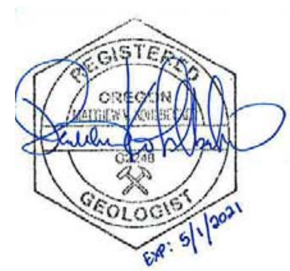
TECHNICAL MEMORANDUM

Infiltration Testing to Estimate Soil Permeability and Infiltration Volumes for a Proposed Treated (Class A) Wastewater Infiltration Facility, North Santiam Canyon, Oregon

To: Peter Olsen, PE / Keller Associates
James Bledsoe, PE / Keller Associates

From: Matt Kohlbecker, RG / GSI Water Solutions, Inc.
Ellen Svadlenak, GIT / GSI Water Solutions, Inc.
Jason Melady, RG / GSI Water Solutions, Inc.



Date: January 18, 2021

This technical memorandum, prepared by GSI Water Solutions, Inc. (GSI), summarizes infiltration testing to measure the permeability of soils in the North Santiam Canyon, Oregon, and presents updated, planning-level estimates for the volume of advanced treated (Class A) wastewater that could potentially be infiltrated at four candidate sites.

1. Introduction

GSI (2020) evaluated the suitability of ten pre-selected sites in the North Santiam Canyon for potential infiltration of advanced treated (Class A) wastewater based on the following characteristics: (1) the level of effort for site development, (2) potential permitting challenges, (3) the volume of water that can likely be infiltrated based on aquifer characteristics, (4) the aerial extent of the aquifer beneath the infiltration facility, and (5) surficial soil permeability (i.e., the upper 6 feet of soil). GSI developed scores for each individual characteristic, and ranked the ten sites by potential for wastewater infiltration.

The GSI (2020) evaluation estimated surficial soil permeability (characteristic number 5 above) based on *regional-scale* studies of soil properties prepared by the U.S. Department of Agriculture (USDA). This technical memorandum documents an evaluation that was conducted to refine our understanding of surficial soil permeability in the North Santiam Canyon, and includes:

- A summary of infiltration testing conducted at four of the ten sites, which were conducted to obtain *site-specific* estimates for the permeability of surficial soils. The four sites were selected so that: (1) two sites would be tested in the Detroit-Idanha area and two sites would be tested in the Gates-Mill City area, and (2) the highest-ranking sites without fatal flaws would be tested in each area[1].
- An updated, planning-level approximation of the volume of advanced treated (Class A) wastewater that could be infiltrated at each the four candidate infiltration sites using the Hantush (1967) equation.

[1] See GSI (2020) for an in-depth discussion of fatal flaws and site raking.

The results of this memo represent a preliminary, planning stage of potential implementation of a treated wastewater infiltration system. Specifically, the Mid Willamette Valley Council of Governments, nor the North Santiam Sewer Authority, have engaged owners of the candidate sites to discuss using their property for wastewater infiltration, and the type of infiltration facility (e.g., rapid infiltration, infiltration basin, etc.) has not yet been determined by project engineers. Therefore, this memo is intended as a planning-level tool that provides preliminary approximation for infiltration feasibility in different soil types at select sites in the North Santiam Canyon.

2. Methods

This section presents an overview of the methods that were used to measure soil permeability (Section 2.1) and to approximate the volume of advanced treated (Class A) wastewater that could potentially be infiltrated at each of the four candidate sites (Section 2.2).

2.1 Field Methods to Measure Soil Permeability

Table 1 lists the sites where infiltration tests were conducted and the soil types that the USDA regional-scale soil survey identifies at each site. The location of the sites are shown in Figures 1 through 4. At relatively small sites (i.e., Freres and Bark Flat), only one infiltration test was performed. At relatively large sites (i.e., Tom Fencl and Rock Creek), two infiltration tests were performed.

Table 1. Tested Sites and USDA Soil Properties

Property	USDA Soil Group	USDA Soil Permeability Profile		USDA Soil Permeability Average
		Depth	Permeability	
Tom Fencl	64 – Malabon Variant Loam	0” – 2”	6 – 100 in/hr	8.9 in/hr
		2” – 16”	2 – 6 in/hr	
		16” – 57”	6 – 20 in/hr	
		57” – 60”	20 – 100 in/hr	
Rock Creek	92 – Sifton Variant Gravelly Loam	0” – 15”	2 – 6 in/hr	13.3 in/hr
		15” – 60”	20 – 100 in/hr	
Freres	7003 – Jimbo Medial Silt Loam	0” – 13”	3 – 11 in/hr	8.5 in/hr
Bark Flat [1]		13” – 43”	2 – 11 in/hr	
		43” – 59”	28 – 43 in/hr	

Notes

(1) The GSI (2020) technical memorandum evaluated infiltration potential of the “Bark Flat West” property (tax lot 106E16CB01300). The infiltration test was conducted at the adjacent “Bark Flat East” property (tax lot 106E16CA01100) because permission could be easily obtained by the property owner. The “Bark Flat West” and “Bark Flat East” properties are characterized by similar characteristics (i.e., development effort, permitting challenges, infiltration volumes, USDA surficial soil type, and width of valley-filling alluvium).

USDA = United States Department of Agriculture

In/hr = inches per hour

Soil permeability was measured in general accordance with the United States Department of the Interior (USDI) Test Pit Method (USDI, 1993). The USDI test pit method measures saturated hydraulic conductivity, which is infiltration rate per unit hydraulic gradient. McKillip Excavating (Donald, Oregon) excavated test pits and a GSI geologist logged the soils in accordance with the Unified Soil Classification System (USCS) visual-manual method (ASTM, 2017). Test pits were excavated up to five feet below ground surface, into the most permeable soil horizon based on the soil logging in the field and the soil horizons identified by the USDA in Table 1. At each testing location, potable water was introduced into the test pit for at least 3 hours and measurements of water column height and flow rate were recorded every five minutes. The purpose of monitoring water column height and flow rate is to ensure that the measured saturated hydraulic conductivity is representative of flow under the saturated conditions that occur in soil beneath an infiltration facility. Specifically, due to matric (negative pressure) forces, water added to dry soils moves faster than water added to saturated soils; a stable flow rate and water column height indicates that matric forces have become negligible as soils have become saturated, and that gravity is the primary force causing infiltration (USDA, 1982; Iowa DNR, 2020).

After infiltration rate and water column height had stabilized for at least 15 minutes. The saturated hydraulic conductivity was calculated using Equation (4) of USDI (pg. 103, 1993):

$$K = \frac{1{,}440(Q)}{(C)(a)(D)} \tag{1}$$

Where:

K is saturated hydraulic conductivity in feet per day,

1,440 is a conversion factor to convert minutes to days,

Q is the flow rate into the test pit during the test in cubic feet per minute,

D is the water column height in the test pit in feet,

a is the smallest surface dimension of the test pit in feet, and

C is the conductivity coefficient, which is a constant based on the shape of the test pit (i.e., a rectangle) and ratio of water column height to test pit surface dimension (i.e., *D* / *a*).

Test pit logs are provided in Attachment A. Infiltration test data sheets showing measurements of *D* and *Q* during each test are provided in Attachment B. Following the infiltration test, excavated soils were returned to the pit and soils were compacted with a compactor.

