MEMORANDUM

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To: **Michael W. Strader, Jr., P.E.**
From: **Brian Rubino, P.G.**
Date: **8/21/2024**
Re: **P99006 Soil and Groundwater Investigation**
Corolla Bay Lots 61-62, Corolla North Carolina

On Monday August 19, 2024, representatives from Quible visited the Site to conduct shallow soil borings in the location of potential a future stormwater collection basin or infiltration area. The purpose of our evaluation was to understand lithologic conditions, to determine the depth and elevation of the Static Water Table (WT), Season High Water Table (SHWT), and to measure infiltration rates for Stormwater Management System design.

Soils consisted of:

- 0-12" bgs: dry, clean, fine-grained sand (10 YR 4/2)
- 12" – 30" bgs: dry, clean, fine-medium grained sand (10 YR 4/1)
- 30" – 40" bgs: saturated, fine-grained sand (10 YR 5/1)

A summary of elevation data collected and observed is as follows:

Soil Boring	Ground Elevation (ft); (NAVD 88)	Elevation of SHWT (ft); (NAVD 88)
T-1	6.0'	3.5'

Ground elevation data was collected on the date of the soil borings using an RTK GPS system. A temporary piezomter, using a two-inch .010 slot pvc well screen was installed at boring locationT-1 and was allowed to recover for a period of at least 1 hour before the depth to groundwater was measured using an electronic water level checker.

Infiltration rate field testing of the in-situ soils in three locations was conducted using the Modified Philip Dunne (MPD) method to test and calculate saturated hydraulic conductivity (Ksat) at the proposed stormwater collection and treatment location. This procedure measures the natural downward movement of water to the groundwater table which can be relied upon to design Site stormwater collection, storage and treatment systems in the area tested. The infiltration tests were done in the soil unit near the surface.

The measured infiltration rates were 12.1 in/hr. Rapid infiltration such as this is expected for clean sands with no confining units. See accompanying MPD infiltration report.

MPD INFILTROMETER
www.upstreamtechnologies.us

Infiltration Report

Quible & Associates, P.C.

T1 - Currituck County, NC

Upstream Technologies
651.237.5123

K_{sat} best-fit site average: 307 mm/hr or 12.1 in/hr

GPS Infiltration Test Site Map

Map Pin #	Test #	Test Name	Ksat (mm/hr)	Ksat (in/hr)	C (mm)	RMS Error of Regression (s)	Normalized RMS
1	1	T1	307	12.1	-293.1	0.1	0.05%

*** Site Average could not be calculated from only 1 viable test

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This report summarizes the results of a set of Modified Philip Dunne (MPD) Infiltrometer tests performed at the above referenced site. Quible & Associates, P.C. personnel performed the field tests. The software used to compute saturated hydraulic conductivity (K_{sat}) and generate this report assumes that the field personnel used infiltrometers manufactured by Upstream Technologies Inc. and followed the procedures outlined in “Manual – Modified Philip - Dunne Infiltrometer” by Ahmed, Gulliver, and Nieber.

The following paragraphs describe the individual tests, input values used in the analysis, and methods used to compute the K_{sat} value.

After individual K_{sat} values were calculated, the method used to determine the overall site K_{sat}value ($K_{best\text{-}fit}$) is described in "Effective Saturated Hydraulic Conductivity of an Infiltration-Based Stormwater Control Measure" by Weiss and Gulliver 2015, "A relationship to more consistently and accurately predict the best-fit value of saturated hydraulic conductivity used a weighted sum of 0.32 times the arithmetic mean and 0.68 times the geometric mean."

METHOD USED TO COMPUTE K_{sat}

The MPD Infiltrometer software uses the following procedure described in "The Comparison of Infiltration Devices and Modification of the Philip-Dunne Permeameter for the Assessment of Rain Gardens" by Rebecca Nestigen, University of Minnesota, November 2007.

The steps are as follows:

1. For each measurement of head, use the following equation to find the corresponding distance to the sharp wetting front.

$$[H_0 - H(t)]r_1^2 = \frac{\theta_1 - \theta_2}{3}[2[R(t)]^3 + 3[R(t)]^2 L_{max} - L_{max}^3 - 4r_0^3]$$

2. Estimate the change in head with respect to time and the change in wetting front distance with respect to time by using the backward difference for all values of R(t) equal to or greater than the distance $\sqrt{r_1^2 + L_{max}^2}$

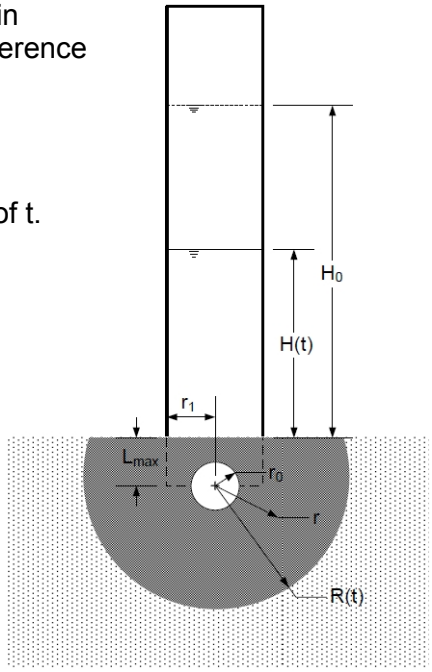
3. Make initial guesses for K and C.

