Geosyntec consultants

engineers | scientists | innovators

REGIONAL CONCEPTUAL HYDROGEOLOGICAL MODEL

Prepared for

State of Washington, Department of Ecology

and

City of Issaquah

Prepared by

Geosyntec Consultants, Inc.
520 Pike Street, Suite 2600
Seattle, WA 98101

Project PNG0989

December 30, 2022

Regional Conceptual Hydrogeological Model

Prepared for

State of Washington, Department of Ecology

and

City of Issaquah

Prepared by

Geosyntec Consultants, Inc.
520 Pike Street, Suite 2600
Seattle, WA 98101

Julie Chambon, PhD, PE
Senior Engineer

Cindy Bartlett, LG
Principal Geologist

Robert Anderson, LHG
Senior Principal Hydrogeologist

Project Number: PNG0989

December 30, 2022

TABLE OF CONTENTS

Geosyntec consultants

LIST OF TABLES (ATTACHED)

LIST OF TABLES (IN TEXT)

LIST OF FIGURES (ATTACHED)

LIST OF FIGURES (IN TEXT)

LIST OF APPENDICES

ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
2D	two-dimensional
3D	three-dimensional
AFFF	aqueous film forming foams
bgs	below ground surface
CARA	Critical Aquifer Recharge Area
City	City of Issaquah
CSM	conceptual site model
Ecology	State of Washington, Department of Ecology
EFR	Eastside Fire and Rescue
Geosyntec	Geosyntec Consultants, Inc.
HG Model	Regional Conceptual Hydrogeological Model
IAA	interagency agreement
IES	Issaquah Elementary School
Koc	organic carbon partitioning coefficient
LIV	Lower Issaquah Valley
MTCA	Model Toxics Control Act
NGWA	National Ground Water Association
PFAS	per- and poly-fluoroalkyl substances
PFBS	perfluorobutanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PRB	permeable reactive barrier
SALs	action levels
SPW or SPWD	Sammamish Plateau Water and Sewer District

1. INTRODUCTION

This report presents the Regional Conceptual Hydrogeological Model (HG Model) and data gaps for the Lower Issaquah Valley (LIV). This report comprises the first and second deliverables for the interagency agreement (IAA[1]) between the State of Washington, Department of Ecology (Ecology) and the City of Issaquah (City) and has been prepared by Geosyntec Consultants, Inc. (Geosyntec), on behalf of the City.

Previous studies conducted by the Issaquah Valley Per- and Poly-Fluoroalkyl Substances (PFAS) Partnership (Partnership), which includes the City, Eastside Fire and Rescue (EFR), and Ecology, have focused along the central portion of the LIV and former fire training source areas where aqueous film forming foams (AFFF) have been used. The City is located in the LIV, which spans approximately 61 square miles extending from the Issaquah-Hobart Gap to Lake Sammamish, and from Front Street to Tibbets Creek. The City location, significant creeks, and Lake Sammamish are shown on **Figure 1**. The monitoring and production well locations in the LIV are shown on **Figure 2**.

This work associated with the IAA is intended to result in a three-dimensional (3D) groundwater model update that will integrate aquifer data and hydrogeological information collected since the City's Critical Aquifer Recharge Area (CARA) groundwater modeling was completed (Geosyntec, 2019, 2021), as well as data from various PFAS investigations completed since 2017. The conceptual hydrogeologic model presented in this report will form the basis for further data collection and refinement of the groundwater model to evaluate PFAS transport and potential remedial actions in the LIV aquifer system.

[1] IAA No. C2200183

2. CONCEPTUAL MODEL AND PREVIOUS MODELING OVERVIEW

2.1 Conceptual Model as Basis for Numerical Model

The conceptual site model (CSM) for the LIV is based on recent fine-grained river (alluvial) sediments underlain by layered interbedded glacial sediments that form significant groundwater aquifers from which the City, Darigold, Lakeside, and the Sammamish Plateau Water and Sewer District (SPWD) operate high-yield production wells. Recharge into the aquifers is from upgradient groundwater flow, precipitation, and stream leakage along the East Fork Issaquah Creek and Issaquah Creek in the southern portion of the study area. Groundwater discharges into local creeks in the northern portion of the study area and into Lake Sammamish. Groundwater flow is thought to be predominantly horizontal through the aquifers, although significantly influenced by pumping wells. Silt and clay units are thought to form aquitards between shallow and deeper high-production aquifers and limit vertical (downward) groundwater migration. The geologic units are described in more detail in Section 3.3 and the groundwater flow in Section 3.4.

A numerical model represents a simplified version of the subsurface geology and hydrogeology, with a focus on hydrostratigraphic units, surface water, and groundwater recharge and provides a tool to evaluate groundwater flow and contaminant fate and transport under multiple future conditions, including potential remedial scenarios. The CSM represents our understanding of the geologic and hydrogeologic setting and groundwater movement. The information summarized in this report and the data to be collected as part of this work will be the basis for developing the representation of the subsurface geology and hydrogeology in the numerical model and for model calibration to match the regional conceptual model and available data.

2.2 CARA MODFLOW Model Overview

A 3D numerical groundwater model was developed in 2017 (CDM Smith, 2017) by SPWD using a proprietary finite element code (DYNFLOW) to evaluate PFAS transport in the LIV. The City converted the DYNFLOW model to a public domain numerical model (MODFLOW, the CARA MODFLOW model) as part of the City's CARA update (Geosyntec, 2019, 2021). In addition, the City conducted two-dimensional (2D) numerical modeling along the main groundwater flow paths from EFR towards City production wells COI-PW04 to improve our understanding of migration pathways and vertical transport within the LIV aquifer system (Geosyntec, 2022) (Section 2.3).

The CARA MODFLOW model will form the basis for the development of the numerical groundwater and fate and transport model for this work.

The layering of the CARA MODFLOW model is based on interpreted subsurface geology described from borehole logs and a resistivity survey conducted in the late 1990s (Golder, 1999). Much of the deeper geology is inferred from this resistivity survey since only five boreholes extend to about 300 feet or greater. A relatively layer-cake stratigraphy is represented in the numerical model, with shallow and deep aquifers separated by a silt aquitard, as follows (see Section 3.3 for details on hydrostratigraphic units):

1. Fine Sand (part of Shallow Aquifer)
2. Silt (part of Shallow Aquifer)
3. Sand (part of Shallow Aquifer)
4. Silt (Shallow Aquitard)
5. A Zone Aquifer
6. Silt (Deep Aquitard)
7. B Zone Aquifer
8. C Zone Aquifer
9. Silt
10. Bedrock

Layering in the model is important because it will quantitatively define the water balance, contaminant mass, and interchange between different aquifer zones as it relates to PFAS migration from source areas towards production wells and Lake Sammamish and will, therefore, be refined as part of this work.

Specified head boundary conditions are assigned along Lake Sammamish to the north/northwest and the Valley boundary to the south. The North Fork, East Fork, and Mainstem of Issaquah Creek, as well as Tibbetts Creek, are included in the MODFLOW model as river boundary conditions to simulate the interactions between groundwater and surface water. Recharge is incorporated into the model using recharge potential from mapped geologic units and soil types, and pumping rates were defined for the City, SPWD, Darigold, and Lakeside production wells, based on pumping rates used in the DYNFLOW model.

2.3 Preliminary Understanding of Migration Pathways and Processes Controlling PFAS Migration

The existing CARA groundwater model is a useful tool to perform a preliminary evaluation of migration pathways from potential PFAS sources and identify processes (i.e., model inputs and parameters) relevant to PFAS migration. This information is used to inform and prioritize data needs to improve the performance of the existing model for evaluating PFAS fate and transport and potential remedial actions. This evaluation was performed using forward particle tracking with particles released at potential PFAS sources under multiple modeling scenarios (Appendix C). Based on this evaluation, the following processes/parameters may impact simulation of PFAS migrations and need to be further refined as part of this work, through refinement of model calibration and collection of additional data:

- Hydraulic connection between the different aquifer units; i.e., hydraulic properties, thickness and extent of low-permeability zones in-between aquifer units;

- Infiltration rates in the vicinity of the potential PFAS sources, and along migration pathways, as it affects vertical gradients and potential downward transport;
- Differences in horizontal hydraulic gradient, controlling groundwater flow direction, in the different aquifer units; and
- Pumping rates at production wells.

In addition, groundwater-surface water interactions are not expected to significantly impact PFAS migration at the regional scale, but may create localized preferential pathways, or downward gradients, that may affect local PFAS migration.

The CARA MODFLOW model has not been calibrated to a range of historical conditions, and significant additional groundwater quality and aquifer data have been collected by the Partnership since the CARA MODFLOW groundwater model was constructed. Therefore, this work objective is to refine and update the CARA MODFLOW groundwater flow model, including the grid, layering geometry, and boundary conditions, and develop a 3D PFAS fate and transport model using MT3D-USGS based on the groundwater flow simulated with the updated MODFLOW groundwater flow model. A review of the geology, hydrogeology, surface water groundwater interaction, and PFAS occurrence is presented in the following sections to describe our current understanding, identify data gaps, and support refinement of the groundwater model.

2.4 Two-Dimensional Cross-sectional Groundwater Model

The 2D cross-section model for groundwater flow was developed using MODFLOW, with MT3DMS for solute transport. The 2D model was used to evaluate the potential subsurface distribution/transport of PFAS, particularly the processes driving downward plume migration and capture by COI-PW04 and provide recommendations for further characterization and potential remedial actions. The major findings from the 2D cross-sectional groundwater model relevant for this work are:

1. Small-scale/localized heterogeneity in the vicinity of the source areas may impact PFAS vertical migration.
2. Infiltration rates in the vicinity of the source areas are important and impact PFAS vertical migration.
3. Operation of production well COI-PW04 has a significant impact on the PFAS plume and may further downgradient migration.
4. PFAS migration pathways to COI-PW05 are uncertain and further characterization of the Deep Aquitard between the A and B Zone Aquifers (see Section 3.3), of vertical gradients between the A and B Zone Aquifers, and of impacts of production pumping are required.

3. HYDROGEOLOGIC SETTING

The subsurface geology encountered across the LIV consists of recent alluvial deposits underlain by a thick sequence of glacial sediments along the LIV that generally dip northward. The following formations (from shallowest to deepest) have been described in the LIV[2] and are shown on **Figure 3**:

- Shallow alluvium (Qa) – Brown sand or sandy silt with gravel, cobbles, and pebbly sand deposited along streams in the LIV. Occasional wetland (Qw) and peat (Qp) deposits are sometimes present in the LIV.
- Ice Contact Deposits (Qvi) – Grey to grey-green sandy silt underlain by a loose, grey sand characterized by heaving. The heaving sand unit was underlain by a grey sandy silt with occasional wood fragments). Some organic material (wood fragments) and one small section of peat were encountered near the base of the ice contact deposits.
- Recessional Outwash (Qvr) – Layered sand and gravel with little silt, moderately to well sorted with stratification. Deltaic complexes are present in the southern, western, and eastern portions of the LIV interpreted to have formed from glacial meltwater.
- Advance Outwash (Qva) – Brown to grey-brown sand to silty sand, well sorted, interpreted to be advance outwash sediments. Glacial channel deposits consisting of coarse sand and gravel grading to a silty medium to coarse sand, typical of an advance glacial deposit were described by Golder, 1999.
- Older glacial deposits (Qpff) – Fine-grained deposits, predominantly silts and clays, formed from lacustrine deposits.
- Older glacial deposits (Qpog) – Sands and gravels with silt, weakly to strongly oxidized, some glacial till.
- Glacial Till (Qvt) – Dense gray silty fine sand with gravel, encountered from approximately 200 to 220 feet below ground surface (bgs) (Golder, 1999). Compact diamict containing subrounded to well-rounded clasts, glacially transported and deposited. Generally, forms an undulating surface 10 to 50 feet thick, and found sporadically within areas of ice-contact deposits (Qvi).
- Bedrock (Tsc and Tb) – Sandstone, conglomeration, tuff, and tuffaceous sandstone (Blakely Formation). Volcanic or Intrusive rocks that form topographic highlands or are present along Squak and Tiger mountains.

[2] Geologic descriptions from Booth et al., 2012, Golder, 1999, and Geosyntec, 2016.

3.1 Depth to Bedrock

There are few bedrock outcrops along the valley margins, and few wells in the LIV have penetrated bedrock. One outcrop of bedrock is present at the intersection of Sunset Way and Newport way. The glacial sediments terminate against this bedrock and represent the western edge of the aquifer system in this part of the valley. The bedrock contact extends northward along Newport way and appears as a “hook-shaped” feature on **Figure 3** that wraps around the western portion of the property at 175 NW Newport Way. The western upland areas where coal was historically mined (Cougar and Squak Mountains and west into Newcastle) comprises sandstone and volcaniclastic sandstone sedimentary rocks, including the Renton Formation with interbedded coal and shale.

Bedrock was encountered in several areas and at varying depths within the LIV during drilling for domestic wells and geothermal installations. Wells greater than 200 feet deep where bedrock was described are shown on **Exhibit A**, below. Boring logs are provided in Appendix A. On the northwestern edge of the valley (Eastside Fire and Rescue well [**Exhibit A**], ID #BCN693 in Appendix A), basalt (although likely volcaniclastic sandstone) was described below interlayered with hard gray sediment from 180 to 300 feet bgs. Variable depths and types of bedrock were described in the northern and eastern areas compared to the southern portion of the LIV, where bedrock was interpreted from one geophysical study. For example, in the Issaquah Highlands, (northeastern/eastern upland area) sandstone was encountered between approximately 20 to over 200 feet bgs (Ramey, McBride, and Leitch-Warren domestic wells; **Exhibit A**), and basalt (also likely volcanic sandstone) was encountered beginning at 70 feet bgs (Howland Development Issaquah well [**Exhibit A**], ID# BCC266 in Appendix A). Another example from the northern area along the eastern edge of the valley, siltstone and “boulders and rock” (likely glacial till) were described beneath silty clay, sand, and silt glacial deposits starting at 18 feet bgs (Anderson domestic well; **Exhibit A**). In the southern portion of the valley, bedrock was interpreted at approximately 100 feet bgs (resistivity station 1-17, Golder 1999). The interpretation of bedrock using geophysical methods has many uncertainties.

This depth to bedrock information will be used to adjust the elevation of the layers defining the top of bedrock in the CARA model so that depth to bedrock in the model takes into account these data points.

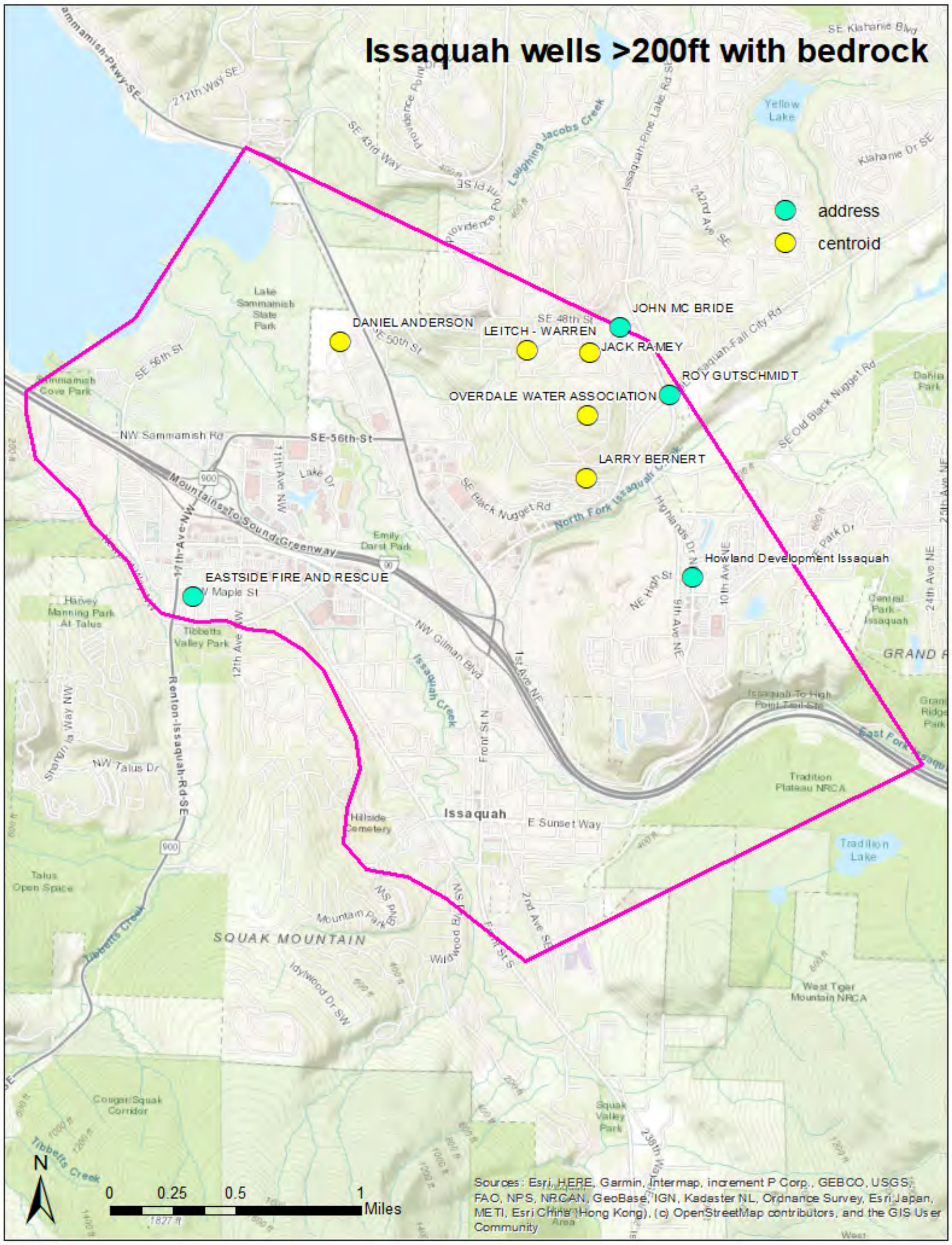


Exhibit A: Wells greater than 200 feet deep with bedrock. Locations with known addresses are shown with a cyan dot, locations with a quarter section centroid (specific address unknown) are shown with a yellow dot.

3.2 Glacial Depositional Features

Most of the sediments that comprise the LIV aquifer system were deposited into a bedrock trough along the axis of the LIV/Lake Sammamish valley during the northward retreat of the continental glacier (Puget Lobe). As the glacier was retreating, the geomorphic environment of the LIV was highly variable, including glacial ice, lacustrine, and riverine depositional environments. During the retreat of the glacier, the LIV experienced several "stages" of deglaciation that created the depositional framework for the sediments that comprise the LIV aquifer system. **Exhibit B** (below) is taken from the LIV Wellhead Protection Plan (Golder, 1993) and shows a schematic of the general geometry of glacial features during each stage.

Tokul Stage: During the initial state of glacial retreat (called the Tokul Delta stage), most of the Lake Sammamish basin was still covered in glacial ice. During this period, glacial till was deposited at the base of the glacier, and this till is still in place in upland areas such as Cougar mountain. Southward draining glacial drainage channels were also formed during this period south of Cougar and Squak mountains.

Inglewood Stage: As glacial retreat continued northward (Inglewood stage), till was eroded in the trough of the LIV and glacial lakes formed. Additional east-west drainage channels were also exposed between Tiger Mountain and the Issaquah Highlands, allowing drainage from the Snoqualmie basin along what is now the East Fork of Issaquah Creek. During this period, deltas began to form into the predecessor of Lake Sammamish, fed by sediments from the east-west drainages. These dipping delta sediments are still visible in the gravel quarry below the Issaquah Highlands along the South Fork of Issaquah Creek. During this period, ancestral Lake Sammamish reached a surface elevation of about 400 feet in the LIV.

Redmond Stage: During the final stage of glacial retreat (Redmond stage), the ice continued its northward retreat, and the current configuration of Lake Sammamish was established. Connections to the Snoqualmie Basin via the East Fork of Issaquah Creek or Evans Creek near Redmond eventually separated, and Lake Sammamish established its northward drainage pattern towards Lake Washington. This depositional sequence (Tokul-Inglewood-Redmond stages) created the overall framework for northward dipping sediments in the LIV that "follow" the retreating glacier and establishment of Lake Sammamish. This glacial retreat also created an environment for glacial channels that were aligned both north-south (following the glacial retreat) and east-west (providing drainage outlets from the Snoqualmie basin).

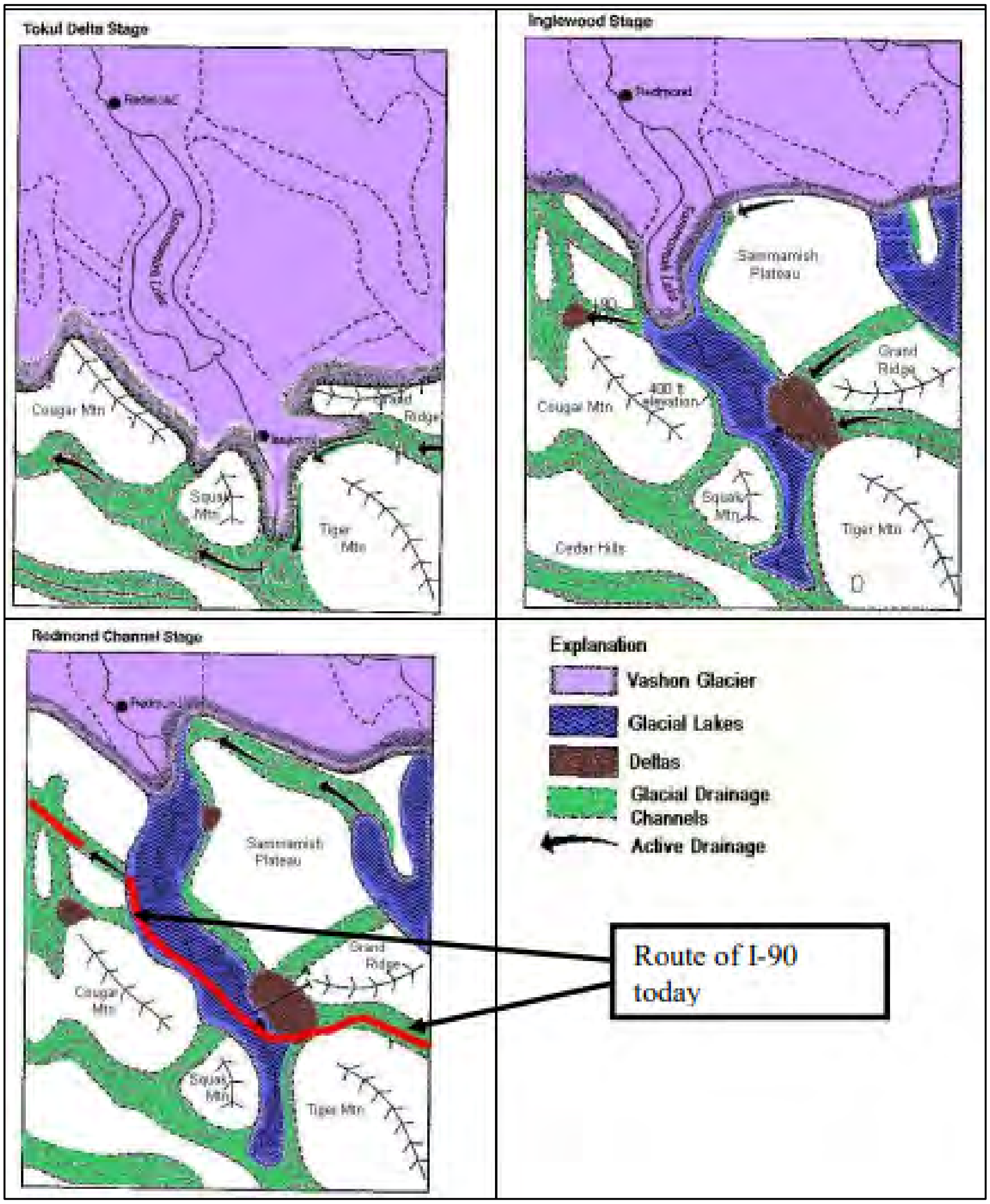


Exhibit B: Vashon Glacial Stages in the LIV

3.3 Hydrostratigraphic Units

A layered glacial stratigraphy has been used previously in hydrogeologic studies of the LIV, including groundwater modeling. The studies generally present a layer-cake stratigraphy, where fine-scale layering is aggregated into a single layer, often with variation in hydraulic properties based on geologic logs or aquifer testing. The multiple studies conducted over the years has led to some divergence in nomenclature for hydrostratigraphic units, as well as how hydraulic properties have been assigned. **Table 1** provides a summary of previous reports, descriptions of the various hydrostratigraphic units, and Geosyntec's suggested nomenclature going forward. A general description of the primary aquifer zones is provided below and shown on **Figures 4A and 4B**.[3]

- Shallow Aquifer – This aquifer zone is also described as the "Shallow Sand" (CDM Smith, 2017), or "Upper Aquifer" (Farallon) and includes the uppermost (first) surficial water-bearing unit in direct hydraulic connection with surface streams. Farallon (2021) has characterized the Shallow Aquifer as between approximately 5 and 60 feet bgs. There are 38 monitoring wells are screened in this aquifer, ranging in screen depths from 5 to 58 feet bgs. The water-producing unit in this aquifer is typically described as a grey, loose, fine- to medium-wet, well-graded sand with gravel. In the CARA groundwater model, the Shallow Aquifer represented with Layers 1 through 3, and includes discontinuous silty layers.

