FINAL

SITE INSPECTION REPORT

HOLLOMAN AIR FORCE BASE, NEW MEXICO

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas Environmental Programs Worldwide

Contract FA8903-16-D-0027
Task Order 0004

Prepared for:

Air Force Civil Engineer Center
JBSA Lackland, Texas

November 2018

Submitted by:

amec foster wheeler

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SITE INSPECTION REPORT

SITE INSPECTION OF AQUEOUS FILM FORMING FOAM (AFFF) RELEASE AREAS ENVIRONMENTAL PROGRAMS WORLDWIDE

HOLLOMAN AIR FORCE BASE
ALAMOGORDO, NEW MEXICO

Project No. RPMO20167118

Prepared for:
Air Force Civil Engineer Center
Joint Base San Antonio – Lackland, Texas

Prepared by:

Amec Foster Wheeler Programs, Inc.

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ACRONYMS

ACC	Air Combat Command
Accutest	SGS Accutest Analytical Laboratory
AEI	Amec Foster Wheeler Environment & Infrastructure, Inc.
AFB	Air Force Base
AFCEC	Air Force Civil Engineer Center
AFFF	Aqueous Film Forming Foam
AFSC	Air Force Systems Command
AMC	Air Materiel Command
Amec Foster Wheeler	Amec Foster Wheeler Programs, Inc., and its affiliate Amec Foster Wheeler Environment & Infrastructure Inc., collectively
BEE	Bioenvironmental Engineering
bgs	below ground surface
BRAC	Base Realignment and Closure
BRACC	Base Realignment and Closure Commission
CoC	Chain-of-Custody
DL	Detection Limit
DO	dissolved oxygen
DoD	Department of Defense
DQO	Data Quality Objective
FTA	fire training area
FTS	fluorotelomer sulfonate
HA	Health Advisory
HDPE	high-density polyethylene
HGL	HydroGeoLogic, Inc.
HSA	Hollow Stem Auger
IDW	Investigation-Derived Waste
ISWP	Installation-Specific Work Plan
LC-MS-MS	Liquid Chromatography and Tandem Mass Spectrometry
LOQ	Limit of Quantification
µg/L	micrograms per liter
µg/kg	micrograms per kilogram
mg/kg	milligrams per kilogram
mg/l	milligrams per liter
MS	Matrix Spike
MSD	Matrix Spike Duplicate

NEtFOSAA	N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)
NMeFOSAA	N-Methyl perfluorooctanesulfonamidoacetic acid
NMED	New Mexico Environment Department
NMWQCC	New Mexico Water Quality Control Commission
ORP	oxygen reduction potential
PA	Preliminary Assessment
PFAS	per- and polyfluorinated alkyl substances
PFBS	perfluorobutanesulfonic acid
PFC	perfluorinated compound
PFDA	Perfluorodecanoic acid
PFDoA	Perfluorododecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	Perfluorohexanoic acid
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFTA	Perfluorotetradecanoic acid
PFTrDA	Perfluorotridecanoic acid
PFUnA	Perfluoroundecanoic acid
PPE	personal protective equipment
PVC	polyvinyl chloride
QC	Quality Control
QPP	Quality Program Plan
RSL	Regional Screening Level
SESD	Science and Ecosystem Support Division
SI	Site Inspection
SIR	Site Inspection Report
SOP	Standard Operating Procedure
S.U.	Standard Unit
SWMU	Solid Waste Management Unit
TAC	Tactical Air Command
TDS	Total Dissolved Solids
THQ	Total Hazard Quotient
TOC	total organic carbon
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
WWTP	waste water treatment plant

EXECUTIVE SUMMARY

This Site Inspection (SI) Report (SIR) was prepared by Amec Foster Wheeler Programs, Inc., together with affiliate Wood Environment & Infrastructure Solutions, Inc. (formerly known as Amec Foster Wheeler Environment & Infrastructure, Inc.)[1], collectively referred to as Amec Foster Wheeler, under Contract No. FA8903-16-D-0027, Task Order 0004, to document the results of SI activities conducted at five aqueous film forming foam (AFFF) release areas located at Holloman Air Force Base (AFB). The purpose of the SI was to determine, through environmental media sampling, if a release of per- and polyfluorinated alkyl substances (PFAS) has occurred at potential AFFF release areas identified during a Preliminary Assessment (PA) conducted by HydroGeologic, Inc. (HGL) (2015), or during the installation scoping visit conducted by Amec Foster Wheeler on 27 October 2016.

The data presented in this SIR were collected and evaluated in accordance with the Final Installation-Specific Work Plan (ISWP) (Amec Foster Wheeler, 2017a) and the General Quality Program Plan (QPP) (Amec Foster Wheeler, 2017b).

PFAS are a class of synthetic organofluorine compounds that possess a chemical structure that gives them unique properties, including thermal stability and the ability to repel both water and oil. These chemical properties make them useful components in a wide variety of consumer and industrial products, including non-stick cookware, food packaging, waterproof clothing, fabric stain protectors, lubricants, paints, and firefighting foams such as AFFF. AFFF concentrate contains fluorocarbon surfactants to meet required performance standards for fire extinguishing agents (Department of Defense [DoD] Military Specification MIL-F-24385F [SH], Amendment 1, 5 August 1984). The United States Air Force (USAF) began purchasing and using AFFF containing PFAS (perfluorooctanesulfonic acid [PFOS] and/or perfluorooctanoic acid [PFOA]) for extinguishing petroleum fires and during firefighting training activities in 1970. AFFF was primarily used on USAF installations at fire training areas (FTAs), but may have also been used, stored or released from hangar fire suppression systems, at firefighting equipment testing and maintenance areas, and during emergency response actions for fuel spills and/or aircraft mishaps.

The United States Environmental Protection Agency (USEPA) Office of Water issued lifetime drinking water Health Advisory (HA) values for PFOS and PFOA in May 2016 that replaced the 2009 Provisional HA values. The HA values for PFOS and PFOA are 0.07 micrograms per liter (µg/L) for each constituent; however, when these two chemicals co-occur in a drinking water source, a conservative and health-protective approach is recommended that compares the sum of the concentrations (PFOS + PFOA) to the HA value (0.07 µg/L). HA values are not to be construed as legally enforceable federal standards and are subject to change as additional information becomes available (USEPA, 2016a and 2016b). Although the

[1] Amec Foster Wheeler Environment & Infrastructure, Inc. changed its name on 6 April 2018 to Wood Environment & Infrastructure Solutions, Inc., to reflect Wood Group's acquisition of Amec Foster Wheeler. All resource documents created, and activities conducted under Amec Foster Wheeler Environment & Infrastructure, Inc. remain in place, will be referred to Amec Foster Wheeler, and are executed under Wood Environment & Infrastructure Solutions, Inc.

USEPA has not established HA values for PFAS in soil, the USAF calculated a residential screening level of 1.26 milligrams per kilogram (mg/kg) for PFOS and PFOA in soil, based on a total hazard quotient (THQ) of 1.0, using the USEPA Regional Screening Level (RSL) calculator (https://epa-prgs.ornl.gov/cgi-bin/chemicals/ csl_search). This screening value was presented in the Final ISWP (Amec Foster Wheeler, 2017a); however, in March 2018, the USAF issued revised guidance, *PFAS Site Inspection Objectives and Follow-On Activities,* whereby a new residential screening level for soil and sediment of 0.126 mg/kg was calculated based on a THQ of 0.1 (USAF, 2018).

While PFOS and PFOA in groundwater are the focus of the HA, the USEPA has also derived Tap Water RSL values for perfluorobutanesulfonic acid (PFBS) for which there is a Tier 2 toxicity value (Provisional Peer Review Toxicity Value) (USEPA, 2017a). Based on the Final ISWP (Amec Foster Wheeler, 2017a), concentrations of PFBS detected in groundwater and soil were to be compared to the Tap Water RSL of 400 µg/L and residential RSL of 1,300 mg/kg, respectively. However, as per the USAF revised guidance issued subsequent to the ISWP, a revised residential screening level for PFBS in soil of 130 mg/kg was calculated based on a THQ of 0.1 and will be used for comparison in this SIR (USAF, 2018).

Neither the USEPA nor New Mexico Environment Department (NMED) have issued HA values or promulgated standards for any other PFAS constituents to date.

Holloman AFB is located in Otero County in south central New Mexico, approximately six miles southwest of the city of Alamogordo and 75 miles north-northeast of El Paso, Texas. The installation covers approximately 59,800 acres (USAF, 2017). The installation is located in the Tularosa Basin, which is bounded by the San Andres Mountains to the west and the Sacramento Mountains to the east.

Holloman AFB is currently home of the 49th wing of the ACC, 96th Test Group, 54th Fighter Group and the German Air Force Flying Training Center. Operations at Holloman AFB include missile testing, aircraft and pilot training, operational equipment and systems testing, and aircraft maintenance and storage (USAF, 2017).

The PA provided findings from research conducted to determine whether and where AFFF, containing PFAS, was stored, handled, used or released at Holloman AFB. Based on the research conducted during the PA, as well as the information collected during an installation scoping visit conducted by Amec Foster Wheeler on 27 October 2016, the following five AFFF release areas were recommended for SI:

- AFFF Release Area 1: Former FTA (FT-31).
- AFFF Release Area 2: Sewage Lagoon Area Outfall
- AFFF Release Area 3: Apache Mesa Golf Course Outfall
- AFFF Release Area 4: Lake Holloman Outfalls
- AFFF Release Area 5: Evaporation Pond No. 2

The specific objectives of the SI were as follows:

- Determine if PFAS are present in soil, sediment, groundwater or surface water at AFFF release areas selected for SI;

- Determine if PFOS and PFOA concentrations in soil or sediment exceed the calculated RSL, based on a residential exposure scenario, of 0.126 mg/kg, and PFBS concentrations exceed the USEPA residential RSL of 130 mg/kg;
- Determine if concentrations of PFOS, PFOA, or the sum of PFOS and PFOA, in groundwater and surface water exceed the USEPA HA value of 0.07 µg /L, and if PFBS concentrations exceed the USEPA Tap Water RSL of 400 µg/L; and,
- Identify potential receptor pathways with immediate impacts to human health (immediate impact to human health is considered consumption of drinking water with PFOS/PFOA above the USEPA HA value, or PFBS above the USEPA Tap Water RSL).

PFAS Analytical Results

PFOS in surface and subsurface soil exceeded the calculated RSL, based on a residential scenario, at AFFF release areas 1 and 5.

PFOS, PFOA, and/or PFOS+PFOA in groundwater exceeded the USEPA HA values at AFFF release areas 1, 2, 3, and 5 (all areas where groundwater was sampled). PFBS in groundwater was detected below the USEPA Tap Water RSL at all AFFF release areas.

PFOS was detected in sediment at AFFF release areas 2, 3, and 4; the detections at release areas 3 and 4 exceeded the calculated RSL. PFOA and PFBS were detected in sediment at AFFF Release Area 4, but the detections were below the respective RSLs.

PFOS, PFOA, and/or PFOS+PFOA in surface water exceeded the USEPA HA values at all AFFF release areas where surface water sampling was conducted (AFFF release areas 2, 3, and 4).

Surface and Subsurface Soil Receptors

Potential human receptors of PFOS and PFOA concentrations in surface and subsurface soil above the RSL at AFFF release areas 1 and 5 include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers. Based on the SI, potential complete pathways for human exposure to PFAS-impacted surface and subsurface soil through inhalation of dust derived from contaminated surface soil, ingestion, and/or dermal contact were identified for AFFF release areas 1 and 5.

Groundwater Receptors

Potential human receptors from PFAS in groundwater include on-base personnel, residents, grounds maintenance workers, utility workers, construction workers that may encounter the shallow water table at AFFF Release Areas 1, 2, 3, and 5 where PFOS, PFOA, and PFOA+PFOA exceeded the USEPA HA value.

Human groundwater receptors via the ingestion pathway are not present for any AFFF release area at or downgradient (southwest) of Holloman AFB since groundwater beneath Holloman AFB is classified as unfit for human consumption due to the generally poor ambient groundwater quality. Concentrations of total dissolved solids (TDS) in groundwater exceed the New Mexico Water Quality Control Commission

(NMWQCC) human health standard of 1,000 milligrams per liter (mg/l) and therefore no potable water supply wells are located at Holloman AFB. All potable water at the installation is obtained from 15 wells located 12 to 35 miles southeast of the installation at an average depth of 450 to 550 feet (Holloman AFB, 2016). The potable water supply at Holloman AFB was sampled for PFAS by Holloman AFB Bioenvironmental Engineering (BEE) personnel and no detections were reported.

Although the City of Alamogordo obtains potable water from the same well field as Holloman AFB, private water supply wells are also utilized outside the city limits and within 4-miles of the installation boundary. Groundwater flow on, and in the vicinity of Holloman AFB is directed to the southwest, coincident with regional topography and therefore all identified private water supply wells are located in up- or side-gradient locations relative to the AFFF release areas and not considered receptors for groundwater from the installation.

As a result, there is currently no potential receptor pathway with immediate impacts to human health at Holloman AFB

Sediment Receptors

Potential human receptors of PFOS concentrations in sediment above the RSL at AFFF release areas 3 and 4 include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, trespassers and/or recreational users of Lake Holloman that may come in contact with impacted sediment. Exposure routes include dermal contact with submerged or exposed sediment during work activities such as maintenance of ponds, drainage ditches, and canals, as well as various recreational activities at or downstream of Lake Holloman or at Apache Mesa Golf Course.

Surface Water Receptors

Potential human exposure receptors from PFAS in surface water include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors or trespassers that may encounter surface water at AFFF release areas 2, 3 and 4 where PFOS, PFOA, and/or PFOA+PFOA exceeded the USEPA HA value.

Surface water at, and adjacent to Holloman AFB has high concentrations of TDS and is not permitted for use as a potable water source, therefore human receptors via the ingestion pathway are not present at the installation. As a result, there is currently no potential surface water receptor pathway with immediate impacts to human health at Holloman AFB.

1.0 INTRODUCTION

This Site Inspection (SI) Report (SIR) was prepared by Amec Foster Wheeler Programs, Inc., together with affiliate Wood Environment & Infrastructure Solutions, Inc. (formerly known as Amec Foster Wheeler Environment & Infrastructure, Inc.)[2], collectively referred to as Amec Foster Wheeler, under Contract No. FA8903-16-D-0027, Task Order 0004, to document the results of SI activities conducted at five aqueous film forming foam (AFFF) release areas located at Holloman Air Force Base (AFB). The purpose of the SI was to determine, through environmental media sampling, if a release of per- and polyfluorinated alkyl substances (PFAS) has occurred at potential AFFF release areas identified during a Preliminary Assessment (PA) conducted by HydroGeologic Inc. (HGL) (2015), or during the installation scoping visit conducted by Amec Foster Wheeler on 27 October 2016.

The data presented in this SIR were collected and evaluated in accordance with the Final Installation-Specific Work Plan (ISWP) (Amec Foster Wheeler, 2017a) and the General Quality Program Plan (QPP) (Amec Foster Wheeler, 2017b).

1.1 PER- AND POLY-FLUORINATED ALKYL SUBSTANCES OVERVIEW

PFAS are a class of synthetic organofluorine compounds that possess a chemical structure that gives them unique properties, including thermal stability and the ability to repel both water and oil. These chemical properties make them useful components in a wide variety of consumer and industrial products, including non-stick cookware, food packaging, waterproof clothing, fabric stain protectors, lubricants, paints, and firefighting foams such as AFFF. AFFF concentrate contains fluorocarbon surfactants to meet required performance standards for fire extinguishing agents (Department of Defense [DoD] Military Specification MIL-F-24385F [SH], Amendment 1, 5 August 1984). The United States Air Force (USAF) began purchasing and using AFFF containing PFAS (perfluorooctanesulfonic acid [PFOS] and/or perfluorooctanoic acid [PFOA]) for extinguishing petroleum fires and during firefighting training activities in 1970, as confirmed by the following federal government documents:

- Military Specification for AFFF (MIL-F-24385), formally issued in 1969;
- General Accounting Office determination on sole source award protest to provide AFFF to the Navy in December 1969; and,
- *A History of USAF Fire Protection Training at Chanute Air Force Base*, 1964-1976 (Coates, 1977).

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AFFF was primarily used on USAF installations at fire training areas (FTAs), but may have also been used, stored or released from hangar fire suppression systems, at firefighting equipment testing and maintenance areas, and during emergency response actions for fuel spills and/or aircraft mishaps.

The United States Environmental Protection Agency (USEPA) Office of Water issued lifetime drinking water Health Advisory (HA) values for PFOS and PFOA in May 2016 that replaced the 2009 Provisional HA values. The HA values for PFOS and PFOA are 0.07 micrograms per liter (µg/L) for each constituent; however, when these two chemicals co-occur in a drinking water source, a conservative and health-protective approach is recommended that compares the sum of the concentrations (PFOS + PFOA) to the HA value (0.07 µg/L). The HA values are non-regulatory concentrations of drinking water contaminants at or below which adverse health effects are not anticipated to occur over specific exposure durations (e.g., 1 day, 10 days, and a lifetime). They serve as informal technical guidance to assist federal, state, and local officials, and managers of public or community water systems in protecting public health when emergency spills or other contamination situations occur. A HA document provides information on the environmental properties, health effects, analytical methodology, and treatment technologies for removing drinking water contaminants. HA values are not to be construed as legally enforceable federal standards and are subject to change as additional information becomes available (USEPA, 2016a and 2016b).

The USEPA has not published Regional Screening Levels (RSLs) for PFOS or PFOA for soil or sediment; however; as per the Final ISWP (Amec Foster Wheeler, 2017a), a residential screening level of 1.26 milligrams per kilogram (mg/kg) for PFOS and PFOA was derived using the USEPA Regional Screening Level (RSL) calculator (https://epa-prgs.ornl.gov/cgi-bin/chemicals/_csl_search), based on a total hazard quotient (THQ) of 1.0. The toxicity value input for the calculator is the Tier 3 value reference dose of 0.00002 mg/kg per day derived by the USEPA in their Drinking Water HA values for both PFOS and PFOA (USEPA, 2016a and 2016b). In March 2018, the USAF issued revised guidance, *PFAS Site Inspection Objectives and Follow-On Activities,* whereby a new residential screening level for soil and sediment of 0.126 mg/kg was calculated based on a THQ of 0.1 (USAF, 2018).

While PFOS and PFOA in groundwater are the focus of the HA, USEPA has also derived Tap Water RSL values for perfluorobutanesulfonic acid (PFBS) for which there is a Tier 2 toxicity value (Provisional Peer Review Toxicity Value) (USEPA, 2017a). Based on the Final ISWP (Amec Foster Wheeler, 2017a), concentrations of PFBS detected in groundwater and soil were to be compared to the Tap Water RSL of 400 µg/L and residential RSL of 1,300 mg/kg, respectively. However, as per the USAF revised guidance issued subsequent to the ISWP, a revised residential screening level for PFBS in soil of 130 mg/kg was calculated based on a THQ of 0.1 and will be used for comparison in this SIR (USAF, 2018).

Table 1.1-1 below presents the screening values for comparing analytical results for PFOS, PFOA, and PFBS. The USEPA and New Mexico Environment Department (NMED) have not issued HA values or promulgated standards for any other PFAS to date.

Table 1.1-1. Regulatory Screening Values

Parameter	Chemical Abstract Number	USEPA Regional Screening Level Table (November 2017)[a]		Calculated RSL for Soils and Sediments[b] (mg/kg)	USEPA Health Advisory for Drinking Water (Surface Water or Groundwater)[c] (µg/L)
		Residential Soil and Sediments (mg/kg)	Tap Water (µg/L)		
PFOS	1763-23-1	NL	NL	0.126	0.07[d]
PFOA	335-67-1	NL	NL	0.126	
PFBS	375-73-5	130	400	NL	NL

Notes:

a USEPA Regional Screening Levels (November, 2017a) [https://semspub.epa.gov/work/HQ/197027.pdf].

b Screening levels calculated using the USEPA Regional Screening Level calculator (https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search)

c USEPA, May 2016a. "Drinking Water Health Advisory for Perfluorooctane Sulfonate (PFOS)" and USEPA, May 2016b. "Drinking Water Health Advisory for Perfluorooctanoic Acid (PFOA)."

d When both PFOA and PFOS are both present, the combined concentrations of PFOA and PFOS should be compared with the 0.07 µg/L health advisory level.

µg/L - micrograms per liter
mg/kg - milligrams per kilogram
NL - not listed
PFBS - perfluorobutanesulfonic acid
PFOA - perfluorooctanoic acid
PFOS - perfluorooctanesulfonic acid
RSL - Regional Screening Level
USEPA - United States Environmental Protection Agency

1.2 PROJECT OBJECTIVES

In accordance with DoD Instruction 4715.18, "Emerging Contaminants (ECs)" (DoD, 2009), the *Interim AF Guidance on Sampling and Response Actions for Perfluorinated Compounds at Active and Base Realignment and Closure (BRAC) Installations* (USAF, 2012), and the *SAF/IE Policy on Perfluorinated Compounds of Concern* (USAF, 2016) the USAF will:

1) Identify locations where there is a reasonable expectation that there may have been a release of PFAS (defined below) associated with USAF actions;

2) Determine if there is unacceptable risk to human health and the environment; and,

3) Address releases that pose an unacceptable risk, including offsite migration.

The primary objectives of this SI were to:

- Determine if PFOS, PFOA, or PFBS are present in soil, groundwater, sediment, or surface water at AFFF release areas selected for SI;

- Determine if PFOS and PFOA concentrations in soil exceed the calculated RSL, based on a residential scenario, of 0.126 mg/kg, and if PFBS concentrations in soil exceed the USEPA residential RSL of 130 mg/kg;
- Determine if PFOS, PFOA, or sum of PFOS and PFOA concentrations in groundwater exceed the USEPA HA value of 0.07 µg /L, and if PFBS concentrations in groundwater exceed the USEPA Tap Water RSL of 400 µg/L;
- Determine if PFOS and PFOA concentrations in sediment exceed the calculated RSL, based on a residential scenario of 0.126 mg/kg, and if PFBS concentrations in sediment exceed the USEPA residential RSL of 130 mg/kg;
- Determine if PFOS, PFOA, or sum of PFOS and PFOA concentrations in surface water exceed the USEPA HA value of 0.07 µg /L; and,
- Identify potential receptor pathways with immediate impacts to human health (immediate impact to human health is considered consumption of drinking water with PFOS/PFOA above the USEPA HA value, or PFBS above the USEPA Tap Water RSL).

1.3 PROJECT SCOPE

AFFF release areas were selected for SI at Holloman AFB based on research conducted by HGL (2015) during a PA, and from the installation scoping visit conducted by Amec Foster Wheeler on 27 October 2016. The following five AFFF release areas recommended for SI are as follows:

- AFFF Release Area 1: Former FTA (FT-31).
- AFFF Release Area 2: Sewage Lagoon Area Outfall
- AFFF Release Area 3: Apache Mesa Golf Course Outfall
- AFFF Release Area 4: Lake Holloman Outfalls
- AFFF Release Area 5: Evaporation Pond No. 2

Media evaluated at these areas consisted of surface and subsurface (vadose zone) soil and groundwater collected from new and existing monitoring wells, surface water, and sediment. In addition, an effluent sample was collected from the wastewater treatment plant (WWTP) as part of SI activities associated with AFFF Release Area 3.

This SIR discusses and provides a comparison of the analytical results to screening values for PFOS, PFOA, and PFBS in soil, groundwater, surface water, and sediment. The remaining PFAS do not have screening values; therefore, only the results of PFOS, PFOA, and PFBS are discussed in detail and presented in figures. However, all data are presented in the soil, groundwater, surface water, and sediment analytical tables.

2.0 AFFF RELEASE AREA BACKGROUND

2.1 SITE LOCATION AND SETTING

Holloman AFB is located in Otero County in south central New Mexico, approximately six miles southwest of the city of Alamogordo and 75 miles north-northeast of El Paso, Texas (**Figure 1**). The installation covers approximately 59,800 acres (USAF, 2017). The installation is located in the Tularosa Basin, a closed basin with no surface drainage outlets, which is bounded by the San Andres Mountains to the west and the Sacramento Mountains to the east.

2.2 SITE HISTORY

Holloman AFB, formerly known as Alamogordo Army Air Field, was initiated as a wartime temporary facility in 1942. In March 1947 after a brief inactivation at the end of World War II, the installation was transferred to the Air Materiel Command (AMC) with the mission of providing facilities and testing of pilotless aircraft, guided missiles and allied equipment in support of the AMC Research and Development Program (CH2M HILL, 1983). The installation was renamed in 1948 after Colonel George Holloman, an early pioneer in pilotless aircraft research (USAF, 2017). In 1951, when the Air Research and Development Command was formed, Holloman AFB was placed under the guidance of the Air Force Missile Test Center. The following year, the installation was named as one of the development centers of the Air Research and Training Development Command and became the Holloman Air Development Center (Ebasco Services, Inc. [Ebasco], 1995). In 1957, the installation was transferred to the Air Force Systems Command (AFSC) and was designated as the Air Force Missile Development Center (CH2M HILL, 1983). In 1971, the installation was transferred from AFSC to the Tactical Air Command (TAC) with the 49th Tactical Fighter Wing assuming host responsibilities. In 1977, the 479th Tactical Training Wing was activated at Holloman and in December 1980, the 833rd Air Division was reactivated and became operational at Holloman AFB (CH2M HILL, 1983). Holloman AFB was transferred from the TAC to the Air Combat Command (ACC) in June 1992 (Ebasco, 1995).

Holloman AFB is currently home of the 49th wing of the ACC, 96th Test Group, 54th Fighter Group and the German Air Force Flying Training Center. Operations at Holloman AFB include missile testing, aircraft and pilot training, operational equipment and systems testing, and aircraft maintenance and storage (USAF, 2017).

2.3 PREVIOUS INVESTIGATIONS

HGL conducted a PA of FTA and non-FTA sites at Holloman AFB to determine locations of potential environmental release of PFAS from AFFF storage or usage areas (HGL, 2015). Thirty-one potential AFFF release areas were identified during the PA research. However, only the following four AFFF areas were recommended for SI (**Figure 2.3-1**):

1) Former FTA (FT-31): Fire training activities were reportedly conducted in the general area of FT-31 since the installation was activated in 1942, although the exact start date of fire training at FT-31

is unknown (Environmental Monitoring Systems Laboratory [EMSL], 1988). Fire training was conducted in two unlined burn pit areas, the first identified as FTA-1 (Solid Waste Management Unit [SWMU]-170), and the second was identified as FTA-2 (SWMU 171) within the former FTA. The volume of AFFF used during each training exercise is unknown. Fire training activities continued at this location until 1990 when training exercises were moved to the current FTA (Bhate Environmental [Bhate], 2005).

2) Sewage Lagoon Area Outfall: Prior to construction of a WWTP in 1996, wastewater from Holloman AFB was discharged directly into the sewage lagoon area that was comprised of seven unlined lagoons (identified as ponds A through G). Approximately 1.2 million gallons of domestic and industrial wastewater were discharged to the sewage lagoon area daily.
3) Apache Mesa Golf Course Outfall: In 2011, the golf course began receiving a portion of the effluent from the WWTP to fill two golf course ponds and irrigate greens. Releases of AFFF from within the industrial shops at Holloman would be routed through the WWTP and eventually lead to the water holding tank at the Apache Mesa Golf Course.
4) Lake Holloman Outfalls: Wastewater from Holloman AFB was discharged directly to the sewage lagoon area, and eventually to Lake Holloman prior to construction of the WWTP in 1996.

The following additional area was recommended for SI based on data obtained during the scoping visit conducted on 27 October 2016**:**

5) Evaporation Pond No. 2: The evaporation basin was installed in 1991 and currently collects all discharges containing AFFF, routed through hangar bay floor drains from hangars located in the western ramp area of the West Hangar Group. The Holloman AFB Fire Department uses this basin for monthly AFFF tests and firehose washouts. AFFF is reportedly sprayed from vehicles into the pond until a consistent flow pattern is established (HGL, 2015).

3.0 FIELD ACTIVITIES AND ANALYTICAL PROTOCOL

SI activities were conducted at Holloman AFB from 30 October to 7 November 2017 at the five AFFF release areas identified during the PA (HGL, 2015) and the installation scoping visit conducted by Amec Foster Wheeler in October 2016 (**Figure 2.3-1**). Sample locations were determined following discussions between Amec Foster Wheeler, Holloman AFB, and Air Force Civil Engineer (AFCEC) personnel, and were documented in the Final ISWP (Amec Foster Wheeler, 2017a). Media sampled during the SI included surface soil, subsurface soil, groundwater collected from new and existing permanent monitoring wells, surface water, sediment and effluent from the WWTP.

Photographic documentation of the SI activities is provided in **Appendix A** and field documentation is provided in **Appendix B**. Inspection activities were recorded by field personnel on field activity daily logs (**Appendix B-1**), and daily PFAS protocol checklists were completed (**Appendix B-2**) to ensure PFAS were not introduced by Amec Foster Wheeler employees or subcontractors in accordance with SOP AFW-01 (PFAS)–*Field Sampling Protocols to Avoid Cross-Contamination of PFAS*. A tailgate safety meeting was conducted each morning prior to beginning work, with the tailgate safety meeting reports provided in **Appendix B-3**.

