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FINAL

Site Inspection Report

for

Per-and Polyfluoroalkyl Substances (PFAS)

at

National Aeronautics and Space Administration (NASA)
Jet Propulsion Laboratory (JPL)
Pasadena, California

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ABBREVIATIONS

%	percent
°F	degrees Fahrenheit
µg/L	micrograms per liter
AFFF	aqueous film-forming foam
AHA	Activity Hazard Analysis
amsl	above mean sea level
AOPC	Areas of Potential Concern
APPL	Agriculture & Priority Pollutants Laboratories
APP/SSHP	Accident Prevention Plan/Site Safety and Health Plan
bgs	below ground surface
Caltech	California Institute of Technology
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CoC	Chain of custody
COC	Contaminants of concern
COPC	Contaminant of Potential Concern
CSM	Conceptual Site Model
DI	deionized
DoD	Department of Defense
DOT	Department of Transportation
DQCR	Daily Quality Control Report
DQO	Data quality objective
DTSC	Department of Toxic Substances Control
CDWR	California Department of Water Resources
Ebasco	Ebasco Services, Inc.
ELAP	Environmental Laboratory Accreditation Program
Feet per day	ft/day
FFA	Federal Facilities Agreement
FFRDC	federally funded research and development center
FID	flame ionization detector
ft	feet/foot
FWEC	Foster Wheeler Environmental Corporation
G2S	G2S LLC
GALCIT	Graduate Aerospace Laboratories of the California Institute of Technology
GAMA	Groundwater Ambient Monitoring and Assessment
gpm	gallons per minute
GPS	Global Positioning System
HA	Health Advisory
HDPE	High Density Polyethylene
IDW	investigation derived waste
IX	ion exchange

JPL	Jet Propulsion Laboratory
LACoFD	Los Angeles County Fire Department
LARWQCB	Los Angeles Regional Water Quality Control Board
LAWC	Lincoln Avenue Water Company
LC-MS/MS	liquid chromatography-tandem mass spectrometry
LGAC	Liquid-Phase Granular Activated Carbon
Ma	million years old
MHTS	Monk Hill Treatment System
MWD	Metropolitan Water District
NASA	National Aeronautics and Space Administration
NGWA	National Groundwater Association
NPL	National Priorities List
NTC	National Training Center
NTU	nephelometric turbidity unit
OU	operable unit
ORP	Oxidation-reduction potential
PA	Preliminary Assessment
PFAS	Per- and Polyfluoroalkyl Substances
PFBA	perfluorobutanoic acid
PFBS	perfluorobutanesulfonic acid
PFDOA	perfluorododecanoic acid
PFHpA	perfluoroheptanoic acid
PFHxA	perfluorohexanoic acid (PFHxA)
PFHxS	perfluorohexane sulfonate
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PFOSA	Perfluorooctanesulfonamide
PFTEDA	perfluorotetradecanoic acid
PFUDA	perfluoroundecanoic acid
PID	photoionization detector
POC	point of contact
PPE	Personal protection equipment
ppm	parts per million
ppt	parts per trillion
psi	pounds per square inch
PWP	Pasadena Water and Power
PWS	Performance Work Statement
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
QSM	Quality Systems Manual
RCRA	Resource Conservation and Recovery Act

RI	Remedial Investigation
ROD	Record of Decision
RML	Removal Management Levels
RSL	Regional Screening Level
RTC	response to comment
RWQCB	Regional Water Quality Control Board
SDWIS	Safe Drinking Water Information System
SI	Site Inspection
SOP	Standard Operating Procedure
SSHO	Site Safety and Health Officer
SWRCB	State Water Resources Control Board
THQ	Target Hazard Quotient
TR	Target Cancer Risk
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
USACE	United States Army Corps of Engineers
USC	United States Code
USCS	Unified Soil Classification System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VOA	volatile organic analysis
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

This report presents the findings of a Site Inspection (SI) conducted at the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) in Pasadena, California, to assess the presence or absence of per- and polyfluoroalkyl substances (PFAS) at five Areas of Potential Concern (AOPCs). PFAS are a class of synthetic organofluorine compounds with unique properties that make them useful in various consumer and industrial products; however, their potential impact to human health and the environment have resulted in evolving guidance and regulations regarding safe levels.

The PFAS SI focused on the following AOPCs at JPL:

1. AOPC 1: Emergency Landing Facility
2. AOPC 2 and 3: Waste Disposal Areas (Seepage Pits and Waste Pits)
3. AOPC 4: Building 170 Fabrication Shop
4. AOPC 5: Former Building 218 and Building 291 Photography Labs

The project scope included groundwater and soil sample collection, sample analyses, third-party data validation, and report preparation. Groundwater samples were collected from multiple existing monitoring wells within and downgradient of JPL to assess PFAS in groundwater. Soil samples were collected at two intervals (0 to 0.5 feet and 0.5 feet to 2 feet below ground surface) within AOPC 1 to assess PFAS presence.

Key findings from the SI are as follows:

1. PFAS constituents were detected in soil and groundwater at JPL and downgradient locations, with sporadic exceedances of the screening criteria. PFAS presence was confirmed in AOPCs 1, 2, 3, and 4, while AOPC 5 could not be determined due to a dry monitoring well.
2. PFOS was found in soil above screening criteria in AOPC 1, and in groundwater above screening criteria in AOPCs 2 and 3. PFOA was present in groundwater above screening criteria in AOPCs 2 and 3.
3. Local water purveyors detected low levels of PFAS in drinking water wells, with one well presenting PFOS concentrations above screening criteria before treatment.

Based on the results of the SI at JPL, NASA recommends the following actions:

1. Conduct more comprehensive PFAS sampling of monitoring wells within and near the JPL Facility in 2024, taking advantage of recent rains that have replenished some previously dry wells. Utilize data from this extensive event to determine if PFAS analysis of samples collected from select wells should be added to the JPL groundwater monitoring program.
2. Coordinate with the City of Pasadena and Lincoln Avenue Water Company (LAWC) on sampling treated water to evaluate the effectiveness of PFAS removal by existing treatment systems, which include treatment using granular activated carbon and perchlorate-selective ion exchange media. Furthermore, collaborate with the City of Pasadena and LAWC on routine sampling of extraction wells to understand variability in PFAS concentrations.
3. Based on current results, additional soil sampling is not planned at this time. Decisions regarding the need for additional soil sampling will be evaluated following the more comprehensive PFAS sampling of monitoring wells within and near the JPL Facility in 2024.

By implementing these recommendations, NASA aims to ensure a thorough understanding of PFAS presence at JPL and effective coordination with local stakeholders to monitor and address potential impacts on water resources.

1 INTRODUCTION

1.1 Purpose of Report

This Site Inspection (SI) Report was prepared by G2S LLC (G2S), under Contract No. W912PL21D0021 as part of Delivery Order No. W912PL21F0046 to document the results of SI activities conducted at five Areas of Potential Concern (AOPCs) located at the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) in Pasadena, California. The purpose of the SI was to determine, through environmental media sampling, the presence or absence of per- and polyfluoroalkyl substances (PFAS) at five AOPCs identified in the PFAS Preliminary Assessment (PA) Report for the Jet Propulsion Laboratory (Tetra Tech, 2021).

The data presented in this SI Report were collected and evaluated in accordance with the Final SI Work Plan for PFAS at NASA JPL (NASA, 2022a).

1.2 Per- and Polyfluoroalkyl 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. Guidance and regulations around safe levels of PFAS in the environment are evolving, and NASA considered published federal and State of California levels when evaluating PFAS concentrations detected at the JPL Site.

The United States Environmental Protection Agency (USEPA) has established an integrated program to address PFAS impacts in the environment (USEPA, 2021). As part of this program, the USEPA announced in March 2023 the proposed National Primary Drinking Water Regulation (NPDWR) for six PFAS, including perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorononanoic acid (PFNA), hexafluoropropylene oxide dimer acid (HFPO-DA, commonly known as GenX Chemicals), perfluorohexane sulfonic acid (PFHxS), and perfluorobutane sulfonic acid (PFBS). The proposed NPDWR establishes Maximum Contaminant Levels (MCLs) for six PFAS in drinking water, PFOA and PFOS as individual contaminants, and PFHxS, PFNA, PFBS, and HFPO-DA as a PFAS mixture. The proposed rule would require public water systems to monitor for these PFAS, notify the public of the levels of these PFAS, and reduce the levels of these PFAS in drinking water if they exceed the proposed standards (USEPA, 2023a).

The USEPA Office of Water issued interim updated drinking water health advisories (HA) for PFOA and PFOS and final HAs for HFPO-DA and PFBS) in June 2022, which replaced those issued in 2016 (USEPA, 2022a). HA values identify the concentration of a contaminant in drinking water at which adverse health effects are not anticipated to occur but are not legally enforceable federal standards and are subject to change as new information becomes available (USEPA, 2022a). The final HAs were considered in the proposed PFAS NPDWR.

On May 18, 2022, the USEPA added five PFAS chemicals for a total of six PFAS chemicals to a list of risk-based values, referred to as Regional Screening Levels (RSLs), that help EPA determine if response or remediation activities are needed. The five PFAS additions include: PFOS, PFOA, PFNA, HFPO-DA, and PFHxS. EPA added the first PFAS substance, PFBS, to the RSL list in 2014 and updated it in 2021 when EPA released its updated toxicity assessment for PFBS (USEPA, 2022b). Therefore, PFAS RSLs have been established for the same six PFAS in the proposed NPDWR. RSLs were established for two additional PFAS chemicals, perfluorobutanoic acid (PFBA) and perfluorohexanoic acid (PFHxA), in May

2023. RSLs were established for three additional PFAS chemicals, perfluorododecanoic acid (PFDOA), perfluorotetradecanoic acid (PFTEDA) and perfluoroundecanoic acid (PFUDA), in November 2023 (USEPA, 2023b).

RSLs are used to identify contaminated media (i.e., air, tap water, and soil) at a site that may need further investigation. In general, if a contaminant concentration is below the screening level, no further action or investigation is needed. If the concentration is above the screening level, further investigation may be needed to determine if action is required. The USEPA updated the RSL tables November 2023 (USEPA, 2023b).

The California State Water Resources Control Board (SWRCB) has not promulgated standards for any PFAS to date but has issued Notification Levels (NLs) and Response Levels (RLs). NLs represent the concentration level of a contaminant in drinking water that does not pose a significant health risk but warrants notification according to the Division of Drinking Water (DDW). A RL is set higher than a NL and represents a recommended chemical concentration at which water systems consider taking a water source out of service or provide treatment. NLs and RLs have been established for PFOA, PFOS, PFBS, and PFHxS (SWRCB, 2023).

For the purposes of NASA's PFAS SI, groundwater analytical results are compared to the November 2023 USEPA RSL table for tap water (Target Cancer Risk [TR] of 1E-06 and Target Hazard Quotient [THQ] of 0.1), the March 2023 USEPA proposed NPDWR, and the SWRCB NLs. Analytical results for soils are compared to the November 2022 USEPA RSL table for residential soil (TR=1E-06, THQ=0.1). Table 1-1 below presents the screening values for comparing analytical results for PFOS, PFOA, PFNA, PFHxS, PFBS, and HFPO-DA.

Table 1-1. Summary of Groundwater and Soil Screening Criteria for PFAS

Parameter	Chemical Abstract Number	USEPA Regional Screening Level Table[a] (November 2023)		USEPA Proposed NPDWR[b] (March 2023) (ng/L)	SWRCB DDW NL[c] (ng/L)
		Residential Soil (µg/kg)	Tap Water (ng/L)		
PFOA	335-67-1	19	6	4	5.1[d]
PFOS	1763-23-1	13	4	4	6.5[d]
PFBA	375-22-4	7800	1800	NE	NE
PFHxA	307-24-4	3200	990	NE	NE
PFBS	375-73-5	1900	600	1.0 (unitless) Hazard Index	500[e]
HFPO-DA (GenX Chemicals)	13252-13-6	23	6		NE
PFNA	375-95-1	19	5.9		NE
PFHxS	355-46-4	130	39		3[f]
PFDOA	307-55-1	320	100	NE	NE
PFTEDA	376-06-7	6300	2000	NE	NE
PFUDA	2058-94-8	1900	600	NE	NE

Notes:

[a] USEPA Regional Screening Levels (November 2023): https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables (TR=1E-06, THQ=0.1)

[b] USEPA proposed National Primary Drinking Water Regulation for PFAS: https://www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas. The combined hazard index (HI) for PFBS, HFPO-DA, PFNA, and PFHxS is determined as follows:

- Step 1. Divide the measured concentration of HFPO-DA (Gen X) by the health-based value of 10 ng/L.
- Step 2. Divide the measured concentration of PFBS by the health- based value of 2000 ng/L.
- Step 3. Divide the measured concentration of PFNA by the health-based value of 10 ng/L.
- Step 4. Divide the measured concentration of PFHxS by the health-based value of 9 ng/L.

- Step 5. Add the ratios from steps 1, 2, 3 and 4 together.
- If the running annual average HI greater than 1.0, it is a violation of the proposed HI MCL.

[c] SWRCB DDW Notification Levels: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/pfas.html.
[d] In August 2019, DDW revised the notification levels to 6.5 ppt for PFOS and 5.1 ppt for PFOA.
[e] On March 5, 2021, DDW issued a drinking water notification level of 500 ppt for PFBS.
[f] On October 31, 2022, DDW issued a drinking water notification level of 3 ppt for PFHxS.
ng/L = nanogram per liter
µg/kg = microgram per kilogram
NE = not established

1.3 Project Objectives

The objective for the PFAS SI at NASA JPL was to implement the environmental investigations following the PA Report for the Jet Propulsion Laboratory (Tetra Tech, 2021). The SI environmental investigation was completed in compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 United States Code (USC) § 9601 et seq. and State of California environmental regulations.

The objectives of the PFAS SI environmental investigations at NASA JPL were to investigate the presence or absence of PFAS at or associated with five AOPCs:

- AOPC 1: Emergency Landing Facility
- AOPC 2 and 3: Waste Disposal Areas (Seepage pits [40] and waste pits [4] comprising AOPC 2 and AOPC 3 respectively are considered as a single potential source)
- AOPC 4: Building 170 Fabrication Shop
- AOPC 5: Former Building 218 and Building 291 Photography Labs

1.4 Project Scope

The project scope was to conduct a PFAS SI at JPL based on findings identified in the PFAS PA Report. The project includes the collection of groundwater and soil samples, sample analyses, third party data validation, and report preparation. As a part of this task, groundwater samples were collected from multiple existing monitoring wells within and downgradient of JPL to assess presence or absence of PFAS in groundwater at or associated with AOPC 1, 2, 3, 4, and 5. The project also included the collection of soil samples at two intervals (0 to 0.5 feet [ft] and 0.5 ft to 2 ft below ground surface (bgs)) to assess presence or absence of PFAS in soil at or associated with AOPC 1. The goal of the SI was to determine whether data warrant subsequent characterization as part of a Remedial Investigation/ Feasibility Study (RI/FS). It should be noted that USEPA considers all PA/SI documentation associated with PFAS at Federal Facilities on the National Priorities List (NPL) to be part of the RI/FS (USEPA, 2023c).

1.5 Regulatory Framework

In October 1992, the JPL site was placed on the NPL and, therefore, is subject to the provisions of CERCLA to regulate investigation and cleanup. The parties to the Federal Facilities Agreement (FFA) include NASA, the USEPA, the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB). NASA is the lead federal agency, and USEPA, DTSC, and RWQCB provide guidance and oversight to the JPL CERCLA Program. The PFAS PA was conducted voluntarily by NASA following the CERCLA process. It should be noted that the USEPA is pursuing future hazardous substance designations of PFAS under CERCLA, and USEPA requested PFAS investigation as part of the JPL CERCLA Program (NASA, 2022b).