- Shallow Aquitard. This aquitard overlies the A Zone Aquifer and is likely discontinuous and interbedded with the A Zone and Shallow Aquifers. This is consistent with the dynamic glacial depositional environment with inflows of sediment from the margins of the LIV interacting with the lacustrine environment during final stages of glacial recession and establishment of the current elevation of Lake Sammamish.
  - The Shallow Aquitard occurs approximately 45 up to 70 feet bgs as 2- to 12-foot thick beds and is described as a moist to wet silt to sandy silt (**Figure 4A**). Interbedded sand and sandy silt, and traces of organics and wood are commonly described. For example, at COI-MW04, a wet silt with trace organics and wood is described at 45 to 47 and 57 to 59 feet bgs (sand interbed), at COI-MW05 as a wet sandy silt with trace organics/wood from 43 to 55 feet bgs, at COI-MW07 as a wet to moist silt to clayey silt from 57 to 70 feet bgs, and at NDS-MW04 as a moist to wet silt from 67 to 72 feet bgs. Based on investigation work completed in 2020, this aquitard is described as silt, or silt and clay with occasional sand interbeds (Farallon, 2020; see Figures 3 and 5).
  - From a groundwater modeling perspective, this aquitard is included as Layer 4 in the CARA groundwater model and is discontinuous (i.e., in the model, Layer 4 hydraulic properties are either similar or distinct from the overlying and underlying aquifer zones). The location and thickness of the low-permeability zones (i.e., portions representing the Shallow Aquitard) are not well constrained by data, but may be locally important to groundwater flow and contaminant transport in some areas. Boring log and water level (i.e., vertical gradient between wells screened above and below this depth interval) will be used to refine the depth, thickness, and presence of this aquitard

[3] As indicated on Figures 4A and 4B, several wells are projected onto the cross-section lines (see also cross-section locations on Figures 2 and 3). The two cross-sections intersect north of COI-MW03.

within the model, specifically along the flow path from the EFR to the center of the LIV, where it is anticipated to impact PFAS migration.

- A Zone Aquifer – This aquifer zone is described as the "A Sand Aquifer" (CDM Smith, 2017), or "Intermediate Aquifer" (Farallon), and is present between approximately 60 – 120 feet bgs. This zone represents a primary production zone for water supply wells in the LIV. There are six water production wells screened in this aquifer including three wells from the City (COI-PW01, COI-PW02, COI-PW04), two wells from SPWD (SP-PW07 and SP-PW08) and the Darigold well (DG-PW01). There are an additional 19 monitoring wells screened in this aquifer, ranging in screen depths from 65 to 150 feet bgs. The water producing unit in this aquifer is typically described as a fine to medium, poorly graded sand with gravel. This unit has also been observed to have silt lenses that vary discontinuously across the LIV. In the CARA groundwater model, the A Zone Aquifer is included as Layer 5. Its depth and thickness in the model will be refined as needed based on boring logs to match existing information and additional data collected as part of this work.

- Deep Aquitard – This aquitard underlies the A Zone Aquifer and overlies the B Zone Aquifer. It is described as silt and leaky aquitard (CDM Smith, 2017). It corresponds to a distinct grey silt and clay unit described at COI-POW04 and COI-PW05 from approximately 135 to 170 feet bgs with sandy silt and clay extending to 240 feet bgs. This silty clay unit clearly separates the deeper B Zone Aquifer pumped by COI-PW05 from the A Zone aquifer pumped by COI-PW04. Water levels in COI-PW04 and COI-PW05 show distinct differences and seasonal responses, indicating that there is hydraulic separation created by this aquitard. In the CARA model, this aquitard is represented by Layer 6 and is continuous, although a "window" is defined in the vicinity of SP-PW09, based on CDM Smith observations that the water levels were similar at different depth intervals at VT-8 monitoring wells (communication with CDM Smith in September 2022). The depth, thickness, and presence of the Deep Aquitard in the model will be refined based on: 1) boring logs and water level data above and below this interval; and 2) to match existing information summarized below and additional data collected as part of this work.
  - This silt clay unit is prevalent in the northern portion of the LIV and becomes both deeper and thicker to the north. North of COI-PW05, the aquitard is described as a sticky clay silt from 135 to 217 feet bgs at VT-7, and as a clayey silt/silty clay at COI TW01 from 130 to 260 feet bgs.
  - South of COI-PW05, the extent of this aquitard in not well defined, but a clay unit was encountered at a depth of approximately 80 to 109 feet bgs at well COI-TW03 and at 87 to 122 feet bgs at COI-TW06. This clay could be continuous with the deep aquitard at COI-PW05. The northward slope of this clay unit (if it is continuous) is on the order of 1.7%, which is consistent with the lacustrine depositional environment during glacial

recession. However, a pumping test at COI-TW06 did not cause a clear hydraulic response at COI-PW5 (Golder, 1999).

  - To the east, a deep aquitard is described at SP-PW09 at a depth of approximately 160 to 185 feet bgs, where it is described as a grey sticky clay silt with occasional gravel. Based on the depth and description, this unit aligns with the grey silt and clay described at COI-PW04/PW05, although the unit is thinner at SP-PW09.

- B Zone Aquifer – This aquifer zone is described as the "B Sand Aquifer" (CDM Smith, 2017), or "Deep Aquifer" (Farallon) and occurs at depths of greater than 200 feet bgs. There are five wells completed at depths of greater than 200 feet, with two production wells, SP-PW09 and COI-PW05. SP-PW09 was completed at a depth of 303 feet bgs, and COI-PW05 was completed at a depth of 405 feet bgs. Monitoring well/test well boreholes that extended deeper than 200 feet include COI-TW02, COI-TW03, COI-TW06, and SP-MW07-2. The water-producing unit in this aquifer is typically described as a coarse sand and gravel grading to a silty medium coarse sand. The connectivity of this aquifer to the A Zone and Shallow Aquifers is not well defined because few wells are completed and monitored at this depth. However, both COI-PW05 and SP-PW09 have shown increasing levels of PFAS over the past 4 years, so there is a migration pathway to this aquifer from one or more of the PFAS source areas identified in the LIV. In the CARA groundwater model, the B Zone Aquifer is included as Layer 7. Its depth and thickness in the model will be refined as needed based on boring logs to match existing information and additional data collected as part of this work.

- C Zone Aquifer – This aquifer is described as the "B/C Sand Aquifer" (CDM Smith, 2017) and appears as glaciofluvial channels hydraulically connected with the B Zone Aquifer. COI-TW03, COI-TW06, and SP-PW09 appear to be screened in a channel aquifer that we have designated as the C Zone Aquifer. In the CARA groundwater model, the C Zone Aquifer is included as Layer 8, is located beneath the B Zone Aquifer, and is of similar thickness. Its depth, thickness, and extent in the model will be refined as needed based on boring logs to match existing information and additional data collected as part of this work.

For the remainder of this report, the aquifer units will be referred to using suggested nomenclature presented in **Table 1**, which includes, Shallow Aquifer, A Zone Aquifer, B Zone Aquifer, and C Zone Aquifer. As the presence and extent of the C Zone Aquifer is uncertain, this unit is also referred to as the B/C Zone Aquifer.

In addition to the hydrostratigraphic outlined above, the CARA model includes two deeper layers: Layer 9, which is a deeper silt and represents older glacial or glaciofluvial deposits; and Layer 10, which represents bedrock and is the floor of the model (no flow boundary at the bottom of Layer 10). Although, it has been encountered or mapped at only a few locations in the LIV (Section 3.1), the subsurface geology has been mapped through a series of resistivity surveys (Golder, 1999) and some borehole/well logs have extended to depths where bedrock was encountered (**Table 2**).

The overall model layering scheme generally depicts the upper Layers 1 through 8 fairly well; however, the geologic units are more variable than the current model depicts and pinch out, slope, or are more interbedded. A higher degree of fine-scale layering and stratigraphic complexity is present within each aquifer zone. For example, Layer 6 (Deep Aquitard) becomes much thicker with more clay at COI-TW01 north of City wells COI-PW04/COI-PW05, but thins to the east at SP-PW09. Layers 7/8 (B and C Zone Aquifers) thicken and occur deeper to east where SP-PW09 is located compared to COI-PW05.

Although the upper 100 feet of the aquifer is better characterized, the deeper portions (greater than 100 feet and up to 400 feet) of the aquifer system, including aquitard(s), are not well characterized. Only five boreholes/wells extend into B Zone Aquifer (~200 to 400 feet bgs), with only one well (COI-PW05) extending to 400 feet bgs. The two deeper units, layers 9 (silt) and 10 (bedrock), are inferred from resistivity surveys (Golder, 1999).

3.4 Groundwater Recharge

The LIV is surrounded by steep upland areas, including Tiger, Squak, and Cougar Mountains, formed from a mix of denser glacial sediments and older volcanic rocks. The steep terrain, narrowness of the LIV, and permeability of surface sediments (soil) are presumed to result in high runoff with variable infiltration and recharge. Generally, recharge is from precipitation that flows from the highlands into the LIV; however, localized differences can significantly affect contaminant flow from source areas (e.g., EFR headquarters, eastward shallow groundwater flow direction). Groundwater infiltration rates within the central portion of the LIV are similar to stormwater infiltration rates and are primarily driven by surficial features (permeable vs. impermeable) (summarized by Golder in its 2003 Stormwater Infiltration Evaluation, 2003). Groundwater recharge is also highly controlled by precipitation patterns observed each year. Years of low precipitation yields low groundwater recharge, and years of high precipitation yields higher groundwater recharge. The relationship between precipitation and recharge is especially important in the Shallow Aquifer and other surficial water bodies such as the Issaquah Creek System and Lake Sammamish where precipitation, surface water, and shallow groundwater interact.

In the CARA MODFLOW model, low, medium, and high recharge zones were defined based on the CARA recharge potential, which takes into account the geologic and soil properties. For the steady-state CARA MODFLOW model, average recharge rates of 6.8, 12.4, and 22.7 inches per year are defined for the low, medium, and high recharge zones, respectively. For the transient CARA MODFLOW model, recharge was varied monthly based on typical seasonal precipitation variations, with approximately 75% of groundwater recharge occurring in November through February. Definition of groundwater recharge including delineation of high, medium, and low recharge zones, as well as average recharge rates and monthly fluctuation, will be further refined in the groundwater flow model, especially in the vicinity of the source areas, based on water level data, including data from pressure transducers, in monitoring wells screened in the Shallow Aquifer (Section 3.6.2).

3.5 Groundwater Pumping

Groundwater discharge at LIV is through discharge into Lake Sammamish, discharge to local streams, and groundwater extraction for drinking water and other usage. Based on the existing CARA model, groundwater extraction in the LIV accounts for approximately 40% of groundwater outflows.

There are seven active or recently active production wells in the LIV, screened in units ranging from 81 to 405 feet bgs. The wells are shown on **Figure 2** and listed in **Table 2**:

- Four production wells are operated by the City:
  - COI-PW01, COI-PW02, and COI-PW04 screened in the A Zone Aquifer; and
  - COI-PW05 screened in the B Zone Aquifer.
- Three production wells are operated by SPWD:
  - SP-PW07 and SP-PW08, screened in the A Zone Aquifer; these wells have been inactive since 2017; and
  - SP-PW09, screened in B/C Zone Aquifer; pumping rate at this well increased since 2017 and shutdown of wells SP-PW07 and SP-PW08.
- Two production wells operated by private users:
  - Darigold, screened in the A Zone Aquifer; and
  - Lakeside, screened in the A Zone Aquifer.

3.6 Groundwater Flow

Groundwater flow is measured by monitoring groundwater levels in wells and interpreting flow directions based on those groundwater elevations. There are numerous groundwater monitoring and water supply/production wells (**Figure 2**). **Table 2** provides a summary of groundwater monitoring wells, water production wells, and geotechnical wells that were installed in the LIV. There are 60 groundwater monitoring wells that are either being used to monitor water quality or have been installed as regional groundwater monitoring wells (generally screened in the uppermost water bearing unit). These monitoring wells have screen depths ranging from 5 to 362 feet bgs.

First encountered groundwater is typically found 20 to 30 feet bgs. Groundwater levels vary seasonally by about 3 to 6 feet in the Shallow Aquifer and 2 to 4 feet in the A Zone aquifer (Intermediate Zone), with the highest groundwater levels observed during spring (March and April) and lowest levels during summer (July) (Farallon, 2021). Based on the available data, groundwater level fluctuations are similar in both magnitude and timing throughout the aquifer system.

Two important geologic features influence groundwater flow and dynamics along the margins of the LIV:

1. Stratified glacial outwash occurs in the Issaquah Highlands and Lake Tradition Upland areas east of the LIV. The Issaquah Highlands in particular, is part of a large delta that formed during the Inglewood stage of glacial retreat. These deltaic sediments (which are visible along the South Fork of Issaquah Creek below the Issaquah Highlands) plunged into ancestral Lake Sammamish and are now below the valley floor and extend toward the center of the LIV. This outwash consists of coarse sand and gravel and transmit recharge from the uplands into the LIV aquifer system, creating a westward component of groundwater flow along the eastern margins of the LIV. In the Lake Tradition area, a more variable assemblage of unconsolidated outwash and fan deposits, consolidated till, and bedrock results in less predictable westward recharge and groundwater flow.

2. On the west side of the LIV, glacial till is predominant at the ground surface on Tiger Mountain, and there are areas of historical coal mining, which is indicative of shallow bedrock. One of the only exposures of bedrock in the LIV is on the west margin of the LIV near the 175 NW Newport Way (EFR Site). These areas west of the LIV have higher run-off, which then infiltrates along the western margin of the LIV. The localized eastward groundwater flow direction at the EFR Site is consistent with this setting, where infiltration along the valley margin creates an eastward component of flow prior to merging into the more northerly regional groundwater flow pattern within the LIV.

Silt interbeds are present in the upper 80 to 120 feet of the glacial sediments, but do not appear to be sufficiently thick nor continuous across the area to limit vertical groundwater flow or connectivity through the upper aquifer.

3.6.1 Horizontal Gradients

Horizontal groundwater flow direction and gradients vary across the LIV. A series of groundwater and surface water elevation figures were provided in Farallon, 2021.

In the Shallow Aquifer, horizontal gradients range from approximately 0.0025 to 0.006 feet per foot (Farallon, 2021). Gradients are steeper with east/northeast flow along the western portion of the LIV (175 NW Newport Way), and flatten out and turn northward mid-valley (Issaquah Valley Elementary School/Dodd’s Field, and Memorial Field/Rainier Trail study areas). Groundwater elevations in the central portion of the LIV, north of NW Dogwood Street, appear to flatten out significantly.

In the A Zone Aquifer, groundwater gradients are similar and range from approximately 0.0027 to 0.0047 feet per foot (Farallon, 2021). The groundwater flow direction is more consistent to the north/northeast, and the gradient steepens towards City pumping well COI-PW04.

In the B and C Zone Aquifers, groundwater flow is similar to the north/northeast, with steeper gradients towards the production wells (COI-PW05 and SP-PW09). However, this is based on limited data, as there are only a few wells screened in the B and C Zone Aquifers (**Figure 2**).

Water level contour maps in the different aquifer units will be used as qualitative metrics during calibration of the updated model.

3.6.2 Vertical Gradients

Vertical hydraulic gradients between the Shallow and A Zone Aquifers are variable (Farallon, 2021), but mostly downward from the Shallow to the A Zone Aquifer. Upward gradients were measured at two locations IES-MW07/COI-MW05 and IES-MW08/IES-MW09, which are the northernmost well pairs in the LIV and north of the confluence of the east fork to the main fork of the Issaquah Creek System (**Figure 2**). These well pairs are located north of where shallow groundwater gradients are observed to flatten out, which could indicate upward pressure in the Shallow Aquifer. This upward pressure could be generated by higher recharge via stream infiltration where the East Fork of Issaquah Creek enters the LIV and could create a "hinge point" where groundwater levels are closely tied to the streambed elevation. This could create flattening of the hydraulic gradient initially and an upward gradient farther down-valley from the hinge point. This information will be used to refine the CARA model, and the observed vertical gradients will be used as calibration targets to better constraint infiltration rate, streambed leakance, and presence and hydraulic properties of the Shallow Aquitard.

The remaining well pairs, IES-MW01/IES-MW06, IES-MW03/IES-MW10, MF-MW02/MF-MW04, NWN-MW02/NWN-MW08, NWN-MW11/COI-MW07, NDS-MW01/COI-MW06, and NDS-MW03/NDS-MW04 monitored in 2020 show a primarily downward groundwater gradient between the Shallow and A Zone Aquifers.

Water level data (manual measurements and recorded with pressure transducers) are available at multiple SPWD monitoring locations, which include several clusters with multiple wells screened at different depth intervals (SP-VT1, 2, 7 and 7 wells, **Figure 2**) and were provided by Sammamish Plateau Water District (SPWD) for time period 2016 through 2021. These data, especially long-term pressure transducer data, will provide valuable information and will be used to refine the model, as follows:

- Water level fluctuations due to seasonal variations, including in response to deep percolation and stream recharge, which will be used in the model to refine infiltration rate and stream-water/groundwater interactions;

- Impacts of pumping in different aquifer units at monitoring wells located in the vicinity of production wells, which will be used to refine hydraulic properties of the aquifer units and properties and extent of aquitard units by simulating the observed response to pumping rate fluctuations and adjusting hydraulic properties and/or layering until a good match is achieved; and

- Vertical gradients between aquifer units, which will be used to refine the hydraulic properties, thickness, and presence of aquitard units.

An example of these data is provided in **Appendix B**.

3.7 Groundwater - Surface Water Interactions

The LIV is an important water supply source for the City of Issaquah and the Sammamish Plateau, and groundwater discharge from the shallow aquifers within the LIV is an important component to stream flow within the Issaquah Creek and other creek systems in the LIV (Golder, 2003). The working CSM shows that creeks in the LIV are both losing and gaining, and generally form groundwater divides (in particular along Issaquah Creek in the center of the LIV).

There are three possible interactions between shallow groundwater table and the creek systems:

- Losing Stream – The Issaquah Creek System is interpreted to be a losing stream during the parts of the year when stream elevations are higher than, and in hydraulic continuity with, the shallow groundwater table.

- Perched Stream – The Issaquah Creek System is interpreted to be a perched stream during the parts of the year when stream elevations are above the shallow groundwater table, but not in hydraulic continuity. During these conditions, there is constant leakage from the stream to the groundwater table.

- Gaining Stream – The Issaquah Creek System is interpreted to be a gaining stream during the parts of the year when stream elevations are lower than, and in hydraulic continuity with, the shallow groundwater table. During these conditions, there is leakage into the stream from the shallow aquifer.

In all cases, the rate of seepage to or from the stream is proportional to both the elevation difference between the stream and the water table and the hydraulic conductance of the streambed, which is defined as the hydraulic conductivity multiplied by the thickness of the streambed.

There are four gauging stations established within the Issaquah Creek System (STR-01, STR-02, STR-03, and STR-04) (Farallon, 2021), that are shown on **Figure 2**. Limited stage measurements are available at STR-02, STR-03, and STR-04 in 2020.

Comparing water levels at stream gauging stations and adjacent monitoring wells screened in the Shallow Aquifer provides valuable information to assess stream-aquifer interactions; stream stage elevation above shallow groundwater elevation is indicative of losing stream conditions (i.e., stream recharges the groundwater), while stream stage elevation below shallow groundwater elevation is indicative of gaining stream conditions (i.e., groundwater discharges to the stream). The following pairs have been identified (**Figure 2**): STR-01 and COI-MW04, about 600 feet southeast; STR-02 and IES-MW08, about 210 feet southwest; STR-03 and RBN-MW02, about 200 feet west; and STR-04 and NWN-MW-11, about 70 feet northwest. Timeseries of groundwater and stream stage elevations are shown in **Exhibit C** below.

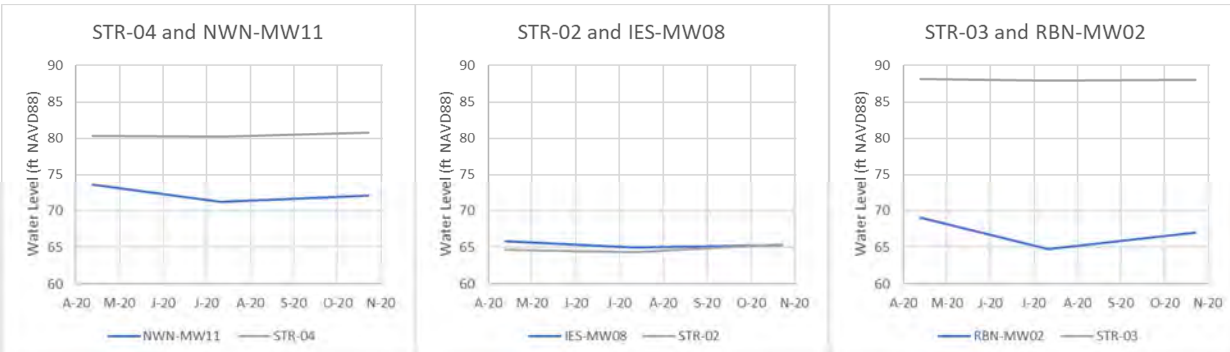


Exhibit C: Comparison of Groundwater and Stream Stage Elevations along Issaquah Creek (STR-04 [south] and STR-02 [north]) and East Fork Issaquah Creek (STR-03). Groundwater levels are shown in blue and stream levels are shown in gray.

The limited data on stream-aquifer relationships at STR-02 and STR04 indicate strong downward leakage from the stream to the aquifer in the southern portion of the study area (south of EFR headquarters), transitioning to slight upward leakage from the aquifer to the stream downstream of the East Fork Issaquah Creek confluence. The elevation difference at STR-04 and NWN-MW11 indicate that the reach in the vicinity of STR-04 is losing water to the shallow aquifer and is possibly "perched" and would have a unit-gradient leakage.

Similarly, groundwater and stream stage elevations at STR-03 indicate strong downward leakage from the East Fork Issaquah Creek in the vicinity of STR-03 (i.e., the stream is losing water to the shallow aquifer).

These observations are consistent with the general stream-aquifer interactions in the CARA groundwater model, with losing conditions simulated along the East Fork Issaquah Creek and the southern portion of the LIV along Issaquah Creek and gaining conditions simulated in the northern reach of Issaquah Creek and toward Sammamish Lake. Overall, the creeks are simulated as recharging groundwater within the LIV, accounting for approximately 25% of inflow to groundwater. Stream-aquifer interactions, including stream stage and streambed properties, will be refined in the model using these data and additional data collected as part of this work (Section 5).