Soil Boring Advancement and Soil Sample Collection

Thirteen soil borings were advanced for the collection of soil samples and/or permanent monitoring well installation by a New Mexico-licensed driller, Yellow Jacket Drilling Services, LLC., of Phoenix, Arizona. Soil borings were first cleared (for buried utilities) to a depth of five feet below ground surface (bgs) with a hand auger and completed for sampling purposes using hollow stem auger (HSA) drilling methods. Soil samples were continuously collected from five feet below ground surface (after completing the hand auger utility pilot hole) to approximately ten feet below first-encountered groundwater using decontaminated 5-foot long stainless-steel split-barrel samplers in accordance with SOP AFW-02 (PFAS)–*Soil Sampling*. The soil samples were field-screened with a photoionization detector equipped with a 10.6 electron volt lamp for volatile organic vapors, and logged by a qualified geoscientist in accordance with the Unified Soil Classification System. The resulting soil boring information, photoionization detector readings, stratigraphic data, and soil sample locations are included on soil boring/monitoring well records provided in **Appendix B-4**, while the soil sample data (sample ID numbers, date/time collected, and depths) are included on soil sample collection logs in **Appendix B-5**. Cross-sections illustrating stratigraphic data are presented on **Figures 3.0-1 and 3.0-2**.

Surface soil samples were collected using hand held decontaminated stainless-steel trowels prior to commencement of each soil boring. Subsurface soil samples were collected from the desired interval within the split-barrel sampling device using a decontaminated stainless-steel spoon and transferred directly into laboratory-provided high-density polyethylene (HDPE) containers. Sample containers were sealed, labeled, packed into ice-filled coolers, and delivered under chain-of-custody (CoC) protocol to SGS

Accutest in Orlando, Florida (Accutest) for PFAS analysis, or CT Laboratories in Baraboo, Wisconsin for physiochemical properties analysis.

Monitoring Well Installation and Development

Five permanent monitoring wells were installed at three of the AFFF release areas during the SI through the 8-inch outside diameter HSA augers. Monitoring well construction was based on observed depth to water at the time of drilling and geologic conditions encountered. All new monitoring wells were constructed in accordance with the ISWP to effectively bracket the water table. The monitoring wells were constructed in accordance with SOP AFW-04 (PFAS)-*Monitoring Well Installation* and NMED's Monitoring Well Construction and Abandonment Guidelines (NMED, 2011). The permanent monitoring wells were constructed of two-inch-diameter, Schedule 40 polyvinyl chloride (PVC) riser casing and a threaded 10-foot section of 0.010-inch slotted 2-inch-diameter Schedule 40 PVC screen and end cap. Well construction details for the monitoring wells installed during the SI are provided on well construction forms in **Appendix B-6**. **Table 3.0-1** provides a summary of the well construction details for the monitoring wells installed during the SI and for the existing monitoring wells sampled during the SI.

The monitoring wells were developed with a Waterra Hydrolift-2 inertial pump outfitted with disposable HDPE tubing and check-valve, in accordance with SOP AFW-05 (PFAS)–*Monitoring Well Development* and NMED's Monitoring Well Construction and Abandonment Guidelines (NMED, 2011). During development, water quality parameters (pH, specific conductance, temperature, oxidation-reduction potential [ORP], dissolved oxygen [DO], and turbidity) were measured with water quality instruments and recorded on Well Development Logs (**Appendix B-7**). A minimum of three saturated casing volumes of water were purged from each newly installed well during development, and continued until the field water quality parameters stabilized (i.e., three consecutive pH, specific conductance, and temperature readings within 10 percent, the maximum turbidity is 50 nephelometric turbidity units or less), or the well was pumped dry. The water quality instrumentation was field calibrated as per the manufacturer's instructions as well as in accordance with the QPP (Amec Foster Wheeler, 2017b), and the results recorded on water quality sampling instrument calibration forms (**Appendix B-8**).

Groundwater Elevations

Depth to water measurements were recorded from each permanent monitoring well prior to groundwater purging and sampling, and groundwater elevations were calculated relative to top-of-casing elevations. Top of casing elevations were surveyed by a professionally licensed New Mexico surveyor from the Amec Foster Wheeler Phoenix, Arizona office. Depth to groundwater in October-November 2017 ranged from 4.47 to 24.02 feet below top of casing, and the calculated groundwater elevations ranged from 4021.82 feet above mean sea level (amsl) in the Sewage Lagoon Area (AFFF Release Area 2) to 4081.678 feet amsl at the Former FTA (AFFF Release Area 1) (**Table 3.0-2**). Local groundwater flow varies and depends on local topography, and the amount of rainfall percolation and stream runoff along the western Sacramento Mountains. Basewide groundwater flow is generally to the southwest towards Lake Holloman with the

exception of groundwater at AFFF Release Area 1 (Former FTA [FT-31]) that flows to the southeast towards the Dillard Draw (**Figure 3.0-3**).

Groundwater Sampling

The groundwater sampling program included the collection of groundwater samples for laboratory chemical analysis of PFAS from five new and three existing permanent monitoring wells. Samples were collected using low-flow groundwater sampling methods with a peristaltic pump in accordance with SOP AFW-03 (PFAS)-*Groundwater Sampling*. The HDPE tubing was connected to a flow-through cell whereby recovered groundwater was monitored for pH, temperature, specific conductivity, DO, and ORP. Turbidity was measured with a separate turbidity meter. Groundwater quality measurement equipment was calibrated prior to use, with the resulting data recorded on water quality sampling instrument calibration forms contained in **Appendix B-8**. Depth to water measurements and field parameters were monitored until groundwater indicator parameters reached stabilization criteria as outlined in SOP AFW-03 (PFAS)–*Groundwater Sampling*. The flow-through cell was then removed, and groundwater samples were collected directly into laboratory-provided HDPE containers from the discharge tubing. The sample containers were sealed, labeled, packed on ice in an insulated cooler, and delivered to Accutest under CoC protocol. Groundwater sampling activities were documented on Groundwater Sampling Logs provided in **Appendix B-9**.

Soil Boring Abandonment

The eight soil boreholes not used for permanent well installation were abandoned with neat Portland cement via the tremie pipe method between 30 October and 2 November 2017, as per SOP AFW-06 (PFAS)–*Borehole Abandonment*, and the New Mexico Environment Department's (NMED) Monitoring Well Construction and Abandonment Guidelines (NMED, 2011).

Sediment/Surface Water Sampling

Sediment and surface water samples were collected to assess the presence or absence of PFAS at surface water features associated with AFFF Release Area 2 (Sewage Lagoon Area Outfall), AFFF Release Area 3 (Apache Mesa Golf Course Outfall), and AFFF Release Area 4 (Lake Holloman Outfalls) during the SI. Sediment samples were collected with a stainless-steel scoop or with a new disposable HDPE sediment core sampler in accordance with SOP AFW-07 (PFAS)–*Sediment Sampling*. The samples were then transferred into the laboratory provided containers using a stainless-steel scoop. Surface water samples were collected with a stainless-steel cup mounted on an extendable pole and decanted into laboratory-provided containers or were collected directly into laboratory-provided containers following a triple rinse of the container, in accordance with SOP AFW-08 (PFAS)–*Surface Water Sampling*. A separate container of water was collected to obtain water quality parameters (pH, temperature, specific conductivity, DO, and ORP). Water quality equipment was calibrated prior to use, with the resulting data recorded on water quality sampling instrument calibration forms contained in **Appendix B-8**. The sample containers were sealed, labeled, packed on ice in an insulated cooler, and delivered to Accutest under CoC protocol.

Sample collection data was documented on sediment/surface water sample collection logs provided in **Appendix B-10**.

WWTP Effluent Water Sampling

A WWTP effluent sample was collected to assess the presence or absence of PFAS in the effluent that is discharged and transferred to the storage tank at the golf course. The effluent sample was collected via an access point as directed by WWTP staff where a HDPE bucket was lowered into an open effluent stream after a triple rinse with effluent water to obtain a bulk quantity (approximately 3 gallons) of effluent water. Samples were then collected into laboratory-provided containers following a triple rinse of the container while discarding rinse water back into the effluent stream, in accordance with SOP AFW-09 (PFAS)– *Groundwater Treatment System Influent and Effluent Sampling*. The sample containers were sealed, labeled, packed on ice in an insulated cooler, and delivered to Accutest under CoC protocol. A separate container of water was collected to obtain water quality parameters (pH, temperature, specific conductivity, DO, and ORP). Water quality equipment was calibrated prior to use, with the resulting data recorded on water quality sampling instrument calibration forms contained in **Appendix B-8**. Sample collection data was documented on sediment/surface water sample collection logs provided in **Appendix B-10**.

Total Sample Counts

The following total sample counts for each media samples (including field duplicate samples) collected during SI activities at Holloman AFB are listed below:

- 30 soil samples (including four duplicate samples) were collected at 13 soil boring locations during the SI;
- 9 groundwater samples (including one duplicate sample) were collected from five permanent monitoring wells and three existing monitoring wells during the SI;
- 2 effluent samples (including one duplicate sample) were collected from the WWTP during the SI;
- 6 sediment samples (including one duplicate sample) were collected from five locations at three AFFF release areas during the SI; and,
- 6 surface water samples (including one duplicate sample) were collected from five locations at three AFFF release areas during the SI

Samples collected during the SI were analyzed for the following 16 PFAS compounds:

- PFOS;
- PFOA;
- PFBS;
- Perfluoroheptanoic acid (PFHpA);
- Perfluorohexanesulfonic acid (PFHxS);
- Perfluorononanoic acid (PFNA);

- N-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA);
- N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA);
- Perfluorodecanoic acid (PFDA);
- Perfluorotetradecanoic acid (PFTA);
- Perfluorododecanoic acid (PFDoA);
- Perfluorohexanoic acid (PFHxA);
- Perfluorotridecanoic acid (PFTrDA);
- Perfluoroundecanoic acid (PFUnA);
- 6:2 fluorotelomer sulfonate (FTS); and,
- 8:2 FTS.

Soil, groundwater, sediment and surface water samples were analyzed by Accutest, a DoD Environmental Laboratory Accreditation Program accredited laboratory. Samples were analyzed by Modified USEPA Method 537 using Liquid Chromatography and Tandem Mass Spectrometry (LC-MS/MS). The LC-MS/MS method provides acceptable detection limits to confirm the presence of PFAS listed above. The laboratory analytical reports for the PFAS samples collected during the SI are included in **Appendix C**.

Analytical results for PFOS, PFOA, and PFBS are discussed in the following sections, while the analytical results for the remaining PFAS constituents are tabulated and provided at the conclusion of this SIR.

Co-occurrence of PFOS and PFOA (PFOS + PFOA) in aqueous samples was reported using the following guidelines:

1. If PFOS and PFOA are both detected in concentrations at or above the laboratory detection limit (DL) in groundwater, then the reported concentration for PFOS was added to the reported concentration for PFOA.
2. If only PFOS or only PFOA is detected at or above the DL in groundwater, then the concentration of the detected analyte only is reported.
3. If neither PFOS nor PFOA are detected at concentrations at or above the DL, then co-occurrence was reported as *Not Detected*.

One composite surface soil sample and one composite subsurface soil sample were also collected at each AFFF release area where soil sampling was conducted and submitted to CT Laboratories in Baraboo, Wisconsin for laboratory analysis of physiochemical properties, including soil pH (USEPA Method 9045B), particle size analysis (ASTM International D422), and total organic carbon (TOC) content (Lloyd Kahn 9060A Method). The particle size analysis was subcontracted to Mi-Tech Services, Inc. in Weston, Wisconsin. The laboratory analytical reports for the physiochemical properties samples collected during the SI are included in **Appendix C**.

Data Validation and Usability Assessment

Laboratory analytical data from soil and groundwater samples analyzed for PFAS were validated in January 2018. Amec Foster Wheeler evaluated a total of 848 data records from field samples during the validation process and J or UJ qualified 152 records (17.9%) as approximate values because of high or low laboratory control sample recoveries, high or low matrix spike (MS)/MS duplicate (MSD) recoveries, MS/MSD imprecision, low surrogate recoveries, field duplicate imprecision, and/or analyte concentrations between the DL and the Limit of Quantification (LOQ). Amec Foster Wheeler also B or Q qualified 36 records (4.2%) because of contamination detected in an associated equipment blank.

During validation, Amec Foster Wheeler J qualified one aqueous PFOA and two aqueous PFOS results as being approximated values because of analyte concentrations between the DL and the LOQ, indicating potentially low bias. The associated PFOA and PFOS results were over two orders of magnitude greater than the screening criteria of 0.07 µg/L; therefore, the potentially low bias in these results is not interpreted to affect overall data usability.

Two sediment PFOS results were J qualified as being approximated values because of low surrogate recovery and/or low MS recovery, biasing the results low. The associated PFOS results were above the screening criteria of 0.126 mg/kg and therefore the potentially low bias in these results is not interpreted to affect overall data usability.

Two soil field duplicate pairs had detected PFOS concentrations at high relative percent difference levels (40% and 48%), and were J qualified due to imprecision between field duplicate results. The analytical uncertainty due to sampling or analytical imprecision is not interpreted to adversely affect overall data usability.

For the areas sampled in this SI, a decision to advance areas for further investigation was based either on non-qualified data or qualified data that are not interpreted to impact overall data usability. A description of the data validation scope, procedures, observations and actions is presented in the Data Validation Report provided in **Appendix D**.

Surveying

Soil borings and newly installed permanent monitoring wells were surveyed by a New Mexico Licensed Professional Surveyor (Amec Foster Wheeler, Phoenix, Arizona) for horizontal coordinates and groundwater surface and/or top-of-casing elevations (**Table 3.0-1**). Horizontal coordinates were surveyed based on New Mexico State Plane Coordinate System, Central Zone, United States Survey Feet, North American Datum of 1983. Groundwater surface and top-of-casing elevations were collected based on North American Vertical Datum of 1988.

Investigation-Derived Waste

Investigation-Derived Waste (IDW) consisted of soil cuttings from soil boring advancement, well development water, groundwater sampling purge water, equipment decontamination water, disposable

personal protective equipment (PPE), and other miscellaneous refuse. Used PPE and other miscellaneous refuse was placed in plastic bags and discarded into an on-site sanitary trash container for disposal at a sanitary landfill. Soil and liquid IDW was containerized in Department of Transportation-approved 55-gallon steel drums. Composite grab samples were collected on 6 November 2017 from the 13 drums of soil IDW and 12 drums of liquid IDW generated during the SI. The samples were laboratory analyzed by Accutest for laboratory analysis of PFAS, and by CT Laboratories for volatile organic compounds, semi-volatile organic compounds, pesticides, herbicides, metals, polychlorinated biphenyls, total petroleum hydrocarbons (gasoline range organics and diesel range organics), percent solids, flashpoint, pH, and cyanide, to determine the applicable disposal options (**Appendix C**).

The 25 drums of IDW were transported off-site on 19 July 2018 by Cactus Environmental Services as non-hazardous waste for disposal at the Turkey Creek Landfill in Alvarado, Texas. The non-hazardous waste manifests are provided in **Appendix E**.

A detailed description of sampling locations and results at each AFFF release area is provided in the following sections.

3.1 AFFF RELEASE AREA 1: FORMER FTA (FT-31)

Fire training activities were conducted performed at the Former FTA located at the northeastern portion of the base between 1942 and 1990 when training exercises were moved to the current FTA (Bhate, 2005). The training exercises were conducted in two unlined burn pit areas, the first identified as FTA-1 (SWMU-170), and the second was identified as FTA-2 (SWMU-171). The volume of AFFF used during each training exercise is unknown.

3.1.1 Sample Location and Methodologies

3.1.1.1 Soil Samples

Soil borings SB01001, SB01002, SB01003, MW01004, and SB01005 were advanced on 30 and 31 October 2017 at the Former FTA within the SWMU-135/OWS Drainage Pit, and within and south of the SWMU-170/FTA-1, and SWMU-171/FTA-2 burn pits where AFFF may have been released (**Figure 3.1-1**). Surface soil samples were collected from all soil boring locations at 0 to 0.5-foot bgs, and subsurface soil samples were collected at depths ranging from 17 to 23 feet bgs, for PFAS analysis. Composite soil samples were collected from all soil borings at 0 to 0.5-foot bgs and 17 to 23 feet bgs for TOC, pH, and particle size analysis. Groundwater was encountered at approximately 21 to 24 feet bgs during boring advancement.

3.1.1.2 Groundwater Samples

One permanent monitoring well was installed in soil boring MW01004 on 30 October 2017 to assess PFAS concentrations at the Former FTA (**Figure 3.1-1**). The installed permanent monitoring well MW01004, as well as two existing monitoring wells FT31-LM4 and FT31-LM5, were developed on 3 November 2017 and sampled on 5 and 6 November 2017.

3.1.2 Analytical Results

3.1.2.1 Soil Results

Six surface soil samples (including one duplicate) and six subsurface soil samples (including one duplicate) were analyzed for PFAS, with the results provided in **Table 3.1-1**, illustrated on **Figure 3.1-2**, and summarized below.

SB01001:

- PFOS was detected below the RSL at the surface sampling interval (0 to 0.5 feet bgs) at a concentration of 0.0576 mg/kg, and was detected above the RSL at the subsurface sampling interval (22 to 23 feet bgs) at a maximum approximate concentration of 1.13 mg/kg.
- PFOA was detected below the RSL at the surface sampling interval (0 to 0.5 feet bgs) at a concentration of 0.0123 mg/kg, and was detected above the RSL at the subsurface sampling interval (22 to 23 feet bgs) at a maximum concentration of 0.19 mg/kg.
- PFBS was detected below the RSL at the two sampling intervals at an approximate maximum concentration of 0.0577 mg/kg (field duplicate; 22 to 23 feet bgs).

SB01002:

- PFOS was detected above the RSL at the two sampling intervals at a maximum approximate concentration of 0.26 mg/kg (0 to 0.5 feet bgs).
- PFOA was detected below the RSL at the two sampling intervals at an approximate maximum concentration of 0.0602 mg/kg (17 to 18 feet bgs).
- PFBS was not detected at either interval.

SB01003:

- PFOS was detected above the RSL at the surface sampling interval (0 to 0.5 feet bgs) at a concentration of 0.33 mg/kg, and below the RSL at the subsurface sampling interval (21 to 22 feet bgs) at a concentration of 0.00077 mg/kg.
- PFOA was detected below the RSL at the two sampling intervals at a maximum concentration of 0.115 mg/kg (21 to 22 feet bgs).
- PFBS was detected below the RSL at the two sampling intervals at a maximum concentration of 0.0583 mg/kg (0 to 0.5 feet bgs).

MW01004:

- PFOS was detected above the RSL at the surface sampling interval (0 to 0.5 feet bgs) at a concentration of 0.217 mg/kg, and was not detected in the subsurface sampling interval (19 to 20 feet bgs).

- PFOA was detected below the RSL at the surface sampling interval (0 to 0.5 feet bgs) at a concentration of 0.031 mg/kg, and was not detected in the subsurface sampling interval (19 to 20 feet bgs).
- PFBS was detected below the RSL at the surface sampling interval (0 to 0.5 feet bgs) at an approximate concentration of 0.00101 mg/kg, and was not detected in the subsurface sampling interval (19 to 20 feet bgs)

SB01005:

- PFOS was detected below the RSL at the surface sampling interval (0 to 0.5 feet bgs) at an approximate concentration of 0.0242 mg/kg, and above the RSL in the subsurface sampling interval at a concentration of 0.247 mg/kg (19 to 20 feet bgs).
- PFOA was detected below the RSL at the two sampling intervals at a maximum approximate concentration of 0.057 mg/kg (19 to 20 feet bgs).
- PFBS was not detected at the surface sampling interval (0 to 0.5 feet bgs), and was detected below the RSL in the subsurface sampling interval at an approximate concentration of 0.0441 mg/kg (19 to 20 feet bgs).

The composite TOC concentrations ranged from 1,720 mg/kg (0 to 0.5 feet bgs) to 5,790 mg/kg (17 to 23 feet bgs), while the composite pH concentrations ranged from 7.79 Standard Units (S.U.) (17 to 23 feet bgs) to 7.89 S.U. (0 to 0.5 feet bgs) (**Table 3.1-2**). The particle size analytical results for the 0 to 0.5 feet bgs sample was 20.4% fines (silt and clay), 37% sand (fine to coarse), and 42.6% gravel (fine and coarse), while the 17 to 23 feet bgs sample was 46.6% fines (silt and clay), 48% sand (fine to coarse), and 5.4% gravel (fine). The material description for the 0 to 0.5 feet bgs sample was a reddish yellow to very pale brown, silty sand to sandy silt with no to some gravels, while the 17 to 23 feet bgs sample was described as light reddish brown clayey sand with gravel, pink or gray silty sand with gravel, red lean clay with silt, and red or yellowish red clayey sand.

3.1.2.2 Groundwater Results

Four groundwater samples (including one duplicate) were collected from permanent monitoring wells FT31-LM4, FT31-LM5, and MW01004. PFAS results are provided in **Table 3.1-3**, illustrated in **Figure 3.1-3,** and summarized below.

FT31-LM4:

- PFOS was detected above the USEPA HA value at a maximum approximate concentration of 1.95 µg/L.
- PFOA was detected above the USEPA HA value at a maximum concentration of 6.09 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a maximum approximate concentration of 8.04 µg/L.

- PFBS was detected below the USEPA Tap Water RSL value at a maximum concentration of 26.6 µg/L.

FT31-LM5:

- PFOS was detected above the USEPA HA value at a concentration of 48.4 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 254 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 302.4 µg/L.
- PFBS was detected below the USEPA Tap Water RSL value at a concentration of 226 µg/L.

MW01004:

- PFOS was detected above the USEPA HA value at a concentration of 1.28 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.746 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 2.026 µg/L.
- PFBS was not detected.

3.1.3 Conclusions

PFOS and PFOA were detected above the USEPA RSL and HA values at selected sample locations in AFFF Area 1. PFBS was detected in soil at AFFF Release Area 1, but at concentrations below the USEPA RSLs. The highest concentrations of PFAS constituents in soil were identified in subsurface soils at SB01001, located within the former unlined burn pit (SWMU-170/FTA-1) where AFFF may have been released. PFOS, PFOA, and PFOS+PFOA concentrations exceeded the USEPA HA values in all three permanent monitoring wells sampled at AFFF Area 1. PFBS was detected below the EPA RSL for Tap water in two of the three permanent monitoring wells.

3.2 AFFF RELEASE AREA 2: SEWAGE LAGOON AREA OUTFALL

Prior to construction of the WWTP in 1996, wastewater from Holloman AFB was discharged directly into the sewage lagoon area that was comprised of seven unlined lagoons (identified as ponds A through G). Approximately 1.2 million gallons of domestic and industrial wastewater were discharged to the sewage lagoon area daily. Eventually, flow from the lagoon reached Lake Holloman.

3.2.1 Sample Location and Methodologies

3.2.1.1 Soil Samples

Six soil borings (SB02001, SB02002 and SB02003, MW02004, MW02005 and MW02006) were advanced at the subject area on 1 and 2 November 2017 (**Figure 3.2-1**). Surface soil samples were collected from 0 to 0.5 feet bgs and subsurface soil samples were collected between 1.5 and 7 feet bgs for PFAS analysis. Composite soil samples were also collected from each soil boring from 0 to 0.5 feet bgs and 4 to 7 feet bgs for TOC, pH, and particle size analysis. Groundwater was encountered at approximately 3 to 15 feet bgs during boring advancement.

3.2.1.2 Groundwater Samples

Three permanent monitoring wells were installed in soil borings MW02004, MW02005, and MW02006 between 1 and 2 November 2017 to assess PFAS concentrations within different sewage lagoon ponds (**Figure 3.2-1**). The permanent monitoring wells were developed on 3 November 2017 and sampled on 5 November 2017.

3.2.1.3 Sediment Samples

One sediment sample was collected at lagoon/pond G (SD02007) on 4 November 2017 (**Figure 3.2-1**).

3.2.1.4 Surface Water Samples

One surface water sample was collected at lagoon/pond G (SW02007) on 4 November 2017 (**Figure 3.2-1**).

3.2.2 Analytical Results

3.2.2.1 Soil Results

Seven surface soil samples (including one duplicate) and seven subsurface soil samples (including one duplicate) were collected from soil borings SB02001, SB02002 and SB02003, MW02004, MW02005 and MW02006 on 1 and 2 November 2017. PFAS results are provided in **Table 3.1-1**, illustrated in **Figure 3.2-2**, and summarized below.

SB02001:

- PFOS was not detected at the surface sampling interval (0 to 0.5 feet bgs), and was detected below the RSL at the subsurface sampling interval (2.0 to 2.5 feet bgs) at a maximum approximate concentration of 0.00167 mg/kg.
- PFOA was not detected at either interval.
- PFBS was not detected at either interval.

SB02002:

- PFOS was not detected at the surface sampling interval (0 to 0.5 feet bgs), and was detected below the RSL at the subsurface sampling interval (1.5 to 2 feet bgs) at an approximate concentration of 0.0176 mg/kg.
- PFOA was not detected at the surface (0 to 0.5 feet bgs) sampling interval, and was detected below the RSL at the subsurface sampling interval (1.5 to 2 feet bgs) at a concentration of 0.00447 mg/kg.
- PFBS was not detected at the surface sampling interval (0 to 0.5 feet bgs), and was detected below the RSL at the subsurface (1.5 to 2 feet bgs) sampling interval at an approximate concentration of 0.00177 mg/kg.

SB02003:

- PFOS was detected below the RSL at the two sampling intervals at a maximum concentration of 0.0461 mg/kg (5 to 6 feet bgs).
- PFOA was detected below the RSL at the two sampling intervals at a maximum concentration of 0.00378 mg/kg (5 to 6 feet bgs).
- PFBS was not detected at the surface sampling interval (0 to 0.5 feet bgs), and was detected below the RSL at the subsurface sampling interval (5 to 6 feet bgs) at an approximate concentration of 0.000905 mg/kg.

MW02004:

- PFOS was detected below the RSL at the two sampling intervals at a maximum approximate concentration of 0.00844 mg/kg (0 to 0.5 feet bgs).
- PFOA was detected below the RSL at the surface sampling interval (0 to 0.5 feet bgs) at an approximate concentration of 0.00104 mg/kg, and was not detected at the subsurface sampling interval (4 to 5 feet bgs; normal and field duplicate).
- PFBS was not detected at either interval.

MW02005:

- PFOS was detected below the RSL at the two sampling intervals at a maximum approximate concentration of 0.00985 mg/kg (0 to 0.5 feet bgs).
- PFOA was detected below the RSL at the two sampling intervals at a maximum approximate concentration of 0.00128 mg/kg (6 to 7 feet bgs).
- PFBS was not detected at either interval.

MW02006:

- PFOS was not detected at the surface sampling interval (0 to 0.5 feet bgs), and was detected below the RSL at the subsurface sampling interval (4 to 5 feet bgs) at an approximate concentration of 0.0228 mg/kg.
- PFOS was not detected at the surface sampling interval (0 to 0.5 feet bgs), and was detected below the RSL at the subsurface sampling interval (4 to 5 feet bgs) at an approximate concentration of 0.0027 mg/kg.
- PFBS was detected below the RSL at the two sampling intervals at a maximum approximate concentration of 0.00119 mg/kg (0 to 0.5 feet bgs).

The composite TOC concentrations ranged from 2,230 mg/kg (4 to 7 feet bgs) to 5,550 mg/kg (0 to 0.5 feet bgs), while the composite pH concentrations ranged from 7.86 S.U. (4 to 7 feet bgs) to 7.9 S.U. (0 to 0.5 feet bgs) (**Table 3.1-2**). The particle size analytical results for the 0 to 0.5 feet bgs sample was 49% fines (silt and clay), 47.1% sand (fine to coarse), and 3.9% gravel (fine), while the 4 to 7 feet bgs sample was 54% fines (silt and clay), 44.8% sand (fine to coarse), and 1.2% gravel (fine). The material description

for the 0 to 1-foot bgs sample was a very pale brown to pinkish gray silty sand with trace gravel, while the 4 to 7 feet bgs sample was described as a pink to very pale brown silty sand and red sandy lean clay (MW02006).

3.2.2.2 Groundwater Results

Three groundwater samples were collected from MW02004, MW02005, and MW02006 on 5 November 2017. PFAS results are provided in **Table 3.1-3**, illustrated in **Figure 3.2-3,** and summarized below.

MW02004:

- PFOS was detected above the USEPA HA value at a concentration of 0.241 µg/L.
- PFOA was detected above the USEPA HA value at an approximate concentration of 0.115 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 0.356 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.378 µg/L.

MW02005:

- PFOS was detected above the USEPA HA value at a concentration of 0.325 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.146 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 0.471 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.301 µg/L.

