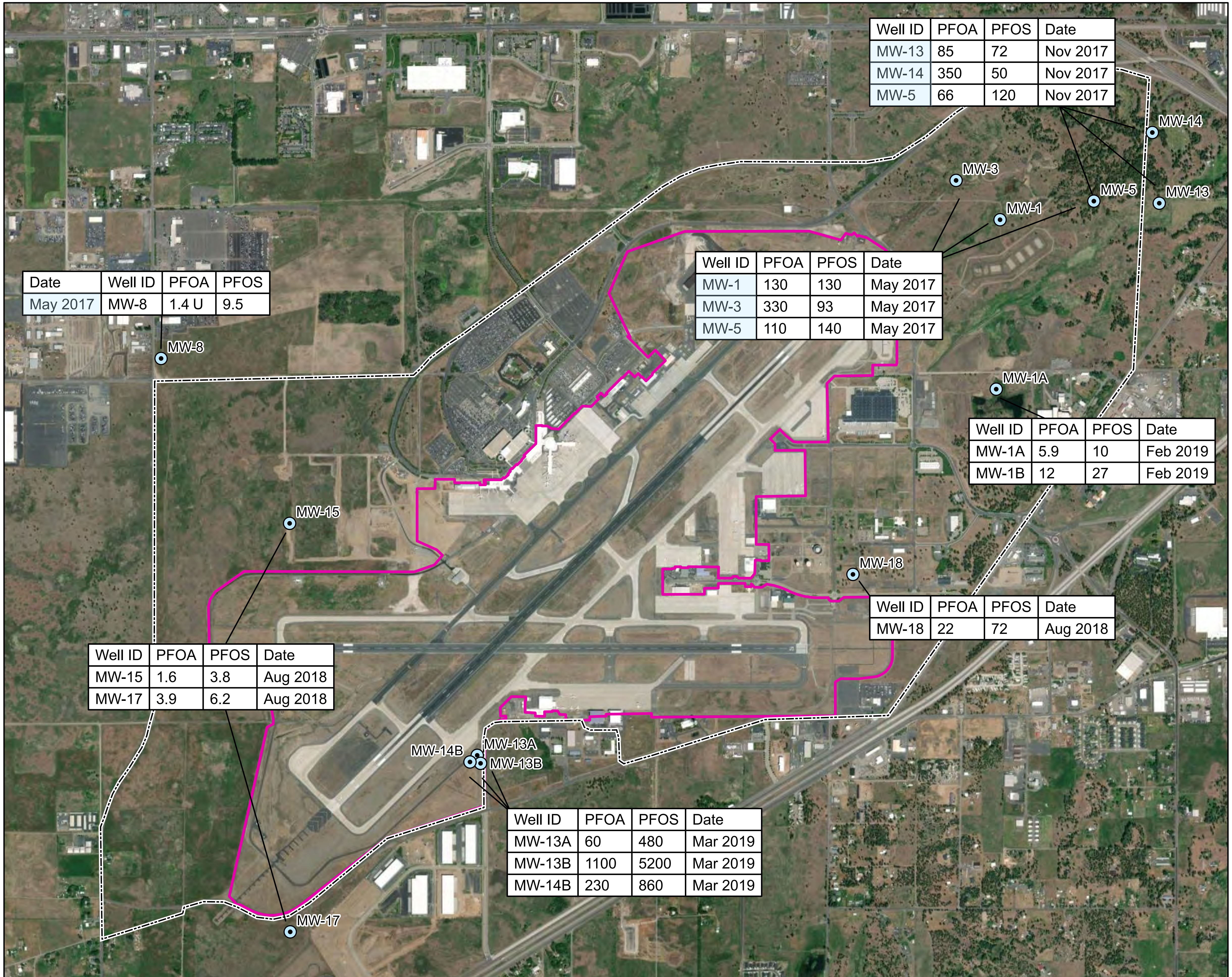


Well ID	PFOA	PFOS	Date
MW-13	85	72	Nov 2017
MW-14	350	50	Nov 2017
MW-5	66	120	Nov 2017

Date	Well ID	PFOA	PFOS
May 2017	MW-8	1.4 U	9.5

Well ID	PFOA	PFOS	Date
MW-1	130	130	May 2017
MW-3	330	93	May 2017
MW-5	110	140	May 2017

Well ID	PFOA	PFOS	Date
MW-1A	5.9	10	Feb 2019
MW-1B	12	27	Feb 2019

Well ID	PFOA	PFOS	Date
MW-18	22	72	Aug 2018

Well ID	PFOA	PFOS	Date
MW-15	1.6	3.8	Aug 2018
MW-17	3.9	6.2	Aug 2018

Well ID	PFOA	PFOS	Date
MW-13A	60	480	Mar 2019
MW-13B	1100	5200	Mar 2019
MW-14B	230	860	Mar 2019

N

LEGEND

- Primary Airport Area
- AOA Fenceline
- 2017 - 2019 PFAS Sampling Locations
- Environmental lab not certified for PFOA and PFOS

Notes

1.) MW-1A and MW-1B are adjacent to one-another
2.) PFOA and PFOS values are presented as previously reported in lab reports appended to previous investigations (2017-2019), at this time validated data has not yet been received by GSI from ALS.
3.) ALS certified by Ecology for USEPA Method 537M in 2018.
4.) 'U' indicates non-detects
5.) Aerial imagery provided by Esri ArcGIS Online, 2023.

Feet
0 750 1,500

Projected Coordinate System
Datum: NAD 83
State Plane Washington North
Units: Feet

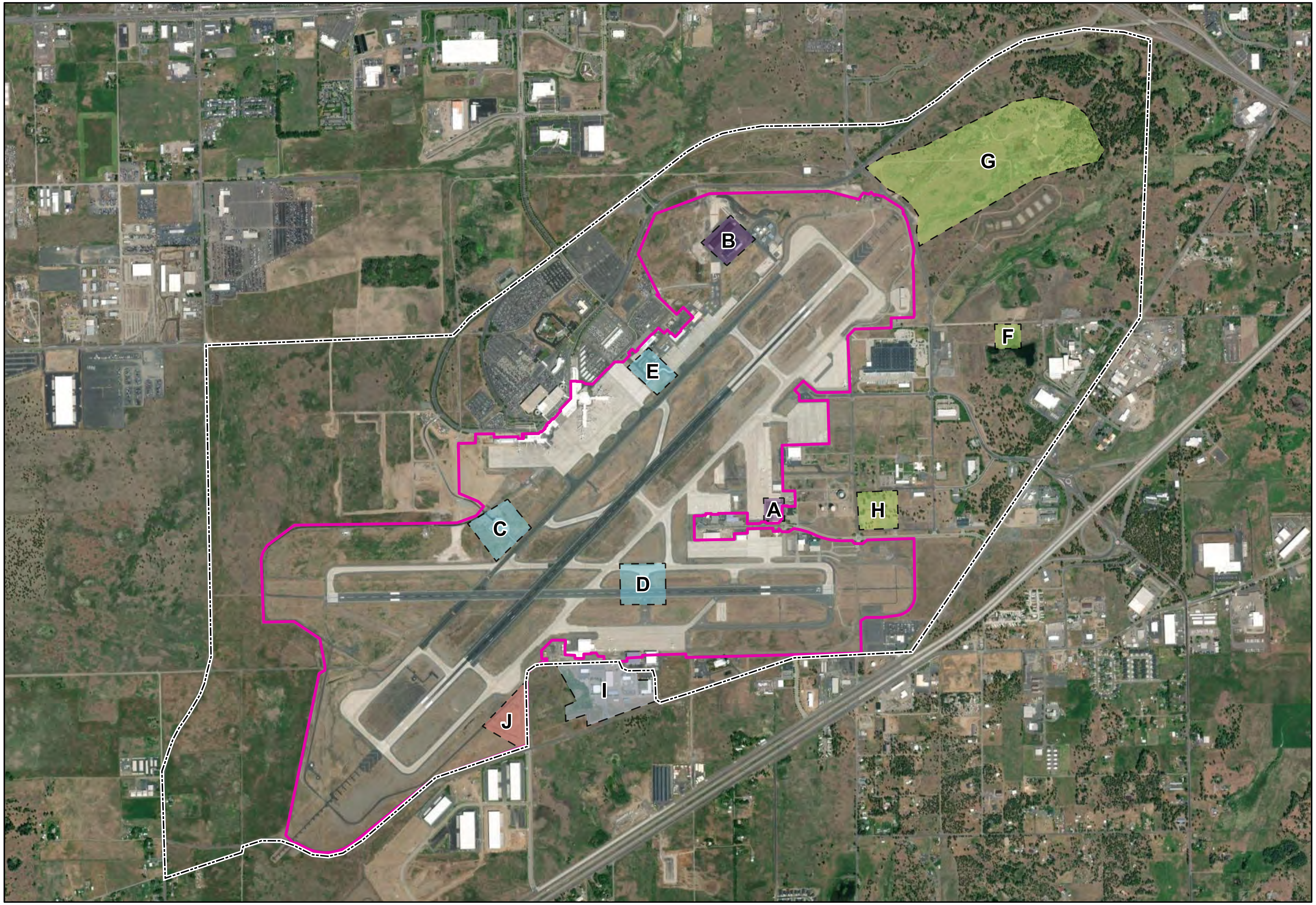
GSI ENVIRONMENTAL

ELEVATED PFAS IN GROUNDWATER

Site Assessment Report
Spokane International Airport
Spokane, Washington

GSI job No.	6892	Drawn By:	EKS
Issued:	13-Aug-2024	Chk'd By:	KW
Map ID:	SIAWA_prvPFAS	Appv'd By:	KW

