FINAL PRELIMINARY ASSESSMENT OF PER- AND POLYFLUOROALKYL SUBSTANCES

Pueblo Chemical Depot, Colorado

Prepared For:
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Preliminary Assessment of Per- and Polyfluoroalkyl Substances

Pueblo Chemical Depot, Colorado

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EXECUTIVE SUMMARY

The United States (U.S.) Army (Army) is performing preliminary assessments (PAs) on the current or potential historical use of per- and polyfluoroalkyl substances (PFAS) with a focus on perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanesulfonic acid (PFBS), at Army installations (installations) nationwide. The PA identifies areas of potential interest (AOPIs) where PFAS-containing materials were used, stored, and/or disposed, or areas where known or suspected releases to the environment occurred. This Pueblo Chemical Depot (PCD) PA was completed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), The National Oil and Hazardous Substances Pollution Contingency Plan, and Army/Department of Defense (DoD) policy and guidance.

PCD is in southeastern Colorado in Pueblo County, north of the Arkansas River and 14 miles east of the city of Pueblo. PCD originally occupied 24,845 acres of land acquired through condemnation, lease, or purchase. PCD has also operated as Pueblo Ordnance Depot; Pueblo Army Depot; Pueblo Depot Activity; U.S. Army Depot Activity, Pueblo; and Pueblo Army Depot Activity. In 2013, using the authority and procedures of the Base Realignment and Closure act, the Army declared 15,847 acres of PCD as federal surplus property and only 7,000 acres were retained for demilitarization operations. This PA report focuses on potential locations within the retained property of PCD.

Based on the results of the PA for the entire installation, no AOPIs were identified. Therefore, further investigation for PFAS at PCD is not warranted at this time.

1 INTRODUCTION

The United States (U.S.) Army (Army) is performing Preliminary Assessments (PAs) on the current or potential historical use of per- and polyfluoroalkyl substances (PFAS) with a focus on perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorobutanesulfonic acid (PFBS), at Army installations (installations) nationwide. The Army is the lead agency under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Executive Order 12580, and is conducting the PAs consistent with its authority under CERCLA, 42 United States Code §§ 9600, et seq. (as amended), and the Defense Environmental Restoration Program, 10 United States Code §§ 2701, et seq. The purpose of this PFAS PA is to identify locations that are areas of potential interest (AOPIs) on the retained property of Pueblo Chemical Depot (PCD) based on the use, storage and/or disposal of potential PFAS-containing materials, in accordance with the 2018 Army Guidance for Addressing Releases of Per-and Polyfluoroalkyl Substances (Army 2018). This report provides the PA for PCD and was completed in accordance with CERCLA and The National Oil and Hazardous Substances Pollution Contingency Plan.

1.1 Project Background

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

In 2016, the United States Environmental Protection Agency (USEPA) established a lifetime health advisory of 70 nanograms per liter (ng/L) in drinking water for PFOS or PFOA and for the sum of PFOS and PFOA when both are present (USEPA 2016). On 15 October 2019, the Office of the Secretary of Defense (OSD) provided guidance on the investigation of PFOS, PFOA, and PFBS at Department of Defense (DoD) restoration sites (OSD 2019). The DoD guidance provides risk screening levels for PFOS, PFOA, and PFBS in tap water or soil, calculated using the USEPA's Regional Screening Level (RSL) calculator for residential and industrial/commercial worker receptor scenarios. Following the issuance of the 2019 OSD memo, on 08 April 2021, USEPA published an updated toxicity assessment for PFBS (USEPA 2021). Based on the updated toxicity assessment for PFBS, the OSD issued a memorandum on 15 September 2021 to include updated PFBS risk screening levels. The September 2021 Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program is provided for reference as **Appendix A**. The OSD risk screening levels for tap water (and also used to evaluate groundwater or surface water used as drinking water sources) are 40 ng/L for PFOS and PFOA, and 600 ng/L for PFBS. The PFOS and PFOA soil screening levels for the residential and industrial/commercial scenarios are 0.13 milligrams per kilogram (mg/kg) (residential) and 1.6 mg/kg (industrial/commercial). The soil screening levels for PFBS are 1.9 mg/kg (residential) and 25 mg/kg (industrial/commercial).

1.2 PA Objectives

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

1.3 PA Process Description

For PCD, PA development followed a similar process as described in **Sections 1.3.1** through **1.3.3** below. **Section 3** provides a summary of the PA activities completed at PCD. The PA processes are documented in the PA Quality Control Checklist included as **Appendix B**.

1.3.1 Pre-Site Visit

First, an installation kickoff teleconference was held between applicable points of contact (POCs) from the United States Army Environmental Command (USAEC), United States Army Corps of Engineers (USACE), PCD, and Arcadis U.S., Inc. (Arcadis). The kickoff call occurred 4 to 6 weeks before the site visit to discuss the goals and scope of the PA, project scheduling, installation access, timeline for the site visit, access to installation-specific databases, and to request available records.

Records review was conducted before the site visit to obtain electronically available documents from the installation and external sources for review. The purpose of the records research was to identify any area on the installation that may have been a location where PFAS-containing materials were used, stored, and/or disposed, as well as gather information on the physical setting and site history at PCD.

A read-ahead package was prepared and submitted to the appropriate POCs 2 weeks before the site visit. The read-ahead package contains the following information:

- The Army Materiel Command operation order
- The Army PA Operations Security requirements package, which includes the antiterrorism/operations security review cover sheet (**Appendix C**)
- The PFAS PA kickoff call minutes
- An information paper on the PA portion of the Army's PFAS PA
- Contact information for key POCs
- A list of the data sources requested and reviewed
- A list of preliminary locations identified during the kickoff call and pre-site visit records review to be evaluated for use, storage, and/or disposal of PFAS-containing materials, where additional information on those areas will be collected through personnel interviews, additional document review, and site reconnaissance
- A list of roles for the installation POC to consider when recommending potential interviewees.

1.3.2 Preliminary Assessment Site Visit

The site visit was conducted on 17 June 2020. An in-brief meeting was held in order to provide installation staff with the objectives of the site visit and team introductions. **Section 3** includes information regarding personnel interviewed.

Personnel interviews were conducted with individuals having significant historical knowledge at PCD. The interviews focused on confirming information discussed in historical documents, collecting information that may have not been in historical documents, corroborating other interviewees' information.

Site reconnaissance included visual surveys that assessed the points of potential use, storage, and/or disposal of PFAS-containing materials, as well as potential secondary impacts and the migration potential from each AOPI (e.g., stormwater drains, building drains and sumps, cracks in the floor/pavement). Physical attributes of the preliminary locations were documented, including local slope and ground and floor conditions (i.e., paved, unpaved, visual staining), surface water bodies and surface flow, potential receptors, and the distance to the former PCD installation boundary. Access to existing groundwater monitoring wells, if present, were also noted during the site reconnaissance in case the monitoring wells could be proposed for SI sampling, if needed. Access limitations or advantages related to potential future sampling activities were noted.

An exit briefing was offered to installation personnel at the conclusion of the site visit to raise any items identified during the site visit, discuss any follow-up items, and review the schedule for submitting deliverables. There was no exit briefing conducted with the installation, USAEC, or USACE since the site visit took place over the course of one day.

1.3.3 Post-Site Visit

Information collected before, during, and after the site visit was reviewed and corroborated by cross-referencing records and reviewing interview details and observations noted during site visit reconnaissance. A site visit trip report was completed and provided to the installation POC, applicable USAEC POCs, and USACE regional POCs following the site visit.

2 INSTALLATION OVERVIEW

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

2.1 Site Location

PCD is in southeastern Colorado, north of the Arkansas River in Pueblo County (**Figure 2-1**). Chico Creek runs along the western border of the installation, and Boone Creek runs along the southeastern portion. The town of Pueblo is located 14 miles to the west and the smaller town of Boone to the southeast of PCD. Other communities include the unincorporated community of Avondale to the south, across the Arkansas River, and the unincorporated community of North Avondale to the south along State Highway 96 (HydroGeoLogic, Inc. [HGL] 2019).

2.2 Mission and Brief Site History

During its history, PCD has operated as the following: Pueblo Ordnance Depot; Pueblo Army Depot; Pueblo Depot Activity; U.S. Army Depot Activity, Pueblo; and Pueblo Army Depot Activity. In 1941, the mission of PCD included supplying western states with military articles necessary for national defense, storing and maintaining all classes of practice ammunition supplied to military installations throughout the central western U.S., maintaining and preserving ordinance materials, and training civilian personnel. By 1946, PCD repaired and stored returning combat materials from overseas. In 1948, PCD began the process of demilitarizing ammunition with the construction of ammunition workshop buildings (HGL 2019).