2.2 Hantush (1967) Calculations to Estimate Infiltration Volume

Previously, GSI (2020) used the Hantush (1967) equation to develop estimates of infiltration volume at the four candidate sites assuming a hydraulic conductivity for the Glacial Till geologic unit (i.e., an average value based on well tests documented on water well driller logs on file with the Oregon Water Resources Department) or for the Alluvium of the Santiam River geologic unit (i.e., from the scientific literature). In this technical memorandum, we re-run the Hantush (1967) equation using the measured saturated hydraulic conductivities from the infiltration tests. If multiple test pits were dug at a site, then we conservatively used the lowest calculated hydraulic conductivity, which would provide an infiltration volume estimate that is biased low. The re-run Hantush (1967) infiltration volume estimates from this technical memorandum were combined with the estimates from GSI (2020) to develop a range of potential infiltration volumes at each site.

The reader is referred to GSI (2020) for a discussion of the Hantush (1967) equation and variables that were used to calculate infiltration volumes (i.e., infiltration basin sizes, storage coefficient, etc.).

3. Results

This section documents the results of the infiltration tests (Section 3.1) and Hantush (1967) infiltration volume estimates (Section 3.2).

3.1 Infiltration Tests to Calculate Hydraulic Conductivity

Table 2 shows the variables that were used to calculate saturated hydraulic conductivity at each test pit location, and the values of saturated hydraulic conductivity calculated using Equation (1). The calculated saturated hydraulic conductivities range over two orders of magnitude (even at the same site), which is an expected range of variation for hydraulic conductivity (Anderson and Woessner, Table 3.3, 1992). In addition, the measured saturated hydraulic conductivities are either within or just outside of the ranges in the USDA soil survey (see Table 1).

Table 2. Tested Sites and USDA Soil Properties

Property (soil type)	Test Location	Flow Rate, *Q*	Conductivity Coefficient, *C*	Surface Dimension, *a*	Water Column Height, *D*	Saturated Hydraulic Conductivity, *K*	Saturated Hydraulic Conductivity, *K*
Tom Fencl (64)[1]	TF-IT-1	1.4 gpm 0.18 ft^3/min	7.615	2.0 ft	2.21 ft	7.8 ft/day	3.9 in/hr
	TF-IT-2	2.3 gpm 0.31 ft^3/min	5.930	2.0 ft	0.79 ft	47.3 ft/day	23.7 in/hr
Rock Creek (92)[2]	RC-IT-1	1.0 gpm 0.13 ft^3/min	5.759	2.0 ft	0.65 ft	26.0 ft/day	13.0 in/hr
	RC-IT-2	1.7 gpm 0.23 ft^3/min	5.568	2.0 ft	0.48 ft	61.3 ft/day	30.7 in/hr
Freres (7003)[3]	F-IT-1	1.8 gpm 0.23 ft^3/min	5.653	1.5 ft	0.42 ft	95.2 ft/day	47.6 in/hr
Bark Flat (7003)[4]	BF-IT-2	0.82 gpm 0.11 ft^3/min	8.084	1.0 ft	1.31 ft	14.9 ft/day	7.47 in/hr

Notes

(1) Soil type is "64 – Malabon Variant Loam"
(2) Soil type is "92 – Sifton Variant Gravelly Loam"
(3) Soil type is "7003 – Jimbo Medial Silt Loam"
ft^3/min = cubic feet per minute
ft/day = feet per day
in/hr = inches per hour
ft = feet
gpm = gallons per minute
USDA = United States Department of Agriculture

3.2 Hantush (1967) Calculations to Estimate Infiltration Volume

Table 3 presents Hantush (1967) estimates for infiltration volume at each candidate site, and includes a low-end infiltration volume and a high-end infiltration volume. The low-end and high-end estimates used different values for hydraulic conductivity: (1) a hydraulic conductivity calculated from the infiltration tests conducted as part of this study (see Table 2) and (2) a hydraulic conductivity from water well tests documented on water well driller logs from the Oregon Water Resources Department (OWRD, 2020) or literature references [see GSI (2020)]. Note that the infiltration volumes in Table 3 do not include safety factors.

Table 3. Infiltration Volume Estimates Calculated from Hantush (1967), Assuming One Year of Infiltration.

Property	Infiltration Basin Area	Low-End Infiltration Volume	High-End Infiltration Volume	Notes [1]
Tom Fencl	12.5 acres	0.87 MGD	1.95 MGD	Low-end from infiltration test (K=7.8 ft/day) and high-end from driller log (K=21 ft/day)
Rock Creek	16.7 acres	1.14 MGD	1.36 MGD	Low-end from driller log (K=21 ft/day) and high-end from infiltration test (K=26 ft/day)
Freres	10.5 acres	0.30 MGD	0.51 MGD	Low-end from book value (K=50 ft/day) and high end from infiltration test (K=95.2 ft/day)
Bark Flat [1]	4.8 acres	0.22 MGD	0.30 MGD	Low-end from infiltration test (K=14.9 ft/day) and high-end from driller log (K=21 ft/day)

Notes
MGD = Million gallons per day
ft/day = feet per day
(1) Saturated hydraulic conductivities from “infiltration tests” are from the testing described in this report. Saturated hydraulic conductivities from “driller logs” or “book value” are from the GSI (2020) report. See the GSI (2020) report for additional details about how these values were calculated, and the limitations of these values.

The Tom Fencl (Malabon Variant Loam) and Rock Creek (Sifton Variant Gravelly Loam) sites have the highest estimated infiltration volumes. Note that infiltration volume is primarily a function of hydraulic conductivity, infiltration basin size, and depth to groundwater (i.e., to accommodate the rising groundwater table during infiltration). Therefore, it is important to recognize that the reason the infiltration volumes are highest at the Fencl and Rock Creek sites is related to the deep water table and large area to accommodate an infiltration basin *in addition to* the high hydraulic conductivities [see GSI (2020) for a detailed discussion of the hydrogeologic characteristics at each site].

The infiltration volumes in Table 3 are planning-level estimates. The following uncertainties may result in actual infiltration volumes that are different than the planning-level estimates in Table 3:

- **Depth to Groundwater.** The depth to groundwater at each site is variable and estimated from water well driller logs. As such, the depth to groundwater at each site is not well understood. Installation of monitoring well(s) at each site and groundwater level monitoring for a year would reduce uncertainties related to depth to groundwater.

- **Long-Term Performance Declines.** The infiltration volumes in Table 3 do not include declines in infiltration rate over time caused by clogging of soil pores. Incorporation of a safety factor into the infiltration volumes can be used to account for long-term performance declines.

- **Variability of Soil Characteristics.** Soil properties will vary across each site. Additional infiltration testing would reduce uncertainties related to the variability of soil characteristics.

- **Other Site-Specific Factors.** Other factors may limit the volume of water that can be infiltrated at each site. For example, a steep slope is present at the Rock Creek site. This slope may limit the volume of water that can be infiltrated at a site due to the formation of seeps as groundwater elevations increase during infiltration. Site-specific hydrogeologic information, and additional details about infiltration system design, are needed to assess whether site-specific factors would limit the volume of water than can be infiltrated at each site.

4. Conclusions and Recommendations

This technical memorandum provides preliminary estimates of soil permeability (hydraulic conductivity) and infiltration volume at four candidate infiltration sites in the Santiam Canyon. The hydraulic conductivity and infiltration volume estimates are intended as a planning-level tool to guide future implementation efforts for a regional advanced (Class A) treated wastewater infiltration system. We make the following conclusions based on this analysis:

- Infiltration testing was conducted in soil classes that the USDA identified as the most permeable soils in the Santiam Canyon; the infiltration testing confirms that these soil classes are in fact highly permeable (specifically, the Malabon Variant Loam, the Sifton Variant Gravelly Loam, and the Jimbo Medial Silt Loam).

