FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

Interoffice Memorandum

SUBJECT: SCS curve numbers vs. Initial and Uniform Loss Rate, for estimation of rainfall excess.

FILE:

TO: DRJ
JJT
JMR

FROM: DJP

DATE: 7-18-88

The use of SCS Curve Numbers in calculating rainfall excess has been widely used in flood hydrology studies. This method has gained acceptance due to the wealth of documentation on curve number selection leading to easy application.

In the on going Gilbert-Chandler Flood insurance study, a concern arose over seemingly unreasonable volumes of runoff being generated from the study area. Due to the existence of C soils, curve numbers for the dominantly agricultural area exceeded those normally used for desert and urban conditions within the valley. This result caused additional research to be initiated at the District as to the appropriateness of curve number methodology, and the possibility of using an alternative method in estimating rainfall excess.

This research led to findings in part related to the Gilbert-Chandler FIS, but more directly impacting those studies where estimation of peak discharge is the primary point of the study.

Initially a review of excess methods in HEC-1 was completed. Three alternative methods were Holtans Method, the Corps Exponential loss method, and the Initial and Uniform Loss Method. Each method examined, attempts to simulate the condition of initial infiltration rates that are relatively high, followed by a decay in infiltration rate to some "constant" infiltration rate.

LOSS METHODS

Holtans Method, and the Exponential method can be considered as the same "type" of model in that both methods simulate a continuous infiltration curve. Holtans Method calculates a continuous infiltration curve, attempting to account for soil moisture allowing some recovery of infiltration rate due to deep percolation. The input for this model are somewhat obscure, especially in the soil moisture/cover relationships. For simulations that occur over several days with hyetographs with periods of low or no rainfall and several peaks this method would be worth future consideration.

The Exponential Method calculates a continuous loss rate curve based on cumulative rainfall and an exponential decay in the initial loss rate. Following this initial loss a linear decay in loss rate is simulated. The Corps has developed several curves for the Phoenix area for general use, but due to their general nature are best suited for large basin modeling.

The Initial and Uniform Loss model, like the SCS method assumes an initial loss or "initial abstraction" of rainfall prior to rainfall excess. This loss is a direct input to the method, and would appear to be reasonable whenever modeling a situation where initial rainfall intensities are low relative to initial soil infiltration rates. In either method if the rainfall intensities exceed infiltration rates during this initial period, excess will not be simulated. Following the initial loss a constant loss rate is achieved, that will limit infiltration to this maximum rate, but will not exceed rainfall intensity. Recently the SCS has published Arizona Irrigation Guide part 681 Soils, which includes tables for many soils on recommended maximum sprinkler rates. Based on discussions by John Schmeltzer with Mr. Lee Hardy of the SCS, it was determined that these rates were estimated for long term wetting, that would not exceed the infiltration capacity of the soil. In general an appropriate assumption for selection of a loss rate function in flood studies.

The SCS curve number following the filling of the initial abstraction will simulate excess based on the net difference in excess between the current and previous computation period. The formula applied in each time period for calculating excess is the standard equation; Q= (P-.2S)**2/(P+.8S). The SCS method does not relate rainfall excess to rainfall intensity. It simply calculates excess based on total rainfall at the time of computation. Therefore based on the SCS method if unit rainfall X were to occur over 1 hour or were to occur over 24 hours, the method would estimate the same rainfall excess for a given curve number. Following the initial abstraction the model simulates a decaying infiltration rate based on total rainfall.

MODEL TESTING

As a test of sensitivity a single sub-basin of the Gilbert-Chandler Study was tested using the SCS method and the Initial and Uniform method. The basin was 0.42 square miles in size with a lag time of 0.35 hours. A curve number of 84 was modeled in the SCS method, with an initial loss of 0.38 and .09 constant loss used in the Initial and Uniform method. This selection of loss rates was made so as to be within a reasonable range for the study area, the Vekol Clay falls into this category, yet simulate the same volume of runoff from each method.

The first simulation used a standard Type II distribution, 3.77 inches of rainfall. At 12 hours, the peak intensity for the storm, a rainfall intensity of 4.1 inches per hour is simulated. The curve number method simulated an infiltration capacity of 1.24 inches per hour, or nearly 14 times the estimated infiltration capacity for this soil. The estimated peak discharge was 391 CFS. The Initial and Uniform method used the estimated infiltration rate of .09 inches per hour for a peak discharge of 558 cfs or roughly a 40% increase in peak discharge.

