2/15/2024

D&K
Soil Consultants, Inc.

7572 Snow Camp Rd.
Snow Camp, NC 27349
(336) 380-1785

Saturated Hydraulic Conductivity Report and TS2 Pretreatment Drip Irrigation System Proposal

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Prepared for:

Mrs. Elizabeth Biggers

Site # 2:

Parcel # 10785

HWY 87s.

Chatham Co. NC

Introduction:

The following soil/site evaluation technical report is submitted to assist in the development, as well as the local health department, in the site assessment for a TS2 Pretreatment Drip Irrigation system off HWY87S. Parcel # 10785 (Site #2), in Chatham County, North Carolina.

Purpose:

The purpose of this report is to evaluate the property for a **TS2 Pretreatment Drip Irrigation** on-site wastewater treatment and disposal system, utilizing a **Special Case Soil Study** to reduce the **Vertical separation** distance by 50% **(justified by .1948 (d)** for a 4-5-bedroom house site.

History:

D&K Soil Consultants, Inc. was contracted by Mrs. Elizabeth Biggers to perform a **Preliminary Soil Evaluation** to see if the approximately 10-acre tract (West side of 87s.) could support two wastewater systems for two potential residences for future subdivision. This Soil Evaluation was performed on 10/08/2022 and the only potential suitable soil/system that was evaluated would be for Surface Drip Irrigation, Surface Spray or Subsurface Drip Irrigation systems. To assess if two potential sites on the approximately 10-acre (West side of 87s.) part of the land was possible, a **Detailed Soil Evaluation** was performed on 01/28/2023 and (after some additional hand clearing) on 04/29/2023.

Under the advisement of *D & K Soil Consultants*, Elizabeth Biggers subsequently applied for a Soil Evaluation and Improvement permit for these two sites at the Chatham County Health Department. This was advised to facilitate the permitting process by ensuring that the *Chatham County Health Dept.* agreed with *D&K,* in that 13" or more Provisionally Suitable or Suitable soil was present on the Sites #1 and Site #2. This is the minimum soil depth required for **Surface TS2 Pretreatment Drip Irrigation Systems. Additionally,** a **Special Case Soil Study, justified by .1948 (d), utilizing Saturated Hydraulic Conductivity testing (Ksat) is required** and was performed performed by *D & K Soil Consultants on* 12-23/2023 for Site #2. The Ksat testing is utilized to measure the relative permeability of the soil, reduce the vertical separation to an unsuitable soil condition by 50%, and to support a long-term acceptance rate (LTAR) that could allow the Initial and Repair area to fit in the proposed ~14,700 Ft² (Area B) soil area found on Site #2. This soil area was found by ***D & K Soil Consultants*** and confirmed by **CCHD (Ray Milosh REHS)** to have at least 13" or more of provisionally suitable soil for a TS2 Pretreatment Drip Irrigation system if Ksat testing proved adequate justification.

Methodology:

Based on the shallowest soil depth of 13" to Soil wetness conditions observed from Soil Boring #'s 58, 64 and 65 (see attached soil map, "Area B") in the proposed Initial and Repair soil areas on Site #2, ***D&K*** would surmise that **TS2 Pretreatment Drip Irrigation** would be the logical system choice. *See sheet titled "**Ksat Soil Profile Descriptions**" at end of report for detailed soil boring characteristics for soil boring descriptions from the Ksat testing soil borings.*

These additional borings were conducted to perform hydraulic conductivity measurements. These borings (6) were excavated at depths of 8, 8, and 9 inches (3 borings, K7, K8, K9) and at 13, 14, and 13 inches (3 borings, K10, K11, K12) below the natural ground surface. These depths were determined by testing below the proposed trench bottom/soil interface at 8-9 inches for the drip tubing and at 13-14 inches for the bottom of the treatment zone in the naturally occurring soil. The permeameters were then set up at each of the 6 boring sites, filled with water and was allowed to infiltrate into the borehole until equilibrium was reached. *See Excel attachments for Ksat worksheets for Ksat testing data.*

Hydraulic Conductivity measurements were performed using the **Johnson Permeameter** (patent US 6,938,461). "The Johnson Permeameter is constructed of high-quality corrosion and shock resistant materials that with ordinary hand auger equipment can be used to measure saturated hydraulic conductivity (Ksats) of soils in the vadose zone. The permeameter establishes a constant head of water at a predetermined depth in the borehole by use of precision valve and float assembly. The rate of water flow into the borehole required to maintain the constant head is then determined at selected intervals." The 2" permeameter was utilized for K7, K8, K9, K10, K11, and K12 test borings.

"The information recorded during the test, including rate of flow, height of constant water in the borehole, and borehole radius, is entered into an appropriate analytical solution to provide a measure of hydraulic conductivity. This procedure is known as the constant head well permeameter method."

"The permeameter can effectively measure hydraulic conductivity at any desired depth in the vadose zone ranging from 16 cm (0.52 ft) to 30 meters (98.4 ft), or more and measure Ksat in the range of 10^{-2} to 10^{-6} cm/sec. The effective flow rate of the permeameter ranges from 0 – 2000 ml/min. The permeameter is capable of measuring Ksat in soils ranging from very low to very high. In addition, the permeameter is designed to resist entry of particulate contaminants and can be set up on any degree of slope and landscape for drilling by hand or machine powered equipment." (Johnson permeameter 2007)

Results

The long-term acceptance rate (LTAR) of this system is based on the most hydraulically limiting soil horizon within 8"-14" of the naturally occurring ground surface or 6" or more

below the proposed trench bottom, whichever is deeper. In this soil area, silt loam and silt clay loam were the soil textures found (group II-III soils). Looking at the table provided by TS1 or TS2 performance standards a group IV soil can have an LTAR range between 0.04 – 0.15 gpd/ft² and a **group III soil can have an LTAR range between 0.4 – 0.15 gpd/ft²** for aerobic (pretreatment) Drip Irrigation systems, without a Special Case Soils study, utilizing Ksat testing. It is our suggestion to use the maximum LTAR of 0.12 gpd/ft² since this is less than our lowest single Ksat reading of 0.22 gpd/ft² at 14" at Ksat test (K10) and is even lower than the suggested range for a group III soil. *See Table 1 for a summary of Ksat testing results:*

Table # 1. Summary of Ksat testing with Anaerobic and Aerobic conversions.