4. PFAS IN GROUNDWATER

4.1 PFAS Characterization in the LIV to Date

The PFAS Partnership has been characterizing the nature and extent of PFAS in the LIV since 2016 (Geosyntec, 2016, Farallon 2019, Farallon 2021). The primary suspected mechanism for release of PFAS to soil and groundwater is the historical use of AFFF during firefighting training exercises. Releases of AFFF resulting in concentrations of PFAS detected in unsaturated soil, saturated soil, and groundwater have been confirmed at the following locations:

- 175 Newport Way Northwest (EFR Headquarters Facility, or EFR);
- Issaquah Valley Elementary West Playfield and Issaquah Valley Elementary East Ballfields (Dodd Fields Park);
- North of 190 East Sunset Way (Memorial Field); and
- West of 135 East Sunset Way on the former rail grade (Rainier Trail Area).

Ecology issued Early Notice Letters for these four sites (areas) in April 2022, after PFAS compounds were confirmed to be considered hazardous substances under the Ecology Model Toxics Control Act (MTCA) in October 2021. The Early Notice Letters provide notification that these sites are considered state cleanup sites that will need to be cleaned up pursuant to MTCA. The PFAS Partnership continues to work with Ecology investigating these sites.

Washington State Department of Health State Action Levels (SALs)[4] for drinking water were established for the following PFAS constituents:

- Perfluorooctanesulfonic acid (PFOS) of 0.015 micrograms per liter (µg/L);
- Perfluorooctanoic acid (PFOA) of 0.01 µg/L;
- Perfluorononanoic acid (PFNA) of 0.009 µg/L;
- Perfluorobutanesulfonic acid (PFBS) of 0.345 µg/L; and
- Perfluorohexanesulfonic acid (PFHxS) 0.065 µg/L.

PFAS monitoring at the four cleanup sites were comprehensively reported by Farallon in 2021 and 2022, and are summarized below. Additional investigation results will be reported following well installations and sampling in 2022. A Pilot Study with installation of a permeable reactive barrier (PRB) in September 2021 was also completed at the EFR Site (Farallon, 2022). Based on the most

[4] Washington State Department of Health State Action Levels (SALs) for Drinking Water as finalized in Washington State Administrative Code (WAC) Chapter 246-290-315 issued on 17 November 2021.

recent round of PFAS results in groundwater, PFOS, PFOA, PFNA, PFBS, and PFHxS have exceeded SALs in at least one monitoring well within the LIV (Farallon, 2021).

PFAS prevalence in the LIV, based on monitoring and production well data, is summarized in **Table A** below.

Table A: PFAS Prevalence in Groundwater in LIV Based on Data at 54 Monitoring Wells Between 2013 and 2022 (concentrations in μg/L)

Analyte	*Number of Samples*	*Number of Detections*	*Detection Frequency (%)*	*Minimum Concentration*	*Mean Concentration*	*Maximum Concentration*	*Location of Maximum Concentration*	*Screening Action Level*	*Number of Exceedances*
PFOS	215	152	71%	0.00130	0.690	8.60	NMW-MW06	0.015	153
PFOA	215	192	89%	0.00052	0.074	1.00	NMW-MW12	0.01	114
PFNA	215	152	71%	0.00110	0.042	0.64	NMW-MW07	0.009	98
PFBS	215	195	91%	0.00037	0.049	0.41	NMW-MW07	0.345	1
PFHxS	215	194	90%	0.00130	0.229	2.00	NMW-MW06	0.065	119

PFAS data review by Geosyntec identified that 38 monitoring wells had exceedances above SALs for at least one of the five PFAS constituents (not including monitoring wells installed in August 2022). Eleven among the 38 wells had at least five measurements above the SALs.

Monitoring wells installed in the LIV are summarized in **Table 2**. Well locations are shown on **Figure 2**. PFAS concentrations are generally higher in the Shallow Aquifer compared to the A Zone Aquifer, and concentrations are highest at the EFR, IES, Memorial Field, and Rainier Trail source areas (in order of magnitude). PFAS concentrations decline downgradient of these source areas, as illustrated for PFOS in **Figures 5A and 5B**.

PFAS concentrations extend northward in both the Shallow and A Zone Aquifer and do not tend to exceed the SALs in wells located along Issaquah Creek and east of Issaquah Creek. PFAS have been detected in Shallow Aquifer SPWD monitoring well VT7-3, located further to the east/northeast of the EFR and IES source areas. PFAS have also been detected in A and B (or B/C) Zone production wells SPW-07, -08, and -09. Geosyntec is still consolidating PFAS data from SPW.

B Zone Aquifer wells include City Test Wells COI-TW03, COI-PW06, and COI-TW01 (not shown on **Figure 2**; located to the north), and B (or B/C) Zone pumping wells COI-PW05 and SPW-09. The three deep test/observation wells have not yet been tested for PFAS, and PFAS have been detected in the two pumping wells. As described earlier, SPW-09 may be screened in a separate channel aquifer (C Zone Aquifer), although hydrogeologic properties are likely similar to the B Zone Aquifer.

PFAS compounds detected in the LIV are dominated by PFOS and PFHxS, with lesser amounts of PFOA, PFBS, and PFNA.

4.2 PFAS in Source Areas

4.2.1 PFAS at Eastside Fire and Rescue (EFR) –Cleanup Site ID 16581

There are 15 monitoring wells screened in the Shallow Aquifer and one monitoring well (NWN-MW08) screened in the A Zone Aquifer at the EFR Site. In addition, there are two piezometers screened in the Shallow Aquifer. Grab groundwater samples have been collected at multiple additional borings/locations. As illustrated in **Exhibit D**, PFOS is the dominant PFAS (~75%), followed by PFHxS (~15-20%), PFOA and PFBS (~5%), and PFNA (~2%). The highest concentrations of PFAS are observed in monitoring wells at the EFR site, compared to the other three cleanup sites; PFOS and PFOA were detected at up to 8.6 and 1.0 µg/L, respectively, in monitoring wells. PFAS concentrations in the A Zone Aquifer monitoring well are at least one order of magnitude lower than in the Shallow Aquifer and are below the SAL.

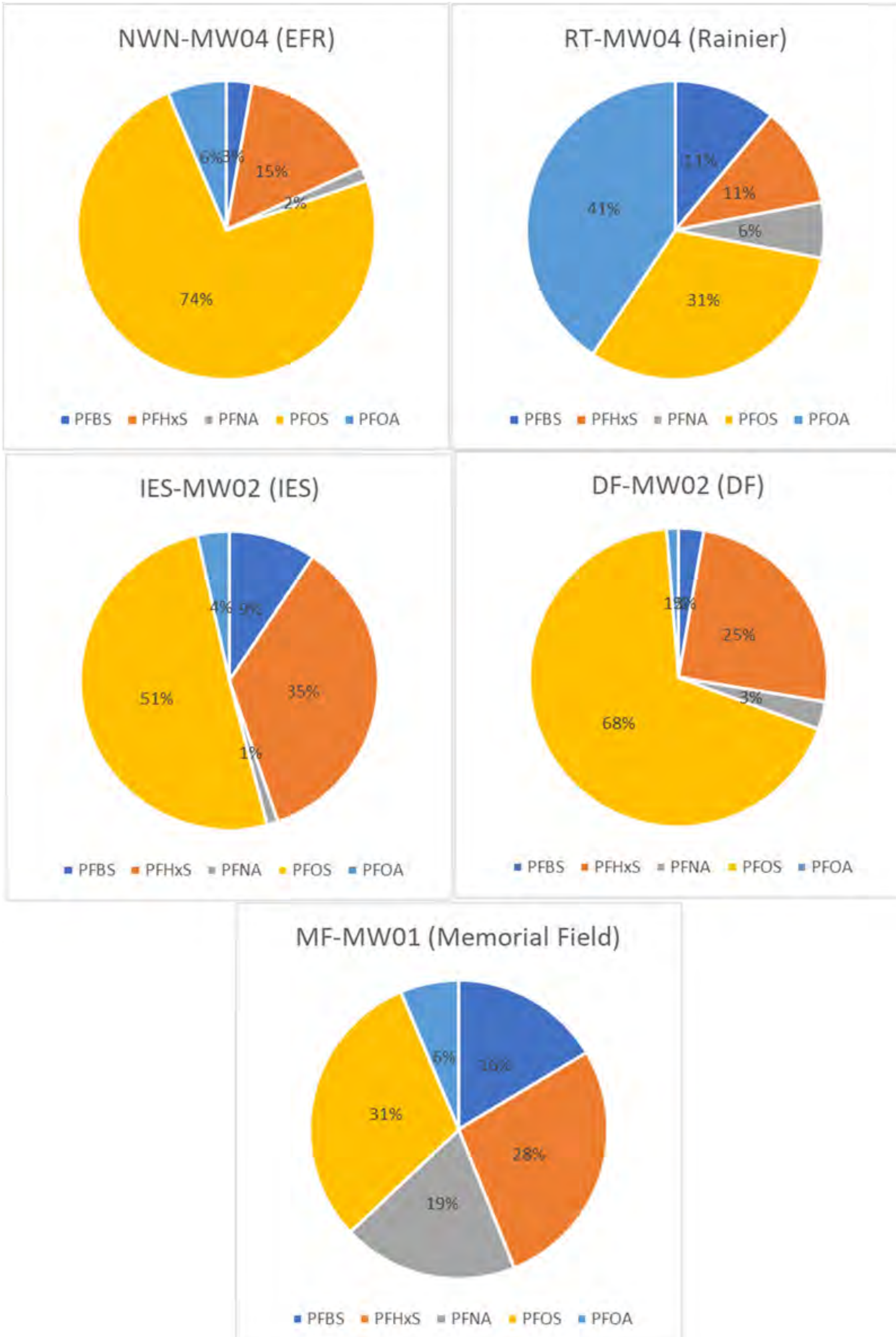


Exhibit D: PFAS Ratios at Monitoring Wells Screened in Shallow Aquifer and Located at the Source Areas

4.2.2 PFAS at Rainier Trail– Cleanup Site ID 16582

There are three Shallow Aquifer wells at the Rainier Trail site. PFAS were detected in the three wells above the SAL. PFOS, PFOA, and PFNA were above the SALs. PFAS concentrations at this Site are relatively low compared to the other three sites. PFOS and PFOA were detected at up to 0.053 and 0.015 µg/L, respectively. PFAS composition is also different at the Rainier Trail site compared to the EFR site, based on PFAS concentrations at RT-MW04 (located at the former AFFF training area). PFOA is the dominant PFAS in groundwater at this site, followed by PFOS, PFHxS and PFBS, and PFNA (**Exhibit D**).

4.2.3 PFAS at Issaquah Elementary School (IES) - Cleanup Site ID 16583

There are 13 wells at the IES site, 10 in the Shallow Aquifer and five in the A Zone Aquifer (intermediate and deep depths). PFAS were detected in each well at concentrations above the SALs. Four PFAS compounds, PFOS, PFOA, PFNA, and PFHxS, were detected above the SALs. In addition, grab groundwater samples have been collected at multiple additional borings/locations (Farallon, 2021).

PFAS compositions at the IES and Dodd Field areas are shown in **Exhibit D**, based on monitoring wells IES-MW02 and DF-MW02, respectively. PFHxS is present in higher proportion at both IES and Dodds Field than at the EFR site. In addition, PFBS proportion is higher at the IES than at the EFR site.

Well IES-MW10, screened in the A Zone Aquifer and co-located with shallow monitoring well IES-MW03, showed the highest concentrations for the PFAS constituents except PFNA, with PFOS and PFOA detected up to 1.2 and 0.067 µg/L, respectively. Well IES-MW05 showed the highest concentration for PFNA. Wells in the A Zone Aquifer (intermediate and deep depths) at the IES site exceeded the SALs and have higher or similar concentrations as Shallow Aquifer monitoring wells at the IES site. This indicates that A Zone Aquifer monitoring wells are likely impacted by upgradient sources (i.e., the EFR). However, the A Zone Aquifer well at the IES source area installed in August 2022 (IES-MW06) and co-located with shallow monitoring well IES-MW01 showed lower PFAS concentrations based on preliminary results.

PFAS concentrations at the IES Shallow Aquifer wells are not as high as at the EFR wells, with maximum PFOS and PFOA concentrations at 0.59 and 0.037 µg/L, respectively, in monitoring wells. Concentrations in the Shallow Aquifer at both the IES and EFR decline to similar magnitudes by approximately 600 feet downgradient of both source areas (e.g., NDS-MW01 downgradient of the EFR and IES-MW07 downgradient of the IES).

Similarly, PFAS concentrations in the A Zone Aquifer are elevated immediately downgradient of the EFR source area (COI-MW06) and IES source area (IES-MW10) and decline to similar concentrations downgradient of both the EFR and IES source areas (e.g., NDS-MW02 and COI-

MW05). The concentrations along the Shallow and A Zone Aquifer plumes are discussed further in Section 4.4, below.

4.2.4 PFAS at Memorial Field – Cleanup Site ID 16584

There are four wells at the Memorial Trail site, three in the Shallow Aquifer and one in the A Zone Aquifer. PFAS concentrations were above the SALs at one Shallow Aquifer well (MF-MW02) (**Figure 5a**). PFOS, PFOA, and PFNA concentrations exceed the SALs, but are relatively low compared to the other three sites (by an order of magnitude), with PFOS and PFOA up to at 0.12 and 0.0052 micrograms per liter (µg/L), respectively. PFAS composition is different than at the other sites, based on groundwater concentrations at MF-MW01, as shown on **Exhibit D**. PFOS and PFHxS are the dominant PFAS, followed by PFNA and PFBS, and PFOA. PFAS concentrations at the A Zone monitoring well (MF-MW04) are below the SALs and over an order of magnitude below concentrations at the co-located Shallow Aquifer well MF-MW02.

4.3 PFAS in Production Wells

PFAS were detected at two of four City production wells (COI-PW04 and COI-PW05) at concentrations above four of the five SALs (except PFBS). COI-PW01 and COI-PW02 were sampled once for PFAS in July 2018 without detections. Only PFOS and PFHxS have been detected at COI-PW05. Of the PFAS, PFOS are the highest concentrations, and PFOS at wells COI-PW04/PW05 are shown on **Exhibit E**, below. PFAS concentrations at the production wells are summarized in **Table B**.

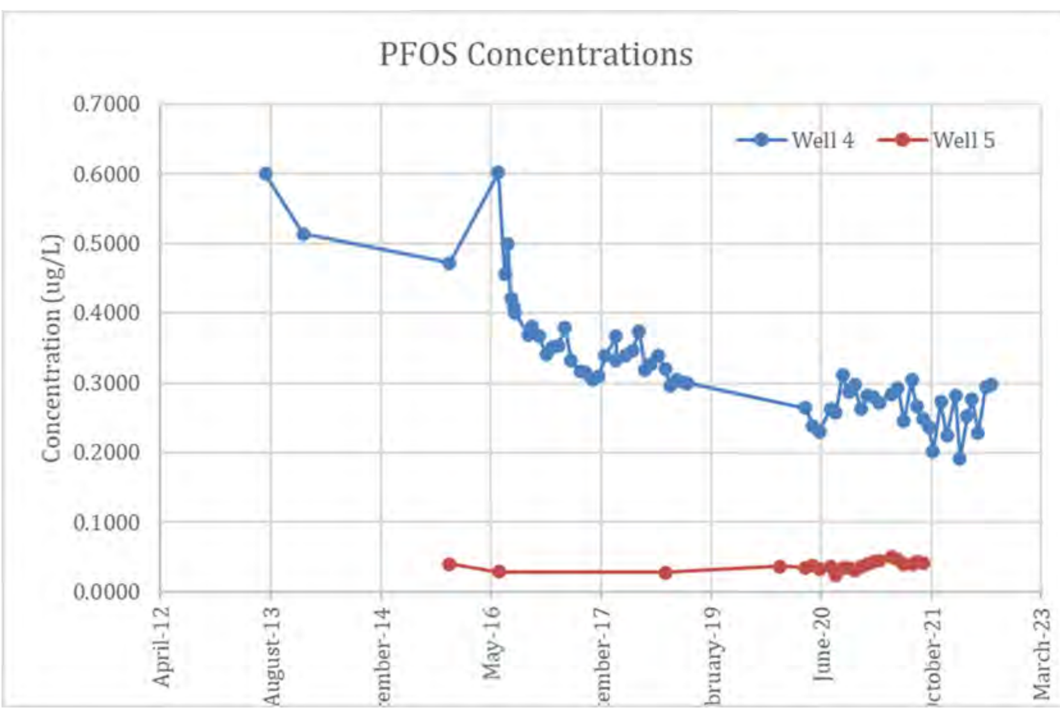


Exhibit E: PFOS Concentrations at COI-PW04 and COI-PW05

Table B: Summary of Detected PFAS Concentrations in City Production Wells

Well Name	Chemical Name	Occurrences Above SAL	Average Concentration (µg/L)	Maximum Concentration (µg/L)
COI-PW01	PFNA	0	< 0.020	< 0.020
	PFOS	0	< 0.040	< 0.040
	PFOA	0	< 0.020	< 0.020
COI-PW02	PFNA	0	< 0.020	< 0.020
	PFOS	0	< 0.040	< 0.040
	PFOA	0	< 0.020	< 0.020
COI-PW04	PFHxS	63	0.127	0.241
	PFNA	53	0.012	0.028
	PFOS	64	0.323	0.602
	PFOA	27	0.0107	0.022
COI-PW05	PFNA	0	< 0.020	< 0.020
	PFOS	26	0.037	0.0504
	PFOA	0	< 0.020	< 0.020

PFAS have been detected in SPW production wells 7, 8, and 9. PFOS concentrations have been detected up to 0.037 µg/L at SP-PW07, 0.038 µg/L at SP-PW08, and 0.0083 µg/L at SP-PW09. PFOA has consistently been detected in wells SP-PW07 and SP-PW08, but only sporadically in SP-PW09. PFHxS and PFBS have consistently been detected in the three wells, and PFNA has been detected only in wells SP-PW07 and SP-PW08.

PFOS, PFHxS, and PFBS were detected in the Darigold well in May 2016 (the PFAS Partnership has not collected additional samples from this well, and it is unknown if Darigold had conducted their own sampling).

4.4 PFAS between EFR and IES Sites and COI-PW04

PFOS, PFOA, PFHxS, and PFNA have been detected above the SALs at wells between the EFR and IES Sites, and City production wells COI-PW04/COI-PW05, as shown in **Exhibit F** below. PFOS most recent concentrations and isoconcentration contours in the Shallow Aquifer, A Zone Aquifer and B Zone Aquifer are shown in **Figures 5A through 5C**. Moving northward and downgradient from the EFR to IES to City pumping wells:

- COI-MW06 is located north and downgradient of the EFR Site and upgradient of the IES Site, and it is screened in the A Zone Aquifer. PFOS concentrations at monitoring well COI-MW06 exceed concentrations detected at other wells along the flow path (**Figure 5B**), indicating significant downward migration from the EFR Site in a relatively short distance (approximately 500 feet).

- IES-MW07 and COI-MW05 are located north (downgradient) of the IES Site and upgradient of production wells COI-PW04/COI-PW05 (**Figures 5A and 5B**). IES-MW07 is screened in the Shallow Aquifer, and COI-MW05 is screened in the A Zone Aquifer. PFAS concentrations at these wells are lower than detected at upgradient well COI-MW06 and higher than concentrations detected at other downgradient wells. Observed PFOS concentration trends and magnitude at well COI-MW05 and production well COI-PW04 were very similar (**Exhibit F**), indicating that COI-MW05 is likely located on the main groundwater flow path towards COI-PW04. Similar concentration trends are also observed at monitoring well COI-MW03 (screened in the A Zone Aquifer and about 260 feet west of COI-PW04), though concentrations are lower than at COI-PW04, indicating that COI-MW03 is likely located cross-gradient from the main flow path and dilution is occurring.

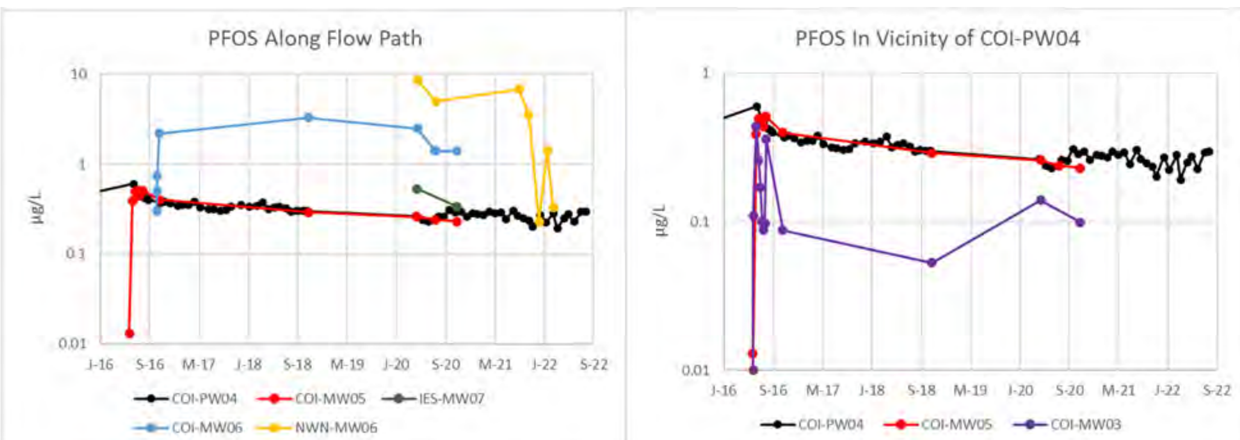


Exhibit F: PFOS Between EFR, IES, and COI-PW04

Figures 5A and 5B indicate the following:

- The PFOS plume in the Shallow Aquifer extends north of NLS-MW01, and is not delineated;
- The core of the PFOS plume in the Shallow Aquifer follows a north/northeast direction north of the EFR;
- The PFOS plume in the A Zone Aquifer is consistent with the modeled groundwater flow paths towards COI-PW04;
- The core of the PFOS plume in the A Zone Aquifer is not delineated but likely located east of NLS-MW02; and
- The PFOS plume in the A Zone Aquifer is not delineated west of NLS-MW02 and COI-MW03.

4.5 Transport Mechanism of Different PFAS Constituents

PFAS partitioning to solid-phase minerals occurs via two main processes: 1) adsorption to organic carbon via hydrophobic interactions; and 2) electrostatic interactions (ITRC, 2022). The organic carbon partitioning coefficient (Koc) is a useful parameter to estimate adsorption to carbon via hydrophobic sorption; however it does not take into account electrostatic interactions and may underestimate sorption (ITRC, 2022). Shorter-chain PFAS are generally expected to be more mobile than longer-chain PFAS. Koc values are shown to vary over significant ranges based on different studies (ITRC, 2022), but generally Koc values are as follows (Anderson et al., 2019; NGWA, 2021):

PFNA-PFOS > PFOA > PFHxS > PFBS or

PFNA-PFOS > PFHxS > PFOA > PFBS

Previous studies have indicated that for modeling plume migration in the saturated zone, a linear sorption isotherm may be appropriate at low PFAS concentrations and can capture most of the sorption processes (Fahrat et al., 2022; Sima and Jaffe, 2021).

Different sorption characteristics of the PFAS compounds affect how PFAS are transported in groundwater and their distribution along the migration flow path(s). Preliminary estimates of PFAS sorption coefficients were determined during the calibration of the 2D cross-section model. Distribution of PFAS in groundwater along the flow path(s) will be used further to adjust the sorption coefficient and refine transport characteristics. **Exhibit G** below illustrated the PFAS distribution along the flow path between the two MTCA site (EFR and IES) and COI-PW04. As discussed above, ratios of PFBS and PFHxS to the total PFAS, generally increase along the flow path, which is consistent with PFBS and PFHxS expected to be more mobile in groundwater (i.e., lower sorption). This analysis is complicated by the presence of multiple sources with different PFAS distribution (**Exhibit D**). The fate and transport model will be a valuable tool to refine PFAS transport characteristics as part of calibration.