- Based on projected 2065 flows for Detroit, Idanha, Gates, and Mill City, the average annual daily infiltration volume is estimated to be 0.365 MGD and the peak daily infiltration volume is estimated to be 0.728 MGD (personal communication, 2021). As shown in Table 3, the Fencl site (Malabon Variant Loam) and the Rock Creek Site (Sifton Variant Gravelly Loam) in the Gates-Mill City area can infiltrate the average annual daily flow <u>and</u> peak daily flow for a year[2], even under the worst case ("Low End") infiltration volumes. <u>Note that this comparison between infiltration capacity and average annual / peak daily flow is for planning purposes only, and needs to be refined with data from a detailed site-specific soils investigation and incorporation of safety factors, as we discussed in Section 3</u>.

We make the following recommendations for implementing an advanced treated (Class A) wastewater infiltration project in the Santiam Canyon:

- Engage the Oregon Department of Environmental Quality (DEQ) to identify potential fatal flaws to implementing an infiltration facility related to the Three Basin Rule [see GSI (2020) for a detailed discussion] and protecting groundwater quality at domestic drinking water wells.

- After receiving property owner agreement for implementation of a wastewater infiltration facility, conduct a drilling program to evaluate site-specific factors that impact the volume of water that could be infiltrated at the site (e.g., aquifer thickness, depth to groundwater, additional measurements of hydraulic conductivity, and specific yield). The drilling program will also be used to collect data that is needed by DEQ to make a permitting decision (i.e., whether the facility is permitted with a National Pollutant Discharge Elimination System permit or Water Pollution Control Facility permit).

- The infiltration volume estimates presented in the technical memorandum assume wastewater is infiltrated at a rectangular infiltration basin. If a different facility design is used to infiltrate wastewater (e.g., rapid infiltration basin, which uses a well to infiltrate water), then develop infiltration volume estimates corresponding to the facility design. Infiltrating at a well is different because: (1) the physics of water movement are different at a well (i.e., water moves radially away from the well), so different equations are needed to estimate mounding, and (2) the area through which water exfiltrates is significantly smaller for a well (however, despite the smaller area, a well

[2] The analysis assumes that the groundwater response to infiltration (i.e., the groundwater mound) reaches steady-state conditions after one year of infiltration.

may encounter more permeable soils and, therefore, infiltrate an equivalent volume of water as a rectangular infiltration basin).

- Refine the infiltration volume estimates by reducing uncertainties related to depth to groundwater, long-term performance declines, variability of soil characteristics, and other site-specific factors.

5. References

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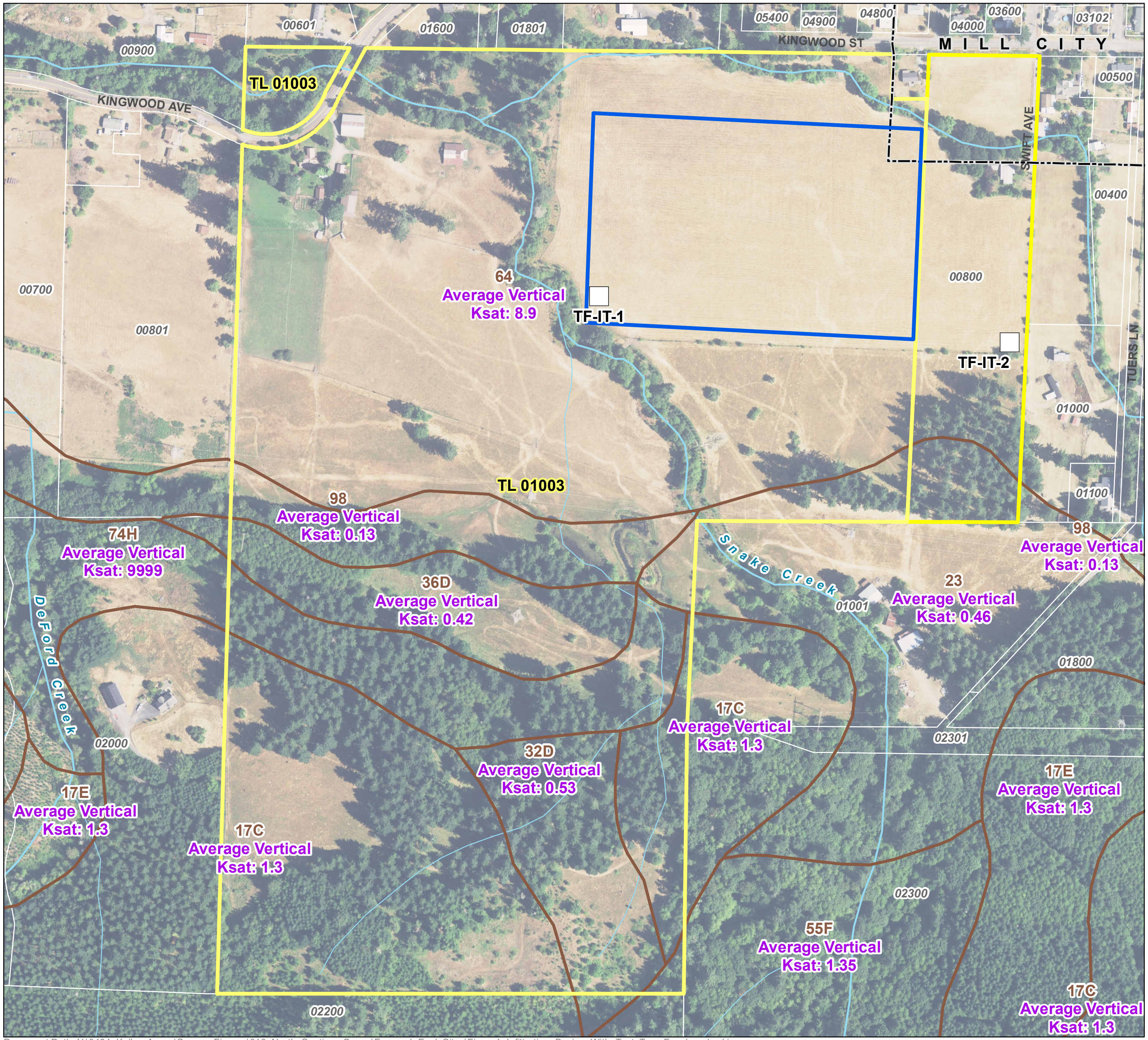

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FIGURE 1

Test Pits at
Tom Fencl Site

North Santiam Canyon
Infiltration Analysis

Mill City, Oregon

LEGEND

- Infiltration Test Location
- Potential Infiltration Basin (12.46 ac.)
- Tom Fencl Property
- Soil Type
- City Boundary
- Watercourse

NOTE

1. Average Saturated Hydraulic Conductivity (Ksat) is in units of in/hr
2. See GSI (2020) for a description of soil types
3. Average Vertical Ksat (denoted by purple text) is from USDA soil survey

N

0 200 400
Feet

Date: November 16, 2020
Data Sources: USDA, USGS, Linn Co., Marion Co., OSIP imagery 2018.