Ksat Values converted to Long Term Acceptance Rates				D&K Soil Consultants, Inc.		
Elizabeth Biggers	Site 2	HWY 87s.	Chatham Co.	Date: 12/23/2023		
Boring #	Horizon	Depth	Ksat pure water	Ksat pure water	Anaerobic	Aerobic
		inches	(Ft/day)	(GPD/Ft²)	(GPD/Ft² x 10%)	(GPD/Ft² x 25%)
K7	A	8	4.36	32.61	3.26	8.15
K8	AB	13	0.33	2.47	0.25	0.62
K9	A	8	2.13	15.93	1.59	3.98
K10	AB	14	0.30	2.24	0.22	0.56
K11	A	9	2.81	21.02	2.10	5.25
K12	AB	13	3.69	27.60	2.76	6.90
Composite Ksats	A	8,9			2.21	
Geometric Means	AB	14,15			0.55	

The geometric mean of these six Ksat tests was used to calculate the tested saturated hydraulic conductivity of the soils on the site. The geometric mean is used to buffer the variability that is common with Ksat tests. Historically the state typically allows a maximum of 10% of the observed Ksat (pure water) for anaerobic rates and up to 25% of the observed Ksat (pure water) for Aerobic rates. Please note that our suggested LTAR of **0.12 gpd/ft²** is much less than the Anaerobic geometric mean of the slowest of the tested horizons the AB horizon at 13"-14" of **0.55 gpd/ft²** and the A horizon at 8"-9" of **2.21 gpd/ft².** Furthermore, it is also much less than the geometric mean for the Aerobic (Pretreatment) rates, from the testing results (see above Table 1). *For detailed testing results with saturation times, run times, borehole depths, dimensions of borehole, etc. see "**Saturated Hydraulic Conductivity Worksheets**", attached in email.*

Linear Footage Required:

In calculating the number of square footages needed for this type of septic system, the design daily flow rate for a 4-BDR-5BDR single family residence is 480gpd to 600gpd respectively. So, **(480-600 gpd)** shall be divided by the proposed LTAR **(0.12 gpd/ft²)** and then multiplied by 2 to get the minimum number of square feet required for the Initial and Repair drainfield area (8,000-10,000 ft² minimum needed). Therefore, if we take the potential drainfield area found for area "B", divided by the theoretical minimum area needed (for a five-bedroom residence), we get (14,700 Ft²/10,000 ft² = 1.47) **1.47X the minimum theoretical area needed for both the Initial and Repair areas for** Site #2. *Please note that standard practice is to allow for a drainfield area to be 1.3 -1.5X larger than the theoretical proposed drainfield area, and in our case the soil area is 1.47X larger.* For example, to calculate linear footage of the Drip tubing required for, Site #2 (area B) the theoretical minimum square footage of the soil area, (10,000 Ft²) is then divided by the **equivalent trench width (2.0')** to get the linear footage required for both the Initial and Repair Areas. This includes a total of 5,000 linear feet of drip tubing required for both the Initial and Repair systems. So, (2,500') is needed for the initial system and (2,500') for the future repair system. **Trench widths shall be spaced at a minimum of 2.0' centers** following the contour of the natural ground surface.

Conclusions

There appears to be adequate space on (Site #2, Area B) Parcel # 10785 (HWY 87s. Chatham County, NC) for an on-site wastewater treatment and disposal system for a 4-5-bedroom residence. This includes maximum design flow of 480 or 600 gallons per day for a Pretreatment Drip Irrigation wastewater treatment and disposal system.

For the engineer: ***In the system design, 2,500 linear feet drip irrigation tubing shall be placed at 6 inches below the naturally occurring ground surface, on two-foot centers, for the initial system's nitrification field. Furthermore, the 2,500 linear feet of drip tubing will accommodate a 5-bedroom residence (600 gpd) with our proposed LTAR of 0.12 gpdft². The engineer must survey all proposed drip lines that are to be delineated in the field using wire color coated flags. Any additional Lines are to be extrapolated by the engineer/or consultant in the design and drawing of the drip irrigation nitrification field. Furthermore, the house, well site, driveway, any proposed buildings, all septic tanks, and septic components, including all pretreatment components, must also be surveyed in with relative elevations and put on a map for the design of the wastewater system. See Site Sketch at end of report for an Arcpro map rendering the soil area with approximate soil boring locations, and Ksat observation sites. This map should serve as a crude field guide to the engineer and its components should be all inclusive in the survey and subsequent CAD drawn map. Any additional requirements must be followed per the Chatham County Health Department.***

This report discusses the general areas of potentially useable areas for on-site wastewater disposal systems and, of course does not guarantee the approval or permit as required by the local health department. Furthermore, *D&K Soil Consultants* is hired to give its professional

opinion on these matters and due to the interpretation and constantly evolving changes in the rules and regulations that govern on-site wastewater treatment and disposals systems we cannot guarantee approval by the local health department. *D&K* recommends that anyone making financial commitments on any plat of land be fully aware that an improvement permit and a construction authorization are required prior to any construction on any lot. Obtaining these two permits would be highly recommended prior the purchase or sale of any tract or lot of land.

Furthermore, septic permits will be required for any lot prior to the issuance of a building permit. The health department will perform a detailed evaluation of the lot which includes soil morphology, soil application rate, topography and slope, minimal set-back requirements, system size and layout, location of house, drive, wells (if applicable), buildings, and so forth.

D&K Soil Consultants appreciates the opportunity to provide soil scientist services to you.

Sincerely,

D&K Soil Consultants, Inc.

David B. Ward, L.S.S.