Subsequent simulations were completed on the same data set however the Type II rainfall was modified to peak at 6 hours and 18 hours. This variation in the rainfall did not alter the basic results from the Initial and Uniform method. However for the SCS method at 6 hours the infiltration rate was estimated to be 1.5 inches per hour and peak discharge of 350 cfs, and at 18 hours the estimated infiltration was 1.04 inches/hour with peak discharge at 423 cfs.

DISCUSSION

The SCS curve number method appears to under estimate rainfall excess for periods of high rainfall intensity leading to potentially low peak discharge estimates. In regions where vegetative canopys play a significant role in intercepting and slowing the actual rainfall intensity at the soil, this observation may not be as significant. However, the intensities simulated in a flood study would very likely exceed the capacity of the vegetation to effectvely intercept rainfall regardless of location. For events of lesser intensity this shortcoming would tend to be less critical, but still inherent to the methodology. The SCS equation used in calculation of excess is based on calibration of curve numbers to daily total precipitation/excess as measured on agricultural fields. There is nothing to suggest that estimates of total excess is in serious error providing the curve number used is appropriate for the soil type and land use condition.

The Initial and Uniform Loss method does appear to satisfactorly simulate rainfall excess for the soils of this area. Due to sparce vegetation, interception of rainfall is considered non-significant. Unlike the SCS method there is no recommended method for adjusting the loss rates for a soil based on compaction and non-connected impervious areas due to urbanization. However it would seem to be reasonable to account for the non-connected impervious areas along with the directly connected impervious areas as a total percent impervious. A slight reduction in soil infiltration capacities might also be warranted specifically in the initial abstraction, due to soil compaction. An advantage of the Initial and Uniform loss method over the other methods discussed is that onsite retention can be effectively simulated in the initial loss. This is due to the fact that in this method, that once the initial loss is filled, excess is independent of this initial loss, and dependent on the constant loss rate and rainfall intensity. In the SCS method excess is dependent on the initial loss and total rainfall, but independent of intensity, thus effecting either infiltration or excess if retention is assumed in the initial abstraction.

RECOMMENDATION

I believe ample evidence exists that we should consider alternative loss rate functions for our studies. For general use the Inital and Uniform loss method would appear to be appropriate.

At this time I have not made copies of output for this memo, but will bring a sample to review when we pursue further discussion. At that time we can determine what modifications if any that we may wish to pursue.

GEORGE V. SABOL Ph.D., P.E.
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(303) 457-0989

27 August 1988

Dr. Herman Bouwer
U.S. Water Conservation Laboratory
4331 E. Broadway
Phoenix, Arizona 85040

Dear Herman:

I am working with the staff of the Flood Control District of Maricopa County in the development of a Maricopa County Hydrology Manual. The intent of the manual will be to define the criteria and recommended procedures to be used within Maricopa County for the purpose of estimating flood discharges from rainfall. We are presently evaluating alternatives for estimating rainfall losses and attempting to define the values of the loss rate parameters for whatever method is selected.

We have selected the HEC-1, Flood Hydrology Program of the Corps of Engineers, as the preferred model for several reasons including; ready availability to all users, history of acceptance within the community, user support by HEC at Davis, and technical adequacy of the program content for our purposes. Regarding the calculation of rainfall excess we have four options in HEC-1 (Which, I believe, is a considerable limitation for our use in Arizona):

1. SCS CN method,
2. Initial loss plus uniform loss rate,
3. Exponential loss rate, and
4. Holtan's equation for infiltration.

We have previously considered and evaluated the CN method but we objected to the high losses that occur during the short period of high intensity rainfall for which we should be designing in Arizona. The Holtan and Exponential methods are generally unacceptable at this time for a variety of reasons. This leaves the Inital Loss plus Uniform Loss Rate method (IL+ULR) which, in fact, has not been a default by eliminating the other alternatives, but rather is a viable method that is often successfully used for flood hydrology purposes. We are presently trying to define the criteria by which the initial loss (STRTL, according to HEC-1 nomenclature) and the uniform loss rate (CNSTL) shall be selected. We have some guidance, such as Musgrave (1955) for which CNSTL is related to the four hydrologic soil groups A, B, C and D, and the SCS Irrigation Guide for Arizona that lists estimated sprinkler intake rates for agricultural soils. The Irrigation Guide is limiting because it is only

applicable to agricultural soils and the sprinkler rate is not necessarily the CNSTL that should be used. I also would like to be a little more flexible than having to define all rainfall losses according to only four hydrologic soil groups. We also have the problem of quantifying the "mysterious" initial loss.