MW02006:

- PFOS was detected above the USEPA HA value at a concentration of 8.27 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.854 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 9.124 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.732 µg/L.

3.2.2.3 Sediment Results

One sediment sample was collected from SD02007 on 4 November 2017. PFAS results are provided in **Table 3.1-4**, illustrated in **Figure 3.2-4,** and summarized below.

SD02007:

- PFOS was detected below the RSL at a concentration of 0.0745 mg/kg.
- PFOA was not detected.
- PFBS was not detected.

3.2.2.4 Surface Water Results

One surface water sample was collected from SW02007 on 4 November 2017. PFAS results are provided in **Table 3.1-5**, illustrated in **Figure 3.2-5,** and summarized below.

SW02007:

- PFOS was detected above the USEPA HA value at a concentration of 2.25 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.941 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 3.191 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.716 µg/L.

3.2.3 Conclusions

PFOS, PFOA and PFBS were detected in soil at AFFF Release Area 2 at concentrations below the USEPA RSLs. The highest concentrations of PFAS constituents were identified in surface soils at SB02003. PFOS, PFOA, and PFOS+PFOA concentrations exceeded the USEPA HA values in groundwater from the three permanent monitoring wells, while PFBS was detected at concentrations below the USEPA Tap Water RSL. PFOS was detected in sediment at concentrations below the USEPA RSL, while PFOA and PFBS were not detected. PFOS, PFOA, and PFOS+PFOA concentrations exceeded the USEPA HA values in the surface water sample.

3.3 AFFF RELEASE AREA 3: APACHE MESA GOLF COURSE OUTFALL

In 2011, the golf course began receiving a portion of the effluent from the WWTP to fill two golf course ponds and irrigate greens. Releases of AFFF from within the industrial shops at Holloman would be routed through the WWTP and eventually lead to the water holding tank at the Apache Mesa Golf Course. As such, effluent used for irrigation purposes and ponds at the golf course may contain PFAS.

3.3.1 Sample Location and Methodologies

3.3.1.1 Soil Samples

No soil borings were advanced at this location.

3.3.1.2 Groundwater Samples

One existing monitoring well (MW-3) was developed on 3 November 2017 and sampled on 5 November 2017 to assess PFAS concentrations adjacent Apache Mesa Golf Course (**Figure 3.3-1**).

3.3.1.3 Sediment Samples

Two sediment samples were collected within the two golf course ponds (SD03001 and SD03002) on 4 November 2017 (**Figure 3.3-1**).

3.3.1.4 Surface Water Samples

Two surface water samples were collected within the two golf course ponds (SW03001 and SW03002) on 4 November 2017 (**Figure 3.3-1**).

3.3.1.5 Effluent Samples

Effluent from the WWTP, located adjacent to the Apache Mesa Golf Course, was sampled on 5 and 6 November 2017 to assess PFAS concentrations in the WWTP effluent (**Figure 2.3-1**).

3.3.2 Analytical Results

3.3.2.1 Groundwater Results

One groundwater sample was collected for PFAS analysis, with the results provided in **Table 3.1-3**, illustrated in **Figure 3.3-2**, and summarized below.

MW-3:

- PFOS was detected below the USEPA HA value at a concentration of 0.048 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.0891 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 0.1371 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.286 µg/L.

3.3.2.2 Sediment Results

Two sediment samples were collected for PFAS analysis, with the results provided in **Table 3.1-4**, illustrated in **Figure 3.3-3**, and summarized below.

SD03001:

- PFOS was detected below the RSL at a concentration of 0.0368 mg/kg.
- PFOA was not detected.
- PFBS was not detected.

SD03002:

- PFOS was detected above the RSL at an approximate concentration of 0.202 mg/kg.
- PFOA was not detected.
- PFBS was not detected.

3.3.2.3 Surface Water Results

Two surface water samples were collected for PFAS analysis, with the results provided in **Table 3.1-5**, illustrated in **Figure 3.3-4**, and summarized below.

SW03001:

- PFOS was detected above the USEPA HA value at a concentration of 1.22 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.097 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 1.317 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.105 µg/L.

SW03002:

- PFOS was detected above the USEPA HA value at a concentration of 0.878 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.117 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 0.995 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.156 µg/L.

3.3.2.4 Effluent Results

Two WWTP effluent samples (including one duplicate) was collected, along with a duplicate sample, for PFAS analysis, with the results provided in **Table 3.1-3** and summarized below.

EF03003:

- PFOS was detected above the USEPA HA value in the normal and duplicate sample at a concentration of 0.776 and 0.721 µg/L, respectively.
- PFOA was detected above the USEPA HA value in the normal sample at a concentration of 0.0738 µg/L, and below the USEPA HA value in the duplicate sample at a concentration of 0.0653.
- PFOS+PFOA was detected above the USEPA HA value in the normal and duplicate sample at a concentration of 0.8498 and 0.7863 µg/L, respectively.
- PFBS was detected below the USEPA Tap Water RSL in the normal and duplicate sample at a concentration of 0.0896 and 0.0954 µg/L, respectively.

3.3.3 Conclusions

PFOS, PFOA, and PFOS+PFOA in water exceeded the USEPA HA values in the existing monitoring well, surface water samples, and WWTP effluent, and PFBS was detected at concentrations below the USEPA Tap Water RSL. PFOS was detected in sediment at concentrations above the USEPA RSL at one sample location, while PFOA and PFBS were not detected. No soil samples were collected at this AFFF release area.

3.4 AFFF RELEASE AREA 4: LAKE HOLLOMAN OUTFALLS

Wastewater from Holloman AFB was discharged directly to the sewage lagoon area, and eventually to Lake Holloman prior to construction of the WWTP in 1996.

3.4.1 Sample Location and Methodologies

3.4.1.1 Sediment Samples

Sediment samples were collected at the north end of Lake Holloman (Holloman AFB Outfall) and at the east side of Lake Holloman (Lagoon G Outfall) (SD04001 and SD04002, respectively) on 4 November 2017 (**Figure 3.4-1**).

3.4.1.2 Surface Water Samples

Surface water samples were collected at the north end of Lake Holloman (Holloman AFB Outfall) and at the east side of Lake Holloman (Lagoon G Outfall) (SW04001 and SW04002, respectively) on 4 November 2017 (**Figure 3.4-1**).

3.4.2 Analytical Results

3.4.2.1 Sediment Samples

Three sediment samples (including one duplicate) were collected for PFAS analysis, with the results provided in **Table 3.1-4**, illustrated in **Figure 3.4-2**, and summarized below.

SD04001:

- PFOS was detected above the RSL at an approximate concentration of 0.185 mg/kg.
- PFOA was detected below the RSL at an approximate concentration of 0.00234 mg/kg.
- PFBS was not detected.

SD04002:

- PFOS was detected above the RSL in the normal and field duplicate samples at a maximum concentration of 0.519 mg/kg.
- PFOA was detected below the RSL in the normal and field duplicate samples at an approximate maximum concentration of and 0.0177 mg/kg.
- PFBS was detected below the RSL in the normal and field duplicate samples at approximate maximum concentration of 0.0034 mg/kg.

3.4.2.2 Surface Water Samples

Three surface water samples (including one duplicate) were collected for PFAS analysis, with the results provided in **Table 3.1-5**, illustrated in **Figure 3.4-3**, and summarized below.

SW04001:

- PFOS was detected above the USEPA HA value at a concentration of 0.951 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 0.0746 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 1.0256 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 0.0798 µg/L.

SW04002:

- PFOS was detected above the USEPA HA value in the normal and field duplicate samples at a maximum concentration of 2.81 µg/L.
- PFOA was detected above the USEPA HA value in the normal and field duplicate samples at a maximum concentration of 0.378 µg/L.

- PFOS+PFOA was detected above the USEPA HA value in the normal and field duplicate samples at a maximum concentration of 3.188 µg/L.
- PFBS was detected below the USEPA Tap Water RSL in the normal and field duplicate samples at a maximum concentration of 0.262 µg/L.

3.4.3 Conclusions

PFOS was detected at concentrations above the USEPA RSL in sediment at SD04001 and SD04002. PFOA and PFBS were detected in sediment, but at concentrations below the USEPA RSL. PFOS, PFOA, and PFOS+PFOA in surface water exceeded the USEPA HA values at both sample locations. PFBS was detected at concentrations below the USEPA Tap Water RSL at both outfall locations.

3.5 AFFF RELEASE AREA 5: EVAPORATION POND NO. 2

The evaporation basin was installed in 1991 and currently collects all discharge including AFFF, routed through hangar bay floor drains from hangars located in the western ramp area of the West Hangar Group. The Holloman AFB Fire Department uses this basin for monthly AFFF tests and firehose washouts. AFFF is reportedly sprayed from vehicles into the pond until a consistent flow pattern is established (HGL, 2015).

3.5.1 Sample Location and Methodologies

3.5.1.1 Soil Samples

Two soil borings (MW05001 and SB05002) were advanced at the evaporation basin are on 1 November 2017 (**Figure 3.5-1**). Surface soil samples were collected from 0 to 0.5 feet bgs, and subsurface soil samples were collected from 14 to 17 feet bgs, for PFAS analysis. Composite soil samples were also collected from each soil boring from 0 to 0.5-foot bgs and 14 to 17 feet bgs for TOC, pH, and particle size analysis. Groundwater was encountered at approximately 5 feet bgs during boring advancement.

3.5.1.2 Groundwater Samples

One permanent monitoring well was installed in soil boring MW05001 on 1 November 2017 to assess PFAS in the evaporation basin area (**Figure 3.5-1**). The permanent monitoring well was developed and sampled on 3 November 2017.

3.5.2 Analytical Results

3.5.2.1 Soil Results

Two surface and two subsurface soil samples were collected for PFAS analysis, with the results provided in **Table 3.1-1**, illustrated in **Figure 3.5-2**, and summarized below.

MW05001:

- PFOS was detected above the RSL at the two sampling intervals at a maximum concentration of 5.71 mg/kg (0 to 0.5 feet bgs)

- PFOA was detected above the RSL at the surface sampling interval (0 to 0.5 feet bgs) at a concentration of 0.335 mg/kg, and was detected below the RSL at the subsurface interval (14 to 15 feet bgs) at an approximate concentration of 0.005 mg/kg.
- PFBS was detected below the RSL at the two sampling intervals at a maximum concentration of 0.205 mg/kg (0 to 0.5 feet bgs).

SB05002:

- PFOS was detected above the RSL at the two sampling intervals at a maximum concentration of 0.745 mg/kg (0 to 0.5 feet bgs).
- PFOA was detected above the RSL at the surface sampling interval (0 to 0.5 feet bgs) at a concentration of 0.228 mg/kg, and was detected below the RSL at the subsurface sampling interval (16 to 17 feet bgs) at an approximate concentration of 0.00565 mg/kg.
- PFBS was detected below the RSL at the two sampling intervals at a maximum concentration of 0.200 mg/kg (0 to 0.5 feet bgs).

The composite TOC concentrations ranged from 1,980 mg/kg (0 to 0.5 feet bgs) to 5,610 mg/kg (14 to 17 feet bgs), while the composite pH concentrations ranged from 7.92 S.U. (14 to 17 feet bgs) to 8.09 S.U. (0 to 0.5 feet bgs) (**Table 3.1-2**). The particle size analytical results for the 0 to 0.5-foot bgs sample was 29.6% fines (silt and clay), 40.2% sand (fine to coarse), and 30.2% gravel (fine), while the 14 to 17 feet bgs sample was 49% fines (silt and clay), 50.5% sand (fine to coarse), and 0.5% gravel (fine). The material description for the 0 to 0.5-foot bgs sample was a light reddish brown silty sand with gravel, while the 14 to 17 feet bgs sample was described as a reddish brown sandy silt with trace clay to yellowish red sandy silt.

3.5.2.2 Groundwater Results

One groundwater sample was collected for PFAS analysis, with the results provided in **Table 3.1-3**, illustrated in **Figure 3.5-3**, and summarized below.

MW05001:

- PFOS was detected above the USEPA HA value at a concentration of 1040 µg/L.
- PFOA was detected above the USEPA HA value at a concentration of 26.6 µg/L.
- PFOS+PFOA was detected above the USEPA HA value at a concentration of 1066.6 µg/L.
- PFBS was detected below the USEPA Tap Water RSL at a concentration of 27.7 µg/L.

3.5.3 Conclusions

PFOS was detected above the RSL at the surface and subsurface sampling intervals at MW05001 and SB05002. PFOA was detected at concentrations above the RSL in surface samples at MW05001 and SB05002. PFBS was detected below RSL in all soil samples. PFOS, PFOA, and PFOS+PFOA in groundwater exceeded the USEPA HA values in the monitoring well. PFBS was detected at concentrations below the USEPA Tap Water RSL in groundwater at AFFF Release Area 5.

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4.0 MIGRATION/EXPOSURE PATHWAYS AND RECEPTORS

An updated base-wide conceptual site model table is provided as **Table 4.0-1**. The table provides an overview of the facility, physical, release, land use, exposure, and ecological profiles at Holloman AFB. The table has been updated to include information collected during this SI. A more detailed description of source area conditions and exposure pathways is described in the following sections.

4.1 SOIL (SURFACE AND SUBSURFACE) EXPOSURE PATHWAY

4.1.1 Local Geologic Setting

The principle soil types at Holloman AFB are primarily of the Holloman-Gypsum land-Yesum complex and Mead silty clay loam (USDA, 1981). The Holloman-Gypsum land-Yesum complex consists of shallow and deep, well-drained soils and areas of exposed gypsum. The surface layer is a relatively thin veneer of light brown, very fine sandy loam, approximately 3 inches thick (HGL, 2015). The Mead series is located across the main drainage area at Holloman AFB. The Mead silty clay loam, is a deep, poorly drained soil formed in fine textured alluvium over lacustrine lake sediment (USDA, 1981). Holloman AFB is located in the Tularosa Sub-basin that is part of the Central Closed Basins. The basin is bound by the San Andres Mountains to the west and Sacramento Mountains to the east (NVB, 2009). The Tularosa Basin is a bolson, or a basin, that has no surface drainage outlet (HGL, 2015). The bolson fill in the Tularosa Basin is derived from the erosion of limestone, dolomite, and gypsum in the surrounding mountains, with coarser material deposited at the base of the mountains and finer material carried to the basin interior (FWEC, 1995). The near surface bolson deposits consist of sediments that are of alluvial, eolian, lacustrine, or playa origin. The alluvial fan deposits are characteristically interbedded sand, silt and clay. The eolian deposits consist primarily of gypsum sand and the lacustrine/playa deposits consist of clay containing gypsum crystals (FWEC, 1995). The lacustrine deposits are juxtaposed with alluvial fan and eolian deposits throughout the installation (Radian, 1992). Basewide geologic cross sections developed from the SI soil boring activities are provided in **Figures 3.0-1 and 3.0-2**.

4.1.2 Soil Exposure Pathways and Receptors

PFOS and, to a lesser extent, PFOA were detected in surface and subsurface soils at AFFF release areas 1 and 5 at concentrations above the RSL of 0.126 mg/kg. PFOS, PFOA, and/or PFBS were also detected below the RSL of 0.126 mg/kg in soil at AFFF release areas 1, 2 and 5. No trends were noted as to depths of PFAS impacted soil, with the exception of Area 5 where surface soils contained higher concentrations of PFAS, PFOA, and PFBS than subsurface soils. None of the AFFF release areas have a clean cover or permanent impenetrable cover above the impacted soil.

Surface soil at Holloman AFB is potentially accessible by on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers. Strong winds, or dust storms, may increase mobility of contaminants if adsorbed to dust particles. Subsurface soil is primarily

accessible by on-site construction and utility workers involved with excavating, drilling, or any activity that exposes them to subsurface soil. Access to source area soil is not expected to change in the future.

Potential exposure routes for soil include inhalation of impacted surface soil dust particles, and ingestion and dermal contact of contaminants in soil.

4.1.3 Soil Exposure Conclusions

Potential human exposure receptors of PFOS and PFOA concentrations in surface and subsurface soil above the RSL at AFFF release areas 1, and 5 include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers via inhalation of dust derived from contaminated surface soil, ingestion, or dermal contact.

4.2 GROUNDWATER MIGRATION PATHWAY

4.2.1 Local Hydrogeologic Setting

Groundwater occurs as an unconfined aquifer in the unconsolidated deposits of the central basin (HGL, 2015). The primary source of groundwater recharge is rainfall percolation and minor amounts of stream run off along the western Sacramento Mountains. Since the Tularosa Basin is a closed system, water only leaves the area through evaporation or percolation and does not discharge to any adjacent aquifers (HGL, 2015). The elevated amount of percolation results in a high-water table with groundwater levels ranging from 5 to 50 feet bgs (NVB, 2009). Groundwater flow at the installation is generally towards the southwest, with localized influences from variations in topography, the presence of surface water features, and the amount of rainfall percolation and stream runoff along the western Sacramento Mountains. In the northern and western portions of Holloman AFB, groundwater flows more to the west toward the Ritas Draw, Malone Draw, and Lost River drainages (HGL, 2015). Groundwater flow is also affected by local topography in areas immediately adjacent to arroyos, where groundwater flows directly toward the drainages regardless of regional flow pattern (NVB, 2009). In the vicinity of the former FTA (FT-31) groundwater flows to the south-southeast towards Dillard Draw which flows towards the south and subsequently to the southwest towards Lake Holloman (**Figure 3.0-3**).

Groundwater quality in the Tularosa Basin is only of potable quality in the recharge areas in close proximity to the Sacramento Mountains east of Holloman AFB and becomes increasingly mineralized towards the central portion of the basin (NVB, 2009). The PA report identified that most (over 70 percent) of Environmental Restoration Program (ERP) sites at HAFB have groundwater with average total dissolved solids (TDS) concentrations greater than 10,000 milligrams per liter (mg/L). These TDS concentrations exceed the New Mexico Water Quality Control Commission (NMWQCC) human health standard of 1,000 mg/l and therefore the groundwater has been designated unfit for human consumption (NVB, 2009).

Historical groundwater analytical results from monitoring wells in the vicinity of select AFFF release areas identified concentrations of TDS exceeding both the NMWQCC human health standard (1,000 mg/L) and the USEPA secondary drinking water standard (500 mg/L). In 2015, concentrations of TDS from monitoring

wells sampled in the vicinity of the former FTA ranged from 22,900 mg/l to 30,600 mg/l and in 2018, concentrations of TDS in groundwater from monitoring wells installed at the golf course ranged from 8,540 mg/l to 52,700 mg/l (Baer Engineering and Environmental Consulting, 2018).

The adjacent surface waters, including Lost River and Lake Holloman also have high concentrations of TDS and are not considered potential drinking water sources (NVB, 2009). In addition, the USEPA has classified the groundwater as a Class IIIB water source, characterized by a low degree of interconnection with adjacent surface water or groundwater of a higher class.

4.2.2 Groundwater Exposure Pathways and Receptors

PFAS, once in groundwater, are highly mobile and will migrate near the same velocity as groundwater due to their high solubility and low partition coefficient value. PFAS are chemically and biologically stable in the environment and resist typical environmental degradation processes. As a result, these chemicals are extremely persistent in the environment, with a half-life greater than 41 years for PFOS and greater than 92 years for PFOA (USEPA, 2014). PFBS is generally less toxic and less bioaccumulative in wildlife and humans (USEPA, 2017b).

PFOS, PFOA, and/or PFBS were detected in groundwater at AFFF Release Areas 1, 2, 3, and 5. PFOS, PFOA, and PFOS+PFOA exceeded the USEPA HA value of 0.07 µg/L in groundwater at these areas, while PFBS was detected below the USEPA Tap Water value of 400 µg/L. Based on the current PFAS analytical results, AFFF Release Areas 1, 2, 3, and 5 are considered groundwater release areas for pathway analysis.

Due to generally poor ambient groundwater quality with TDS at concentrations above 10,000 mg/L, no water supply wells are located at Holloman AFB. Potable water at Holloman AFB is obtained from four well fields (Boles, Escondido, San Andreas and Frenchy) located between 12 and 35 miles southeast of the installation near the foothills of the Sacramento Mountains (Holloman AFB, 2016). Groundwater is obtained from 15 wells with an average depth of 450-550 feet. The water is subsequently stored in ground level tanks and transported via pipeline to the installation (Holloman AFB, 2016). The installation water supply was sampled for PFAS by Bioenvironmental Engineering (BEE) personnel and no detections were reported.

The City of Alamogordo, also utilizes water from the referenced well field; however, a review of water well records available from the New Mexico Office of the State Engineer, Water Rights Reporting System identified the presence of 407 wells within 4-miles of the installation boundary (**Figure 4.2-1**). As shown on **Figure 4.2-1,** most wells are identified northeast and east of Holloman AFB in the foothills of the Sacramento Mountains at a topographically higher elevation than the installation. Groundwater flow on, and in the vicinity of Holloman AFB is directed to the southwest, coincident with regional topography and therefore the majority of the identified wells are located in up- or side-gradient locations relative to the installation and AFFF release areas. Of the identified 407 wells, 11 were identified as being potentially downgradient of the groundwater release area (**Figure 4.2-2)**. Details regarding well locations, depth, ownership and use are provided in **Table 4.2-1**. No domestic wells were identified within 4-miles

downgradient of the installation boundary and therefore no potential groundwater receptors were identified.

4.2.3 Groundwater Migration Pathway Conclusions

PFOS and PFOA in groundwater exceeded the USEPA HA value of 0.07 µg/L for PFOS, PFOA, and/or the sum of PFOS/PFOA, at AFFF Release Areas 1, 2, 3, and 5. Human groundwater receptors via the ingestion pathway are not present for any AFFF release area at or downgradient of Holloman AFB because water at the installation does not meet the drinking water standards established by the NMWQCC due to high levels of TDS.

All drinking water at the installation is supplied from well fields located 12 to 35 miles southeast of Holloman AFB. The water supply at the installation was sampled for PFAS by BEE personnel and no detections were reported. In addition, no private potable water wells were identified downgradient of the installation or AFFF release areas and therefore there is currently no potential groundwater receptor pathway with immediate impacts to human health at Holloman AFB.

4.3 SEDIMENT EXPOSURE PATHWAY

4.3.1 Sediment Exposure Pathways and Receptors

PFOS was detected in all sediments collected from AFFF Release Areas 2, 3, and 4; sediments from AFFF release areas 3 and 4 contained PFOS at concentrations above the RSL of 0.126 mg/kg. PFOA and PFBS were also detected in sediments from AFFF Release Area 4, but below the respective screening levels.

Sediment at Holloman AFB is potentially accessible by on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers. Potential exposure routes for sediment include dermal contact with submerged or exposed sediment during work activities such as maintenance of ponds, drainage ditches, and canals that contain PFAS-impacted sediment, as well as various recreational activities at Lake Holloman or at Apache Mesa Golf Course.

4.3.2 Sediment Exposure Conclusions

PFOS was detected in sediments collected from AFFF release areas 3 and 4 at concentrations above the calculated RSL of 0.126 mg/kg. Potential receptors include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers that may come into contact with PFAS-impacted sediment at or downstream of AFFF release areas 2, 3, and 4.

4.4 SURFACE WATER EXPOSURE PATHWAY

4.4.1 Surface Water Exposure Pathways and Receptors

PFOS and PFOA were detected in surface water at AFFF release areas 2, 3, and 4 (all surface water sampling areas) at concentrations above the USEPA HA value of 0.07 µg/L. However, the USEPA HA value for PFOS and PFOA is only applicable to surface water used as a drinking water source and the surface waters at Holloman AFB are not currently used as sources for drinking water due to high concentrations

of TDS (NVB, 2009). PFBS was also detected in surface waters from Areas 2, 3, and 4, but no criteria exists for PFBS in surface water.

Surface water at Holloman AFB is potentially accessible by on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers. Surface water extraction points for the city of Alamogordo water supply include springs and stream diversions in the Fresnal and La Luz Canyon Systems, springs in the Alamo Canyon System, and Bonito Lake located upstream (north and east) of Holloman AFB (Alamogordo, 2016). Primary surface water exposure points downgradient of the installation are the Lagoon Outfall and Lake Holloman; however, surface water at these locations is unfit for human consumption due to high concentrations of TDS and are therefore not considered potential sources of drinking water. Potential exposure routes for surface water include dermal contact with surface water during work activities such as maintenance of ponds, drainage ditches, and canals that contain PFAS-impacted surface water, as well as during various recreational activities at Lake Holloman and/or Apache Mesa Golf Course.

4.4.2 Surface Water Exposure Conclusions

PFOS and PFOA were detected in surface water at concentrations above the USEPA HA value in samples collected from AFFF release areas 2, 3, and 4. However, the USEPA HA for PFOS and PFOA is only applicable to drinking water sources and since surface water at Holloman AFB contains high concentrations of TDS, it is not considered a potential drinking water source and therefore there is no potential exposure pathway for immediate impacts to human health via ingestion.

Potential exposure receptors include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers that may come in contact with PFAS-impacted surface water at or downstream of AFFF release areas 2, 3, and 4. These exposure routes for PFAS-impacted surface water sampled at these areas are not considered immediate impacts to human health.

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5.0 SUMMARY AND CONCLUSIONS

As stated in the introduction, the objectives of this study were to:

- Determine if PFOS, PFOA, or PFBS are present in soil, groundwater, sediment, or surface water at AFFF release areas selected for SI;
- Determine if PFOS and PFOA concentrations in soil exceed the calculated RSL, based on a residential scenario, of 0.126 mg/kg, and if PFBS concentrations in soil exceed the USEPA residential RSL of 130 mg/kg;
- Determine if PFOS, PFOA, or sum of PFOS and PFOA concentrations in groundwater exceed the USEPA HA value of 0.07 µg /L, and if PFBS concentrations in groundwater exceed the USEPA Tap Water RSL of 400 µg/L;
- Determine if PFOS and PFOA concentrations in sediment exceed the calculated RSL, based on a residential scenario of 0.126 mg/kg, and if PFBS concentrations in sediment exceed the USEPA residential RSL of 130 mg/kg;
- Determine if PFOS, PFOA, or sum of PFOS and PFOA concentrations in surface water exceed the USEPA HA value of 0.07 µg /L; and,
- Identify potential receptor pathways with immediate impacts to human health (immediate impact to human health is considered consumption of drinking water with PFOS/PFOA above the USEPA HA value, or PFBS above the USEPA Tap Water RSL).

Section 3 of this SI detailed the analytical results for PFAS at each AFFF release area. A summary table (**Table 5.0-1**) is also provided below which lists specific exceedances by area and media, fulfilling the objectives of the SI.

Table 5.0-1. Summary of Analytical Results and Screening Level Exceedances.