Soil Scientist

Ksat Soil Profile Descriptions

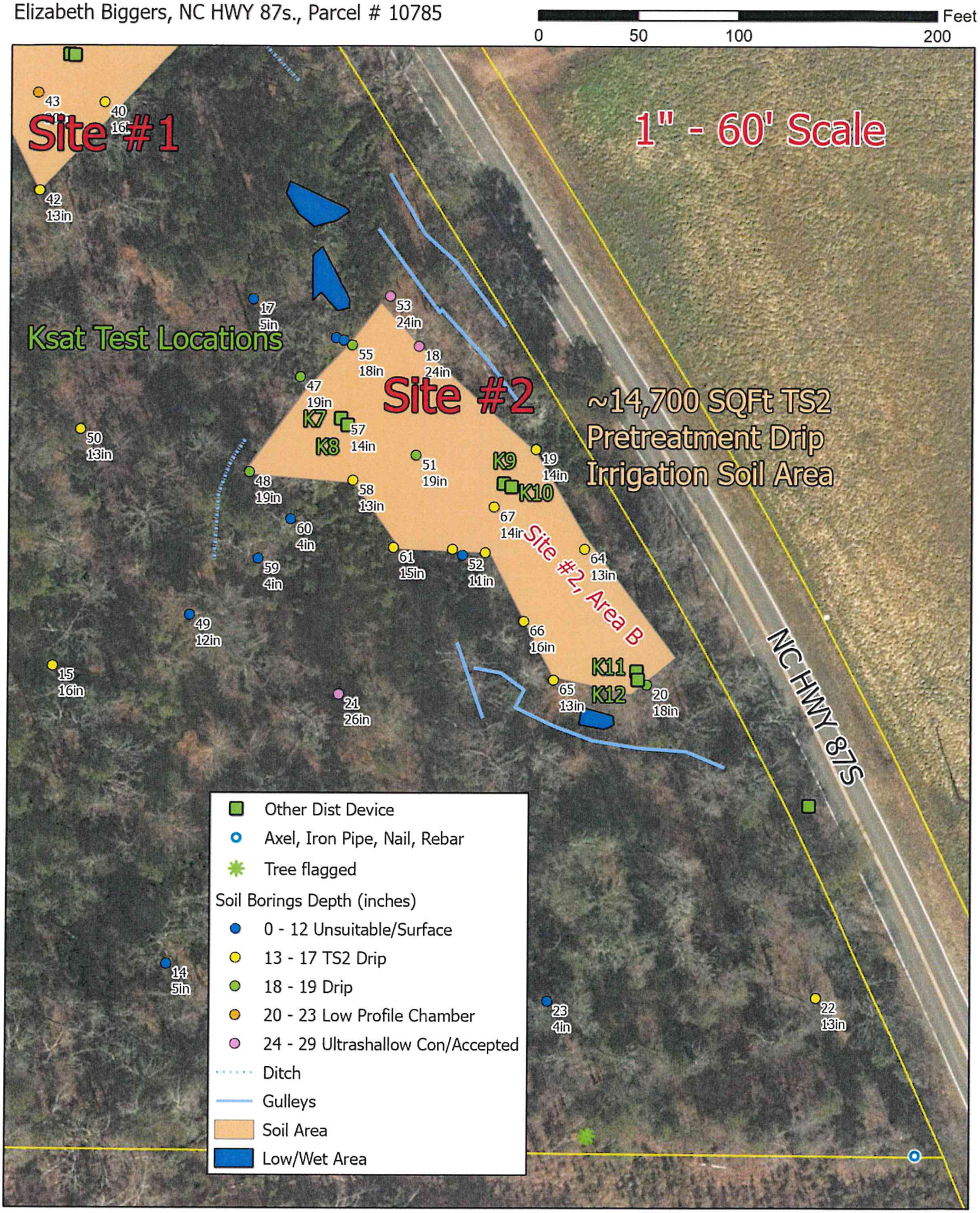
Owner/Buyer- **Elizabeth Biggers**
Proposed Facility- ***4-5 BDR House***
Water Supply- ***Private***

Date Evaluated- ***12/23/2023***
Proposed Design Flow- ***480-600 GPD***
Evaluation Method- ***Auger***

Site Location- **Site 2, NC HWY 87s Chatham C., NC**

	Topography		**Horizon**	**Texture**	**Soil Structure**			**Mineralogy**		**Soil Color**		**Additional notes**	
Profile	Slope %	Flag						*Consistence*		*Matrix*	*Mottles*	**Suggested LTAR**	
#		Color	depth (in)		Grade	Class	Type	Moist	Wet				
K7			0-5	SiL	1	F	Cr	Fr	SS SP				TS2 drip
			5-8	SiCL	1	F	Cr/SBK	FR	SS SP				
K8			0-15	SiL	1	F	Cr	Fr	SS SP				TS2 drip
			5-13	SiCL	1	F	Cr	Fr	SS SP				
K9			0-4	SiL	1	F	Cr	Fr	SS SP				TS2 drip
			4-8	SiCL	1	F	Cr	Fr	SS SP				
K10			0-4	SiL	1	F	Cr	Fr	SS SP				TS2 drip
			4-14	SiCL	1	F	Cr	Fr	SS SP				
K11			0-3	SiL	1	F	Cr	Fr	SS SP				TS2 drip
			3-9	SiCL	1	F	Cr	Fr	SS SP				
K12			0-3	SiL	1	F	Cr	Fr	SS SP				TS2 drip
			3-13	SiCL	1	F	Cr	Fr	SS SP				

Elizabeth Biggers, NC HWY 87s., Parcel # 10785



D & K Soil Consultants, Inc. This map is based on the Chatham County GIS site. It is not a survey. Additional attributes were taken with a sub-meter GPS handheld device and has inherent errors. D & K Soil Consultants shall not assume liability for any errors, omissions, or inaccuracies in the information provided.

Ksat Values converted to Long Term Acceptance Rates				D&K Soil Consultants, Inc.		
Elizabeth Biggers	Site 2	HWY 87s.	Chatham Co.	Date: 12/23/2023		
Boring #	Horizon	Depth	Ksat pure water	Ksat pure water	Anaerobic	Aerobic
		inches	(Ft/day)	(GPD/Ft²)	(GPD/Ft² x 10%)	(GPD/Ft² x 25%)
K7	A	8	4.36	32.61	3.26	8.15
K8	AB	13	0.33	2.47	0.25	0.62
K9	A	8	2.13	15.93	1.59	3.98
K10	AB	14	0.30	2.24	0.22	0.56
K11	A	9	2.81	21.02	2.10	5.25
K12	AB	13	3.69	27.60	2.76	6.90
Composite Ksats	A	8,9			2.21	
Geometric Means	AB	14,15			0.55	

D & K Soil Consultants, Inc.

SATURATED HYDRAULIC CONDUCTIVITY WORKSHEET

Sheet No.: 1 of 2

Project Name.:	Elizabeth Biggers, Site 2, HWY 87S	**Parcel.....:**	
Boring No.....:	K7	**Date.....:**	12/23/23
Investigators.:	David Ward/Kasey Vaughans-Ward	**File Name.....:**	
Boring Depth.:	8 inches	**WCU Base Ht. h:**	17.0 cm
Boring Dia.....:	6.4 cm	**WCU Susp. Ht. S:**	0.0 cm
Boring Rad. (r):	3.20 cm	**Const. Wtr. Ht. H:**	17.0 cm
		H/r.....:**	5.3
Dyn. Vsc. at T °C:	0.001308 kg/m.s	**Dyn. Vsc. at 20 °C:**	0.001003 kg/m.s