From 1959 to 1961, a missile maintenance facility constructed in Building 529 allowed fifth echelon maintenance work on the Sergeant, Pershing, Redstone, and ENTAC missile systems. From 1959 to 1966, PCD also stored sealed nuclear warheads. By 1966, depot level maintenance of Hercules, Nike, Ajax, and Hawk air defense missile systems occurred at PCD. Additionally, PCD had the mission of storing, supplying, and maintaining fixed and floating engineer bridges. In 1971, PCD was designated as a historical property repository for the storage of artifacts from Germany and South Vietnam that could be used in museum displays or on military posts, remanufacturing the Pershing Guided Missile, and to receive, store, inspect, and issue the Maverick missile (HGL 2019).

Realignment of the Army Materiel Command in 1974 resulted in PCD ultimately being reassigned to the Tooele Army Depot. During the 1980s and 1990s, PCD operated as a supply depot under the command of Tooele Army Depot. PCD received, stored, issued, maintained, and disposed of certain military items and provided limited maintenance to prevent deterioration of facilities and to retain shipping and receiving capabilities (HGL 2019). The Base Realignment and Closure (BRAC) 1988 realignment dispersed most missions, with the sole remaining mission consisting of safely storing chemical weapons awaiting final destruction (PCD 2016). The BRAC realignment action was declared complete in September 1994 and the retained property of the installation was renamed U.S. Army Pueblo Chemical Depot (USACE 2017).

The current PCD mission is to safely secure, store, and monitor the chemical stockpile while protecting the workforce, the public, and the environment; prepare for and support stockpile elimination; and transition the depot and the workforce for closure (PCD 2016).

2.3 Current and Projected Land Use

The former PCD encompassed approximately 23,000 acres of prairie lands and includes a variety of buildings and other structures, as well as open and undeveloped lands (PCD 2016). In 2013, using the authority and procedures of the BRAC act, the Army declared 15,847 acres of PCD as federal surplus property and only 7,000 acres were retained for demilitarization operations, outlined on **Figure 2-2** (USACE 2017). The 7,000 acres retained at PCD includes the Pueblo Chemical Agent Destruction Pilot Plant, cantonment area, and sanitary waste treatment evaporation lagoons. The federal surplus property (i.e., excessed property) remains under U.S. ownership and control (HGL 2019). The federal surplus property is considered off-post and the 7,000 acres of retained property is the focus of this PA.

PCD land use is primarily industrial with some administrative and limited residential and recreational development. Administrative, residential, and recreational land uses are located in the south-central portion of the PCD federal surplus property around the cantonment area. The industrial portion of PCD includes storage igloos, warehouses, rail lines, maintenance areas, workshops, and associated administrative buildings with open spaces surrounding each area that serves as a safety buffer zone (USACE 2017).

2.4 Climate

The regional average climate ranges from a low of 14.7 degrees Fahrenheit during January to a high of 93.8 degrees Fahrenheit during July. Average annual precipitation is 12.6 inches per year and the wettest month of the year is August with an average rainfall of 2.1 inches (USACE 2017). From October until May, precipitation generally occurs in the form of snow. Most of the area's moisture occurs from June to September, when summer thunderstorms provide more intense precipitation (Jacobs Engineering Group Inc. 1991).

2.5 Topography

The topography of PCD is broadly rolling hills with steep scarps at the edges of the terrace upon which it is situated (**Figure 2-3**). The elevation of PCD ranges from 4,810 feet at the northern boundary to 4,650 feet along the southern boundary (HGL 2019). Somewhat abrupt bluffs are found along the northwestern side of the plateau, dropping the land's profile down to Chico Creek, while the slope to the creek on the southwest side is much more gradual at approximately 15 percent (%). At the southeast corner, the profile drops down to the Boone Creek drainage. At the southern edge, PCD is approximately 150 feet above the Arkansas River, which flows west to east (USACE 2017).

Most of PCD is located outside of the 100-year floodplains of Chico and Haynes Creeks with a small portion along the southern and western boundaries. The 100-year floodplain of Boone Creek and the Arkansas River begins south of the PCD boundary (USACE 2017).

2.6 Geology

PCD is located on a terrace on the western part of the Colorado Piedmont sections of the Great Plains. The terrace alluvium is composed of stratified, unconsolidated clayey or silty sand, fine to coarse sand, sand and fine gravel, and a few thin beds of gravel (HGL 2019). The relatively permeable terrace alluvium is a Holocene/Pleistocene formation of the Quaternary Period that can be up to 100 feet thick (USACE 2017).

Underlying the terrace alluvium is the Pierre Shale of the Upper Cretaceous Series (USACE 2017). The Pierre Shale is nearly impermeable and extends throughout eastern Colorado. It is composed of gray clay and sandy shale. The unit is more than 1,000 feet thick. Below the Pierre Shale is a sequence of shale and limestone deposits. These deposits are underlain by the Dakota Sandstone (HGL 2019). The Dakota Sandstone is of the Lower Cretaceous Series and lies at a depth of approximately 2,200 feet. The formation is the most intensively studied bedrock formation in the area because of its oil-, gas-, and water-producing potential (USACE 2017).

The soils of Chico Creek are fine sandy loams and silty clays and soils associated with Boone Creek are gravelly sand loams. The remaining soils at PCD are associated with soils found on plains that include: loamy sands and sands to the west; loams, clay loams, sandy loams, and silty clay loams within the central portion; and silty clays, silty clay loams, and clay to the east (HGL 2019).

2.7 Hydrogeology

There are two alluvial aquifers that underlie PCD consisting of the Chico Creek alluvial aquifer and the terrace alluvial aquifer, and a deep bedrock aquifer in the Dakota Sandstone. The Chico Creed alluvial aquifer is the smaller aquifer located in the alluvial system along Chico Creek. The terrace alluvial aquifer is a southernmost, downgradient part of an erosional remnant of an extensive terrace deposit. Both aquifers consist primarily of sand separated by clay layers, underlain by the nearly impermeable Pierre Shale (HGL 2019).

The Chico Creek aquifer underlies the western portion of the PCD surplus property and generally flows south, consistent with the course of Chico Creek itself. The total thickness ranges from 16 to 41 feet and approximately 0 to 30 feet are saturated (USACE 2017). The measured hydraulic conductivity is 14 to 310 feet per day. The aquifer is hydraulically connected with the Arkansas River alluvial aquifer (HGL 2019).

The terrace alluvium aquifer underlies the eastern portion of PCD and is underlain by bedrock that slopes south-southeast. It forms an irregular surface of troughs, hills, and ridges in the southwestern part of the terrace alluvium. The saturated thickness of the terrace aquifer ranges from 0 to 45 feet (HGL 2019). Water in the aquifer typically flows southward with the exception of the southwestern part where flow is more complex and controlled by the underlying bedrock surface. The terrace alluvial aquifer is hydraulically connected with the Arkansas River aquifer by a narrow zone of alluvium at the unnamed creek immediately south the southern boundary of the PCD surplus property (USACE 2017). Hydraulic conductivity ranges from 0.4 to 400 feet per day. Potential recharge of the terrace aquifer is minimal with much precipitation rapidly evaporating (HGL 2019).

A deep bedrock aquifer in the Dakota Sandstone and the underlying Cheyenne Sandstone make up the Dakota-Cheyenne aquifer. This aquifer is approximately 2,200 feet below ground surface and ranges from 50 to 100 feet thick (USACE 2017).

2.8 Surface Water Hydrology

The entirety of PCD is drained by three creeks: Chico Creek to the west, Boone Creek to the southeast, and Haynes Creek on the east (**Figure 2-2**). All three creeks flow into the Arkansas River Valley. Chico Creek flows along the western side of the PCD excess property. Chico creek typically only flows during the winter at approximately 2.5 miles upstream from the confluence with the Arkansas River Valley. During periods of average annual precipitation, Chico Creek flows through the north and central portions of PCD, typically only after local or upstream precipitation events. Boone Creek begins approximately 1.5 miles south of the northern Former PCD Installation Boundary and runs south to Lynda Ann Reservoir before continuing south to the Arkansas River (USACE 2017). The creek is an ephemeral stream, sourced from a perennial spring that disperses into the stream bed sediments shortly after the spring. The creek typically flows after rainfall or seasonal snow melt. Haynes Creek is intermittent but typically flows in the winter (HGL 2019).

The Lynda Ann Reservoir is a man-made feature, dredged out and dammed in 1953, located on the PCD surplus property. It is fed primarily by groundwater from Boone Creek and by runoff from the surrounding area (USACE 2017). Other surface water features include the Ammunition Workshop Pond and an unnamed pond to the north. The Ammunition Workshop Pond is supplied by springs at the bedrock-alluvium interface. The unnamed pond receives waters from Chico Creek. No surface water bodies are associated with the potable water system at PCD (HGL 2019).