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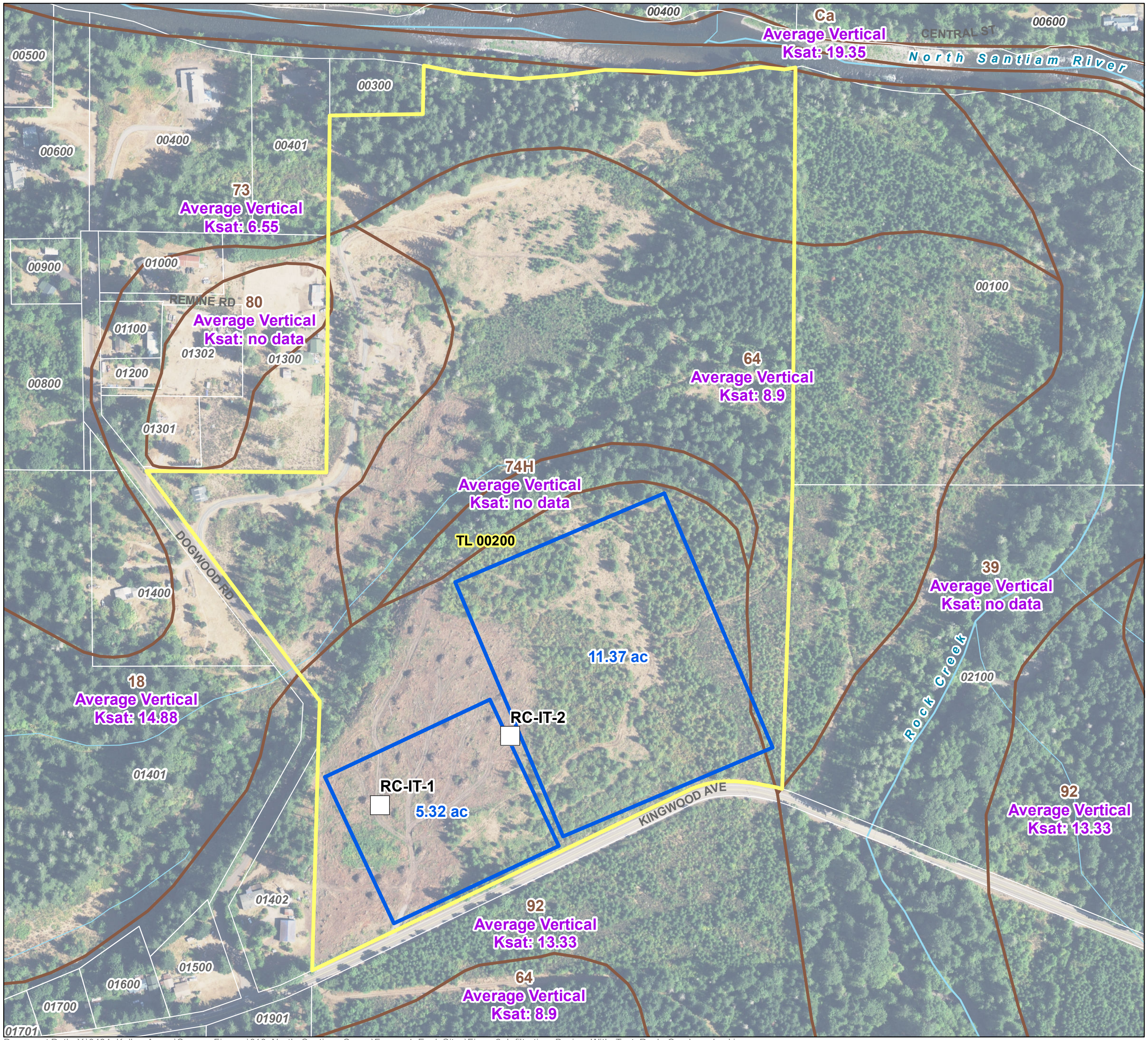

FIGURE 2

Test Pits at
Rock Creek Site
North Santiam Canyon
Infiltration Analysis
Mill City, Oregon

LEGEND

- Infiltration Test Location
- Potential Infiltration Basin
- Rock Creek Site
- Soil Type
- Watercourse

NOTE

1. Average Saturated Hydraulic Conductivity (Ksat) is in units of in/hr
2. See GSI (2020) for a description of soil types
3. Average Vertical Ksat (denoted by purple text) is from USDA soil survey

N

0 200 400
Feet

Date: November 16, 2020
Data Sources: USDA, USGS, Linn Co., Marion Co., OSIP imagery 2018.

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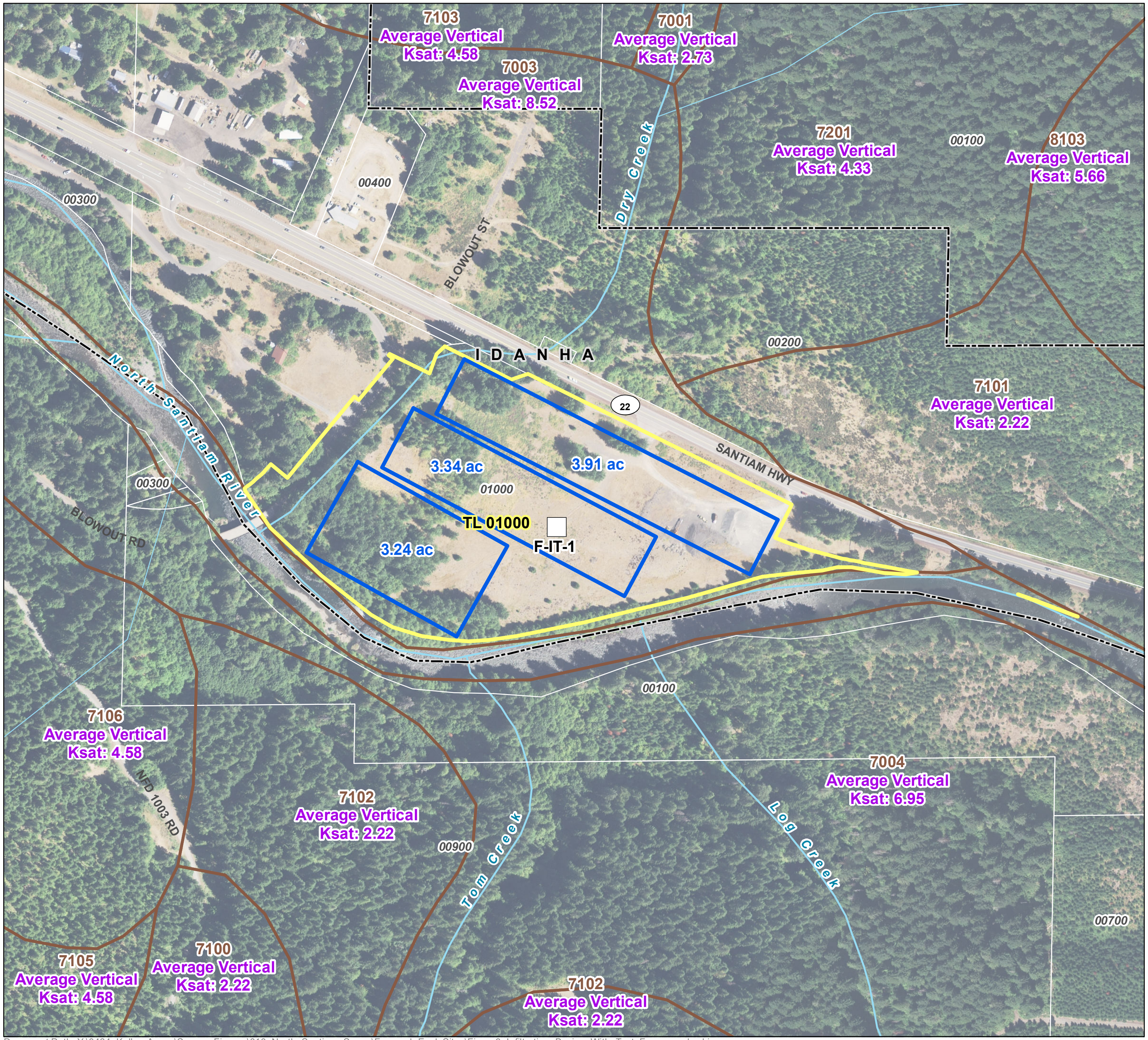
FIGURE 3

Test Pit at Freres Site

North Santiam Canyon Infiltration Analysis

Idanha, Oregon



LEGEND

- Infiltration Test Location
- Potential Infiltration Basin
- Freres Site
- Soil Type
- City Boundary
- Watercourse

NOTE

1. Average Saturated Hydraulic Conductivity (Ksat) is in units of in/hr
2. See GSI (2020) for a description of soil types
3. Average Vertical Ksat (denoted by purple text) is from USDA soil survey

N

0 200 400
Feet

Date: November 16, 2020
Data Sources: USDA, USGS, Linn Co., Marion Co., OSIP imagery 2018.