Terminology and Solution (USBR 7300 Condition I)*

K_{20}: Ksat (Coefficient of Permeability) at 20 °C

Q: Steady-state rate of water flow into the soil

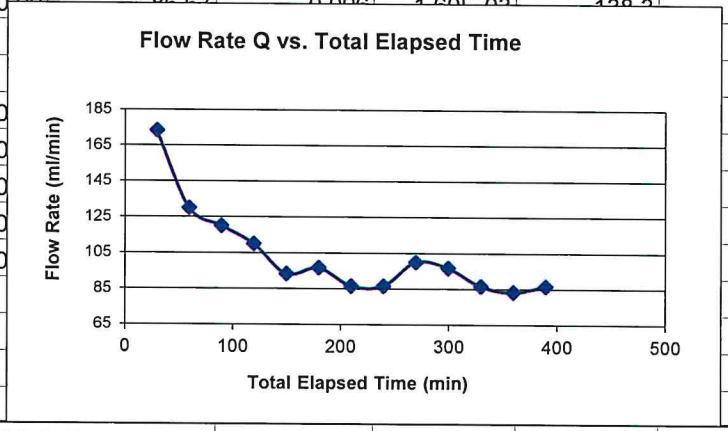
H: Constant height of water in borehole

r: Radius of cylindrical borehole

V: Viscosity of water at Temp. T °C/Viscosity of water at 20 °C

$$K_{20} = QV/(2\pi H^2)[\ln\{H/r+((H/r)^2+1)^{0.5}\}-((H/r)2+1)^{0.5}/(H/r)+1/(H/r))]$$

VOLUME (ml)	Volume Out (ml) [a]	TIME (m/d/yy h:mm:ss A/P)	Elapsed Time (hr:min:sec)	Elapsed Time (min) [b]	Flow Rate Q (ml/min) [a/b]	Ksat Equivalent Values (cm/min)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
15,000		12/23/23 8:10:00 AM								
9,800	5200	12/23/23 8:40:00 AM	0:30:00	30.00	173.33	0.192	3.20E-03	276.5	4.536	9.07
5,900	3900	12/23/23 9:10:00 AM	0:30:00	30.00	130.00	0.144	2.40E-03	207.4	3.402	6.80
2,300	3600	12/23/23 9:40:00 AM	0:30:00	30.00	120.00	0.133	2.22E-03	191.4	3.140	6.28
15,000		12/23/23 9:41:00 AM								
11,700	3300	12/23/23 10:11:00 AM	0:30:00	30.00	110.00	0.122	2.03E-03	175.5	2.879	5.76
8900	2800	12/23/23 10:41:00 AM	0:30:00	30.00	93.33	0.103	1.72E-03	148.9	2.443	4.89
6000	2900	12/23/23 11:11:00 AM	0:30:00	30.00	96.67	0.107	1.78E-03	154.2	2.530	5.06
3400	2600	12/23/23 11:41:00 AM	0:30:00	30.00	86.67	0.096	1.60E-03	138.3	2.268	4.54
800	2600	12/23/23 12:11:00 PM	0:30:00	30.00	86.67	0.096	1.60E-03	138.3	2.268	4.54
15000		12/23/23 12:12:00 PM								
12000	3000	12/23/23 12:42:00 PM	0:30:00	30					2.617	5.23
9100	2900	12/23/23 1:12:00 PM	0:30:00	30					2.530	5.06
6500	2600	12/23/23 1:42:00 PM	0:30:00	30					2.268	4.54
4000	2500	12/23/23 2:12:00 PM	0:30:00	30					2.181	4.36
1400	2600	12/23/23 2:42:00 PM	0:30:00	30					2.268	4.54



Natural Moisture:	moist	**Init. Satur.Time:**	8:10:00 AM	**ESTIMATED FIELD Ksat.....:**	
Texture/Classif.:	SiCl	**Consistency:**	Fr, ms mp	**Water Tmp. T °C:**	10
Structure/Fabric:	Gr, f, 1	**Water Tbl. Dpth.:**			

Notes: Estimated field Ksat is determined by averaging and/or rounding of test results for final three or four stabilized values and analyzing the graph

File: USBR-7300-Condition-I-graph *Condition I exists when the distance from the water surface in the well to the water table or an impervious layer is GREATER than 3 times the depth of the water in the well. **H/r > 10 Johnson Permeameter, LLC 4/3/2012, Rev. 7/26/13

D & K Soil Consultants, Inc.

SATURATED HYDRAULIC CONDUCTIVITY WORKSHEET

Sheet No.: 2 of 2

Project Name.:	Elizabeth Biggers, Site 1, HWY 87S Cha	**Parcel.....:**	
Boring No.....:	K7	**Date.....:**	12/23/23
Investigators.:	David Ward/Kasey Vaughans-Ward	**File Name.....:**	
Boring Depth.:	8 inches	**WCU Base Ht. h:**	17.0 cm
Boring Dia.....:	6.4 cm	**WCU Susp. Ht. S:**	0.0 cm
Boring Rad. (r):	3.20 cm	**Const. Wtr. Ht. H:**	17.0 cm
		H/r.....:**	5.3
Dyn. Vsc. at T °C:	0.001308 kg/m.s	**Dyn. Vsc. at 20 °C:**	0.001003 kg/m.s

Terminology and Solution (USBR 7300 Condition I)*

K_{20}: Ksat (Coefficient of Permeability) at 20 °C

Q: Steady-state rate of water flow into the soil

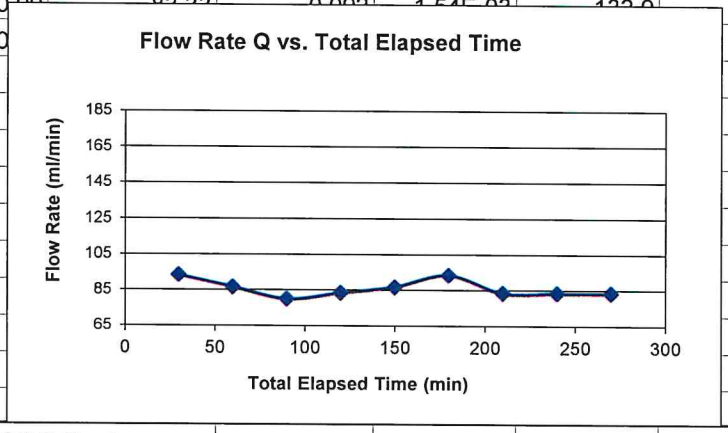
H: Constant height of water in borehole

r: Radius of cylindrical borehole

V: Viscosity of water at Temp. T °C/Viscosity of water at 20 °C

$$K_{20} = QV/(2\pi H^2)[\ln\{H/r+((H/r)^2+1)^{0.5}\}-((H/r)2+1)^{0.5}/(H/r)+1/(H/r))]$$