NASA Headquarters conducted PFAS PAs at 10 NASA Centers/Facilities (JPL being one of the ten facilities) to identify whether past or present activities may have resulted in a release of PFAS into the environment and to qualitatively evaluate potential exposure to PFAS in environmental media for receptors at and within a 1-mile radius of each NASA Center/Facility. The PFAS PA for JPL was finalized in February 2021 and the PFAS SI that is the subject of this report is the next step in the CERCLA process based on the findings of the PA.

1.6 Report Organization

This PFAS SI Report is organized as follows:

- Section 1, Introduction – Describes the project objectives, regulatory framework, and content of the PFAS SI Work Plan.
- Section 2, Site Background – Provides background information including site location and description, site history, summary of previous investigations, and regulatory history.
- Section 3, Environmental Setting – Summarizes physical characteristics of the Site including climate, topography, geology, hydrogeology, surface water features, and land use.
- Section 4, Field Activities and Analytical Protocols – Provides an overview of the soil and groundwater sampling field activities, analytical methods, and analytical results.
- Section 5, Quality Assurance/Quality Control – Overview of the Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) requirements, documentation that the QAPP requirements have been met, and a data review and usability evaluation.
- Section 6, Migration and Exposure Pathways and Targets – Provides a summary of the groundwater migration pathway, the soil exposure pathway, and potential targets for PFAS based on the results of the SI.
- Section 7, Summary and Conclusions.

The following are appended to this document:

- APPENDIX A: Tabulated Results and Figures
- APPENDIX B: Laboratory Analytical Data Package
- APPENDIX C: Third Party Data Validation Package
- APPENDIX D: Field Documentation – Daily Tailgate Safety Meeting Forms, PFAS Sampling Checklists, Sampling Logs, Test Equipment Calibration Log, Boring Logs
- APPENDIX E: Final Site Inspection Work Plan for Per-and Polyfluorinated Substances (PFAS) at National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL), Pasadena, California (October 2022)

2 SITE BACKGROUND

2.1 Site Location and Description

JPL is a federally funded research and development center (FFRDC) in Pasadena, California, currently operated under contract with the California Institute of Technology (Caltech) for NASA. JPL's primary activities include the exploration of the earth and solar system by automated spacecraft and the design and operation of the Global Deep Space Tracking Network.

Located in Los Angeles County, the JPL site is situated between the incorporated cities of La Cañada Flintridge and Pasadena and is bordered on the east by the unincorporated community of Altadena. JPL encompasses approximately 176 acres of land and more than 150 buildings and other structures. Of the JPL Facility's 176 acres, approximately 156 acres are federally owned. The remaining land is leased for parking from the City of Pasadena and the Flintridge Riding Club. Development at JPL is primarily located in two regions, an early-developed northeastern area and a later-developed southwestern area. Figure 2-1 is a location map showing the JPL Facility and surrounding areas.

Under the CERCLA program, JPL has been divided into three operable units (OUs). OU1 addresses on-facility groundwater at JPL; OU2 addresses on-facility vadose zone soil at JPL; and OU3 addresses off-facility groundwater adjacent to the JPL property. Cleanup of OU2 is complete, as documented in the Remedial Action Report for Operable Unit 2 (NASA, 2007). A Final Record of Decision (ROD) is currently in place for both OU1 and OU3 (NASA, 2018). The Third Five-Year Review was completed for OU1 and OU3 in 2022 (NASA, 2022).

The remedies for OU1 and OU3 include three treatment systems: the Source Area Treatment System (OU1) and two systems in OU3, the Monk Hill Treatment System (MHTS) and the Lincoln Avenue Water Company (LAWC) Treatment System. These systems utilize liquid-phase granular activated carbon (LGAC) to remove volatile organic compounds (VOCs) and ion exchange (IX) to remove perchlorate. For the source area treatment system, the treated water is reinjected into the aquifer utilizing three injection wells located approximately 350 feet up gradient from the extraction wells. Treated water from the MHTS and LAWC Treatment System is used as drinking water.

The PA Report recommended four AOPCs (the Site) for further assessment and one AOPC was added during the SI. The description of each AOPC location is provided below. Figure 2-2 presents a Site map showing the locations of the AOPCs.

2.1.1 AOPC 1: Emergency Landing Facility

The Emergency Landing Facility is an approximately 1.25-acre area located in the northern portion of JPL off Mesa Road near Building 243. The facility is located on the mesa north of and at a higher elevation than the main campus of JPL (north of the JPL Thrust Fault) and has a heliport that is used to support Los Angeles County Fire Department (LACoFD) helicopters in the event of a forest fire (Tetra Tech, 2021).

2.1.2 AOPC 2 and 3: Waste Disposal Areas (Seepage Pits and Waste Pits)

40 seepage pits (collectively AOPC 2) and four waste pits (collectively AOPC 3) are being considered as a single potential source based on proximity to each other. The seepage pits were used from approximately 1945 to 1960 to dispose of a variety of liquid wastes associated with laboratory operations, including sanitary wastes, solvents, paints, wastewater from parts cleaning, and other chemicals. Seepage pits are located primarily in the eastern/northeastern portion the JPL Facility.

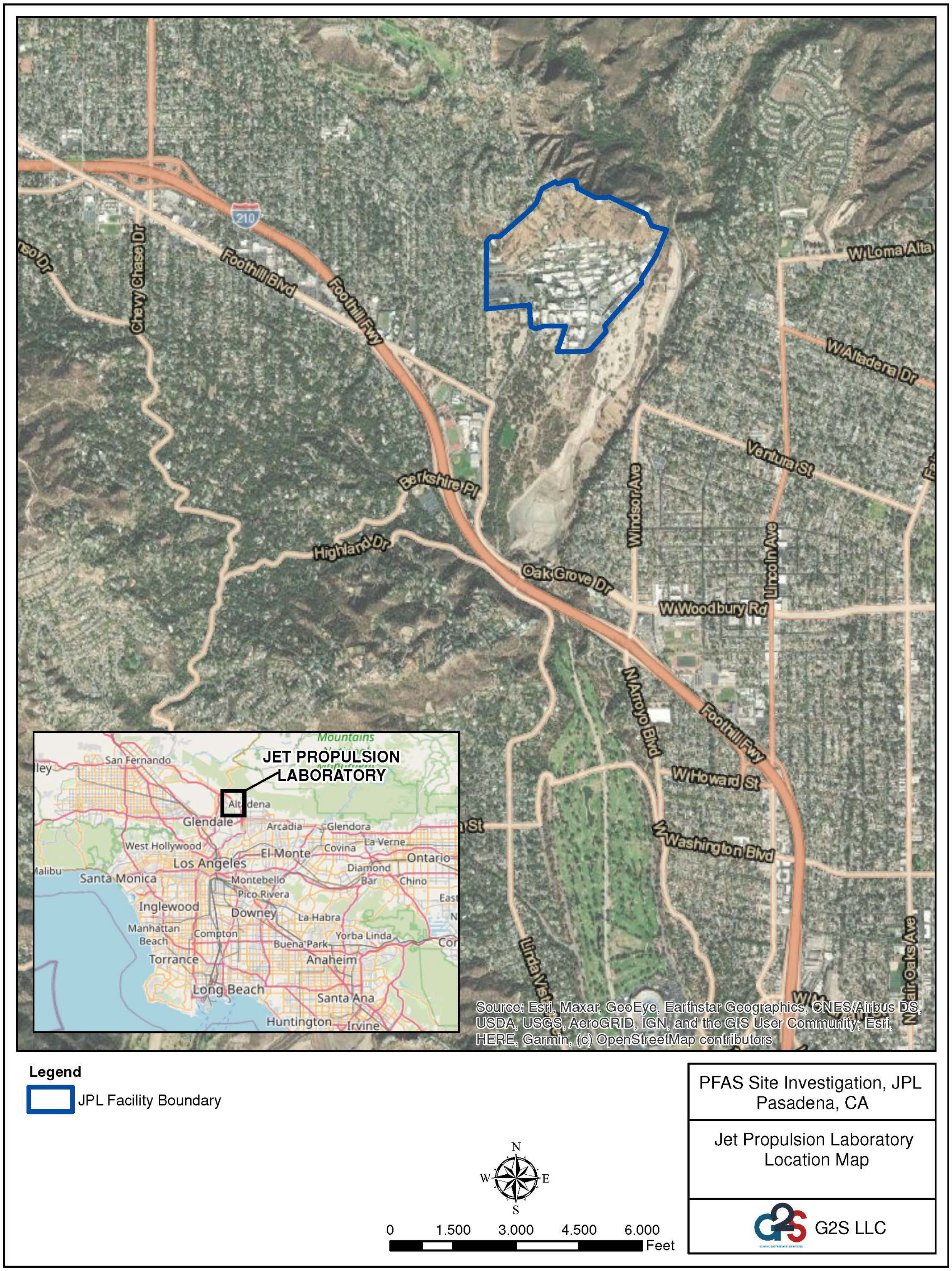


Figure 2-1. Site Location Map

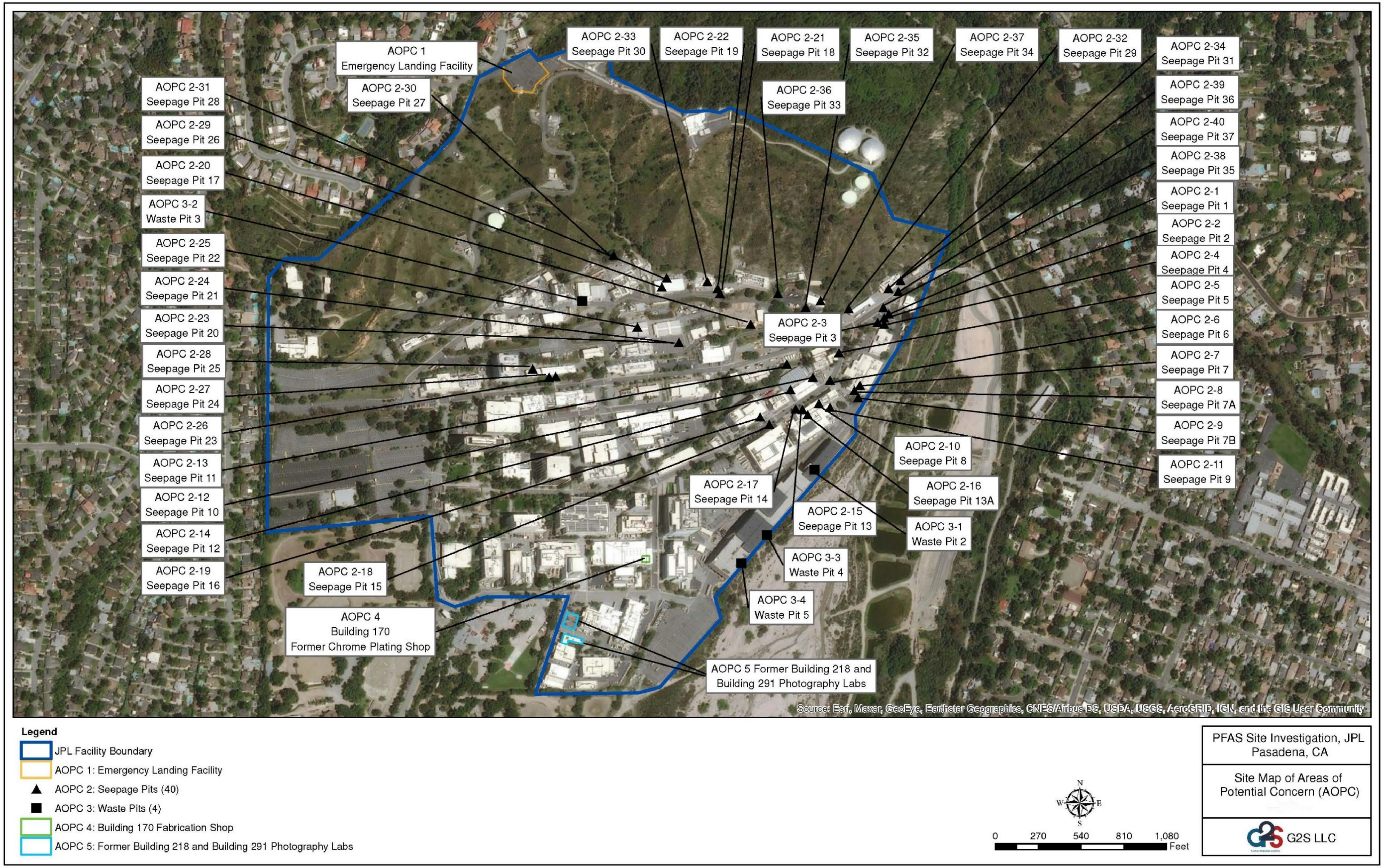


Figure 2-2. Site Map of AOPCs

The waste pit disposal areas were located along what was the boundary between JPL and the Arroyo Seco at the time, but they currently fall within the JPL boundary. One additional waste disposal area was documented to the south of Former Building 45. Waste pits were used from 1945 to 1960 to dispose of materials such as wood, glass, metal parts and shavings, drums of chemical wastes, and other hazardous and municipal wastes and were designed as open, bermed areas that were later backfilled.

2.1.3 AOPC 4: Building 170 Fabrication Shop

Building 170 houses the Fabrication Shop and is in the southern portion of JPL between Mariner Road and Forestry Camp Road.

2.1.4 AOPC 5: Former Building 218 and Building 291 Photography Labs

Former Building 218 was located in the southern portion of JPL directly west of current Building 202. Building 291 is located in the southern portion of JPL.

2.2 Site History

JPL is a NASA facility for research and development of space exploration, including rocket propellant design and testing, spacecraft material and equipment design, assembly and testing, and research related to alternative energy sources and pollution control (Ebasco Services, Inc. [Ebasco], 1988). JPL was originally founded in 1944 in partnership with the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT) and the U.S. Army to develop rocket-based weapons, guided missiles, and solid rocket propellant. Activities at JPL supported the launch of the U.S.'s first satellite in 1958. In recent decades, JPL has functioned as NASA's primary center for unmanned interplanetary exploration and assists with aeronautical research and development (Ebasco, 1988 as cited in Tetra Tech, 2021).

The history of each AOPC being investigated as part of the PFAS SI is provided below.

2.2.1 AOPC 1: Emergency Landing Facility

According to the 2021 PA Report, the current heliport area was paved and housed antennae by 1964. In addition, aerial photographs reviewed during the PA indicate that the heliport may have been present as early as 1972 but did not appear on a site map until 1986. Aqueous film-forming foam (AFFF) was stored in Building 242A (covered shed adjacent to the helipad and Building 243) to support emergency response for a potential helicopter fire. The PA Report found limited information regarding the type of AFFF stored or the period during which the AFFF was stored in Building 243A. They learned of a one-time training exercise that was conducted by JPL and the LACoFD during which AFFF was applied on the helipad. The PA was unable to determine the timing of the exercise through records review, but interviews indicated it was before 2010. Once the training exercise was completed, the AFFF was washed from the helipad and directed to the southern edge of the helipad toward the sloped edge of the mesa. The AFFF-containing wash water may have been diverted through a storm drain at the southwestern corner of the helipad, which empties downslope in a catchment drain at the bottom of the hill and/or it may have washed down the side of the mesa south of the Emergency Landing Facility. AFFF-containing wash water from the uphill mesa could have potentially entered storm drain inlets located on the slope of the mesa below the southern edge of the helipad. These inlets appear to ultimately discharge to the off-Site Arroyo Seco (Tetra Tech, 2021).