FIGURE 7.1



LEGEND

- Primary Airport Area
- AOA Fenceline

Potential Areas of Concern by Usage Type:

- AFFF Storage
- FAA Mandated Testing
- Elevated PFAS in Groundwater
- Joint Training Area
- AFFF Storage and Training

Notes

1.) AOA - Air Operations Area
2.) Elevated PFAS in groundwater as reported from sampling events from 2017-2019
2.) Spatial extent of highlighted areas for visual purposes only and subject to further evaluation during subsequent investigations.
3.) Aerial imagery provided by Esri ArcGIS Online, 2023.

LOCATION KEY

Key	Name
A	Hangar 725
B	Field Maintenance Building
C	Current SIA Fire House
D	FAA Inspection Testing
E	Historical SIA Fire House
F	Park Dr. Waste Disposal Area
G	Stormwater Recovery Area
H	Southeast Area of Business Park
I	Air National Guard
J	Joint Fire Training Area

GSI ENVIRONMENTAL

GSI job No. 6892	Drawn By: EKS
Issued: 13-Aug-2024	Chk'd By: KW
Map ID: SIAWA_AOC	Appv'd By: KW
FIGURE 8.1	

Potential or Known PFAS Areas of Concern

Site Assessment Report
Spokane International Airport
Spokane, Washington

Projected Coordinate System
Datum: NAD 83
State Plane Washington North
Units: Feet

Feet 0 1,000 2,000

SITE ASSESSMENT REPORT
Spokane International Airport
Spokane, WA

APPENDIX A

Hydrology and Geology

www.haleyaldrich.com

REPORT ON

SPOKANE INTERNATIONAL AIRPORT - GEOLOGY AND HYDROGEOLOGY
9000 WEST AIRPORT DRIVE
SPOKANE, WASHINGTON

by
Haley & Aldrich, Inc.
Spokane, Washington

for
Spokane International Airport
Felts Field & Airport Business Park
Spokane, Washington

File No. 0209800-001
13 August 2024

HALEY & ALDRICH, INC.
505 WEST RIVERSIDE AVENUE,
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SPOKANE, WA 99201
509.960.7447

SIGNATURE PAGE FOR

REPORT ON

SPOKANE INTERNATIONAL AIRPORT - GEOLOGY AND HYDROGEOLOGY
9000 WEST AIRPORT DRIVE
SPOKANE, WASHINGTON

PREPARED FOR

SPOKANE INTERNATIONAL AIRPORT
FELTS FIELD & AIRPORT BUSINESS PARK
SPOKANE, WASHINGTON

PREPARED AND APPROVED BY:

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Haley & Aldrich, Inc.

Breeyn Greer, P.E.
Senior Technical Specialist | Civil Engineer
Haley & Aldrich, Inc.

Table of Contents

HALEY ALDRICH

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1. Introduction

The objective of this report is to summarize the geologic and hydrogeologic framework around the Spokane International Airport (SIA) (Figure 1) as an Appendix to the Task 1.A “Site Assessment Report for Per-and Polyfluoroalkyl Substances (PFAS)” (Site Assessment Report) deliverable under Exhibit B “Scope of work and schedule” of Enforcement Order Number DE 22585 (EO), dated 29 March 2024. We understand that the Washington State Department of Ecology (Ecology) delivered the EO to the Airport Board City of Spokane/Spokane County (Airport Board) identifying them as the potentially liable party for the SIA PFAS Site (Facility Site ID 6332493, Cleanup Site ID 16774; the Site[1]). This report, as a component of the Site Assessment Report, will complete Task 1.A of the EO. This report provides a foundational understanding of the geologic and hydrogeologic framework around the Site and will help prepare a Site-specific geologic and hydrogeologic framework during the Final Remedial Investigation and Feasibility Study listed as Task 1.C in the EO.

Haley & Aldrich, Inc. (Haley & Aldrich) prepared this report by reviewing and compiling information from existing reports. This report relies mainly on data, reports, and information collected by the cited authors describing the geologic and hydrogeologic conditions around the Site and study area. This information has not been reinterpreted and will be used as a foundation to better understand the Site-specific geologic and hydrogeologic framework at SIA after future monitoring events at the Site, as required by the EO, are completed.

The study area for this report is located within the West Plains of western Spokane County, and the Site resides near the southeastern boundary of the West Plains as shown in Figure 1. The general location, Site area topography, geologic and hydrogeologic framework, and details of the limited available Site-specific geologic and hydrogeologic data are summarized in the following sections.

[1] The term ‘Site’ as used in this appendix refers to the main operational area within the SIA property boundary as shown in Exhibit A of the EO and presented in Figure 2 as Primary Airport Area and is not meant to define the Site boundary as defined by WAC 173-340-350. The Site boundary as defined by anywhere contamination has come to be located due to recent or historical releases at the SIA property (WAC 173-340-100) is undefined at the time of this report.

2. Site Location, Topography, and Landscape

The Primary Airport Area (Site) is located at the southwestern limit of the City of Spokane generally in Sections 5 and 6 of Township 24 North Range 42 East (T24N R42E) and Sections 28, 29, 30, 31, 32, and 33 of T25N R42E. For the purpose of this initial assessment, the Primary Airport Area is defined below and shown on Figure 2:

Northern Boundary: an unnamed road marking the northern boundary of Section 31 (T25N R42E) east from South Hayford Road to West Airport Drive; West Airport Drive east from the northern boundary of Section 31 (T25N R42E) to a point on the south side of the West Airport Drive onramp onto eastbound United States Highway 2 (US2) that lies south of the westbound US2 offramp underpass to West Airport Drive.

Eastern Boundary: the point on the south side of the West Airport Drive onramp onto eastbound US2 that lies south of the westbound US2 offramp underpass to West Airport Drive, south-southwest to the intersection of South Geiger Boulevard and West Garden Springs Road; South Geiger Boulevard south to the intersection with West Electric Avenue.

Southern Boundary: West Electric Avenue, west from the intersection with South Geiger Boulevard to the unnamed access road to 8520 West Electric Avenue; the unnamed access road to 8520 West Electric Avenue from West Electric Avenue looping north, west, and south back to West Electric Avenue at 9198 West Electric Avenue; West Electric Avenue west to intersection with West 53rd Avenue; West 53rd Avenue west to South Hayford Road.

Western Boundary: South Hayford Road, north from the intersection with West 53rd Avenue, to intersection with an unnamed road marking the northern boundary of Section 31 (T25N R42E).

The topography of the Site area is a relatively flat plain, gently sloping downward from an elevation of 2,390 feet above mean sea level (amsl) in the south Site area to approximately 2,290 feet amsl in the northeast Site area (Derkey et al., 2004; Hamilton et al., 2004). The landscape within the West Plains consists of mixed semi-arid shrub steppe grasslands, sparse mixed conifer forest and shrub steppe, barren rock surfaces, agricultural land, and urban-semi urban uses (GSI Water Solutions, Inc. [GSI Water Solutions] et al., 2015). The landscape around the Site also includes stormwater infrastructure and impermeable surfaces due to outcrops.

3. Geologic and Hydrogeologic Framework

The Site area lies in the West Plains in the northeast corner of the Columbia Basin. The West Plains is a physiographic region to the west of the City of Spokane, mostly lying in western Spokane County. The West Plains is bounded in the north by the Spokane River; bounded in the east by Marshall Creek, Latah Creek (formerly Hangman Creek), and the Spokane River; bounded to the south by upland buttes; and bounded in the west by the upland buttes and Spring Creek of eastern Lincoln County (McCollum and Pritchard, 2012); see Figure 1. Hydrogeologically, the West Plains region is unique in the eastern Columbia Basin in that groundwater generally flows from southwest to northeast. The West Plains is hydrogeologically separated from the greater Columbia Basin aquifer system by a divide that trends along the upland buttes of eastern Lincoln County, south and east along the upland buttes around Medical Lake and Four Lakes (Deobald and Buchanan, 1995); see Figure 1.