Previous thoughts and dabblings in this area had lead me to the Green-Ampt equation because of its appealling representation of the physical process. The recent work by Brakensiek and Rawls makes it attractive because the parameters can be related to soil texture and therefore it is very flexible and not limited to broad soil classifications. Rawls has also recently expanded his work to consider surface conditions, which makes the technique even more appealling. The drawback is that the Green-Ampt equation is presently not an option in HEC-1. However, in a conversation with Dave Woolhiser he suggested that I use the Green-Ampt equation to estimate the initial loss, and this be set equal to STRTL in the IL+ULR method. The Green-Ampt hydraulic conductivity would be set equal to CNSTL. I have tried this and the results are pleasing. a question that arose is, what should be used for the initial soil moisture content? This seems particularly important in Maricopa County where soil moisture could easily range from wilting point or less to field capacity and even near saturation for irrigated land.

I would like your opinion and suggestions concerning the initial soil moisture that should be used, and also your comments and suggestions concerning this approach. What are your thoughts in this area of rainfall losses?

I have enclosed two pages of computer output that show the calculated losses for loamy sand soil by both the Green-Ampt equation and the IL+ULR method for a synthetic, 6-hour, 100-year rainfall. I repeated this for each of the 11 soil texture classes and the results are listed in Table A.

In Table A, Column (2) is the assumed initial soil moisture content (volumetric); Column (3) is the final soil moisture content that I assumed equal to the effective porosity; Columns (4) and (5) are the capillary pressure and hydraulic conductivity, respectively. The values for Columns (3) through (5) are taken from Table 2 of Rawls, Brakensiek, and Miller (1983) and a copy is enclosed for your convenience. For the IL+ULR method the STRTL, Column (6), was calculated from the results by the Green-Ampt method and the CNSTL, Column (7), is equal to the hydraulic conductivity, Column (5). Could you follow all of that!

The results for the 11 soil classes are shown in Columns (8) through (11). As illustrated, both the rainfall excess depths and peak intensities are comparable for the two methods (How nice!). Again, a question that I need resolved is how appropriate is my assumption of

initial soil moisture content. You will notice that I have simply assumed that initial soil mosture equals one-half of final soil moisture. I believe that I should consider the wilting point for each soil class and maybe also vegetation type and land-use, such as irrigated lawns, in making this determination. I don't have the data that is necessary for this. Can you help?

I hope that you can follow this rather long letter. I will call you during the week of 29 August to talk to you about this, and I appreciate any assistance that you can offer. I am in Phoenix often and I could come to your office to talk about this.

I hope all is well with you.

Sincerely yours,

George V. Sabol

GVS/jr

Enclosures:
1. Two pages of computer output for calculation of losses by the Green-Ampt equation and IL+ULR method for loamy sand
2. Table A
3. Copy of ASCE paper by Rawls, Brakhensiek, and Miller (1983)

Copies: Joe Rumann, FCDMC w/ enclosures

Green-Ampt

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

LOAMY SAND

RAINFALL DATA FILENAME IS FCD6.DAT

INITIAL LOSS IS 0 INCHES — This is a surface infiltration loss

INITIAL SOIL MOISTURE CONTENT IS .2
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 2.41 INCHES
HYDRAULIC CONDUCTIVITY IS 1.18 INCHES PER HOUR
} parameters

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES		INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0300	0.0000		0.0300	0.0000
15 - 30	0.0300	0.0000		0.0300	0.0000
30 - 45	0.0300	0.0000		0.0300	0.0000
45 - 60	0.0300	0.0000		0.0300	0.0000
60 - 75	0.0300	0.0000		0.0300	0.0000
75 - 90	0.0300	0.0000		0.0300	0.0000
90 - 105	0.0300	0.0000		0.0300	0.0000
105 - 120	0.0400	0.0000		0.0400	0.0000
120 - 135	0.0400	0.0000		0.0400	0.0000
135 - 150	0.0400	0.0000		0.0400	0.0000
150 - 165	0.2700	0.0000		0.2700	0.0000
165 - 180	0.5600	0.1924	.60	0.3676	0.0000
180 - 195	1.4600	1.1151		0.3449	0.0000
195 - 210	0.2700	0.0000		0.2700	0.0000
210 - 225	0.0400	0.0000		0.0400	0.0000
225 - 240	0.0400	0.0000		0.0400	0.0000
240 - 255	0.0400	0.0000		0.0400	0.0000
255 - 270	0.0400	0.0000		0.0400	0.0000
270 - 285	0.0300	0.0000		0.0300	0.0000
285 - 300	0.0300	0.0000		0.0300	0.0000
300 - 315	0.0300	0.0000		0.0300	0.0000
315 - 330	0.0300	0.0000		0.0300	0.0000
330 - 345	0.0300	0.0000		0.0300	0.0000
345 - 360	0.0300	0.0000		0.0300	0.0000
	3.2300	1.3075		1.9225	0.0000