AFFF Release Area	Parameter	Maximum Detected Concentration	Screening Value	Units	Number of Samples*/ Number of Exceedances	Exceeds Screening Level	Potentially Complete DW Exposure Pathway	Recommen-dation
AFFF Release Area 1 Former FTA (FT-31)	Surface Soil (0 to 0.5 feet)						NO	Advance Area to RI
	PFOS	**0.33**	0.126	mg/kg	5/4	**Yes**		
	PFOA	0.0561	0.126	mg/kg	5/0	No		
	PFBS	0.0583	130	mg/kg	5/0	No		
	Subsurface Soil (17 to 23 feet)							
	PFOS	**1.13J**	0.126	mg/kg	5/3	**Yes**		
	PFOA	**0.19**	0.126	mg/kg	5/1	**Yes**		
	PFBS	0.0577	130	mg/kg	5/0	No		
	Groundwater							
	PFOS	**48.4**	0.07	µg/L	3/3	**Yes**		
	PFOA	**254**	0.07	µg/L	3/3	**Yes**		
	PFOS+PFOA	**302.4**	0.07	µg/L	3/3	**Yes**		
	PFBS	226	400	µg/L	3/0	No		
AFFF Release Area 2 Sewage Lagoon Area Outfall	Surface Soil (0 to 0.5 feet)						NO	Advance Area to RI
	PFOS	0.00985B	0.126	mg/kg	6/0	No		
	PFOA	0.00117B	0.126	mg/kg	6/0	No		
	PFBS	0.00119J	130	mg/kg	6/0	No		
	Subsurface Soil (1.5 to 7 feet)							
	PFOS	0.0461	0.126	mg/kg	6/0	No		
	PFOA	0.00447	0.126	mg/kg	6/0	No		
	PFBS	0.00177J	130	mg/kg	6/0	No		
	Groundwater							
	PFOS	**8.27**	0.07	µg/L	3/3	**Yes**		
	PFOA	**0.854**	0.07	µg/L	3/3	**Yes**		
	PFOS+PFOA	**9.124**	0.07	µg/L	3/3	**Yes**		
	PFBS	0.732	400	µg/L	3/0	No		
	Sediment							
	PFOS	0.0745	0.126	mg/kg	1/0	No		
	PFOA	ND	0.126	mg/kg	1/0	No		
	PFBS	ND	130	mg/kg	1/0	No		
	Surface Water							
	PFOS	**2.25**	0.07	µg/L	1/1	**Yes**		
	PFOA	**0.941**	0.07	µg/L	1/1	**Yes**		
	PFOS+PFOA	**3.191**	0.07	µg/L	1/1	**Yes**		
	PFBS	0.716	400	µg/L	1/0	No		

AFFF Release Area	Parameter	Maximum Detected Concentration	Screening Value	Units	Number of Samples*/ Number of Exceedances	Exceeds Screening Level	Potentially Complete DW Exposure Pathway	Recommen-dation
AFFF Release Area 3 Apache Mesa Golf Course Outfall	Groundwater						NO	Advance Area to RI
	PFOS	0.048	0.07	µg/L	3/3	No		
	PFOA	**0.0891**	0.07	µg/L	3/3	**Yes**		
	PFOS+PFOA	**0.1371**	0.07	µg/L	3/3	**Yes**		
	PFBS	0.286	400	µg/L	3/0	No		
	Sediment							
	PFOS	**0.202J**	0.126	mg/kg	2/1	**Yes**		
	PFOA	ND	0.126	mg/kg	2/0	No		
	PFBS	ND	130	mg/kg	2/0	No		
	Surface Water							
	PFOS	**1.22**	0.07	µg/L	2/2	**Yes**		
	PFOA	**0.117**	0.07	µg/L	2/2	**Yes**		
	PFOS+PFOA	**1.317**	0.07	µg/L	2/2	**Yes**		
	PFBS	0.156	400	µg/L	2/0	No		
	WWTP Effluent							
	PFOS	**0.776**	0.07	µg/L	1/1	**Yes**		
	PFOA	**0.0738**	0.07	µg/L	1/1	**Yes**		
	PFOS+PFOA	**0.8498**	0.07	µg/L	1/1	**Yes**		
	PFBS	0.0954	400	µg/L	1/0	No		
AFFF Release Area 4 Lake Holloman Outfalls	Sediment						NO	Advance Area to RI
	PFOS	**0.519**	0.126	mg/kg	2/2	**Yes**		
	PFOA	0.0177J	0.126	mg/kg	2/0	No		
	PFBS	0.0034J	130	mg/kg	2/0	No		
	Surface Water							
	PFOS	**2.81**	0.07	µg/L	3/3	**Yes**		
	PFOA	**0.378**	0.07	µg/L	3/3	**Yes**		
	PFOS+PFOA	**3.188**	0.07	µg/L	3/3	**Yes**		
	PFBS	0.262	400	µg/L	3/0	No		

AFFF Release Area	Parameter	Maximum Detected Concentration	Screening Value	Units	Number of Samples*/ Number of Exceedances	Exceeds Screening Level	Potentially Complete DW Exposure Pathway	Recommen-dation
AFFF Release Area 5 Evaporation Pond No. 2	Surface Soil (0 to 0.5 feet)						NO	Advance Area to RI
	PFOS	**5.71**	0.126	mg/kg	2/2	**Yes**		
	PFOA	**0.335**	0.126	mg/kg	2/2	**Yes**		
	PFBS	0.205	130	mg/kg	2/0	No		
	Subsurface Soil (14 to 17 feet)							
	PFOS	**0.262**	0.126	mg/kg	2/2	**Yes**		
	PFOA	0.00565Q	0.126	mg/kg	2/0	No		
	PFBS	0.00578J	130	mg/kg	2/0	No		
	Groundwater							
	PFOS	**1,040**	0.07	µg/L	1/1	**Yes**		
	PFOA	**26.6**	0.07	µg/L	1/1	**Yes**		
	PFOS+PFOA	**1066.6**	0.07	µg/L	1/1	**Yes**		
	PFBS	27.7	400	µg/L	1/0	No		

Notes:
* includes normal and field duplicate samples (count does not include QC samples)
AFFF – aqueous film forming foam
B - The analyte was identified in an associated blank as well as the sample
bgs – below ground surface
DW – Drinking Water
J - The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample
µg/L - micrograms per liter
mg/kg - milligrams per kilogram
ND – not detected
RI – Remedial Investigation
NFRAP – No Further Remedial Action Planned
PFBS – perfluorobutanesulfonic acid
PFOS – perfluorooctanesulfonic acid
PFOA – perfluorooctanoic acid
Q = The analyte is both B-qualified because of blank detection and J-qualified because of an additional QC issue

Potential human health pathways were identified and detailed in Section 4 of this SIR. The potential receptors vary by AFFF release area. Media-specific pathways and receptors are discussed below.

Surface and Subsurface Soil Receptors

Potential human receptors from PFAS in surface and subsurface soil at AFFF release areas 1, 2 and 5 include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers. PFOS and PFOA concentrations in several surface soil samples at AFFF release areas 1 and 5 exceeded the calculated RSL, based on a residential exposure scenario. However, this soil would only be accessed via work activities in the impacted areas, with the exception of AFFF Release Area

1 where wind has the potential to disturb PFOS-impacted surface soil and create a potential for transport and inhalation of dust derived from contaminated surface soil.

Groundwater Receptors

Potential human receptors from PFAS in groundwater include on-base personnel and residents, grounds maintenance workers, utility workers, construction workers that may encounter the shallow water table at AFFF Release Areas 1, 2, 3, and 5 where PFOS, PFOA, and PFOA+PFOA exceeded the USEPA HA value.

Human groundwater receptors via the ingestion pathway are not present for any AFFF release area at or downgradient (southwest) of Holloman AFB since groundwater beneath Holloman AFB is classified as unfit for human consumption due to the generally poor ambient groundwater quality. Concentrations of total dissolved solids (TDS) in groundwater exceed the New Mexico Water Quality Control Commission (NMWQCC) human health standard of 1,000 mg/l and therefore no potable water supply wells are located at Holloman AFB. All potable water at the installation is obtained from 15 wells located 12 to 35 miles southeast of the installation at an average depth of 450 to 550 feet (Holloman AFB, 2016). The potable water supply at Holloman AFB is routinely sampled for PFAS and no detections have been reported.

Although the City of Alamogordo obtains potable water from the same well field as Holloman AFB, private water supply wells are also utilized outside the city limits and within 4-miles of the installation boundary. Groundwater flow on, and in the vicinity of Holloman AFB is directed to the southwest, coincident with regional topography and therefore all identified private water supply wells are located in up- or side-gradient locations relative to the AFFF release areas and not considered receptors for groundwater from the installation.

As a result, there is currently no potential receptor pathway with immediate impacts to human health at Holloman AFB.

Sediment Receptors

Potential human receptors from PFAS in sediment include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, trespassers and/or recreational users of Lake Holloman that may come in contact with PFAS-impacted sediment. PFOS concentrations exceeded the RSL in sediments at AFFF Release Areas 3 and 4, Apache Mesa Golf Course and Lake Holloman outfalls. Exposure routes include dermal contact with submerged or exposed sediment during work activities such as maintenance of ponds, drainage ditches, and canals, as well as various recreational activities at or downstream of Lake Holloman or at Apache Mesa Golf Course.

Surface Water Receptors

Potential human receptors include on-base personnel, grounds maintenance workers, utility workers, construction workers, site visitors, and/or trespassers that may come into contact with PFAS-impacted surface water within the Apache Mesa Golf Course, the sewage lagoon area outfalls, or Lake Holloman. PFOS, PFOA, and/or PFOS+PFOA in surface water exceeded the USEPA HA values at AFFF Release Areas 2,

3, and 4 (all surface water sampling areas). However, the USEPA HA value for PFOS and PFOA is only applicable to drinking water sources, and the surface waters that were sampled as a part of this SI are not used as a drinking water source due to elevated levels of TDS above the NMWQCC limit for potable water.

Furthermore, City of Alamogordo drinking water surface water extraction points are located upgradient from HAFB within the canyons of the surrounding mountains ranges. Therefore, the only exposure routes for PFAS-impacted surface water sampled during this SI are dermal contact or accidental ingestion and are not considered immediate impacts to human health.

6.0 REFERENCES

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FIGURES

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FIGURE ACRONYMS

AFFF	aqueous film forming foam
ft bgs	feet below ground surface
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
PFAS	per- and polyfluorinated alkyl substances
PFBS	perfluorobutanesulfonic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
SB	soil boring
SD	sediment
SW	surface water

FIGURE NOTES

Pink shaded = Exceeds applied USEPA Health Advisory Value or RSL
Groundwater elevations in NAVD88 (feet)
[A] Higher concentration observed in field duplicate sample
B = The analyte was detected in the sample, and in an associated blank, and the concentration detected in the sample was less than 10x the concentration detected in the blank
J = The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample
U = The analyte was analyzed for, but was not detected above the reported limit of detection
UJ = The reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample
Q = The analyte is both B-qualified because of blank detection and J-qualified because of an additional QC issue.

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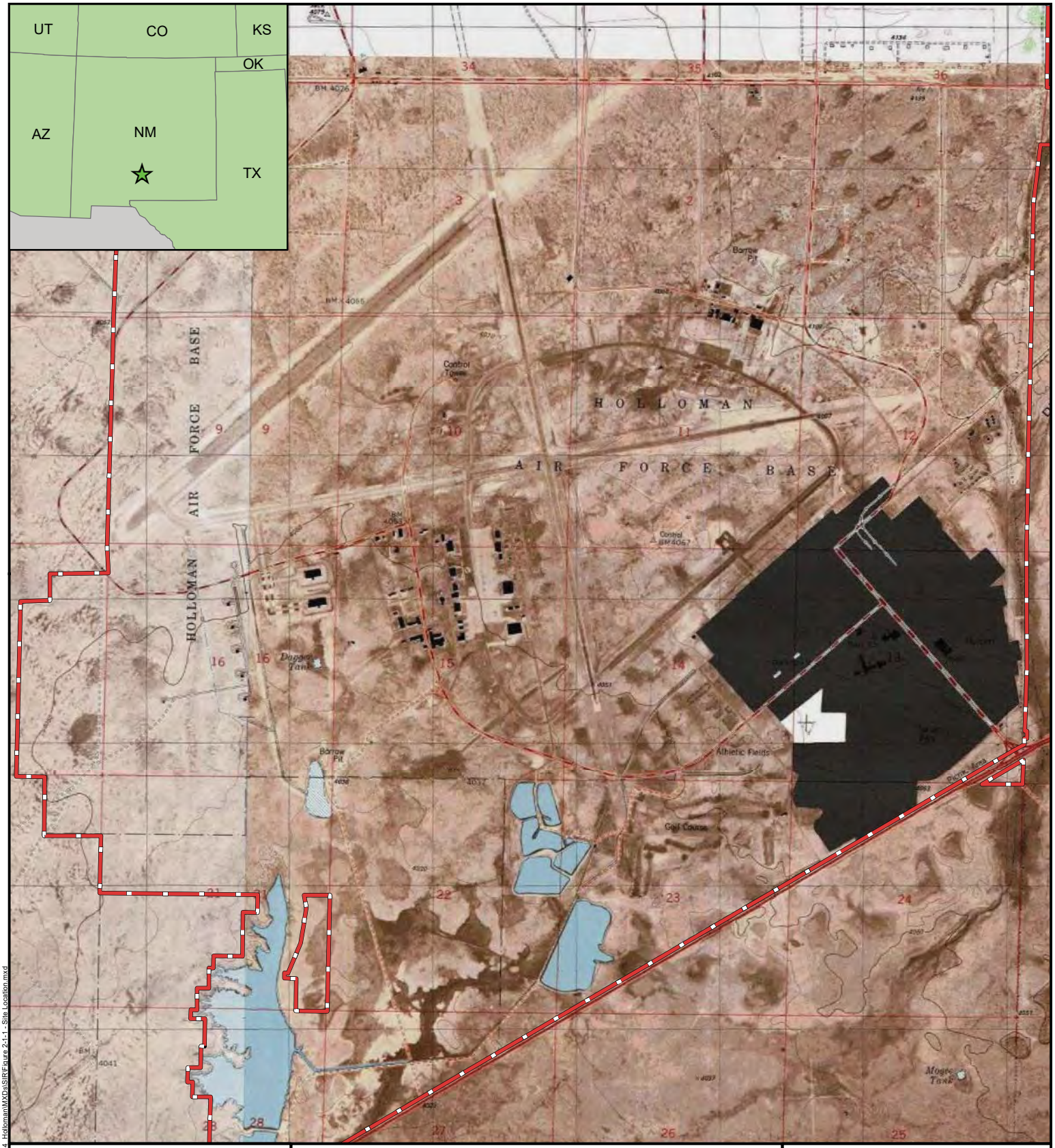

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0 1,000 2,000 4,000 Feet

Symbol Key

Holloman AFB Installation Boundary

FIGURE 2.1-1
Site Location Map
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

Path: C:\Workspace\GIS Projects\775303101_USAF Active_PFCs\0014_Holloman\MXDs\SIR\Figure 2-1-1 - Site Location.mxd

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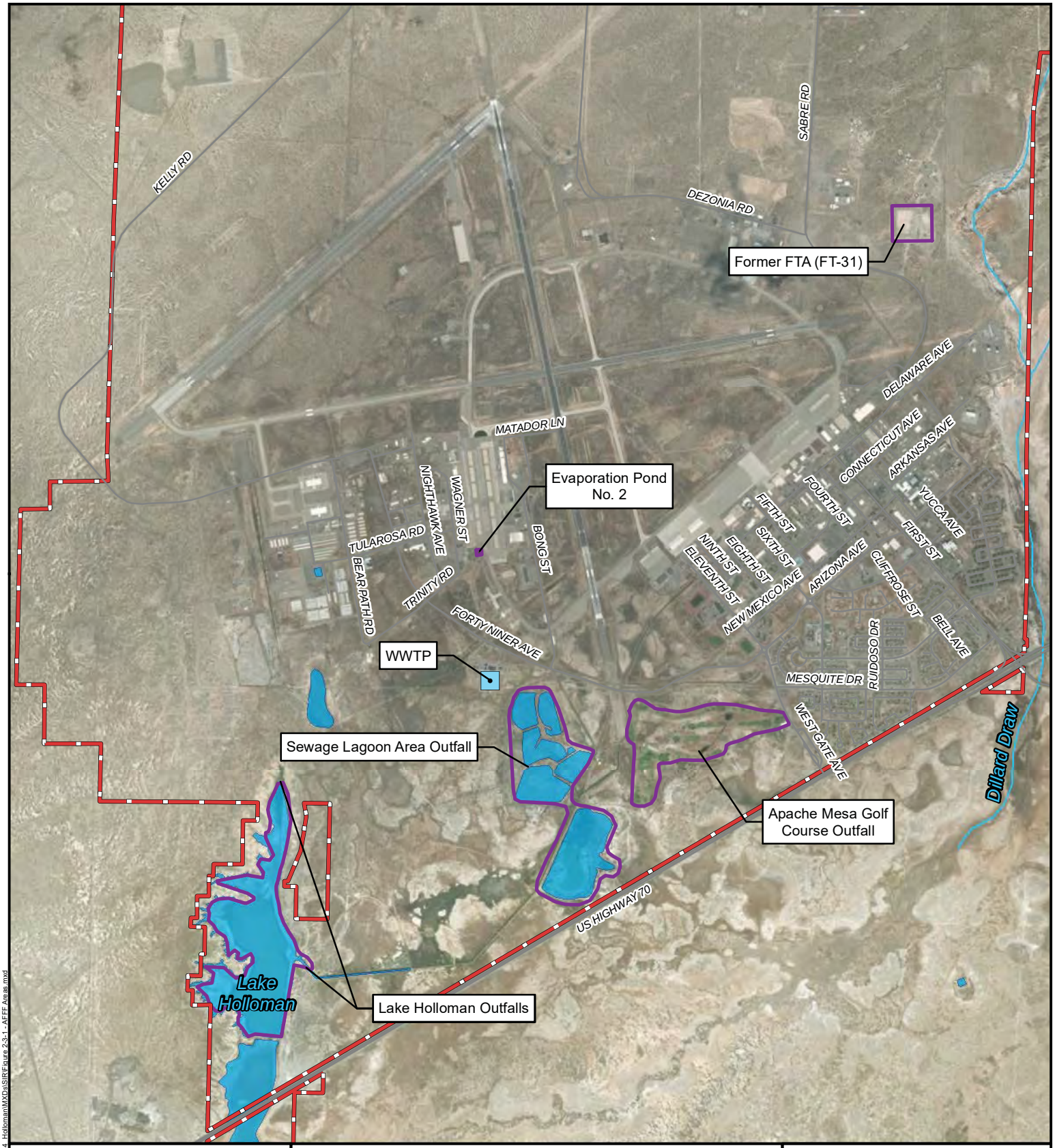

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0 1,000 2,000 4,000 Feet

Symbol Key

- Waste Water Treatment Plant
- Roads
- Streams
- Surface Water
- AFFF Release Area
- Holloman AFB Installation Boundary

Figure 2.3-1
AFFF Release Areas
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide Site Inspection Report

Path: C:\Workspace\GIS Projects\775303101_USAF_Active_PFCs\0014_Holloman\MXDs\SIR\Figure 2-3-1 - AFFF Areas.mxd

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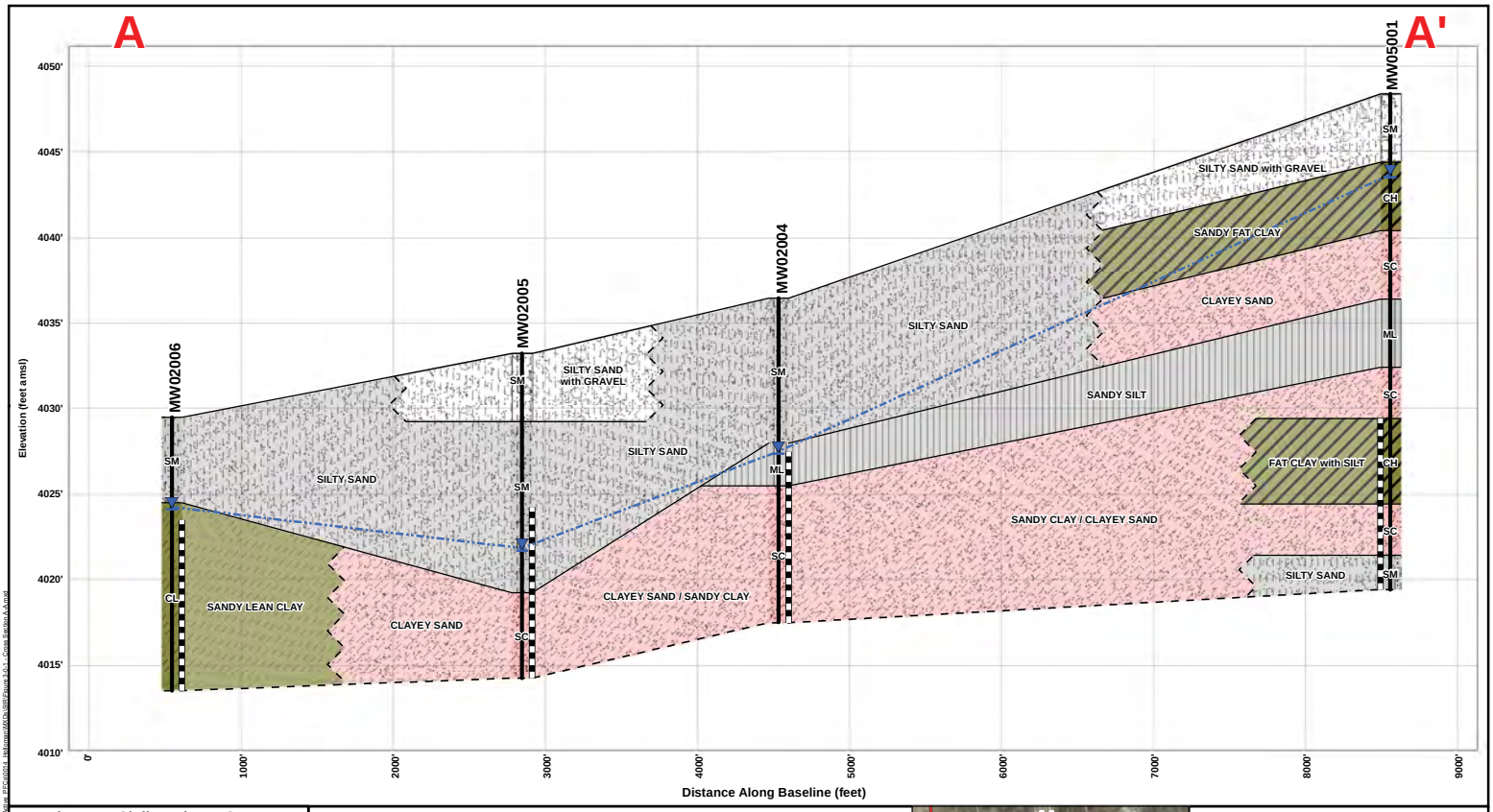

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Symbol Key

- Water Level (November 2017)
- Approximate Water Table
- Well Screen Zone
- Monitoring Well / Soil Boring
- Holloman AFB Installation Boundary
- USCS Lean Clay
- USCS Fat Clay
- USCS Clayey Sand / Sandy Clay
- USCS Sandy Silt
- USCS Silty Sand
- USCS Silty Sand with Gravel

FIGURE 3.0-1
Base Cross-Section A-A'
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous
Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

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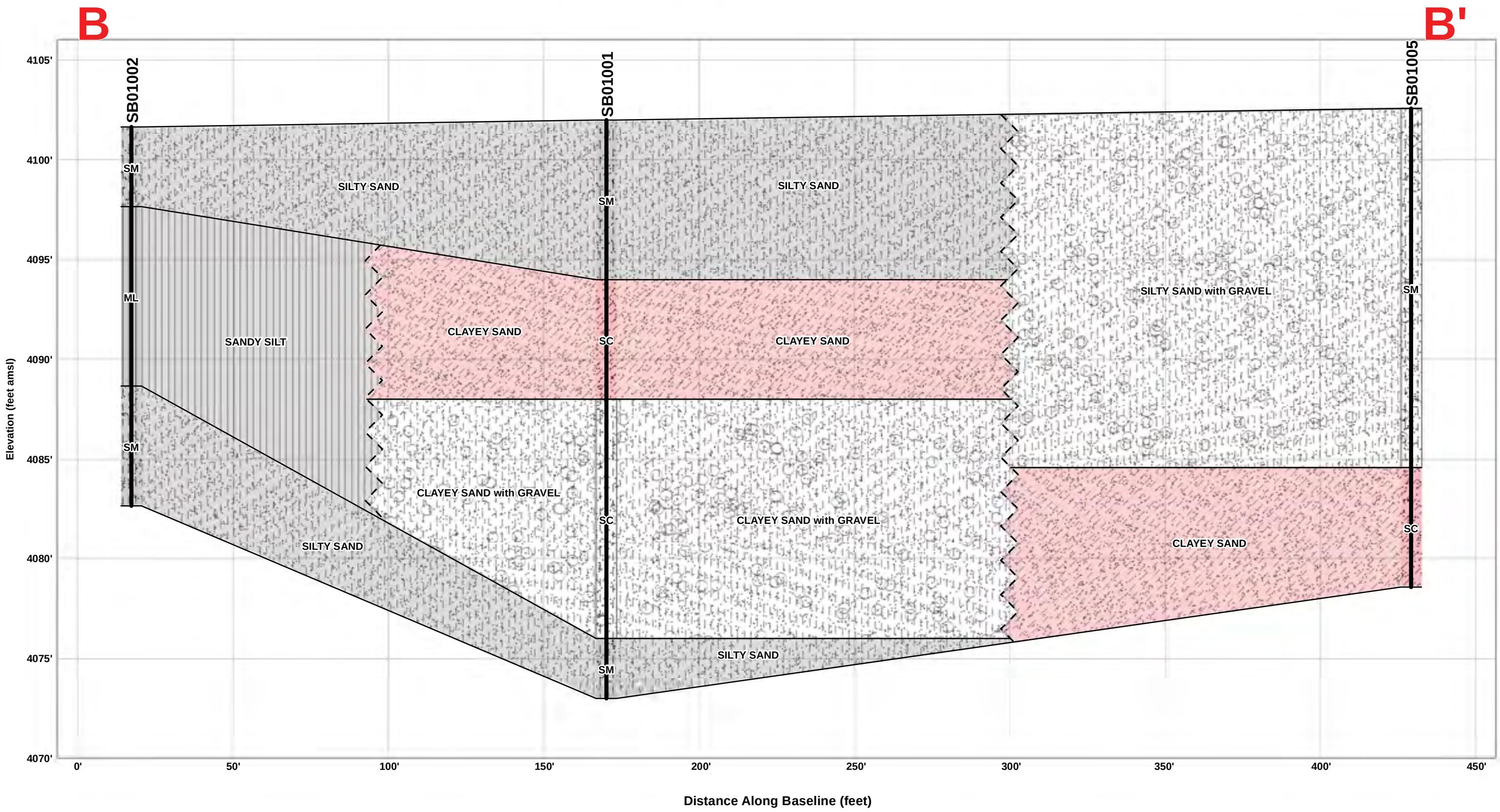

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Symbol Key

- Water Level (November 2017)
- Approximate Water Table
- Well Screen Zone
- Soil Boring
- Holloman AFB Installation
- USCS Lean Clay
- USCS Fat Clay
- USCS Clayey Sand / Sandy Clay
- USCS Sandy Silt
- USCS Silty Sand
- USCS Silty/Clayey Sand with Gravel

FIGURE 3.0-2
Base Cross-Section B-B'
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous
Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

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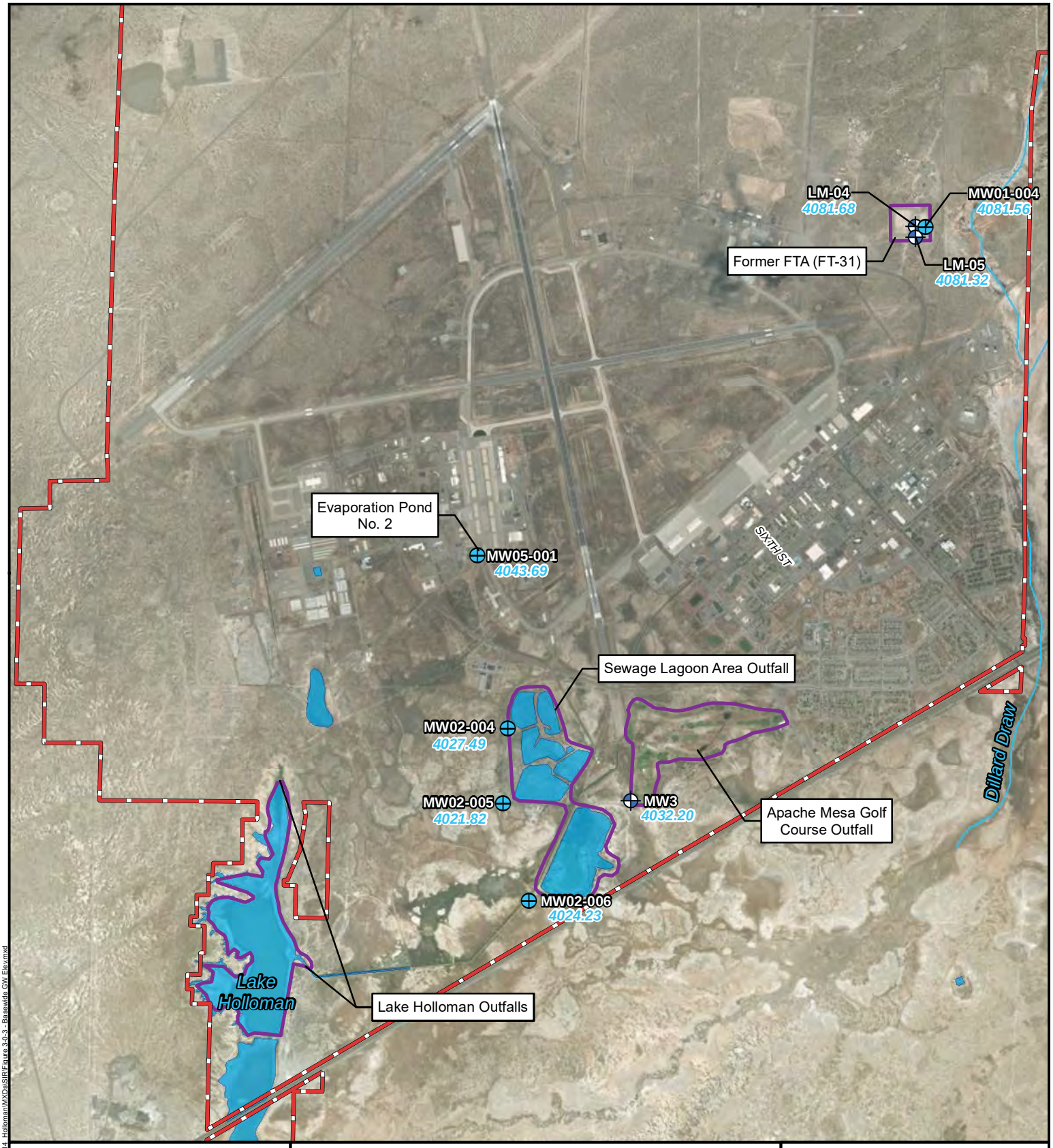