The regional geology of the northeast Columbia Basin consists of Precambrian metasediment and Cretaceous to Paleogene (K-Pg) intrusive basement rock (Deobald and Buchanan, 1995). The basement rock is cut by faults recording successive phases of pre-Miocene compression and tension. Along these faults, the Precambrian and K-Pg basement rock formed rugged paleotopographic highs (Soderberg et al., 2024). As Miocene flood basalts erupted, lava filled the valleys between these paleotopographic highs, leaving basement summits peaking though the surrounding lava. These upland buttes of basement rock surrounded by flood basalt are called buried hills or steptoes (Webster and Nunez, 1982; GWMA, 2009). Pleistocene glaciolacustrine and glacial flood deposits and Holocene alluvium overly the flood basalts that onlap the steptoes (Derkey et al., 2004; Hamilton et al., 2004).

Hydrogeologically, the basement rock has low permeability. As with the greater Columbia Basin, the West Plains aquifers are contained in units of the flood basalts, called the Columbia River Basalt Group (CRBG), and the overlying unconfined Pleistocene sediment (Deobald and Buchanan, 1995). The CRBG is frequently at the surface in the West Plains where it has been scoured by Pleistocene glacial floods, referred to here generally as Missoula Floods (Kiver et al., 2006). Understanding the CRBG stratigraphy and Missoula Flood deposits, which are presented in the following sections, is crucial to understanding the West Plains hydrogeologic system.

3.1 CRBG AND SEDIMENTARY INTERBEDS

The CRBG erupted during the Miocene (Kasbohm et al., 2023) and covers an area of greater than 81,000 square miles (mi^2) in Washington, Oregon, and Idaho (Reidel et al., 2013a). The greatest thickness of the CRBG is in the Pasco Basin of southeastern Washington where the CRBG is estimated to be 15,000 ft thick, but in the West Plains the CRBG thickness is less than 1,000 ft (Derkey et al., 2004; Hamilton et al., 2004; Burns et al., 2011).

The CRBG formations are formally referred to by their geographic designator followed by “Basalt.” Of the seven formal formations comprising the CRBG in the Columbia Basin (Reidel et al., 2013a), only two are found in the West Plains: the Grande Ronde Basalt and the overlying Wanapum Basalt. Across the Columbia Basin, the Grande Ronde Basalt consists of 25 members (Reidel and Tolan, 2013a) and the Wanapum Basalt consists of six members (Reidel et al., 2013a). However, the CRBG thins toward the basin edges, and in the West Plains there are only three members between the Grande Ronde and Wanapum Basalts. Derkey et al., (2004) and McCollum and Hamilton (2012) identify the Wapshilla Ridge and Sentinel Bluffs Members of the Grande Ronde Basalt and the Priest Rapids Member of the

Wanapum Basalt in both outcrop and well logs (see Figure 3). Reidel (2005) further divided the Sentinel Bluffs Member into six chemically distinct compositions.

During eruptive hiatuses, fluvial, lacustrine, pedogenic, volcaniclastic debris flow, and ash-fall deposits accumulated between flood basalts. These primarily sedimentary beds interfinger with the CRBG. Generally, the term for these sediments is the Ellensburg Formation in most of Washington and the Latah Formation toward Idaho (Swanson et al., 1979; Reidel et al., 2013a). The Ellensburg and Latah Formations are composed of many formal and informal sedimentary members and beds (Swanson et al., 1979) (see Figure 3).

3.1.1 Stratigraphic Architecture of the CRBG

More than 350 lava flows comprise the CRBG (Reidel et al., 2013a), each of which represents a single outpouring of lava (Self et al., 1996). Flows range from 10-300 feet thick (Tolan et al., 1989) and show repeated stratigraphic patterns, often consisting of the following: a sparsely vesicular flow bottom; a dense, jointed, and typically non-vesicular flow interior; and a vesicular, brecciated flow top (Reidel and Tolan, 2013a) as generally shown in Figure 4.

The pattern of flow bottom, flow interior, and flow top is often complicated by inflation, a process of lava flow emplacement where hot magma injects into the interior of a cooler, previously emplaced flow (Soderberg et al., 2024). The inflation process results in compound flows consisting of several individual lava flows stacked through internal emplacement rather than vertical superposition (Self et al., 1998). Individual flows within these compound flows may lack the complete sequence of flow bottom, flow interior, and flow top. Furthermore, porous zones of vesicles may form within the usually dense, non-vesicular flow interiors, but these instances lack the brecciation found in vesicular flow tops (Goff et al., 1996; Reidel et al., 2013a). This complexity is important for understanding the position and connectivity of aquifer zones.

Aside from the process of flow inflation, each successive lava flow stacked on top of the preceding flow. Sedimentary interbeds deposited during eruptive hiatuses (Reidel et al., 1989) (see Figure 5). CRBG stratigraphy does not always consist of horizontal stacked lava flows. Lava flow deposition followed paleotopography, filling in paleo-geomorphic depressions before ponding to form horizontal strata (Reidel and Tolan, 2013). Horizontal flows were frequently cut by paleochannels (Soderberg et al., 2024) related to the paleo-Columbia River drainage (Reidel and Tolan, 2013). Where lava flows deposited in fluvial or lacustrine environments, flow bottoms commonly consist of pillow basalts (Reidel et al., 2013a) consisting of highly porous and permeable hyaloclastite (Soderberg et al., 2024). Horizontal and extensive basalt flows also are cut by vertical feeder dikes that tend to regionally mass in swarms (Reidel et al., 2013b). Dikes are considered to be hydrologic flow barriers (GWMA, 2009).

On a regional scale, sedimentary interbeds are considered confining units while CRBG flow tops and flow bottoms form aquifers (Burns et al., 2011). However, locally, sedimentary interbeds may form significant aquifers (Lite, 2013; Taylor and Gazis, 2014). The hydrogeologic unit called an interflow zone is the combination of a lava flow top, any subsequently deposited interbed sediments, and an overlying flow base of the subsequent lava flow (Reidel et al., 2003). The hydrologic significance of interflow zones is their wide range of permeabilities (Lite, 2013), cementation (Gaylord et al., 1989), and connectivity (Reidel et al., 2003). Because of variation in the permeability and connectivity of interflow zones, they are referred to in this report as aquifer zones rather than discreet aquifers.

The hydrologic significance of CRBG stratigraphic architecture is the connectivity of porous and permeable flow tops and flow bottoms (Spane, 2013; Burns et al., 2016; White et al., 2020). Despite endemic jointing, flow interiors are considered confining units (Reidel et al., 2003; Burns et al., 2016; White et al., 2020) but may transmit groundwater through structurally controlled fracture networks (Jayne and Pollyea, 2018). Similarly, the thickness, extent, pinch-out patterns, and cementation of sedimentary interbeds influence both regional and local hydrology (Lite, 2013; Burns et al., 2011; Taylor and Gazis, 2014; Burns et al., 2016).

3.2 OVERBURDEN

Near surface or surficial overburden which overlies the CRBG generally includes sedimentary deposits and sedimentary rocks varying in thickness and origin (Drost et al., 1990). Across the Columbia Basin, these deposits consist of Pliocene and Pleistocene deposits of alluvium, colluvium, eolian, glacial, lacustrine, and peat deposits (Kahle et al., 2011) (Figure 5). In the West Plains area, these sediments are restricted to Pleistocene alluvium and glacial flood sediment (Derkey et al., 2004; Hamilton et al., 2004). In this report the overburden aquifer is synonymous with alluvial aquifer.

3.3 COLUMBIA BASIN HYDROGEOLOGIC FRAMEWORK

Kahle et al. (2011) divided the hydrogeologic framework of the Columbia Basin into four general regions as shown on Figure 6. The Columbia Basin hydrogeologic units generally consist of the confining basement, a series of aquifer zones consisting of interflows divided among the CRBG formations, significant interbed confining units between the CRBG formations, and an overlying unconfined aquifer in the Pleistocene alluvium and glacial flood deposits, also known as the overburden aquifer (Kahle et al., 2011). Local groundwater flow direction is dependent on stratigraphic architecture and structure. These local variables include the thickness, lateral extent, and internal continuity of interflows; the extension or truncation of interflows based on paleotopography; the presence of dikes or faults may act as barriers or conduits; and fracture networks that may compromise the confining capacity of basalt flow interiors.