08-25-1987 10:29:09

IL+ULR

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

LOAMY SAND

RAINFALL DATA FILENAME IS FCD6.DAT

INITIAL LOSS IS .6 INCHES
UNIFORM LOSS RATE IS 1.18 INCHES PER HOUR } parameters

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0300	0.0000	0.0300
15 - 30	0.0300	0.0000	0.0300
30 - 45	0.0300	0.0000	0.0300
45 - 60	0.0300	0.0000	0.0300
60 - 75	0.0300	0.0000	0.0300
75 - 90	0.0300	0.0000	0.0300
90 - 105	0.0300	0.0000	0.0300
105 - 120	0.0400	0.0000	0.0400
120 - 135	0.0400	0.0000	0.0400
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.2700	0.0000	0.2700
165 - 180	0.5600	0.2650	0.2950
180 - 195	1.4600	1.1650	0.2950
195 - 210	0.2700	0.0000	0.2700
210 - 225	0.0400	0.0000	0.0400
225 - 240	0.0400	0.0000	0.0400
240 - 255	0.0400	0.0000	0.0400
255 - 270	0.0400	0.0000	0.0400
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0300	0.0000	0.0300
300 - 315	0.0300	0.0000	0.0300
315 - 330	0.0300	0.0000	0.0300
330 - 345	0.0300	0.0000	0.0300
345 - 360	0.0300	0.0000	0.0300
	3.2300	1.4300	1.8000

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am Dg
25 Aug 88

TABLE A

Summary of rainfall excess for the FCD, 6-hr, nested distribution according to the Green-Ampt equation and initial loss + uniform loss rate

Soil Texture Class	Green-Ampt Parameters (G-A): Volumetric Soil Moisture Initial	Volumetric Soil Moisture Final	Capillary Pressure inches	Hydraulic Conductivity in/hr	IL+ULR: Initial Loss (STRTL) inches	Loss Rate (CNSTL) in/hr	Rainfall Excess inches: G-A	Rainfall Excess inches: IL+ULR	Peak intensity (15-min. in/hr): G-A	Peak intensity (15-min. in/hr): IL+ULR
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
sand	.20	.42	1.95	4.64	1.2	4.64	.18	.26	.74	1.04
loamy sand	.20	.40	2.41	1.18	.6	1.18	1.31	1.43	4.46	4.64
sandy loam	.21	.41	4.33	.43	.5	.43	1.89	1.97	5.21	5.40
loam	.22	.43	3.50	.13	.4	.13	2.33	2.39	5.64	5.72
silt loam	.24	.49	6.57	.26	.5	.26	1.96	2.13	5.28	5.60
sandy clay loam	.16	.33	8.60	.06	.3	.06	2.50	2.71	5.72	5.80
clay loam	.16	.31	8.22	.04	.2	.04	2.67	2.85	5.76	5.80
silty clay loam	.21	.43	10.75	.04	.3	.04	2.49	2.78	5.72	5.80
sandy clay	.16	.32	9.41	.02	.2	.02	2.82	2.94	5.80	5.82
silty clay	.22	.42	11.50	.02	.2	.02	2.71	2.94	5.76	5.82
clay	.19	.38	12.45	.01	.2	.01	2.87	2.98	5.80	5.84

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29 August 1988

Mr. Joe Rumann
Hydrologist
Flood Control District of Maricopa County
3335 W. Durango Street
Phoenix, Arizona 85009

Subject: Hydrology Manual, rainfall losses

Dear Joe:

I've been looking at information and procedures that we can use to define rainfall loss parameters for the initial loss plus uniform loss rate (IL+ULR) method and I want to inform you of my findings.

Uniform Loss Rate (CNSTL)

In regard to the uniform loss rate, that I'll call CNSTL according to HEC-1 nomenclature, we have the following:

1. Musgrave (1955), according to hydrologic soil group:

A	.30-.45 inch/hour
B	.15-.30
C	.05-.15
D	0-.05

2. U.S. Bureau of Reclamation, Design of Small Dams, Second Edition, 1975, Appendix A. The flood hydrology method was based on the SCS CN methodology with an adjustment for minimum loss rate to be used along with CN:

A	.40 inch/hour
B	.24
C	.12
D	.08

3. U.S. Bureau of Reclamation, Design of Small Dams, Third Edition, 1988. The flood hydrology procedure is not as rigidly defined as in the Second Edition. Much more discretionary judgement is left to the hydrologist, and it is expected that the hydrologist is experienced and qualified to do dam flood hydrology. Therefore only very general guidance is provided. Suggested loss rates are:

A	.30-.50 inch/hour
B	.15-.30
C	.05-.15
D	0-.05

References 1 through 3 above, all provide about the same values and certainly do not contradict each other. The problem that I see is that all soils are rather broadly set into four classes.