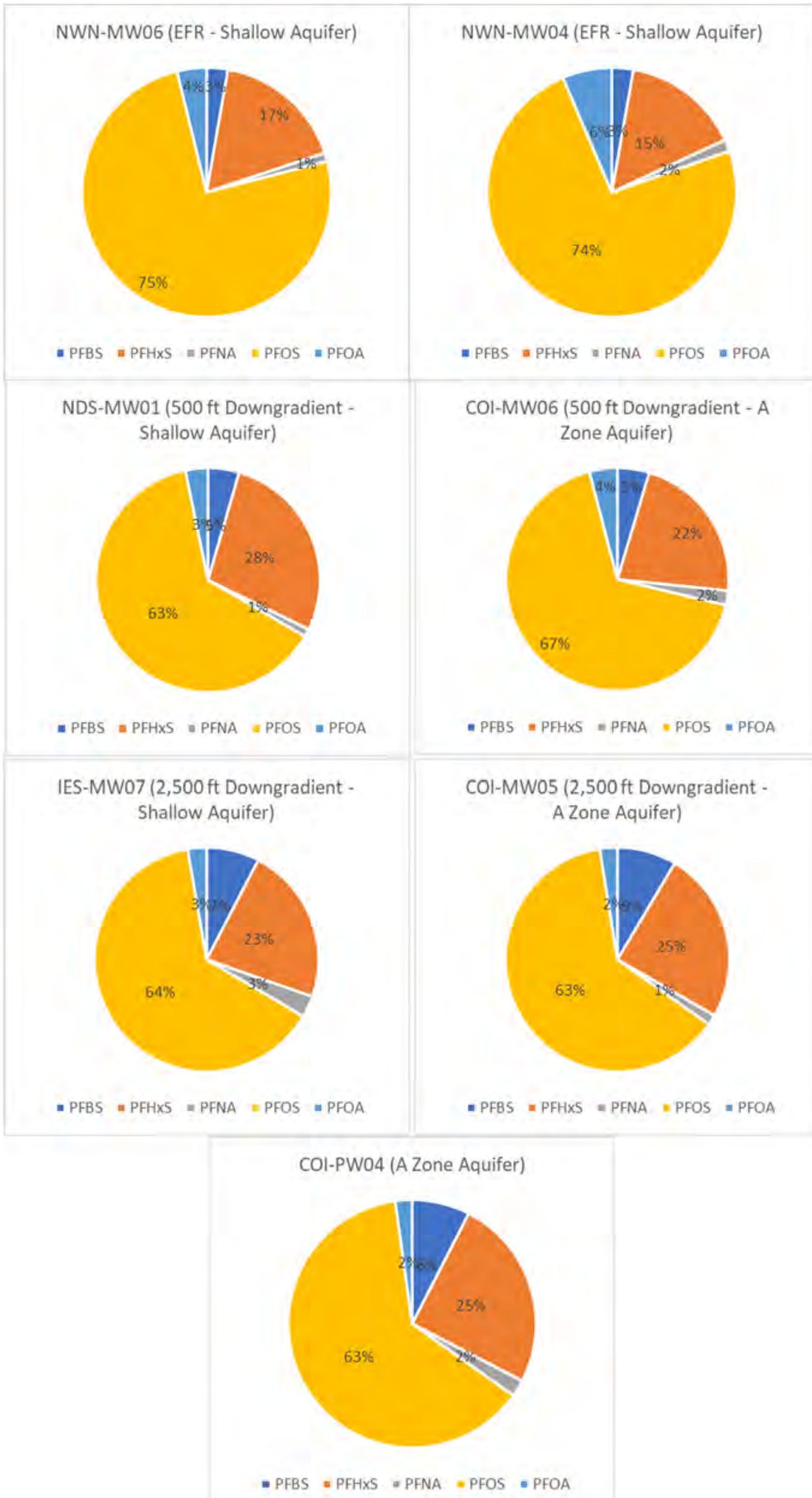


Exhibit G: PFAS Ratios Along Flow Path

4.6 Approach for Future PFAS Modeling

Following additional data collection (Section 5), the numerical groundwater flow model will be refined and calibrated under steady-state and transient conditions. PFAS transport will be added using MT3D-USGS to the MODFLOW groundwater flow model to allow for simulations of up to three PFAS compounds. Fate and transport calibration will be mostly qualitative and focus on comparison of PFAS plumes over time and comparison of relative PFAS concentrations at different locations, based on adjustment of the sorption coefficients.

Consistent with the approach used in the 2D cross-section model, the model will simulate the transport of PFAS originating at the water table, which becomes a "continuous" source of PFAS that can move to downgradient areas long after the release of AFFF at the ground surface. The model will not simulate AFFF releases to the unsaturated soil surface, AFFF partitioning in the soil following release, or the transport of PFAS in the unsaturated zone. Soil can be a significant reservoir for PFAS that then leaches into the water table and begins to flow with groundwater. Because of complex retention processes in soil and unsaturated zone, PFAS concentrations in soil are generally an order of magnitude higher than concentrations in groundwater, and significant retention of PFAS in the vadose zone over long timeframes is expected (Brusseau et al., 2020). This approach is a reasonable and common practice in groundwater modeling to simulate groundwater fate and transport and better understand contaminant migration in the subsurface in order to design effective remediation strategies.

Following the model update and calibration, the model will be used to assess up to four future regional pumping scenarios and simulate PFAS migration under those different future conditions. The model will be used to assess anticipated PFAS concentrations at multiple locations under the different future conditions and evaluate PFAS mass in the different subsurface units. This information will be valuable to support decision making for regional pumping and consideration of remedial strategies.

5. PRELIMINARY DATA GAPS SUMMARY AND RECOMMENDED DATA COLLECTION

Hydrogeologic and PFAS concentration data gaps are identified in the table below. The table includes the potential approach to investigating each data gap , along with proposed data collection to support refinement of the model. Not all data gaps will be investigated as part of the model refinement.

Table C: Hydrogeological and PFAS Concentration Data Gaps

Identified Data Gap	Potential Investigations	Proposed 2022 Data Collection
Migration between the A Zone Aquifer and the B Zone Aquifer. Thickness and competency of silt aquitard 2 and if PFAS is present in or diffusing through this layer. PFAS Transport to Deeper production Aquifers (B Zone and B/C Zone)	Investigate the lithological and hydrogeological connection between the A, B, and C Zone Aquifers, specifically the depth, thickness, and characteristics of the silt aquitard and PFAS diffusion across or migration pathways from A and B Zone Aquifers	Install one deep monitoring well east of NLS-MW01 (Shallow Aquifer) and NLS-MW02 (A Zone Aquifer), along potential flow path from the two MTCA sites (EFR and IES) to COI-PW04. The boring and monitoring well will be drilled/installed up to 300 feet bgs to provide data to characterize/better understand PFAS migration deeper to B Zone (COI-PW05) along core of known PFAS plume. The proposed well location is shown on **Figure 6**, co-located with monitoring wells IES-MW07 (Shallow Aquifer), COI-MW05, and IES-MW12 (A Zone Aquifer). This location was selected based on access and other logistical constraints.
Characterization and monitoring of transition areas between A Zone to B Zone and potential identification of a	Investigate the lithological and hydrogeological connection between the A, B, and C Zone Aquifers, specifically the depth, thickness, and characteristics of the Deep Aquifer and transition from and into A and B Zone Aquifers. There is potential for pinching	Install one deep monitoring well along a potential flow path from the two MTCA sites (EFR and IES) to the east side of the LIV and SPWD pumping wells.

Identified Data Gap	Potential Investigations	Proposed 2022 Data Collection
B/C Zone on the eastern side of the LIV. PFAS Transport to Deeper production Aquifers (B Zone and B/C Zone)	out and interfingering of the silt and sand units across the valley. Potential location: East of Issaquah Creek, north of the confluence of the East Fork of Issaquah Creek and approximately 1,000 feet northwest of Darigold Production Well (DG-PW01). Provides monitoring point at similar depth to SPW-PW09, along potential cross-gradient flow path to east side of LIV.	Not selected at this time; migration and flow paths from source areas to SPWD wells appears complicated and not yet well understood or modeled
Lateral and Vertical characterization of the Deep Aquitard (Silt layer), between A Zone and B Zone (Model layer 6)	Drill two borings to approximately 150 to 200 feet bgs, tag the Deep Aquitard, and install two monitoring wells in A Zone Aquifer above the Deep Aquitard. Potential location: Same as above, along eastern side of LIV flow paths towards SPW pumping wells and northwest location along flow paths to Lake Sammamish.	Not selected. Existing shallow well network is extensive. Depending on results from deep well, future monitoring of A Zone Aquifer may be recommended.
Shallow aquifer – groundwater-surface water interaction	Install transducers in select Shallow and A Zone Aquifer monitoring wells and stream gauging stations, and monitor throughout the year.	Install transducers in well and stream pairs shown on **Figure 6**.
Aquifer and aquitard hydraulic properties	Conduct aquifer pumping tests.	Not selected. After initial modeling and sensitivity analysis, areas where aquifer property uncertainty has significant influence on contaminant transport will be identified and pumping tests will be considered.

Identified Data Gap	Potential Investigations	Proposed 2022 Data Collection
PFAS extent in B and B/C Zone Aquifers	PFAS sampling at COI-TW06 and COI-TW03 and new deep monitoring well.	Partnership will sample these wells.

The proposed B Zone Aquifer well (**Figure 6**) will provide information on the hydrostratigraphy in this area and on potential PFAS migration pathways to COI-PW04 and COI-PW-5, as follows:

- Observed PFAS concentrations during drilling in A Zone Aquifer will support further evaluation of the vertical extent of the PFAS plume in the A Zone Aquifer as it approaches COI-PW04 and whether there are high PFAS concentrations at the base of the A-zone. Understanding the vertical extent of the plume is also important for evaluating total PFAS mass in the A Zone and for evaluating remedial strategies.
- Presence of the Deep Aquitard (and its thickness) at this location will provide important geologic data on the composition and texture of the aquitard and will help with refinement of the hydrostratigraphy and model layering. If the deep aquitard is present, a profile of PFAS concentrations can be generated that will be very valuable for both the model and evaluating potential remedial strategies. If PFAS is present in the aquitard and underlying B Zone, it will suggest diffusion/dispersion through the Deep Aquitard is likely the pathway for PFAS migration from the A Zone Aquifer to the B Zone Aquifer. If PFAS concentrations are low (or zero) in the aquitard, the pathway to COI-PW05 will be modeled as a more direct PFAS pathway or “window” in the Deep Aquitard allowing transport to the B Zone aquifer from the upgradient source areas.
- Low (or zero) PFAS concentrations in the B Zone Aquifer at this location would indicate a different pathway for PFAS migration to the B Zone Aquifer than downward migration from the A Zone Aquifer, and would suggest additional monitoring locations (such as the other options discussed in Table C, above) should be considered.
- Absence of the Deep Aquitard at this location will indicate a more permeable PFAS pathway to the B Zone Aquifer and COI-PW05, which will require that the model layering be refined with respect to the thickness and hydraulic properties of the aquitard layer. If PFAS is present at depth and in the underlying B Zone Aquifer, the pathway to COI-PW05 will be modeled as a more direct PFAS pathway to the B Zone aquifer from the upgradient source areas.

In addition to better characterization of PFAS migration and the conceptual model to refine the numerical model, information collected at the proposed well location will be used to develop recommendations for future additional sampling locations.

6. REFERENCES

Anderson, R. Hunter, Dave T. Adamson, and Hans F. Stroo. 2019. "Partitioning of poly- and perfluoroalkyl substances from soil to groundwater within aqueous film-forming foam source zones." Journal of Contaminant Hydrology 220:59-65. https://doi.org/10.1016/j.jconhyd.2018.11.011.

Brusseau, Anderson, Guo, 2020. PFAS concentrations in soils: Background levels versus contaminated sites. Science of the Total Environment, 740 (140017). https://doi.org/10.1016/j.scitotenv.2020.140017

CDM Smith, 2017. Technical Memorandum, Groundwater Model Development and Applications for PFC Risk Mitigation. April 24.

Farallon Consulting, LLC (Farallon), 2019. Per- And Poly-Fluoroalkyl Substances Characterization Study Summary Report, Lower Issaquah Valley Issaquah, Washington. January 8.

Farallon, 2021. Per- And Poly-Fluoroalkyl Substances Additional Characterization Study Summary Report Lower Issaquah Valley Issaquah, Washington. April 14.

Farhat S.K., Newell, C.J., Lee, S.A., Looney, B.B., Falta, R.W., 2022. Impact of matrix diffusion on the migration of groundwater plumes for Perfluoroalkyl acids (PFAAs) and other non-degradable compounds. Journal of Contaminant Hydrology 247, 103987.

Geosyntec Consultants, Inc (Geosyntec), 2016. Phase 1 Hydrogeological Characterization. Issaquah, Washington, 4 March 2016.

Geosyntec, 2019. Critical Aquifer Recharge Area (CARA) Mapping and Assessment Report, Issaquah, Washington. November 25.

Geosyntec, 2021. Groundwater Flow and PFAS Transport Modeling Report, Issaquah, Washington. September 13.

Golder Associates Inc. (Golder), 2003. Draft Stormwater Infiltration Evaluation, Issaquah, Washington. Prepared for the City of Issaquah, 23 January.

Golder, 1999. Draft Groundwater Exploration and Pumping Tests, Lower Issaquah Valley, Washington. Prepared for the City of Issaquah, 22 January.

Interstate Technology Regulatory Council (ITRC), 2022. Environmental Fate and Transport Processes (https://pfas-1.itrcweb.org/). Accessed September 2022.

National Ground Water Association (NGWA, 2021). PFAS Fate and Transport 2021. NGWA White Paper. July 26.

Sima, M.W., Jaffe, P.R., 2021. A critical review of modeling poly- and Perfluoroalkyl substances (PFAS) in the soil-water environment. Sci. Total Environ. 757, 143793. https://doi.org/10.1016/j.scitotenv.2020.143793

TABLES

Table 1
Aquifer Designation Summary
Issaquah Regional Conceptual Hydrogeological Model

Geologic & Hydrogeologic Unit Summary Table and Recommended Nomenclature						
Geological Units Description **Geosyntec 2016 Report, Boring Logs, Golder 1999 Report**	**Geological Units**	**Geologic Unit & Aquifer Depth Intervals from Other Studies**			**Recommended Depth Designations**	**Recommended Nomenclature**
		Farallon	**Golder**	**CDM Smith**	**Geosyntec**	
Brown sand or sandy silt with gravel, cobbles, and pebbly sand deposited along streams in the LIV. Occasional wetland (Qw) and peat (Qp) deposits are sometimes present in the LIV. Grey to grey-green sandy silt underlain by a loose, grey sand characterized by heaving.	Qa - alluvium Qvi - ice contact deposits	Shallow (0-60 feet)	Shallow or Uppermost Aquifer	Surficial Water Bearing Units Model Layers 1, 2, 3	0-60 feet	Shallow Aquifer
Grey sandy silt with occasional wood fragments. Some organic material (wood fragments) and one small section of peat were encountered near the base of the ice contact deposits.	peat/lake deposits		Uppermost aquitard (first)	Model Layer 4		Shallow Aquitard
Layered sand and gravel with little silt, moderately to well sorted with stratification. Deltaic complexes are present in the southern, western, and eastern portions of the LIV interpreted to have formed from glacial meltwater. Brown to grey-brown sand to silty sand, well sorted. Glacial channel deposits consisting of coarse sand and gravel grading to a silty medium to coarse sand.	Qvr - recessional outwash	Intermediate (60-120 feet)	0-80' Upper Unconfined Aquifer	A Sand Aquifer Model Layer 5	60-120 feet	A Zone Aquifer (Potable Production Aquifer)
Clayey silt, silts, silty sand; sands and gravels with silt, weakly to strongly oxidized, some glacial till.	Qpff - Older glacial deposits Qpog - Older glacial deposits	Deep (>120 feet)	Silt (second aquitard) Older Lacustrine Deposits	Silt Model Layer 6	120-180 (200?)	Deep Aquitard
Sand and gravel Silty sand and gravel in some areas (water producing)	Qvr - recessional outwash		Deep Aquifer	B Sand Aquifer Model Layer 7	~(180) 200-250 feet	B Zone Aquifer (Potable Production Aquifer)
Medium to coarse sand and gravel; silty sand (water producing).	Qva - advance outwash Qpog (?) - Older glacial deposits; channelized	--	Glaciofluvial Channels Deep Aquifer	B/C Sand Aquifer Model Layer 8	250-375 (~400?)	C Zone Channel Aquifer (Potential potable production aquifer)

Table 2
Well Construction Details
Regional Conceptual Hydrogeological Model

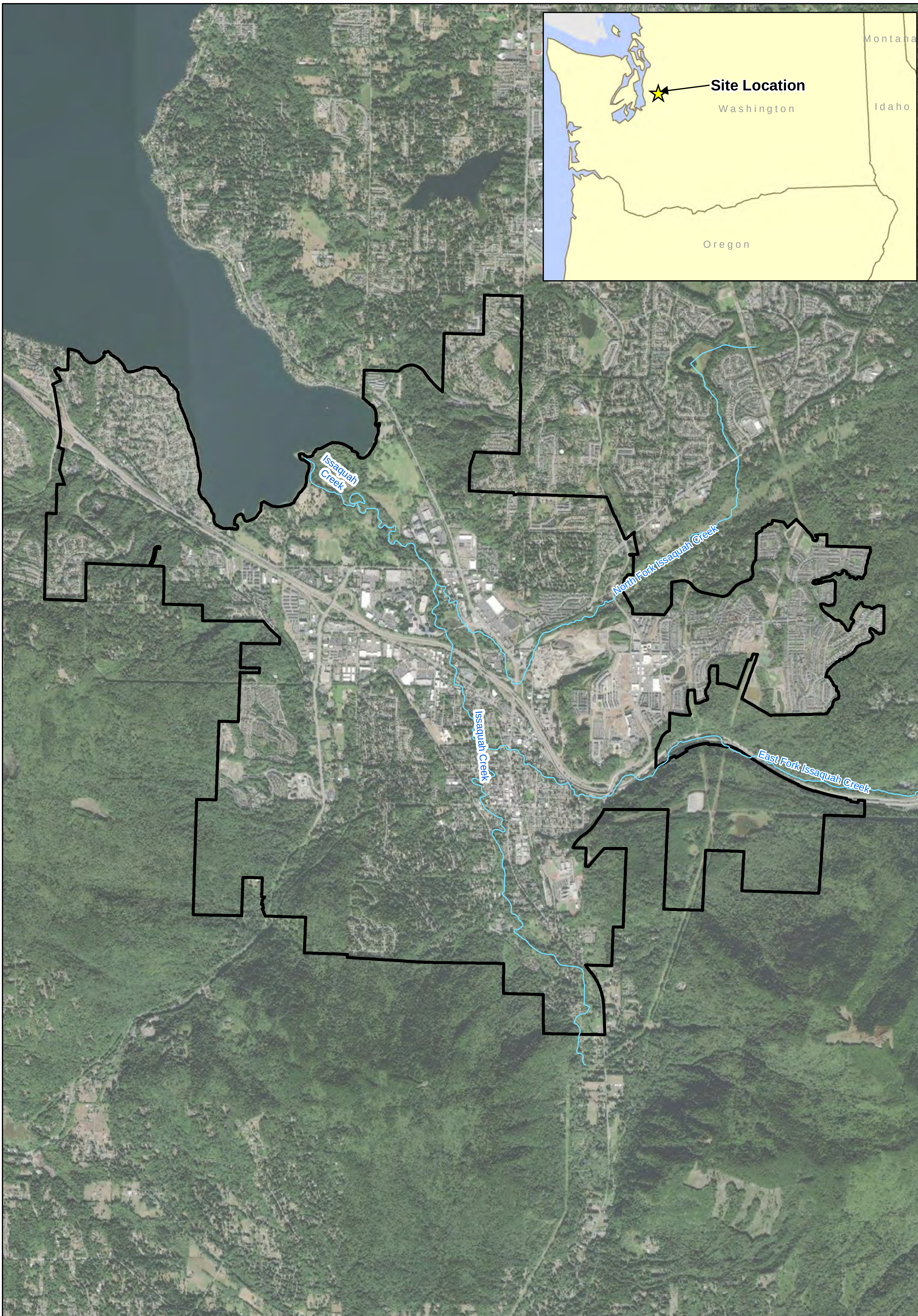
Well ID	Well Type	Other Classification	Aquifer Designation	Water Level Monitoring record	Water Quality Monitoring Record	Easting	Northing	Previous Monitoring Well ID	Well Owner	Ground Surface Elevation (feet NAVD88)	Top of Casing Elevation (feet NAVD88)	Top of Screen (feet bgs)	Bottom of Screen (feet bgs)	Screened Length (feet)	Screen Top Elevation (feet NAVD88)	Screen Bottom Elevation (feet NAVD88)
Water Production Wells																
COI-PW01	A Zone Production Well	Water Production Wells	Shallow Zone Aquifer	--	2013, 2014, 2018	1344158	197898	Well 1	City of Issaquah	NM	92.57	90	106	16	2.57	-13.43
COI-PW02	A Zone Production Well	Water Production Wells	Shallow Zone Aquifer	--	2013, 2014, 2018	1344184	197865	Well 2	City of Issaquah	NM	93.06	82	97	15	11.06	-3.94
COI-PW04	A Zone Production Well	Water Production Wells	A Zone Aquifer	--	2013-2014, 2016-2018, 2020-2022	1341271	200772	Well 4	City of Issaquah	NM	66.19	77	102	25	-10.81	-35.81
COI-PW05	B Zone Production Well	Water Production Wells	B Zone Aquifer	2016	2013-2014, 2016-2021	1341310	200669	Well 5	City of Issaquah	NM	67.16	323	405	82	-255.84	-337.84
SP-PW07	A Zone Production Well	Water Production Wells	A Zone Aquifer	--	2016	1342984	200506	SPWSD Well 7	Sammamish Plateau	NM	70.19	82.6	146.9	64.3	-12.41	-76.71
SP-PW08	A Zone Production Well	Water Production Wells	A Zone Aquifer	--	2016	1343076	200077	SPWSD Well 8	Sammamish Plateau	NM	73.94	105	179	74	-31.06	-105.06
SP-PW09	C Zone Production Well	Water Production Wells	B/C Zone Aquifer	--	2016	1343953	199191	SPWSD Well 9	Sammamish Plateau	NM	77.65	194	219	25	-116.35	-141.35
DG-PW01	A Zone Production Well	Water Production Wells	A Zone Aquifer	--	2016	1342972	197877	ABY249	Darigold	NM	85.29	81	96	15	4.29	-10.71
Lakeside	A Zone Production Well	Water Production Wells	A Zone Aquifer	--	--	1344222	200519	Lakeside	Lakdside	NM	NM	102	108	6	NM	NM
Geotechnical Wells-Newport Way Northwest																
B-7	temp well	Geotechnical Wells-Newport Way Northwest	Shallow Zone Aquifer	--	--	1340581	198050	---	City of Issaquah	NM	NM	22.5	32.5	10	NM	NM
B-12	temp well	Geotechnical Wells-Newport Way Northwest	Shallow Zone Aquifer	--	--	1341680	196381	---	City of Issaquah	NM	NM	20	30	10	NM	NM
Resource Protection Monitoring Wells																
175 Newport Way Northwest (EFR) - Cleanup Site ID 16581																
NWN-MW01	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2018, 2020-2022	2018, 2020-2022	1341269	196417	---	Eastside Fire & Rescue	90.93	90.69	15	30	15	75.69	60.69
NWN-MW02	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2018, 2020-2022	2018, 2020	1341462	196584	---	Eastside Fire & Rescue	90.04	89.84	15	30	15	74.84	59.84
NWN-MW03	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2018, 2020-2022	2018, 2020, 2021, 2022	1341264	196600	---	Eastside Fire & Rescue	91.60	91.35	15	30	15	76.35	61.35
NWN-MW04	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2018, 2020-2022	2018, 2020-2022	1341096	196495	---	Eastside Fire & Rescue	90.68	90.41	13	23	10	77.41	67.41
NWN-MW05	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2020-2022	2020	1341075	196597	---	Eastside Fire & Rescue	90.65	90.34	7	17	10	83.34	73.34
NWN-MW06	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2020-2022	2020-2022	1341125	196598	---	Eastside Fire & Rescue	91.19	90.98	15	25	10	75.98	65.98
NWN-MW07	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2020-2022	2020-2022	1341204	196570	---	Eastside Fire & Rescue	91.28	90.89	16.5	26.5	10	74.39	64.39
NWN-MW08	A Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	A Zone Aquifer	2020-2022	2020	1341456	196583	---	Eastside Fire & Rescue	90.37	89.95	70	80	10	19.95	9.95
NWN-MW09	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2020-2022	2020-2022	1341257	196600	---	Eastside Fire & Rescue	91.63	91.29	45	50	5	46.29	41.29
NWN-MW10	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2022	2022	1341148	196565	---	Eastside Fire & Rescue	91.04	90.66	10	25	15	80.66	65.66
NWN-MW11	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2022	2022	1342184	196195	---	Eastside Fire & Rescue	90.91	90.58	15	25	10	75.58	65.58
NWN-MW12	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2022	2022	1341146	196492	---	Eastside Fire & Rescue	91.04	90.56	8	23	15	82.56	67.56
NWN-MW13	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2022	2022	1341046	196465	---	Eastside Fire & Rescue	90.28	89.90	3	18	15	86.90	71.90
NWN-MW14	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2022	2022	1341141	196443	---	Eastside Fire & Rescue	91.01	90.68	7	22	15	83.68	68.68
NWN-MW15	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2022	2022	1341234	196460	---	Eastside Fire & Rescue	90.77	90.37	15	30	15	75.37	60.37
NWN-MW16	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2022	2022	1341235	196537	---	Eastside Fire & Rescue	90.87	90.55	15	30	15	75.55	60.55
NWN-PZ01	Piezometer	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2020	--	1341235	196537	---	Eastside Fire & Rescue	91.20	90.76	20	30	10	70.76	60.76
NWN-PZ02	Piezometer	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	2020	2020	1341243	196576	---	Eastside Fire & Rescue	90.99	90.44	20	30	10	70.44	60.44
Rainier Trail - Cleanup Site ID 16583																
RT-MW01	Shallow Zone Monitoring Well	Memorial Field - Cleanup Site ID 16584	Shallow Zone Aquifer	2018, 2020	2018	1343590	195910	MW-01	City of Issaquah	99.13	98.67	25	45	20	73.67	53.67
RT-MW03	Shallow Zone Monitoring Well	Memorial Field - Cleanup Site ID 16584	Shallow Zone Aquifer	2018, 2020	2018	1343676	195900	MW-02	City of Issaquah	99.39	99.06	25	45	20	74.06	54.06
RT-MW04	Shallow Zone Monitoring Well	Memorial Field - Cleanup Site ID 16584	Shallow Zone Aquifer	2018, 2020	2018	1343630	195466	---	Eastside Fire & Rescue	101.00	100.76	28	38	10	72.76	62.76
Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583																
IES-MW01	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2018, 2020	2018, 2020	1341197	197783	---	Eastside Fire & Rescue	76.52	76.31	16	26	10	60.31	50.31
IES-MW02	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2018, 2020	2018, 2020	1340885	197926	---	Eastside Fire & Rescue	74.43	73.74	15	25	10	58.74	48.74
IES-MW03	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2018, 2020	2018, 2020	1340736	198407	---	Eastside Fire & Rescue	73.09	72.70	15	25	10	57.7	47.7
IES-MW04	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2018, 2020	2018, 2020	1341051	198402	---	Eastside Fire & Rescue	72.97	72.43	15	30	15	57.43	42.43
IES-MW05	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2018, 2020	2018, 2020	1341434	198390	---	Eastside Fire & Rescue	72.75	72.76	20	30	10	52.76	42.76
IES-MW06	A Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	A Zone Aquifer	2020	2020	1341204	197797	---	Eastside Fire & Rescue	76.29	75.92	80	90	10	-4.08	-14.08
IES-MW07	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2020	2020	1341387	199096	---	Eastside Fire & Rescue	70.54	70.25	20	30	10	50.25	40.25
IES-MW08	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2020	2020	1341809	198349	---	Eastside Fire & Rescue	72.55	72.07	20	30	10	52.07	42.07
IES-MW09	A Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	A Zone Aquifer	2020	2020	1341819	198351	---	Eastside Fire & Rescue	72.45	72.18	75	85	10	-2.82	-12.82
IES-MW10	A Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	A Zone Aquifer	2020	2020	1340747	198407	---	Eastside Fire & Rescue	73.08	72.66	75	85	10	-2.34	-12.34
DF-MW01	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2018, 2020	2020	1341733	197859	EB-1W	Eastside Fire & Rescue	77.99	77.71	5	15	10	72.71	62.71
DF-MW02	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2018, 2020	2018, 2020	1341342	197988	EB-5W	Eastside Fire & Rescue	74.57	74.21	15	25	10	59.21	49.21
DF-MW03	Shallow Zone Monitoring Well	Issaquah Valley Elementary West Playfield / Dodd Fields Park - Cleanup Site ID 16583	Shallow Zone Aquifer	2018, 2020	2018	1341663	198264	EB-3W	Eastside Fire & Rescue	74.71	74.35	20	30	10	54.35	44.35
Memorial Field - Cleanup Site ID 16584																
MF-MW01	Shallow Zone Monitoring Well	Memorial Field - Cleanup Site ID 16584	Shallow Zone Aquifer	2018, 2020	2018	1343913	195913	---	Eastside Fire & Rescue	102.88	102.57	16	26	10	86.57	76.57
MF-MW02	Shallow Zone Monitoring Well	Memorial Field - Cleanup Site ID 16584	Shallow Zone Aquifer	2018, 2020	2018, 2020	1343727	196215	---	Eastside Fire & Rescue	100.16	99.51	25	45	20	74.51	54.51
MF-MW03	Shallow Zone Monitoring Well	Memorial Field - Cleanup Site ID 16584	Shallow Zone Aquifer	2018, 2020	2018	1343967	196294	---	Eastside Fire & Rescue	104.36	104.17	35	50	15	69.17	54.17
MF-MW04	A Zone Monitoring Well	Memorial Field - Cleanup Site ID 16584	A Zone Aquifer	2020	2020	1343721	196214	---	Eastside Fire & Rescue	100.32	99.94	65	75	10	34.94	24.94