2.2.2 AOPC 2 and 3: Waste Disposal Areas (Seepage Pits and Waste Pits)

When JPL was operated by GALCIT and the U.S. Army, 40 seepage pits (collectively AOPC 2) and 4 waste pits (collectively AOPC 3) were used for liquid and solid waste disposal. The seepage pits were used from approximately 1945 to 1960 to dispose of a variety of liquid wastes associated with laboratory operations, including sanitary wastes, solvents, paints, wastewater from parts cleaning, and other chemicals. The waste pits were used within the same period to dispose of materials such as wood, glass, metal parts and shavings, drums of chemical wastes, and other hazardous and municipal wastes and were designed as open, bermed areas that were later backfilled. The seepage pits were constructed as open boreholes, often lined with brick, that were designed to have liquids seep directly into the soils. Plumbing from sinks and drains in the buildings at JPL were piped directly to the seepage pits. Many seepage pits also had cleanouts outside the building where liquids could be dumped directly into the pits. Historical operations in buildings connected to various seepage pits include propellant preparation and testing, and laboratories for hydraulics and solid fuels. The exact materials that were disposed into seepage pits were not well documented but based on historical operations at JPL and the period of seepage and waste pit use, it is possible that PFAS-containing materials were also disposed in AOPCs 2 and 3 (Tetra Tech, 2021). Use of seepage pits was discontinued in the 1950s and other materials disposed into seepage pits have been addressed as part of the JPL CERCLA program (NASA, 2007; NASA, 2018).

2.2.3 AOPC 4: Building 170 Fabrication Shop

Building 170 was constructed in the early 1960s and expanded in the late 1960s or early 1970s. A small metal plating shop was formerly located within the southeast portion of the building that was used for electroplating and chrome plating as recently as the early 1990s. Liquids used in the plating process were reportedly discharged to a floor drain in the plating room and passed through a below ground clarifier on the southern side of Building 170 prior to discharge to the sanitary sewer. The room housing the plating shop was renovated in 2016 and the floor was raised, covering the floor drain with wooden floorboards. The room is currently used to wash and clean parts made in the fabrication shop (Tetra Tech, 2021).

According to the USEPA, PFAS were used as a surfactant, wetting agent, and mist suppressing agent for chrome plating, and PFAS were used to improve the quality of electroless plating of copper and stabilize coating baths for depositing nickel-boron layers. Further, the USEPA identified PFAS use to treat metal surfaces to prevent corrosion, reduce mechanical wear, and enhance aesthetic appearance. Lastly, machine parts were at times cleaned after nickel plating with a solution containing PFOS. Therefore, Building 170 was identified as an AOPC based on potential use of PFAS in the fabrication shop.

2.2.4 AOPC 5: Former Building 218 and Building 291 Photography Labs

Former Building 218 and current Building 291 formerly housed photography labs. Former Building 218 was constructed in the late 1960s or early 1970s and demolished sometime between 2015 and 2018. Building 291 was constructed in the late 1960s or early 1970s. Building 291 was also titled Procurement Services (1970s and 1980s) and Compensation (1990s and possibly early 2000s). No information regarding the operational period of or details about the activities in the photography labs was found during the PA (Tetra Tech, 2021). These buildings were identified as an AOPC due to their potential to house photolithology processes and the use of PFAS in photographic solutions.

2.3 Past Site Investigations

Numerous environmental investigations pertaining to OU1, OU2 and OU3 have been carried out under the CERCLA program and are available on the NASA JPL electronic repository of related documents available at http://jplwater.nasa.gov.

A groundwater monitoring program has been in place at JPL since August 1996 and has been expanded as the number of monitoring wells was also expanded. Currently the monitoring program is made up of 25 monitoring wells and 82 different sampling points. JPL monitoring wells are sampled on a quarterly basis to maintain a comprehensive understanding of the subsurface conditions within OU1 and OU3 groundwater (Tetra Tech, 2021). PFAS analyses had not been conducted on any of the JPL groundwater monitoring wells prior to NASA’s PFAS SI. PFAS analyses have not been conducted on samples collected from the OU1 system.

LAWC sampled LAWC Well No. 6 in 2018 for six PFAS: PFOA, PFOS, PFBS, PFHxS, perfluoroheptanoic acid (PFHpA), and PFNA. No PFAS were detected above laboratory reporting limits, which were 20.00 ng/L for PFOA, 40.00 ng/L for PFOS, 90.00 ng/L for PFBS, 30.00 ng/L for PFHxS, 10.00 ng/L for PFHpA, and 20.00 ng/L for PFNA. It should be noted that the laboratory detection limits were significantly higher than the current USEPA RSLs for PFOA, PFOS, and PFNA. Better methods now exist to achieve lower detection limits.

Pasadena Water and Power (PWP) sampled untreated groundwater from Arroyo Well and Well 52 in April and May 2020 for the same six PFAS. PFBS was detected in Arroyo Well at 3.20 ng/L (April) and 3.10 ng/L (May). In April, PFBS and PFHxS were detected in Well 52 at 3.10 ng/L and 2.00 ng/L, respectively. No other PFAS were detected in Arroyo Well and Well 52 above the laboratory reporting limits, which were 2.00 ng/L for all six PFAS. The April and May 2020 detections of PFBS and PFHxS are below the November 2022 tap water USEPA RSLs, USEPA proposed NPDWR levels, and the SWRCB NLs.

A PA for PFAS was carried out for JPL and was completed in 2021. The PA involved extensive records review, interview of key JPL personnel, a Site visit, development of an initial CSM and recommendations of AOPCs for further assessment.

3 ENVIRONMENTAL SETTING

The following sections provide information regarding the environmental setting for JPL including the climate, topography and surface features, geology, hydrogeology, surface water features, and land use. The information in this section is drawn from Section 3 of the JPL PFAS PA Report and provides a baseline of information to support the development of the PFAS SI Work Plan, the execution of the PFAS SI field activities, and the context to interpret future results and findings.

3.1 Climate

JPL is located in an area with a Mediterranean climate at an elevation of 1,100 ft above sea level. The average temperature over the course of a year in Pasadena is 64 degrees Fahrenheit (°F). The average summer high is 88°F with a winter low of 46°F. Summers are hot, arid, and clear, whereas winters are cool, wet, and partly cloudy. JPL receives approximately 21 inches of rain a year, with most of the precipitation received between November and April. Most of the rainfall occurs in February, with an average of 3.2 inches of rain over the course of the month. (Tetra Tech, 2021)

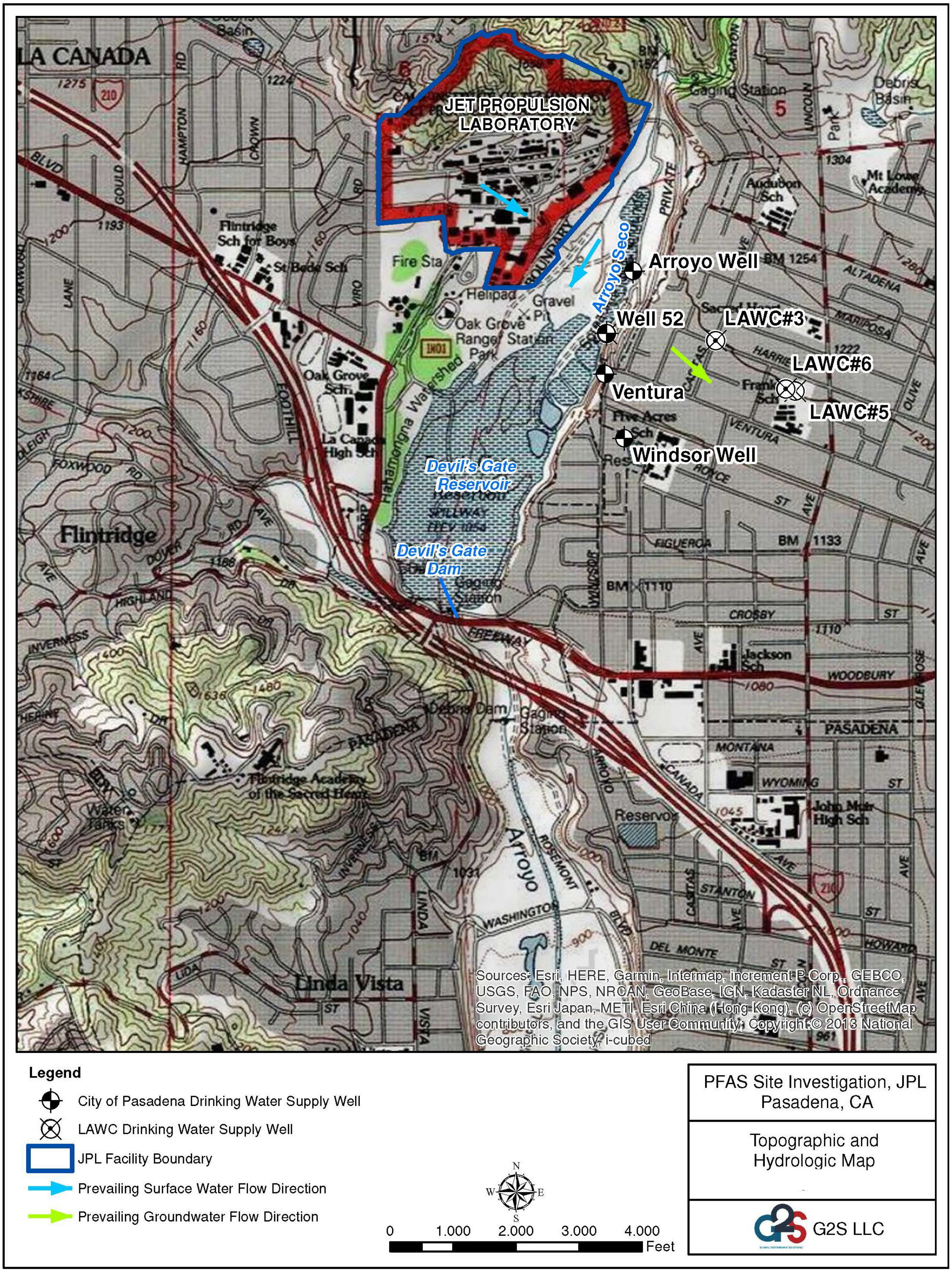
3.2 Topography and Surface Features

JPL is located in Los Angeles County, California, encompassing approximately 176 acres in the San Gabriel Mountains east of the City of Los Angeles (Figure 3-1). JPL consists of office buildings, laboratories, and other facilities related to propulsion research and development. The JPL property is divided into two main areas: a relatively undeveloped northern area and the main campus, which encompasses the remainder of the property. Elevations of JPL range from approximately 1,080 to 1,280 ft above mean sea level (amsl) within the main campus to 1,560 ft amsl near the northern boundary. Steep hills and slopes generally separate the northern portion from the main JPL campus. Hills continue from the base of the high elevation northern portion of JPL down into and throughout the main campus, ultimately leveling off to the south/southeast. A mesa is present in the northern area of JPL, and a helipad for emergency use and radio and antenna testing facilities are located on the mesa. (Tetra Tech, 2021)

3.3 Geology

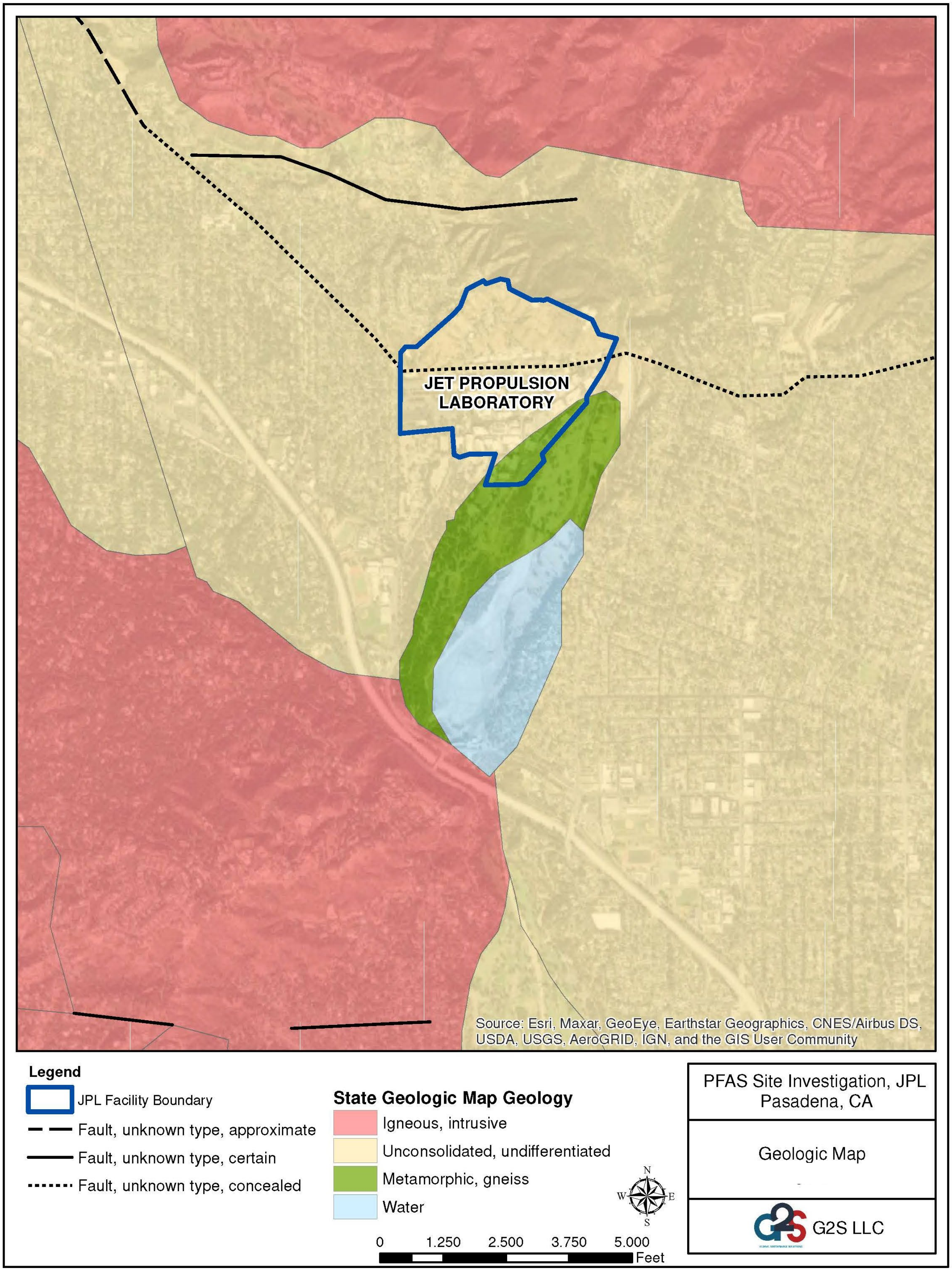
JPL is located in the far northwestern region of the San Gabriel Valley along the southern flank of the San Gabriel Mountains (Figure 3-2). The San Gabriel Mountains are part of the Transverse Ranges geomorphic province, which is comprised of east-west trending mountain ranges resulting from north-south compression and deformation (Foster Wheeler Environmental Corporation [FWEC], 1999a; FWEC, 1999b). The San Gabriel Valley, like other valleys in the region, is filled with Quaternary alluvial deposits of Pleistocene to Holocene age (approximately 2.5 million years old [Ma] to present). In the vicinity of JPL, these deposits extend from the ground surface to a depth of approximately 600 to 2,000 feet, depending on proximity to the San Gabriel Mountains and relationship to underlying faults (FWEC, 1999a). These alluvial deposits are typically poorly sorted sands and gravels with some discontinuous lenses of finer (fine sand and silt) and coarser (cobbles and boulders) material. The alluvial deposits overlie the regional basement rock, a leucrocratic granodiorite of Cretaceous age (approximately 65 to 122 Ma), which is light gray to buff colored and has a fine- to medium-grained crystalline texture (Dibblee, 1989; FWEC, 1999a). This basement rock also constitutes the San Gabriel Mountains and outcrops in some areas near JPL on steeper slopes on the north end of the Site and along the Arroyo Seco (Dibblee, 1989)

Lithology at JPL is characterized as medium to coarse-grained sand and gravel interbedded with fine sands and silts consistent with the regional alluvial deposits (FWEC, 1999a). Relatively thin intervals of cobbles and boulders are present throughout the alluvial sequence and represent higher energy depositional environments (e.g., stream channels). Detailed characterization of the JPL lithology was



Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community; Copyright:© 2013 National Geographic Society, i-cubed

Figure 3-1. Topographic and Hydrologic Map



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 3-2. Geologic Map

conducted during the installation of the on- and off-site monitoring well network at JPL (FWEC, 1999a), and the discontinuous layers of finer grained (silty) material at depth are used to define the aquifer layer boundaries, which are described in section 3.4 below.