3.4 WEST PLAINS GEOLOGY

3.4.1 West Plains Basement Hydrogeology

The basement rocks within the West Plains consist of a variety of crystalline rocks of igneous and metamorphic origin that span in age over 1.4 billion years old (giga annum-Ga) (McCollum and Pritchard, 2012; GSI Water Solutions et al., 2015). These rocks originated as either sediments, which had undergone compaction and cementation of pore space through a process called diagenesis, or as magmatic (igneous) intrusions, subject to mineral recrystallization during igneous cooling and/or metamorphism. The region was subjected to tectonic compression in the Cretaceous period followed by extension in the Eocene time which resulted in several periods of igneous intrusion, folding, normal and reverse faulting, and repeated reactivation of faults during periods of tectonic activity (McCollum and Pritchard, 2012). Several of these structural features are mapped in the West Plains area and are interpreted to influence the occurrence and topography of the basement units, as well as enhance groundwater flow.

These rocks are predominantly exposed in the bedrock buttes and hills (locally termed steptoes) within and surrounding the West Plains and represent the elevated portions of ancient paleotopography that was buried by CRBG flows in the Miocene time. The basement rocks appear to underlie each geologic unit within the West Plains. GSI Water Solutions et al. (2015) included a top of basement map using hydrographs of regional groundwater wells and geologic mapping by state and local agencies that indicates the top of bedrock elevation varies across the West Plains forming buried ridges in the subsurface that likely influence groundwater flow and aquifer compartmentalization; a general representative cross-section of buried ridges is shown in Figures 7. These buried highs appear to form the northern, southern, and western boundaries of the West Plains aquifer system, separating it from the regional Columbia Plateau Regional Aquifer System [CPRAS (GSI Water Solutions et al., 2015)].

Groundwater flow in the West Plains generally is from southwest to northeast, as opposed to a regional flow direction that is northeast to southwest in the majority of the Palouse Slope sub-province. Additionally, several northwest-southeast trending basement ridges are identified and create several sub-basins within the West Plains that influence groundwater conditions (Figure 8). GSI Water Solutions, et al. subdivided these basement ridges into four sub-basins including the Central Plains Subsystem where the Site is located. According to Figure 8, the SIA generally sits within the Medical Lake-Airway Heights Ridge and the Needham Hill Ridge creating a divide between the Central Plains Subsystem and the other subsystems within the West Plains.

3.4.2 West Plains CRBG

Two CRBG formations exist in the area: the overlying Wanapum Basalt and underlying Grande Ronde Basalt units (GSI Water Solutions et al., 2015). Individual members identified by others in the West Plains include the Priest Rapids Member of the Wanapum Basalt and the Sentinel Bluffs and Wapshilla Ridge Members of the Grande Ronde Basalt (see Figure 3).

Table 1. Basalt Stratigraphy in the West Plains

Wanapum Basalt	Priest Rapids Member
Grande Ronde Basalt	Sentinel Bluffs Member
	Wapshilla Ridge Member

Note:
Derkey et al. (2004); Reidel (2005)

Variations in geologic properties exist within and between individual basalt flows, as well as the occurrence of sedimentary interbeds between flows/members create a geologically complex stratigraphy that affects both horizontal and vertical heterogeneity of the basalt aquifer system of the West Plains. Identifying the areal extent and thickness of these formations is critical to understanding groundwater flow within the aquifer zones hosted in the CRBG formations. Sedimentary strata interbedded within the CRBG are collectively referred to as the Latah Formation (Figure 7).

3.4.2.1 Wapshilla Ridge Member, Grande Ronde Basalt

The lowest CRBG member in the West Plains is the Wapshilla Ridge Member of the Grande Ronde Basalt. Within the CRBG, the Wapshilla Ridge Member is the greatest volume of the Grande Ronde Basalt members and contains at least 18 individual basalt flows (Reidel and Tolan, 2013). Locally, the Wapshilla Ridge Member consists of several individual basalt flows and is only exposed in the lower reaches of incised creek valleys, such as the Deep Creek and Latah Creek valleys (Figure 9).

The Wapshilla Ridge flows were the first CRBG flows to be deposited the West Plains area and buried the existing paleotopography which was eroded into the basement rocks, filling valleys, and flowing around ridges and peaks. These flows encountered thick deposits of Miocene-age sediments of the Latah Formation that were deposited over the basement rocks, forming extensive pillow basalt at the base of the flows (McCollum and Pritchard, 2012). A period of erosion and alluvial deposition followed emplacement of the Wapshilla Ridge flows, resulting in hundreds of feet of relief and extensive Latah Formation sediments between it and the overlying flows of the Sentinel Bluffs Member (McCollum and Hamilton, 2012). The top of the Wapshilla Ridge Member was mapped in the subsurface by Pritchard (2013) using well log data and “whole rock” geochemistry and is shown as sloping down to the east-northeast, dropping from 1,950 feet amsl at the bedrock highs in the south and west of the West Plains to lower than 1,700 feet amsl at the bottom of the Latah Creek and Spokane River Valleys.

3.4.2.2 Sentinel Bluffs Member, Grande Ronde Basalt

Basalt belonging to the Sentinel Bluffs member of the Grande Ronde Formation overlies the Wapshilla Ridge Member across the West Plains. The Sentinel Bluff Member is identified as the “upper Grande Ronde Basalt” hydrogeologic unit by GSI Water Solutions et al. (2015) and contains several interbeds of Latah Formation sediments. Each flow is bounded by a vesicular flow top and massive base that overlies either the vesicular top of the flow below or a sedimentary layer. Flow thickness ranges from 26 to 88 feet, and the vesicular flow top of the Airway Heights flow is up to 45 feet thick (Reidel, 2005). Where exposed, the three flow units have well-developed entablatures and colonnades exposed in the West Plains but can exhibit blocky jointing near the flow edges (Reidel, 2005).

The upper surface of the Sentinel Bluffs Member is mapped by Pritchard (2013) as between approximately 2,300 and 2,000 feet above amsl, except where ridges of basement rock extend above ground surface or where erosion has incised into underlying units (Figure 9). Total thickness of the Sentinel Bluffs unit can be quite variable due to irregular erosion of the upper contact and underlying topography at the time of emplacement (Reidel, 2005). The underlying Wapshilla Ridge Member flows blocked drainages and created extensive lakes, which formed lacustrine and alluvial deposits that were invaded by Sentinel Bluff flows, which “buried” into soft sediments during emplacement (McCollum and Hamilton, 2012).

3.4.2.3 Priest Rapids Member, Wanapum Basalt

The Wanapum Basalt is the uppermost CRBG formation in the West Plains and consists of one to four flows of the Priest Rapids Member emplaced approximately 14.5 to 15.3 Ma (Derkey et al., 2004). This formation is generally found between approximately 2,300 feet and 2,450 feet amsl across the West Plains and forms the capping unit that overlies all other basalt flows (SCWR, 2013). The total thickness is up to 250 feet thick (SCWR, 2011); however, it is not present in areas where the flows thin and onlap basement rocks that extend above ground surface or where this unit has been removed by erosion (SCWR, 2013). In general, the top of the Wanapum Basalt gently slopes eastward toward the Spokane River valley, and individual units dip to the east-northeast (GSI Water Solutions et al., 2015).
The top of the Wanapum Basalt was heavily eroded by glacial-outburst megafloods at the end of the last glacial period; these events incised several paleochannels that subsequently were filled with later megaflood and recent alluvial sediments (see Figure 1). Some reaches of these paleochannels appear to fully incise locally through the Wanapum Basalt and into the underlying units (GSI Water Solutions et al., 2015;). Several creek channels, such as the Deep Creek, Marshall Creek, and Coulee Creek canyons, fully penetrate the Wanapum Basalt in the West Plains.

3.4.2.4 Latah Formation

Throughout the Columbia Plateau, a wide variety of sedimentary strata are interbedded within the CRBG as the lava flows buried existing sediments, dammed natural drainages, and were subjected to erosion after emplacement creating accommodation for sediments to accumulate on the surface of the flow. These sedimentary deposits collectively are referred to as the Latah Formation in eastern Washington and Idaho and are correlative to other sedimentary formations interbedded with the CRBG flows, such as the Ellensburg Formation in the western Columbia Plateau (Reidel et al., 2013).

The Latah Formation deposits in the West Plains were formed in river and lake systems prior to and after CRBG flow emplacement (GSI Water Solutions et al., 2015). The Latah Formation interbeds observed in the Palouse Slope region, including in wells drilled within the West Plains, are commonly 20 feet thick but can vary from 1 to 200 feet thick and are predominantly described as clays and silts that can locally be cemented, forming relatively hard, 0.5- to 2-foot-thick shale and siltstone layers (Northwest Land & Water, Inc. [NLW], 2011; NLW, 2012). Sandy to gravelly deposits are described throughout the Latah Formation as isolated layers within CRBG units but typically occur in direct contact with clays (NLW, 2011). Because of the variable composition of Latah Formation interbeds, they can locally behave as either aquifer or aquitard units.