2.9 Relevant Utility Infrastructure

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

2.9.1 Stormwater Management System Description

The stormwater drainage system at PCD is extensive and consists of both open and closed drainage throughout the developed areas. The subsurface drainage serves the PCD's warehouse, equipment maintenance, and general administration areas. Stormwater is transmitted through pipes ranging in size from 12 to 36 inches in diameter. The stormwater piping system opens to drainage ways near the eastern and southern boundaries of the warehouse area and south and east of the housing area. Many areas are not serviced by the stormwater system and drain to open roadside ditches that generally drain towards Boone or Chico Creeks (USACE 2017).

2.9.2 Sewer System Description

PCD used a sanitary sewage treatment plant from 1942 until 1991. Operations were terminated due to low flow rates and the plant was demolished. Since 1991, wastewater has been conveyed to evaporation lagoons known as the East Lagoon system for treatment. The system consists of two 7.5-acre

evaporation lagoons, the north lagoon and south lagoon, constructed in 1977 and 1984, respectively. Each lagoon is lined with 30-millimeter polyvinyl chloride to prevent leakage. Wastewater is transported through a system that consists primarily of a gravity system of 6 to 10-inch vitrified clay pipe sewer mains and one lift station. Wastewater discharged to the lagoons consists of sanitary waste from PCD's administrative area, backwash from a groundwater extraction treatment and injection system, and wastewater from the Pueblo Chemical Agent Destruction Pilot Plant reverse-osmosis filters and boilers. The East Lagoon system is located within the retained portion of PCD; however, sanitary waste generated from the federal surplus property area is conveyed to the system (USACE 2017).

A second lagoon system constructed in 1995 and two active septic systems are also located in the Pueblo Chemical Agent Destruction Pilot Plant area and support chemical demilitarization efforts. In 1999, sanitary wastes generated and pumped to the lagoon systems totaled 8 million gallons. The lagoon discharges were regulated under a National Pollutant Discharge Elimination System permit that allowed discharge to Boone Creek; but no discharge had occurred, and the permit was terminated in August 2000 (USACE 2017)

2.10 Potable Water Supply and Drinking Water Receptors

PCD has two separate water supply areas; one in the northern part of PCD and one in the southern portion of the federal surplus property (**Figure 2-2**). Eleven wells supplied domestic, industrial, and irrigation waters to PCD beginning in 1942. The wells were developed to depths ranging from 48 to 70 feet below ground surface. Groundwater within the well system draws from the underlying alluvial aquifer (USACE 2017).

As of July 2011, 11 permitted water supply wells remain at PCD. Of the 11 wells, five were capped in 2010 and are planned to be deactivated, four are within the PCD Retained Property, and two serve the administrative area of PCD. The six operating wells supplying the administrative area have a pumping capacity of 74 million gallons per year (USACE 2017).

The water distribution network consists of three pump houses, three elevated storage tanks, valves, fire hydrants, and approximately 180,000 feet of water mains and service lines. Two of the storage tanks have 100,000-gallon capacities and the third has a capacity of 75,000 gallons. One of the 100,000-gallon tanks and the 75,000-gallon tank are maintained and used for fire protection/suppression (USACE 2017).

In response to the third Unregulated Contaminant Monitoring Rule (UCMR3) and Installation Management Command (IMCOM) Operations Order 16-088, the Saint Charles Mesa Water District collected quarterly samples during 2013, southwest of PCD; however, the water supply wells on PCD were not sampled under UCMR3. Results from the Saint Charles Mesa Water District samples were non-detect for six PFAS compounds. The laboratory which analyzed samples under UCMR3 met the USEPA's UCMR3 Laboratory Approval Program application and Proficiency Testing criteria for USEPA Method 537 Version 1.1.

An Environmental Data Resources, Inc. (EDR) report includes search results from a variety of environmental, state, city, and other publicly available databases for a referenced property. An EDR report was generated for PCD, which identified several off-post public and private wells within 5 miles of the PCD retained property boundary (**Figure 2-4**). The EDR report providing well search results is provided in **Appendix E.**

2.11 Ecological Receptors

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

The primary surface water features at PCD include Chico Creek, Boone Creek, Haynes Creek, Linda Ann Reservoir, Ammunition Workshop Pond, and an unnamed pond. These surface water features and associated plant and animal species are the primary ecological receptors at PCD. Chico Creek enters the Arkansas River approximately one-mile northeast of the nearest surface water intake and potentially receives surface water migrating off PCD, though evapotranspiration rates are very high and limited surface waters reach the Arkansas River (HGL 2019).

There are no designated wilderness areas or wildlife preserves within 1 mile of PCD; however, PCD does support populations of pronghorn antelope, coyote, various rodents, and reptiles. According to the U.S. Fish and Wildlife Service and Colorado Parks and Wildlife, the following federally- and state-listed endangered specifies have the potential to exist in Pueblo County, Colorado: the Least Turn, the Southwestern Willow Flycatcher, the Whooping Crane, and the Black-footed Ferret. In addition to the listed specifies, numerous wetlands identified as sensitive environmental receptors are located along the creek drainage pathways within the PCD boundaries (HGL 2019).

2.12 Previous PFAS Investigations

In November 2016, PCD sampled six of the water supply wells located on retained property and the federal surplus property for six PFAS compounds. Samples were collected from Wells 14 through 17 on the retained property, shown on **Figure 2-2**, which are located at varying distances from the potential release locations within the federal surplus property. Of the four water supply wells sampled on the retained portion of PCD, none were found to have detectable concentrations of the PFAS analytes (**Table 2-1**). The limits of quantitation (LOQ) for non-detected PFOS, PFOA, and PFBS are less than the 2019 OSD risk screening levels.

3 SUMMARY OF PA ACTIVITIES

To document areas where any potential current and/or historical PFAS-containing materials were used, stored and/or disposed at PCD, data was collected from three principal sources of information:

1. Records review
2. Personnel interviews
3. Site reconnaissance.

These sources of data, along with their relative application to this PA, are discussed below. The specific findings of records review, personnel interviews, and site reconnaissance relevant to PFAS-containing materials at PCD are described in **Section 4**.

3.1 Records Review

The records reviewed for this PA included, but were not limited to, various Installation Restoration Program administrative record documents, compliance documents, PCD fire department documents, PCD directorate of public works documents, and GIS files, along with BRAC transfer and restoration documents. Internet searches were also conducted to identify publicly available and other relevant information. A list of the specific documents reviewed for PCD is provided in **Appendix F**.

3.2 Personnel Interviews

Interviews were conducted during the site visit. The list of roles for the installation personnel interviewed during the PA process for PCD is presented below (affiliation is with PCD unless otherwise noted).

- BRAC Coordinator
- BRAC Installation Restoration Program Manager
- Fire Chief

Although this PA focuses on the PCD retained property, personnel affiliated with BRAC were present at the installation prior to the decision to excess property in 2013. Interviews with BRAC personnel were conducted as an additional source of operational information. The compiled interview logs are provided in **Appendix G**.

3.3 Site Reconnaissance

Site reconnaissance and visual surveys were conducted at the preliminary locations identified at PCD during the records review process, the installation in-brief meeting, and/or during the installation personnel interviews. The site reconnaissance logs are provided in **Appendix H**.

Preliminary locations of potential use, storage, and/or disposal of PFAS-containing materials were then evaluated in the PA (during records review, personnel interviews, and/or site reconnaissance) and were categorized as AOPIs or as areas not retained for further investigation at this time. A summary of the observations made, and data collected through records reviews (**Appendix F**), installation personnel

interviews (**Appendix G**), during the PA process for PCD is presented in **Section 4**. Further discussion regarding rationale for not retaining areas for further investigation is presented in **Section 5.1**.

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

PCD was evaluated for all potential current and historical use, storage, and/or disposal of PFAS-containing materials. There are a variety of PFAS-containing materials 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 prevalent potential source of PFAS chemicals at DoD facilities. As such, this section is organized to summarize the AFFF-related uses first, and all remaining potential PFAS-containing materials in the subsequent section.

4.1 AFFF Use, Storage, and Disposal Areas

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

Following the analysis of data collected from site reconnaissance, installation personnel interviews, and records review, there is no current or historical AFFF use or storage at PCD retained property. The PCD Fire Chief, who has been present at PCD since 1999, stated that there are no fire suppression systems containing AFFF at PCD retained property (**Appendix G**). One Fire Station, Building 62, exists on the PCD retained property and was constructed in 2011. Records review stated all AFFF was removed from the installation in 2008, prior to the construction of Building 62, which eliminates the fire station as a potential source area and is further discussed in **Section 5.1** (**Appendix F**). There is one current fire station and one historical fire station located on the federal surplus property of PCD, which are further discussed in **Section 4.3**.