VOLUME (ml)	Volume Out (ml) [a]	TIME (m/d/yy h:mm:ss A/P)	Elapsed Time (hr:min:sec)	Elapsed Time (min) [b]	Flow Rate Q (ml/min) [a/b]	Ksat Equivalent Values (cm/min)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
15,000		12/23/23 2:43:00 PM								
12,200	2800	12/23/23 3:13:00 PM	0:30:00	30.00	93.33	0.103	1.72E-03	148.9	2.443	4.89
9,600	2600	12/23/23 3:43:00 PM	0:30:00	30.00	86.67	0.096	1.60E-03	138.3	2.268	4.54
7,200	2400	12/23/23 4:13:00 PM	0:30:00	30.00	80.00	0.089	1.48E-03	127.6	2.094	4.19
4,700	2500	12/23/23 4:43:00 PM	0:30:00	30.00	83.33	0.092	1.54E-03	132.9	2.181	4.36
2,100	2600	12/23/23 5:13:00 PM	0:30:00	30.00	86.67	0.096	1.60E-03	138.3	2.268	4.54
15000		12/23/23 5:16:00 PM								
12200	2800	12/23/23 5:46:00 PM	0:30:00	30.00	93.33	0.103	1.72E-03	148.9	2.443	4.89
9700	2500	12/23/23 6:16:00 PM	0:30:00	30.00	83.33	0.092	1.54E-03	132.9	2.181	4.36
7200	2500	12/23/23 6:46:00 PM	0:30:00	30.00	83.33	0.092	1.54E-03	132.9	2.181	4.36
4700	2500	12/23/23 7:16:00 PM	0:30:00	30					2.181	4.36



Natural Moisture:	moist	**Init. Satur.Time:**	8:10:00 AM	**ESTIMATED FIELD Ksat.....:**	
Texture/Classif.:	SiCl	**Consistency:**	Fr, ms mp	**Water Tmp. T °C:**	10
Structure/Fabric:	Gr, f, 1	**Water Tbl. Dpth.:**			

Notes: Estimated field Ksat is determined by averaging and/or rounding of test results for final three or four stabilized values and analyzing the graph

File: USBR-7300-Condition-I-graph *Condition I exists when the distance from the water surface in the well to the water table or an impervious layer is GREATER than 3 times the depth of the water in the well. **H/r > 10 Johnson Permeameter, LLC 4/3/2012, Rev. 7/26/13

D & K Soil Consultants, Inc.

SATURATED HYDRAULIC CONDUCTIVITY WORKSHEET

Sheet No.: 1

Project Name.:	Elizabeth Biggers, Site 2, HWY 87S	**Parcel.....:**	
Boring No.....:	K12	**Date.....:**	12/23/23
Investigators.:	David Ward/Kasey Vaughans-Ward	**File Name.....:**	
Boring Depth.:	13 inches	**WCU Base Ht. h:**	17.0 cm
Boring Dia.....:	6.4 cm	**WCU Susp. Ht. S:**	0.0 cm
Boring Rad. (r):	3.20 cm	**Const. Wtr. Ht. H:**	17.0 cm
		H/r.....:**	5.3
Dyn. Vsc. at T °C:	0.001202 kg/m.s	**Dyn. Vsc. at 20 °C:**	0.001003 kg/m.s

Terminology and Solution (USBR 7300 Condition I)*

K_{20}: Ksat (Coefficient of Permeability) at 20 °C

Q: Steady-state rate of water flow into the soil

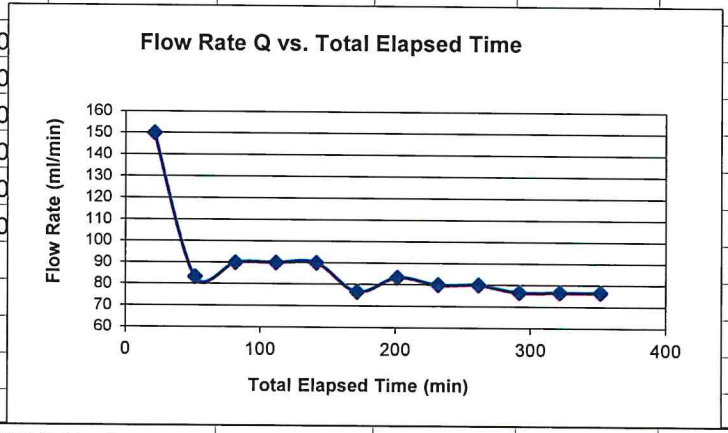
H: Constant height of water in borehole

r: Radius of cylindrical borehole

V: Viscosity of water at Temp. T °C/Viscosity of water at 20 °C

$$K_{20} = QV/(2\pi H^2)[\ln\{H/r+((H/r)^2+1)^{0.5}\}-((H/r)2+1)^{0.5}/(H/r)+1/(H/r))]$$

VOLUME (ml)	Volume Out (ml) [a]	TIME (m/d/yy h:mm:ss A/P)	Elapsed Time (hr:min:sec)	Elapsed Time (min) [b]	Flow Rate Q (ml/min) [a/b]	Ksat Equivalent Values (cm/min)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3,300		12/23/23 8:31:00 AM								
0	3300	12/23/23 8:53:00 AM	0:22:00	22.00	150.00	0.153	2.55E-03	219.9	3.607	7.21
15,100		12/23/23 8:56:00 AM								
12,600	2500	12/23/23 9:26:00 AM	0:30:00	30.00	83.33	0.085	1.41E-03	122.2	2.004	4.01
9,900	2700	12/23/23 9:56:00 AM	0:30:00	30.00	90.00	0.092	1.53E-03	131.9	2.164	4.33
7,200	2700	12/23/23 10:26:00 AM	0:30:00	30.00	90.00	0.092	1.53E-03	131.9	2.164	4.33
4500	2700	12/23/23 10:56:00 AM	0:30:00	30.00	90.00	0.092	1.53E-03	131.9	2.164	4.33
2200	2300	12/23/23 11:26:00 AM	0:30:00	30.00	76.67	0.078	1.30E-03	112.4	1.844	3.69
15000		12/23/23 11:30:00 AM								
12500	2500	12/23/23 12:00:00 PM	0:30:00	30					2.004	4.01
10100	2400	12/23/23 12:30:00 PM	0:30:00	30					1.924	3.85
7700	2400	12/23/23 1:00:00 PM	0:30:00	30					1.924	3.85
5400	2300	12/23/23 1:30:00 PM	0:30:00	30					1.844	3.69
3100	2300	12/23/23 2:00:00 PM	0:30:00	30					1.844	3.69
800	2300	12/23/23 2:30:00 PM	0:30:00	30					1.844	3.69



Natural Moisture:	very moist	**Init. Satur.Time:**	8:31:00 AM	**ESTIMATED FIELD Ksat.....:**	
Texture/Classif.:	SiCl	**Consistency:**	Fr, ms mp	**Water Tmp. T °C:**	13
Structure/Fabric:	Gr, f, 1	**Water Tbl. Dpth.:**			

Notes: Estimated field Ksat is determined by averaging and/or rounding of test results for final three or four stabilized values and analyzing the graph.

File: USBR-7300-Condition-I-graph *Condition I exists when the distance from the water surface in the well to the water table or an impervious layer is GREATER than 3 times the depth of the water in the well. **H/r > 10 Johnson Permeameter, LLC 4/3/2012, Rev. 7/26/13

D & K Soil Consultants, Inc.