GSI Water Solutions, Inc.

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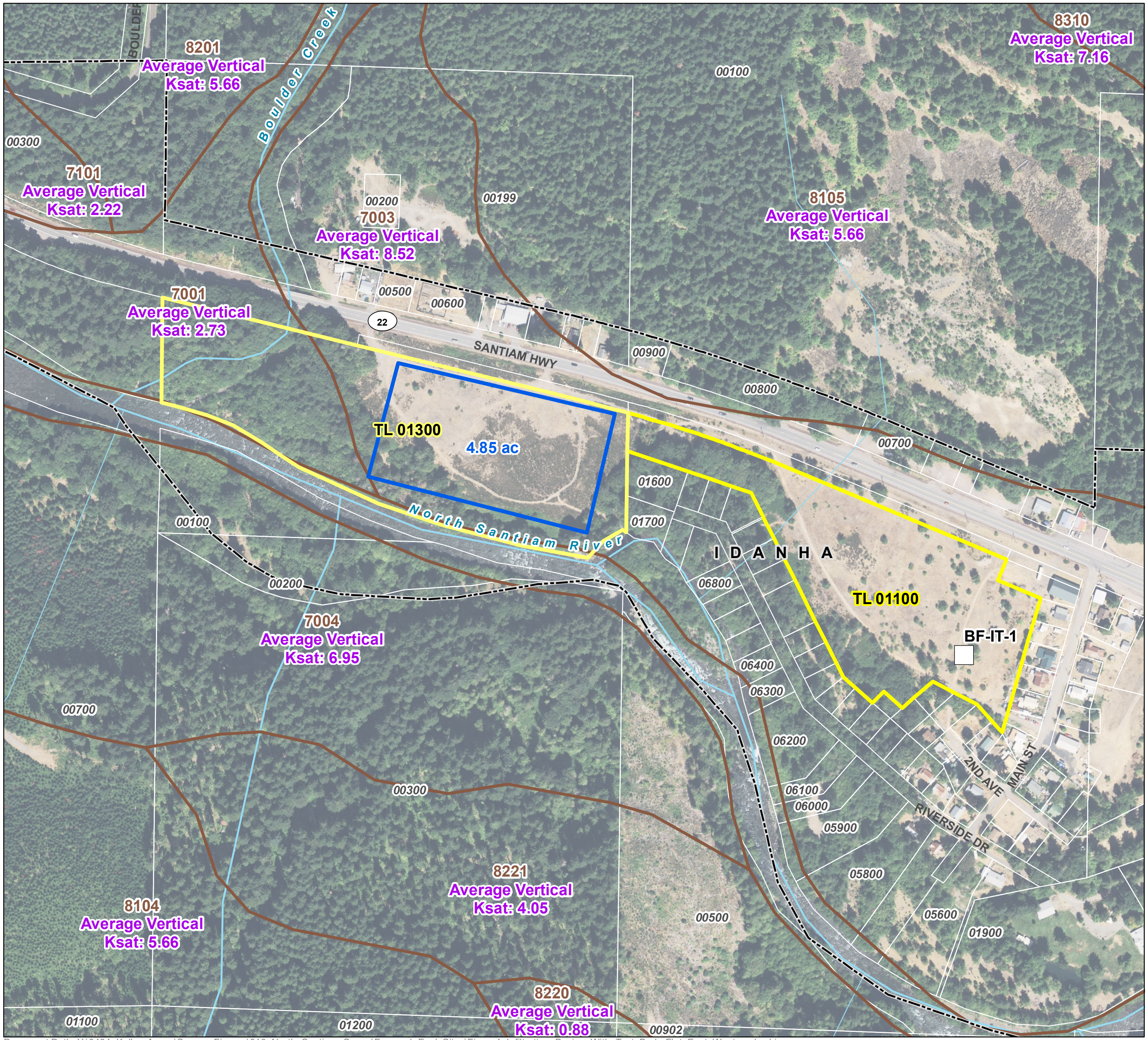
FIGURE 4

Test Pit at
Bark Flat West Site
North Santiam Canyon
Infiltration Analysis
Idanha, Oregon



LEGEND

- Infiltration Test Location
- Potential Infiltration Basin
- Bark Flat East and West Site
- Soil Type
- City Boundary
- Watercourse

NOTE

1. Average Saturated Hydraulic Conductivity (Ksat) is in units of in/hr
2. See GSI (2020) for a description of soil types
3. Average Vertical Ksat (denoted by purple text) is from USDA soil survey

N

0 200 400
Feet

Date: November 16, 2020
Data Sources: USDA, USGS, Linn Co., Marion Co., OSIP imagery 2018.

GSI Water Solutions, Inc.

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ATTACHMENT A

Test Pit Logs

GSI Water Solutions, Inc.

Well ID: TF-TP-1	Project Number 464.010	Sheet 1 of 1

Drilling LOG

Project: Santiam	**Location:** Tam Fend Site
Drilling Contractor: McKillip	**Drilling Method:** backhoe
Start Date: ~~End Date:~~ 11/2/20	**Field Personnel:** ES + MK
	Water Levels:
Start Card No:	**Total Depth:** ~~4 ft~~ 56"

Depth Below Surface (ft)	Sample: Sample Interval/ Recovery	Sample: USCS Summary	Description: Relative density or consistency, color, moisture, MAJOR CONSTITUENT, trace descriptors, plasticity, grain size/shape, structure, (geologic name)	Comments: Issues Encountered, Water Levels
0-4'	ML		moderately dense, ~~silt~~ dark brown, dry to moist, SILT (ML) ≤10% clay, ~~moderate to~~ low plasticity, firm, roots in ~top 1 ft, trace gravel + cobbles, max size = 5 in, rounded some oxidized zones gravel/cobbles = 1-5"	
4.5'			hit gravel/cobbles 5-8", rounded	

GSI Water Solutions, Inc.

Well ID:	Project Number	
TF-TP-2	464.010	Sheet 1 of 1

Drilling LOG

Project: Santiam **Location:** Tom Fenel Site

Drilling Contractor: **Drilling Method:** back hoe

Start Date: ~~End Date:~~ 11/2/20 **Field Personnel:** GS

Water Levels:

Start Card No: **Total Depth:** 5'

Depth Below Surface (ft)	Sample: Sample Interval/ Recovery	Sample: USCS Summary	Description: Relative density or consistency, color, moisture, MAJOR CONSTITUENT, trace descriptors, plasticity, grain size/shape, structure, (geologic name)	Comments: Issues Encountered, Water Levels
0-5'		ML	medium dense, dark brown, dry to moist; SILT (ML), well sorted, trace (~1in) gravel + ~~sa~~ fine sand, low plasticity, medium toughness most roots in top few inches	

GSI Water Solutions, Inc.	Well ID: RC-TP-1	Project Number 464.010	Sheet 1 of

Drilling LOG

Project: Santiam | Location: Rock Creek
Drilling Contractor: McKillip | Drilling Method: Backhoe
Start Date: ~~End Date:~~ 10/29/20 | Field Personnel: GS + MK
Water Levels:
Start Card No: | Total Depth: 2.5'

Depth Below Surface (ft)	Sample: Sample Interval/ Recovery	Sample: USCS Summary	Description: Relative density or consistency, color, moisture, MAJOR CONSTITUENT, trace descriptors, plasticity, grain size/shape, structure, (geologic name)	Comments: Issues Encountered, Water Levels
0-2.5			loose, dark brown, dry Silty Gravel (GM) % Vol : 40% gravel 60% fines % wt : 60% gravel, 40% fines subrounded to subangular max size: 1.6' diameter nonplastic, uncemented glacial fill abundant roots in upper ft boulders primarily tuff	

GSI Water Solutions, Inc.