Use of AFFF during emergency response to a small wildfire at an unknown location is also discussed in **Section 4.3**.

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

Following document research, personnel interviews, and site reconnaissance at PCD, it was identified that other potential PFAS source types were either not identified on the PCD retained property or did not prompt further research or constitute categorization as AOPIs. Specific discussion regarding areas not retained for further investigation is presented in **Section 5.1**.

Potential PFAS use associated with metal plating activities may also be relevant to Army installations. During metal plating operations, a metal surface may be treated with a layer of electrochemically deposited metals in an acid bath. PFAS, specifically PFOS, have been used in metal plating operations as surface tension-reducing wetting agents to mitigate the release of aerosolized chemicals into a working environment. Hard chromium plating is one type of metal plating operation where PFAS-containing mist suppressants were commonly used. Historically, it was common for spent plating baths from metal plating operations to be disposed of in a lined or unlined pit or into a sanitary or storm sewer. Therefore, PFAS present in mist suppressants during the metal plating process could be released to the environment.

Following the analysis of data collected from site reconnaissance, installation personnel interviews, and records review, it was identified that no metal plating operations occurred on the retained property of PCD. Metal plating operations historically occurred at Building 539, located on federal surplus property of PCD, and is further discussed in **Section 4.3**.

During a telephonic interview with the IMCOM Pest Management Consultant, it was noted that products containing Sulfluramid (i.e., associated with insecticides) may have contained PFAS and were phased out in 1996. During the PA records review, the IMCOM Pest Management Consultant provided records of potentially PFAS-containing pesticides and insecticides used at and/or stored at Army installations, and did not identify PCD as an installation having used or stored PFAS-containing pesticides/insecticides. Following records review, personnel interviews, and site reconnaissance at PCD, these other potential PFAS source types were either not identified at the installation or did not prompt further research or constitute categorization as AOPIs.

4.3 Readily Identifiable Off-Post PFAS Sources

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

Potential sources identified on PCD federal surplus property from the BRAC realignment actions are considered off-post sources. The land area that was federally surplused during the BRAC realignment actions is described in **Section 2.3** and the retained portion of PCD is outlined on **Figure 2-2**. The following summaries of the potential off-post sources are based on the Preliminary Assessment of Aqueous Film Forming Foam Areas at Pueblo Chemical Depot conducted by HydroGeoLogic, Inc in 2019 (HGL 2019).

The Fire Protection Training Area (Solid Waste Management Unit [SWMU] 29) is in the southern portion of the federal surplus property of PCD, just north of the Landfill (SWMU 14), shown on **Figure 2-5**. Based on records review, the area consists of a shallow depression approximately 24 feet wide by 25 feet long and 1.5 feet deep and was used for fire training exercises twice in the 1980s. Exercises consisted of burning off-specification oil and diesel in a lined pit and extinguishing the fire. The use of AFFF during these exercises could not be confirmed. The depression was lined with a synthetic liner, covered with soil and gravel, and surrounded by an earthen berm. After completion of fire exercises, the soil from the lined pit was removed, and the old liner was replaced. Removal actions conducted in 2006 removed 318 cubic yards of soil from the fire training pit and adjacent drainage channel.

Based on records review (**Appendix F**) and installation personnel interviews (**Appendix G**), two fire stations have served federal surplus property of PCD during its operational history, shown on **Figure 2-5**. Building 3 is a former fire station, built in the 1950s or 1960s, and was the oldest known fire station to have served PCD. Building 3 was in use until the construction of Building 61 in the late 1980s. There is no documentation of what was stored in Building 3 from the 1960s to the late 1980s, when AFFF would likely have been used. Currently, Building 3 contains an exercise gym and administrative offices. The current south fire station, Building 61, was built in the late 1980s. The PCD Fire Chief stated that AFFF was stored in the northern bay of Building 61 and in a single fire truck tank until 2008, when the AFFF supply was disposed of by PCD. The Fire Chief also stated any AFFF would gel and became unusable, resulting in AFFF being containerized and eventually turned in for disposal. The method of disposal prior to 1999 is unknown. Building 3 and Building 61 are both located on federal surplus property.

Metal plating operations were conducted in Building 539, located on federal surplus property of PCD, until 1973 when the building was demolished. Operational wastes from the former metal plating shop and the metal surface treatment shop went to a drainage ditch that runs east to west along the southern boundary of the warehouse area and dissipates to the east. The Plating Waste Drainage Ditch and Former Building 539 (SWMU 28) are located on federal surplus property, shown on **Figure 2-5.** It is unknown if PFAS were used as a vapor suppressant during plating operations in the shops. In 2010, excavation along the length of the drainage ditch removed 1,700 cubic yards of soil. As part of an exit strategy investigation at SWMU 28 in 2018, groundwater was sampled at two locations and analyzed for 18 PFAS. The two piezometers selected for sampling were based on their proximity to the head of the former drainage ditch where the highest concentrations of trichloroethene were observed. The sampling depths of each piezometer were not reported, however groundwater depths in the area range from 30 to 56 feet below ground surface. PFOS, PFOA, and PFBS were not detected above the LOQ (20 parts per trillion) during this sampling event (**Table 2-1**). The full analytical results from the 2018 sampling event are included as **Appendix I**.

The Landfill (SWMU 14) is located along the southern boundary of PCD federal surplus property and occupies 153 acres (**Figure 2-5**). The landfill is divided by Post Engineer Dump Road and bounded by a natural ditch to the east. The eastern section of the landfill was used from 1941 to 1967 for disposing general installation waste and combustible material was open burned. From 1967 to 1979, ash from the boiler plants was still dumped in the eastern section. The western section of the landfill was used from 1967 to 1992 for the disposal of installation waste. Waste received in this section included industrial waste from the metal plating and metal surface treatment shops until 1973. Fire training exercises reportedly occurred at SWMU 14 during its operational period. As part of an exit strategy investigation in 2018, groundwater was sampled for PFAS at two piezometers. The two piezometers selected for sampling were based on their proximity to the centers of the two largest and most contaminated burn pits. Sampling depths were not reported but groundwater depths in the area range from 29 and 38 feet below ground surface. PFOS, PFOA, and PFBS were not detected above the LOQ (20 parts per trillion) during this sampling event (**Table 2-1**). The full analytical results from the 2018 sampling event are included as **Appendix I**.

In November 2016, PCD sampled six of the water supply wells for six PFAS on both retained property and the federal surplus property. Samples were collected from Wells 12 and 13, shown on **Figure 2-2**, which are located on federal surplus property at varying distances from the off-post potential release locations. Of the two water supply wells sampled on the federal surplus property of PCD, neither were

found to have detectable concentrations of the PFAS analytes (**Table 2-1**). The LOQs for non-detected PFOS, PFOA, and PFBS are less than the 2019 OSD risk screening levels.

AFFF used by the PCD fire department during emergency response was required at a small wildfire prior to 1999. The quantity used, approximately date of occurrence, and location of the wildfire remain unknown. Numerous historical wildfires have been reported near the surrounding area of PCD, including wildfires in 2011 and 2018. Emergency response to these wildfires and proximity to the PCD retained property is unknown.

Other potential off-post sources include a volunteer fire station in the unincorporated community of Avondale located approximately 1.5 miles south of PCD and a volunteer fire station in the Town of Boone located approximately 2 miles southeast of PCD.

5 SUMMARY AND DISCUSSION OF PA RESULTS

The preliminary locations evaluated for potential use, storage, and/or disposal of PFAS-containing materials at PCD were refined during the PA process and identified either as an area not retained for further investigation or as an AOPI. In accordance with the established process for the PA, no areas have been identified as AOPIs. The process used for refining these areas is presented on **Figure 5-1**, below.