4. Solve the following equations for ΔP(t) at each incremental value of t.

$$\Delta P(t) = \frac{\pi^2}{8}\left\{\theta_1 - \theta_0 \frac{[R(t)^2] + [R(t)]L_{max}}{K}\frac{dr}{dt} - 2r_0^2\right\}\frac{ln[\frac{R(t)[r_0 + L_{max}]}{r_0[R(t) + L_{max}]}]}{L_{max}}$$

$$\Delta P(t) = C - H(t) - L_{max} + \frac{L_{max}}{K}\frac{dh}{dt}$$

5. Minimize the absolute difference between the two solutions found in Step 4 by adjusting the values of K and C.



Parameters for Equations

Θ_0 = volumetric water content of soil before MPD test

Θ_1 = volumetric water content of soil after MPD test

MPD INFILTROMETER
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Infiltration Report

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T1 - Currituck County, NC

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T1

Date	8/19/2024
Time	11:40 AM
Latitude	36.352433
Longitude	-75.825584
Initial Volumetric Moisture	0.00 %
Final Volumetric Moisture	85.00 %
Cylinder Size	3 Liter

T1 Results

Map Pin #	1
Test Number	1
Ksat - mm/hr	307
Ksat - in/hr	12.1
Capillary Pressure C mm	-293.1
RMS Error of Regression	0.1
Normalized RMS	0.05%

Readings

#	Time	Head	#	Time	Head	#	Time	Head	#	Time	Head
1	0 s	36.76 cm	26	125 s	26.12 cm	51	250 s	17.58 cm	76	375 s	10.53 cm
2	5 s	36.23 cm	27	130 s	25.75 cm	52	255 s	17.28 cm	77	380 s	10.27 cm
3	10 s	35.69 cm	28	135 s	25.36 cm	53	260 s	16.98 cm	78	385 s	10.02 cm
4	15 s	35.18 cm	29	140 s	24.99 cm	54	265 s	16.67 cm	79	390 s	9.76 cm
5	20 s	34.69 cm	30	145 s	24.62 cm	55	270 s	16.38 cm	80	395 s	9.52 cm
6	25 s	34.24 cm	31	150 s	24.26 cm	56	275 s	16.08 cm	81	400 s	9.27 cm
7	30 s	33.78 cm	32	155 s	23.91 cm	57	280 s	15.78 cm	82	405 s	9.02 cm
8	35 s	33.34 cm	33	160 s	23.54 cm	58	285 s	15.47 cm	83	410 s	8.77 cm
9	40 s	32.92 cm	34	165 s	23.19 cm	59	290 s	15.18 cm	84	415 s	8.53 cm
10	45 s	32.5 cm	35	170 s	22.84 cm	60	295 s	14.88 cm	85	420 s	8.28 cm
11	50 s	32.08 cm	36	175 s	22.49 cm	61	300 s	14.6 cm	86	425 s	8.04 cm
12	55 s	31.67 cm	37	180 s	22.14 cm	62	305 s	14.32 cm	87	430 s	7.79 cm
13	60 s	31.26 cm	38	185 s	21.8 cm	63	310 s	14.04 cm	88	435 s	7.56 cm
14	65 s	30.85 cm	39	190 s	21.46 cm	64	315 s	13.77 cm	89	440 s	7.32 cm
15	70 s	30.43 cm	40	195 s	21.12 cm	65	320 s	13.48 cm	90	445 s	7.09 cm
16	75 s	30.03 cm	41	200 s	20.78 cm	66	325 s	13.2 cm	91	450 s	6.85 cm
17	80 s	29.62 cm	42	205 s	20.47 cm	67	330 s	12.94 cm	92	455 s	6.62 cm
18	85 s	29.22 cm	43	210 s	20.14 cm	68	335 s	12.66 cm	93	460 s	6.39 cm
19	90 s	28.83 cm	44	215 s	19.81 cm	69	340 s	12.38 cm	94	465 s	6.16 cm
20	95 s	28.42 cm	45	220 s	19.5 cm	70	345 s	12.12 cm	95	470 s	5.93 cm
21	100 s	28.04 cm	46	225 s	19.18 cm	71	350 s	11.85 cm	96	475 s	5.7 cm
22	105 s	27.64 cm	47	230 s	18.84 cm	72	355 s	11.58 cm	97	480 s	5.48 cm
23	110 s	27.26 cm	48	235 s	18.52 cm	73	360 s	11.31 cm	98	485 s	5.26 cm
24	115 s	26.88 cm	49	240 s	18.2 cm	74	365 s	11.05 cm			
25	120 s	26.49 cm	50	245 s	17.89 cm	75	370 s	10.78 cm			