Multiple mapped faults are located at JPL and in the nearby area (Dibblee, 1989; FWEC, 1999a; FWEC, 1999b; Morton and Yerkes, 1987). The Tujunga Fault (also referred to as the JPL Thrust Fault) cuts east-west across the main JPL property and other unnamed fault traces run outside the JPL boundary to the north in a similar orientation. These faults are broadly referred to as the Sierra Madre Fault Zone. The JPL Thrust Fault represents a north-south boundary between shallow bedrock and deeper alluvium (NASA, 2018). North of the fault, bedrock occurs within 2 to 100 feet of ground surface, with groundwater primarily present in joints and fractures within the shallow bedrock. Due to its low porosity, this shallow bedrock is considered non-water bearing and separate from the JPL groundwater system (NASA, 2018). Therefore, the bedrock north of the JPL Thrust Fault is not therefore a possible migration pathway for contaminants into the JPL groundwater system (NASA 2018). South of the JPL Thrust Fault, groundwater occurs in the deeper aquifer layers described in Section 3.4 (NASA, 2018). Further to the north in the San Gabriel Mountains, the south branch of the San Gabriel Fault trends northwest-southeast (Tetra Tech, 2021).

3.4 Hydrogeology

JPL is located within a groundwater basin known as the Raymond Basin, which is adjacent to the San Fernando Valley and San Gabriel Valley Basins (State of California Department of Water Resources [DWR], 2004a; DWR, 2004b; DWR, 2004c). Groundwater drawn from the Raymond and San Fernando Valley groundwater basins is used for drinking water in communities surrounding JPL. Drinking water supply wells (also referred to as production wells) in both the Raymond and San Fernando Valley Basins are located within a 4-mile radius of JPL (Appendix B; NASA, 2019a). Based on prior hydrogeologic investigations of the Raymond Basin, there are four distinct aquifer layers in the area surrounding JPL (FWEC, 1999a; FWEC, 1999b; NASA, 2019b): the upper Older Fanglomerate Series; the lower Older Fanglomerate Series; the Pacoima Formation; and the Saugus Formation.

In most areas, only the first three aquifer layers are present; however, in areas where the crystalline basement is deeper, the fourth and deepest alluvial aquifer layer (the Saugus Formation) is present. These aquifers, while similar in their alluvial composition, are defined by observed differences in hydraulic head during pumping of production wells in the vicinity of JPL. The differing responses to pumping at different screen depths, along with subtle differences in geologic composition, have been used to define the aquifer boundaries (FWEC, 1999a; FWEC, 1999b).

The shallowest two aquifers are the upper and lower Older Fanglomerate Series, which are sometimes simply referred to collectively as the Older Fanglomerate Series. These aquifers are present in the Cenozoic basin-filling alluvial deposits described above and underlie the current surface alluvium (FWEC, 1999a). These deposits range in thickness from 300 to 800 feet in the vicinity of JPL. The composition of the alluvial deposits that comprise the Older Fanglomerate Series is similar to that of recent alluvial and stream channel deposits in the area. The Older Fanglomerate Series is subdivided into upper and lower parts based on inferred age and spatial relationship to present-day stream channels. The composition of the upper and lower parts of the series is generally the same, with lithology dominated by fluvial arkosic sands (i.e., sands composed of less than 25 percent [%] feldspar grains) with abundant gravel and boulders. The upper and lower sections of the Older Fanglomerate Series are inferred to be separated, at least locally, by fine-grained (silt-rich) layers of relatively low permeability. As mentioned above, the boundary between the upper and lower Older Fanglomerate has been distinguished based on the hydraulic response to pumping of nearby production wells screened at different depths (FWEC, 1999a; FWEC, 1999b).

The third aquifer layer is the Pacoima Formation, which lies, in most areas around JPL, unconformably upon the granodiorite basement. In some areas where the regional basement is deeper, the Pacoima Formation lies unconformably atop a fourth alluvial aquifer layer, described below. This formation is characterized by fluvial sands with gravel and boulders and is differentiated from the overlying Older Fanglomerate Series by characteristic dark reddish-orange weathering. This formation is 200 to 300 feet thick in the vicinity of JPL.

The fourth aquifer layer, the Saugus Formation, is present in some areas of the Raymond Basin between the Pacoima Formation and crystalline basement rock. The Saugus Formation is up to 200 feet thick and is composed of arkosic sand with some pebbles and areas that are more conglomeratic. The differentiation of the Saugus and overlying formations is not clearly defined. The formations are generally defined based on the degree of sorting and the composition of lithic clasts in the sediments. Broadly, the Saugus Formation represents a lower-energy depositional environment (e.g., floodplain) relative to the overlying fanglomerate deposits.

Observation and monitoring wells are screened in all four aquifer layers, and groundwater present in the first (shallowest) aquifer layer is considered to be under unconfined conditions. Drinking water supply wells within 4 miles of JPL are also screened within all four aquifer layers. Recharge in the vicinity of JPL occurs naturally through precipitation and through flooding of the Arroyo Seco spreading grounds with water during the rainy season (FWEC, 1999a). In the vicinity of JPL, depth to groundwater in the shallowest aquifer is approximately 200 feet (NASA, 2018), although it ranges between approximately 20 feet and 270 feet due to the steep topography present at JPL and the effects of seasonal groundwater recharge in the Arroyo Seco spreading grounds to the southeast of JPL (Figure 3-1) and groundwater pumping from the nearby municipal production wells (FWEC, 1999a). Depth to groundwater in monitoring wells located at the northern extent of the Arroyo Seco are typically 80 to 120 feet shallower than the surrounding water table (NASA, 2018). At this location, groundwater mounding attributed to recharge and faulting results in depths to water between approximately 80 and 120 feet (NASA, 2018).

Deeper groundwater in the second to fourth aquifer layers may be under semi-confined conditions due to local lenses of fine-grained material separating some layers. These lenses are discontinuous and occur at a range of depths throughout the stratigraphic sequence. The influence of these fine-grained layers on local hydrogeologic conditions is observed in hydraulic head differences in deeper, multiport monitoring wells (FWEC, 1999a). During periods when production wells are extracting groundwater in the area, hydrographs from multiport monitoring wells indicate that downward migration of groundwater would be expected. However, in winter months when groundwater extraction is typically paused, the hydraulic head in deeper aquifer layers can temporarily be equal to or above that of shallower aquifer layers in some monitoring wells (FWEC, 1999a). The hydraulic response recorded at the monitoring wells during these pumping events suggests a semi-confined nature for these deeper aquifers; however, vertical hydraulic communication between the aquifers appears to occur given the presence of perchlorate and various VOCs in deeper aquifer layers and the spatially discontinuous nature of the confining layers (FWEC, 1999a; NASA, 2019a). Hydraulic conductivity values were estimated during large-scale pump testing completed in 2001. Horizontal conductivity values were estimated to be 14.4 feet per day (ft/day), 28.2 ft/day, 27.9 ft/day, and 3.9 ft/day in the upper Older Fanglomerate Series, lower Older Fanglomerate Series, Pacoima Formation, and Saugus Formation, respectively. Vertical conductivity between the upper and lower Older Fanglomerate Series was estimated at 0.0092 ft/day, between the lower Older Fanglomerate Series and Pacoima Formation at 0.0060 ft/day, and between the Pacoima and Saugus formations at 0.011 ft/day.

The direction of groundwater flow in the vicinity of JPL is dynamic due to the influences of natural seasonal groundwater recharge, groundwater recharge in the Arroyo Seco spreading grounds, and groundwater pumping from municipal production wells in the immediate JPL vicinity, with groundwater pumping having the most pronounced influence (FWEC, 1999a). Throughout most of the year, groundwater flow in the aquifers is predominantly to the southeast (NASA, 2019a) towards the pumping City of Pasadena municipal supply wells. The groundwater production wells are typically shut down for a relatively short period of time during the wet, winter season, during which time the groundwater flow direction has been observed to reverse flow towards the west across JPL. Although the duration of these flow reversal can span multiple weeks, they generally last for only a period of days (FWEC, 1999a). Further, based on measurements of contaminants in JPL monitoring wells there does not appear to be significant contaminant migration to the west (FWEC, 1999a; NASA, 2003).

Beneficial uses for groundwater in the aquifers of the Raymond and San Fernando Valley Basins have been designated by the Los Angeles Regional Water Quality Control Board (LARWQCB) in their Basin Plan (LARWQCB, 2014). In both the Raymond and San Fernando Valley Basins, beneficial uses exist, and are protected under the Basin Plan, for municipal, industrial service supply, industrial process supply, and agricultural purposes. (Tetra Tech, 2021)

3.5 Surface Water Features

JPL is located in an urban setting, and rainfall in the area is generally captured by engineered storm drain systems. Runoff from the San Gabriel Mountains above JPL is transferred via a network of underground storm drains to the Arroyo Seco. Runoff collected on JPL is directed via a network of underground storm drains that lead to 13 discharge points along the east/southeastern JPL property boundary that outfall to the Arroyo Seco. Some storm drains on JPL are directed to the sanitary sewer, but most are directed to the Arroyo Seco. The largest stormwater discharge outfall from JPL is located at the southeastern corner of Building 349.

The Devils Gate Dam is located south of JPL along the Arroyo Seco and north of Interstate 210. The area upstream from the dam along the Arroyo Seco is referred to as Devils Gate Reservoir. Water levels in the reservoir fluctuate throughout the year as rainfall is received and allowed to flow through the dam. Significant portions of the reservoir bed are not inundated with water throughout the year. During wet periods, surface water is periodically diverted to the Arroyo Seco spreading grounds along the eastern banks of the reservoir. These areas serve to provide groundwater recharge to the Raymond Basin. The Arroyo Seco is channelized downstream from the Devils Gate Dam and drains into the Los Angeles River. The main pathways for surface water in the area are downstream or down-system flow in natural or engineered waterways, percolation into alluvial aquifers, and evaporation.

Beneficial uses for Arroyo Seco surface water have been identified in the LARWQCB Basin Plan (LARWQCB, 2014). The designations include existing, intermittent, and potential beneficial uses for different parts of the Arroyo Seco water course; these three categories are to be protected under the Basin Plan. In the immediate vicinity of JPL, beneficial uses are designated for the upper and lower portions of Devils Gate Reservoir along the Arroyo Seco; these include potential (municipal), intermittent (groundwater recharge and municipal), and existing (wildlife habitat) uses. Recreational activities such as swimming and boating are not among the beneficial uses identified for the Arroyo Seco waterway in the vicinity of JPL. (Tetra Tech, 2021)

3.6 Land Use

JPL is a NASA facility for research and development of space exploration, including rocket propellant design and testing, spacecraft material and equipment design, assembly and testing, and research related to alternative energy sources and pollution control (Ebasco Services, Inc. [Ebasco], 1988). In recent decades, JPL has functioned as NASA's primary center for unmanned interplanetary exploration and assists with aeronautical research and development (Ebasco, 1988). The area of JPL is zoned as Public/Semi-Public (City of La Cañada Flintridge, 2016). There is no residential use of the property.

The land use within a 1-mile radius of JPL is residential, recreational, and commercial. The Los Angeles County Fire Camp #2 (a Los Angeles County-operated station established to respond to fires, floods, and other natural or manmade disasters) and the Hahamongna Watershed Park are located adjacent to and south of JPL. Potentially sensitive receptors located within a 1-mile radius of JPL include 42 daycare centers, 4 schools (public and private), 6 schools/day care centers, a community center, and the Angeles National Forest (Tetra Tech, 2021).

4 FIELD ACTIVITIES AND ANALYTICAL PROTOCOL

4.1 Sample Locations and Methodologies

The SI evaluated potential contaminant sources for PFAS at JPL at five AOPCs identified as AOPC 1 through AOPC 5. AOPC 1 consists of an Emergency Landing Facility with a heliport where an AFFF release potentially occurred during a one-time training exercise. AOPC 2 and AOPC 3 consist of 40 seepage pits and four waste pits, respectively, and are considered as a single potential source. The seepage pits, constructed as open boreholes, were historically used to dispose of liquid wastes associated with laboratory operations. The waste pits were constructed as open, bermed areas and used to dispose of various types of solid waste as well as hazardous and municipal wastes. AOPC 4 consists of the Fabrication Shop, identified as Building 170, where chrome plating operations were formerly performed. AOPC 5 includes Former Building 218 and current Building 291 that formerly housed photography labs with potential for photolithology processes that used of PFAS in photographic solutions. See Sections 2.2.3 and 2.2.4 for further detail on each of the AOPC's and previous PFAS investigations.

Samples were collected from soil and groundwater to evaluate AOPC 1. Only groundwater samples were collected for AOPC 2 through AOPC 5 based on the historical release via seepage pits. Figure 4-1 shows the locations of soil samples in AOPC 1. Figure 4-2 shows the locations of groundwater samples for AOPC 1 through 5. Table 1-1 summarizes the sampling locations and methodologies by AOPC.

4.1.1 Groundwater Samples

The PFAS SI included field inspection activities involving the collection of groundwater samples from existing monitoring wells.

- Sampling groundwater associated with AOPC 1 involved two wells (MW-4 and MW-16) at various depth intervals, analyzing samples for 32 PFAS compounds using liquid chromatography-tandem mass spectrometry (LC-MS/MS) compliant with Department of Defense (DoD) Quality Systems Manual (QSM) 5.3 Table B-15. Locations coincide with the stormwater conveyance from the potential release (MW-4) and downgradient of the downstream stormwater outfall (MW-16) as detailed in Table 4-1and Figure 4-2.
- Sampling groundwater associated with AOPCs 2 and 3 involved six existing monitoring wells (MW-4, MW-16, MW-12, MW-15, MW-17, and MW-24) at various depth intervals, analyzing samples for 32 PFAS compounds using LC-MS/MS. Locations as shown in Figure 4-2 include areas downgradient of waste and seepage pits, downgradient of the Site, as well as a historical source area associated with the JPL Superfund Site as described in Table 4-1.
- Sampling groundwater associated with AOPC 4 involved one well (MW-4) at various depth intervals, analyzing samples for 32 PFAS compounds using LC-MS/MS. The selected location as shown in Figure 4-2 is downgradient of the building associated with former chrome plating operations.
- Sampling groundwater associated with AOPC 5 involved one well (MW-5), analyzing samples for 32 PFAS compounds using LC-MS/MS. The selected location as shown in Figure 4-2 is downgradient of Former Building 218 and Building 291.