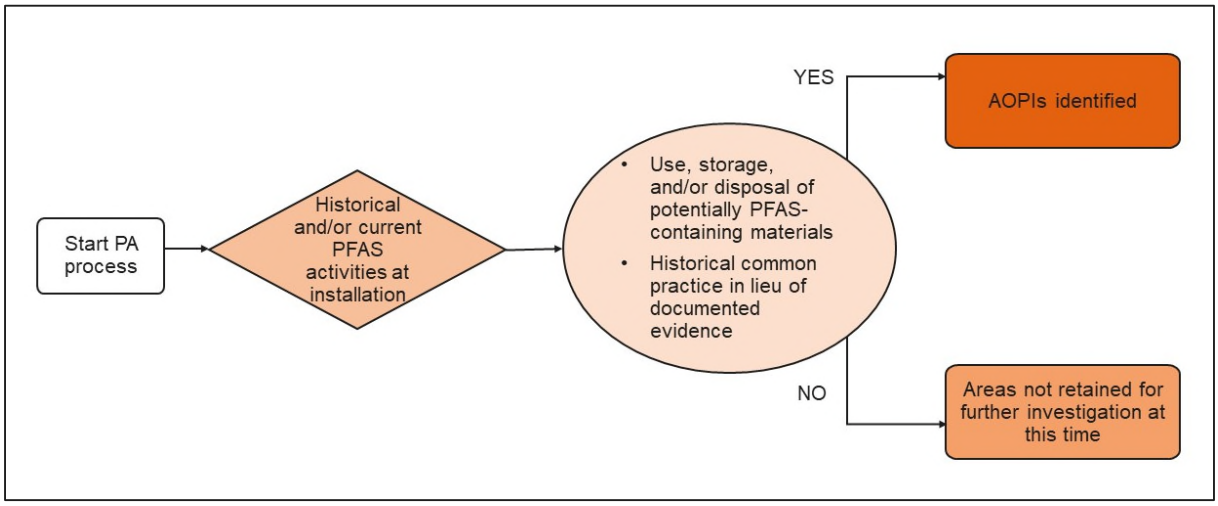

Figure 5-1: AOPI Decision Flowchart

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

Data limitations for this PA at PCD are presented in **Section 6**.

5.1 Areas Not Retained for Further Investigation

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

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

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

Area Description	Dates of Operation	Relevant Site History	Rationale
Building 576 and Building 581	2018	Warehouse fires at PCD in March 2018. No emergency response was required.	No historical use, storage, and/or disposal of PFAS-containing materials

Area Description	Dates of Operation	Relevant Site History	Rationale
Building 62 – Fire Station	2011 to Present	North fire station constructed in 2011. AFFF was eliminated from use at PCD in 2008 and there is no knowledge of AFFF storage at the station. Currently uses Cold Fire during emergency response.	No historical use, storage, and/or disposal of PFAS-containing materials
East Burn Area (SMWU 4)	1946 to 1953	Used for the demilitarization of naval rounds and Composition B bombs. Munitions and explosives of concern clearance was conducted during Site Investigations from 1997 to 1999 and in 2014. All other burn areas are expected to have comparable historical practices.	No historical use, storage, and/or disposal of PFAS-containing materials
East Chemical Munitions Burial Ground (SMWU 13)	1942 to 1946	Disposal pits lined with bleach, dunnage, and fuel to decontaminate bombs both thermally and chemically, including use of bleaching powder and residual ignition sources including thermite and white phosphorus. Primarily destroyed sulfur mustard agent filled and Lewsite filled bombs. Area was leveled and fenced off in 1946.	No historical use, storage, and/or disposal of PFAS-containing materials

6 CONCLUSIONS AND RECOMMENDATIONS

The PFAS PA did not identify any AOPIs at PCD based on the use, storage, and/or disposal of PFAS-containing materials, in accordance with the 2018 Army Guidance for Addressing Releases of Per-and Polyfluoroalkyl Substances (Army 2018).

OSD provided residential risk screening levels based on the USEPA oral reference dose for PFOS, PFOA, and PFBS in soil and groundwater (tap water) and industrial/commercial risk screening levels for PFOS, PFOA, and PFBS in soil (**Appendix A**). A combination of document review, internet searches, interviews with installation personnel, and an installation site visit were used to identify specific areas of suspected PFOS, PFOA, and PFBS use, storage, and/or disposal at PCD. Following the evaluation, no AOPIs were identified.

Data collected during the PA, as discussed in **Sections 3** through **5**, were sufficient to draw the conclusion summarized above. The data limitations relevant to the development of this PA for PFOS, PFOA, and PFBS at PCD are discussed below.

AFFF was used during an emergency response to a small wildfire prior to 1999. However, quantity of AFFF used, approximate date, and location of the wildfire remains unknown.

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

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

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

Finally, the available PFOS, PFOA, and PFBS analytical data is limited to UCMR3, groundwater samples from on-post supply wells, and groundwater samples from existing piezometers during previous site investigations.

Results from this PA indicate further study in a site investigation is not warranted at PCD in accordance with the guidance provided by the OSD.

7 REFERENCES

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ACRONYMS

%	percent
AFFF	aqueous film-forming foam
AOPI	area of potential interest
Arcadis	Arcadis U.S., Inc.
Army	United States Army
BRAC	Base Realignment and Closure
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
EDR	Environmental Data Resources, Inc.
GIS	geographic information system
HGL	HydroGeoLogic, Inc.
IMCOM	Installation Management Command
installation	U.S. Army or Reserve installation
LOQ	limit of quantitation
ng/L	nanograms per liter (parts per trillion)
OSD	Office of the Secretary of Defense
PA	preliminary assessment
PCD	Pueblo Chemical Depot
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
POC	point of contact
SWMU	solid waste management unit
UCMR3	third Unregulated Contaminant Monitoring Rule
U.S.	United States
USACE	United States Army Corps of Engineers
USAEC	United States Army Environmental Command
USEPA	United States Environmental Protection Agency

TABLES

Table 2-1 - Historical PFAS Analytical Results
USAEC PFAS Preliminary Assessment
Pueblo Chemical Depot, Colorado

Sample Location		Well 12[1]	Well 13[1]	Well 14[1]	Well 15[1]	Well 16[1]	Well 17[1]	SWMU 14		SWMU 28	
Piezometer ID		N/A	N/A	N/A	N/A	N/A	N/A	LFPIEZ005A[2]	LFPIEZ001A[2]	DDPIEZ003A[2]	DDPIEZ0038B[2]
Sample Date[2]		14-Nov-2016	14-Nov-2016	14-Nov-2016	14-Nov-2016	14-Nov-2016	14-Nov-2016	January 2018			
PFAS	**units**										
6:2 Fluorotelomer sulfonate	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
8:2 Fluorotelomer sulfonate	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
Perfluorobutanoic acid	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
Perfluorobutane sulfonic acid (PFBS)	µg/L	<0.042	<0.042	<0.043	<0.042	<0.044	<0.043	<0.020	<0.020	<0.020	<0.020
Perfluorodecane Sulfonate	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
Perfluoroheptanoic acid (PFHpA)	µg/L	<0.0040	<0.0041	<0.0041	<0.0041	<0.0042	<0.0042	<0.020	<0.020	<0.020	<0.020
Perfluorohexane sulfonic acid (PFHxS)	µg/L	<0.010	<0.010	<0.011	<0.011	<0.011	<0.011	<0.020	<0.020	<0.020	<0.020
Perfluorononanoic acid (PFNA)	µg/L	<0.0099	<0.010	<0.010	<0.010	<0.010	<0.010	<0.020	<0.020	<0.020	<0.020
Perfluorooctane sulfonamide (PFOSA)	µg/L	--	--	--	--	--	--	<0.020	**0.020 J[3]**	<0.020	<0.020
Perfluoropentanoic acid (PFPeA)	µg/L	--	--	--	--	--	--	<0.020	**0.022**	<0.020	<0.020
Perfluorooctanesulfonic acid (PFOS)	µg/L	<0.014	<0.014	<0.014	<0.014	<0.014	<0.014	<0.020	<0.020	<0.020	<0.020
Perfluorooctanoic acid (PFOA)	µg/L	<0.0083	<0.0083	<0.0084	<0.0084	<0.0087	<0.0085	<0.020	<0.020	<0.020	<0.020
Perfluorodecanoic acid (PFDA)	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
Perfluorohexanoic acid (PFHxA)	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
Perfluorododecanoic acid (PFDoA)	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
Perfluorotetradecanoic acid (PFTeA)	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
Perfluorotridecanoic acid (PFTrDA)	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020
Perfluoroundecanoic acid (PFudA)	µg/L	--	--	--	--	--	--	<0.020	<0.020	<0.020	<0.020