Due to the nature of these deposits, they are also laterally variable in the subsurface and are shown thickening, thinning, and pinching out in cross-sections based on publicly available well logs (NLW, 2011; NLW, 2012; McCollum and Pritchard, 2012; GSI Water Solutions et al., 2015;). In the West Plains area, informal subdivisions of the Latah Formation have been variably applied based on their stratigraphic position between the CRBG unit (GSI Water Solutions et al., 2015):

- Latah I - Sediments between Wanapum Basalt and Grande Ronde Basalt
- Latah II - Sediments between the Sentinel Bluffs Member and Wapshilla Ridge Member of the Grande Ronde Basalt
- Latah III - Sediments between the Grand Ronde Basalt and the Basement Rocks

Complications can arise when using these Latah subdivisions, because in addition to the numbered subdivisions, unnumbered interbeds can and do occur within individual CRBG units. Additionally, because they are not defined by their lithological characteristics and instead by the correct identification of the bounding CRBG units, separate named units cannot be identified where CRBG units either are missing or cannot be determined by lithological or geochemical identifiers.

3.4.3 Glacial Outburst Flood Deposits and Alluvium

Sedimentary strata overlying the CRBG in the West Plains consist predominantly of Pleistocene glacial-outburst flood deposits, Pleistocene loess, and Pleistocene to Holocene-aged (11,700 years before present to present) alluvium (GSI Water Solutions et al., 2015). During the last glacial period, the Purcell Trench lobe of the Cordilleran Ice Sheet periodically formed an ice dam near the Idaho-Montana border approximately 70 miles upstream from the West Plains and impounded glacial Lake Missoula. Between 17,500 to 14,500 years before present, this dam repeatedly failed releasing glacial-outburst megafloods that flowed down the Spokane River valley and across the West Plains and deposited high-energy flood deposits that the Spokane Valley Rathdrum Prairie Aquifer now inhabits. These megafloods produced erosional features in the underlying basalt, including steep sided canyons called “coulees,” dry falls, cataracts, and potholes across the Columbia Plateau in areas that are now called the Channeled

Scablands (Baker, 2009). The megafloods also deposited widespread gravel fan and bar accumulations, gravel-dominated megaripples, and thick successions of sand, silt, and clay-rich slackwater deposits (Waitt, 2017).

GSI Water Solutions et al. (2015) subdivided these sediments into two hydrogeologic units based on their granular characteristics: coarse-grained Quaternary deposits and fine-grained Quaternary deposits. The coarse Quaternary deposits consist of silt, sand, and gravel deposited predominantly by Pleistocene glacial outburst floods and by stream reworking of flood deposits. These Quaternary deposits generally are located within and near coulees, streams, and river canyons, and steep cliffs cut into CRBG basalt and basement bedrock. Fine-grained Quaternary deposits consist predominantly of silt, silty sand, and fine, sandy loess. These materials mantle many of the hills and valleys in the northern and western portions of the West Plains and are largely absent from coulees and drainages.

Five northeast- to southwest-trending, sediment-filled paleochannels on the West Plains were carved from glacial-outburst megaflood channels trending north and east from the steptoes along the southern West Plains as shown on Figure 1 (Deobald and Buchanan, 1995; Budinger and Associates, 2001; Pritchard, 2013; Osborn et al., 2021). These paleochannels are approximately 3 to 12 miles long by 0.3 to 1.5 miles wide and can be several hundred feet deep, incising into the upper Wanapum Basalt and occasionally into the underlying Latah Formation (Latah I subdivision) and Grande Ronde Basalt (Pritchard, 2013). The sedimentary deposits that fill the West Plains paleochannels contain from several feet to greater than 300-foot-thick successions of poorly to moderately sorted, relatively clean gravelly and sandy sediment containing massive, horizontal strata, and low- to high-angle planar cross-strata (Derkey et al., 2004; GSI Water Solutions et al., 2015; Osborn et al., 2021). Paleochannel deposits generally dip 10 to 20 degrees to the west-southwest and are different in alignment from the southwest-northeast orientation of the paleochannels (Pritchard, 2013). These cross-stratified sedimentary deposits may locally influence groundwater movement.

Reworking of glacial-outburst megaflood sediments during the latest Pleistocene and Holocene produced variable alluvial and colluvial deposits across the West Plains. These post-megaflood sedimentary deposits also served as sources for eolian sand dunes and loess deposits that mantle much of the West Plains and obscure the extent of the underlying paleochannel deposits (Hamilton et al., 2004). The eolian sedimentary deposits include inches-thick to several-feet-thick accumulations of loess and northeast-trending parabolic dunes in the western West Plains (Hamilton et al., 2004).

3.4.4 Structural Geology

Surface geologic maps of the West Plains area indicate little to no major structural deformation of surficial geologic units, however, major structural features mapped outside of and shown projecting into the West Plains include the Latah Fault, St. Joe Fault, Minnie Creek Lineament, and the Jump Off Joe Fault (GSI Water Solutions et al., 2015) (Figure 10). These faults and structural features are discontinuously mapped within the underlying basement rock units and likely continue into the West Plains, influencing the distribution of geologic units, providing structural weakness for preferential erosion, and acting as pathways for groundwater flow within the basement rocks. For example, the Latah Fault is mapped following a 50-mile-long linear feature that trends north-northwest which corresponds to the valley of Latah Creek and the Spokane River and forms the eastern boundary of the West Plains (Figure 10).

While the faults exposed in basement rocks are shown to have several thousands of feet of either vertical or horizontal offset; no deformation has been observed in the exposed CRBG units within the West Plains (McCollum and Pritchard, 2012). These faults are related to pre-Miocene orogenic events that influenced the observed paleotopography that formed ridges and steptoes (Soderberg et al., 2024); this paleotopography influences regional groundwater flows.

High density fracture zones of the Cheney Fracture Zone are observed in the CRBG units to the southwest in the Cheney-Palouse Scabland Tract and have a similar orientation as mapped basement faults. This indicates that younger faults and folds associated with basement faults projected into the West Plains either are missing or overlain by the surficial cover in the West Plains region (McCollum and Pritchard, 2012).

3.5 WEST PLAINS HYDROGEOLOGY

As discussed above, the West Plains is at the northeast margin of the CPRAS and generally shares the same conceptual hydrogeology: unconfined aquifers are hosted in overburden deposits overlying the basalt and bedrock units, while generally confined aquifers are hosted in water-bearing intervals within basalt interflow zones and interbedded Latah Formation sediments (GSI Water Solutions et al., 2015). As discussed in Section 3.4, the West Plains aquifer system appears to be cut off from the larger CPRAS and is an isolated basin surrounded by basement rocks on the south and west (see Figure 8) and by the Spokane River and Latah Creek on the north and east (see Figure 1). As a result, the general groundwater flow direction in the West Plains is toward the east-northeast, as opposed to the west-southwest direction of much of the CPRAS (SCWR, 2013). Groundwater recharge is therefore dependent on local surface recharge areas, and basement highs also create sub-basins within the West Plains that may be isolated from each other (Section 3.4.1, Figure 8).

Well data indicates depth to water in the West Plains varies geographically from tens of feet to several hundred feet below ground surface (bgs) (GSI Water Solutions et al., 2015). In addition to geographic location, variability of observed groundwater elevations also is influenced by the water-bearing zone or zones that wells are completed in. Further discussion of the hydrogeology of each of these hydrogeologic units is provided below.

3.5.1 CRBG Aquifer System

Based on a review of previous studies and water level data from Spokane County, GSI Water Solutions et al. (2015) identified three basic parts of the basalt aquifer system in the West Plains generally corresponding to (from top to bottom) the Wanapum Basalt (Priest Rapids Member), the upper Grande Ronde Basalt (Sentinel Bluffs Member), and the lower Grande Ronde Basalt (Wapshilla Ridge Member). In general, aquifer zones in the CRBG are approximately 1 to 25 feet in thickness and are limited in lateral extent to less than 1 mile (SCWR, 2011; NLW, 2012). The flows also are locally interbedded with sedimentary deposits resulting in multiple “stacked” aquifers that are confined to semi-confined, forming potentially connected aquifer zones within each CRBG unit (NLW, 2012; SCWR, 2013).

Groundwater is hosted primarily in the joints, vesicles, fractures, brecciated flow tops and bottoms, and sedimentary (Latah Formation) interbeds within the interflow zones of the basalt units. Lateral conductivity in these interflow zones is dependent on the thickness of the basalt, location within a flow, and the scale and density of folds and faults. The dense basalt flow interiors, which make up 90 to 95 percent of the typical total flow volume, host limited amounts of groundwater in fully penetrating joints and fractures (GSI Water Solutions et al., 2015) and can act as an aquitard in many cases (Lindholm and Vaccaro, 1988).