Well ID:	Project Number	
RC-TP-2	464.010	Sheet 1 of

Drilling LOG

Project: Santiam		**Location:** Rock Creek, Mill City	
Drilling Contractor: McKillip		**Drilling Method:** back hoe	
Start Date:	~~**End Date:**~~ 10/29/20	**Field Personnel:** ES	
		Water Levels:	
Start Card No:		**Total Depth:** 2' x 4' x 3'	

Depth Below Surface (ft)	Sample: Sample Interval/ Recovery	Sample: USCS Summary	Description: Relative density or consistency, color, moisture, MAJOR CONSTITUENT, trace descriptors, plasticity, grain size/shape, structure, (geologic name)	Comments: Issues Encountered, Water Levels
0-3'	[illegible]	GM	loose, dark brown, dry Silty gravel (GM) ~60% gravel, 40% fines by wt Sub angular to sub rounded cobbles/boulders max size: 1.8' diameter non plastic poorly sorted matrix Glacial till roots abundant in upper ~1ft	2 large (>15in) boulders removed from top 1.5 ft

GSI Water Solutions, Inc.	Well ID: FR-TP-1	Project Number 464.010	Sheet 1 of

Drilling LOG

Project:	Santiam	**Location:**	Freres property
Drilling Contractor:	McKillip	**Drilling Method:**	backhoe
Start Date:	~~End Date:~~ 11/3/20	**Field Personnel:**	ES
		Water Levels:	dimensions: ~3 x 6'
Start Card No:		**Total Depth:**	3.5 ft

Depth Below Surface (ft)	Sample: Sample Interval/ Recovery	Sample: USCS Summary	Description: Relative density or consistency, color, moisture, MAJOR CONSTITUENT, trace descriptors, plasticity, grain size/shape, structure, (geologic name)	Comments: Issues Encountered, Water Levels
0-3.5			loose, brown, dry to moist GRAVEL (GW) w/ silt + v. fine sand, well graded/poorly sorted, low plasticity matrix, gravels are subrounded to rounded from <1 cm size to max size of 1.5 ft	soil very ~~rocky~~, rocky, large boulders @ 2.5 ft bgs, rocks caused pit to cave, had to enlarge

GSI Water Solutions, Inc.

Well ID:	Project Number	
BF-TP-1	464.010	Sheet 1 of

Drilling LOG

Project: Santiam **Location:** Bark Flat East

Drilling Contractor: McKillip **Drilling Method:** backhoe + shovel

Start Date: ~~End Date:~~ 11/3/20 **Field Personnel:** ES

Water Levels:

Start Card No: **Total Depth:**

Depth Below Surface (ft)	Sample: Sample Interval/ Recovery	Sample: USCS Summary	Description: Relative density or consistency, color, moisture, MAJOR CONSTITUENT, trace descriptors, plasticity, grain size/shape, structure, (geologic name)	Comments: Issues Encountered, Water Levels
0			loose, brown, moist to dry GRAVEL (GM) w/ silt + sand, well graded / poorly sorted, matrix is non plastic clasts range from <1 cm to max diameter of 1.3 ft well rounded to subrounded	

ATTACHMENT B

Infiltration Test Data Sheets

Infiltration Test Pit Measurements

Project Santiam - 464.010
Site ID Tom Fencl

Page 1 of ____
Date 11/2/20

Test ID TF-TP-1
Test Start ______
Test Stop ______
Initial Water Level ______
Final Water Level ______
Measuring Point Descrip. ______
Remarks ______

Pit Depth 56" ~~ft~~
Pit Area 2' X 4.5' ft

Date/Time 11/2/20	Elapsed Time (min)	Water ~~Depth~~ level ~~(ft)~~ in	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
0906	pre-test		642.9		
0908					water on
0910	2	2.25"	650.6	3.692	
0915	7	6.75"	668.0	3.626	
0921	13	11"	691.1	3.527	
0925	17	1' 0.75"	703.7	3.461	
0930	22	1' 3.25"	721.0	3.378	
935	27	1' 5.5"	736.0	3.296	@ 936 DECREASE FLOW RATE TO 2.381 GPM
940	32	1' 7"	748.5	2.340	
945	37	1' 8"	760.1	2.315	
950	42	1' 9.25"	771.9	2.258	
955	47	1' 10.25"	782.9	2.241	@ 956 REDUCE FLOW RATE TO 1.994 GPM
1000	52	1' 10.75	793.0	1.945	
1005	57	1' 11.5"	803.2	1.920	
1010	62	2'	813.3	1.912	adjust Q↓ to maintain 2'
1015	67	2' 0.5"	821.8	1.646	↓ Q to 1.5 gpm @ 1018
1020	72	2' 0.5"	830.1	1.508	
1025	77	2' 0.75"	837.3	1.483	
1030	82	2' 1"	844.8	1.483	
1035	87	2' 1"	852.3	1.483	switched water tanks @ 1036
1040	92	2' 0.5"	855.9	1.003	adjusted Q to 1.4 gpm
1045	97	2' 1"	864.6	2.011	drifted higher.
1047	100	~~2' 0.75"~~	872.6	1.483	adjust Q = 1.5 gpm
1050	102	2' 1.25"			

Infiltration Test Pit Measurements

Project Santiam 464.010
Site ID TF-TP-1

Date 11/2/20

Date/Time 11/2/20	Elapsed Time (min)	Water Depth (ft)	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
1055	107	2' 1.5"	879.7	1.450	
1100	112	2' 1.5"	887.2	1.442	
1105	117	2' 1.75"	894.1	1.417	↓Q, slightly close valve
1110	122	2' 1.75"	901.1	1.384	
1115	127	2' 2"	908.1	1.384	↓Q to ~1.2 gpm
1120	132	2' 1.75"	914.1	1.170	↑Q to ~1.3 gpm
1125	137	2' 2"	921.0	1.360	
1130	142	2' 2"	927.5	1.335	
1135	147	2' 2"	934.3	1.310	
1140	152	2' 2.25"	940.8	1.318	
1145	157	2' 2.25"	946.9	1.277	adjust Q to 1.327 @1145
1150	162	2' 2.25"	953.6	1.318	
1155	167	2' 2.25"	960.0	1.302	
1200	172	2' 2.4"	966.7	1.294	↑Q to 1.351
1205	177	2' 2.5"	973.3	1.310	
1210	182	2' 2.5"	979.9	1.360	
1215	187	2' 2.5"	986.8	1.368	Water off @ 1215
1220		2' 2"			
1225		2' 1"			
1230		2'			
1235		1' 11"			
1240		1' 10.25"			
1245		1' 9.25"			
1250		1' 8.5"			
1255		1' 7.5"			
1300		1' 7"			
1305		1' 6.25"			

Infiltration Test Pit Measurements

Project Santiam-464.010
Site ID ~~TF-TP-2~~ Tom Fend

Page 1 of
Date 11/2/20

Test ID TF-TP-2
Test Start 1325 (presoak)
Test Stop
Initial Water Level
Final Water Level
Measuring Point Descrip.
Remarks