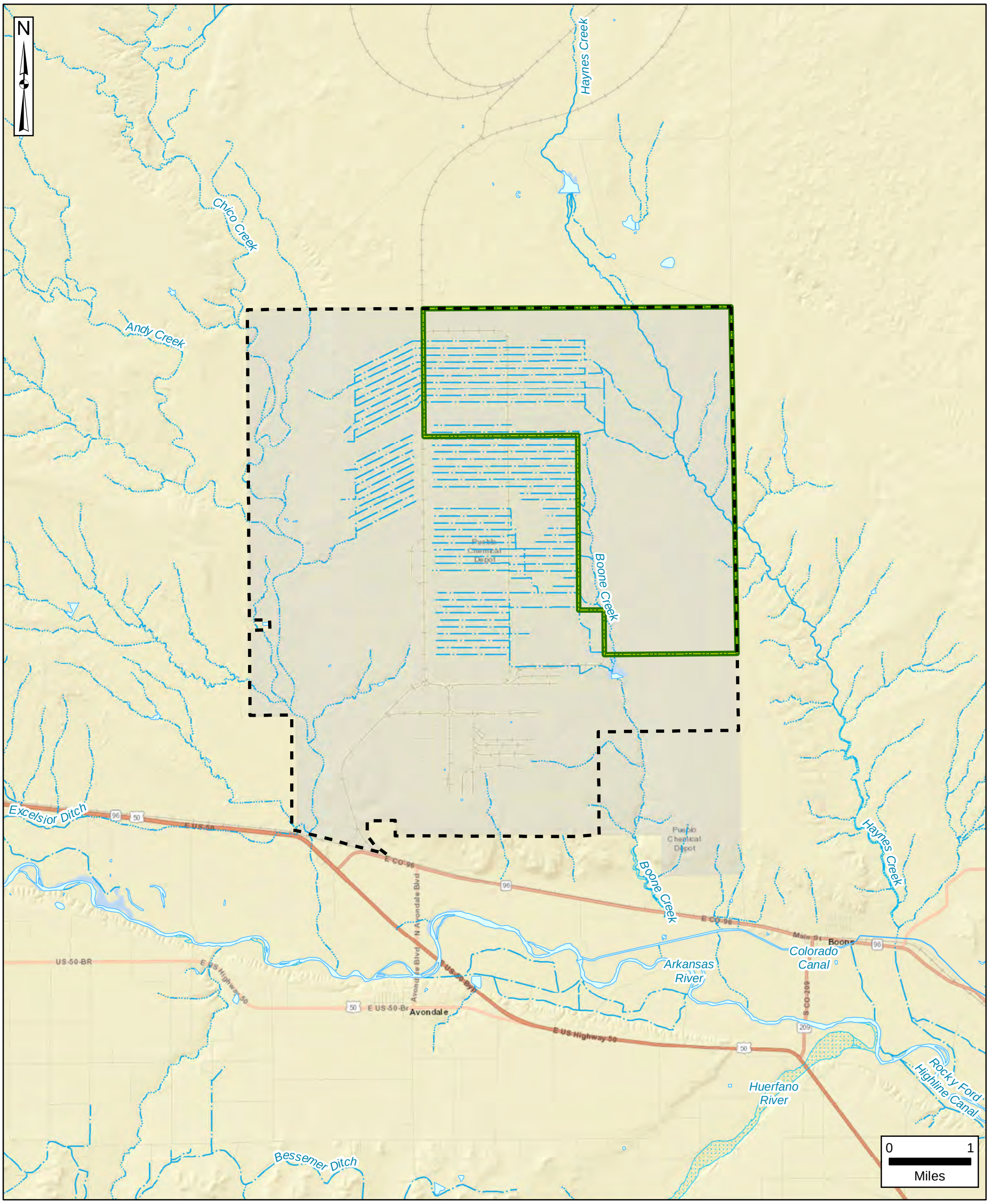
Notes:
[1] Samples were analyzed by USEPA Method 537 Drinking Water. TestAmerica Laboratories, Inc. performed the November 2016 analyses.
[2] Samples were collected and analyzed as part of the 2018 First Quarter Exit Strategy Investigation conducted by TLI Solutions, Inc. Samples were analyzed by method CAM SOP-00894. Maxxam Analytics performed the January 2018 analyses.
[3] J flagged qualifier was not defined with the 2018 analytical data reported in the *Draft Preliminary Assessment of Aqueous Film Forming Foam Areas Pueblo Chemical Depot* nor the Maxxam Analtytics laboratory reports.

Acronyms/Abbreviations:
Bold = concentration detected greater than the method reporting limit
< = compound was not detected greater than the method reporting limit
-- = not applicable
HQ = hazard quotient
ID = identification
LHA = Lifetime Health Advisory
N/A = not applicable
OSD = Office of the Secretary of Defense
SWMU = Solid Waste Management Unit
µg/L = micrograms per liter
USEPA = United States Environmental Protection Agency

FIGURES

USAEC PFAS Preliminary Assessment
Pueblo Chemical Depot, CO

Figure 2-1
Site Location



PCD Retained Property
Former PCD Installation Boundary
River/Stream (Perennial)
Stream (Intermittent/Ephemeral)
Canal/Ditch
Water Body
Wash

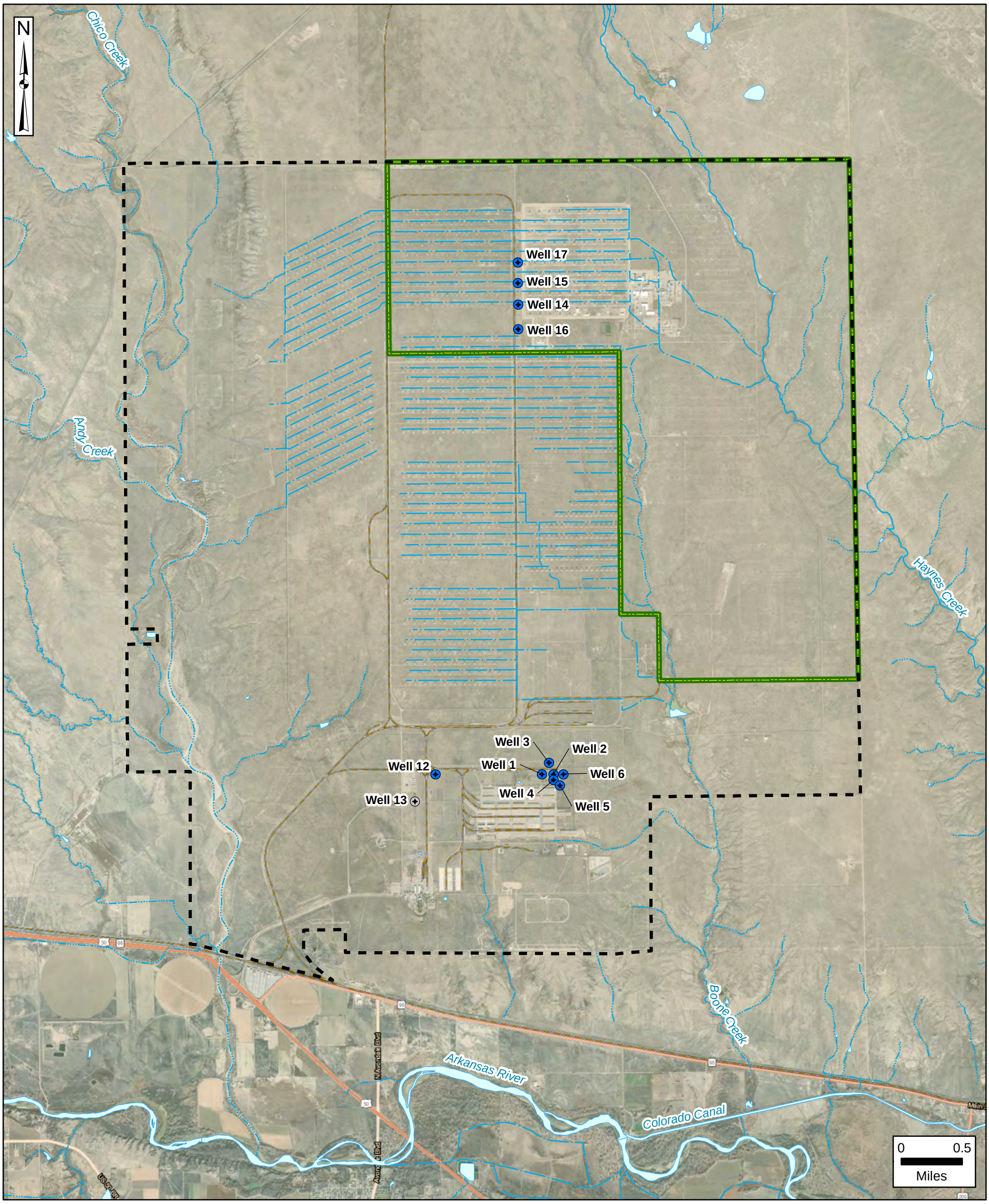
PCD = Pueblo Chemical Depot

Data Sources:
PCD, GIS Data, 2020
USGS, NHD Data, 2018
ESRI, ArcGIS Online, StreetMap Data

Coordinate System:
WGS 1984, UTM Zone 13 North

USAEC PFAS Preliminary Assessment
Pueblo Chemical Depot, CO

Figure 2-2
Site Layout



PCD Retained Property
Former PCD Installation Boundary
River/Stream (Perennial)
Stream (Intermittent/Ephemeral)
Canal/Ditch
Water Body
Installation Water Supply Well
Former Installation Water Supply Well (not permitted for use)