SATURATED HYDRAULIC CONDUCTIVITY WORKSHEET

Sheet No.: 1

Project Name.:	Elizabeth Biggers, Site 2, HWY 87S	**Parcel.....:**	
Boring No.....:	K10	**Date.....:**	12/23/23
Investigators.:	David Ward/Kasey Vaughans-Ward	**File Name.....:**	
Boring Depth.:	14 inches	**WCU Base Ht. h:**	17.0 cm
Boring Dia.....:	6.4 cm	**WCU Susp. Ht. S:**	0.0 cm
Boring Rad. (r):	3.20 cm	**Const. Wtr. Ht. H:**	17.0 cm
		H/r.....:**	5.3
Dyn. Vsc. at T °C:	0.001386 kg/m.s	**Dyn. Vsc. at 20 °C:**	0.001003 kg/m.s

Terminology and Solution (USBR 7300 Condition I)*

K_{20}: Ksat (Coefficient of Permeability) at 20 °C

Q: Steady-state rate of water flow into the soil

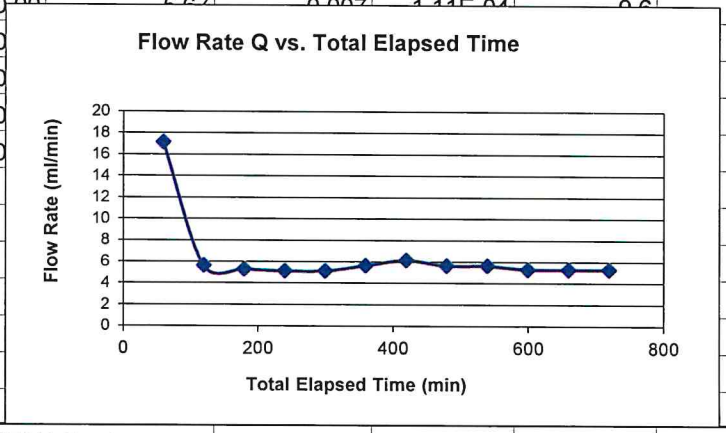
H: Constant height of water in borehole

r: Radius of cylindrical borehole

V: Viscosity of water at Temp. T °C/Viscosity of water at 20 °C

$$K_{20} = QV/(2\pi H^2)[\ln\{H/r+((H/r)^2+1)^{0.5}\}-((H/r)2+1)^{0.5}/(H/r)+1/(H/r))]$$

VOLUME (ml)	Volume Out (ml) [a]	TIME (m/d/yy h:mm:ss A/P)	Elapsed Time (hr:min:sec)	Elapsed Time (min) [b]	Flow Rate Q (ml/min) [a/b]	Ksat Equivalent Values (cm/min)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3,230		12/23/23 8:19:00 AM								
2,200	1030	12/23/23 9:19:00 AM	1:00:00	60.00	17.17	0.020	3.36E-04	29.0	0.476	0.95
1,860	340	12/23/23 10:19:00 AM	1:00:00	60.00	5.67	0.007	1.11E-04	9.6	0.157	0.31
1,540	320	12/23/23 11:19:00 AM	1:00:00	60.00	5.33	0.006	1.04E-04	9.0	0.148	0.30
1,230	310	12/23/23 12:19:00 PM	1:00:00	60.00	5.17	0.006	1.01E-04	8.7	0.143	0.29
920	310	12/23/23 1:19:00 PM	1:00:00	60.00	5.17	0.006	1.01E-04	8.7	0.143	0.29
580	340	12/23/23 2:19:00 PM	1:00:00	60.00	5.67	0.007	1.11E-04	9.6	0.157	0.31
210	370	12/23/23 3:19:00 PM	1:00:00	60.00	6.17	0.007	1.21E-04	10.4	0.171	0.34
3230		12/23/23 3:20:00 PM								
2890	340	12/23/23 4:20:00 PM	1:00:00	60.00	5.67	0.007	1.11E-04	9.6	0.157	0.31
2550	340	12/23/23 5:20:00 PM	1:00:00	60					0.157	0.31
2230	320	12/23/23 6:20:00 PM	1:00:00	60					0.148	0.30
1910	320	12/23/23 7:20:00 PM	1:00:00	60					0.148	0.30
1590	320	12/23/23 8:20:00 PM	1:00:00	60					0.148	0.30



Natural Moisture:	moist	**Init. Satur.Time:**	8:13:00 AM	**ESTIMATED FIELD Ksat.....:**	
Texture/Classif.:	SiCl	**Consistency:**	Fr, ms mp	**Water Tmp. T °C:**	8
Structure/Fabric:	Gr, f, 1	**Water Tbl. Dpth.:**			

Notes: Estimated field Ksat is determined by averaging and/or rounding of test results for final three or four stabilized values and analyzing the graph.

File: USBR-7300-Condition-I-graph *Condition I exists when the distance from the water surface in the well to the water table or an impervious layer is GREATER than 3 times the depth of the water in the well. **H/r > 10 Johnson Permeameter, LLC 4/3/2012, Rev. 7/26/13

D & K Soil Consultants, Inc.

SATURATED HYDRAULIC CONDUCTIVITY WORKSHEET

Sheet No.: 1

Project Name.:	Elizabeth Biggers, Site 2, HWY 87S	**Parcel.....:**	
Boring No.....:	K9	**Date.....:**	12/23/23
Investigators.:	David Ward/Kasey Vaughans-Ward	**File Name.....:**	
Boring Depth.:	8 inches	**WCU Base Ht. h:**	17.0 cm
Boring Dia.....:	6.4 cm	**WCU Susp. Ht. S:**	0.0 cm
Boring Rad. (r):	3.20 cm	**Const. Wtr. Ht. H:**	17.0 cm
		H/r.....:**	5.3
Dyn. Vsc. at T °C:	0.001386 kg/m.s	**Dyn. Vsc. at 20 °C:**	0.001003 kg/m.s

Terminology and Solution (USBR 7300 Condition I)*

K_{20}: Ksat (Coefficient of Permeability) at 20 °C

Q: Steady-state rate of water flow into the soil

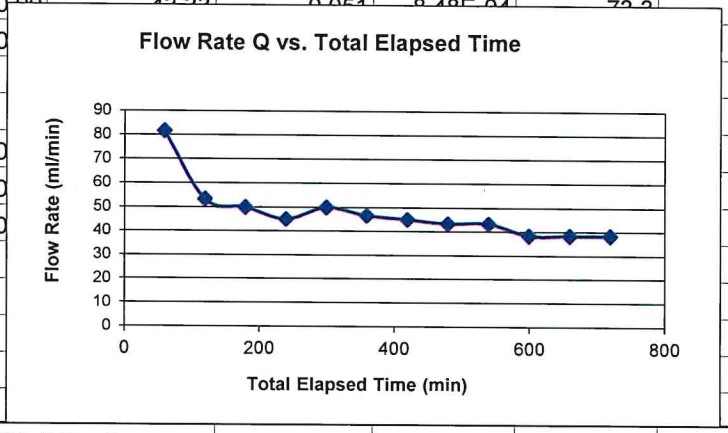
H: Constant height of water in borehole

r: Radius of cylindrical borehole

V: Viscosity of water at Temp. T °C/Viscosity of water at 20 °C

$$K_{20} = QV/(2\pi H^2)[\ln\{H/r+((H/r)^2+1)^{0.5}\}-((H/r)2+1)^{0.5}/(H/r)+1/(H/r))]$$