It should be noted that the sample collected from MW-16 and the samples collected from the four discrete depths of MW-4 were used in the evaluation of multiple AOPCs as indicated in Table 4-1. Sampling design and rationale was detailed in Worksheet #17 of Appendix A (i.e., Uniform Federal Policy-Quality Assurance Project Plan [UFP-QAPP]) in NASA's SI Work Plan (NASA, 2022a).

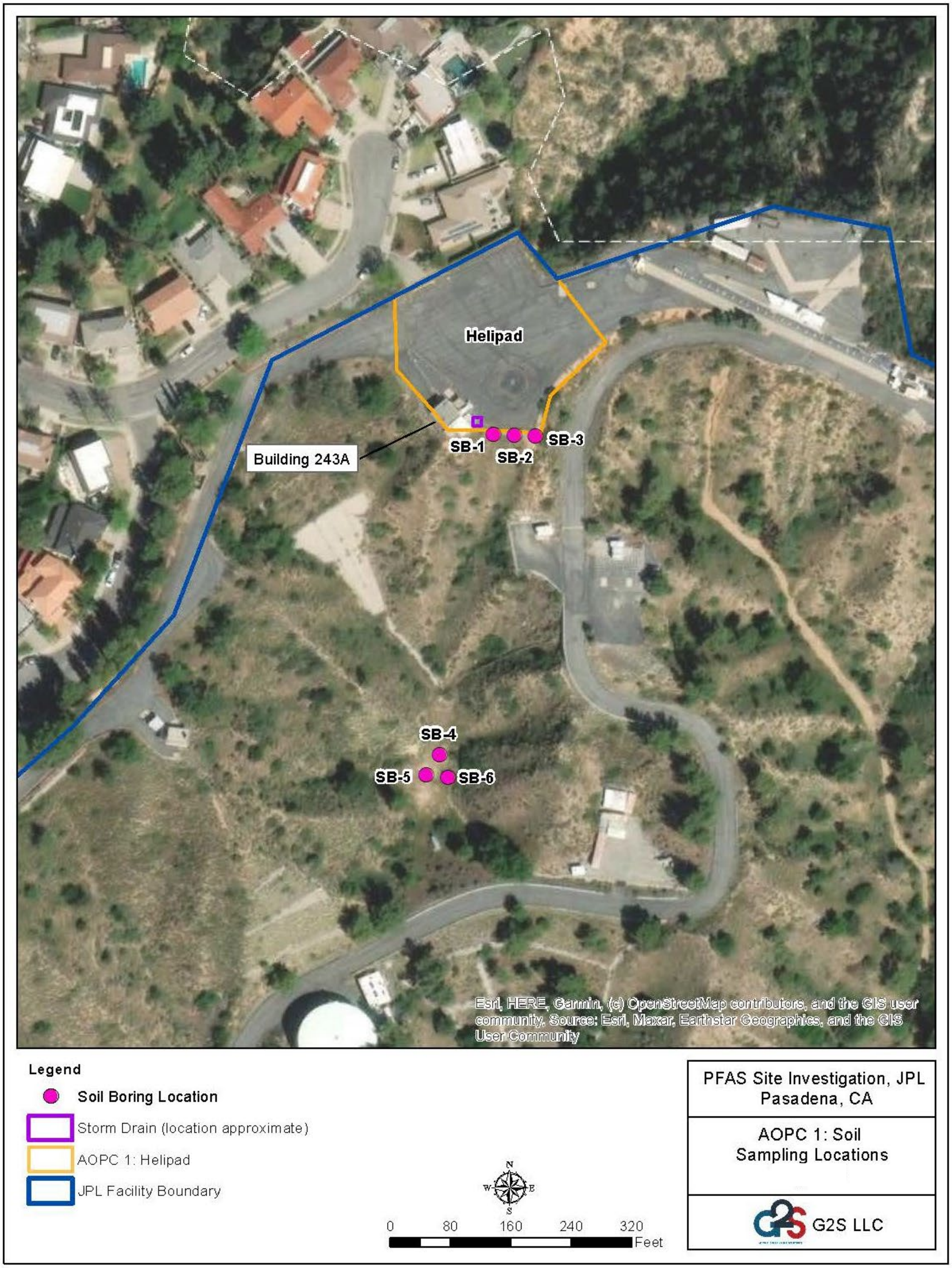


Figure 4-1. AOPC 1: Soil Sampling Locations.

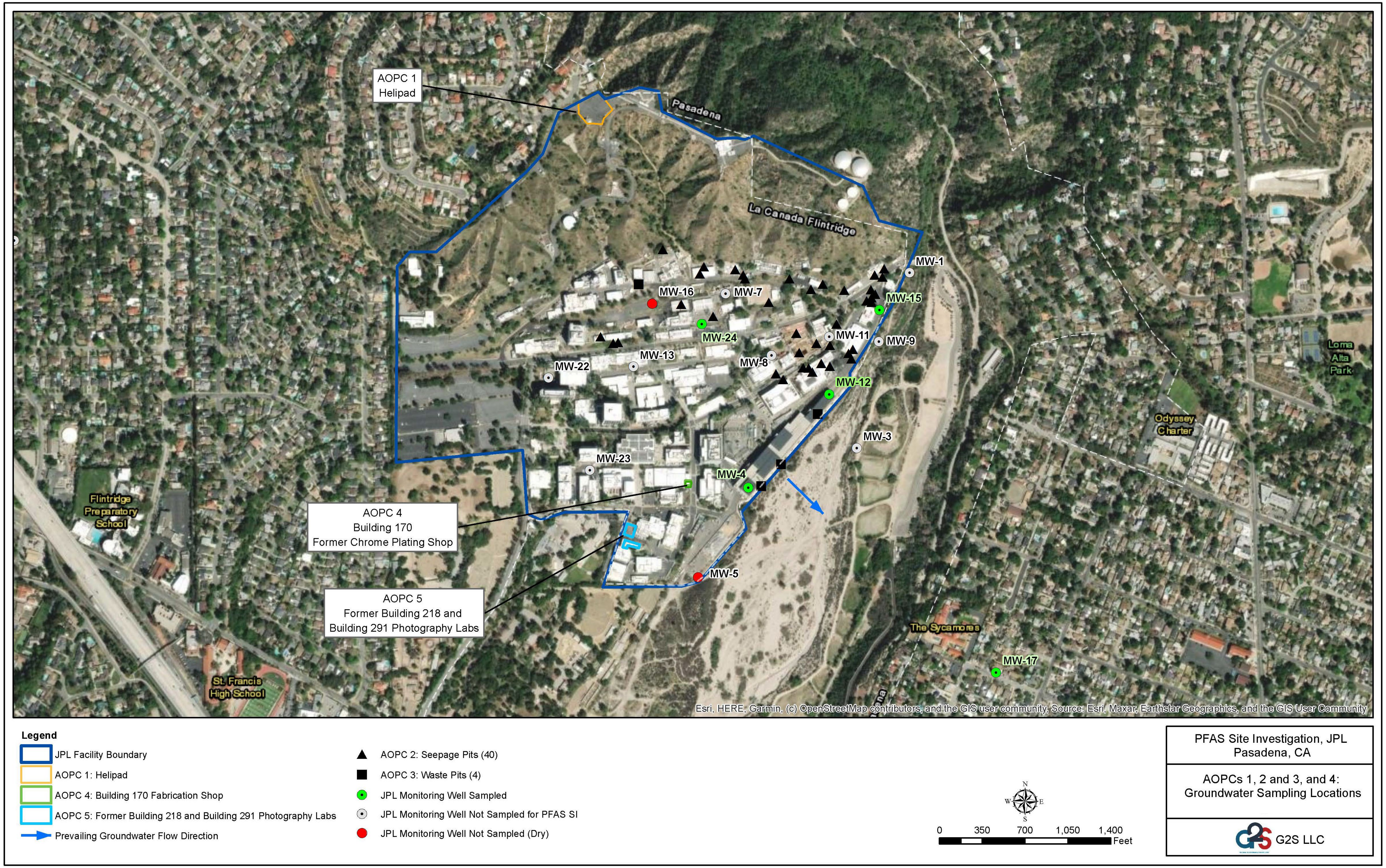


Figure 4-2. AOPCs 1, 2 and 3, 4, and 5: Groundwater Sampling Locations

Table 4-1. SI Sampling Locations and Methodology Summary for the Jet Propulsion Laboratory

Area of Potential Concern	Location	Number of Samples	Rationale
AOPC 1: Emergency Landing Facility Soil	3 locations adjacent to and 3 locations downgradient of heliport	12 samples (0-0.5 and 0.5-2.0 ft bgs at each of 6 locations)	Determine presence or absence of PFAS in surface soils adjacent to the helipad where an AFFF release occurred during a one-time AFFF training exercise (may have washed off the helipad at the end of training).
AOPC 1: Emergency Landing Facility Groundwater	MW-4	4 depths/screens	Determine presence or absence of PFAS in Site groundwater adjacent to stormwater conveyance from the AFFF release area to the largest stormwater outfall.
	MW-16	1 depth	Determine presence or absence of PFAS in groundwater downgradient of the AFFF release near the downstream stormwater outfall.
AOPCs 2 and 3: Waste Disposal Areas Groundwater	MW-4	4 depths/screens	Determine presence or absence of PFAS in groundwater downgradient of the area associated with multiple waste pits.
	MW-16	1 depth	Determine presence or absence of PFAS in groundwater downgradient of Waste Pit 3.
	MW-12	5 depths/screens	Determine presence or absence of PFAS in groundwater downgradient of the area associated with multiple seepage and waste pits.
	MW-15	1 depth	Determine presence or absence of PFAS in groundwater within the perched aquifer adjacent to the area of former seepage pits.
	MW-17	5 depths/screens	Determine presence or absence of PFAS in groundwater downgradient of JPL in the vicinity of City of Pasadena wells Arroyo Well and Well 52.
	MW-24	5 depths/screens	Determine presence or absence of PFAS in groundwater within an area of former seepage pits identified as the historical source area for groundwater contaminants associated with the JPL Superfund Site.
AOPC 4: Building 170 Fabrication Shop Groundwater	MW-4	4 depths/screens	Determine presence or absence of PFAS in groundwater downgradient of former chrome plating operations at Building 170.
AOPC 5: Former Building 218 and Building 291 Photography Labs Groundwater	MW-5	1 depth	Determine presence or absence of PFAS in groundwater downgradient of photography labs for Former Building 218 and Building 291.

Groundwater samples were collected November 28 – 30, 2022 from existing NASA groundwater monitoring wells located both on-site and downgradient of the JPL site as part of the SI. NASA's monitoring well network consists of a total of twenty-five (25) wells, fifteen (15) of which contain multiple screened intervals (e.g., Westbay® multiport wells) and the remaining ten (10) are shallow standpipe wells with single screened intervals and dedicated submersible pumps. The sampling was conducted in accordance with the SI Work Plan (NASA, 2022a). The work plan included the collection of groundwater samples from three shallow standpipe wells (e.g., MW-5, MW-15, and MW-16), however, MW-5 and MW-16 were dry due to the drought and could not be sampled. The SI work plan included the collection of groundwater samples from four Westbay® multiport wells: MW-4, MW-12, MW-17, and MW-24. Each of the groundwater samples was analyzed for 32 PFAS compounds using LC-MS/MS.

As the well cover for each monitoring well was removed, the air in the breathing zone was monitored with a photoionization detector (PID) or equivalent to ensure that escaping VOCs do not pose an adverse health effect to the field sampling team. The instrument was calibrated in accordance with the manufacturer's requirements. Calibration data was recorded in the instrument use log.

Since two different well types were sampled for PFAS compounds, sampling procedures are described separately below. Section 4.1.2 covers sampling of shallow standpipe wells and section 4.1.3 covers sampling of the Westbay® wells.

4.1.2 Shallow Well Sampling

As a precautionary measure, dedicated submersible pumps were removed from monitoring wells MW-5, MW-15, and MW-16 one month prior to sampling due to the potential presence of Teflon™ components.

Three shallow groundwater monitoring wells were to be sampled as part of NASA's SI. However, two of the wells (i.e., MW-5 and MW-16) contained insufficient water to collect a sample due to the drought conditions in Southern California. Therefore, samples were collected from only one shallow monitoring well (i.e., MW-15) during the SI and the procedure is described below.

A groundwater-level measurement was taken from the well before purging in accordance with G2S Standard Operating Procedure (SOP) No. 1 Water Level Measurement (PFAS Specific). This measurement was documented on the field log sheet. Brand-new high-density polyethylene (HDPE) tubing was connected to the PFAS-free non-dedicated bladder pump, and the well was purged using the low flow/minimal drawdown method. The recovered groundwater was monitored for temperature, pH, specific conductivity, turbidity, dissolved oxygen (DO), and oxidation-reduction potential (ORP). Groundwater sampling equipment was calibrated before use, and the resulting data was recorded on a test equipment calibration log included in Appendix D.

Depth to water measurements and field parameters were closely monitored and documented on the field log sheet. Purging continued until parameters met stabilization criteria in accordance with the SOP. Upon stabilization, sampling was initiated. Groundwater samples were collected directly into two laboratory-provided 250 mL HDPE containers from the discharge tubing. The containers were sealed, labeled, packed on ice in insulated coolers, and shipped via FedEx to Agriculture & Priority Pollutants Laboratories (APPL) under chain of custody (CoC) protocol. Groundwater sampling activities were thoroughly documented on Groundwater Sampling Logs, which can be found in Appendix D.

4.1.3 Westbay® Multiport Well Sampling

For the purposes of NASA's PFAS SI, four multiport wells with a total of 19 ports (see Table 4-2) were scheduled to be sampled (i.e., MW-4 [Screens 1, 2, 4, and 5], MW-12 [Screens 1 through 5], MW-17 [Screens 1 through 5], and MW-24 [Screens 1 through 5]) by Westbay® trained and certified technicians. However, the uppermost sampling port (i.e., Screen 1) in multiport wells MW-4, MW-12, MW-17, and MW-24 were dry due to the drought and could not be sampled.

The procedure for collecting a groundwater sample from a multiport well is as follows:

The sampling apparatus consists of an electrically activated valve opening assembly (i.e., sampling probe) which is connected to four 250-mL stainless steel tube-shaped containers (i.e., sample containers) that are linked with flexible hose. The probe and container were prepared (e.g., cleaned and evacuated) and then lowered to the sampling port using an electric winch. Upon reaching the port, the operator used a control unit to activate the valve opening assembly to connect the sampling probe to the sampling port. Next, the sampling valve in the probe was opened, allowing groundwater to flow through the probe and enter the sample container. Once the container was full, the sampling valve was closed, the arms were retracted, and the sampling probe and sample containers were raised to the surface. The sample was transferred to two laboratory-provided 250 mL HDPE sample containers, then sealed, labeled, packed on ice in insulated coolers, and shipped via FedEx to APPL under CoC protocol. The sampling probe and containers were cleaned, and the procedure was repeated. Groundwater sampling activities were documented on field logs, which are presented in Appendix D.