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0 1,000 2,000 4,000 Feet

Symbol Key

- Monitoring Well
- Monitoring Well / Soil Boring
- Streams
- Surface Water
- AFFF Release Area
- Holloman AFB Installation Boundary

Figure 3.0-3
Basewide Groundwater Elevations (October/November 2017)
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide Site Inspection Report

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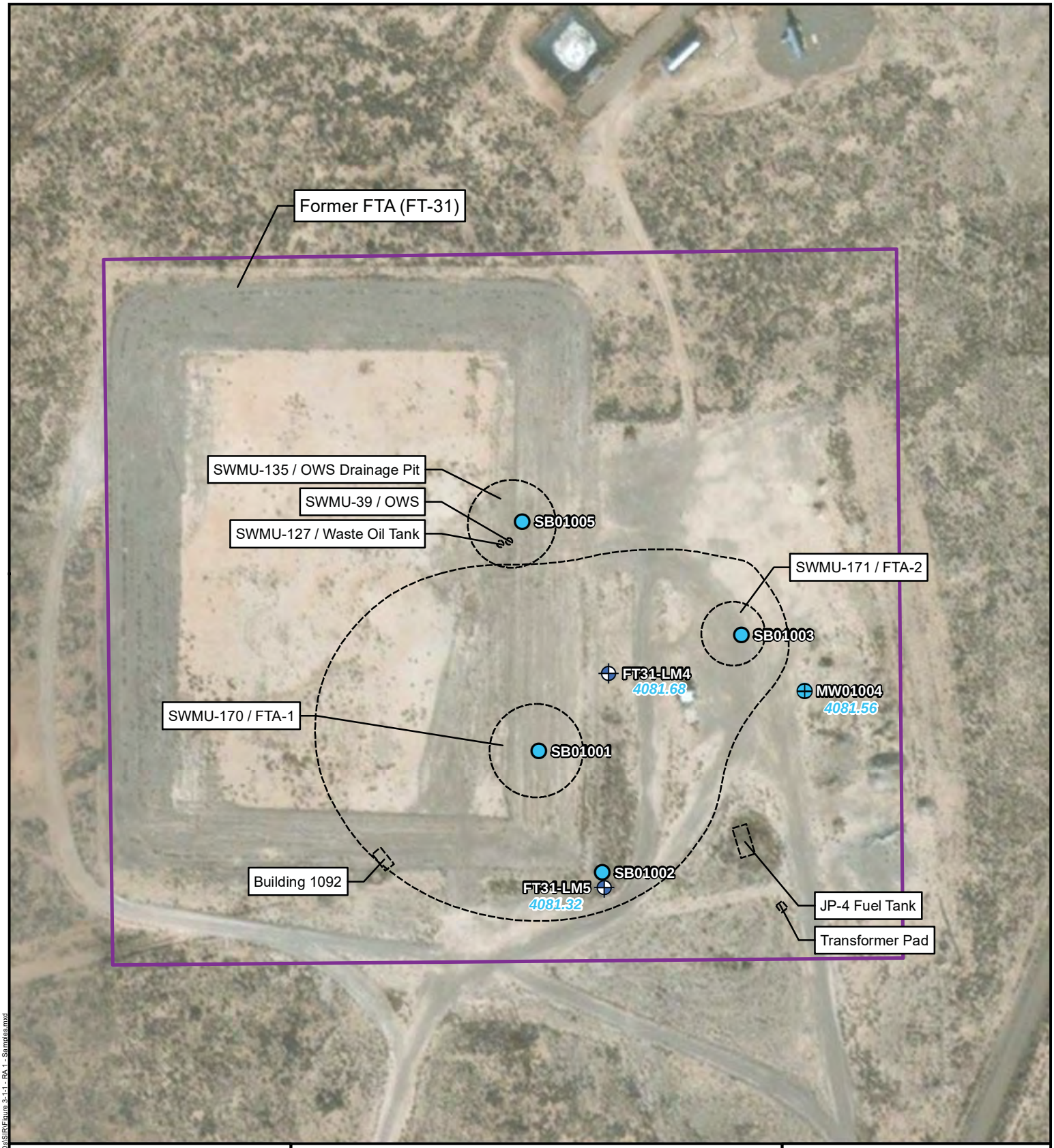

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0 50 100 200 Feet

Symbol Key

- Monitoring Well
- Monitoring Well / Soil Boring
- Soil Boring
- AFFF Release Area
- Approximate Historic Features

FIGURE 3.1-1
Sampling Locations and Groundwater Elevations
Former FTA (FT-31)
AFFF Release Area 1
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

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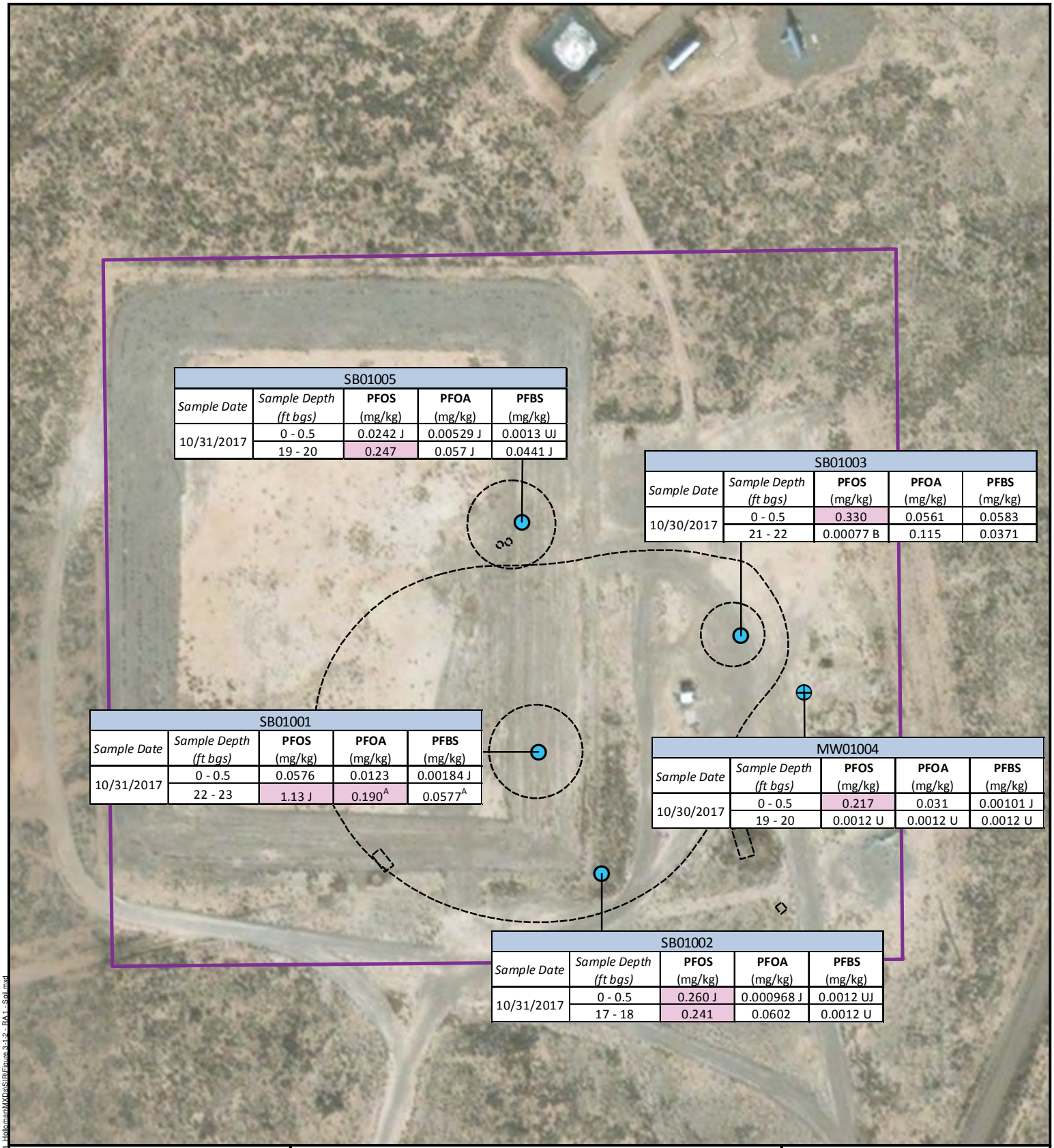

SB01005				
Sample Date	*Sample Depth (ft bgs)*	**PFOS** (mg/kg)	**PFOA** (mg/kg)	**PFBS** (mg/kg)
10/31/2017	0 - 0.5	0.0242 J	0.00529 J	0.0013 UJ
	19 - 20	0.247	0.057 J	0.0441 J

SB01003				
Sample Date	*Sample Depth (ft bgs)*	**PFOS** (mg/kg)	**PFOA** (mg/kg)	**PFBS** (mg/kg)
10/30/2017	0 - 0.5	0.330	0.0561	0.0583
	21 - 22	0.00077 B	0.115	0.0371

SB01001				
Sample Date	*Sample Depth (ft bgs)*	**PFOS** (mg/kg)	**PFOA** (mg/kg)	**PFBS** (mg/kg)
10/31/2017	0 - 0.5	0.0576	0.0123	0.00184 J
	22 - 23	1.13 J	0.190[A]	0.0577[A]

MW01004				
Sample Date	*Sample Depth (ft bgs)*	**PFOS** (mg/kg)	**PFOA** (mg/kg)	**PFBS** (mg/kg)
10/30/2017	0 - 0.5	0.217	0.031	0.00101 J
	19 - 20	0.0012 U	0.0012 U	0.0012 U

SB01002				
Sample Date	*Sample Depth (ft bgs)*	**PFOS** (mg/kg)	**PFOA** (mg/kg)	**PFBS** (mg/kg)
10/31/2017	0 - 0.5	0.260 J	0.000968 J	0.0012 UJ
	17 - 18	0.241	0.0602	0.0012 U

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0 50 100 200 Feet

Symbol Key

- Monitoring Well / Soil Boring
- Soil Boring
- AFFF Release Area
- Approximate Historic Features

FIGURE 3.1-2
PFAS in Soil
Former FTA (FT-31)
AFFF Release Area 1
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

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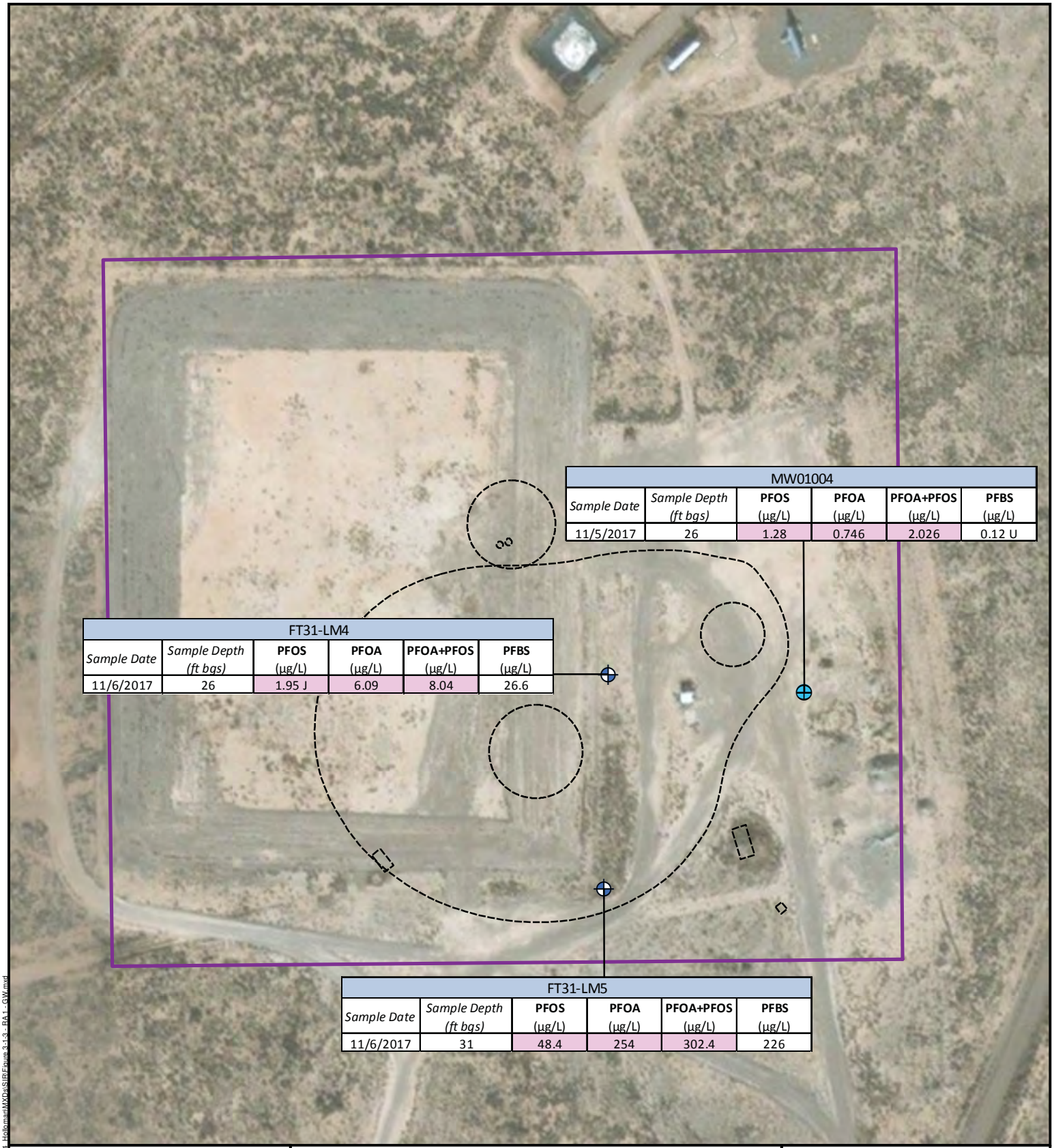

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0 50 100 200 Feet

Symbol Key

- Monitoring Well
- Monitoring Well / Soil Boring
- AFFF Release Area
- Approximate Historic Features

FIGURE 3.1-3
PFAS in Groundwater
Former FTA (FT-31)
AFFF Release Area 1
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

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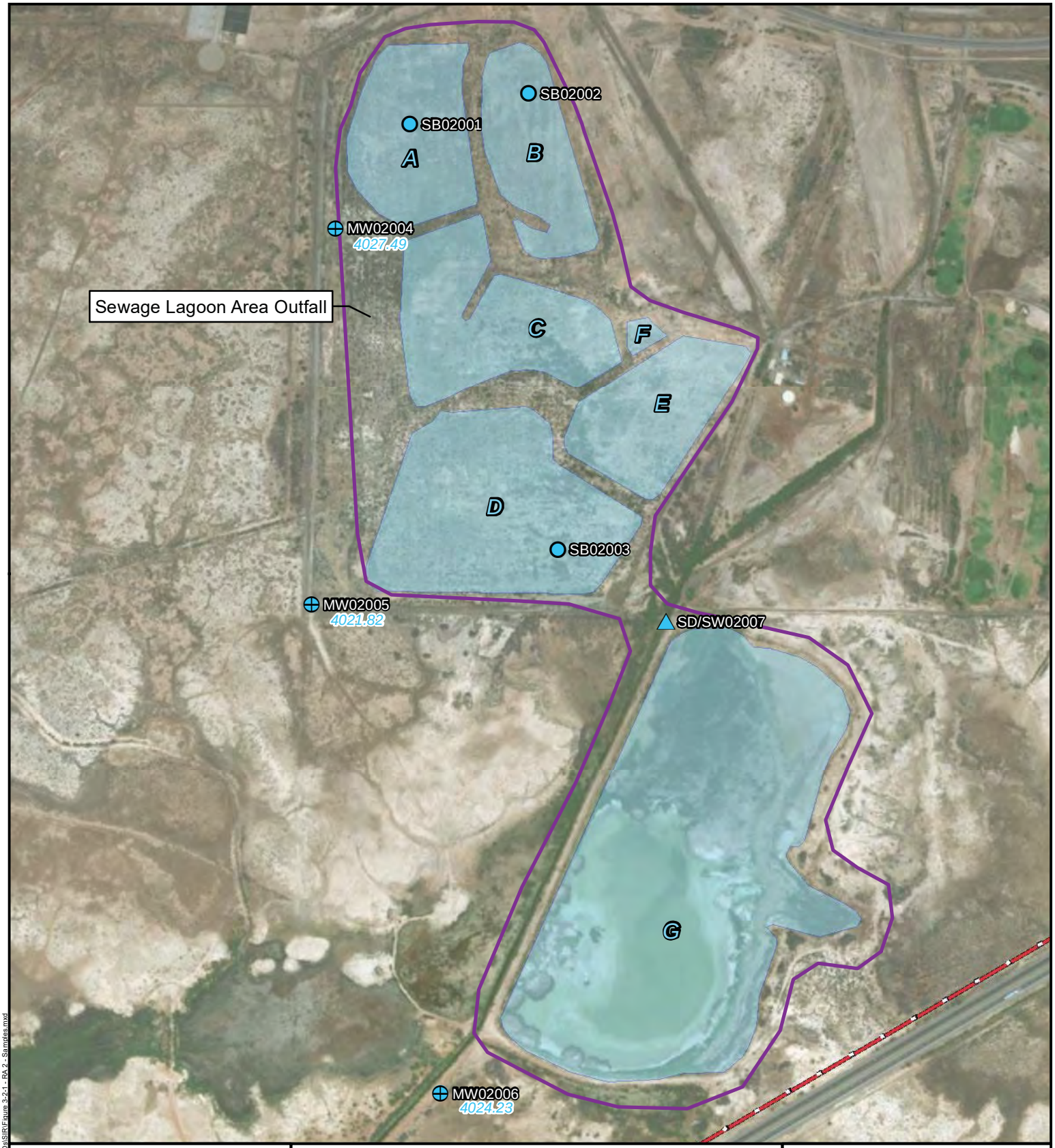

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0 250 500 1,000 Feet

Symbol Key

- Monitoring Well / Soil Boring
- Soil Boring
- Surface Water / Sediment Sample
- AFFF Release Area
- Former Sewage Lagoons
- Holloman AFB Installation Boundary

FIGURE 3.2-1
Sampling Locations and Groundwater Elevations
Sewage Lagoon Area Outfall
AFFF Release Area 2
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

Path: H:\Projects\775303101_USAF_Active_PFCs\0014_Holloman\MXDs\SI\RF\Figure 3-2-1 - RA 2 - Samples.mxd

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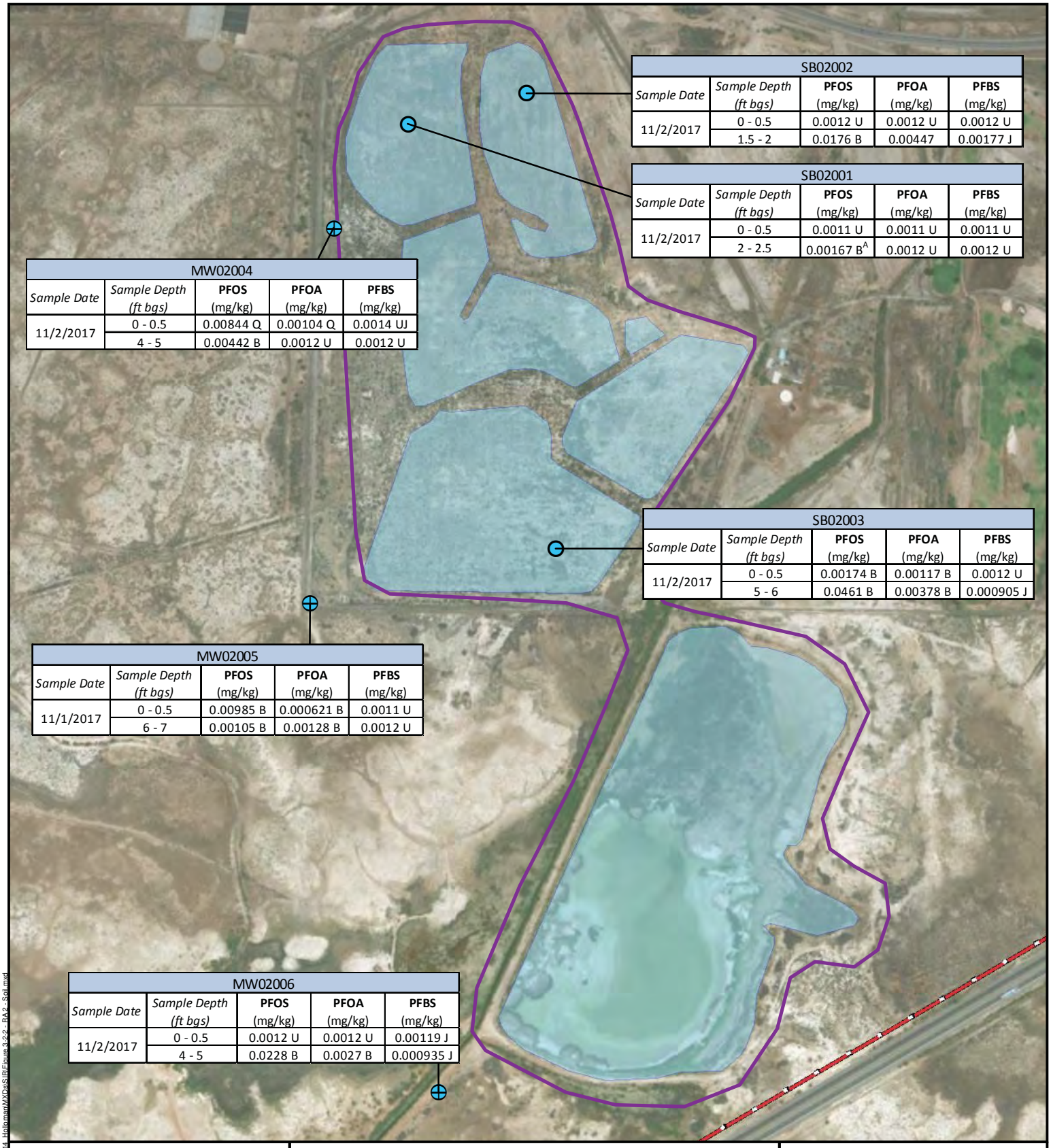

SB02002				
Sample Date	Sample Depth (ft bgs)	PFOS (mg/kg)	PFOA (mg/kg)	PFBS (mg/kg)
11/2/2017	0 - 0.5	0.0012 U	0.0012 U	0.0012 U
	1.5 - 2	0.0176 B	0.00447	0.00177 J

SB02001				
Sample Date	Sample Depth (ft bgs)	PFOS (mg/kg)	PFOA (mg/kg)	PFBS (mg/kg)
11/2/2017	0 - 0.5	0.0011 U	0.0011 U	0.0011 U
	2 - 2.5	0.00167 B[A]	0.0012 U	0.0012 U

MW02004				
Sample Date	Sample Depth (ft bgs)	PFOS (mg/kg)	PFOA (mg/kg)	PFBS (mg/kg)
11/2/2017	0 - 0.5	0.00844 Q	0.00104 Q	0.0014 UJ
	4 - 5	0.00442 B	0.0012 U	0.0012 U

SB02003				
Sample Date	Sample Depth (ft bgs)	PFOS (mg/kg)	PFOA (mg/kg)	PFBS (mg/kg)
11/2/2017	0 - 0.5	0.00174 B	0.00117 B	0.0012 U
	5 - 6	0.0461 B	0.00378 B	0.000905 J

MW02005				
Sample Date	Sample Depth (ft bgs)	PFOS (mg/kg)	PFOA (mg/kg)	PFBS (mg/kg)
11/1/2017	0 - 0.5	0.00985 B	0.000621 B	0.0011 U
	6 - 7	0.00105 B	0.00128 B	0.0012 U

MW02006				
Sample Date	Sample Depth (ft bgs)	PFOS (mg/kg)	PFOA (mg/kg)	PFBS (mg/kg)
11/2/2017	0 - 0.5	0.0012 U	0.0012 U	0.00119 J
	4 - 5	0.0228 B	0.0027 B	0.000935 J

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0 250 500 1,000 Feet

Symbol Key

- Monitoring Well / Soil Boring
- Soil Boring
- AFFF Release Area
- Former Sewage Lagoons
- Holloman AFB Installation Boundary

FIGURE 3.2-2
PFAS in Soil
Sewage Lagoon Area Outfall
AFFF Release Area 2
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\00014 Holloman\MXDs\SIR\Figure 3.2-2 - RA 2 - Soil.mxd

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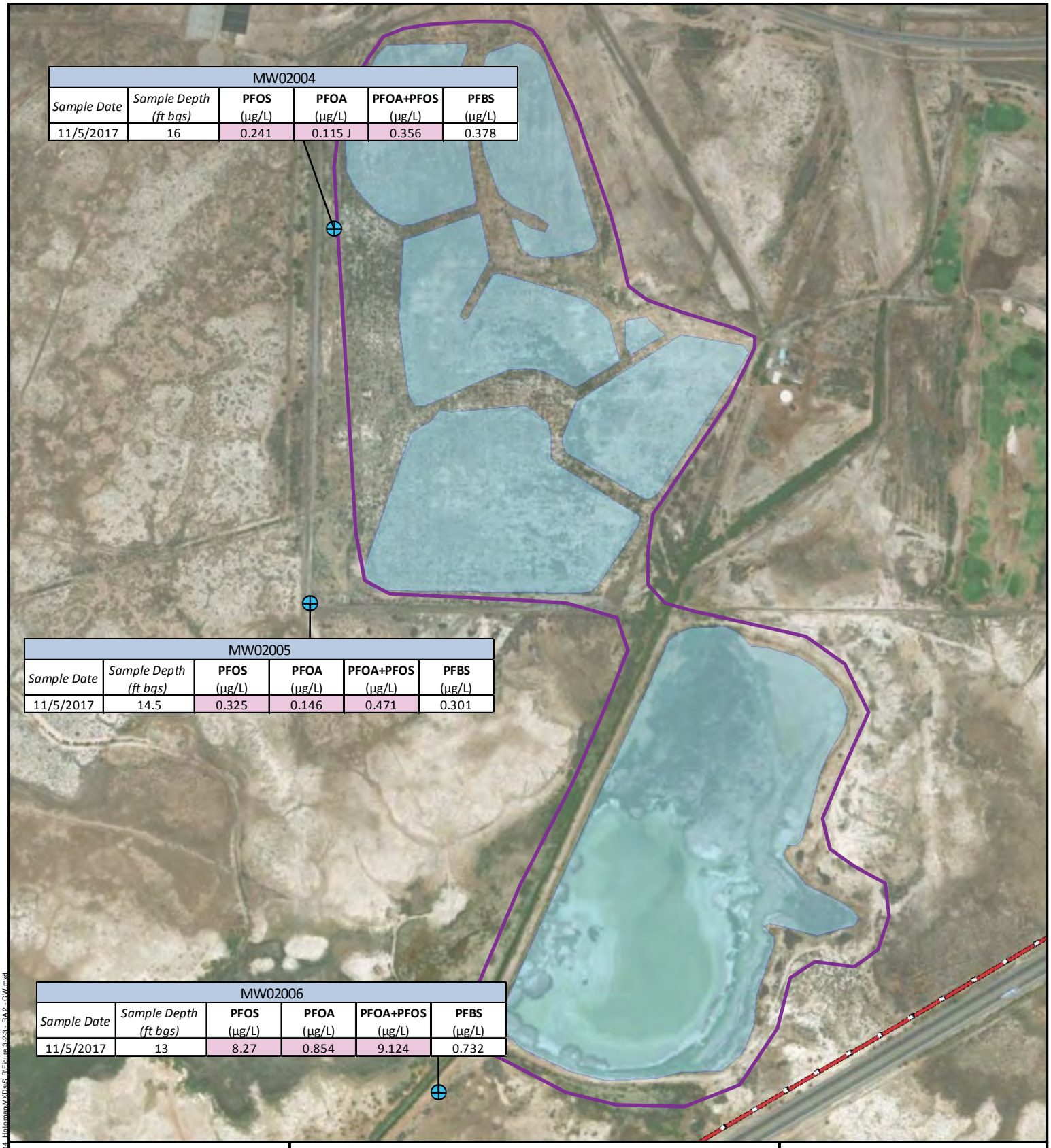

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0 250 500 1,000 Feet

Symbol Key

- Monitoring Well / Soil Boring
- AFFF Release Area
- Former Sewage Lagoons
- Holloman AFB Installation Boundary

FIGURE 3.2-3
PFAS in Groundwater
Sewage Lagoon Area Outfall
AFFF Release Area 2
Holloman Air Force Base
Alamogordo, New Mexico

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Environmental Programs Worldwide
Site Inspection Report

Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\00 14 Holloman\MXDs\SIR\Figure 3.2-3 - RA 2 - GW.mxd