VOLUME (ml)	Volume Out (ml) [a]	TIME (m/d/yy h:mm:ss A/P)	Elapsed Time (hr:min:sec)	Elapsed Time (min) [b]	Flow Rate Q (ml/min) [a/b]	Ksat Equivalent Values (cm/min)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
15,000		12/23/23 8:16:00 AM								
10,100	4900	12/23/23 9:16:00 AM	1:00:00	60.00	81.67	0.096	1.60E-03	138.1	2.265	4.53
6,900	3200	12/23/23 10:16:00 AM	1:00:00	60.00	53.33	0.063	1.04E-03	90.2	1.479	2.96
3,900	3000	12/23/23 11:16:00 AM	1:00:00	60.00	50.00	0.059	9.78E-04	84.5	1.387	2.77
1,200	2700	12/23/23 12:16:00 PM	1:00:00	60.00	45.00	0.053	8.80E-04	76.1	1.248	2.50
15,000		12/23/23 12:18:00 PM								
12000	3000	12/23/23 1:18:00 PM	1:00:00	60.00	50.00	0.059	9.78E-04	84.5	1.387	2.77
9200	2800	12/23/23 2:18:00 PM	1:00:00	60.00	46.67	0.055	9.13E-04	78.9	1.294	2.59
6500	2700	12/23/23 3:18:00 PM	1:00:00	60.00	45.00	0.053	8.80E-04	76.1	1.248	2.50
3900	2600	12/23/23 4:18:00 PM	1:00:00	60.00					1.202	2.40
1300	2600	12/23/23 5:18:00 PM	1:00:00	60					1.202	2.40
15000		12/23/23 5:22:00 PM								
12700	2300	12/23/23 6:22:00 PM	1:00:00	60					1.063	2.13
10400	2300	12/23/23 7:22:00 PM	1:00:00	60					1.063	2.13
8100	2300	12/23/23 8:22:00 PM	1:00:00	60					1.063	2.13



Natural Moisture:	moist	**Init. Satur.Time:**	8:16:00 AM	**ESTIMATED FIELD Ksat.....:**	
Texture/Classif.:	SiCl	**Consistency:**	Fr, ms mp	**Water Tmp. T °C:**	8
Structure/Fabric:	Gr, f, 1	**Water Tbl. Dpth.:**			

Notes: Estimated field Ksat is determined by averaging and/or rounding of test results for final three or four stabilized values and analyzing the graph

File: USBR-7300-Condition-I-graph *Condition I exists when the distance from the water surface in the well to the water table or an impervious layer is GREATER than 3 times the depth of the water in the well. **H/r > 10 Johnson Permeameter, LLC 4/3/2012, Rev. 7/26/13

D & K Soil Consultants, Inc.

SATURATED HYDRAULIC CONDUCTIVITY WORKSHEET

Sheet No.: 1

Project Name.:	Elizabeth Biggers, Site 2, HWY 87S	**Parcel.....:**	
Boring No.....:	K8	**Date.....:**	12/23/23
Investigators.:	David Ward/Kasey Vaughans-Ward	**File Name.....:**	
Boring Depth.:	13 inches	**WCU Base Ht. h:**	17.0 cm
Boring Dia.....:	6.4 cm	**WCU Susp. Ht. S:**	0.0 cm
Boring Rad. (r):	3.20 cm	**Const. Wtr. Ht. H:**	17.0 cm
		H/r.....:**	5.3
Dyn. Vsc. at T °C:	0.001386 kg/m.s	**Dyn. Vsc. at 20 °C:**	0.001003 kg/m.s

Terminology and Solution (USBR 7300 Condition I)*

K_{20}: Ksat (Coefficient of Permeability) at 20 °C

Q: Steady-state rate of water flow into the soil

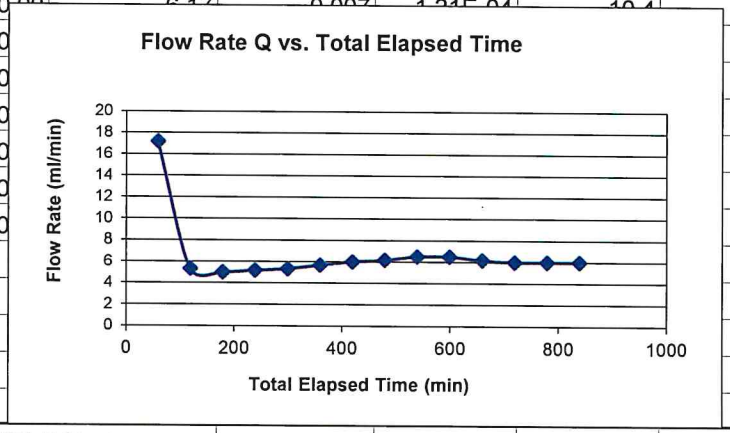
H: Constant height of water in borehole

r: Radius of cylindrical borehole

V: Viscosity of water at Temp. T °C/Viscosity of water at 20 °C

$$K_{20} = QV/(2\pi H^2)[\ln\{H/r+((H/r)^2+1)^{0.5}\}-((H/r)2+1)^{0.5}/(H/r)+1/(H/r))]$$