Pit Depth 5 ft
Pit Area 2 X 4 ft

Date/Time 11/2/20	Elapsed Time (min)	Water ~~Depth~~ level (~~ft~~) ft:in	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
1322	pre-test	0	987.0	0	
1325					water on.
1330	5	3.75"	1006.4	3.7	
1335	10	5"	1025.4	3.749	
1340	15	5.75"	1043.8	3.667	
1345	20	6.25"	1062.0	3.609	
1350	25	6.5"	1080.1	3.576	
1355	30	6.5"	1098.1	3.518	
1400	35	6.75"	1115.7	3.527	
1405	40	7.25"	1133.4	3.453	
1410	45	7.5"	1150.5	3.420	
1415	50	7.75"	1167.7	3.420	
1420	55	8"	1184.6	3.428	
1425	60	8.25"	1201.9	3.370	↓Q to 3 gpm @ 1426
1430	65	8.25"	1217.3	3.016	
1435	70	8.25"	1232.5	2.975	
1440	75	8.25"	1247.2	2.991	
1445	80	8.5"	1262.1	2.950	↓Q to 2.8 gpm @ 1446
1450	85	8.25"	1276.6	2.777	
1455	90	8.25"	1290.3	2.777	
1500	95	8.25"	1304.1	2.752	switch water tanks @ 1502
1505	100	8.25"	1314.5	2.777	
1510	105	8"	1328.0	2.703	
1515	110	8"	1341.8	2.645	↑Q back to 2.7 gpm @ 1516

Infiltration Test Pit Measurements

Project Santiam 464.010

Site ID TF-TP-2

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Date 11/2/20

Date/Time	Elapsed Time (min)	Water ~~Depth~~ level ~~(ft)~~ in	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
1520	115	8.25"	1355.6	2.727	
1525	120	8.5"	1369.2	2.703	sightly ↓ Q @ 1526, ~2.63 gpm
1530	125	8.5"	1382.7	2.604	
1535	130	8.75"	1395.1	2.579	↓ Q to 2.5 gpm @ 1536
1540	135	~8.8"	1408.0	2.505	
1545	140	9"	1420.4	2.406	↓ Q to 2.4 gpm @ 1540
1550	145	9"	1432.7	2.406	
1555	150	9"	1444.6	2.381	
1600	155	9"	1456.6	2.406	
1605	160	9.25"	1468.6	2.431	
1610	165	9.25"	1480.6	2.381	
1615	170	9.5"	1492.5	2.357	
1620	175	9.5"	1504.2	2.324	
1625	180	9.5"	1515.7	2.307	
1630	185	9.25"	1524.5	0	water off
1635		7.5"			
1640		6.5"			
1645		5"			

Infiltration Test Pit Measurements

Project 464.010
Site ID Rock Creek

Date 10/29/20

Test ID RC-TP-1
Test Start 0914 (pre-Soak)
Test Stop
Initial Water Level
Final Water Level
Measuring Point Descrip. STAFF GAUGE, 0.25" ACCURACY
Remarks
WATER LEVEL IS WATER COLUMN HEIGHT ABOVE PIT BOTTOM

Pit Depth 2.5 ft
Pit Area 2 X 4 ft

14.5

Date/Time 10/29/20	Elapsed Time (min)	Water ~~Depth~~ HEIGHT ~~(ft)~~	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
09:14	0		14.5	2.5	
0920	6	4"	30.9		
0925	11	4.5"	44.1		0925, 2.4gpm using bucket
0930	16	5"	54.6	2.4	
0935	21	6"	66.6	2.39	
0936	22			1.3	adjust @ ↓, close
0940	26	5.75"	74.3	1.327	ball valve 1/4 turn
0945	31	5.25"	81.2	1.335	
0950	36	5"	87.9	1.318	↑@, open 1/8 turn to 2.15gpm
0955	41	5.75"	98.8	2.142	
1000	46	6.25"	109.0	2.118	
1005	51	7"	119.5	2.118	
1008	54			1.7	↓@, slightly close valve
1010	56	7.25"	130.9	1.689	
1015	61	7.5"	137.8	1.706	
1020	66	~7.4"	146.4	1.68	
1025	71	7.5"	153.5	1.689	
1030	76	7.75"	~~160~~ 162.8	1.673	REDUCE FLOW TO 1.467 GPM @ 10:32
1035	81	7.75"	170.5	1.442	FLOW TEST, 6 QT IN 60 S = 1.5 gpm
1040	86	7.75"	176.6	1.437	
1045	91	7.75"	184.2	1.434	REDUCE FLOW TO 1.29 @ 1047
1050	96	8.00"	191.0	1.294	REDUCE FLOW TO 1.07 GPM @ 1053
1055	101	8.00"	196.6	1.038	
1100	106	7.75	202.0	1.038	

Infiltration Test Pit Measurements

Project 464.010
Site ID ROCK CREEK

Date 10/29/2020

Date/Time	Elapsed Time (min)	Water Depth (ft)	Totalizer Reading (x__ gal)	Flow Rate gpm	Comments
1105	111	7.5"	207.4	1.030	
1110	116	7.5"	214.0	1.030	
1115	121	7.25"	219.8	1.022	
1120	126	7.25"	222.8	1.014	2.5 min ET
1125	131	7.25"	228.0	1.022	
1130	136	7.25"	233.4	1.014	
1135	141	7.25"	239	1.030	
1140	146	7.25"	244	0.997	slightly open valve
1145	151	7.25"	248.8	1.071	
1151	147	7.5"	255.2	1.079	
1155	161	7.5"	259.6	1.071	
1200	166	7.75"	264.9	1.046	slightly close valve - 1.014
1205	171	7.75"	270.3	1.005	
1210	176	7.75"	274.9	1.005	
1215	181	7.75"	280.0	0.989	
			280.3		← final totalizer
1220		6.5"			falling head
1225		5.75"			
1230		4.75"			
1235		4.00"			

Infiltration Test Pit Measurements

Project 464.010 Santiam
Site ID ~~RC-TP-2~~ Rock Creek

Page 1 of 2
Date 10/29/20

Test ID RC-TP-2
Test Start 1255 (pre soak start)
Test Stop
Initial Water Level
Final Water Level
Measuring Point Descrip.
Remarks

Pit Depth ~~2~~ 3.0 ft
Pit Area 2 X 4 ft

Date/Time 10/29/20	Elapsed Time (min)	Water level ~~Depth~~ (~~ft~~) in	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
1253	pre-start		280.3		
1254			288.1	3.329	~~water on~~ 1253, water flowing
1300	5	2.75"	"	"	
1305	10	4.75"	304.4	3.263	
1310	15	~5.8"	321.0	3.222	
~~13~~ 1312	~~20~~	5.5"	333	2.002	Adjust Q↓, ~2 gpm @1312
1315	~~25~~ 20				
1320	25 ~~30~~ ~~25~~	5.0"	343.3	1.928	
1325	30 ~~35~~	4.75"	352.9	1.969	
1330	35	4.75"	362.6	1.978	
1335	40	~4.6"	372.7	1.953	
1340	45	"	382.4	1.961	
1345	50	4.75"	392.3	1.936	
1350	55	4.75"	402.0	1.936	WL creeping back up?
1355	60	4.75"	411.6	1.928	
1400	65	4.75"	421.0	1.920	
1406	71	5.00"	432.5	1.920	
1410	75	5.00"	440.5	1.895	
1415	80	5"	449.7	1.862	
1420	85	5"	459.4	1.854	
1425	90	~5.1"	468.4	1.854	
1430	95	"	477.7	1.838	↑Q to bring WL to 6", @~2.5 gpm
1435	100	6"	489.7	2.546	
1440	105	5.5"	499.1	1.578	↓Q to maintain 6" WL, @~1.6 gpm