Table 4-2. Multiport Well Identification, Screened Interval, and Sampling Port Depth

Well ID	Screened Interval (ft bgs)	Sampling Port (ft bgs)
MW-4 (Screen 1)	147 – 157	150.00
MW-4 (Screen 2)	237 – 247	240.00
MW-4 (Screen 4)	389 – 399	392.00
MW-4 (Screen 5)	509 – 519	513.00
MW-12 (Screen 1)	135 – 145	140.00
MW-12 (Screen 2)	240 – 250	243.00
MW-12 (Screen 3)	315 – 325	323.00
MW-12 (Screen 4)	430 – 440	436.00
MW-12 (Screen 5)	546 – 556	548.00
MW-17 (Screen 1)	246 – 256	250.00
MW-17 (Screen 2)	336 – 376	370.00
MW-17 (Screen 3)	466 – 476	468.00
MW-17 (Screen 4)	578 – 588	582.00
MW-17 (Screen 5)	723 – 733	726.00
MW-24 (Screen 1)	275 – 285	279.00
MW-24 (Screen 2)	370 – 380	373.00
MW-24 (Screen 3)	430 – 440	435.00
MW-24 (Screen 4)	550 – 560	554.00
MW-24 (Screen 5)	675 – 685	678.00

4.1.4 Soil Samples

The PFAS SI included field inspection activities involving the collection of soil samples. The approach to soil sampling was to sample surface soils from six locations at two depths (0-0.5 and 0.5-2.0 ft bgs) adjacent to the helipad and in the catch basin below the helipad in AOPC 1 as shown in Figure 4-1. Samples were analyzed for 32 PFAS compounds using LC-MS/MS.

Soil sampling was conducted in accordance with the SI Work Plan and described as follows. Sampling included the collection of six soil samples from the southern edge of the helipad at AOPC 1 and six samples from the catch basin below the helipad where runoff water from AOPC 1 may have accumulated. The sample locations corresponded closely with the proposed locations in the work plan. Sample collection was conducted using a hand auger with a 3-inch diameter stainless steel auger. Soil was hand augered to a depth of 0.5 ft bgs and a soil sample was collected directly from the auger and placed into one 50 mL HDPE sample container provided by the laboratory. The sample container was sealed, labeled, and packed on ice in insulated coolers. Next soil was placed into a gallon sized Ziplock bag for logging and PID readings. Soil samples were logged using the Unified Soil Classification System (USCS) and PID readings were recorded on the boring log. Next, the hand auger was decontaminated and cleaned. This was followed by hand augering to a depth of 2.0 feet bgs and a soil sample was collected using the same procedure. After decontaminating and cleaning the hand auger, the process of hand augering, sampling, decontaminating, and logging soils was repeated until sampling was completed. The Global Positioning System (GPS) coordinates for each soil sampling location was recorded using Gaia GPS because the rental Trimble handheld GPS unit malfunctioned during field sampling.

4.1.5 Total Sample Counts

The following total sample counts for each media (including field duplicate and matrix spike/matrix spike duplicates [MS/MSDs]) during SI activities at JPL are listed below:

- Fifteen soil samples (including two field duplicates and one MS/MSD) were collected from six boring locations during the SI.
- One field blank and one equipment rinsate were collected during soil sampling activities.
- Twenty groundwater samples (including three field duplicates and one MS/MSD) were collected from five groundwater monitoring wells.
- Three field blanks and three source blanks were collected during groundwater sampling activities.

Each of the samples were analyzed for the PFAS compounds using LC-MS/MS and according to the quality control procedures included in Section 5.4.

4.1.6 Dry Sampling Ports and Wells

During SI activities the uppermost sampling port (i.e., Screen 1) in multiport wells MW-4, MW-12, MW-17, and MW-24 were dry and could not be sampled. In addition, shallow standpipe wells MW-5 and MW-16 contained insufficient water (i.e., dry) to collect a sample.

4.2 Analytical Methods

The regulatory status and analytical methods associated with PFAS compounds continue to evolve rapidly. For the purpose of this PFAS SI, analysis of 32 PFAS compounds was included as presented in Table 4-3. This list encompasses PFAS compounds from the California SWRCB's Order for the Determination of the Presence of Per- and Polyfluoroalkyl Substances at Publicly Owned Treatment Works (SWRCB, 2020), the SWRCB's Order for the Determination of the Presence of Per- and Polyfluoroalkyl Substances at Chrome Plating Facilities (SWRCB, 2019), and compounds listed in DoD Quality Systems Manual (QSM) 5.3 Table B-15 (DoD, 2019).

Table 4-3. SI List of PFAS Compounds

Analyte	CAS Number	CA POTW Order 31 compounds	CA Chrome Plating Order 25 compounds	DoD QSM 5.3 Table B-15 24 compounds
FTS 4:2	757124-72-4	X	X	X
FTS 6:2	27619-97-2	X	X	X
FTS 8:2	39108-34-4	X	X	X
N-ETFOSAA	2991-50-6	X	X	X
N-MEFOSAA	2355-31-9	X	X	X
PFBA	375-22-4	X	X	X
PFBS	375-73-5	X	X	X
PFDA	335-76-2	X	X	X
PFDOA	307-55-1	X	X	X
PFDS	335-77-3	X	X	X
PFHpA	375-85-9	X	X	X
PFHPS	375-92-8	X	X	X
PFHXA	307-24-4	X	X	X
PFHxS	355-46-4	X	X	X
PFNA	375-95-1	X	X	X
PFNS	98789-57-2			X
PFOA	335-67-1	X	X	X
PFOS	1763-23-1	X	X	X
PFOSA	754-91-6	X	X	X
PFPEA	2706-90-3	X	X	X
PFPES	630402-22-1	X	X	X
PFTEDA	376-06-7	X	X	X
PFTRDA	72629-94-8	X	X	X
PFUDA	2058-94-8	X	X	X

Analyte	CAS Number	CA POTW Order 31 compounds	CA Chrome Plating Order 25 compounds	DoD QSM 5.3 Table B-15 24 compounds
HFPO-DA (GenX)	13252-13-6	X		
11-Cl-PF3OUdS	763051-92-9	X	X	
9-Cl-PF3ONS	756426-58-1	X	X	
ADONA	919005-14-4	X		
N-ETFOSA	4151-50-2	X		
N-ETFOSE	1691-99-2	X		
N-MEFOSA	31506-32-8	X		
N-MEFOSE	24448-09-7	X		

Soil and groundwater samples were analyzed by APPL in Clovis, California, a DoD Environmental Laboratory Accreditation Program (ELAP) accredited laboratory. Samples were analyzed by EPA Method 537-modified by 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 B.

Following laboratory analysis by APPL, third party data validation was performed by an independent subcontractor, Laboratory Data Consultants, Inc. of Carlsbad, California.

Validated analytical results for PFOS, PFOA, PFBS, HFPO-DA, PFNA, and PFHxS are discussed in the following sections, while the analytical results for the remaining PFAS constituents are provided in tables at the conclusion of this SI Report.

4.3 Analytical Results

Validated analytical results for PFAS were compared with the screening levels presented in Table 1-1. Analytical results for PFBS, PFOA, PFOS, HFPO-DA (GenX Chemicals), PFNA, and PFHxS are discussed in the following sections and presented in Tables 4-4 and 4-5. The analytical results for the remaining PFAS constituents are provided in tables in Appendix A.

4.3.1 Groundwater Sample Results

Low levels (below screening levels) of PFOA, PFNA, PFBS, PFHxS, and PFOS were detected in all monitoring wells sampled at the JPL Site, with the exception that PFNA was not detected in MW-4. HFPO-DA was not detected in any monitoring well at the JPL Site. Results are presented in Table 4-4.

The screening levels presented in Table 1-1 (see Section 1.2) were exceeded in two samples. The sample collected from MW-12 (Screen 2) contained 9.50 ng/L of PFOA. This PFOA concentration exceeds the USEPA RSL for Tap Water (6 ng/L), the USEPA proposed NPDWR (4 ng/L), and the SWRCB NL (5.1 ng/L). MW-12 was sampled to evaluate PFAS in AOPCs 2 and 3 (Waste Disposal Areas). In addition, the sample (and its duplicate) collected from MW-17 (Screen 3) contained 6.6 ng/L of PFOS. This PFOS concentration exceeds the USEPA RSL for Tap Water (4 ng/L), the USEPA proposed NPDWR (4 ng/L), and the SWRCB NL (6.5 ng/L). MW-17 was sampled to evaluate PFAS in AOPCs 2 and 3 (Waste Disposal Areas). No other PFAS were detected at concentrations above the screening levels.

PFAS was not detected above screening levels in MW-4, which was selected for evaluating AOPC 4 (former chrome plating operations at Building 170).

Table 4-4. Groundwater PFAS Results

Sample Location	Sample Date	Sample Number	PFOA (ng/L)	PFNA (ng/L)	PFBS (ng/L)	PFHxS (ng/L)	PFOS (ng/L)	HFPO-DA (GenX Chemicals) (ng/L)	NPDWR HI
MW-4-1	--	DRY	NS	NS	NS	NS	NS	NS	
MW-4-2	11/28/2022	MW-4-S2-112822	**1.10**	0.18 U	**2.90**	**2.00**	**0.20 J**	0.90 U	0.33
MW-4-4	11/28/2022	MW-4-S4-112822	**0.40 J**	0.18 U	**0.39 J**	**0.28 J**	**0.15 J**	0.91 U	0.14
MW-4-5	11/28/2022	MW-4-S5-112822	**0.27 J**	0.19 U	**0.79 J**	**0.42 J**	**0.14 J**	0.93 U	0.16
MW-4-5	11/28/2022	DUP-1-112822	**0.94 J**	0.18 U	**4.90**	**0.44 J**	0.18 U	0.88 U	0.16
MW-5	--	DRY	NS	NS	NS	NS	NS	NS	
MW-12-1	--	DRY	NS	NS	NS	NS	NS	NS	
MW-12-2	11/28/2022	MW-12-S2-112822	**9.50**	**1.20**	**7.40**	**0.73**	**3.80**	0.91 U	0.30
MW-12-3	11/28/2022	MW-12-S3-112822	**1.40**	0.18 U	**0.24 J**	**0.41 J**	**0.62 J**	0.92 U	0.16
MW-12-4	11/28/2022	MW-12-S4-112822	**2.10**	0.19 U	**0.23 J**	**0.25 J**	**1.10**	0.93 U	0.14
MW-12-5	11/28/2022	MW-12-S5-112822	**1.10**	**3.50**	**0.45 J**	**0.36 J**	**2.00**	0.89 U	0.48
MW-15	11/30/2022	MW-15-113022	**2.50**	**0.88**	**0.97**	**0.32 J**	**1.50**	0.85 U	0.21
MW-16	--	DRY	NS	NS	NS	NS	NS	NS	
MW-17-1	--	DRY	NS	NS	NS	NS	NS	NS	
MW-17-2	11/29/2022	MW-17-S2-112922	**0.23 J**	0.18 U	**1.30**	**0.54 J**	**0.83**	0.89 U	0.17
MW-17-3	11/29/2022	MW-17-S3-112922	**2.30**	**0.37 J**	**2.20**	**1.40**	**6.60**	0.90 U	0.28
MW-17-3	11/29/2022	DUP-3-112922	**2.00**	**0.53 J**	**2.40**	**1.40**	**5.90**	0.88 U	0.30
MW-17-4	11/29/2022	MW-17-S4-112922	**2.30**	**0.36 J**	**0.50 J**	**1.20**	**2.00**	0.89 U	0.26
MW-17-5	11/29/2022	MW-17-S5-112922	**1.50**	0.17 U	**0.47 J**	**1.30**	**2.00**	0.87 U	0.25
MW-24-1	--	DRY	NS	NS	NS	NS	NS	NS	
MW-24-2	11/29/2022	MW-24-S2-112922	**0.68 J**	0.17 U	**0.84**	**2.30**	**0.33 J**	0.85 U	0.36
MW-24-2	11/29/2022	DUP-2-112922	**0.83 J**	0.17 U	**0.65 J**	**2.20**	**0.55 J**	0.84 U	0.35
MW-24-3	11/29/2022	MW-24-S3-112922	**2.30**	**0.31 J**	**0.36 J**	**0.82**	**0.70**	0.85 U	0.21
MW-24-4	11/29/2022	MW-24-S4-112922	**0.26 J**	0.17 U	0.17 U	0.17 U	0.17 U	0.86 U	0.12
MW-24-5	11/29/2022	MW-24-S5-112922	**0.21 J**	0.18 U	0.18 U	0.18 U	0.18 U	0.88 U	0.13
USEPA RSL for Tap Water (November 2023) (ng/L)			6	5.9	600	39	4	6	--
USEPA Proposed NPDWR (March 2023) (ng/L)			4	HI<1	HI<1	HI<1	4	HI<1	1
SWRCB DDW NL (ng/L)			5.1	NE	500	3	6.5	NE	--

NS = Not Sampled; NE = Not Established; bold = detection; J = estimated concentration; U = not detected

Table 4-5. PFAS Soil Boring Results

Sample Location	Sample Date	Sample Number	PFOA (µg/kg)	PFNA (µg/kg)	PFBS (µg/kg)	PFHxS (µg/kg)	PFOS (µg/kg)	HFPO-DA (GenX Chemicals) (µg/kg)
Soil Boring-1 (0.5 feet)	11/30/2022	SB-1-0.5-113022	**0.52 J**	**2.70**	0.12 U	0.17 U	**0.66 J**	0.23 U
Soil Boring-1 (2.0 feet)	11/30/2022	SB-1-2.0-113022	**2.20**	**2.20**	0.10 U	0.15 U	**0.13 J**	0.20 U
Soil Boring-2 (0.5 feet)	11/30/2022	SB-2-0.5-113022	**3.50**	**0.45 J**	0.11 U	0.17 U	**0.15 J**	0.22 U
Soil Boring-2 (2.0 feet)	11/30/2022	SB-2-2.0-113022	**10.00**	**1.20**	0.11 U	0.16 U	**0.19 J**	0.22 U
Soil Boring-3 (0.5 feet)	11/30/2022	SB-3-0.5-113022	**0.40 J**	**0.24 J**	0.10 U	0.15 U	0.10 UJ	0.21 U
Soil Boring-3 (2.0 feet)	11/30/2022	SB-3-2.0-113022	**4.60**	**0.59 J**	**0.13 J**	0.15 U	**0.39 J**	0.20 U
Soil Boring-4 (0.5 feet)	11/30/2022	SB-4-0.5-113022	0.15 U	0.10 U	0.10 U	0.15 U	**1.80 J**	0.20 U
Soil Boring-4 (2.0 feet)	11/30/2022	SB-4-2.0-113022	0.15 U	0.10 U	0.10 U	0.15 U	**0.13 J**	0.20 U
Soil Boring-5 (0.5 feet)	11/30/2022	SB-5-0.5-113022	0.15 U	0.10 U	0.10 U	0.15 U	**1.70 J**	0.19 U
Soil Boring-5 (2.0 feet)	11/30/2022	SB-5-2.0-113022	0.14 U	0.09 U	0.09 U	0.14 U	0.09 UJ	0.18 U
Soil Boring-5 (2.0 feet)	11/30/2022	DUP-1-113022	0.15 U	0.10 U	0.10 U	0.15 U	0.10 UJ	0.20 U
Soil Boring-6 (0.5 feet)	11/30/2022	SB-6-0.5-113022	0.19 U	0.12 U	0.12 U	**0.90 J**	**22.00 J**	0.25 U
Soil Boring-6 (0.5 feet)	11/30/2022	DUP-2-113022	**0.28 J**	**0.19 J**	0.12 U	**1.50**	**48.00 J**	0.24 U
Soil Boring-6 (2.0 feet)	11/30/2022	SB-6-2.0-113022	**0.16 J**	0.10 U	0.10 U	**2.40**	**1.50 J**	0.20 U
USEPA RSL for Residential Soil (November 2023) (µg/kg)			19	19	1900	130	13	23

The presence or absence of PFAS in AOPC 5: Former Building 218 and Building 291 Photography Labs groundwater could not be determined because the well was dry due to the drought in Southern California. It is recommended that MW-5 be sampled as part of a subsequent sampling event in 2024 (see Section 7.2).