Table 2
Well Construction Details
Regional Conceptual Hydrogeological Model

Well ID	Well Type	Other Classification	Aquifer Designation	Water Level Monitoring record	Water Quality Monitoring Record	Easting	Northing	Previous Monitoring Well ID	Well Owner	Ground Surface Elevation (feet NAVD88)	Top of Casing Elevation (feet NAVD88)	Top of Screen (feet bgs)	Bottom of Screen (feet bgs)	Screened Length (feet)	Screen Top Elevation (feet NAVD88)	Screen Bottom Elevation (feet NAVD88)
Lower Issaquah Valley Regional Wells																
COI-MW01	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2016	2016	1338949	201384	MW01	City of Issaquah	58.36	58.40	28	38	10	30.4	20.4
COI-MW02	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016, 2018, 2020	2016, 2018	1340781	201348	MW02	City of Issaquah	59.7	62.8	70	90	20	-7.2	-27.2
COI-MW03	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016, 2018, 2020	2016, 2018, 2020	1341030	200668	MW03	City of Issaquah	63.16	62.90	78	98	20	-15.1	-35.1
COI-MW04	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016, 2018, 2020	2016, 2018, 2020	1341895	199847	MW04	City of Issaquah	73.3	73.1	70	90	20	3.1	-16.9
COI-MW05	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016, 2018, 2020	2016, 2018, 2020	1341394	199048	MW05	City of Issaquah	72.05	71.90	70	90	20	1.9	-18.1
COI-MW06	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016, 2018, 2020	2016, 2018, 2020	1341319	197107	MW06	City of Issaquah	86.5	86.3	80	100	20	6.3	-13.7
COI-MW07	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016, 2018, 2020	2016, 2018, 2020	1342211	196184	MW07	City of Issaquah	90.7	90.3	100	110	10	-9.7	-19.7
NDS-MW01	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2020	2020	1341326	197104	---	Eastside Fire & Rescue	86.16	85.48	22	32	10	63.48	53.48
NDS-MW02	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2020	2020	1341398	197439	---	Eastside Fire & Rescue	82.10	81.75	71	81	10	10.75	0.75
NDS-MW03	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2020	2020	1341935	197357	---	Eastside Fire & Rescue	82.54	82.07	25	35	10	57.07	47.07
NDS-MW04	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2020	2020	1341933	197337	---	Eastside Fire & Rescue	82.19	81.71	72	82	10	9.71	-0.29
RBN-MW01	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2020	2020	1342586	199284	---	Eastside Fire & Rescue	74.5	74.2	70	80	10	4.24	-5.76
RBN-MW02	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2020	2020	1343631	197109	---	Eastside Fire & Rescue	99.56	99.01	70	80	10	29.01	19.01
B-4	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	--	2020	1340063	198862	---	City of Issaquah	NM	74.37	20	30	10	54.37	44.37
B-2	Shallow Zone Monitoring Well	175 Newport Way Northwest (EFR) - Cleanup Site ID 16581	Shallow Zone Aquifer	--	2020	1339406	199916	---	City of Issaquah	NM	80.98	20	30	10	60.98	50.98
SP-VT1-1	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2016-2021	--	1343702	199872	SPVT1-1	Sammamish Plateau	NM	73.16	28	38	10	45.16	35.16
SP-VT1-2	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016-2021	--	1343702	199872	SPVT1-2	Sammamish Plateau	NM	73.16	70	80	10	3.16	-6.84
SP-VT1-3	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016-2021	--	1343702	199872	SPVT1-3	Sammamish Plateau	NM	73.16	150	160	10	-76.84	-86.84
SP-VT2-1	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2016-2021	2016	1341545	201239	SPVT2-1	Sammamish Plateau	NM	59.68	19	24	5	40.35	35.35
SP-VT2-2	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2016-2021	2016	1341579	201204	SPVT2-2	Sammamish Plateau	NM	61.88	34	39	5	27.87	22.87
SP-VT2-3	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016-2021	2016	1341592	201153	SPVT2-3	Sammamish Plateau	NM	62.14	74	79	5	-11.86	-16.86
SP-VT7-1	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2016-2021	--	1344491	198956	SPVT7-1	Sammamish Plateau	NM	82.78	23	33	10	59.78	49.78
SP-VT7-2	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2016-2021	--	1344491	198956	SPVT7-2	Sammamish Plateau	NM	82.78	43	53	10	39.78	29.78
SP-VT7-3	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016-2021	--	1344491	198956	SPVT7-3	Sammamish Plateau	NM	82.78	51	71	10	31.78	11.78
SP-VT7-4	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016-2021	--	1344491	198956	SPVT7-4	Sammamish Plateau	NM	82.78	108	118	10	-25.22	-35.22
SP-VT8-1	Shallow Zone Monitoring Well	Lower Issaquah Valley Regional Wells	Shallow Zone Aquifer	2016-2021	--	1344235	199055	SPVT8-1	Sammamish Plateau	NM	79.70	45	55	10	34.70	24.70
SP-VT8-2	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016-2021	--	1344235	199055	SPVT8-2	Sammamish Plateau	NM	79.70	83	93	10	-3.30	-13.30
SP-VT8-3	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016-2021	--	1344235	199055	SPVT8-3	Sammamish Plateau	NM	79.70	158	168	10	-78.30	-88.30
SP-VT8-4	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016-2021	--	1344235	199055	SPVT8-4	Sammamish Plateau	NM	79.70	192	214	22	-112.30	-134.30
SP-MW07-1	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	--	--	1343024	200205	SP-MW07-1.1	Sammamish Plateau	72.30	73.80	35	58	23	37.30	14.30
SP-MW07-2	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	--	--	1343024	200205	SP-MW07-1.2	Sammamish Plateau	72.30	73.80	135	220	85	-62.70	-147.70
SP-MW07-3	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	2016	2016	1343022	200507	SP-MW07-3	Sammamish Plateau	70.10	72.10	85	150	65	-14.90	-79.90
COI-TMW1[1]	A Zone Monitoring Well	Lower Issaquah Valley Regional Wells	A Zone Aquifer	--	--	1342570	197378	COI-MW1	City of Issaquah	NM	81.90	84	94	10	-2.10	-12.10
COI-TW01	Deep borehole (no well)	--	B Zone Aquifer	--	--	--	--	GATW-1	City of Issaquah	--	--	--	--	--	--	--
COI-TW02	Deep borehole (no well)	--	B Zone Aquifer	--	--	--	--	TW-2	City of Issaquah	--	--	--	--	--	--	--
COI-TW03[1]	B/C Zone Monitoring Well	Lower Issaquah Valley Regional Wells	B/C Zone Aquifer	2016	2016	1342444	197417	COI-TW3	City of Issaquah	NM	81.80	284	289	5	-202.20	-207.20
COI-TW06	B/C Zone Monitoring Well	Lower Issaquah Valley Regional Wells	B/C Zone Aquifer	--	--	1342579	197291	COI-TW6	City of Issaquah	NM	NM	258	362	104	Unknown	Unknown
COI-PW05-OBS	B Zone Monitoring Well	Lower Issaquah Valley Regional Wells	B Zone Aquifer	2016	2016	--	--	COI Well5OBS	City of Issaquah	NM	NM	Unknown	Unknown	Unknown	Unknown	Unknown

Notes:
Adapted from (Farallon, 2021) Table 1: Monitoring Well Construction Details
-- = data not available and/or still consolidating data received from Sammamish Plateau
[1]TOC elevations are calculated values reported by Geosyntec, 2016
bgs = below ground surface
NAVD88 = North American Vertical Datum of 1988
NM = not measured
Sammamish Plateau = Sammamish Plateau Water and Sewer District
Blue = Top of casing and ground surface elevations will need to be confirmed.

FIGURES



Legend

Issaquah Creek

City Limits

Notes:
1. Aerial image from 2012.

N

0 0.5 Miles

Site Location

Issaquah, Washington

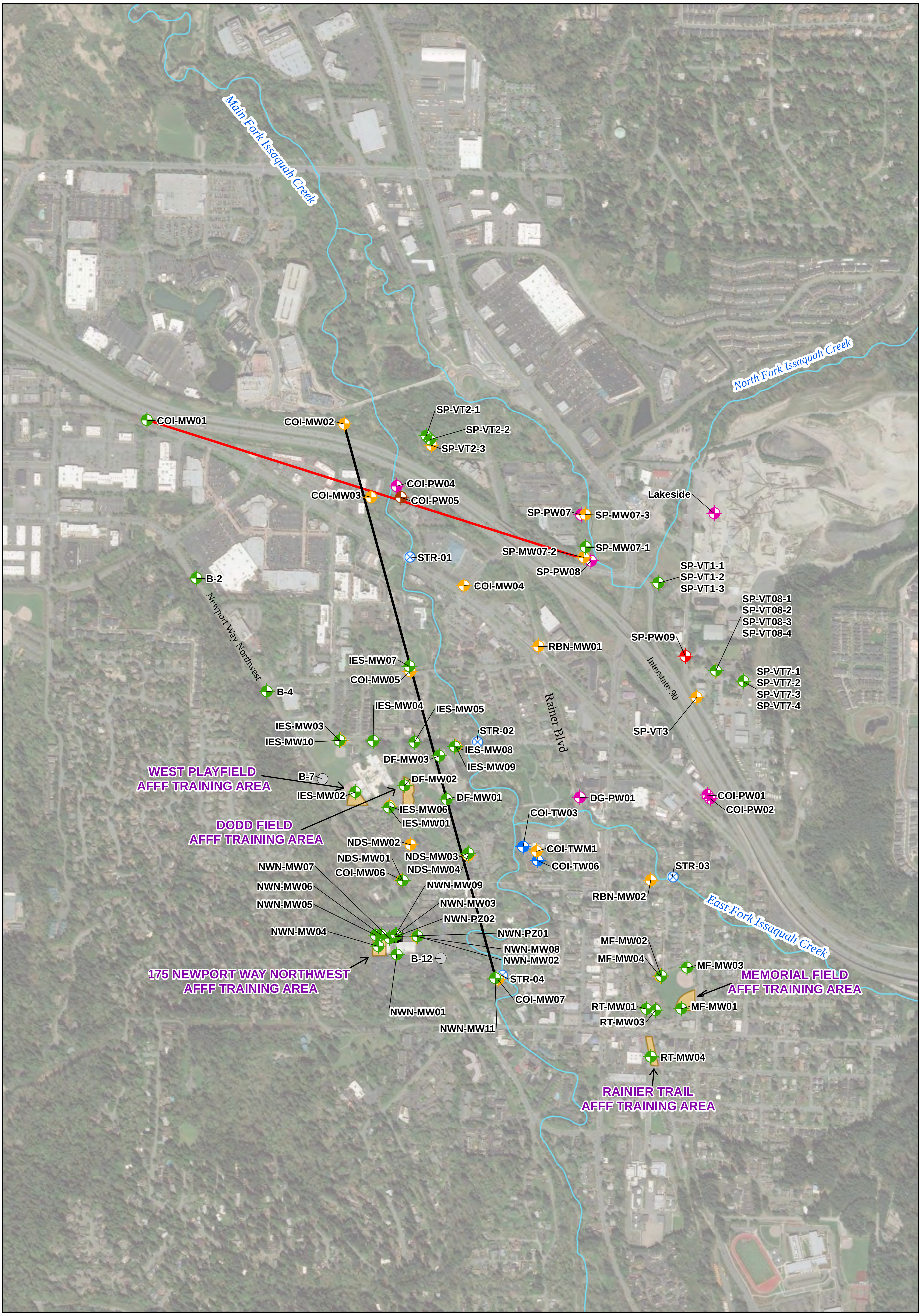
Geosyntec consultants

Figure

1

Seattle, Washington | July 2022

P:\CAD_GIS\Projects\PNG0714 - Issaquah\Projects\06_CSM Memo\Figure 1_Site Location.mxd 7/26/2022 6:01:41 AM



Legend

Well Type

- Shallow Zone Monitoring Well
- A Zone Monitoring Well
- B Zone Monitoring Well
- Temporary Well
- Piezometer
- A Zone Production Well
- B Zone Production Well
- C Zone Production Well
- Stream Gauging Station
- East-West Cross-Section
- North-South Cross-Section
- AFFF Training Area
- Issaquah Creek

Notes:
1. Aerial image from 2012.

N

1 inch = 1000 feet

0 2,000 Feet

Feature Locations

Issaquah, Washington

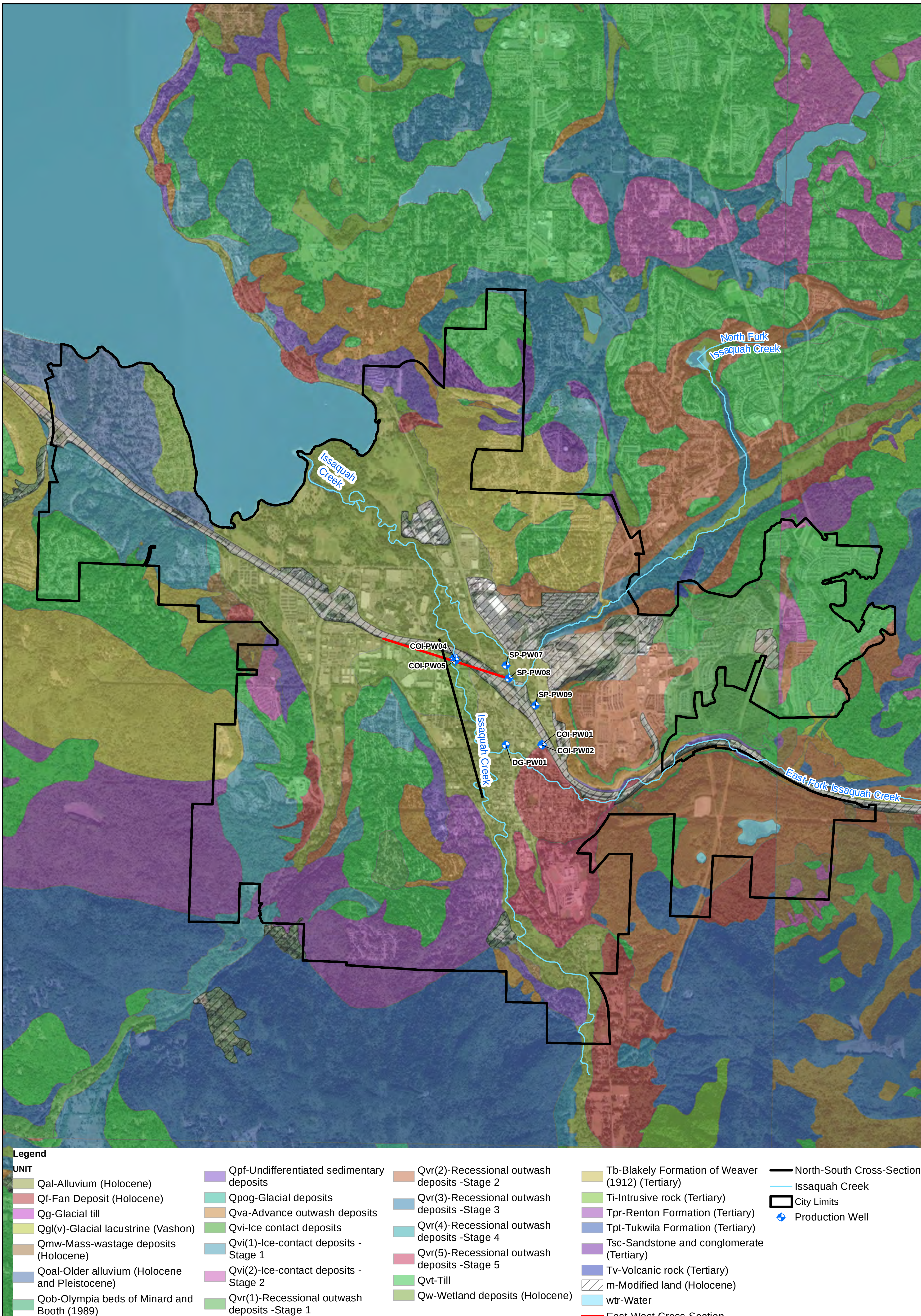
Geosyntec
consultants

Figure

2

Seattle, Washington | September 2022

P:\CAD_GIS\Projects\PNG0714 - Issaquah\Projects\06_CSM Memo\Figure 2 Well Locations.mxd 9/27/2022 10:31:07 AM



Issaquah Quadrangle (2 maps):
Booth, D.B., and Minard, J.P., 1992, Geologic map of the Issaquah 7.5' quadrangle, King County, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-2116, scale 1:24,000.
Booth, D.B., Walsh, T.J., Troost, K.G., and Shimel, S.A., 2012, Geologic map of the East Half of the Bellevue South 7.5' x 15' quadrangle, Issaquah Area, King County, Washington: U.S. Geological Survey Scientific Investigations Map 3211, scale 1:24,000.
Quadrangle south of Issaquah:
Booth, D.B., 1995, Surficial geologic map of the Maple Valley quadrangle, King County, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-2297, scale 1:24,000.
Quadrangle east of Issaquah:
Dragovich, J.D., Anderson, M.L., Walsh, T.J., Johnson, B.L., and Adams, T.L., 2007, Geologic map of the Fall City 7.5-minute quadrangle, King County, Washington: Washinton Division of Geology and Earth Resources Geologic Map GM-67, scale 1:24,000.

Notes:
1. Aerial image from 2012.