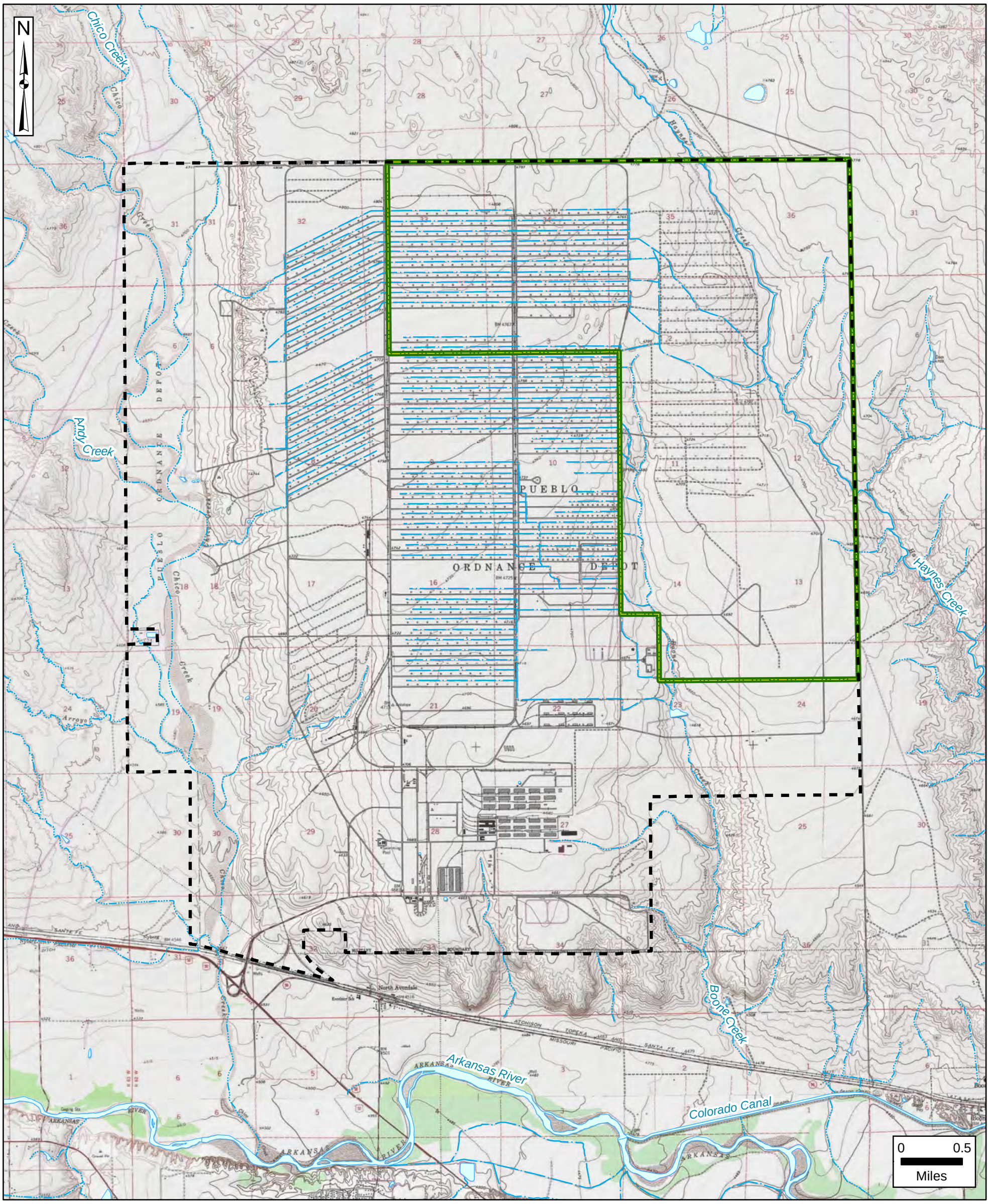
PCD = Pueblo Chemical Depot

Data Sources:
PCD, GIS Data, 2020
USGS, NHD Data, 2018
ESRI, ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 13 North

USAEC PFAS Preliminary Assessment
Pueblo Chemical Depot, CO

Figure 2-3
Topographic Map



PCD Retained Property
Former PCD Installation Boundary
River/Stream (Perennial)
Stream (Intermittent/Ephemeral)
Canal/Ditch
Water Body

Contour interval = 10 feet

Note: PCD formerly operated as Pueblo Ordnance Depot.

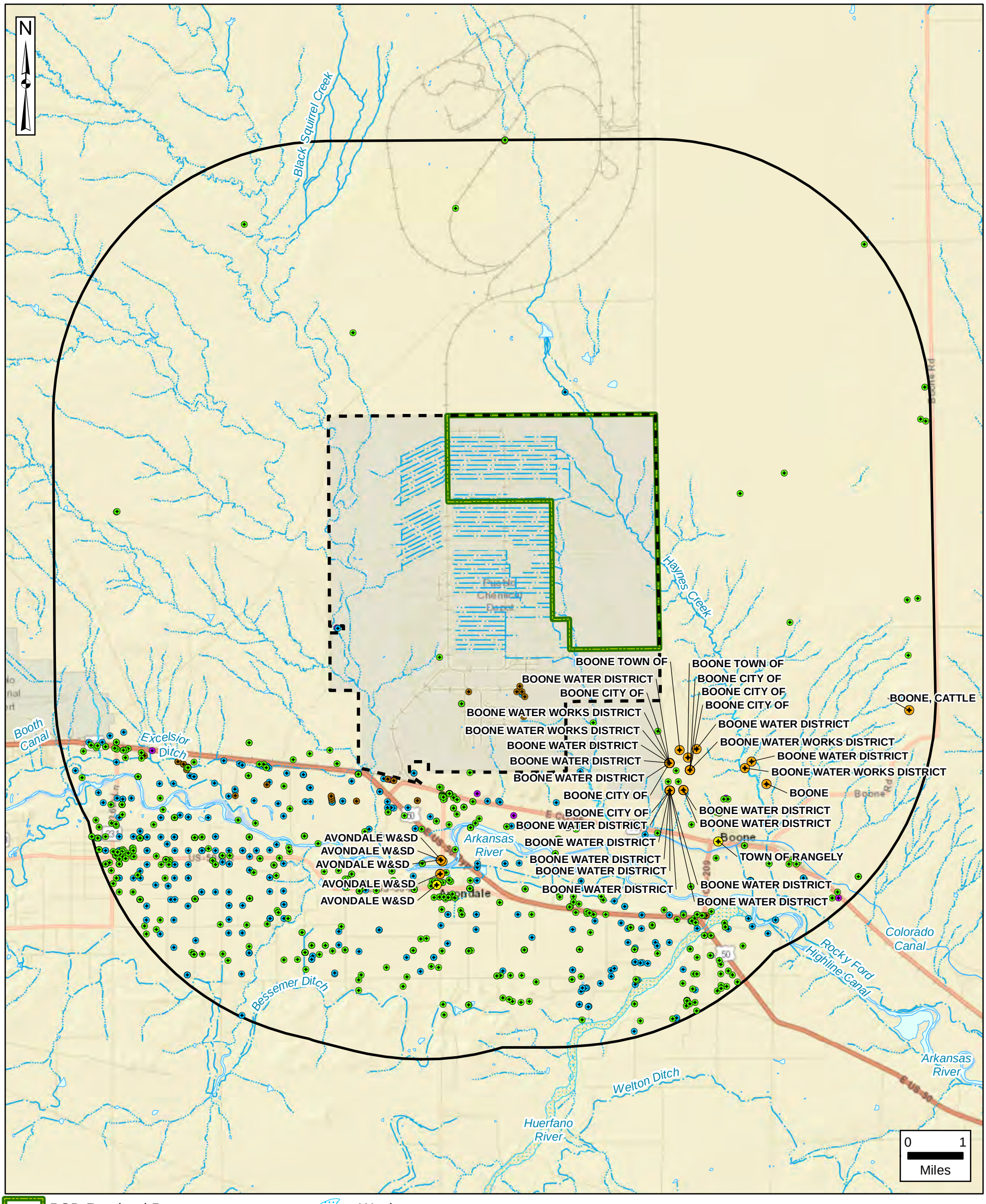
PCD = Pueblo Chemical Depot

Data Sources:
PCD, GIS Data, 2020
USGS, NHD Data, 2018
ESRI, ArcGIS Online, USA Topo Maps