Lateral hydraulic conductivity of the flow tops and bottoms ranges between 1 x 10^{-6} to 1,000 feet per day (average 0.1 foot per day) (GSI Water Solutions et al., 2015). In contrast, vertical and horizontal hydraulic conductivities of the dense interiors are 6 to 9 orders of magnitude less (GSI Water Solutions et al., 2015). This implies that lateral groundwater flow in the CRBG units primarily is through the interflow zones and is therefore parallel to these units. Vertical groundwater movement is inferred to be influenced by several factors, including: fractures and joints within the dense flow interiors, at the edges of flows where interflow zones join, and/or through faults, if present. The vertical hydraulic gradient in the West Plains is predominantly downward and ranges from 0.2 to 1.2 (unitless; NLW, 2012). Additionally, modern creek valleys and paleochannels deeply dissect the CRBG, and buried basement ridges influence aquifer extents in the CRBG aquifer system.

3.5.1.1 Wanapum Basalt Aquifer

The uppermost basalt-hosted aquifer zone on the West Plains is located within the lower portion of the Priest Rapids Member of the Wanapum Basalt and locally within sand-rich interbeds of the Latah Formation interbed. Groundwater levels in the Wanapum Basalt aquifer decrease to the east, with potentiometric elevations ranging between 2,350 and 2,450 feet amsl in the western West Plains to approximately 2,300 feet amsl in the eastern part of the West Plains (GSI Water Solutions et al., 2015). Groundwater levels are influenced by modern streams and creek valleys with groundwater flow shown deflecting toward canyons and interrupting lateral flow (SCWR, 2013). The Latah I interbed generally consists of clay with variable sand and gravel and is up to 120 feet thick in the West Plains, functioning primarily as a confining unit separating the upper Wanapum Basalt aquifer zones from the Grande Ronde aquifer zones in some locations (TetraTech, 2007).

3.5.1.2 Grande Ronde Basalt Aquifers

Two aquifer zones are hosted in the Grande Ronde Basalt in the West Plains, one in the Sentinel Bluffs Member and underlying interbed (Latah II) and another below the Wapshilla Ridge Member (GSI Water Solutions et al., 2015). The upper surface of the Wapshilla Ridge Member is densely fractured and eroded, with deposits of the Latah II formation discontinuously overlying the upper surface. The lowermost aquifer zone is largely confined due to the relatively massive and impermeable flow interiors of the Wapshilla Ridge Member flows, as well as silt and clay deposits of the Latah III interbed.

Based on wells screened in the Grande Ronde Basalt, potentiometric elevations in the West Plains have a greater range; upgradient elevations range between 2,200 and 2,300 feet amsl, while downgradient elevations generally are less than 1,800 feet amsl (GSI Water Solutions et al., 2015). Groundwater flow follows the general dip of the upper Grande Ronde surface toward the east-northeast with little to no influence from stream canyons, except at the furthest east zone near the Spokane River (GSI Water Solutions et al., 2015).

3.5.2 Overburden Aquifer System

The overburden aquifer system in the West Plains consists of unconfined groundwater within glacial-outburst flood and alluvial sediments overlying basalt and/or basement rocks, with the thickest deposits found in both present day canyons and ancient paleochannels (TetraTech, 2007; GSI Water Solutions et al., 2015; Osborn, 2021). Elsewhere, alluvial aquifers are thin (less than 10 feet thick) and typically occupy shallow depressions in the surface of the Wanapum Basalt. The distribution of saturated alluvial sediments is discontinuous, with little to no lateral continuity between separate areas (GSI Water Solutions et al., 2015). The irregular elevation of the upper contact of the Wanapum Basalt creates high hydraulic gradients where high-conductivity gravel and sand deposits are juxtaposed with relatively low-permeable basalt.

Hydraulic conductivity of the alluvial sediments is controlled by the variation of coarse-grained (sand and gravel) and fine-grained (silt and clay) sediments. Where present, coarse-grained deposits generally will have higher hydraulic conductivity and transmissivity than fine-grained sediments. Hydraulic conductivity in coarse outburst-flood deposits ranges from hundreds to thousands of feet per day (0.03 to greater than 0.35 centimeters per second [cm/s]), with transmissivity of 10,000 to more than 100,000 square feet per day (900 to more than 9000 square meters per day) (GSI Water Solutions et al., 2015). Values for fine- grained sediments can be three to five orders of magnitude lower than the coarse-grained sediments (GSI Water Solutions et al., 2015).

3.5.3 Paleochannels

As discussed in Section 3.4.3, five northeast- to southwest-trending, sediment-filled paleochannels are present in the West Plains (see Figure 1) and are a significant part of the overburden aquifer system. Depth to water and aquifer thickness varies based on the elevation of the top of the basalt but likely is several tens of feet or more (GSI Water Solutions et al., 2015). In the development of the West Plains Stormwater Action Plan, Osborn et al. (2021) summarized and built upon work by others to assess the physical and hydrogeologic characteristics of two of the paleochannels closest to the project site (Airway Heights and Northeast Paleochannels). Paleochannel boundaries shown on Figure 1 are based on Osborn, et al. (2021), and are subject to revision based on forthcoming investigations.

The hydraulic conductivity property of the sediments within the paleochannels generally are higher than in the surrounding basalt bedrock (GeoEngineers, 2021; NLW, 2012; Osborn et al., 2021). Based on the references reviewed for this report, the interaction between aquifers hosted in paleochannel deposits and CRBG-hosted aquifer is poorly constrained in the West Plains and likely is dependent upon highly variable, location-specific conditions, such as (but not limited to): depth to basalt, groundwater elevation, aquifer characteristics, and lithologic composition of geologic units. Regional studies estimated hydraulic conductivities range between approximately 100 and 6,000 feet per day for glaciofluvial deposits in Spokane County (Bolke and Vaccaro, 1981; CH2M Hill, 1998). The high hydraulic conductivity paleochannels are a potential preferential flow path for both the overburden aquifer systems and CRBG-hosted aquifer zones. Osborn, et al., (2021) and GeoEngineers (2021) interpret the unconfined aquifers within these paleochannels generally act “as a drain resulting in subsurface discharge from the Wanapum Unit into the paleochannel” due to the aquifers’ relatively high permeability and low hydraulic head. Geochemical and groundwater elevation data presented in NLW 2012 and NLW 2014 led the authors to infer that preferential flow from paleochannels allow “younger water to be introduced into the deeper groundwater within the Grande Ronde” (see Section 4.4 for discussion of geochemical data). However, GSI Water Solutions et al. (2015) interpreted hydrographs of water wells as showing limited to “no significant influence on the basalt groundwater system beneath the incision depths of the paleochannels”. Based on review of available references, it is our understanding that the hydrogeologic variability indicates preferential flow paths might exist between the paleochannel aquifers and the CRBG-hosted aquifers at select locations, elevations, and/or basalt flow structure (i.e., flow tops, bottoms).

3.5.3.1 Airway Heights Paleochannel

The Airway Heights paleochannel is the longest paleochannel within the West Plains based on historical information. The eastern edge of the paleochannel is located approximately 1.5 miles west of the Site and the western edge of the paleochannel is adjacent to Fairchild Air Force Base (FAFB). The paleochannel generally trends north-northeast starting near I-90 and extends toward the Spokane River valley, a potential discharge area according to GeoEngineers (2021) and Osborn et al. (2021). The maximum sediment thickness in the Airway Heights paleochannel averages between 100 and 300 feet across its length, increasing from about 50 feet to greater than 300 feet from south to north (Osborn et al., 2021). Based on cross-sections presented in Pritchard (2013), the Airway Heights Paleochannel locally incises through the Wanapum Basalt and into the uppermost Grande Ronde Basalt.

Groundwater flow is thought to flow downgradient toward the north-northwest within the paleochannel (GeoEngineers, 2021; Osborn, et al., 2021). Minimum unconfined aquifer thickness was measured between 89 and 125 feet in water supply wells for the City of Airway Heights (GeoEngineers, 2021) and generally is estimated to be about 100 feet thick south of the City of Airway Heights (Osborn et al., 2021). Hydraulic conductivities from pump tests conducted within the Airway Heights paleochannel water-bearing zone were estimated to range between 490 and 770 feet per day (GeoEngineers, 2021).

3.5.3.2 Northeast Paleochannel

The southern extent of the Northeast Paleochannel potentially is located within the northeastern boundary of the Site (Budinger and Associates, 2001; Derkey et al, 2004; Osborn et al., 2021) and generally extends to the north-northeast, terminating approximately 4 to 5 miles northeast of the Site at a suspected discharge area to the Spokane River Valley (Osborn et al., 2021). This paleochannel is the deepest of the five paleochannels identified in the West Plains: Ecology well logs indicate glaciofluvial deposits are up to 429 feet deep within the paleochannel boundary (Osborn et al., 2021). Based on cross-sections presented in Pritchard (2013), the northeast paleochannel appears to incise through the Wanapum Basalt and into the uppermost Grande Ronde Basalt along most of its length. Unconfined aquifer thicknesses have been locally reported to range between 63 and greater than 98 feet (Osborn et al., 2021), but hydrogeologic parameters generally have not been established for the Northeast Paleochannel.