N
0 0.5 Miles

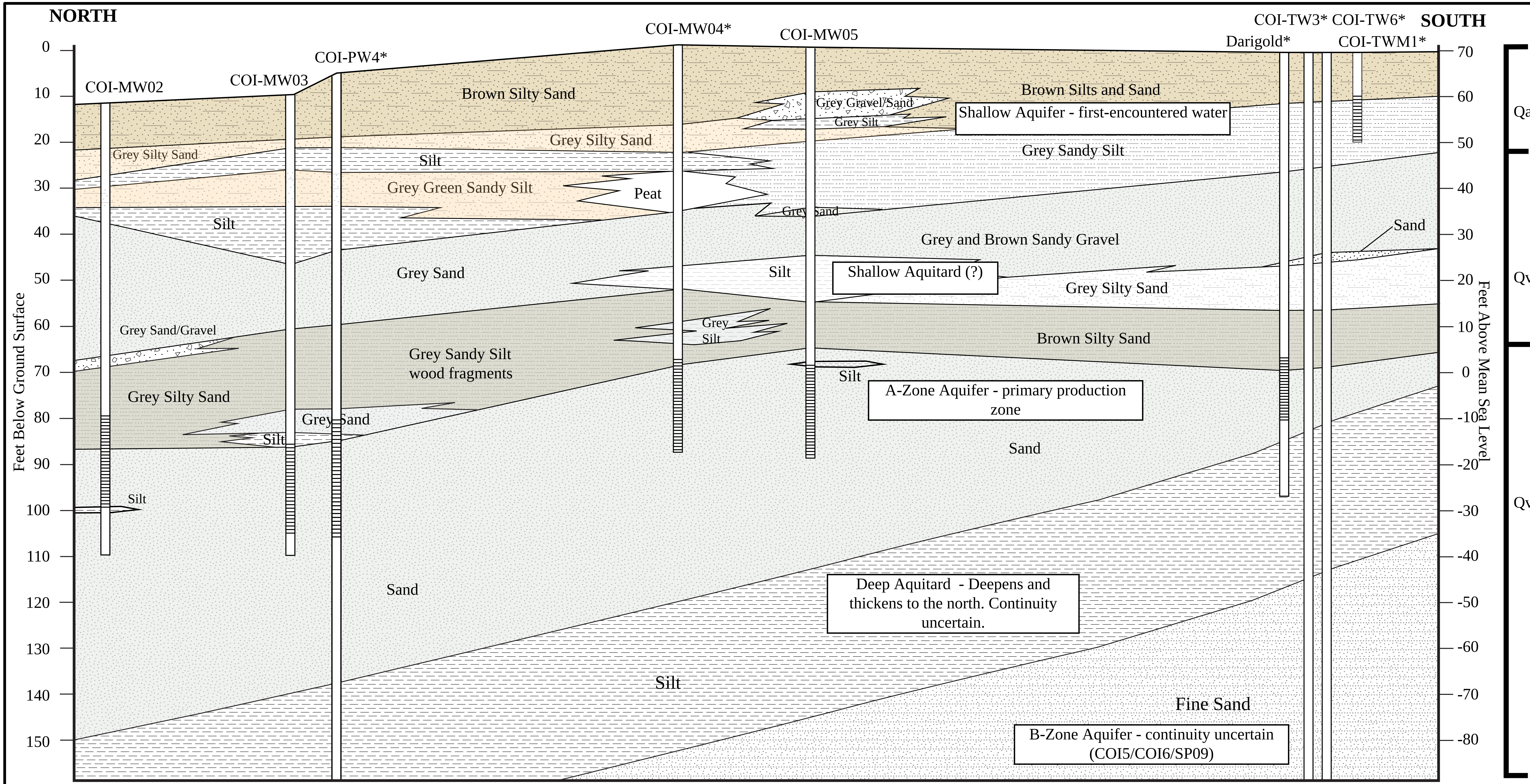
Geologic Map of Issaquah Area
Issaquah, Washington

Geosyntec consultants

Seattle, Washington | September 2022

Figure 3

P:\CAD_GIS\Projects\PNG0714 - Issaquah\Projects\06_CSM Memo\Figure 3 Geologic Map.mxd 9/27/2022 6:06:16 AM



20 Feet
10
0

Cross Section locations shown on Figures 2 and 3.

0 500 1,000 Feet

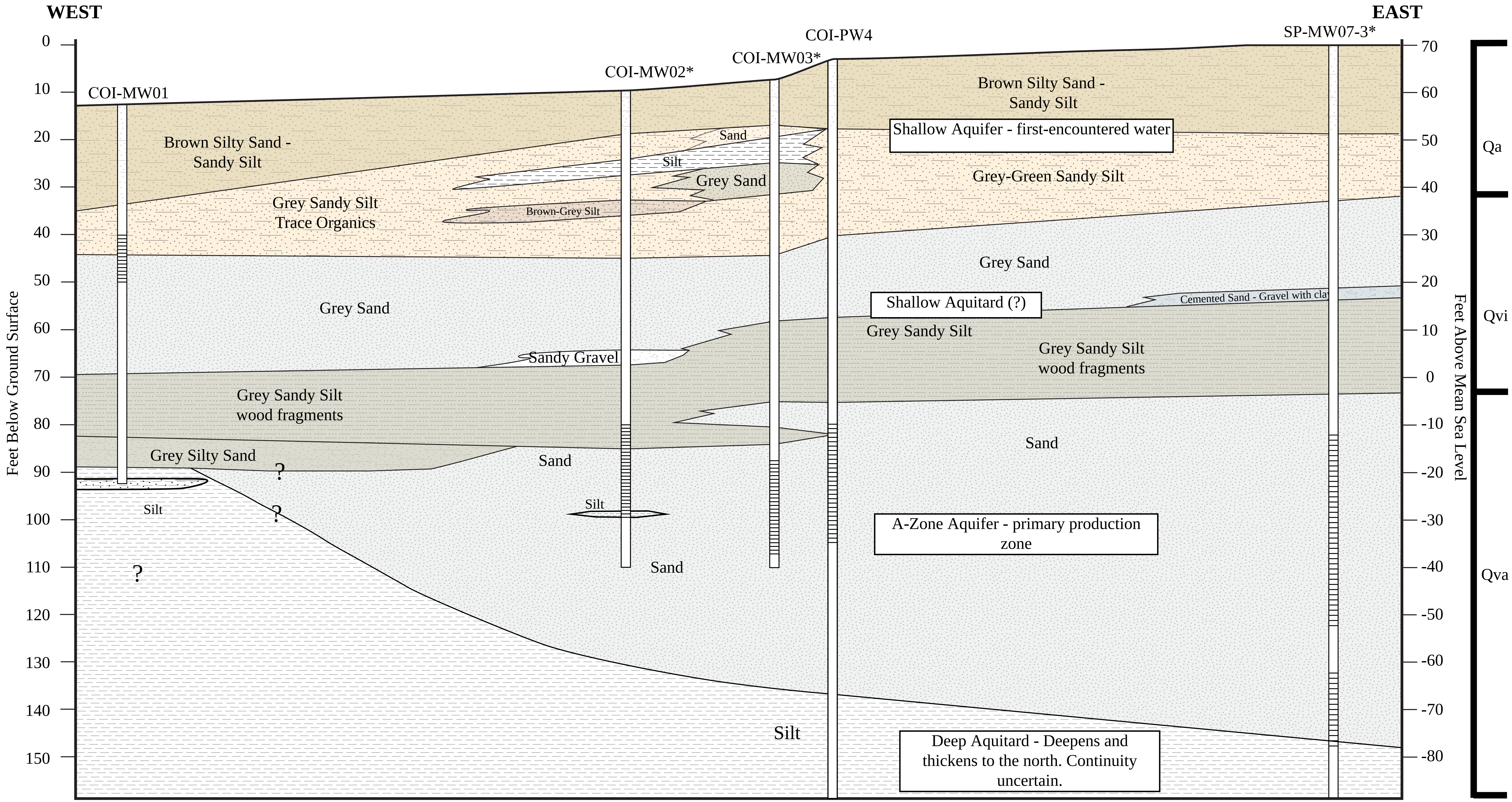
Notes:
Qa - Quaternary Alluvium
Qvi - Quaternary Ice Contact Deposits
Qva - Quaternary Advance Outwash Deposits
20x Vertical Exaggeration
*Wells Projected into line of section

Interpreted North-South Cross Section
City of Issaquah

Geosyntec consultants

Figure 4A

Seattle, WA | November 2022



Cross Section locations shown on Figures 2 and 3.

Note: 20x Vertical Exaggeration

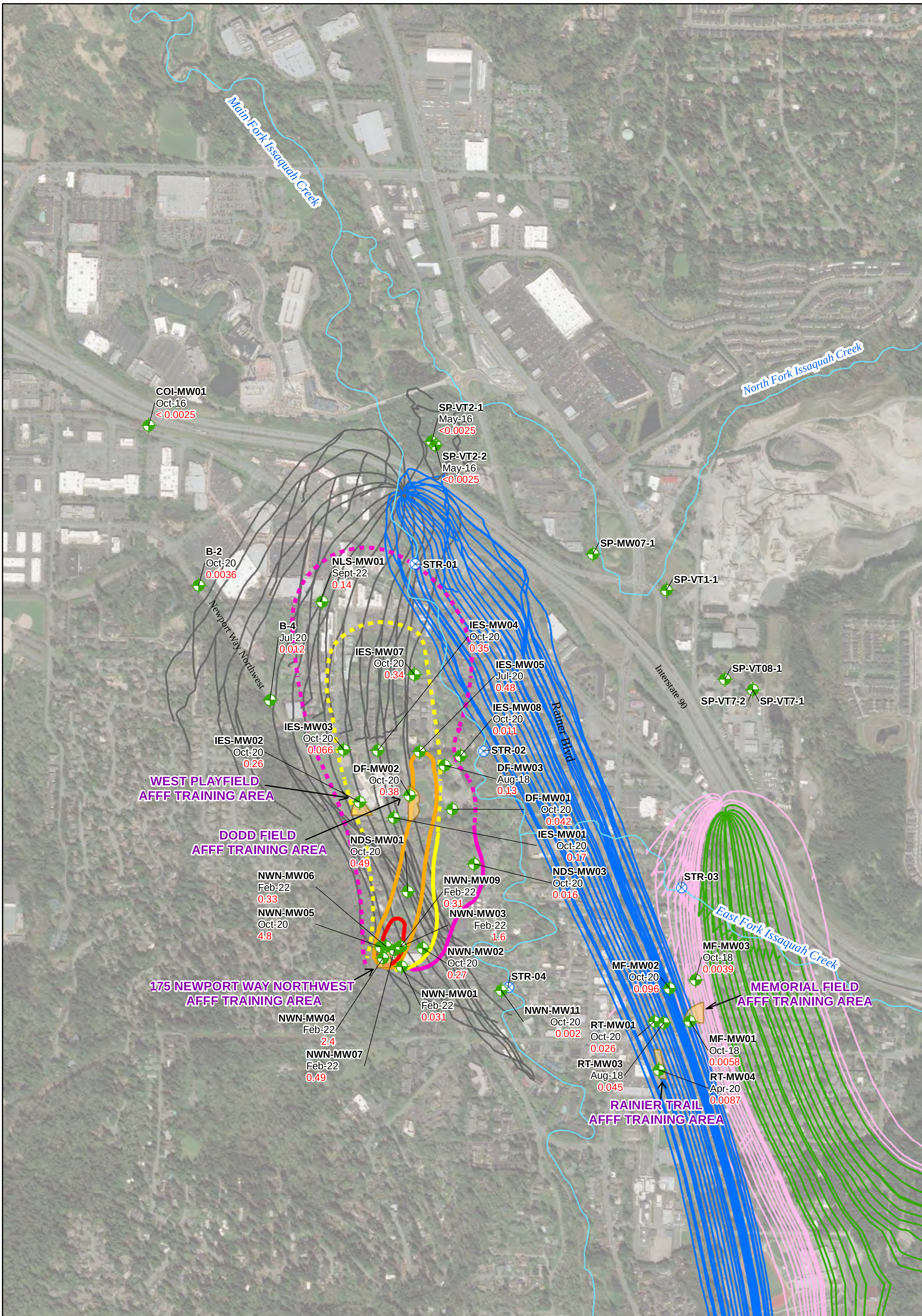
Notes:
Qa - Quaternary Alluvium
Qvi - Quaternary Ice Contact Deposits
Qva - Quaternary Advance Outwash Deposits
20x Vertical Exaggeration
*Wells Projected into line of section

Interpreted West-East Cross Section
City of Issaquah

Geosyntec consultants

Seattle, WA | November 2022

Figure 4B



Legend

Well Type

- Shallow Zone Monitoring Well
- Stream Gauging Station

Simulated Capture Zone (10 yr)

- COI1
- COI2
- COI4
- COI5

AFFF Training Area

PFOS Concentration (dashed where inferred in micrograms per liter)

- 0.015
- 0.25
- 0.5
- 1.0

Issaquah Creek

RT-MW01 — Location ID
Oct-20 — Most Recent Sample Date (Month and Year)
0.026 — PFOS Concentration in micrograms per liter

Notes:
1. Aerial image from 2012.

N

1 inch = 1000 feet

0 2,000 Feet

PFOS Concentration Shallow Aquifer

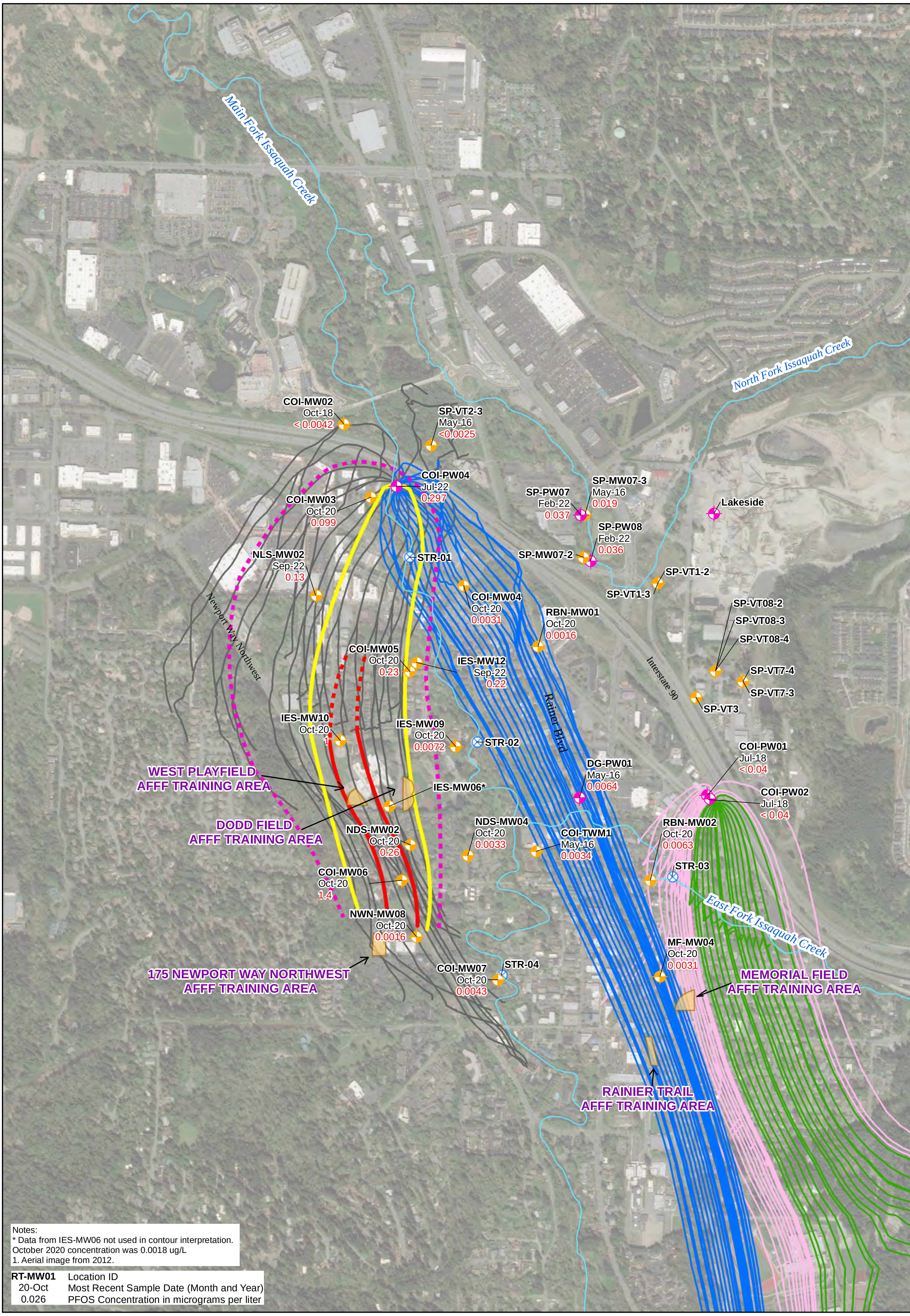
Issaquah, Washington

Geosyntec consultants

Seattle, Washington | October 2022

Figure 5A

P:\CAD_GIS\Projects\PNG0714 - Issaquah\Projects\06_CSM Memo\Figure 2a Well Locations Shallow AquiferV2.mxd 10/6/2022 4:40:50 AM



Legend

Well Type

- A Zone Production Well
- A Zone Monitoring Well
- Stream Gauging Station

Simulated Capture Zone (10 yr)

- COI1
- COI2
- COI4
- COI5

PFOS Concentration (dashed where inferred in micrograms per liter)

- 0.015
- 0.25
- 1.0

- AFFF Training Area
- Issaquah Creek

N

1 inch = 1000 feet

0 — 2,000 Feet

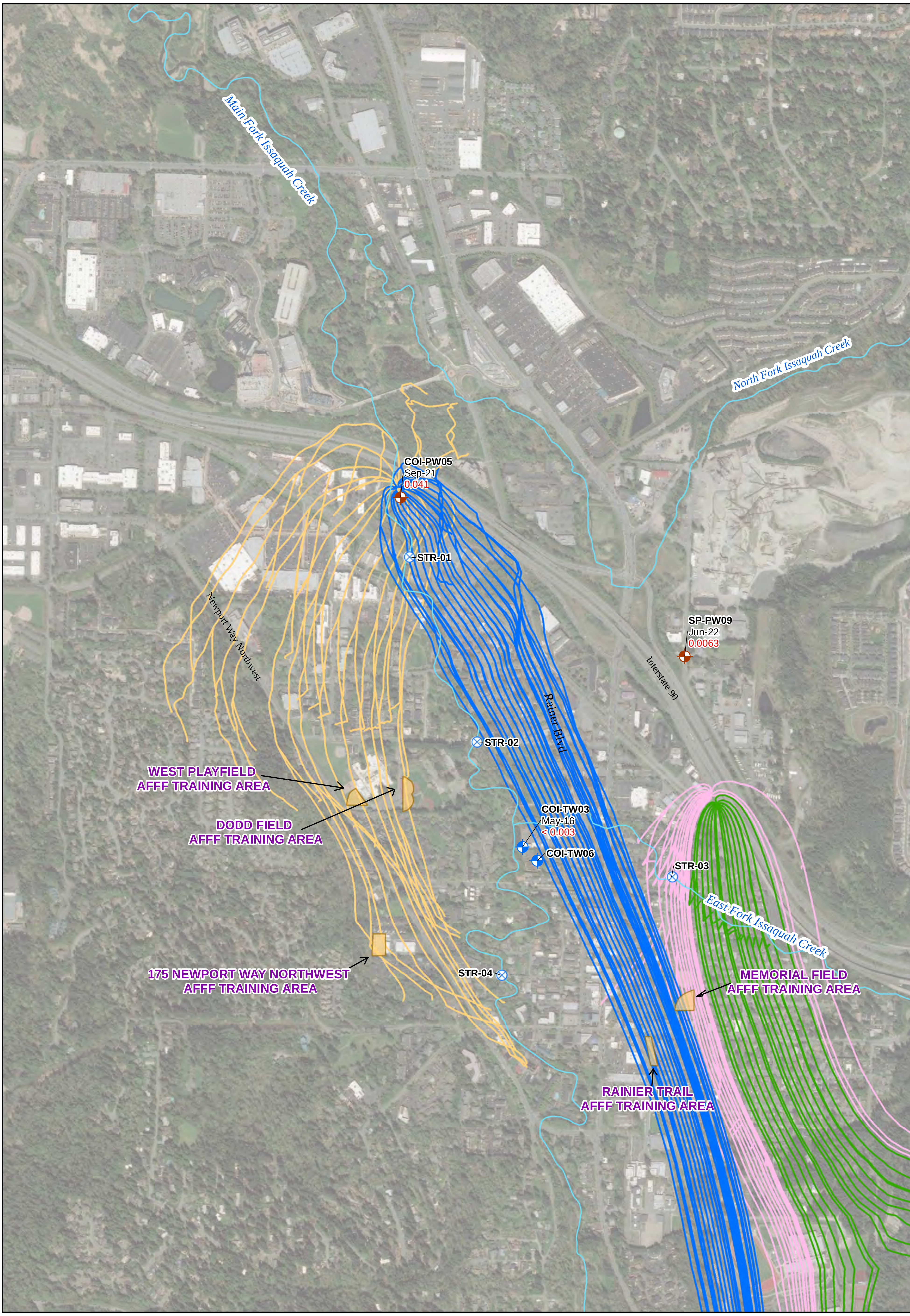
PFOS Concentrations
A Zone Aquifer
Issaquah, Washington

Geosyntec consultants

Seattle, Washington | October 2022

Figure 5B

P:\CAD_GIS\Projects\PNG0714 - Issaquah\Projects\06_CSM Memo\Figure 2b Well Locations Zone AV2.mxd 10/6/2022 5:10:14 AM



Legend

Well Type

- B/C Zone Production Welll
- B Zone Monitoring Well
- Stream Gauging Station

Simulated Capture Zone (10 yr)

- COI1
- COI2
- COI4
- COI5
- AFFF Training
- Issaquah Creek

RT-MW01 Location ID
Oct-20 Most Recent Sample Date (Month and Year)
0.026 PFOS Concentration in micrograms per liter

Notes:
1. Aerial image from 2012.

N

1 inch = 1000 feet

0 2,000 Feet

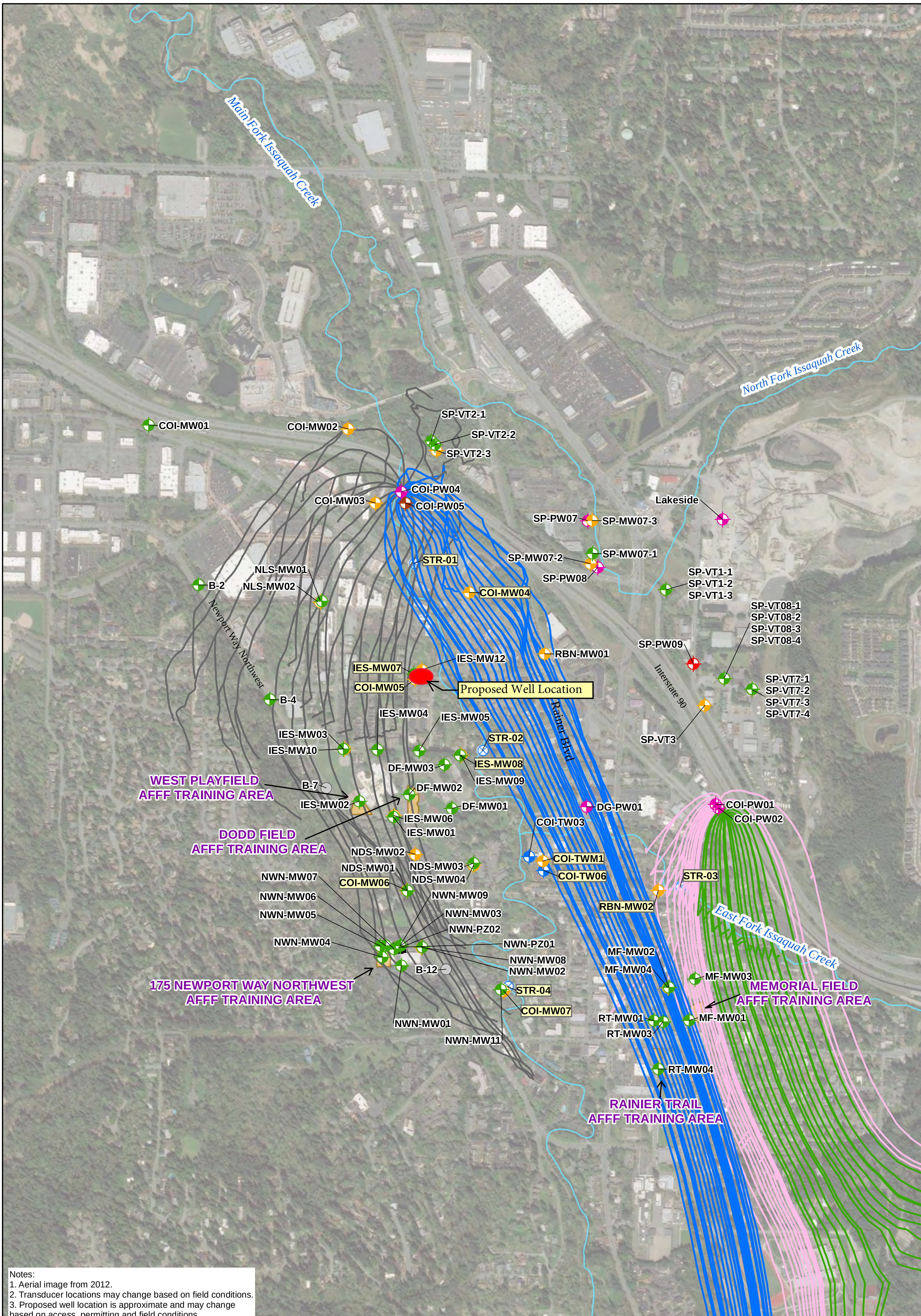
PFOS Concentrations
B Zone Aquifer
Issaquah, Washington

Geosyntec consultants

Figure 5C

Seattle, Washington | October 2022

P:\CAD_GIS\Projects\PNG0714 - Issaquah\Projects\06_CSM Memo\Figure 2c Well Locations Zone BV2.mxd 10/4/2022 6:58:50 AM



Notes:
1. Aerial image from 2012.
2. Transducer locations may change based on field conditions.
3. Proposed well location is approximate and may change based on access, permitting and field conditions.