Coordinate System:
WGS 1984, UTM Zone 13 North

USAEC PFAS Preliminary Assessment / Site Inspection
Pueblo Chemical Depot, CO

Figure 2-4
Off-Post Potable Supply Wells



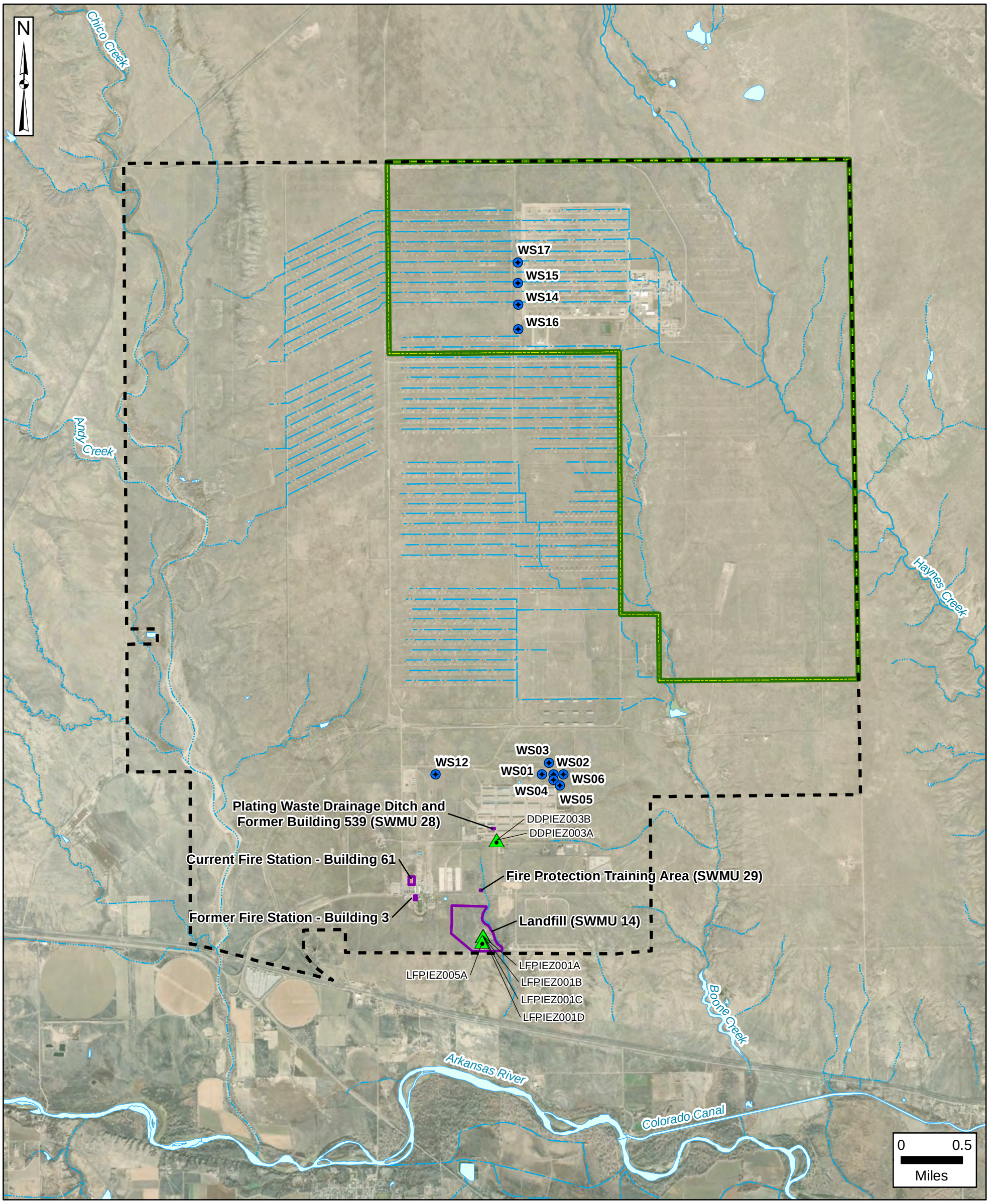
PCD = Pueblo Chemical Depot
W&SD = Water & Sanitation District

Data Sources:
EDR, PWSS Well Data, 2020
CO DNR, Well Data, 2020
PCD, GIS Data, 2020
ESRI, ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 13 North

USAEC PFAS Preliminary Assessment
Pueblo Chemical Depot, CO

Figure 2-5
Off-Post Potential Source Areas



PCD Retained Property
Former PCD Installation Boundary
Potential Source Area
River/Stream (Perennial)
Stream (Intermittent/Ephemeral)
Canal/Ditch
Water Body
Installation Water Supply Well
Piezometer

PCD = Pueblo Chemical Depot
SWMU = Solid Waste Management Unit

Data Sources:
PCD, GIS Data, 2020
ESRI, ArcGIS Online, Aerial Imagery

Coordinate System:
WGS 1984, UTM Zone 13 North

APPENDIX A

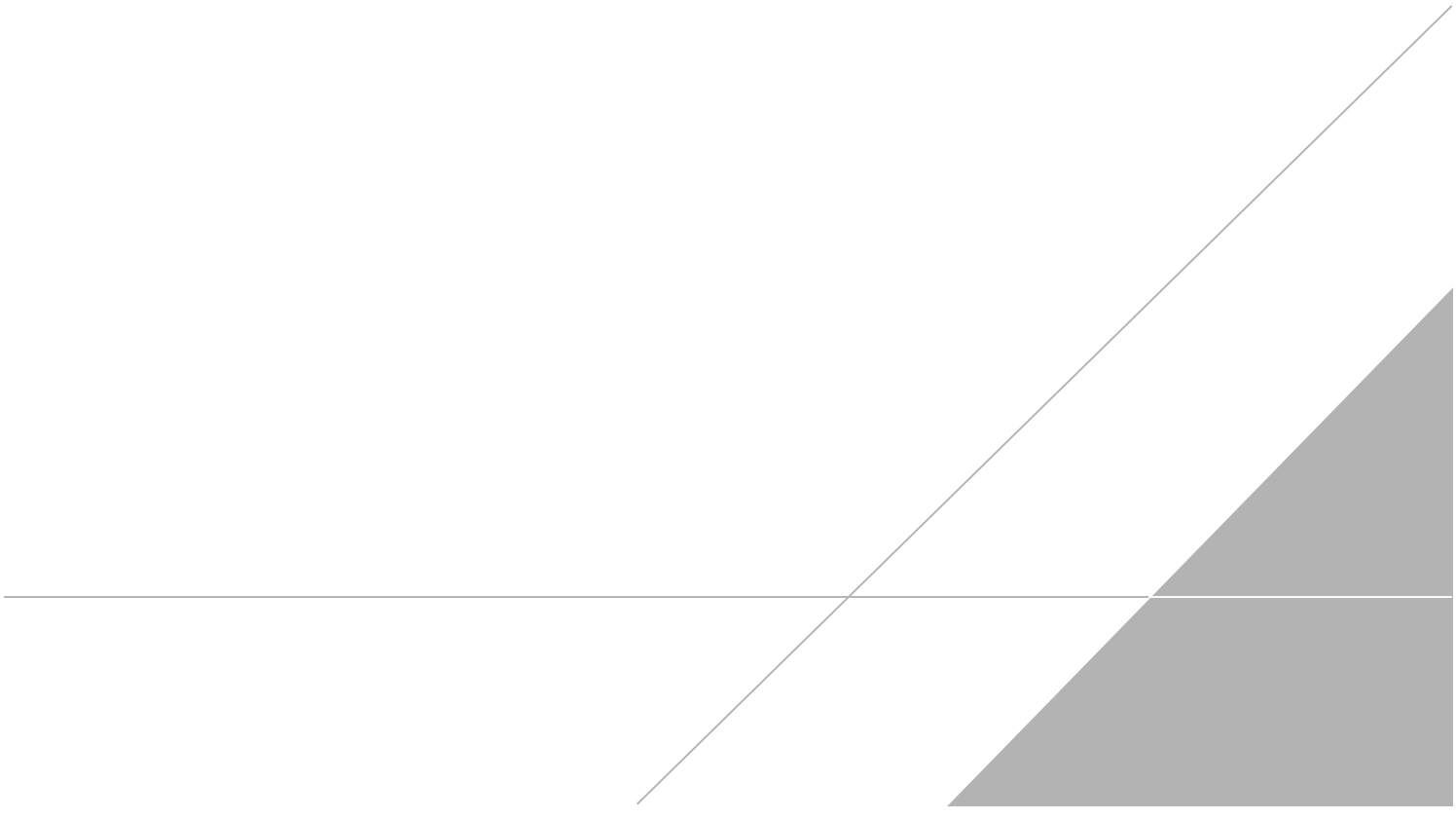
Office of the Secretary of Defense. 2021. Memorandum: Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program. September 15.

APPENDIX B

Preliminary Assessment Quality Control Checklist

APPENDIX C

Antiterrorism/Operations Security Review Cover Sheet



APPENDIX E

Installation EDR Survey Reports

APPENDIX F

Research Log

APPENDIX G

Compiled Interview Logs

APPENDIX H

Compiled Site Reconnaissance Log

APPENDIX I

2018 Exit Strategy Analytical Results

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