VOLUME (ml)	Volume Out (ml) [a]	TIME (m/d/yy h:mm:ss A/P)	Elapsed Time (hr:min:sec)	Elapsed Time (min) [b]	Flow Rate Q (ml/min) [a/b]	Ksat Equivalent Values (cm/min)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3,230		12/23/23 8:13:00 AM								
2,200	1030	12/23/23 9:13:00 AM	1:00:00	60.00	17.17	0.020	3.36E-04	29.0	0.476	0.95
1,880	320	12/23/23 10:13:00 AM	1:00:00	60.00	5.33	0.006	1.04E-04	9.0	0.148	0.30
1,580	300	12/23/23 11:13:00 AM	1:00:00	60.00	5.00	0.006	9.78E-05	8.5	0.139	0.28
1,270	310	12/23/23 12:13:00 PM	1:00:00	60.00	5.17	0.006	1.01E-04	8.7	0.143	0.29
950	320	12/23/23 1:13:00 PM	1:00:00	60.00	5.33	0.006	1.04E-04	9.0	0.148	0.30
610	340	12/23/23 2:13:00 PM	1:00:00	60.00	5.67	0.007	1.11E-04	9.6	0.157	0.31
250	360	12/23/23 3:13:00 PM	1:00:00	60.00	6.00	0.007	1.17E-04	10.1	0.166	0.33
3200		12/23/23 3:14:00 PM								
2830	370	12/23/23 4:14:00 PM	1:00:00	60.00	6.17	0.007	1.21E-04	10.4	0.171	0.34
2440	390	12/23/23 5:14:00 PM	1:00:00	60					0.180	0.36
2050	390	12/23/23 6:14:00 PM	1:00:00	60					0.180	0.36
1680	370	12/23/23 7:14:00 PM	1:00:00	60					0.171	0.34
1320	360	12/23/23 8:14:00 PM	1:00:00	60					0.166	0.33
960	360	12/23/23 9:14:00 PM	1:00:00	60					0.166	0.33
600	360	12/23/23 10:14:00 PM	1:00:00	60					0.166	0.33



Natural Moisture:	moist	**Init. Satur.Time:**	8:13:00 AM	**ESTIMATED FIELD Ksat.....:**
Texture/Classif.:	SiCl	**Consistency:**	Fr, ms mp	**Water Tmp. T °C:** 8
Structure/Fabric:	Gr, f, 1	**Water Tbl. Dpth.:**		

Notes: Estimated field Ksat is determined by averaging and/or rounding of test results for final three or four stabilized values and analyzing the graph

File: USBR-7300-Condition-I-graph *Condition I exists when the distance from the water surface in the well to the water table or an impervious layer is GREATER than 3 times the depth of the water in the well. **H/r > 10 Johnson Permeameter, LLC 4/3/2012, Rev. 7/26/13

D & K Soil Consultants, Inc.

SATURATED HYDRAULIC CONDUCTIVITY WORKSHEET

Sheet No.: 1

Project Name.:	Elizabeth Biggers, Site 2, HWY 87S	**Parcel.....:**	
Boring No.....:	K11	**Date.....:**	12/23/23
Investigators.:	David Ward/Kasey Vaughans-Ward	**File Name.....:**	
Boring Depth.:	9 inches	**WCU Base Ht. h:**	17.0 cm
Boring Dia.....:	6.4 cm	**WCU Susp. Ht. S:**	0.0 cm
Boring Rad. (r):	3.20 cm	**Const. Wtr. Ht. H:**	17.0 cm
		H/r.....:**	5.3
Dyn. Vsc. at T °C:	0.001170 kg/m.s	**Dyn. Vsc. at 20 °C:**	0.001003 kg/m.s

Terminology and Solution (USBR 7300 Condition I)*

K_{20}: Ksat (Coefficient of Permeability) at 20 °C

Q: Steady-state rate of water flow into the soil

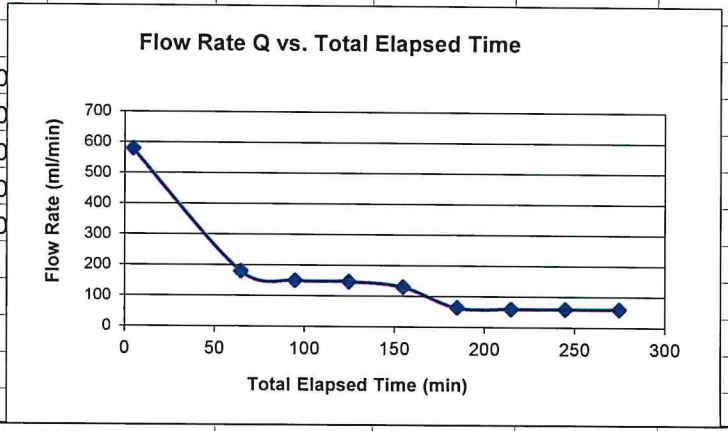
H: Constant height of water in borehole

r: Radius of cylindrical borehole

V: Viscosity of water at Temp. T °C/Viscosity of water at 20 °C

$$K_{20} = QV/(2\pi H^2)[\ln\{H/r+((H/r)^2+1)^{0.5}\}-((H/r)2+1)^{0.5}/(H/r)+1/(H/r))]$$

VOLUME (ml)	Volume Out (ml) [a]	TIME (m/d/yy h:mm:ss A/P)	Elapsed Time (hr:min:sec)	Elapsed Time (min) [b]	Flow Rate Q (ml/min) [a/b]	Ksat Equivalent Values (cm/min)	(cm/sec)	(cm/day)	(in/hr)	(ft/day)
3,250		12/28/23 8:28:00 AM								
350	2900	12/28/23 8:33:00 AM	0:05:00	5.00	580.00	0.575	9.58E-03	827.7	13.577	27.15
15,000		12/28/23 8:34:00 AM								
4,200	10800	12/28/23 9:34:00 AM	1:00:00	60.00	180.00	0.178	2.97E-03	256.9	4.214	8.43
15,000		12/28/23 9:35:00 AM								
10500	4500	12/28/23 10:05:00 AM	0:30:00	30.00	150.00	0.149	2.48E-03	214.1	3.511	7.02
6100	4400	12/28/23 10:35:00 AM	0:30:00	30.00	146.67	0.145	2.42E-03	209.3	3.433	6.87
2200	3900	12/28/23 11:05:00 AM	0:30:00	30.00	130.00	0.129	2.15E-03	185.5	3.043	6.09
15000		12/28/23 11:06:00 AM								
13100	1900	12/28/23 11:36:00 AM	0:30:00	30					1.483	2.97
11300	1800	12/28/23 12:06:00 PM	0:30:00	30					1.405	2.81
9500	1800	12/28/23 12:36:00 PM	0:30:00	30					1.405	2.81
7700	1800	12/28/23 12:36:00 PM	0:00:00	0						
5900	1800	12/28/23 1:06:00 PM	0:30:00	30					1.405	2.81



Natural Moisture:	very moist	**Init. Satur.Time:**	8:28:00 AM	**ESTIMATED FIELD Ksat.....:**	
Texture/Classif.:	SiCl	**Consistency:**	Fr, ms mp	**Water Tmp. T °C:**	14
Structure/Fabric:	Gr, f, 1	**Water Tbl. Dpth.:**			

Notes: Estimated field Ksat is determined by averaging and/or rounding of test results for final three or four stabilized values and analyzing the graph

File: USBR-7300-Condition-I-graph *Condition I exists when the distance from the water surface in the well to the water table or an impervious layer is GREATER than 3 times the depth of the water in the well. **H/r > 10 Johnson Permeameter, LLC 4/3/2012, Rev. 7/26/13