New RSLs were issued by the USEPA in May 2023 for PFBA and PFHxA. PFBA was detected at a maximum concentration of 8.1 ng/L (MW-12 Screen 2), which is well below the RSL of 1,800 ng/L. PFHxA was detected at a maximum concentration of 9.2 ng/L (MW-12 Screen 2), which is well below the RSL of 990 ng/L.

New RSLs were issued by the USEPA in November 2023 for PFDOA, PFTEDA, and PFUDA. PFUDA was detected at a maximum concentration of 0.14J ng/L (MW-12 Screen 5), which is well below the RSL of 600 µg/kg.

It should be noted that additional PFAS including PFPEA, PFHpA, PFDA, PFPES, FTS 6:2, PFOSA, N-MEFOSAA, and N-ETFOSAA were detected (see Appendix A); however, no state or federal screening levels have been established for these analytes.

4.3.2 Soil Sample Results

Low levels of PFOA, PFNA, PFBS, PHXS, and PFOS were detected in one or more soil samples collected from AOPC 1. HFPO-DA was not detected in any soil samples collected in AOPC 1. Results are presented in Table 4-5.

Only PFOS in Soil Boring 6 (0.5 ft bgs) and its duplicate contained PFAS at a concentration that exceeded the screening levels. Specifically, PFOS was detected at an estimated concentration of 48 µg/kg in the duplicate sample from Soil Boring 6. The primary sample from Soil Boring 6 contained an estimated PFOS concentration of 22 µg/kg. The PFOS concentrations in Soil Boring 6 and its duplicate exceeds the USEPA RSL for residential soil, which is 13 µg/kg. The sample collected from Soil Boring 6 (0.5 ft bgs) is one of six samples collected from the catch basin below the helipad where runoff water from AOPC 1 may have accumulated.

New RSLs were issued by the USEPA in May 2023 for PFBA and PFHxA. PFBA was detected at a maximum concentration of 7.1 µg/kg (Soil Boring 3), which is well below the RSL of 7,800 µg/kg. PFHxA was detected at a maximum concentration of 32 ng/L (Soil Boring 3), which is well below the RSL of 3,200 µg/kg.

New RSLs were issued by the USEPA in November 2023 for PFDOA, PFTEDA, and PFUDA. PFDOA was detected at 0.2J µg/kg (Soil Boring 6), which is well below the RSL of 320 µg/kg. PFUDA was detected at a maximum concentration of 0.25J µg/kg (Soil Boring 6), which is well below the RSL of 1,900 µg/kg.

It should be noted that additional PFAS, including PFPEA, PFHpA, PFDA, PFTRDA PFNS, PFDS, FTS 6:2, FTS 8:2, and PFOSA were detected in soil (see Appendix A); however, no USEPA RSLs (which are used to determine need for further investigation) have been established for these analytes.

4.4 Decontamination Procedures

Field sampling equipment, including Westbay® sample probe assembly and sample containers, water level probe, bladder pump, stainless steel auger bucket, and other non-dedicated equipment used at each sample location were decontaminated between use. The field sampling crew used Liquinox® detergent which is PFAS-free, potable water, distilled water, and laboratory-supplied certified PFAS-free water during decontamination of non-dedicated sampling equipment.

4.5 Instrument Calibration Procedures

All field instruments were calibrated prior to sampling according to manufacturer's specifications and instrument calibration was checked and documented on-site daily. Calibration standard(s), dates, times and all calibration results were recorded in the field log.

4.6 Investigation Derived Wastes (IDW)

During the site investigation, G2S generated potentially contaminated IDW that included the following:

- Used personal protective equipment (PPE),
- Disposable sampling equipment,
- Decontamination fluids,
- Soil cutting from soil borings, and
- Purged groundwater.

Used PPE and disposable sampling equipment was double bagged and placed in municipal refuse dumpster. These wastes are not considered hazardous and were sent to the local landfill.

Decontamination fluids (residual contaminants, water with non-phosphate detergent) and purged groundwater (contaminants, water) were containerized and transferred to NASA's OU-1 source area groundwater treatment system for processing.

Soil cuttings from soil borings were containerized in a 55-gallon, department of transportation (DOT) approved, steel drum labeled as to type of waste (soil), the source locations, date, and contact information. Due to the small quantity of soil generated during hand auger activities (e.g., 0.022 cubic yards), the soil is being temporarily stored on-site until the next routine waste removal associated with the groundwater treatment system.

5 QUALITY ASSURANCE (QA) / QUALITY CONTROL (QC)

All work performed under this task order adhered to the site-specific UFP-QAPP which is included as Appendix A of NASA's SI Work Plan (NASAa, 2022) that was prepared to define a project-specific set of procedures and performance criteria to assure delivery of data that met the client's expectations, acceptable scientific and engineering standards, and project quality objectives.

Measures of quality included the appropriateness and accuracy of the sample collection; adherence to sample handling protocols; the quality and appropriateness of the laboratory analysis; and the representativeness of the data with respect to the study objectives. Method 537.1 requires a field blank per every sample set. A sample set is composed of samples collected from the same sample site and at the same time.

Field and laboratory QC samples were collected and analyzed to fulfill quality requirements. Proper sample collection and handling procedures were utilized to ensure the integrity of the analytical results. NASA's SI was conducted in compliance with Appendix A of NASA's SI Work Plan (NASAa, 2022).

5.1 Field QA/QC (Groundwater)

The field QA/QC samples collected for JPL groundwater monitoring included field duplicate samples, equipment rinsate blanks, source blanks, and field blanks. The QC sample results were used for the qualitative evaluation of the data. Table 5-1 summarizes analytical results for the QC samples collected during NASA PFAS SI.

5.1.1 Field Duplicate Samples

Duplicate samples were collected to evaluate the precision of the sample collection process. Duplicate samples for PFAS were collected from monitoring wells MW-4 (Screen 5), MW-17 (Screen 3), and MW-24 (Screen 2). The analytical results for the field duplicate samples were comparable to the results of the original groundwater samples for PFAS, with the following exceptions:

- PFOA results in the MW-4 (Screen 5) duplicate pair (0.27J ng/L vs. 0.94J ng/L), MW-17 (Screen 3) duplicate pair (2.30 ng/L vs. 2.00 ng/L), and MW-24 (Screen 2) duplicate pair (0.68J ng/L vs. 0.83J ng/L).
- PFNA results in the MW-17 (Screen 3) duplicate pair (0.37J ng/L vs. 0.53J ng/L).
- PFBS results in the MW-4 (Screen 5) duplicate pair (0.79J ng/L vs. 4.90 ng/L), MW-17 (Screen 3) duplicate pair (2.20 ng/L vs. 2.40 ng/L), and MW-24 (Screen 2) duplicate pair (0.84 ng/L vs. 0.65J ng/L).
- PFHxS results in the MW-3 (Screen 5) duplicate pair (0.42J ng/L vs. 0.44 ng/L) and MW-24 (Screen 2) duplicate pair (2.30 ng/L vs. 2.20 ng/L).
- PFOS results in the MW-4 (Screen 5) duplicate pair (0.14J ng/L vs. non-detect), MW-17 (Screen 3) duplicate pair (6.60 ng/L vs. 5.90 ng/L), and MW-24 (Screen 2) duplicate pair (0.33J ng/L vs. 0.55J ng/L).

The source of the differences could not be determined.

5.1.2 Equipment Rinsate Blanks

Equipment rinsate blanks were collected each day that non-dedicated sampling equipment was used. The equipment rinsate blanks, consisting of laboratory-provided PFAS-free water run through the sampling equipment after decontamination, were analyzed for PFAS to monitor possible cross-contamination of the samples due to inadequate decontamination.

Table 5-1. QA/QC Sample Results (Groundwater Sampling)

Sample Location	Sample Date	Sample Number	PFOA (ng/L)		PFNA (ng/L)		PFBS (ng/L)		PFHxS (ng/L)		PFOS (ng/L)		HFPO-DA (GenX Chemicals) (ng/L)	
Source Blank-1	11/28/2022	SB-1-112822	**0.17**	**J**	0.18	U	0.18	U	0.18	U	**0.12**	**J**	0.92	U
Source Blank-2	11/28/2022	SB-2-112922	**0.19**	**J**	0.18	U	0.18	U	0.18	U	**0.06**	**J**	0.88	U
Source Blank-3	11/30/2022	SB-3-113022	0.17	U	0.17	U	0.17	U	0.17	U	0.17	U	0.86	U
Field Blank-1	11/28/2022	FB-1-112822	0.97	U	0.97	U	0.97	U	0.97	U	0.97	U	4.90	UJ
Field Blank-2	11/29/2022	FB-2-112922	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	5.20	UJ
Field Blank-3	11/30/2022	FB-3-113022	1.00	U	1.00	U	1.00	U	1.00	U	1.00	U	5.10	UJ
Equipment Blank-1	11/28/2022	EQP-1-112822	**0.23**	**J**	0.18	U	0.18	U	0.18	U	0.18	U	0.90	U
Equipment Blank-2	11/29/2022	EQP-2-112922	0.18	U	0.18	U	0.18	U	0.18	U	**0.11**	**J**	0.92	U
Equipment Blank-3	11/30/2022	EQP-3-113022	**0.21**	**J**	0.18	U	0.18	U	0.18	U	0.18	U	0.91	U

- PFOA was detected in the equipment blank collected on November 28, 2022 (i.e., EQB-1-112822) at a concentration of 0.23J ng/L. PFOA was also detected in the equipment blank collected on November 30, 2022 (i.e., EQB-2-112822) at a concentration of 0.21J ng/L.
- PFOS was detected in the equipment blank collected on November 29, 2022 (i.e., EQB-3-113022) at a concentration of 0.11J ng/L.

The source of the PFAS contamination in the equipment rinsate blanks could not be determined. Detected PFAS concentrations in the equipment rinsate blanks were compared to the detected concentrations in the associated monitoring wells during the data validation process to determine if data validation qualifiers were necessary. Validation qualifiers were added by the data validators to select PFOA and PFOS analytical results.

No other PFAS constituents were detected in the equipment rinsate blanks as shown in Table 5-1.

5.1.3 Field Blanks

During groundwater sampling activities, field blanks were collected each day for a total of three (i.e., FB-1-112822, FB-2-112922, and FB-3-113022). The field blanks consisted of a small sample vial filled with PFAS-free water by the laboratory. For each day of groundwater sampling, the screw top of the vial was removed for the duration of sampling. After groundwater samples were collected, the vial was capped.

- No PFAS constituents were detected in the field blanks.

5.1.4 Source Blanks

Three source blanks which consisted of distilled water used by sampling personnel for equipment decontamination were collected during the sampling event. This QC sample serves as a check for any contamination present in the source water.

- PFOA was detected in SB-1-112822 and SB-2-112922 at concentrations of 0.17J ng/L and 0.19J ng/L, respectively.
- PFOS was detected in SB-1-112822 and SB-2-112922 at concentrations of 0.12J ng/L and 0.059J ng/L, respectively.

No other PFAS constituents were detected in the source blanks as shown in Table 5-1.

5.2 Field QA/QC (Soil)

The field QA/QC samples collected during soil sampling included field duplicate samples, equipment rinsate blanks, and field blanks. The QC sample results were used for the qualitative evaluation of the data. Table 5-1 summarizes analytical results for the QC samples collected during NASA PFAS SI.

5.2.1 Field Duplicate Samples

Duplicate samples were collected to evaluate the precision of the sample collection process. Duplicate samples for PFAS were collected from soil sampling locations SB-5-2.0-113022 and SB6-0.5-113022. The analytical results for the field duplicate samples were comparable to the results of the original soil samples for PFAS, with the following exceptions:

- PFOA results in the SB-6-0.5-113022 duplicate pair (non-detect vs. 0.28J ng/g).
- PFNA results in the SB-6-0.5-113022 duplicate pair (non-detect vs. 0.19J ng/g).
- PFHxS results in the SB-6-0.5-113022 duplicate pair (0.90J ng/g vs. 1.50 ng/g).
- PFOS results in the SB-6-0.5-113022 duplicate pair (22.00J ng/g vs. 48.00J ng/g).
- PFNA results in the SB-6-0.5-113022 duplicate pair (non-detect vs. 0.19J ng/g).

- PFDA results in the SB-6-0.5-113022 duplicate pair (0.27J ng/g vs. 0.38J ng/g).
- PFUnA results in the SB-6-0.5-113022 duplicate pair (0.17J ng/g vs. 0.25J ng/g).
- PFDOA results in the SB-6-0.5-113022 duplicate pair (0.20J ng/g vs. non-detect).
- PFTRDA results in the SB-6-0.5-113022 duplicate pair (0.12J ng/g vs. non-detect).
- PFNS results in the SB-6-0.5-113022 duplicate pair (2.00 ng/g vs. 5.30 ng/g).
- PFDS results in the SB-6-0.5-113022 duplicate pair (1.50J ng/g vs. 2.50 ng/g).
- PFOSA results in the SB-6-0.5-113022 duplicate pair (non-detect vs. 0.15J ng/g).

The source of the differences could not be determined.

5.2.2 Equipment Rinsate Blank

One equipment rinsate blank was collected during soil sampling using a non-dedicated hand auger. The equipment rinsate blank, consisting of laboratory-provided PFAS-free water run through the auger head after decontamination, was analyzed for PFAS to monitor possible cross-contamination of the samples due to inadequate decontamination.

- No PFAS constituents were detected in the equipment rinsate blank.

5.2.3 Field Blank

One field blank was collected during soil sampling activities. The field blank consisted of a small sample vial filled with PFAS-free water by the laboratory. During soil sample collection, the screw top of the vial was removed for the duration of sampling. After the soil samples were collected, the vial was capped.

- No PFAS constituents were detected in the field blank.

5.3 Laboratory QA/QC

Laboratory QC samples included surrogate compounds, matrix spike samples, blank spike samples, and method blanks. The results of the laboratory QC samples were used by the laboratory to determine the accuracy and precision of the analytical techniques, and to identify anomalous results due to laboratory contamination or instrument malfunction.

5.4 Data Verification and Validation

The purposes of data verification and validation is to ensure that the data collected meet the data quality objectives (DQOs) outlined in the Appendix A (i.e., UFP-QAPP) of NASA’s SI Work Plan (NASAa, 2022).

5.4.1 Data Verification

Data verification is a review of analytical data that includes confirming that the sample identification numbers on the laboratory reports match those on the CoC records. Data verification also includes a review of the analytical data reports to confirm that all samples were analyzed, and all required analytes were quantified for each sample.

5.4.2 Data Validation

Data validation is a systematic review of analytical data to determine compliance with established method performance criteria. Validation of a data package included review of sample receipt and technical holding time requirements, LC/MS instrument performance check, review of the initial and continuing calibration data, continuing calibration and instrument sensitivity check, review and recalculation of the laboratory QC sample data, review of the equipment performance, reconciliation of the raw data with the

reduced results, identification of data anomalies, and qualification of data to identify data usability limitations.
Data validation was performed by an independent contractor, Laboratory Data Consultants, Inc., of Carlsbad, CA. All of the data provided by APPL, of Clovis, California were validated. Ninety percent of the data were subjected to Level III validation and 10 percent of the data were subjected to Level IV validation in accordance with a modified outline of the USEPA Data Review and Validation Guidelines for Perfluoroalkyl Substances (PFAS) Analyzed Using the EPA Method 537 (November 2018). Where specific guidance was not available, the data was evaluated in a conservative manner consistent with industry standards using professional experience.