Infiltration Test Pit Measurements

Project Santiam

Site ID RC-TP-2

Page 2 of 2

Date 10/29/20

Date/Time	Elapsed Time (min)	Water Depth (ft)	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
1443	108				↑Q to maintain WL, Q~1.85 gpm
1445	110	5.5"	507.5	1.862	
1450	115	5.5"	516.8	1.838	
1455	120	5.5"	526.1	1.821	
1500	125	5.5"	535.1	1.829	
1505	130	5.5"	545.1*	1.796	*late reading, siphon stopped
1515	140	5.5"	562.6	1.756	
1520	145	5.5"	572.6	1.755	siphon restarted, still losing same pressure
1525	150	5.5"	580.1	1.755	
1530	155	5.5"	588.7	1.739	
1535	160	5.5"	597.5	1.73	open valve slightly to maintain rate
1540	165	5.75"	606.6	1.796	
1545	170	5.75"	615.3	1.772	
1550	175	5.75"	624.3	1.739	
1555	180	~5.8"	632.9	1.739	
1600	180	"	641.5	1.714	water off
			642.9		← Final value

Infiltration Test Pit Measurements

Project Santiam 464.010
Site ID Freres

Page 1 of ____
Date 11/3/20

Test ID	FR-TP-~~2~~1
Test Start	0900
Test Stop	
Initial Water Level	
Final Water Level	
Measuring Point Descrip.	
Remarks	

Pit Depth 1.5 ft
Pit Area 1.5 X 3 ft

Date/Time 11/3/20	Elapsed Time (min)	Water ~~Depth~~ level (ft)	Totalizer Reading (x___ gal)	Flow Rate (gpm)	Comments
0857	pre test	0	1560.3	0	
0900	0	0		~2.7	water on, valve fully open
0905	5	3.75"	1574.1	2.76	
0910	10	4.5"	1587.8	2.719	↓Q to 2.5 gpm @ 911
0916	16	4.5"	1604.9	2.480	
0920	20	4.5"	1614.2	2.447	
0925	25	4.5"	1624.4	2.447	
0930	30	4.75"	1636.7	2.431	
0935	35	4.75"	1648.8	2.406	
0940	40	4.75"	1660.7	2.390	
0945	45	4.75"	1672.7	2.365	
0950	50	4.75"	1684.5	2.373	
0955	55	4.75"	1696.3	2.324	
1000	60	4.75"	1708.4	2.307	↓Q to 2 gpm @ 1001
1010	70	4.25"	1729.8	2.044	
1017	77	4.25"	1744.5	2.027	
1020	80	4.25"	1749.8	1.994	
1025	85	4.00"	1759.9	1.986	slightly ↑Q to ~2 gpm
1030	90	4.00"	1769.9	2.035	
1035	95	4.25"	1780.1	2.002	
1040	~~90~~ 100	4.5"	1790.3	2.118	WL↑, ↓Q to 1.9 gpm @ 1042
1045	105	4.5"	1800.3	1.903	
1050	110	~4.6"	1809.8	1.887	
1055	115	~4.5"	1819.2	1.862	

Infiltration Test Pit Measurements

Project Santiam 464.010

Site ID Freres, FR-TP-1

Page 2 of ____

Date 11/3/20

Date/Time	Elapsed Time (min)	Water Depth (ft)	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
1100	120	4.25"	1827.1	1.761	switched H2O tanks @ 1057
1105	125	4.5"	1836.5	1.805	@1102 adjust Q to ~1.85 gpm
1110	130	4.5"	1845.7	1.788	
1115	135	4.5"	1854.5	1.755	
1120	140	4.75"	1863.2	1.747	~~to 1.7 gpm @ 1121~~
1125	145	4.75"	1872	1.763	
1130	150	4.75"	1881	1.739	
1135	155	4.75"	1889.7	1.722	slightly open valve to maintain Q
1140	160	4.75"	1898.3	1.763	
1145	165	5"	1907.2	1.739	
1150	170	5"	1916	1.722	
1155	175	5"	1924.4	1.714	
1200	180	5"	1933.3	1.747	water off
			1933.6		← final
1202		3"			
1205		2"			
1206		1.25"			

Infiltration Test Pit Measurements

Project Santiam 464.010 | Page 1 of ____
Site ID Bark Flat East | Date 11/3/20

Test ID BF-TP-1
Test Start
Test Stop
Initial Water Level
Final Water Level
Measuring Point Descrip.
Remarks

Pit Depth 1.8 ft
Pit Area 1 X 2 ft @ depth
2 x 4 ft @ surface

Date/Time 11/3/30	Elapsed Time (min)	Water ~~Depth~~ level (ft), in	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
1326	0	0	1933.6	0	pre-test
1330				~3.1	water on
1336	6	7.75"	1951.5	2.9	
1340	10	10"	1962.5	2.851	lots of sloughing into hole
1345	15	1' 0.25"	1976.6	2.727	↓ Q to 2 gpm @ 1346
1350	20	1' 1.5"	1987.5	2.002	set up siphon
1355	25	1' 2.5"	1997.5	2.002	↓ Q to 1.5 gpm @ 1356
1400	30	1' 3"	2005.7	1.541	
1405	35	1' 3.5"	2013.5	1.500	WL↑, ↓ Q to 1 gpm @ 1406
1410	40	1' 3.75"	2019.4	1.071	
1415	45	1' 3.75"	2025	1.071	
1420	50	1' 4"	2030.2	1.055	
1425	55	1' 4"	2035.6	1.055	
1430	60	1' 4"	2040.7	1.055	pit slopes inward but water surface area is 2' x 4'
1435	65	1' 4"	2045.7	1.055	
1440	70	1' 4"	2051.1	1.046	
1445	75	1' 4.25"	2056.4	1.030	↓ Q to 0.8 gpm @ 1446
1450	80	1' 4.25"	2060.6	0.808	
1455	85	1' 4"	2064.8	0.799	
1500	90	1' 4"	2068.6	0.799	
1505	95	1' 4"	2072.6	0.783	
1510	100	1' 4"	2076.6	0.799	
1515		1' 4	2080.4	0.799	
1520		1' 3.75"	2084.6	0.775	

Infiltration Test Pit Measurements

Project Santiam 464.010
Site ID Bark Flat East BF-TP-

Page 2 of ____
Date 11/3/20

Date/Time	Elapsed Time (min)	Water Depth (ft)	Totalizer Reading (x___ gal)	Flow Rate gpm	Comments
1525	115	1'3.75"	2088.1	0.775	
1530	120	1'3.75"	2092.2	0.766	↑@ back to 0.8 gpm @1532
1535	125	1'3.75"	2096.1	0.824	
1540	130	1'3.5"	2100.2	0.808	
1545	135	1'3.5"	2104.2	0.799	
1550	140	1'3.5"	2108.2	0.808	
1555	145	1'3.5"	2112.3	0.832	
1600	150	1'3.5"	2116.3	0.783	
1610	160	1'3.5"	2124.3	0.799	
1615	165	1'3.5"	2128.3	0.791	
1620	170	1'3.5"	2132.3	0.783	↑@ back to 0.8 gpm
1627	177	1'3.5"	2138.0	0.808	
1630	180	1'3.75"	2140.4	0.824	Water off
			2141.0		← final
1635		1'3"			
1640		1'2.5"			
1646		1'1.5"			