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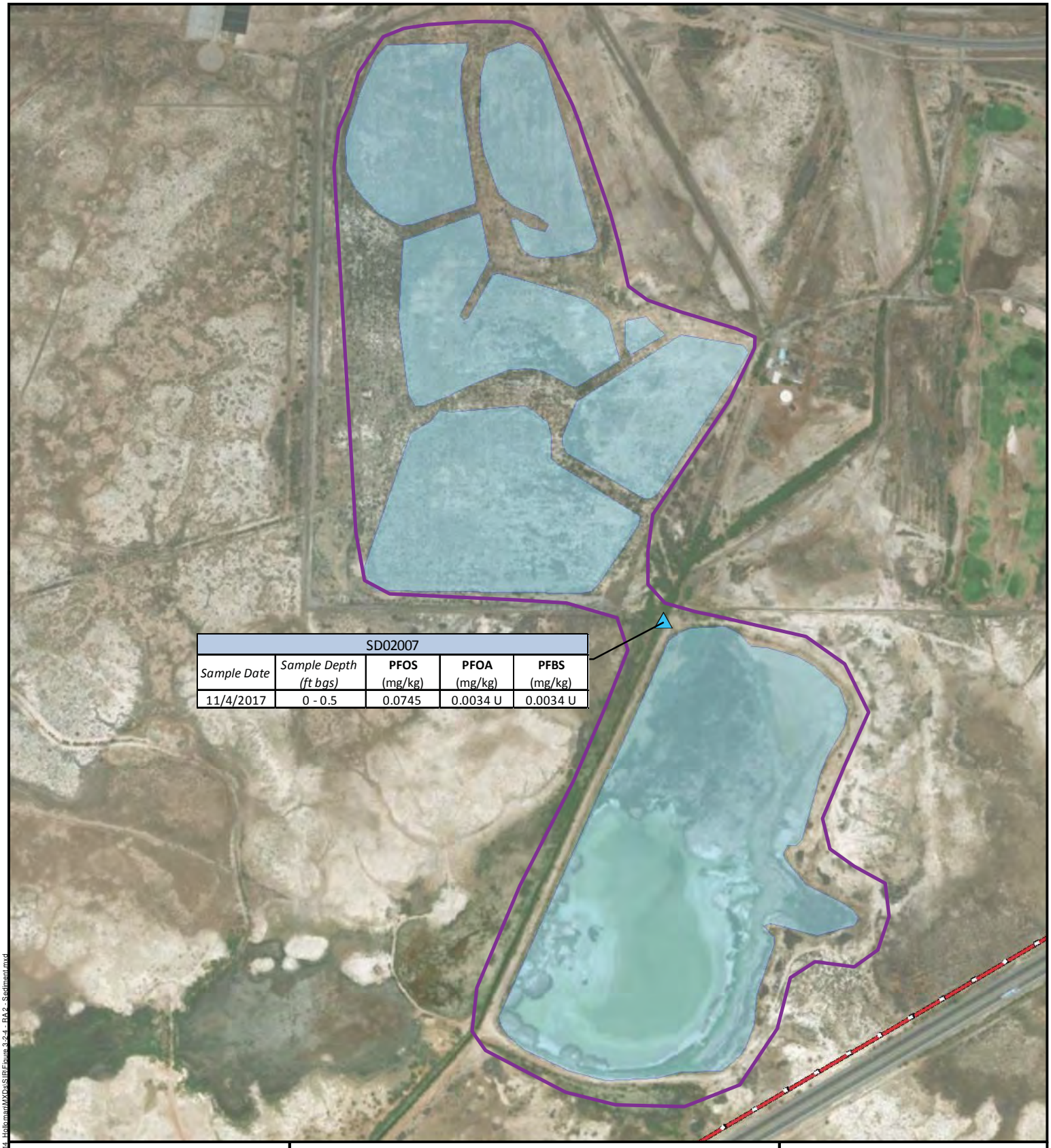

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0 250 500 1,000 Feet

Symbol Key

- Surface Water / Sediment Sample
- AFFF Release Area
- Former Sewage Lagoons
- Holloman AFB Installation Boundary

FIGURE 3.2-4
PFAS in Sediment
Sewage Lagoon Area Outfall
AFFF Release Area 2
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\00014 Holloman\MXDs\SIR\Figure 3.2-4 - RA 2 - Sediment.mxd

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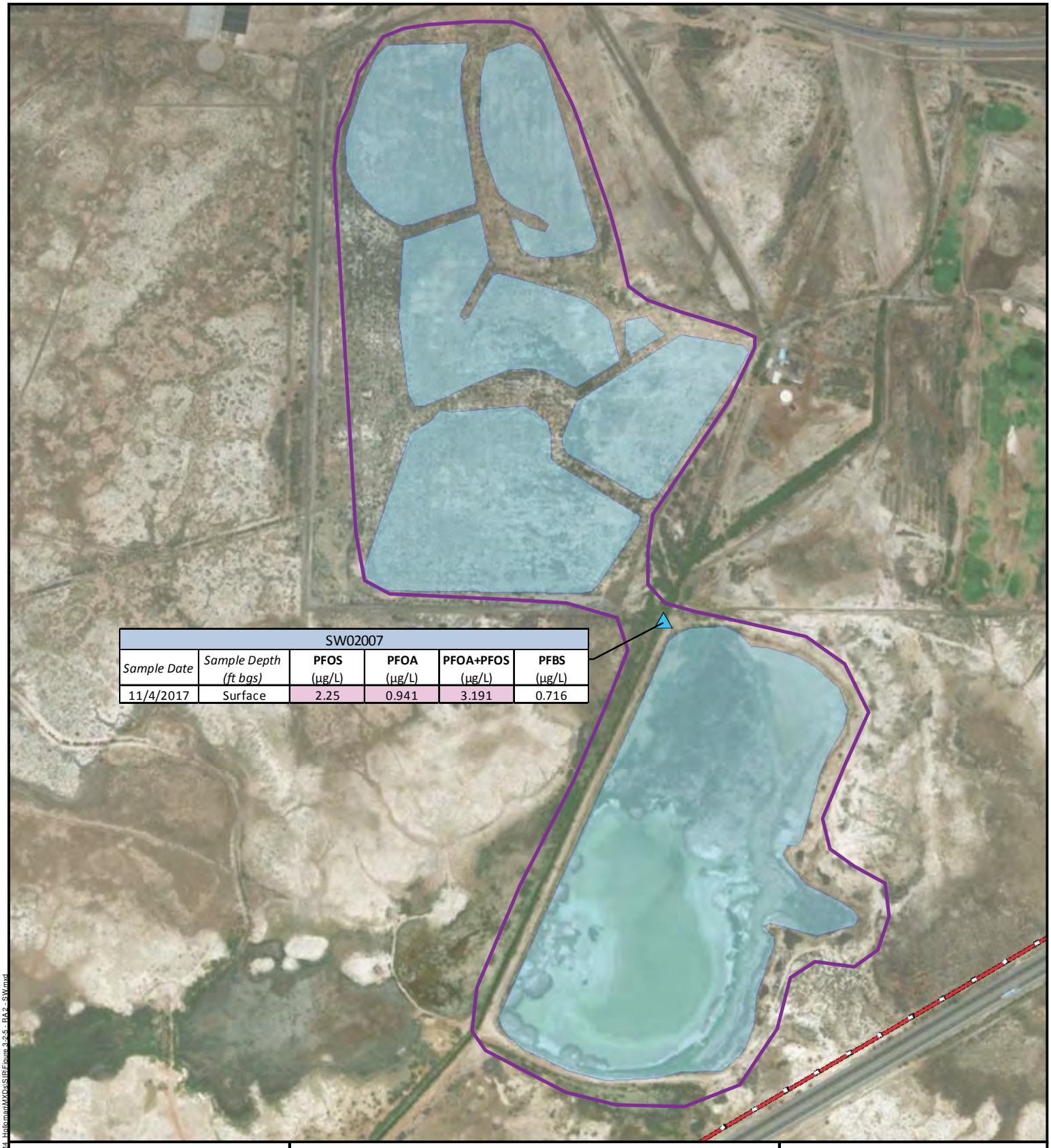

SW02007					
Sample Date	*Sample Depth (ft bgs)*	**PFOS** (µg/L)	**PFOA** (µg/L)	**PFOA+PFOS** (µg/L)	**PFBS** (µg/L)
11/4/2017	Surface	2.25	0.941	3.191	0.716

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0 250 500 1,000 Feet

Symbol Key

- Surface Water / Sediment Sample
- AFFF Release Area
- Former Sewage Lagoons
- Holloman AFB Installation Boundary

FIGURE 3.2-5
PFAS in Surface Water
Sewage Lagoon Area Outfall
AFFF Release Area 2
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
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0 200 400 800 Feet

Symbol Key

- Monitoring Well
- Surface Water / Sediment Sample
- AFFF Release Area
- Holloman AFB Installation Boundary

FIGURE 3.3-1
Sampling Locations and Groundwater Elevations
Apache Mesa Golf Course Outfall
AFFF Release Area 3
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

Path: H:\Projects\775303101_USAF_Activa_PFCs\0014_Holloman\MXDs\SIR\Figure 3-3-1 - RA 3 - Samples.mxd

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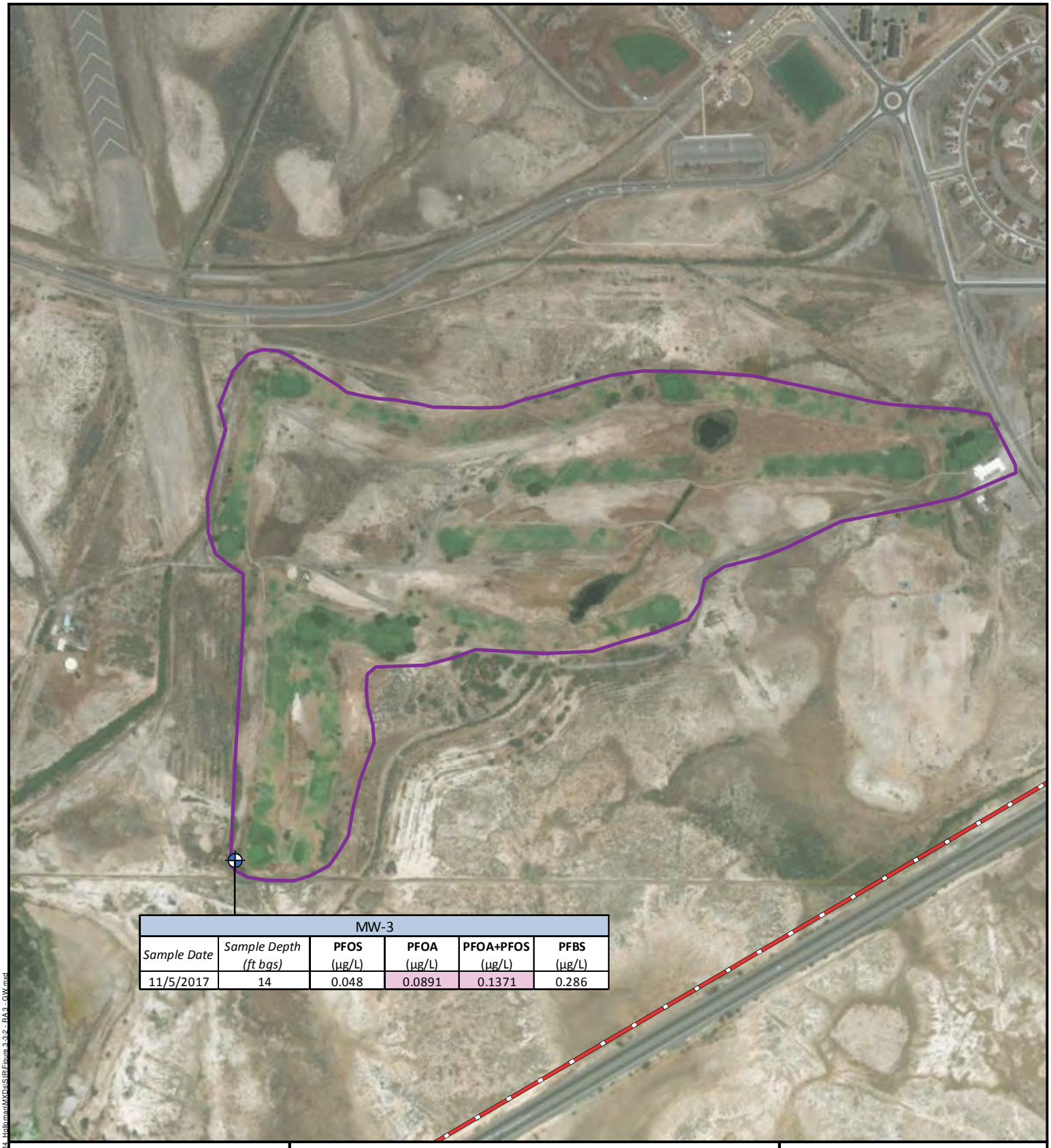

MW-3					
Sample Date	*Sample Depth (ft bgs)*	**PFOS (µg/L)**	**PFOA (µg/L)**	**PFOA+PFOS (µg/L)**	**PFBS (µg/L)**
11/5/2017	14	0.048	0.0891	0.1371	0.286

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0 200 400 800 Feet

Symbol Key

- Monitoring Well
- AFFF Release Area
- Holloman AFB Installation Boundary

FIGURE 3.3-2
PFAS in Groundwater
Apache Mesa Golf Course Outfall
AFFF Release Area 3
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
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Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\00014 Holloman\MXDs\SIR\Figure 3.3-2 - RA3 - GW.mxd

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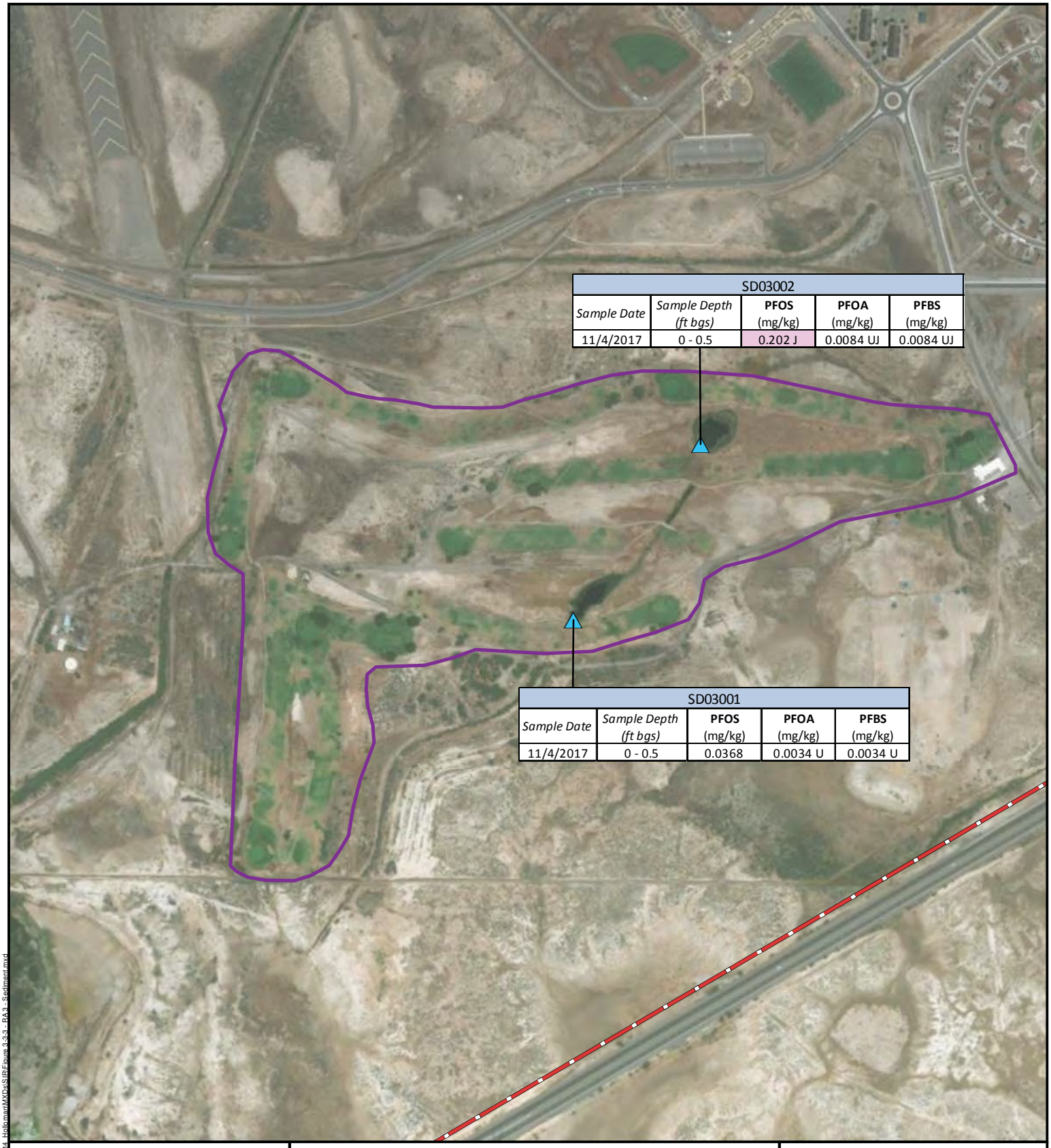

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0 200 400 800 Feet

Symbol Key

- Surface Water / Sediment Sample
- AFFF Release Area
- Holloman AFB Installation Boundary

FIGURE 3.3-3
PFAS in Sediment
Apache Mesa Golf Course Outfall
AFFF Release Area 3
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
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Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\00014 Holloman\MXDs\SIR\Figure 3.3-3 - RA 3 - Sediment.mxd

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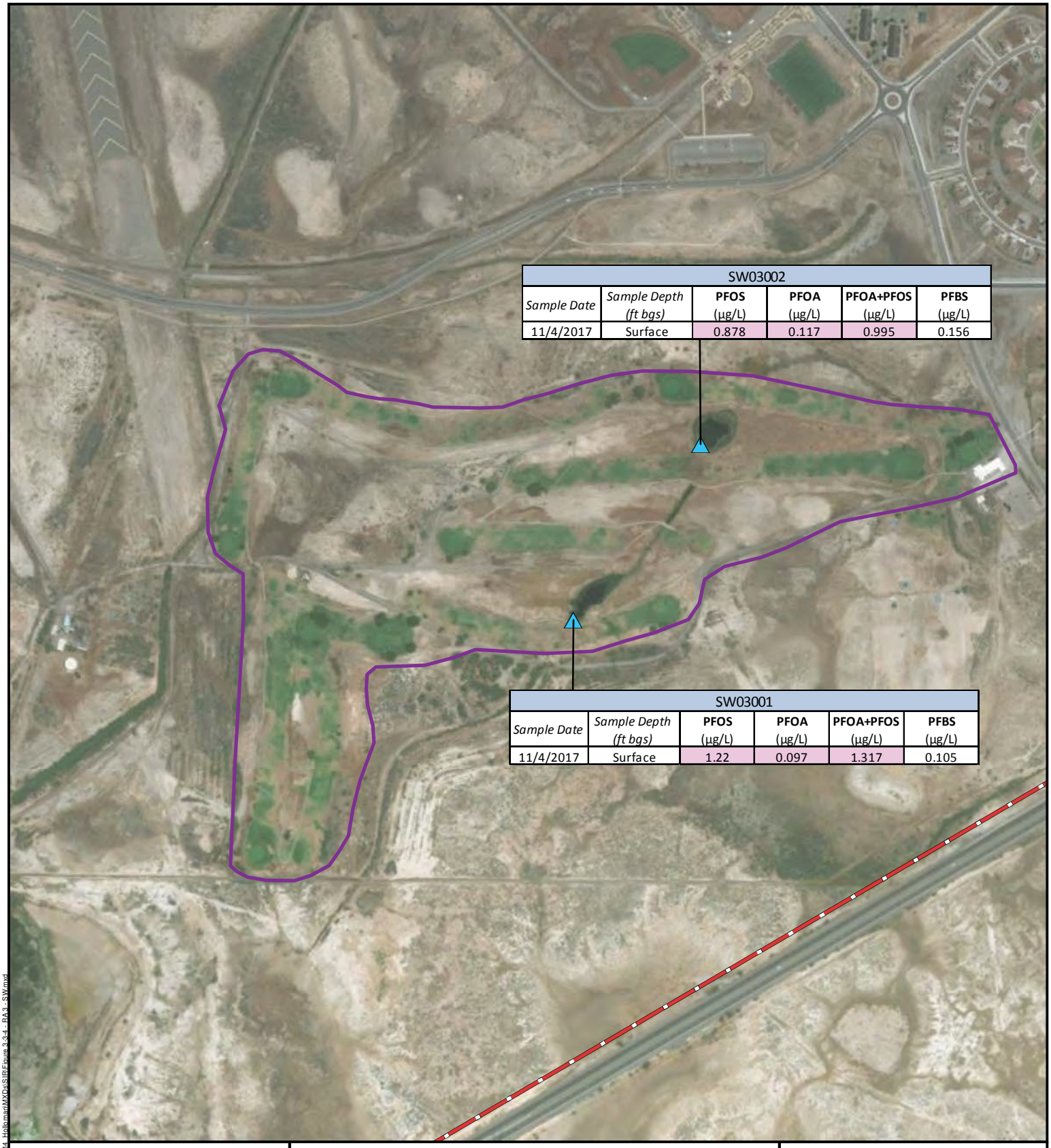

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0 200 400 800 Feet

Symbol Key

- Surface Water / Sediment Sample
- AFFF Release Area
- Holloman AFB Installation Boundary

FIGURE 3.3-4
PFAS in Surface Water
Apache Mesa Golf Course Outfall
AFFF Release Area 3
Holloman Air Force Base
Alamogordo, New Mexico

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Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\00 14 Holloman\MXDs\SI\RFigure 3.3-4 - RA 3 - SW.mxd

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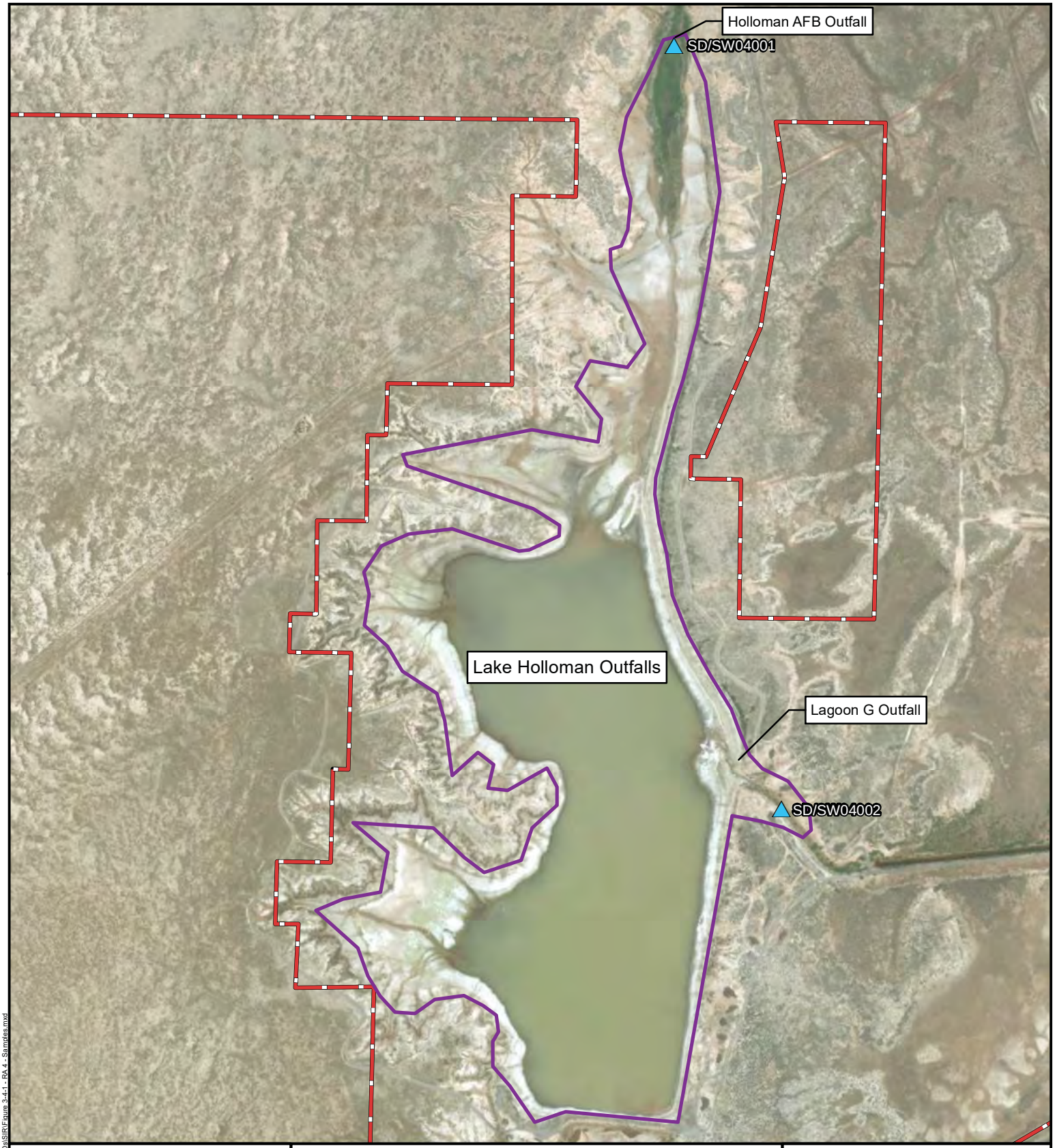

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0 250 500 1,000 Feet

Symbol Key

- Surface Water / Sediment Sample
- AFFF Release Area
- Holloman AFB Installation Boundary

FIGURE 3.4-1
Sampling Locations
Lake Holloman Outfalls
AFFF Release Area 4
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous
Film Forming Foam (AFFF)
Release Areas
Environmental Programs Worldwide
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Path: H:\Projects\775303101_USAF_Activa_PFCs\0014_Holloman\MXDs\SI\RF\Figure 3-4-1 - RA 4 - Samples.mxd

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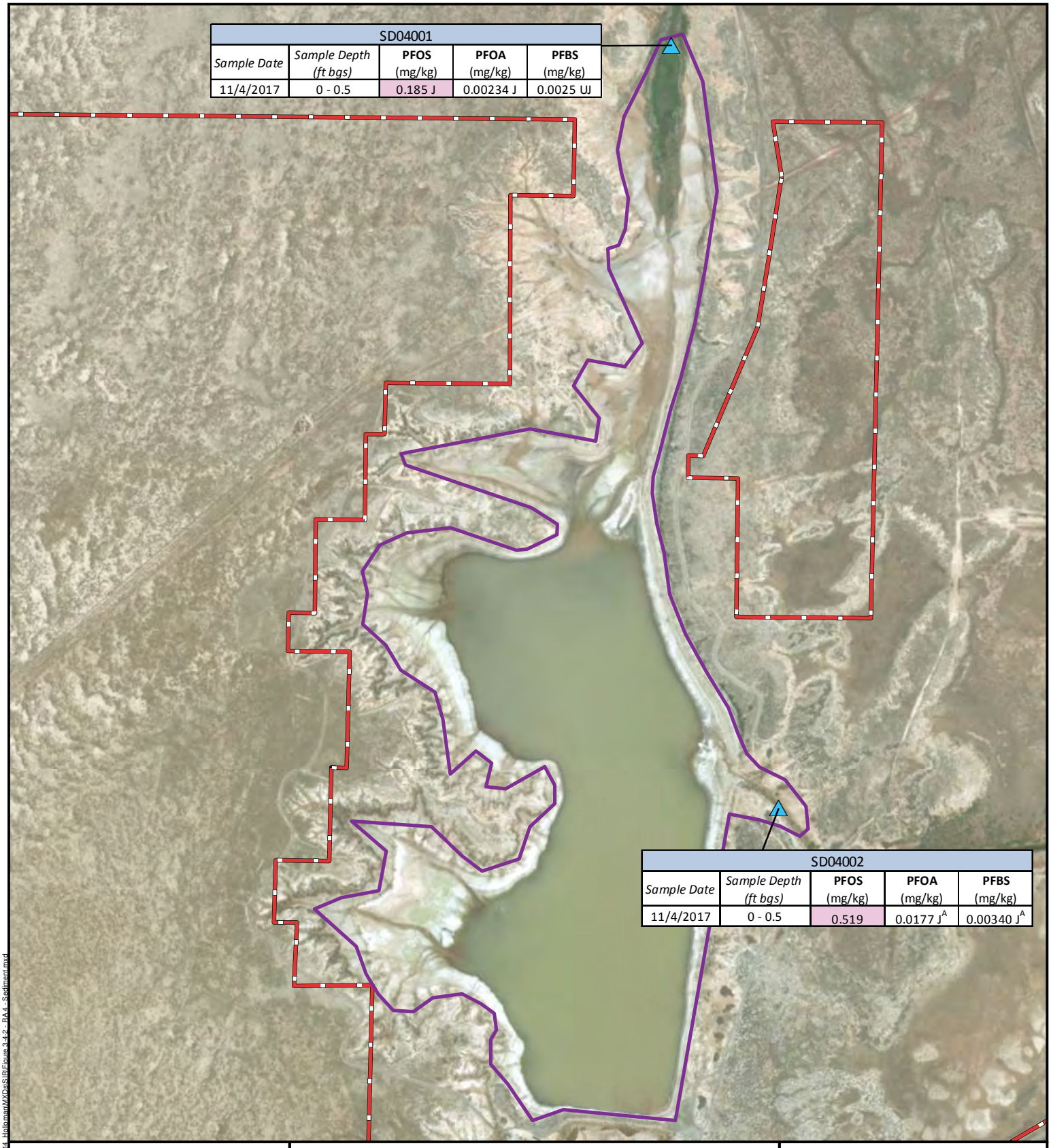

