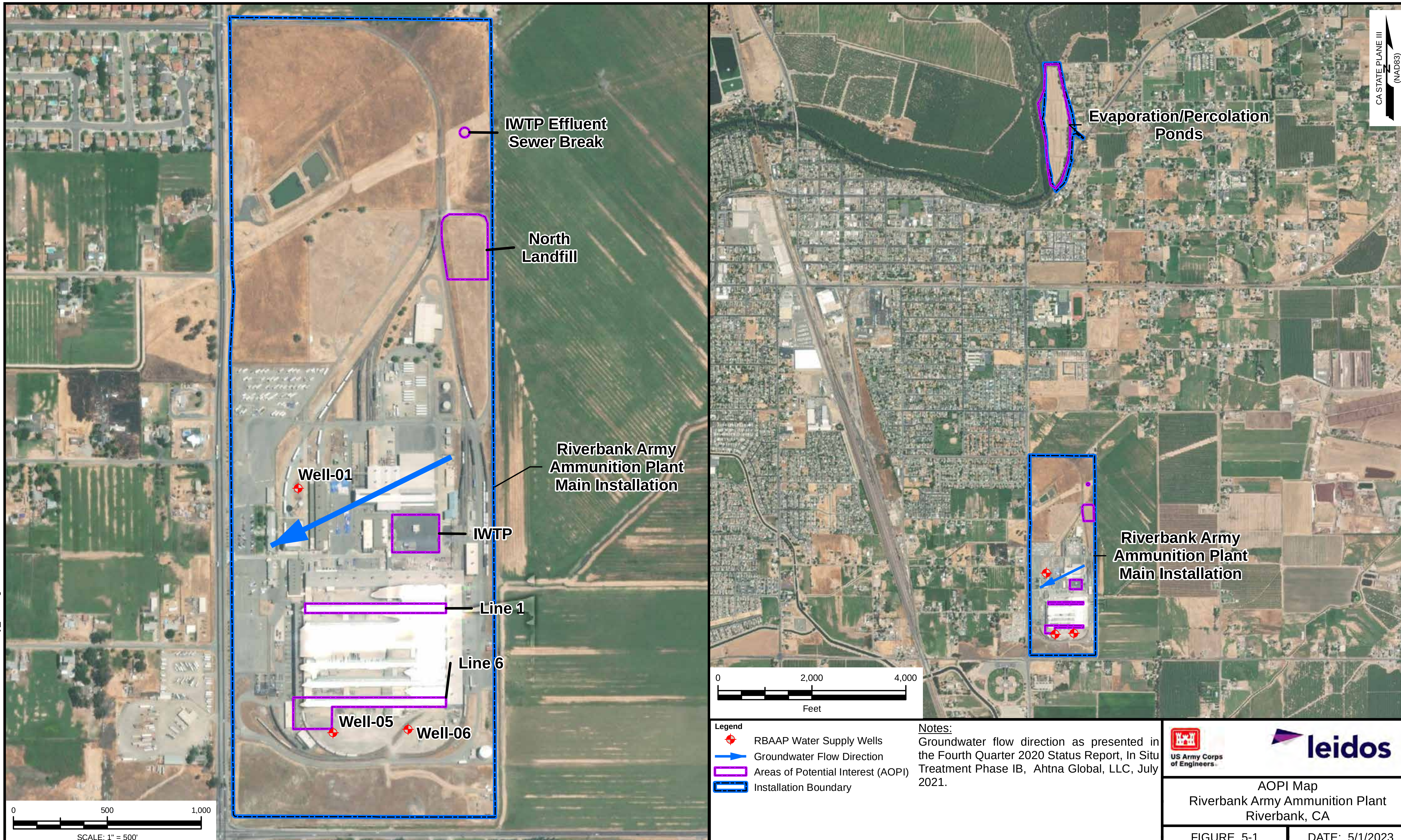
Potential PFAS Sources Within a 5-Mile Radius Riverbank Army Ammunition Plant
Riverbank, CA

FIGURE 4-2 DATE: 5/18/2023



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