5.4.3 Data Validation Qualifiers

Analytical data were qualified based on the data validation. Data qualifiers were assigned in accordance with EPA guidelines.

All samples were analyzed for PFAS within the analytical holding times. Data validation indicated that all data from the NASA PFAS SI were acceptable for their intended use of characterizing groundwater and soil. The data validation reports are included in Appendix C.

6 MIGRATION/EXPOSURE PATHWAYS AND TARGETS

This section evaluates the potential for migration/exposure pathways in groundwater and soil associated with the JPL Site. The environmental setting including climate, topography and surface features, geology, hydrogeology, surface water features, and land use are discussed in Section 3.0 of this report.

6.1 Groundwater Migration Pathway

Based on the hydrogeological setting (Sections 3.4), the main aquifer system for the JPL area is provided by the alluvial basin-filling sediments of the Raymond Basin. Based on previous investigations and remedial actions associated with the JPL Site, it is known that groundwater flows southeast from the site toward Altadena. There wells owned by the City of Pasadena and LAWC that are downgradient of the JPL Site and are known to contain chemicals originating from JPL. The nature and extent of chemicals has been established and remedies are in place to treat chemicals originating from the JPL Site.

Like other chemicals originating from the JPL Site, potential releases of PFAS at JPL would migrate in groundwater toward the southeast (downgradient) toward the City of Pasadena MHTS wells and the LAWC wells. Previous investigations have found that VOCs, including carbon tetrachloride, trichloroethene, and tetrachloroethene, and perchlorate released at JPL have impacted groundwater in these wells. The MHTS and LAWC wells are considered primary potential receptors and are part of NASA's CERCLA OU-3 remedy and is working effectively (NASA, 2022b). These wells include Arroyo, Well 52, Ventura, and Windsor wells owned by the City of Pasadena and LAWC#3, LAWC#5, and LAWC#6 owned by LAWC. PWP's wells are located within or immediately east of the Arroyo Seco and LAWC's are further east. Since groundwater flow direction at JPL is to the southeast, potential release of PFAS in groundwater would migrate downgradient to PWP's and LAWC's wells (NASA, 2019a). Groundwater extraction of these wells prevents further downgradient migration of chemicals originating from the JPL CERCLA Site COCs (NASA, 2018; NASA, 2022b).

The CSM for contaminant migration at JPL identifies seepage pits and waste pits as a primary source for contaminants of concern (COCs), which migrate into soil and subsequently down to groundwater through the highly permeable vadose zone in dissolved phase via surface water infiltration. If PFAS were released into the vadose zone overlying the alluvial aquifer south of the JPL Thrust Fault, they would migrate through the vadose zone due to surface water infiltration and into the shallowest aquifer. Therefore, potential PFAS impacts to shallow groundwater in the upper Older Fanglomerate Series may be more likely close to or on JPL. There is no migration pathway to groundwater north of the JPL Thrust Fault, so any release of PFAS in the high elevation northern area of JPL would have to be carried south of the JPL Thrust Fault before infiltrating the vadose zone to impact the underlying alluvial aquifer, which is unlikely.

Pumping tests and hydrogeologic observations suggest semi-confined groundwater conditions in the lower three aquifer units of the Raymond Basin. Despite this, vertical transmission of contaminants from JPL has been observed, implying that all four aquifer layers could be affected by potential chemical releases. The intermediate aquifer layers (the lower Older Fanglomerate Series and the Pacoima Formation) currently have the highest concentrations of VOCs and perchlorate and would likely be most impacted by a PFAS release.

6.1.1 Sample Locations

As part of NASA's SI, groundwater samples were collected from five NASA groundwater monitoring wells (i.e., MW-4, MW-12, MW-15, MW-17, and MW-24) in November 2022 and analyzed for 32 PFAS constituents using LC-MS/MS. Only two groundwater samples contained concentrations of PFAS in excess of the screening criteria. PFOA was detected in MW-12 (Screen 2) and PFOS was detected in

MW-17 (Screen 3) concentrations in excess of the screening criteria. MW-12 is located near the eastern property line of the JPL Facility and is located within the capture zone of the MHTS wells. MW-17 is located in between the MHTS wells and the LAWC wells and is within the capture zone of the LAWC wells.

6.1.2 Groundwater Migration Pathway Analytical Results

In November 2022, samples were collected from select NASA groundwater monitoring wells and analyzed for 32 PFAS constituents. PFOA was detected in MW-12 (Screen 2) at a concentration of 9.50 ng/L, which exceeds the USEPA RSL for Tap Water (6 ng/L), the USEPA proposed NPDWR (4 ng/L), and the SWRCB NL (5.1 ng/L). In addition, PFOS was detected in the sample (and its duplicate) collected from MW-17 (Screen 3) at a concentration of 6.6 ng/L. This PFOS concentration exceeds the USEPA RSL for Tap Water (4 ng/L), the USEPA proposed NPDWR (4 ng/L), and the SWRCB NL (6.5 ng/L).

The PFOA concentration detected in MW-12 (Screen 2) and the PFOS concentration detected in MW-17 (Screen 3) indicate that levels of these compounds in excess of the available screening criteria exist at the JPL Site in close proximity to the MHTS and LAWC drinking water wells. Groundwater samples collected from the MHTS wells in 2020 did not show any exceedances of screening criteria for PFAS. Recent samples collected from LAWC wells in 2022 revealed detections of PFOS in LAWC#6 at 5 ng/L. This concentration exceeds the USEPA RSL for Tap Water (4 ng/L) and the USEPA proposed NPDWR (4 ng/L) but is below the SWRCB NL (6.5 ng/L).

6.1.3 Groundwater Migration Pathway Conclusions

PFAS are known to have been released at AOPC 1 during AFFF training at the Emergency Landing Facility (Tetra Tech, 2021). In addition, groundwater data show that PFAS was released at AOPC 2 and 3 via waste pits and seepage pits. AOPC 4 evaluated releases from chrome plating operations and no PFAS were detected in MW-4 above screening criteria. AOPC 5 (photography laboratory operations) was not evaluated because MW-5 was dry. PFAS released in soils would have been transported through the vadose zone by percolating water, reached the water table, and migrated to the southeast.

Exposure pathways related to groundwater associated with potential PFAS releases from JPL sources are likely limited to the drinking water wells located downgradient to the southeast of the facility (i.e., MHTS and LAWC wells). PFAS have been detected in MHTS and LAWC wells; however, only PFOS in LAWC#6 has been detected at a concentration slightly above the screening criteria. In addition, LGAC treatment and IX treatment (using perchlorate selective resin) are in place for this well. These two treatment technologies are effective for addressing several PFAS and have been demonstrated to remove PFOS. Evaluation of PFAS removal at MHTS and LAWC treatment system is recommended in Section 7.2.

6.2 Soil Exposure Pathway

Pavement, concrete, and buildings cover most areas of JPL. Some areas within the main campus are unpaved and covered with landscaping or vegetated with grass. A flat, cleared, undeveloped mesa is located in the northernmost portion of JPL, which is used as the Emergency Landing Facility. A steep, vegetated slope separates the Emergency Landing Facility from the rest of the JPL buildings in the main campus of JPL. Surface conditions are briefly discussed for each AOPC in the PA Report (Tetra Tech, 2021). Soil samples were collected from AOPC 1 and groundwater samples were collected in the other AOPCs to evaluate potential releases from waste pits, seepage pits, chrome plating operations and/or photography laboratory operations.

6.2.1 Sample Locations

As part of NASA's SI, soil samples were collected from six soil borings associated with AOPC 1. Only one soil sample contained concentrations of PFAS in excess of the screening criteria. PFOS was detected in Soil Boring 6 (0.5 ft bgs) at a concentration above the screening criteria. Soil Boring 6 is located near the corrugated drain in the catch basin below the helipad.

6.2.2 Soil Exposure Analytical Results

In November 2022, samples were collected from six soil borings in AOPC 1 and analyzed for 32 PFAS constituents. Only PFOS in Soil Boring 6 exceeded the screening criteria. The duplicate sample from Soil Boring 6 (0.5 ft bgs) had an estimated PFOS concentration of 48 µg/kg and the primary sample from Soil Boring 6 (0.5 ft bgs) had an estimated PFOS concentration of 22 µg/kg. PFOS detections exceed the USEPA RSL for Residential Soil (HI = 0.1) of 13 µg/kg. The PFOS detection does not exceed the USEPA RSL for Residential Soil (HI = 1) of 130 µg/kg.

6.2.3 Soil Exposure Conclusions

Soil samples collected as part of the SI in AOPC 1 demonstrate that PFAS (specifically PFOS) is present in shallow soil at concentrations in excess of the USEPA RSL for Residential Soil. In addition, groundwater sample results indicate PFAS releases in one or more of the 40 former seepage pits and four former waste pits comprising AOPCs 2 and 3.

7 SUMMARY AND CONCLUSIONS

This section summarizes data from the PFAS SI at JPL and provides conclusions regarding subsequent actions at JPL associated with PFAS.

7.1 Summary

AOPC 1: Low levels of PFOA, PFBA, PFHxA, PFNA, PFBS, PHXS, and PFOS were detected in one or more soil samples collected from AOPC 1. HFPO-DA was not detected in any soil samples collected in AOPC 1.

Only PFOS in Soil Boring 6 (0.5 ft bgs) and its duplicate contained PFAS at a concentration that exceeded the screening levels. Specifically, PFOS was detected at an estimated concentrations of 22 µg/kg and 48 µg/kg in the primary and duplicate samples from Soil Boring 6 (0.5 ft bgs). The PFOS concentrations in Soil Boring 6 (0.5 ft bgs) exceed the USEPA RSL for residential soil, which is 13 µg/kg. The PFOS concentration in the deeper sample from Soil Boring 6 (2.0 ft bgs) was 1.5 µg/kg indicating that the vertical migration of PFAS near Soil Boring 6 appears limited.

Additional PFAS, including PFPEA, PFHpA, PFDA, PFUnA, PFDOA, PFTRDA PFNS, PFDS, FTS 6:2, FTS 8:2, and PFOSA were detected in soil. No USEPA RSLs have been established for these analytes.

Low levels of PFOA, PFBA, PFHxA, PFNA, PFBS, PFHxS, and PFOS were detected in all monitoring wells sampled at the JPL Site, with the exception that PFNA was not detected in MW-4. HFPO-DA was not detected in any monitoring well at the JPL Site.

MW-4 and MW-16 were identified to support evaluation of impacts in AOPC 1. No PFAS was detected in MW-4 at concentrations above screening criteria. MW-16 was not sampled because it was dry. It should be noted that there are no existing monitoring wells located within 1,500 feet of AOPC 1. It is recommended that MW-16 be sampled a as part of a subsequent sampling event in 2024 (see Section 7.2).

AOPCs 2 and 3: The groundwater sample collected from MW-12 (Screen 2) contained 9.50 ng/L of PFOA. This PFOA concentration exceeds the USEPA RSL for Tap Water (6 ng/L), the USEPA proposed NPDWR (4 ng/L), and the SWRCB NL (5.1 ng/L). MW-12 was sampled to evaluate PFAS in AOPCs 2 and 3 (Waste Disposal Areas). In addition, the sample (and its duplicate) collected from MW-17 (Screen 3) contained 6.6 ng/L of PFOS. This PFOS concentration exceeds the USEPA RSL for Tap Water (4 ng/L), the USEPA proposed NPDWR (4 ng/L), and the SWRCB NL (6.5 ng/L). MW-17 was sampled to evaluate PFAS in AOPCs 2 and 3 (Waste Disposal Areas). No other PFAS were detected at concentrations above the screening levels.

AOPC 4: PFAS was not detected above screening levels in MW-4, which was selected for evaluating AOPC 4 (former chrome plating operations at Building 170).

AOPC 5: The presence or absence of PFAS in AOPC 5: Former Building 218 and Building 291 Photography Labs groundwater could not be determined because the well was dry due to the drought in Southern California. It is recommended that MW-5 be sampled as part of a subsequent sampling event in 2024 (see Section 7.2).

7.2 Conclusions

The PFAS analytical results, included as part of the scope of the SI, confirm the presence of PFAS constituents in soil and groundwater at the JPL Site and downgradient of the JPL Facility at concentrations in excess of USEPA and California SWRCB screening criteria (see Section 1.2). Specifically, PFAS are present in AOPCs 1, 2, 3, and 4 (the monitoring well associated with determining the presence or absence of PFAS in AOPC 5 was not sampled because it was dry). PFOS is present in soil above screening criteria in AOPC 1, and PFOS is present in groundwater above screening criteria in AOPCs 2 and 3. In addition, PFOA is present in groundwater above screening criteria in AOPCs 2 and 3.

While PFAS are present, exceedances of the screening criteria in soil and groundwater were sporadic and concentrations were relatively low. Only 2 of 16 groundwater sampling locations exceeded any PFAS screening criteria at concentrations between 1.5 and 2.4 times the screening value. Only one of 12 soil sample locations exceeded any PFAS screening criteria with a concentration 3.7 times the screening value.

Sampling of drinking water wells by local water purveyors (City of Pasadena and LAWC) demonstrate that PFAS are present in one or more of their drinking water wells that are part of the JPL CERCLA cleanup program. That said, only PFOS has been detected at a concentration above screening criteria in one well, LAWC#6, before treatment at a concentration just above the screening criteria. The City of Pasadena MHTS and LAWC treatment system currently use granular activated carbon and perchlorate-selective ion exchange media to treat groundwater extracted from drinking water wells. Although these systems were not specifically designed for PFAS removal, the treatment methods are the primary technologies used for removal of PFAS from groundwater.

Based on the results of the SI at JPL, NASA recommends the following actions:

- Conduct a comprehensive PFAS sampling of all monitoring wells within and near the JPL Facility in early 2024. NASA will utilize data from this more comprehensive event to determine if PFAS analysis of samples collected from select wells should be added to the JPL groundwater monitoring program. This is consistent with the approach used at JPL for other emerging compounds including 1,2,3-trichloropropane and 1,4-dioxane. It should be noted that due to recent rains, wells that were dry during the PFAS SI (i.e., MW-4 [Screen 1], MW-5, MW-12 [Screen 1], MW-16, and MW-24 [Screen 1]) are no longer dry and will be part of the comprehensive PFAS sampling event. During this comprehensive PFAS sampling event, USEPA Method 1633 will be used for PFAS analysis.
- Coordinate with the City of Pasadena and LAWC on sampling treated water to evaluate removal of PFAS by existing systems and coordinate with the City of Pasadena and LAWC on routine sampling of extraction wells to understand variability in concentrations.
- While PFOS was detected in one sample at a concentration exceeding the screening criteria, the screening value used for PFOS is based on conservative residential use scenario (HI = 0.1). USEPA also publishes RSLs for a generic non-residential scenario (USEPA, 2023b), which is more applicable to soil exposure at JPL. The PFOS RSL for the non-residential scenario (i.e., composite worker, HI = 0.1) is 160 µg/kg. The PFOS composite worker RSL is approximately over 3 times higher than the highest concentration of PFOS detected in soil at JPL (i.e., 48 µg/kg in Soil Boring 6 (0.5 ft bgs)). In addition, PFOS detected in soil at JPL does not exceed the USEPA RSL for Residential Soil (HI = 1) of 130 µg/kg. Decisions regarding the need for additional soil sampling will be evaluated following the more comprehensive PFAS sampling of monitoring wells within and near the JPL Facility in 2024.

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