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0 250 500 1,000 Feet

Symbol Key

- Surface Water / Sediment Sample
- AFFF Release Area
- Holloman AFB Installation Boundary

FIGURE 3.4-2
PFAS in Sediment
Lake Holloman Outfalls
AFFF Release Area 4
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\00 14 Holloman\MXDs\SIR\Figure 3.4-2 - RA4 - Sediment.mxd

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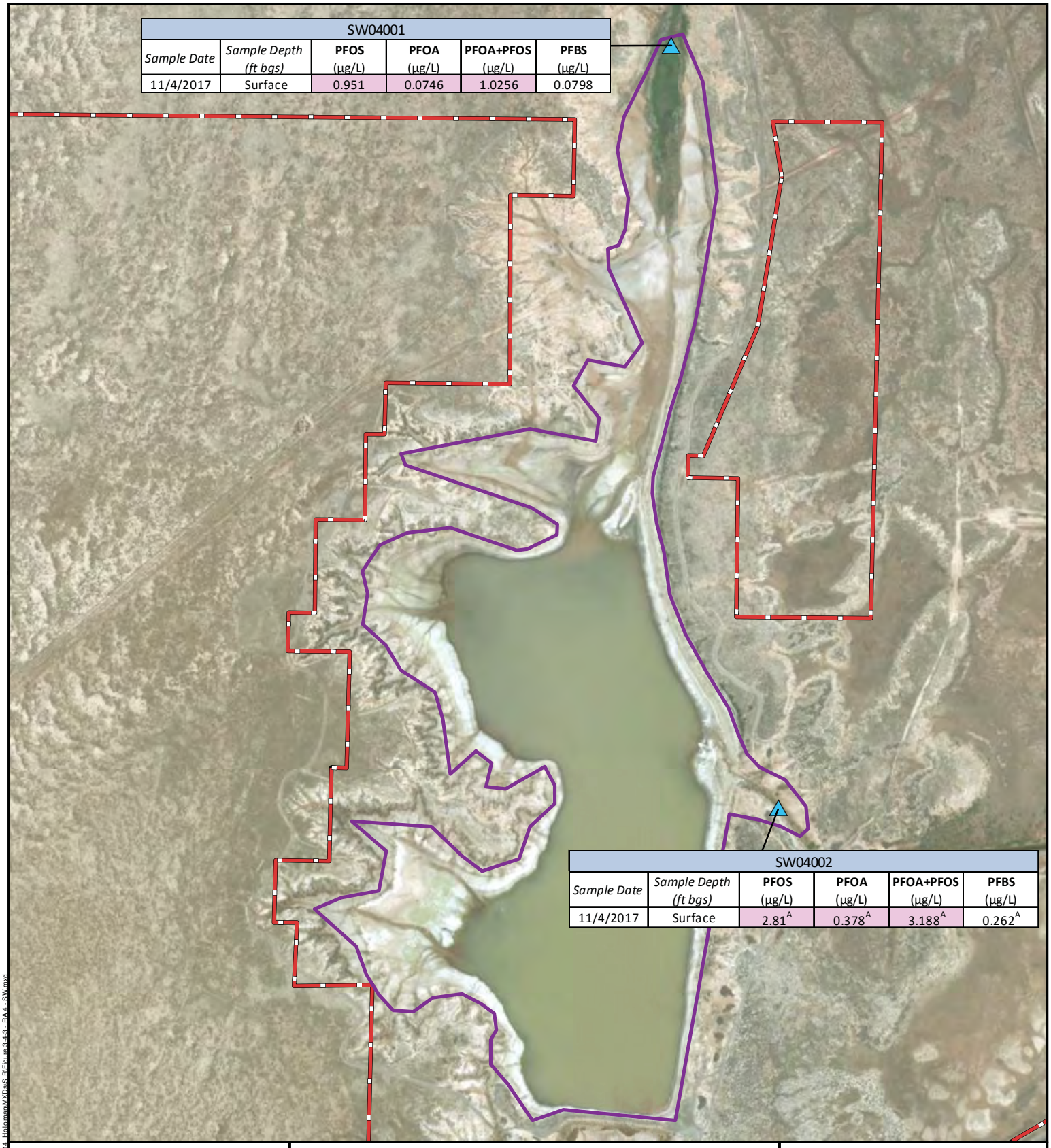

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0 250 500 1,000 Feet

Symbol Key

- Surface Water / Sediment Sample
- AFFF Release Area
- Holloman AFB Installation Boundary

FIGURE 3.4-3
PFAS in Surface Water
Lake Holloman Outfalls
AFFF Release Area 4
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\00 14 Holloman\MXDs\SIR\Figure 3.4-3 - RA 4 - SW.mxd

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0 25 50 100 150 Feet

Symbol Key

- Monitoring Well / Soil Boring
- Soil Boring
- AFFF Release Area

FIGURE 3.5-1
Sampling Locations and Groundwater Elevations
Evaporation Pond No. 2
AFFF Release Area 5
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
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Path: H:\Projects\775303101_USAF_Activa_PFCs\0014_Holloman\MXD\SI\RF\Figure 3-5-1 - RA 5 - Samples.mxd

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0 25 50 100 150 Feet

Symbol Key

- Monitoring Well / Soil Boring
- Soil Boring
- AFFF Release Area

FIGURE 3.5-2
PFAS in Soil
Evaporation Pond No. 2
AFFF Release Area 5
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
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Path: C:\Workspace\GIS Projects\775303101 USAF Active PFCs\0014 Holloman\MXDs\SI\RFigure 3-5-2 - RA 5 - Soil.mxd

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0 25 50 100 150 Feet

Symbol Key

- Monitoring Well / Soil Boring
- AFFF Release Area

FIGURE 3.5-3
PFAS in Groundwater
Evaporation Pond No. 2
AFFF Release Area 5
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
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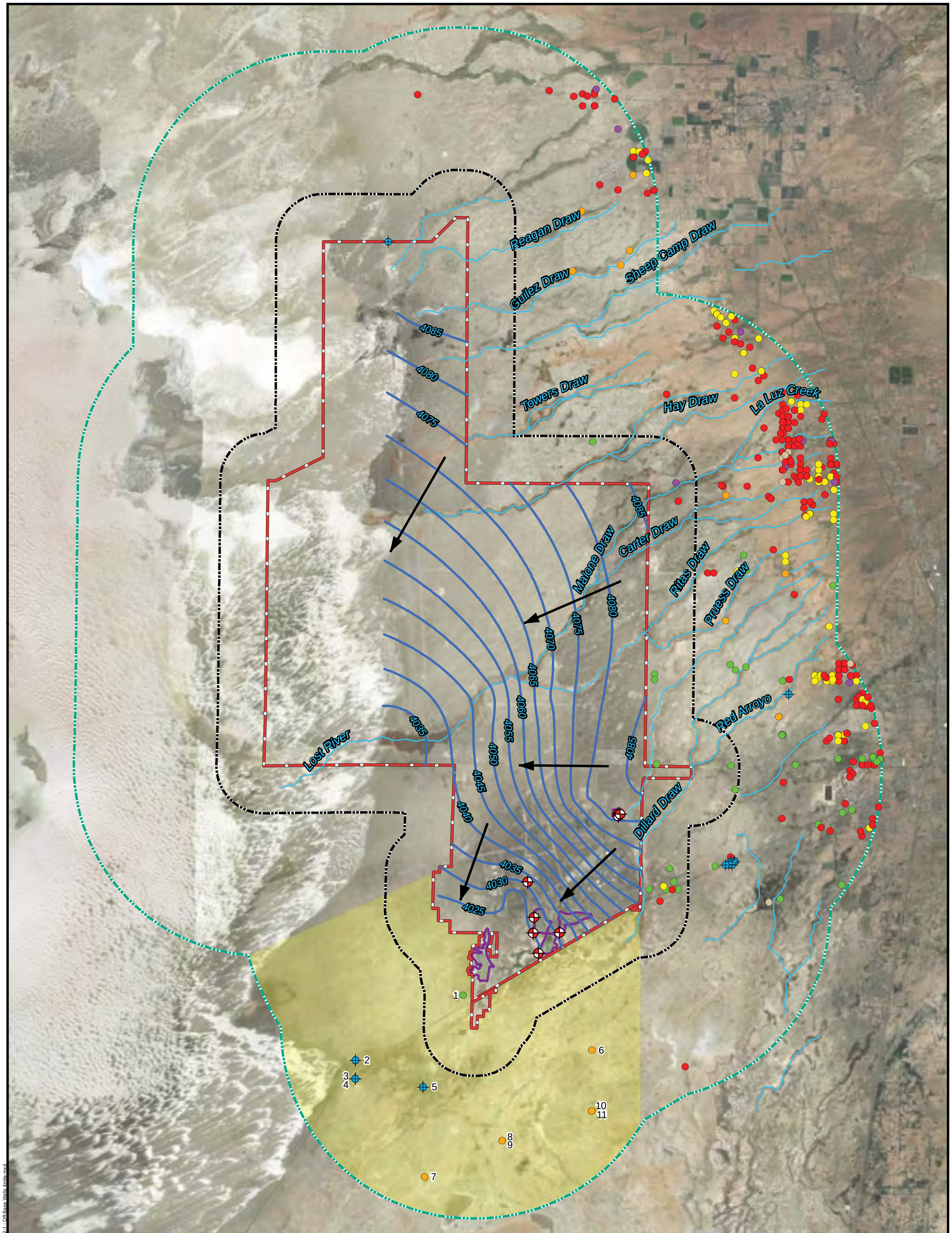

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0 5,000 10,000 20,000 Feet

Symbol Key

- Monitoring Well with PFAS Exceedance
- Approximate Groundwater Elevation Contour (Nationview/Bhate 2008)
- Approximate Groundwater Flow Direction
- Streams
- AFFF Release Area / Potential AFFF Release Area
- Holloman AFB Installation Boundary
- 1-Mile Installation Boundary
- 4-Mile Installation Boundary
- Potentially Impacted Groundwater in Downgradient Direction

NM Water Rights Database

- Domestic Well
- Commercial Well
- Dairy and Livestock Well
- Domestic and Livestock Well
- Irrigation Well
- Monitoring Well
- Other Well

FIGURE 4.2-1
Desktop 4-mile Water Well Review Results (All Wells)
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

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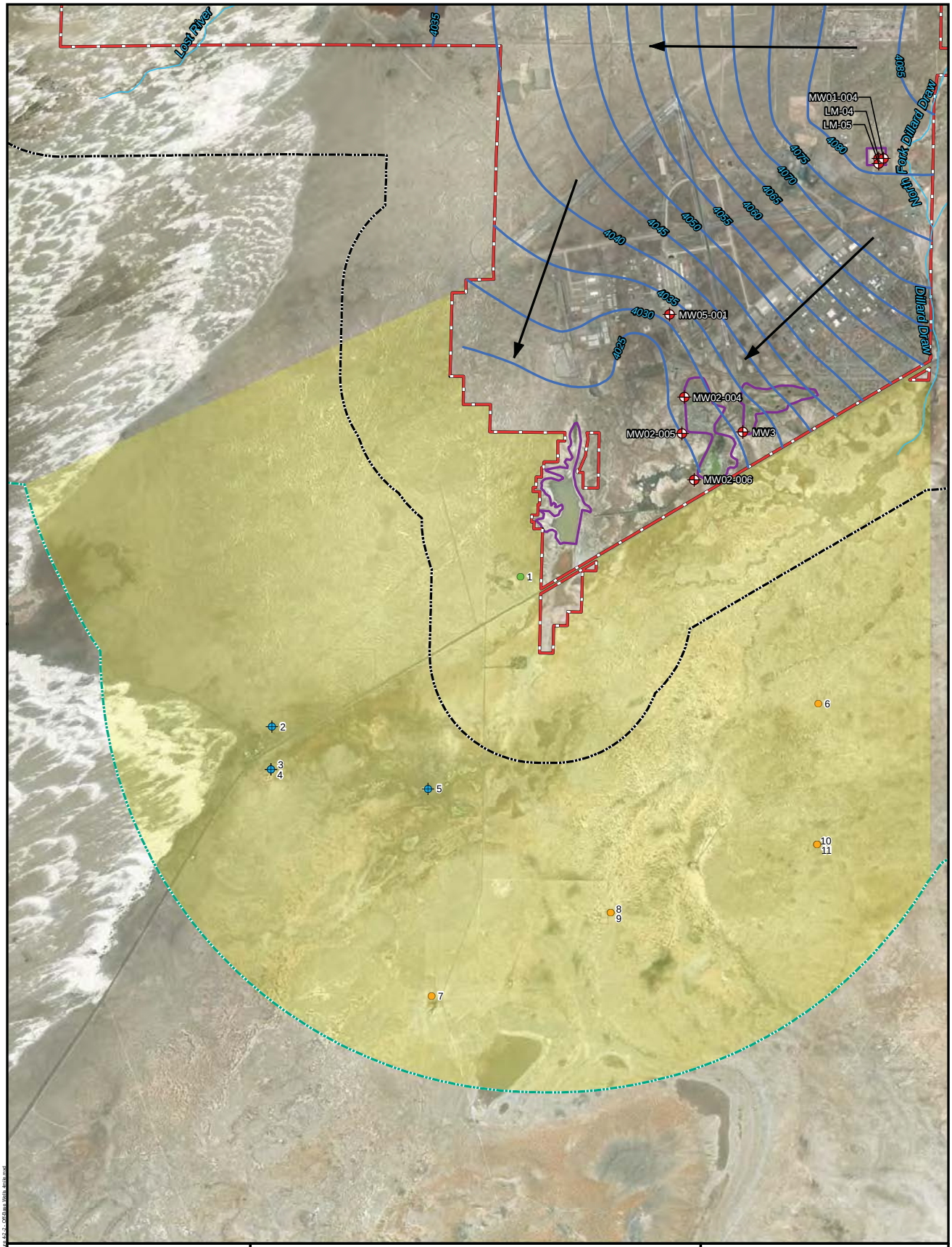

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0 2,000 4,000 8,000 Feet

Symbol Key

- Monitoring Well with PFAS Exceedance
- Approximate Groundwater Elevation Contour (Nationview/Bhate 2008)
- Approximate Groundwater Flow Direction
- Streams
- AFFF Release Area
- Potential AFFF Release Area
- Holloman AFB Installation Boundary
- 1-Mile Installation Boundary
- 4-Mile Installation Boundary
- Potentially Impacted Groundwater in Downgradient Direction

NM Water Rights Database

- Commercial Well
- Dairy and Livestock Well
- Irrigation Well
- Monitoring Well

FIGURE 4.2-2
Desktop 4-mile Water Well Review Results (Downgradient Wells)
Holloman Air Force Base
Alamogordo, New Mexico

Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Environmental Programs Worldwide
Site Inspection Report

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TABLES

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Table 3.0-1
Monitoring Well Construction Details
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman AFB, Alamogordo, New Mexico

AFFF Release Area	Location ID	Installation Date	Well Material	Northing	Easting	Ground Elevation (ft amsl)	TOC elevation (ft amsl)	Well Depth (ft bgs)	Well Diameter (in)	Screen Length (ft)	Screen Size (in)	Screen Interval (ft bgs)	Depth to Groundwater (ft btoc)	Groundwater Elevation (ft amsl)
1	FT31-LM4	11/6/2017	PVC	676249.07	1693865.4	4102.84	4105.7	28.2	2	NA	NA	NA	24.02	4081.68
	FT31-LM5	11/6/2017	PVC	675999.06	1693865.27	4101.83	4105.09	33.59	2	NA	NA	NA	23.14	4081.95
	MW01004	11/5/2017	PVC	676229.23	1694092.05	4102.59	4102.74	27.92	2	10	0.01	18.01-28.01	21.18	4081.56
2	MW02004	11/5/2017	PVC	664630.78	1684649.06	4036.46	4036.6	17.91	2	10	0.01	7.01-17.01	9.11	4027.49
	MW02005	11/5/2017	PVC	662904.98	1684559.34	4033.22	4033.39	16.65	2	10	0.01	6.01-16.01	11.57	4021.82
	MW02006	11/5/2017	PVC	660670.65	1685176.71	4029.48	4029.2	15.71	2	10	0.01	6.01-16.01	4.97	4024.23
3	MW-3	11/5/2017	PVC	668588.46	1683902.61	4038.24	4038.34	19.13	2	NA	0.01	NA	6.14	4032.2
5	MW05001	11/6/2017	PVC	668588.46	1683902.61	4048.40	4048.16	27.7	2	10	0.01	19.01-29.01	4.47	4043.69

Notes:
AFFF - aqueous film forming foam
amsl - above mean sea level
bgs - below ground surface
ft - feet
in - inches
NA - not available
PVC - Polyvinyl Chloride
TOC - top of casing

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Table 3.0-2
Groundwater Elevations
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman AFB, Alamogordo, New Mexico

AFFF Release Area	Location ID	Well Depth (ft bgs)	Ground Surface Elevation (ft amsl)	TOC elevation (ft amsl)	Date Measured	Depth to Groundwater (ft btoc)	Groundwater Elevation (ft amsl)
1	FT31-LM4	31.05	4102.844	4105.697	11/6/2017	24.02	4081.677
	FT31-LM5	36.85	4101.828	4105.090	11/6/2017	23.77	4081.320
	MW01004	27.92	4102.590	4102.744	11/5/2017	21.18	4081.564
2	MW02004	17.91	4036.458	4036.595	11/5/2017	9.11	4027.485
	MW02005	16.65	4033.219	4033.392	11/5/2017	11.57	4021.822
	MW02006	15.71	4029.475	4029.199	11/5/2017	4.97	4024.229
3	MW-3	19.13	4038.235	4038.340	11/5/2017	6.14	4032.200
5	MW05001	27.7	4048.400	4048.159	11/6/2017	4.47	4043.689

Notes:
AFFF - aqueous film forming foam
amsl - above mean sea level
bgs - below ground surface
btoc - below top of casing
ft - feet
TOC - top of casing

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Table 3.1-1
Summary of Soil Analytical Testing Results
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman Air Force Base, New Mexico

						Analyte:	Perfluorooctanesulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)	Perfluorobutanesulfonic acid (PFBS)	6:2 Fluorotelomer sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonate (8:2 FTS)	N-Ethyl perfluorooctanesulfonamidoacetic acid (NETFOSAA)	N-Methyl perfluorooctanesulfonamidoacetic acid (NMEFOSAA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanesulfonic acid (PFHxS)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnA)
						Screening Level:	0.126[1]	0.126[1]	130[2]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AFFF Area	**Location**	**Sample ID**	**Sample Date**	**Sample Depth (ft.)**	**Sample Type**		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
1	MW01004	HOLMN01-SO-007	30-Oct-17	0.0-0.5	N		0.217	0.031	0.00101 J	0.00836	0.0043 U	0.0043 U	0.0043 U	0.0011 U	0.0011 U	0.00101 J	0.0562	0.00808	0.00506	0.0011 U	0.0011 U	0.0011 U
		HOLMN01-SO-008	30-Oct-17	19.0-20.0	N		0.0012 U	0.0012 U	0.0012 U	0.005 U	0.005 U	0.005 U	0.005 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U
	SB01001	HOLMN01-SO-001	31-Oct-17	0.0-0.5	N		0.0576	0.0123	0.00184 J	0.0045 U	0.0045 U	0.0045 U	0.0045 U	0.0011 U	0.0011 U	0.00155 J	0.0203	0.006	0.00127 J	0.0011 U	0.0011 U	0.0011 U
		HOLMN01-SO-002	31-Oct-17	22.0-23.0	N		1.13 J	0.178	0.0435	0.169	0.101	0.048 U	0.048 U	0.012 U	0.012 U	0.0214 J	0.325	0.155	0.00763 J	0.012 U	0.012 U	0.012 U
		HOLMN-FD-SO-001	31-Oct-17	22.0-23.0	FD		0.753 J	0.19	0.0577	0.168	0.127	0.0048 U	0.0048 U	0.00179 J	0.0012 U	0.0214	0.375	0.153	0.00855	0.0012 U	0.0012 U	0.0012 U
	SB01002	HOLMN01-SO-003	31-Oct-17	0.0-0.5	N		0.26 J	0.000968 J	0.0012 UJ	0.0046 UJ	0.0046 UJ	0.0046 U	0.0046 U	0.0012 UJ	0.0012 UJ	0.0012 UJ	0.00185 J	0.0012 UJ	0.00287 J	0.0012 UJ	0.0012 UJ	0.0012 UJ
		HOLMN-FD-SO-002	31-Oct-17	0.0-0.5	FD		0.159 J	0.000844 J	0.0011 U	0.0046 U	0.0046 U	0.0046 U	0.0046 U	0.0011 U	0.0011 U	0.0011 U	0.0013 J	0.0011 U	0.00215 J	0.0011 U	0.0011 U	0.0011 U
		HOLMN01-SO-004	31-Oct-17	17.0-18.0	N		0.241	0.0602	0.0012 U	0.177	0.00824	0.0049 U	0.0049 U	0.0012 U	0.0012 U	0.00675	0.198	0.00994	0.00178 J	0.0012 U	0.0012 U	0.0012 U
	SB01003	HOLMN01-SO-005	30-Oct-17	0.0-0.5	N		0.33	0.0561	0.0583	0.0205	0.0617	0.0044 U	0.0044 U	0.00135 J	0.0011 U	0.0328	0.0895	0.196	0.0142	0.0011 U	0.0011 U	0.0011 U
		HOLMN01-SO-006	30-Oct-17	21.0-22.0	N		0.00077 B	0.115	0.0371	0.114	0.0053 U	0.0053 U	0.0053 U	0.0013 U	0.0013 U	0.0131	0.0013 U	0.0813	0.0013 U	0.0013 U	0.0013 U	0.0013 U
	SB01005	HOLMN01-SO-009	31-Oct-17	0.0-0.5	N		0.0242 J	0.00529 J	0.0013 UJ	0.0051 UJ	0.0051 UJ	0.0051 U	0.0051 U	0.0013 UJ	0.0013 UJ	0.000805 J	0.0111 J	0.00188 J	0.0013 UJ	0.0013 UJ	0.0013 UJ	0.0013 UJ
		HOLMN01-SO-010	31-Oct-17	19.0-20.0	N		0.247	0.057 J	0.0441 J	0.065 J	0.0106	0.005 U	0.005 U	0.0012 U	0.0012 U	0.0182 J	0.244	0.152	0.0015 J	0.0012 U	0.0012 U	0.0012 U
2	MW02004	HOLMN02-SO-007	02-Nov-17	0.0-0.5	N		0.00844 Q	0.00104 Q	0.0014 UJ	0.0057 UJ	0.0057 U	0.0057 U	0.0057 U	0.0014 U	0.0014 U	0.000735 J	0.00393 Q	0.0014 UJ	0.0014 U	0.0014 U	0.0014 U	0.0014 U
		HOLMN02-SO-008	02-Nov-17	4.0-5.0	N		0.00442 B	0.0012 U	0.0012 U	0.0049 U	0.0049 U	0.0049 U	0.0049 U	0.0012 U	0.0012 U	0.000657 J	0.00243 B	0.00112 B	0.0012 U	0.0012 U	0.0012 U	0.0012 U
		HOLMN-FD-SO-003	02-Nov-17	4.0-5.0	FD		0.00295 B	0.0012 U	0.0012 U	0.0048 U	0.0048 U	0.0048 U	0.0048 U	0.0012 U	0.0012 U	0.0012 U	0.00148 B	0.0008 B	0.0012 U	0.0012 U	0.0012 U	0.0012 U
	MW02005	HOLMN02-SO-009	01-Nov-17	0.0-0.5	N		0.00985 B	0.000621 B	0.0011 U	0.0045 U	0.0045 U	0.0045 U	0.0045 U	0.0011 U	0.0011 U	0.0011 U	0.000984 B	0.0011 U	0.0011 U	0.0011 U	0.0011 U	0.0011 U
		HOLMN02-SO-010	01-Nov-17	6.0-7.0	N		0.00105 B	0.00128 B	0.0012 U	0.0046 U	0.0046 U	0.0046 U	0.0046 U	0.0012 U	0.0012 U	0.000816 J	0.00356 B	0.00117 B	0.0012 U	0.0012 U	0.0012 U	0.0012 U
	MW02006	HOLMN02-SO-011	02-Nov-17	0.0-0.5	N		0.0012 U	0.0012 U	0.00119 J	0.0047 U	0.0047 U	0.0047 U	0.0047 U	0.0012 U	0.0012 U	0.0012 U	0.00138 B	0.00157 B	0.0012 U	0.0012 U	0.0012 U	0.0012 U
		HOLMN02-SO-012	02-Nov-17	4.0-5.0	N		0.0228 B	0.0027 B	0.000935 J	0.0048 U	0.0048 U	0.0048 U	0.0048 U	0.0012 U	0.0012 U	0.00152 J	0.0105 B	0.00423 B	0.000695 J	0.0012 U	0.0012 U	0.0012 U
	SB02001	HOLMN02-SO-001	06-Nov-17	0.0-0.5	N		0.0011 U	0.0011 U	0.0011 U	0.0045 U	0.0045 U	0.0045 U	0.0045 U	0.0011 U	0.0011 U	0.000664 J	0.00284	0.0011 U	0.0011 U	0.0011 U	0.0011 U	0.0011 U
		HOLMN02-SO-002	02-Nov-17	2.0-2.5	N		0.00127 B	0.0012 U	0.0012 U	0.0046 U	0.0046 U	0.0046 U	0.0046 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.0021 J	0.0012 U	0.0012 U	0.0012 U	0.0012 U
		HOLMN-FD-SO-004	02-Nov-17	2.0-2.5	FD		0.00167 B	0.0012 U	0.0012 U	0.0047 U	0.0047 U	0.0047 U	0.0047 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.00186 J	0.0012 U	0.0012 U	0.0012 U	0.0012 U

Notes:
Purple Shaded = Exceeds Screening Level
B = The analyte was found in an associated blank, as well as in the sample.
FD = Field Duplicate Sample
ft = Feet
ID = Identification
J = The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample.
N = Normal Field Sample
NA = Not applicable
U = The analyte was analyzed for, but was not detected above the reported limit of detection (LOD).
UJ = The reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
mg/kg = milligrams per kilogram
PFAS analysis by Modified USEPA Method 537 using Liquid Chromatography and Tandem Mass Spectrometry
[1]Screening levels calculated using the EPA Regional Screening Level calculator [https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search]
[2]USEPA Regional Screening Levels (November, 2017a) [https://semspub.epa.gov/work/HQ/197027.pdf]

Report Date: 3/30/2018

Table 3.1-1
Summary of Soil Analytical Testing Results
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman Air Force Base, New Mexico