4. SIA Hydrogeologic Framework

Additional Site-specific data should be collected to better understand the geologic and hydrogeologic framework at the Site. Additional data collection will help provide a better understanding of the geologic contacts, depths, and lithology, the hydrogeologic characteristics (i.e., groundwater flow direction, hydraulic gradient, etc.), and potential pathways that likely attribute fate and transport of potential contaminants of concern. However, to prepare for a future Site-specific geologic and hydrogeologic assessment, Haley & Aldrich reviewed publicly available geologic data from adjacent properties and Site-specific data provided by the Airport Board, including: 23 boring logs, drilling logs, and/or well installation logs from the Site.

Because monitoring well names are similar, appear repetitive, and can be difficult to distinguish, Haley & Aldrich divided Site boring log data into six areas within the Site boundaries. The six areas, area abbreviations (in parentheses below), and area descriptions are summarized below and shown on Figure 2.

- The Land Treatment Area (LA), located near the northwest boundary;
- The West Peripheral Area (W), located near the west-southwest-central boundary;
- Joint Fire Training (EA), located near the southern boundary;
- The Stormwater Recovery Area (SWN), located near the northeastern boundary;
- The Park Drive Waste Disposal Area (PD), located near the east-central boundary; and
- The Southeast Area of Business Park (FGF), located near the east-central boundary.

The Electric Avenue area is a location where firefighting training was conducted jointly between SIA, Air National Guard, and Army National Guard (Joint Training Area) prior to 1999 and the current location of the Air National Guard. Area abbreviations have also been added to monitoring well names to distinguish between redundant well names.

4.1 SITE GEOLOGY AND HYDROGEOLOGY

Based on our review of the available boring logs and geologic maps, the geology at the Site generally consists of sedimentary overburden deposits (mostly sand to silty sand with gravels and a silt zone toward the northwest boundary of the Site) from the ground surface that are underlain by the CRBG at variable depths across the Site. The geologic map used in our review is provided in Appendix A.
The southeastern boundary of the Airway Heights paleochannel parallels the western portion of the Site and is located approximately 1.5 miles west of SIA. The extent of the southern point of the Northeast Paleochannel is unknown but generally exists within the north side of SIA (according to Osborne et al., 2021) and the Marshall paleochannel is located approximately 5 miles south of the Site.

Boring logs for the Land Application area suggest that the overburden consists of an approximate 10-foot-thick silt zone starting at or near the ground surface that is underlain by sand/gravel to silty sandy gravel, with some clay zones approximately 5 feet thick (MW-8 [LA-MW-8] in Appendix B). The overburden within this area ranges from 12 feet to 20 feet thick and is underlain by weathered to competent basalt. Seasonally high groundwater was reported to be less than 10 feet bgs by Cascade

Earth Sciences (CES), 2018. CES concluded that groundwater flow direction in the Land Application area was to the northwest.

Overburden within the Western Peripheral area consists of silty sand to sand/gravel and is approximately 8.5 to at least 25 feet thick toward the south of the area (note: monitoring well MW-17 [W-MW-17] is the deepest boring within this area and bedrock was not encountered during drilling). Consequently, and when compared to the boring logs located near the Electric Avenue area at the Joint Training Area, it appears that the overburden/ basalt contact increases with depth toward the southwest of the Primary Airport Area.

The boring logs from the Joint Fire Training Area indicate that the overburden consists of silty sand and gravel with potential fill material to approximately 16 to 25 feet bgs[2]and is underlain by basalt. ERM, Inc., 1996, reported the Electric Avenue area previously was used as a landfill and that overburden and fill is reported in boring logs to a depth of 24 feet bgs. Depth to water has been observed in this area at between 14 and 20 feet bgs in wells screened in overburden and 19 to 26 feet bgs in wells screened in basalt (ERM, Inc., 1996).

In the Stormwater North area and the Park Drive area, the overburden consists of silty sand to sand/gravel, is approximately 4 to 18.5 feet thick and is underlain by basalt.

The Former Geiger Field area contains one boring, MW-18 [FGF-MW-18], that currently is assumed to be within the investigation boundary of the Site. At MW-18 [FGF-MW-18], the overburden is approximately 11 feet thick, consists of silty gravel and sand, and is underlain by weathered basalt. Northeast of MW-18 [FGF-MW-18] and within the Former Geiger Field area is the Geiger Corrections Facility cleanup site (Facility/ Site No. 663, VCP No. EA0263). Shallow aquifer wells are reported to have a depth to water of 2.15 to 12.57 feet bgs with a flow direction to the northeast; deeper aquifer wells are reported to have a depth to water of 10.30 to 38.50 feet bgs with a flow direction of east to northwest (GHD, 2023).

In summary, the overburden thickness can range between 4 feet and 32 feet across the Site and primarily consists of silt, silty sand to sand, and gravels (excluding the potential fill material identified at MW-13A [EA-MW-13A]). The depth to basalt under the overburden generally is deeper in the southwest of the Site and shallower in the Stormwater North area to the northeast.

4.2 WRIA 54 GEOLOGIC CROSS-SECTIONS

Haley & Aldrich reviewed the West Plains Hydrogeologic Data Base report cross-sections (specifically Cross Sections R-R' through V-V' near the Site's footprint) prepared for the WRIA 54 Phase IV Implementation Project (WRIA Project) to assess the general depths of Site geologic units and compare them to Site boring logs. The cross-sections used in our review are provided in Appendix C).

Based on our review, the overburden thicknesses from the WRIA Project generally are in agreement with Site boring logs. The WRIA cross-sections indicate that overburden is less than 40 feet thick and overlies the Wanapum Basalt formation of the CRBG, indicating that the basalt encountered during drilling at the Site likely is the Wanapum Basalt formation. Furthermore, the "Latah I" formation likely is

[2] One exception is at monitoring well MW-13A [EA-MW-13A] where fill may extend to 32 feet bgs. MW-13A [EA-MW-13A] boring log indicates "trace charcoal and leaves" between 17.5 feet and 32 feet bgs, indicating that fill likely is present).

between 100 feet and 200 feet bgs overlaying the Grand Ronde basalt formation. Based on the WRIA Project, the top of the Grand Ronde basalt likely is greater than 200 feet bgs at the Site and the thicknesses is approximately 200 feet (based on Cross- Sections R-R', S-S', and T-T'). According to the WRIA Project, the "Latah II" formation underlies the Grand Ronde basalt unit below the Site footprint and is approximately 50 feet thick overlaying the Basement Rock.

4.3 STORMWATER RUNOFF AND PREFERENTIAL FLOW

Haley & Aldrich reviewed the West Plains Stormwater Action Plan (stormwater plan) (Osborn et al., 2021) to assess potential transport mechanisms, and potential recharge/discharge areas of the West Plains. The surface flow paths in the West Plains are influenced by the relatively flat topography, with a slight slope from the southwest toward the northeast, and varies locally based on locations of basement ridges and the CRBG surface/near-surface topography.

According to the stormwater plan, precipitation in the West Plains ranges from less than 10 inches per year to more than 22 inches per year and much of the precipitation occurs as snow. The wet season is defined as November through March (Osborn et al., 2021) and the majority of precipitation falls on frozen ground or as snow resulting in rapid runoff and minimal infiltration to groundwater.

Approximately 85 percent of West Plains precipitation is lost to evaporation, evapotranspiration, and runoff (Osborn et al., 2021). Groundwater around the Site generally is recharged by precipitation or stormwater runoff and groundwater flow typically occurs within glaciofluvial deposits (i.e., paleochannels or overburden overlying basalt), individual basalt flows (transmitted through fractured and vesicular interflow zones near the top of each flow), and/or within the basement rock (within fractured and/or weathered zones) (Osborn et al., 2021).

Site-specific stormwater flow pathways and recharge/discharge areas were interpreted from SIA's Stormwater Pollution Prevention Plan (SWPPP; Valley Science and Engineering, 2022). Based on the SWPPP, stormwater at the Site is collected in two primary collection areas: the Alpha Collection Area and the 3-21 Collection Area. A third minor collection area, referred to as Perimeter Drainage area, also drains to the northeast. All three of these collection areas discharge to the northeast of the airport property into a stormwater recovery area (for infiltration and/or evaporation). Additional data collection will result in a better understanding of stormwater discharge as a potential contributor to potential contaminant fate and transport at the Site.