Legend

Well Type

- Shallow Zone Monitoring Well
- A Zone Monitoring Well
- B Zone Monitoring Well
- Temporary Well
- Piezometer
- A Zone Production Well
- B Zone Production Well
- C Zone Production Well
- Stream Gauging Station

Simulated Capture Zone (10 yr)

- COI1
- COI2
- COI4
- COI5
- AFFF Training Area
- Issaquah Creek
- Proposed Locations for Transducers

Proposed Monitoring Well & Transducer Locations

Issaquah, Washington

Geosyntec consultants

Seattle, Washington | October 2022

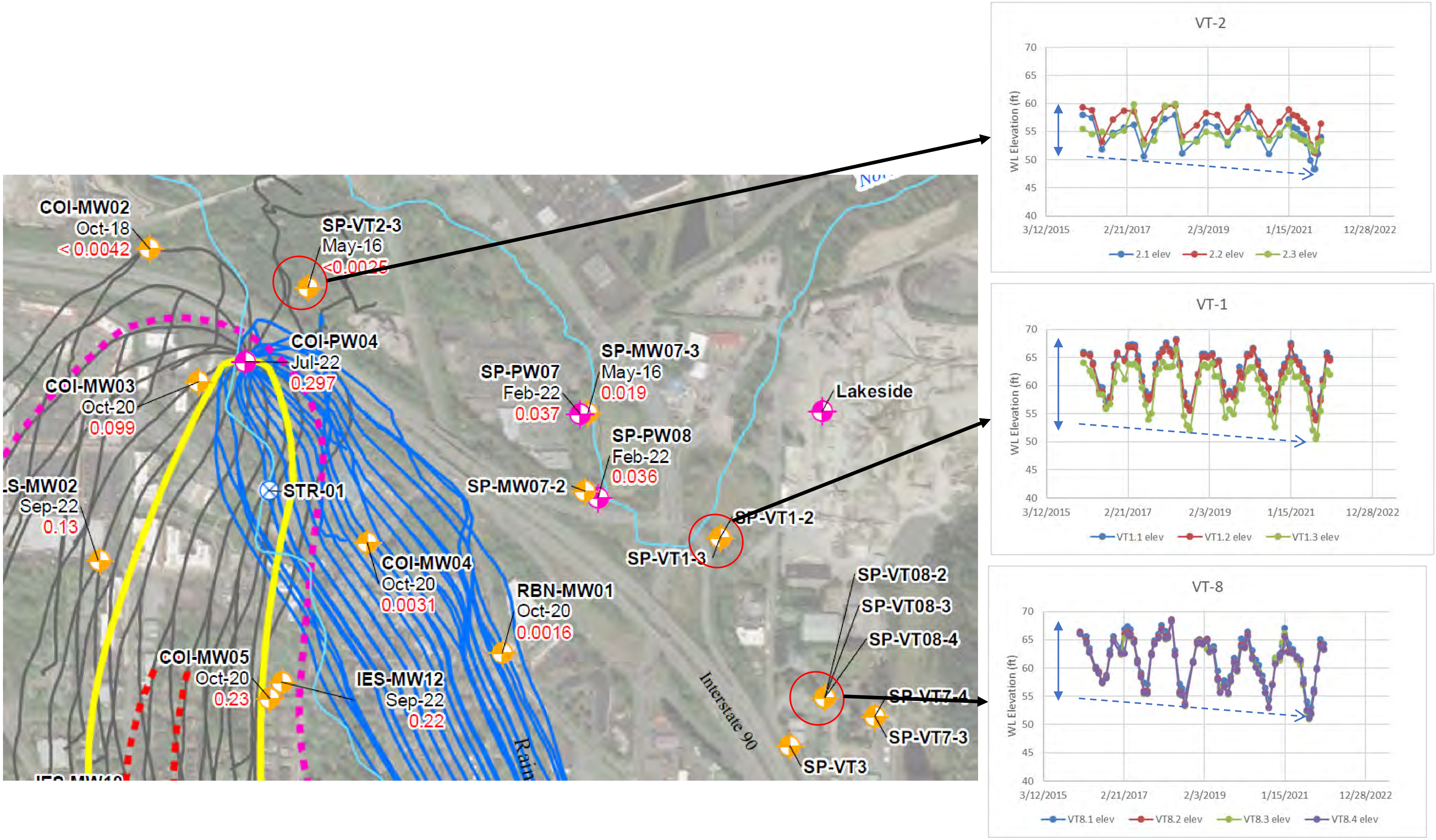
Figure 6

P:\CAD_GIS\Projects\PNG0714 - Issaquah\Projects\06_CSM Memo\Figure 4 Proposed Monitoring Well & Transducer LocationsV2.mxd 10/6/2022 5:18:15 AM

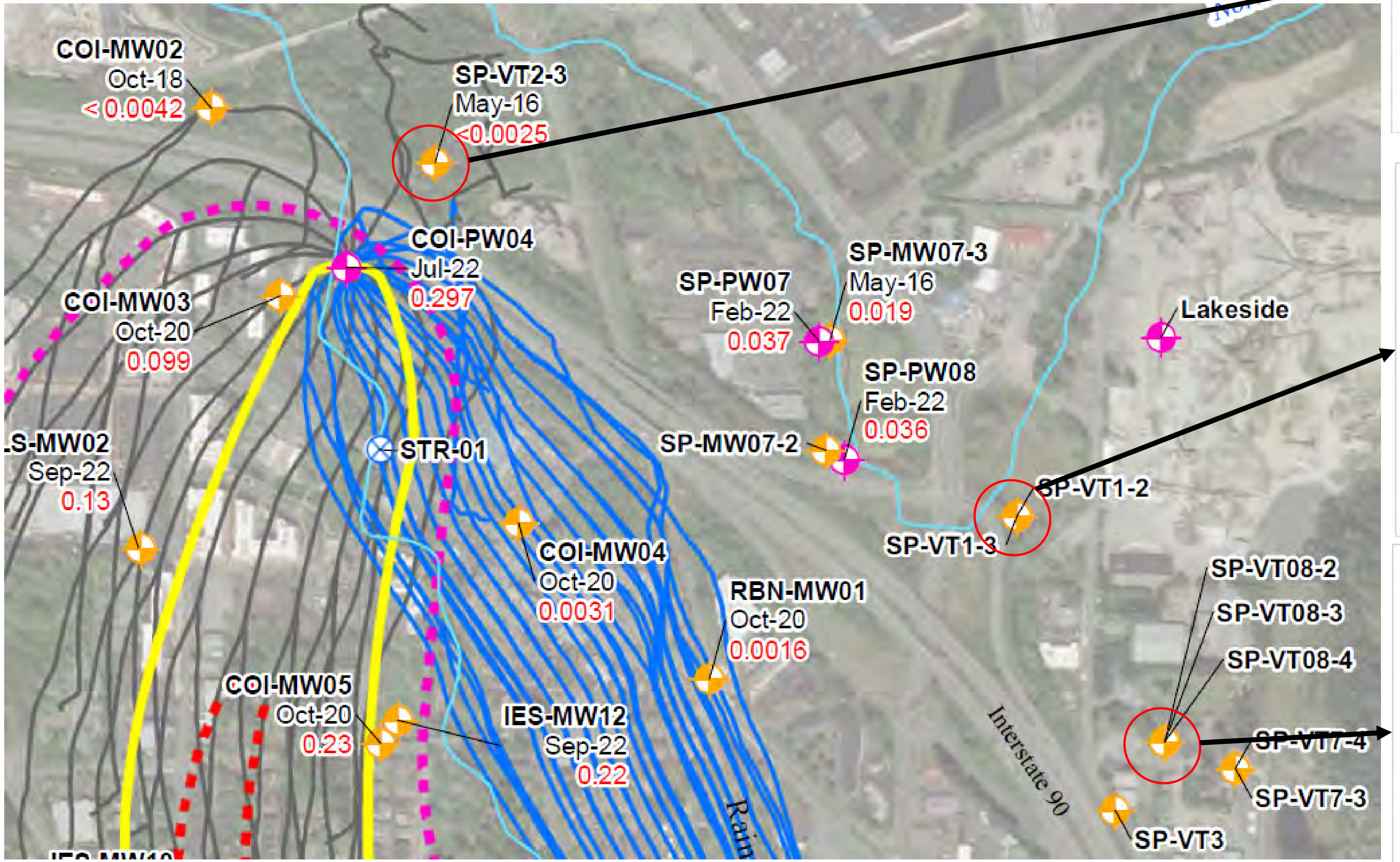
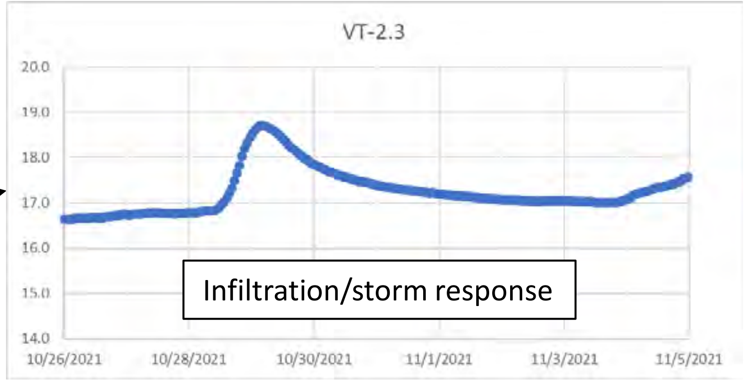
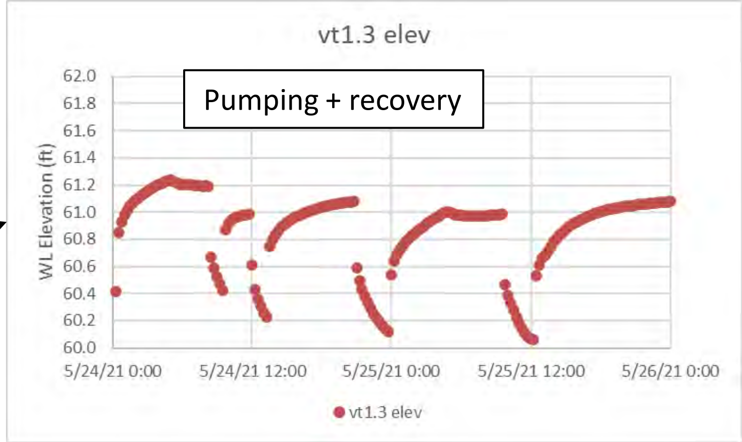
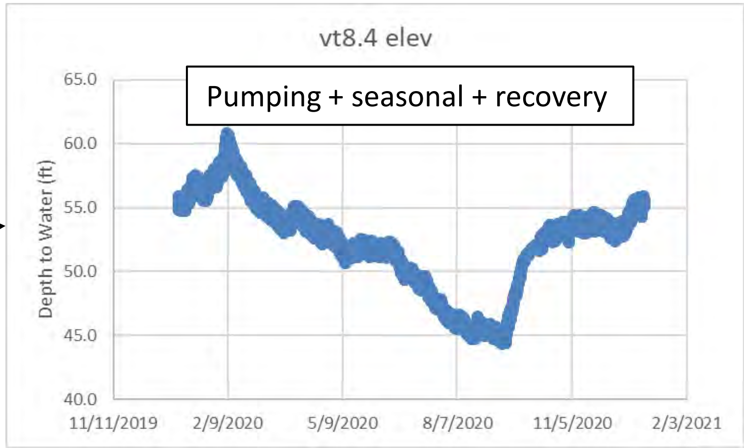
APPENDIX A
Boring and Monitoring Well Construction Logs
(provided electronically)

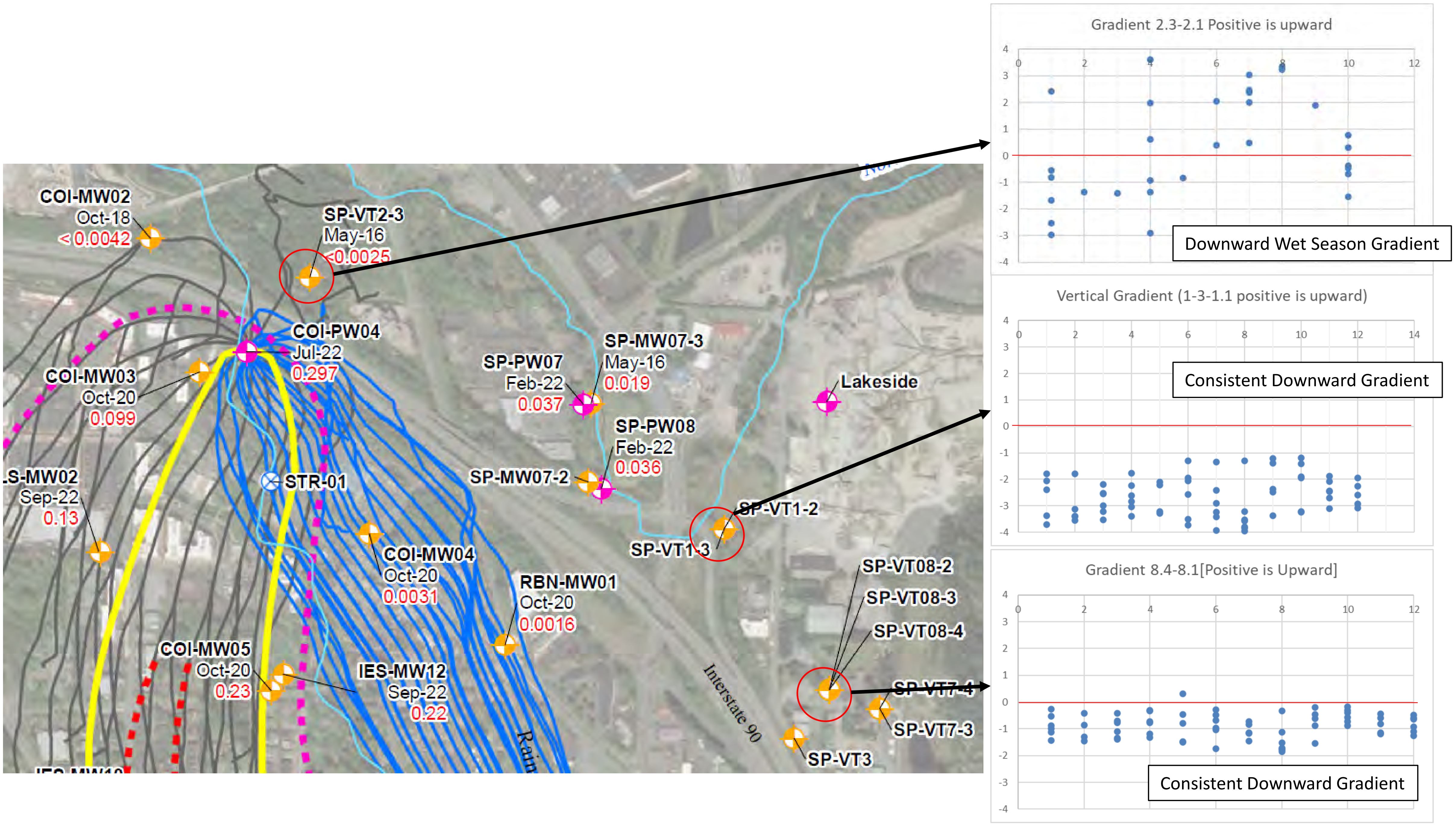
APPENDIX B

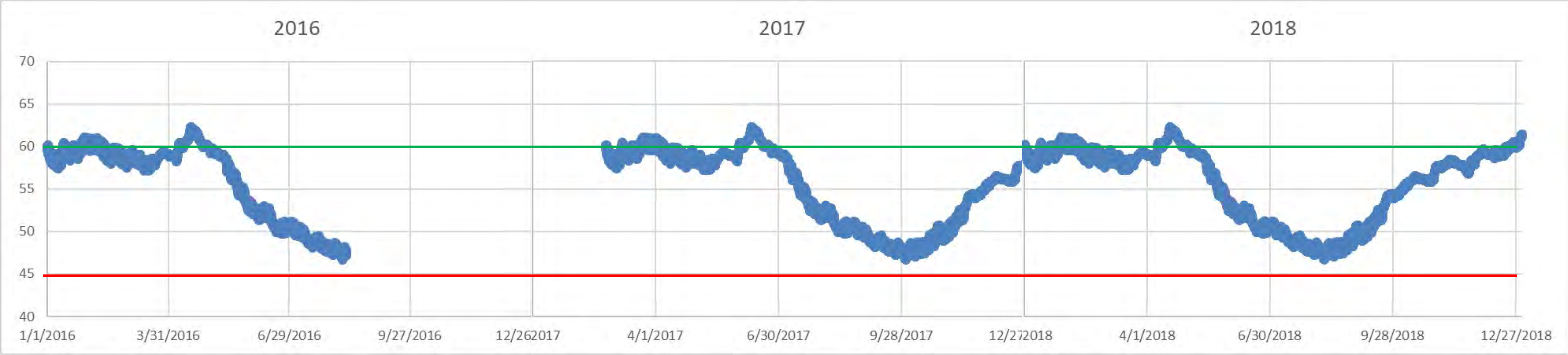
Water Level Data Examples

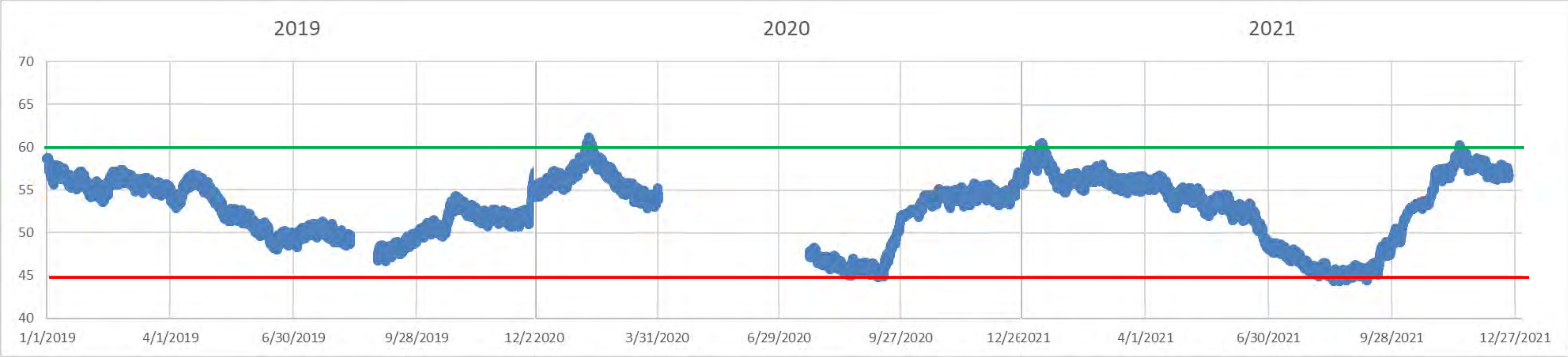


COI-MW02
Oct-18
< 0.0042
SP-VT2-3
May-16
<0.0025
COI-PW04
Jul-22
0.297
COI-MW03
Oct-20
0.099
S-MW02
Sep-22
0.13
STR-01
SP-PW07
Feb-22
0.037
SP-MW07-3
May-16
0.019
SP-PW08
Feb-22
0.036
SP-MW07-2
Lakeside
SP-VT1-2
SP-VT1-3
COI-MW04
Oct-20
0.0031
RBN-MW01
Oct-20
0.0016
COI-MW05
Oct-20
0.23
IES-MW12
Sep-22
0.22
SP-VT08-2
SP-VT08-3
SP-VT08-4
SP-VT7-4
SP-VT7-3
SP-VT3
Interstate 90
VT-2
WL Elevation (ft)
70
65
60
55
50
45
40
3/12/2015
2/21/2017
2/3/2019
1/15/2021
12/28/2022
2.1 elev
2.2 elev
2.3 elev
VT-1
VT1.1 elev
VT1.2 elev
VT1.3 elev
VT-8
VT8.1 elev
VT8.2 elev
VT8.3 elev
VT8.4 elev

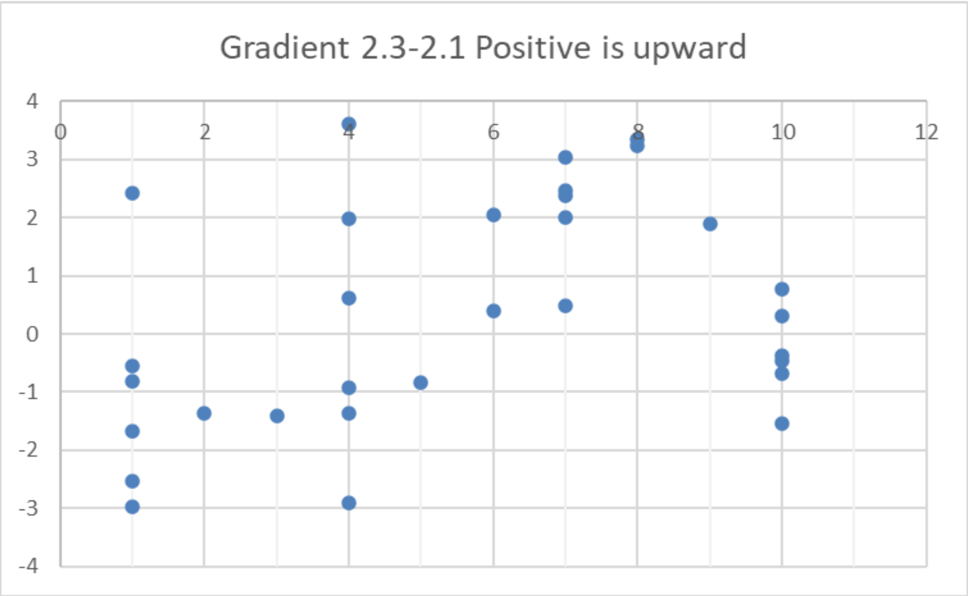

COI-MW02
Oct-18
< 0.0042
SP-VT2-3
May-16
<0.0025
COI-PW04
Jul-22
0.297
COI-MW03
Oct-20
0.099
S-MW02
Sep-22
0.13
STR-01
SP-PW07
Feb-22
0.037
SP-MW07-3
May-16
0.019
SP-PW08
Feb-22
0.036
SP-MW07-2
Lakeside
SP-VT1-2
SP-VT1-3
COI-MW04
Oct-20
0.0031
RBN-MW01
Oct-20
0.0016
COI-MW05
Oct-20
0.23
IES-MW12
Sep-22
0.22
SP-VT08-2
SP-VT08-3
SP-VT08-4
SP-VT7-4
SP-VT7-3
SP-VT3
Interstate 90