						Analyte:	Perfluorooctanesulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)	Perfluorobutanesulfonic acid (PFBS)	6:2 Fluorotelomer sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonate (8:2 FTS)	N-Ethyl perfluorooctanesulfonamidoacetic acid (NETFOSAA)	N-Methyl perfluorooctanesulfonamidoacetic acid (NMEFOSAA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanesulfonic acid (PFHxS)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnA)
						Screening Level:	0.126[1]	0.126[1]	130[2]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AFFF Area	**Location**	**Sample ID**	**Sample Date**	**Sample Depth (ft.)**	**Sample Type**		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
2	SB02002	HOLMN02-SO-003	02-Nov-17	0.0-0.5	N		0.0012 U	0.0012 U	0.0012 U	0.0047 U	0.0047 U	0.0047 U	0.0047 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.00101 J	0.0012 U	0.0012 U	0.0012 U	0.0012 U
		HOLMN02-SO-004	02-Nov-17	1.5-2.0	N		0.0176 B	0.00447	0.00177 J	0.0049 U	0.0049 U	0.0049 U	0.0049 U	0.0012 U	0.0012 U	0.000713 J	0.00837	0.00966	0.0012 U	0.0012 U	0.0012 U	0.0012 U
	SB02003	HOLMN02-SO-005	02-Nov-17	0.0-0.5	N		0.00174 B	0.00117 B	0.0012 U	0.0047 U	0.0047 U	0.0047 U	0.0047 U	0.0012 U	0.0012 U	0.000905 J	0.00339 B	0.000593 B	0.0012 U	0.0012 U	0.0012 U	0.0012 U
		HOLMN02-SO-006	02-Nov-17	5.0-6.0	N		0.0461 B	0.00378 B	0.000905 J	0.0049 U	0.0049 U	0.0049 U	0.0049 U	0.0012 U	0.0012 U	0.00251	0.00824 B	0.00498 B	0.000668 J	0.0012 U	0.0012 U	0.0012 U
5	MW05001	HOLMN05-SO-001	01-Nov-17	0.0-0.5	N		5.71	0.335	0.205	2.29	0.44 U	0.044 U	0.044 U	0.011 U	0.011 U	0.129	1.73	1.22	0.0823	0.011 U	0.011 U	0.011 U
		HOLMN05-SO-002	01-Nov-17	14.0-15.0	N		0.186	0.005 B	0.00559	0.0199	0.0041 J	0.0047 U	0.0047 U	0.0012 U	0.0012 U	0.00218 J	0.0568	0.0227	0.0012 U	0.0012 U	0.0012 U	0.0012 U
	SB05002	HOLMN05-SO-003	01-Nov-17	0.0-0.5	N		0.745	0.228	0.2	0.454	0.045 U	0.0045 U	0.0045 U	0.000864 J	0.0011 U	0.0998 J	2	0.865	0.0314	0.0011 U	0.0011 U	0.0011 U
		HOLMN05-SO-004	01-Nov-17	16.0-17.0	N		0.262	0.00565 Q	0.00578 J	0.0279 J	0.0044 J	0.0048 U	0.0048 U	0.0012 U	0.0012 U	0.00199 J	0.0523 J	0.0236 J	0.0012 U	0.0012 U	0.0012 U	0.0012 U

Notes:
Purple Shaded = Exceeds Screening Level
B = The analyte was found in an associated blank, as well as in the sample.
FD = Field Duplicate Sample
ft = Feet
ID = Identification
J = The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample.
N = Normal Field Sample
NA = Not applicable
U = The analyte was analyzed for, but was not detected above the reported limit of detection (LOD).
UJ = The reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
mg/kg = milligrams per kilogram
PFAS analysis by Modified USEPA Method 537 using Liquid Chromatography and Tandem Mass Spectrometry
[1]Screening levels calculated using the EPA Regional Screening Level calculator [https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search]
[2]USEPA Regional Screening Levels (November, 2017a) [https://semspub.epa.gov/work/HQ/197027.pdf]

Report Date: 3/30/2018

Table 3.1-2
Summary of Soil General Chemistry Analytical Testing Results
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman Air Force Base, New Mexico

						PH	TOC
					Analyte:		
AFFF Area	**Location**	**Sample ID**	**Sample Date**	**Sample Depth (ft.)**	**Sample Type**	pH Units	mg/kg
1	HOLMN01-C	HOLMN01-C (0-0.5)	06-Nov-17	0.0-0.5	N	7.89	1720Y
		HOLMN01-C (17-23)	06-Nov-17	17.0-23.0	N	7.79	5790
2	HOLMN02-C	HOLMN02-C (0-0.5)	06-Nov-17	0.0-0.5	N	7.9	5550
		HOLMN02-C (4-7)	06-Nov-17	4.0-7.0	N	7.86	2230
5	HOLMN05-C	HOLMN05-C (0-0.5)	06-Nov-17	0.0-0.5	N	8.09	1980
		HOLMN05-C (14-17)	06-Nov-17	14.0-17.0	N	7.92	5610

Notes:
ft = Feet
ID = Identification
J = The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample.
N = Normal Field Sample
mg/kg = milligrams per kilogram

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Table 3.1-3
Summary of Groundwater Analytical Testing Results
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman Air Force Base, New Mexico

					Analyte:	Perfluorooctanesulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)	PFOS+PFOA	Perfluorobutanesulfonic acid (PFBS)	6:2 Fluorotelomer sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonate (8:2 FTS)	N-Ethyl perfluorooctanesulfonamidoacetic acid (NETFOSAA)	N-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanesulfonic acid (PFHxS)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnA)
					Health Advisory:	0.07	0.07	0.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
					EPA RSL Tapwater[1]:	NA	NA	NA	400	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AFFF Area	**Location**	**Sample ID**	**Sample Date**	**Sample Depth (ft.)**	**Sample Type**	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
1	FT31-LM4	HOLMN01-GW-003	06-Nov-17	26.0-26.0	N	1.95 J	6.09	8.04	26.6	11.3	4 U	4 U	4 U	1.5 U	1.5 U	4.56	88.3	30.3	0.8 U	1.5 U	1.5 U	1.5 U
		HOLMN-FD-GW-001	06-Nov-17	26.0-26.0	FD	1.62 J	5.11	6.73	21.7	9.28	4 U	4 U	4 U	1.5 U	1.5 U	3.79	71.9	25.3	0.8 U	1.5 U	1.5 U	1.5 U
	FT31-LM5	HOLMN01-GW-001	06-Nov-17	31.0-31.3	N	48.4	254	302.4	226	329	40 U	40 U	40 U	15 U	15 U	66.1	859	672	8 U	15 U	15 U	15 U
	MW01004	HOLMN01-GW-002	05-Nov-17	26.0-26.0	N	1.28	0.746	2.026	0.12 U	0.271 J	0.33 U	0.33 U	0.33 U	0.12 U	0.12 U	0.12 U	1.22	0.817	0.067 U	0.12 U	0.12 U	0.12 U
2	MW02004	HOLMN02-GW-001	05-Nov-17	16.0-16.0	N	0.241	0.115 J	0.356	0.378	0.33 U	0.33 U	0.33 U	0.33 U	0.12 U	0.12 U	0.269	0.791	1.02	0.067 U	0.12 U	0.12 U	0.12 U
	MW02005	HOLMN02-GW-002	05-Nov-17	14.5-14.5	N	0.325	0.146	0.471	0.301	0.0465	0.033 U	0.033 U	0.033 U	0.012 U	0.012 U	0.136	0.729	0.775	0.0067 U	0.012 U	0.012 U	0.012 U
	MW02006	HOLMN02-GW-003	05-Nov-17	13.0-13.0	N	8.27	0.854	9.124	0.732	1.7	0.31 U	0.31 U	0.31 U	0.12 U	0.12 U	0.963	6.69	3.52	0.228	0.12 U	0.12 U	0.12 U
3	EF03003	HOLMN03-EF-001	06-Nov-17	0-0	N	0.776	0.0738	0.8498	0.0896	0.118	0.033 U	0.033 U	0.033 U	0.012 U	0.012 U	0.0602	0.602	0.229	0.00648 J	0.012 U	0.012 U	0.012 U
		HOLMN-FD-EFF-001	06-Nov-17	0-0	FD	0.721	0.0653	0.7863	0.0954	0.103	0.031 U	0.031 U	0.031 U	0.012 U	0.012 U	0.0514	0.541	0.224	0.00597 J	0.012 U	0.012 U	0.012 U
	MW-3	HOLMN03-GW-001	05-Nov-17	14.0-14.0	N	0.048	0.0891	0.1371	0.286	0.0546 J	0.062 U	0.062 U	0.062 U	0.023 U	0.023 U	0.114	1.47	0.598	0.012 U	0.023 U	0.023 U	0.023 U
5	MW05001	HOLMN05-GW-001	06-Nov-17	27.5-27.5	N	1040	26.6	1066.6	27.7	115	40 U	40 U	40 U	15 U	15 U	10.1 J	264	96.7	8 U	15 U	15 U	15 U

Notes:
Purple Shaded = Exceeds Health Advisory
Underlined results exceed the EPA RSL standard.
FD = Field Duplicate Sample
ft = Feet
ID = Identification
J = The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample.
N = Normal Field Sample
NA = Not applicable
U = The analyte was analyzed for, but was not detected above the reported limit of detection (LOD).
µg/L = micrograms per liter

PFOS+PFOA = Co-occurrence of PFOA and PFOS (PFOA + PFOS) in aqueous samples is reported using the following guidelines.
1. If both PFOA and PFOS are detected at or above the detection limit (DL), then the sum of PFOA+ PFOS is reported.
2. If either PFOA or PFOS is detected at or above the DL and the other is below the DL, then PFOA + PFOS is reported as "NA" representing Not Applicable.
3. If neither PFOA nor PFOS is detected at or above the DL, then PFOA + PFOS is reported as "ND" representing Not Detected.

PFAS analysis by Modified USEPA Method 537 using Liquid Chromatography and Tandem Mass Spectrometry
Health Advisory from USEPA Office of Water, 2016a and 2016b, Health Advisories (HAs) for drinking water.
[1]USEPA Regional Screening Levels (November, 2017a) [https://semspub.epa.gov/work/HQ/197025.pdf]

Report Date: 3/30/2018

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Table 3.1-4
Summary of Sediment Analytical Testing Results
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman Air Force Base, New Mexico

					Analyte:	Perfluorooctanesulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)	Perfluorobutanesulfonic acid (PFBS)	6:2 Fluorotelomer sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonate (8:2 FTS)	N-Ethyl perfluorooctanesulfonamidoacetic acid (NETFOSAA)	N-Methyl perfluorooctanesulfonamidoacetic acid (NMEFOSAA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanesulfonic acid (PFHxS)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnA)
					Screening Level:	0.126[1]	0.126[1]	130[2]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AFFF Area	**Location**	**Sample ID**	**Sample Date**	**Sample Depth (ft.)**	**Sample Type**	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
2	SD/SW02007	HOLMN02-SD-001	04-Nov-17	0.0-0.5	N	0.0745	0.0034 U	0.0034 U	0.0122 J	0.014 U	0.014 U	0.014 U	0.0034 U	0.0034 U	0.0034 U	0.00813	0.00287 J	0.0034 U	0.0034 U	0.0034 U	0.0034 U
3	SD/SW03001	HOLMN03-SD-001	04-Nov-17	0.0-0.5	N	0.0368	0.0034 U	0.0034 U	0.014 U	0.014 U	0.014 U	0.014 U	0.0034 U	0.0034 U	0.0034 U	0.0032 J	0.0034 U	0.0034 U	0.0034 U	0.0034 U	0.0034 U
	SD/SW03002	HOLMN03-SD-002	04-Nov-17	0.0-0.5	N	0.202 J	0.0084 UJ	0.0084 UJ	0.034 UJ	0.034 U	0.034 UJ	0.034 UJ	0.0084 U	0.0084 U	0.0084 UJ	0.0199 J	0.0084 UJ	0.0084 U	0.0084 UJ	0.0084 UJ	0.0084 U
4	SD/SW04001	HOLMN04-SD-001	04-Nov-17	0.0-0.5	N	0.185 J	0.00234 J	0.0025 UJ	0.01 UJ	0.01 UJ	0.01 UJ	0.01 UJ	0.00133 J	0.0025 UJ	0.0025 UJ	0.0119 J	0.00206 J	0.00168 J	0.0025 UJ	0.0025 UJ	0.0025 UJ
	SD/SW04002	HOLMN04-SD-002	04-Nov-17	0.0-0.5	N	0.519	0.0173 J	0.00258 J	0.00669 J	0.0087 UJ	0.0087 UJ	0.0087 UJ	0.00221 J	0.0022 UJ	0.00664 J	0.163 J	0.0136 J	0.00643 J	0.0022 UJ	0.0022 UJ	0.0022 UJ
		HOLMN-FD-SD-001	04-Nov-17	0.0-0.5	FD	0.507	0.0177 J	0.0034 J	0.00854 J	0.0085 UJ	0.0085 UJ	0.0085 UJ	0.00204 J	0.0021 UJ	0.00812 J	0.172 J	0.0182 J	0.0062 J	0.0021 UJ	0.0021 UJ	0.0021 UJ

Notes:
Purple Shaded = Exceeds Screening Level
FD = Field Duplicate Sample
ft = Feet
ID = Identification
J = The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample.
N = Normal Field Sample
NA = Not applicable
U = The analyte was analyzed for, but was not detected above the reported limit of detection (LOD).
UJ = The reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
mg/kg = milligrams per kilogram
PFAS analysis by Modified USEPA Method 537 using Liquid Chromatography and Tandem Mass Spectrometry
[1]Screening levels calculated using the EPA Regional Screening Level calculator [https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search]
[2]USEPA Regional Screening Levels (November, 2017a) [https://semspub.epa.gov/work/HQ/197027.pdf]

Report Date: 3/30/2018

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Table 3.1-5
Summary of Surface Water Analytical Testing Results
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman Air Force Base, New Mexico

						Analyte:	Perfluorooctanesulfonic acid (PFOS)	Perfluorooctanoic acid (PFOA)	PFOS+PFOA	Perfluorobutanesulfonic acid (PFBS)	6:2 Fluorotelomer sulfonate (6:2 FTS)	8:2 Fluorotelomer sulfonate (8:2 FTS)	N-Ethyl perfluorooctanesulfonamidoacetic acid (NETFOSAA)	N-Methyl perfluorooctanesulfonamidoacetic acid (NMEFOSAA)	Perfluorodecanoic acid (PFDA)	Perfluorododecanoic acid (PFDoA)	Perfluoroheptanoic acid (PFHpA)	Perfluorohexanesulfonic acid (PFHxS)	Perfluorohexanoic acid (PFHxA)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorotridecanoic acid (PFTrDA)	Perfluoroundecanoic acid (PFUnA)
						Health Advisory:	0.07	0.07	0.07	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
AFFF Area	**Location**	**Sample ID**	**Sample Date**	**Sample Depth (ft.)**	**Sample Type**		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
2	SD/SW02007	HOLMN02-SW-001	04-Nov-17	0.0-0.5	N		2.25	0.941	3.191	0.716	5.34	0.33 U	0.33 U	0.33 U	0.12 U	0.12 U	0.881	3.87	3.16	0.0442 J	0.12 U	0.12 U	0.12 U
3	SD/SW03001	HOLMN03-SW-001	04-Nov-17	0.0-0.5	N		1.22	0.097	1.317	0.105	0.0513 J	0.067 U	0.067 U	0.067 U	0.025 U	0.025 U	0.0849	0.803	0.337	0.0106 J	0.025 U	0.025 U	0.025 U
	SD/SW03002	HOLMN03-SW-002	04-Nov-17	0.0-0.5	N		0.878	0.117	0.995	0.156	0.067 U	0.067 U	0.067 U	0.067 U	0.025 U	0.025 U	0.13	1.2	0.539 J	0.011 J	0.025 UJ	0.025 U	0.025 U
4	SD/SW04001	HOLMN04-SW-001	04-Nov-17	0.0-0.5	N		0.951	0.0746	1.0256	0.0798	0.127	0.067 U	0.067 U	0.067 U	0.025 U	0.025 U	0.0542	0.585	0.229	0.013 U	0.025 U	0.025 U	0.025 U
	SD/SW04002	HOLMN04-SW-002	04-Nov-17	0.0-0.5	N		2.45	0.31	2.76	0.239	0.455	0.33 U	0.33 U	0.33 U	0.12 U	0.12 U	0.286	2.74	0.979	0.0456 J	0.12 U	0.12 U	0.12 U
		HOLMN-FD-WS-001	04-Nov-17	0.0-0.5	FD		2.81	0.378	3.188	0.262	0.522	0.33 U	0.33 U	0.33 U	0.12 U	0.12 U	0.332	3.08	1.15	0.0512 J	0.12 U	0.12 U	0.12 U

Notes:
FD = Field Duplicate Sample
ft = Feet
ID = Identification
J = The analyte was positively identified and the associated numerical value is the approximate concentration of the analyte in the sample.
N = Normal Field Sample
NA = Not applicable
U = The analyte was analyzed for, but was not detected above the reported limit of detection (LOD).
UJ = The reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
µg/L = micrograms per liter
PFAS analysis by Modified USEPA Method 537 using Liquid Chromatography and Tandem Mass Spectrometry
Health Advisory from USEPA Office of Water, 2016a and 2016b, Health Advisories (HAs) for drinking water.

Report Date: 2/1/2018

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Table 4.0-1
Conceptual Site Model: Installation-Wide Summary
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman AFB, Alamogordo, New Mexico

Facility Profile	Physical Profile	Release Profile	Land Use and Exposure Profile	Ecological Profile

Installation Description/History:
• Years of Operation: 1942 to Present
• Size: Approximately 59,800 acres
• Location: Southwestern New Mexico, approximately 6 miles west of central business district of Alamogordo, in Otero County, New Mexico.
• History: Holloman AFB was activated in 1942 as Alamogordo Army Air Field for overseas training. In 1945 it was relieved of its training mission and assigned to Continental Air Forces as a permanent installation. Shortly after in 1946 it was temporarily inactivated and was used mainly as a refueling station for emergency landings. Alamogordo AAF merged with the White Sands Proving Ground in 1947 and was eventually re-named in 1948 after Col. George Holloman, an early pioneer in rocket and pilot-less aircraft research (Holloman AFB, 2014).
• Current Mission: Holloman AFB is currently home of the 49th wing of the ACC, 96th Test Group, 54th Fighter Group and German Air Force Flying Training Center. Operations at Holloman AFB include missile testing, aircraft and pilot training, operational equipment and systems testing, and aircraft maintenance and storage. Present aircraft flown at Holloman include the T-38 Talon, MQ-1 Predator, MQ-9 Reaper, QF-4 Drone, and German Air Force Tornado. The installation supports approximately 21,000 Active Duty, Guard Reserve, retirees, DoD civilians and their family members (Holloman AFB, 2014).
 	
AFFF Use:
• AFFF containing PFAS was used for firefighting training activities, testing of firefighting equipment, extinguishing petroleum fires, and in fire suppression systems at several hangars and FTAs.
• Thirty-one potential AFFF release areas were identified during the PA research by HGL with the following four potential AFFF release areas recommended in the PA for SI:
  • FT-31 (Former FTA).
  • Sewage Lagoon Area Outfall.
  • Lake Holloman Outfall.
  • Apache Mesa Golf Course Outfall.
	Topography:
	• Holloman AFB is characterized by high tablelands with rolling summit plains, cuesta-formed mountains dipping eastward and west-facing escarpments with the wide bracketed basin forming the basin and range complex. The AFB is located in the Tularosa Sub-basin that is part of the Central Closed Basins and sits at a mean elevation of 4,093 feet above mean sea level (Holloman AFB, 2014). The basin is bound by the San Andres Mountains to the west and Sacramento Mountains to the east.
	Vegetation:
	• Native vegetation within developed portions of Holloman AFB consists primarily of shrub lands dominated by four-wing saltbrush, and grasslands dominated by alkali sacaton. Uplands and lowlands within undeveloped areas are dominated by native vegetation including creosote bush, and sacaton and saltgrass, respectively (Lake Holloman EA, 2011).
	• Vegetation within the AFB has largely been removed over time due to site construction and development, and general military activity. Where vegetation has been replaced, ornamental plants (both native and introduced) and shade trees such as desert willow (*Chilopsis linearis*), ocotillo (*Fouquieria splendens*), yuccas (*Yucca* spp.), pines (*Pinus* spp.), and mulberry (*Morus* sp.) have been established.
	Surface Water:
	• Surface water within Holloman AFB is captured by an unnamed stream flowing northeast to southwest, eventually draining to the Sewage Lagoon Area and Lake Holloman Outfalls.
	• Other surface water bodies include the Sewage Lagoon Area and Lake Holloman.
	• Since Holloman AFB was activated in 1942, storm water runoff has collected in the Sewage Lagoon Area and Lake Holloman where it either evaporates or percolates into the soil.
	• Since 1996, treated effluent from the WWTP has discharged into Pond G and Lake Holloman.
	Soils:
	• There are two primary soil associations in the vicinity of Holloman AFB; the Holloman-Gypsum land-Yesum complex, and Mead silty clay loam (USDA, 1981).
	• The Holloman-Gypsum land-Yesum complex consists of shallow and deep, well-drained soils and areas of exposed gypsum. The surface layer is a relatively thin veneer of light brown, very fine sandy loam, approximately 3 inches thick (HGL, 2015).
	• The Mead series is located across the main drainage area at Holloman AFB. The Mead silty clay loam, is a deep, poorly drained soil formed in fine textured alluvium over lacustrine lake sediment (USDA, 1981).
	Geology:
	• Holloman AFB is located within the Sacramento Mountains Physiographic Province on the western edge of the Sacramento Mountains (HGL, 2015).
		Contaminants of Potential Concern:
		• PFAS are the contaminants of potential concern during the SI.
		• Petroleum-related compounds and chlorinated solvents are historical site contaminants.
		Media of Potential Concern:
		• Soil, sediment, surface water, and groundwater.
		Confirmed AFFF Releases:
		• Former FTA (FT-31): AFFF released during fire training exercises conducted at this location. SI data indicated that PFOS, PFOA and PFOS+PFOA were detected above the USEPA drinking water HA values in groundwater. Surface and subsurface soils also contain PFOS and to a lesser extent PFOA above residential screening limit (RSL).
		• Sewage Lagoon Area Outfall: Effluent containing AFFF from WWTP discharges to this location. SI data indicated that PFOS, PFOA and PFOS+PFOA were detected above the USEPA drinking water HA values in groundwater and surface water.
		• Apache Mesa Golf Course Outfall: Wastewater from WWTP containing AFFF stored on-site and used as irrigation and pond water at this location. SI data indicated that PFOS, PFOA and PFOS+PFOA were detected above the USEPA drinking water HA values in effluent water from the WWTP, groundwater and surface water at this location. PFOS was also detected above the RSL in sediment of one of the golf course ponds.
		• Lake Holloman Outfall: AFFF released from WWTP wastewater effluent, which discharges to lagoon outfall and eventually flows to this location. SI data indicated that PFOS, PFOA and PFOS+PFOA were detected above the USEPA drinking water HA values in surface water, and PFOS was detected above the USEPA RSL in sediment.
		• Evaporation Pond No. 2: Evaporation basin and surrounding area that contains AFFF from previous monthly foam testing. SI data indicated that PFOS and PFOA were detected above the RSL in soil, and PFOS, PFOA and PFOS+PFOA were detected above the USEPA drinking water HA values in groundwater.
			Current Land Use:
			• Occupied by Holloman AFB.
			Future Land Use:
			• Land use is not expected to change in the future.
			Potential Receptors:
			• Potential receptors associated with current and future land use include USAF personnel and residents, grounds maintenance workers, utility workers, construction workers.
			• Recreational users of Apache Mesa Golf Course and Lake Holloman.
				Potential Ecological Receptors:
				• Inland and aquatic plant species, reptiles, birds, and mammals that inhabit or migrate through or adjacent to the installation.
				• These areas provide habitat for over 73 species of migrating and resident wetlands birds (49FW, 2009)
				Threatened and Endangered Species:
				• Endangered species of birds, mammals and plants that were identified in Otero County and may exist at Holloman AFB include the following:
				• Bald eagle (*Haliaeetus leucocephalus*)
				• Northern Aplomado Falcon (*Falco femoralis septentrionalis*)
				• Mexican Spotted Owl (*Strix occidentalis lucida*)
				• Mountain Plover (*Charadrius montanus*)
				• Black Footed Ferret (*Mustela nigripes*)
				• Sacremento Mountains Thistle (*Cirsium vinaceum*)
				• Sacramento Prickly Poppy (*Argemone pleiacantha* ssp. *pinnatisecta*)
				• Kuenzler Hedgehog Cactus (*Echinocereus fendleri* var. *kuenzleri*)
				• Todsen's Pennyroyal (*Hedeoma todsenii*)

Facility Profile	Physical Profile	Release Profile	Land Use and Exposure Profile	Ecological Profile
• Evaporation Pond No. 2. was identified as a potential AFFF release requiring SI activities based on information collected during the scoping visit conducted on 27 October 2016. • A total of five potential AFFF release areas were evaluated during SI activities.	• The region is characterized by high tablelands with rolling summit plains, cuesta-formed mountains dipping eastward and west-facing escarpments with the wide bracketed basin forming the basin and range complex. • Holloman AFB is located in the Tularosa Sub-basin that is part of the Central Closed Basins. The basin is bound by the San Andres Mountains to the west and Sacramento Mountains to the east (NVB, 2009). • The Tularosa Basin is a bolson, or a basin that has no surface drainage outlet. The bolson fill in the Tularosa Basin is derived from the erosion of limestone, dolomite, and gypsum in the surrounding mountains, with coarser material deposited at the installation of the mountains and finer material carried to the basin interior (FWEC, 1995). • The near surface bolson deposits consist of sediments that are of alluvial, eolian, lacustrine, or playa origin. The alluvial fan deposits are characteristically interbedded sand, silt and clay. The eolian deposits consist primarily of gypsum sand and the lacustrine/playa deposits consist of clay containing gypsum crystals (FWEC, 1995). The lacustrine deposits are juxtaposed with alluvial fan and eolian deposits throughout the installation (Radian, 1992). • Different areas of the installation have included stiff caliche layers of varying thickness (NVB, 2009) **Hydrogeology:** • Groundwater occurs as an unconfined aquifer in the unconsolidated deposits of the central basin (HGL, 2015). • The primary source of groundwater recharge is rainfall percolation and minor amounts of stream run off along the western Sacramento Mountains. • Since the Tularosa Basin is a closed system, water only leaves the area through evaporation or percolation. The elevated amount of percolation results in a high water table with groundwater levels ranging from 5 to 50 ft bgs (NVB, 2009). Groundwater levels during the SI soil boring and monitoring well installation program ranged from 4029.20 feet amsl to 4105.74 feet amsl. • Groundwater flow at the installation is generally toward the southwest. Groundwater flow is affected by local topography in areas immediately adjacent to arroyos, where groundwater flows directly toward the drainages regardless of regional flow pattern (NVB, 2009). • Groundwater at Holloman AFB generally has a total dissolved solids concentration greater than 10,000 mg/L that exceed the New Mexico Water Quality Control Commission limits for potable water. Groundwater beneath Holloman AFB has therefore been designated unfit for human consumption (HGL, 2015). **Meteorology:** • Average annual precipitation ranges from 8 to 11 inches/year in the basin and from 12 to 18 inches/year at higher elevations (USDA, 1981) • Average number of days with measurable rainfall is 47 days • Average high temperature of 94.5 degrees Fahrenheit (°F) occurs in June and average low temperature of 29.2°F occurs in January.	**Primary Release Pathways:** • Release or application of AFFF to the ground at potential source areas. • Infiltration of PFAS deeper into the soil column over time reaching groundwater. • AFFF washed into drainage and storm water systems. • Effluent containing AFFF stored in evaporation ponds and former sewage lagoons. • Effluent discharged from WWTP to Pond G and Lake Holloman. **Secondary Release Pathways:** • Golf course irrigation water from the WWTP • Golf course pond water from the WWTP		

Table 4.2-1
Off-Base Well Summary (Downgradient Wells)
Site Inspection of Aqueous Film Forming Foam (AFFF) Release Areas
Site Inspection Report, Holloman AFB, Alamogordo, New Mexico

Map Reference Number[1]	Well ID	NMOSE POD Reference ID	UTM Easting (Zone 13 North)	UTM Northing (Zone 13 North)	Owner	Owner Address	Use	Total Depth (feet bgs)	First Water (feet bgs)	Construction Date
1	02758	91141	394077.00	3630020.00	CEMEX El Paso, Inc.	#1 McKelligon Road	Commercial	140	--	9/25/1995
2	04976	213937	390430.00	3627827.00	White Sands National Monument	19955 Highway 70	Monitoring	25	13	1/12/2006
3	04978	213951	390418.00	3627202.00	White Sands National Monument	19955 Highway 70	Monitoring	23	13	1/12/2006
4	04979	213953	390418.00	3627202.00	White Sands National Monument	19955 Highway 70	Monitoring	23	13	1/12/2006
5	05502	240582	392720.60	3626916.50	White Sands National Monument	PO Box 1086	Monitoring	30	--	Not Listed
6	00224	154638	398444.00	3628161.00	White Sands Ranch Inc.	PO Box 637	Livestock	200	--	8/31/1935
7	02808	162103	392773.00	3623881.00	White Sands Ranch Inc.	PO Box 637	Livestock	--	--	Not Listed
8	00226	154644	395403.00	3625099.00	White Sands Ranch Inc.	PO Box 637	Irrigation	800	--	12/31/1970
9	00227	154645	395403.00	3625099.00	White Sands Ranch Inc.	PO Box 637	Livestock	400	--	12/31/1970
10	00228	154649	398424.00	3626099.00	White Sands Ranch Inc.	PO Box 637	Livestock	52	40	12/31/1936
11	00228	154650	398424.00	3626099.00	White Sands Ranch Inc.	PO Box 637	Livestock	52	40	12/31/1937

Notes:
Wells identified include only those wells located downgradient of groundwater release areas within 4 miles of the Holloman AFB installation boundary.
[1] Map Reference Number pertains to reference numbers shown on Figure 4.2-1 of this SIR
NMOSE = New Mexico Office of State Engineer
POD = Point of Diversion
Water well data available from the New Mexico Water Rights Reporting System (NMWRRS) online (http://nmwrrs.ose.state.nm.us/index.html); accessed February 2018

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