Stormwater runoff near the northeastern corner of the Site generally flows and discharges into drainage ditches and nearby shallow ponds and depressional wetlands ponds without continuous drainage systems (Osborn et al., 2021). Surface water discharged into this area likely evaporates or infiltrates through preferential pathways within the overburden and/or basalt.

4.4 GEOCHEMICAL DATING AND LOCALIZED GROUNDWATER LEVELS

Between 2010 and 2014, NLW installed and collected groundwater samples from wells in the West Plains for the Spokane County Conservation District (NLW, 2012; NLW, 2014). The intent of this work was to develop a groundwater flow model of the hydrogeologic system in the West Plains and lower Hangman Creek watersheds and evaluate potential limitations on long-term water supply. Using stable and radioactive isotope data from analyzed groundwater samples, the source and age of groundwater recharge, as well as the degree of mixing between aquifers, can be inferred. At a high-level, 'old' water indicates a longer residence time and potential limitations on groundwater recharge under pumping conditions. 'Young' water indicates a shorter residence time and may be a less limited resource. Additionally, the presence of hydrogen isotope and tritium indicates the presence of groundwater that likely recharged within the last 70 years. GSI Water Solutions et al. (2015) reviewed and summarized this age-dating analysis by area and the two closest study areas to the Site (Marshall Creek Area [located to the southeast of the Site] and the Central West Plains Area [between FAFB and SIA]) are summarized below.

4.4.1 Marshall Creek Area

According to GSI Water Solutions et al. (2015), the Marshall Creek Area comprises the southeastern portion of the West Plains, encompassing Marshall Creek Canyon and adjacent areas. The basement highs associated with Needman Hill (Needman Hill Ridge area; Figure 8) bound much of the western side of the Marshall Creek area. The eastern boundary follows Latah Creek valley at the eastern boundary of the West Plains.

Five Marshall Creek area wells were evaluated, including two wells installed within alluvial overburden, with open-well intervals approximately 60 to 78 feet and 230 to 240 feet bgs, respectively. The other three wells were installed within the CRBG units, Wanapum, and/or Grande Ronde, with open-well intervals ranging between 100 and 440 feet bgs. The bottom of the wells installed within the CRBG units ranged between 137 feet and 440 feet bgs. Out of these five wells, two water samples were collected and analyzed for age-dating using Carbon-14 and/or tritium analyses: one from the overburden aquifer and one from groundwater hosted in the Grand Ronde Formation. Analytical results indicate that the overburden groundwater estimated age was approximately 3,470 years and the Grand Ronde groundwater estimated age was approximately 10,670 years (GSI Water Solutions et al., 2015; NLW, 2014). The presence of tritium in groundwater samples from the basalt-hosted aquifer zones indicates that the physical age of the 'old' water likely is significantly greater than the apparent age of the sample and that the aquifer experiences some mixing of 'younger' water (NLW, 2012; NLW, 2014).

4.4.2 Central West Plains Area

The Central West Plains area comprises the geographic area generally bounded to the west by FAFB, to the south-southwest by basement highlands around Medical Lake and Four Lakes (Figure 1 and Figure 8), to the southeast and east by the basement rock associated with Needham Hill, to the west by the SIA, and to the north by US-2 (GSI Water Solutions et al., 2015). According to GSI Water Solutions et al., this area hosts (or has hosted) production wells for three primary municipalities and consists of several monitoring wells that monitor shallow and deep basalt zones.

During this study, 21 Central West Plains Area wells with long-term water level records were evaluated within this area (with approximately 11 of the monitoring wells located at Craig Road Landfill west of the Site). This area includes one well installed within the overburden aquifer, 20 wells installed within Wanapum and/or Grand Ronde aquifer zones, and one well installed within the Basement aquifer unit (Four Lakes School). The bottom of the well installed within the overburden aquifer is approximately 27 feet bgs, and the bottom of the wells installed within CRBG aquifer zones were installed between 82 feet bgs and 1,404 feet bgs. The bottom of the well installed within the Basement aquifer unit was installed at approximately 200 feet bgs. Based on our review, samples from three wells were collected and analyzed for age-dating; two from the Wanapum/Grand Ronde and one with a well depth and unknown open-well interval. Analytical results indicate that the water within CRBG aquifer zones ranged between 1,490 and 10,670 years. The wide variability in estimated groundwater age may be due to the mixing of younger water via preferential flow paths and/or multi-aquifer wells into the CRBG aquifer zone (NLW, 2012; NLW, 2014).

In summary, groundwater age dating in the West Plains suggests that the rate of recharge to the CRBG aquifer system is relatively slow, and groundwater present more than several hundred feet deep displays geochemical characteristics indicative of residence time in the subsurface of hundreds to thousands of years (Osborn et al., 2021). The time required to recharge CRBG aquifer system likely is dependent on preferential flow paths (i.e., fractures, vesicles) and is greater than the time required to recharge the surficial overburden aquifer system. The presence of tritium in 'old' groundwater samples from wells in both the Marshall Creek Area and the Central West Plaines Area indicates that even the deep aquifers experience some influence from 'younger' water sources (NLW, 2012).

5. Summary

The Site is located along the eastern boundary of Washington State within the southeastern boundary of the West Plains, west of the City of Spokane, Washington (Figure 1). The topography of the West Plains is a relatively flat plateau with deep surface water canyons and rolling hills. The geologic framework of the West Plains includes a Precambrian crystalline igneous and metamorphic basement rock, overlain by members of the CRBG (specifically the Wanapum and Grande Ronde basalt) with associated interbeds (including sedimentary interbed deposits), overlain by Pleistocene alluvial and Missoula flood deposits and eolian deposits. The West Plains top of bedrock elevation varies across the area and forms buried ridges in the subsurface that influence groundwater flow and create aquifer compartmentalization (Figure 8).

The landscape within the West Plains generally consists of mixed semi-arid, agricultural, and urban/semi-urban landscapes, and the landscape at the Site includes stormwater infrastructure, impermeable surfaces caused by shallow to surficial bedrock, and coarse-grained alluvial deposits that infilled paleochannels.

The hydrogeology of the West Plains is uniquely disconnected from the Palouse Slope due to the presence of basement rock boundaries (Figure 8). The groundwater within the West Plains generally is found within the Wanapum and Grand Ronde basalt units, and within a much smaller extent, the Pleistocene alluvial sediments (overburden), with the underlying Precambrian basement acting as an aquitard of the West Plains aquifer system. The aquifers within the overburden are unconfined aquifers overlying the basalt, and the bedrock aquifers generally are confined with water-bearing intervals within interflow zones and interbedded Latah Formation sediments (GSI Water Solutions et al., 2015).

Depth to groundwater in the West Plains varies from several feet to several hundred feet (GSI Water Solutions et al., 2015) depending on the well location and water-bearing zone screened. GSI Water Solutions et al. (2015) identified four aquifers within the West Plains, an upper alluvial aquifer and three aquifers within the CRBG basalt units (the Wanapum Basalt, upper Grande Ronde Basalt, and lower Grande Ronde Basalt). Five northeast- to southwest-trending, sediment-filled paleochannels are found in the West Plains and are a significant part of the overburden aquifer system. The hydraulic conductivity and connectivity of paleochannel alluvial aquifers to CRBG-hosted aquifers has a high degree of variability based on elevation, location, and underlying basalt flow structure.

Additional data is needed to provide an accurate Site-specific geologic and hydrogeologic framework to better assess transport mechanisms at the Site. Based on Haley & Aldrich's review of available information, the overburden thickness can range between 4 feet and 32 feet across the Site and mostly consists of silt, silty sand to sand, and gravels (excluding the potential fill material at MW-13A). The depth to basalt under the overburden generally is deeper within the southwestern boundary of the Site and shallower in areas around the Stormwater North area to the northeast. Due to the incomplete survey data for the Site monitoring wells the following hydrogeologic data gaps exist at this time:

- Site-specific groundwater elevations,
- Site-specific groundwater flow direction(s), and
- Site-specific hydraulic gradient(s).

Surface water discharged into the Stormwater Recovery Area likely evaporates or infiltrates through preferential pathways within the overburden and/or basalt. The SIA SWPPP indicates that stormwater from the airport is diverted into three basins, all of which are routed for discharge at the northeast side of the Site. Based on the age of the groundwater within the aquifers (NLW, 2014), the rate of recharge to the West Plains CRBG aquifer system is relatively slow and groundwater more than a few hundred feet deep displays geochemical characteristics indicative of hundreds to thousands of years residence time in the subsurface (Osborn et al., 2021). The time required to recharge CRBG aquifer system likely is dependent on preferential flow paths (i.e., fractures, vesicles, etc.) and is greater than the time required to recharge the surficial overburden aquifer system.

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FIGURES