VT-2.3
Infiltration/storm response
20.0
19.0
18.0
17.0
16.0
15.0
14.0
10/26/2021
10/28/2021
10/30/2021
11/1/2021
11/3/2021
11/5/2021

vt1.3 elev
Pumping + recovery
WL Elevation (ft)
62.0
61.8
61.6
61.4
61.2
61.0
60.8
60.6
60.4
60.2
60.0
5/24/21 0:00
5/24/21 12:00
5/25/21 0:00
5/25/21 12:00
5/26/21 0:00
vt1.3 elev

vt8.4 elev
Pumping + seasonal + recovery
Depth to Water (ft)
65.0
60.0
55.0
50.0
45.0
40.0
11/11/2019
2/9/2020
5/9/2020
8/7/2020
11/5/2020
2/3/2021

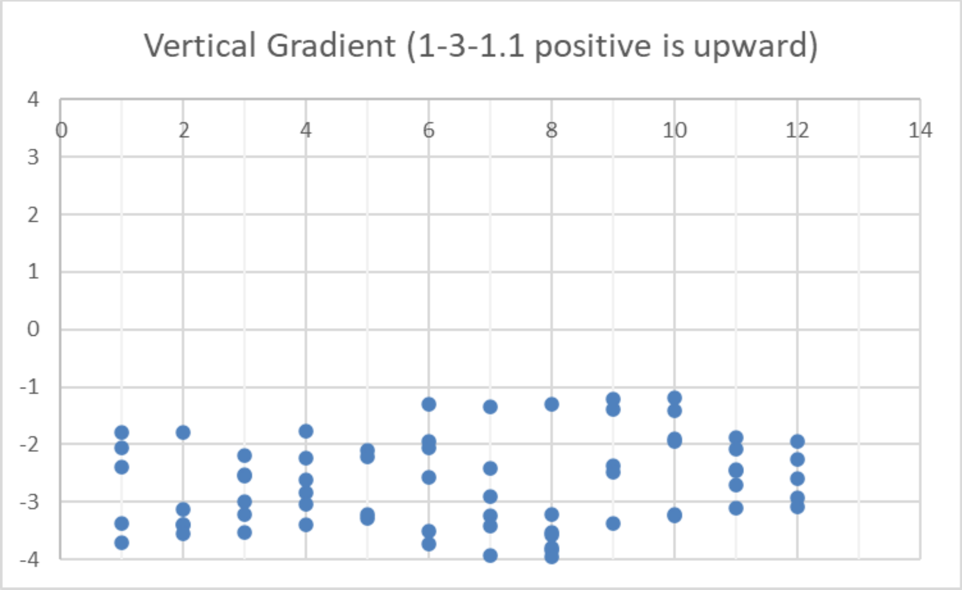

COI-MW02
Oct-18
< 0.0042
SP-VT2-3
May-16
<0.0025
COI-PW04
Jul-22
0.297
COI-MW03
Oct-20
0.099
S-MW02
Sep-22
0.13
STR-01
SP-PW07
Feb-22
0.037
SP-MW07-3
May-16
0.019
SP-PW08
Feb-22
0.036
SP-MW07-2
Lakeside
SP-VT1-2
SP-VT1-3
COI-MW04
Oct-20
0.0031
RBN-MW01
Oct-20
0.0016
COI-MW05
Oct-20
0.23
IES-MW12
Sep-22
0.22
SP-VT08-2
SP-VT08-3
SP-VT08-4
SP-VT7-4
SP-VT7-3
SP-VT3
Interstate 90
Gradient 2.3-2.1 Positive is upward
Downward Wet Season Gradient
Vertical Gradient (1-3-1.1 positive is upward)
Consistent Downward Gradient
Gradient 8.4-8.1[Positive is Upward]
Consistent Downward Gradient



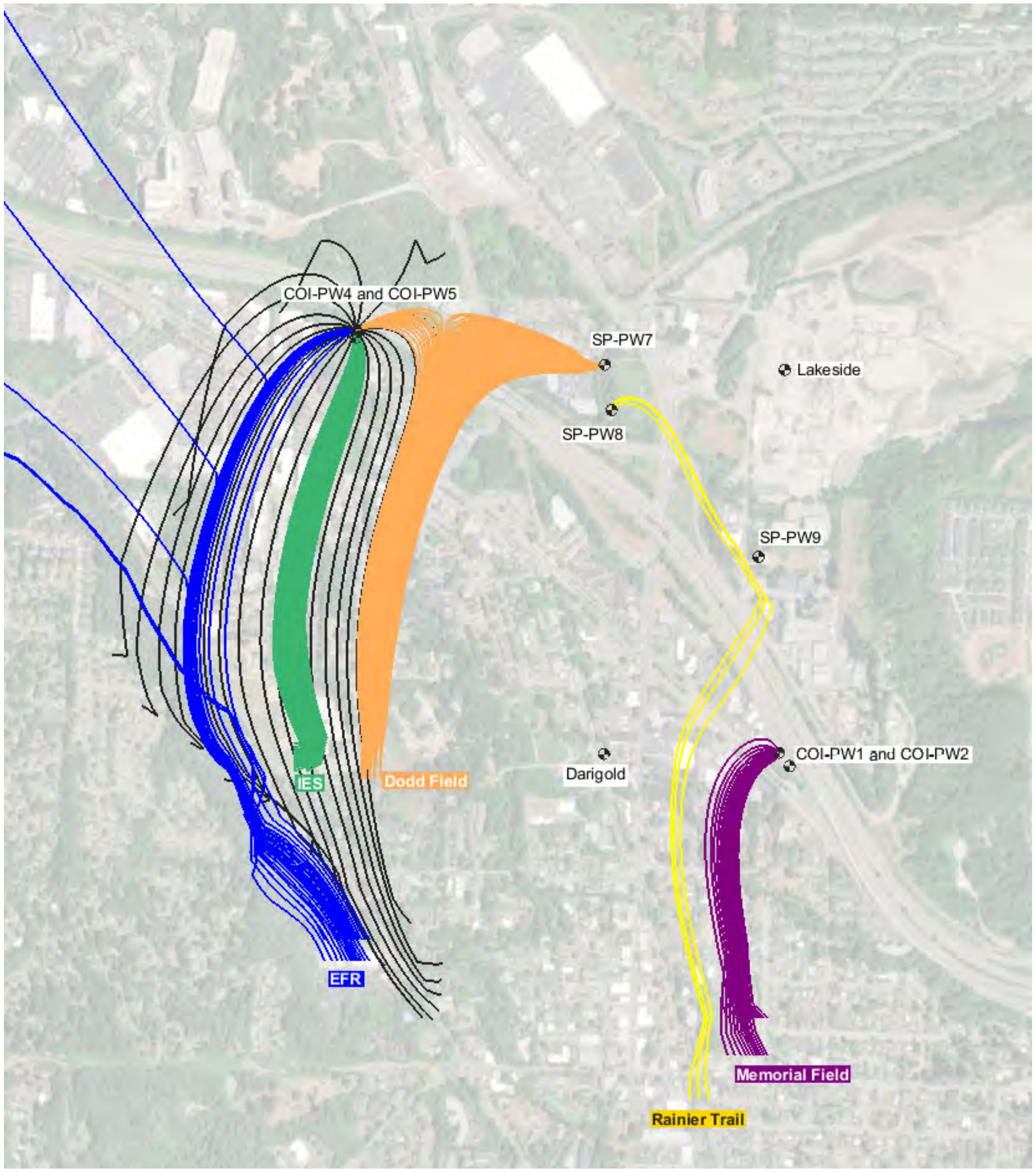


Well VT-8.3 Transducer


Gradient 2.3-2.1 Positive is upward
4
3
2
1
0
-1
-2
-3
-4
0
2
4
6
8
10
12

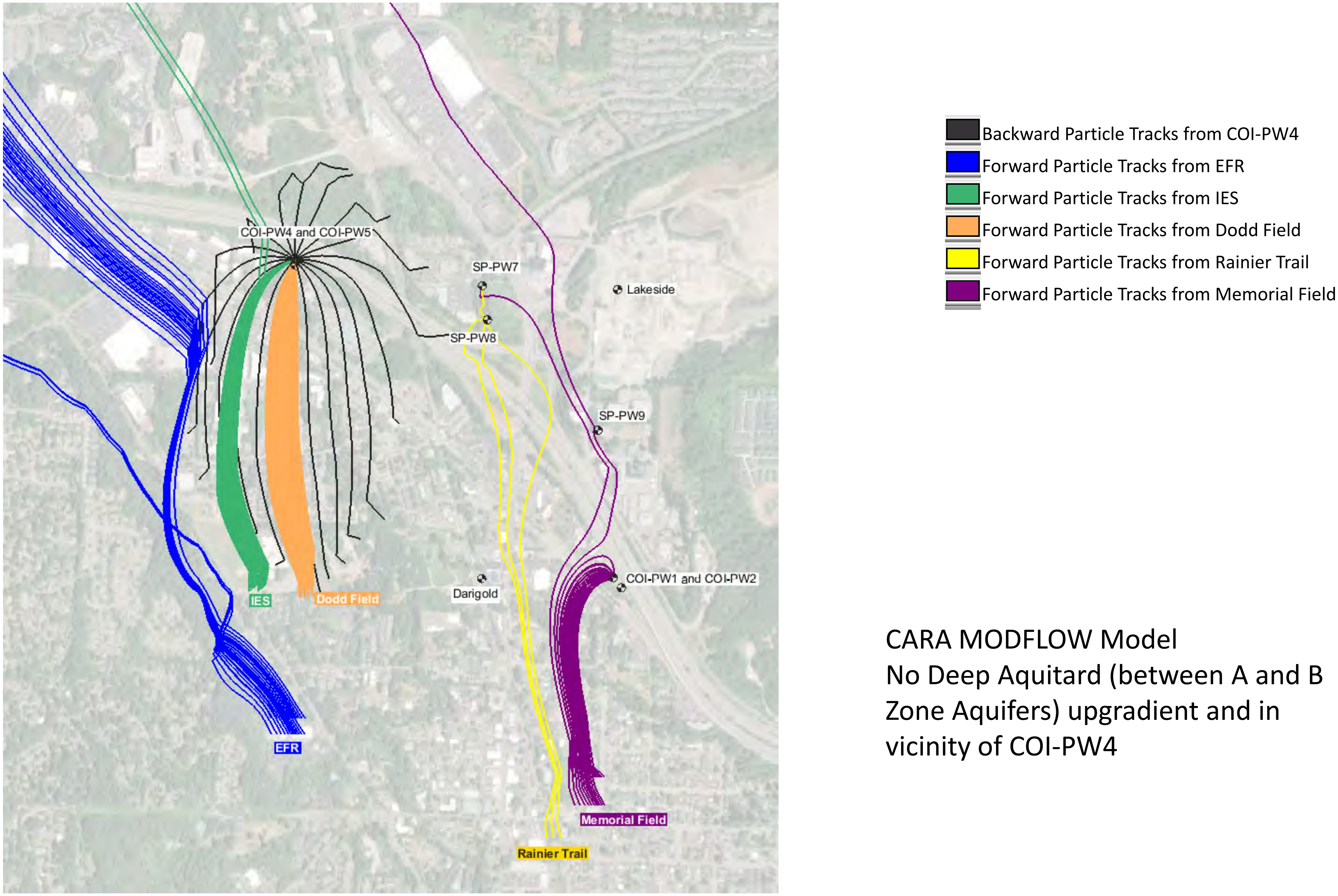

Vertical Gradient (1-3-1.1 positive is upward)
4
3
2
1
0
-1
-2
-3
-4
0
2
4
6
8
10
12
14

APPENDIX C
Forward Particle Tracking

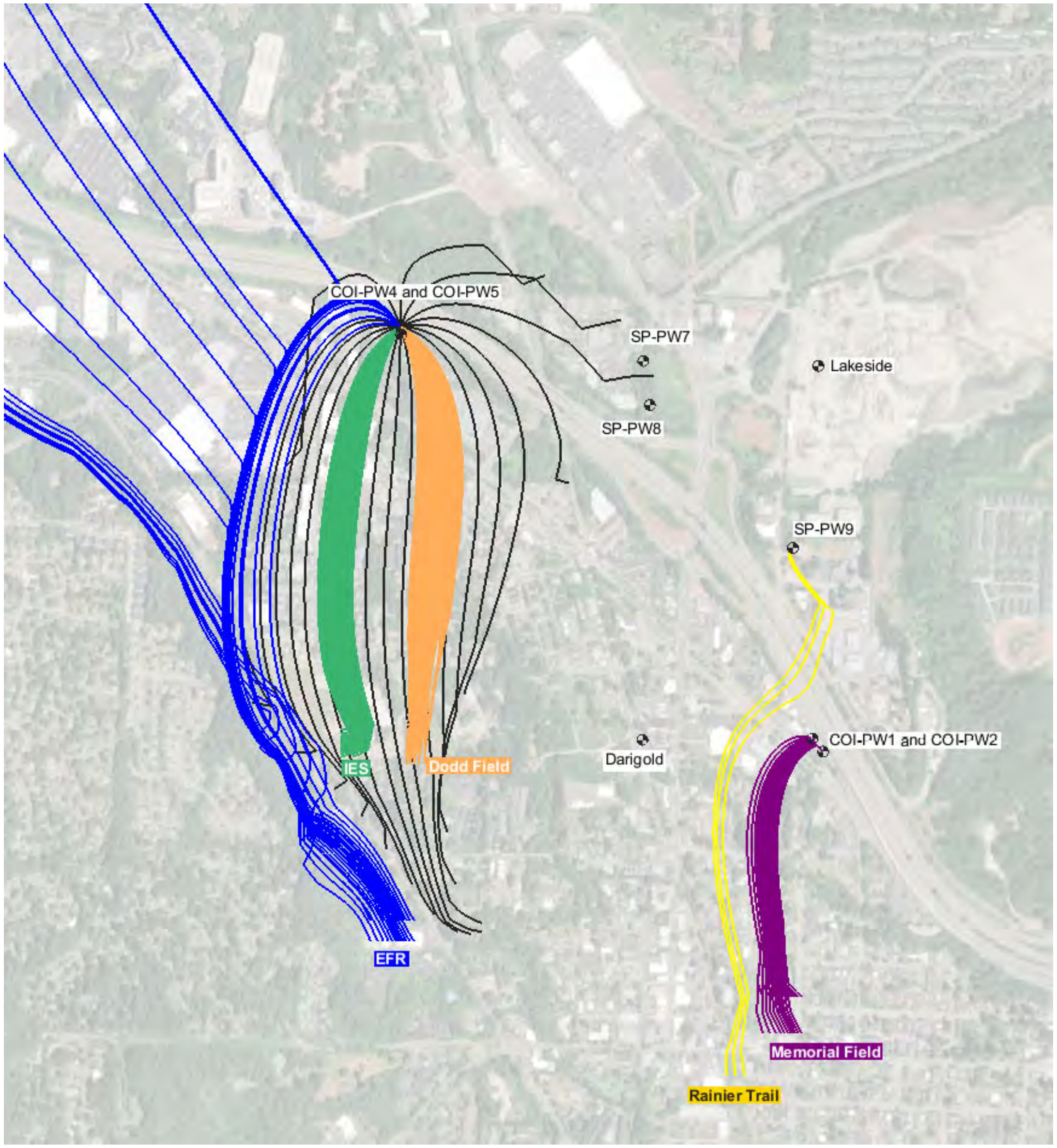


- Backward Particle Tracks from COI-PW4
- Forward Particle Tracks from EFR
- Forward Particle Tracks from IES
- Forward Particle Tracks from Dodd Field
- Forward Particle Tracks from Rainier Trail
- Forward Particle Tracks from Memorial Field

CARA MODFLOW Model

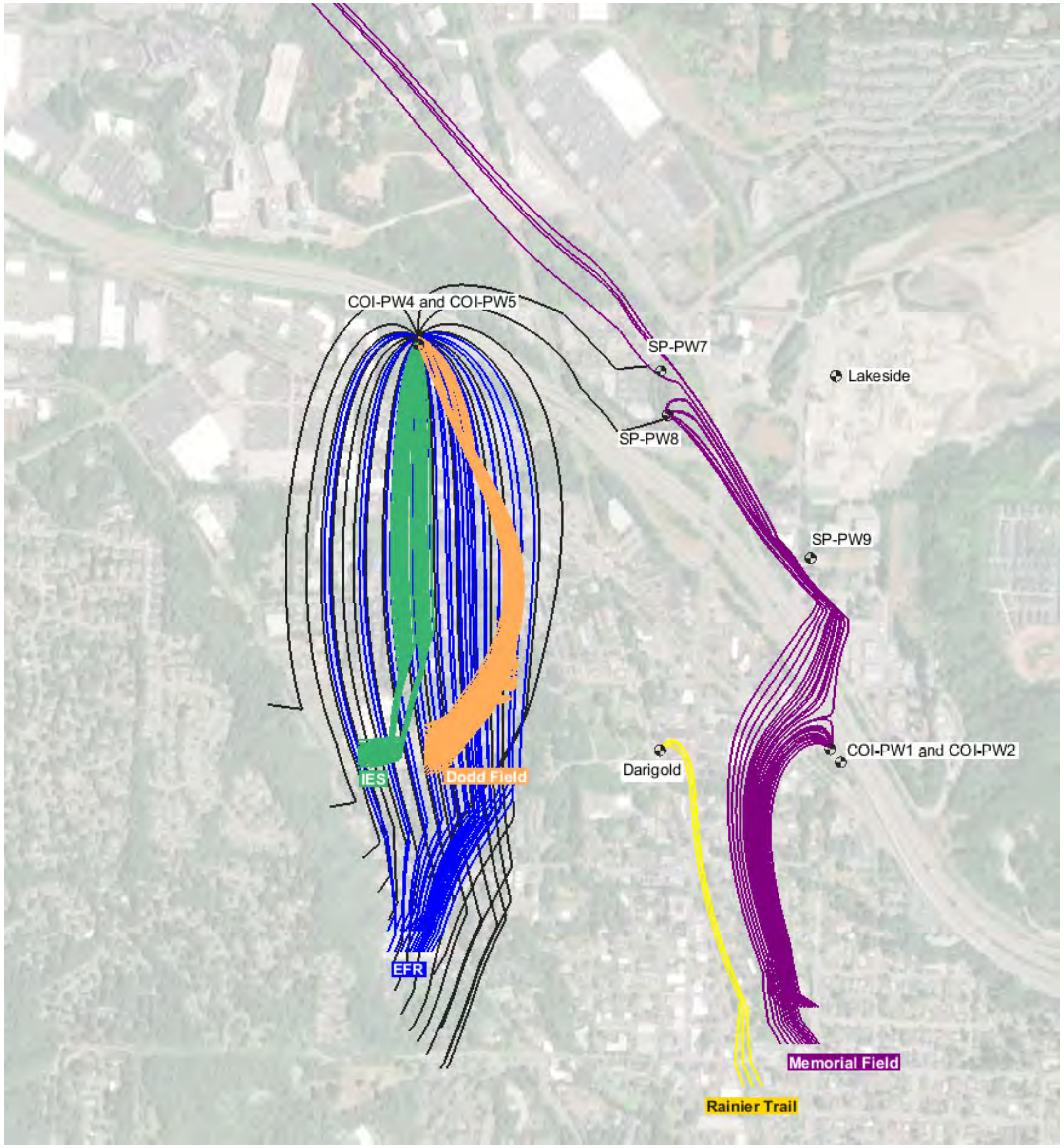


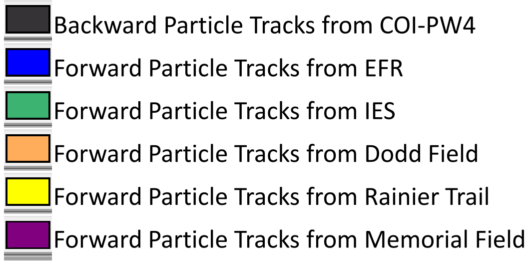
CARA MODFLOW Model
No Deep Aquitard (between A and B Zone Aquifers) upgradient and in vicinity of COI-PW4



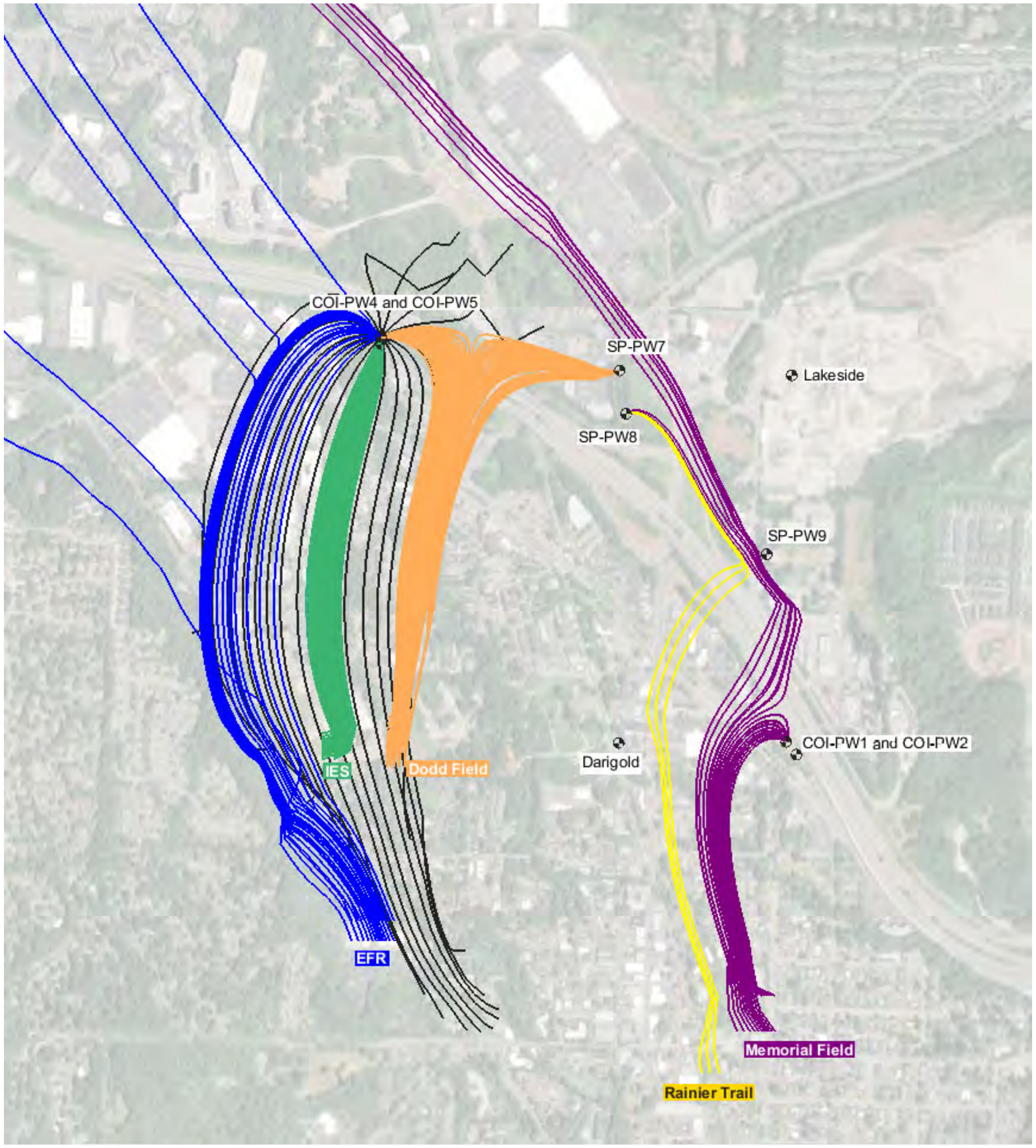
Backward Particle Tracks from COI-PW4
Forward Particle Tracks from EFR
Forward Particle Tracks from IES
Forward Particle Tracks from Dodd Field
Forward Particle Tracks from Rainier Trail
Forward Particle Tracks from Memorial Field

CARA MODFLOW Model
SP-PW7 and SP-PW8 not pumping





CARA MODFLOW Model
Increase recharge by 50%



Backward Particle Tracks from COI-PW4
Forward Particle Tracks from EFR
Forward Particle Tracks from IES
Forward Particle Tracks from Dodd Field
Forward Particle Tracks from Rainier Trail
Forward Particle Tracks from Memorial Field

CARA MODFLOW Model
Increased river conductance by 100%