4. SCS, Irrigation Guide for Arizona. An intake rate for sprinkler irrigation is provided for agricultural soils. This rate varies from 0.2 to 0.4 inch/hour, which would be expected for A and B soils. Although this is certainly good information I would hesitate to equate irrigation sprinkler rates with infiltration rate. This publication also leaves us without guidance for non-agricultural soils.

5. In performing the flood reconstitutions for the unit-hydrograph study I used the IL+ULR method and I have tabulated these results (Table 1). In general the value of CNSTL seems reasonable although they are inconsistant which is probably due more to the inaccuracy of the recorded data. I wouldn't want to try to develop general criteria from these values.

Initial Loss (STRTL)

Estimating the initial loss (STRTL) is even more uncertain. One method that can be used is to equate the initial abstraction (I_a) from the CN method to STRTL. This is based on virtually no theoretical or sound empirical basis. The relation $I_a = .2S$ where $S = (1000/CN) - 10$ was the result of a very gross data fitting procedure. Table 2 shows I_a for CN, and I'm surprised (maybe disappointed, knowing my predisposition against the CN method!) that I_a is a reasonable estimate for STRTL. The STRTL for the flood reconstitutions and corresponding CN for STRTL = .2S are shown in Table 1. Again, these seem very reasonable.

STRTL and CNSTL from Green-Ampt equation

This is explained in my letter to Dr. Herman Bouwer (copy enclosed). Several advantages exist in using this technique. First, we can use the Green-Ampt equation to define STRTL and CNSTL for each of the 11 soil classes which provides more flexibility than limiting the criteria to four hydrologic soil groups. Second, the Green-Ampt equation will be added as an option to HEC-1 in the near future and we would only need to update the Hydrology Manual with the appropriate Green-Ampt parameter selection guidance. When Green-Ampt comes on-line in HEC-1, the "new" method would give results that would be consistent with the "old" method. Third, the method would be theoretically sound and be representative of state-of-the-art. Fourth, depending on what information I can get from Herman Bouwer and Walter Rawls, the losses could be tailored to soils, vegetation, and land-use in Maricopa County and be representative of local conditions and

not an adoption of someone else's method and parameters. I think that the fourth advantage may be particularly important for the desert and irrigated lands that we must address.

We'll have time to talk about this when we're in Los Angeles. I'll be calling you to confirm our LA trip. There is a nice hotel a couple of blocks from the Corps office that has a reasonable price.

Sincerely yours,

George V. Sabol

GVS/jr

Enclosure:
1. Table 1 - Rainfall losses from HEC-1 optimization of flood reconstitutions for unit-hydrograph study
2. Table 2 - Estimation of initial loss according to initial abstraction by CN method
3. Letter to Dr. Herman Bouwer dated 27 August 1988.

TABLE 1

Rainfall Losses from HEC-1 optimizations

Code (1)	Initial Loss STRTL inches (2)	Loss Rate CNSTL in/hr (3)	CN for STRTL = .2S (4)	
Tucson				
THS1	.48	.57	81	
THS2	.48	.28	81	
TAR1	.91	.42	69	
TAR2	1.00	.52	67	
TAR3	.83	.44	71	
TAR4	.62	.32	76	1" antecedent rain
TRR1	.24	.05	98	.6" antecedent rain
TRR2	.52	.26	79	
TAT1	.17	.33	92	
Denver				
D1161	.61	.23	77	
DVI1	.74	.15	73	
DCD1	1.62	.46	55	
DGC1	.61	.04	77	
DSC1	.74	1.33	73	
DSC2	.95	.55	68	
Albuquerque				
AVD01	.33	.27	86	
AVD02	.56	1.32	78	
AAA1	.44	.11	82	
AAA2	.20	.35	91	
ATR1	.33	.49	86	
ALA1	.69	.47	74	
ALA2	,55	.26	78	
ALA3	,59	.49	77	
ACA1	.36	.35	85	
ACA2	.62	.15	76	
ANCA1	2.15	1.50	48	long duration rainfall
ANCA2	.36	.15	85	
Walnut Gulch				
4-1	.70	.40	74	
4-2	1.13	.76	64	
8-1	.43	.41	82	
8-2	1.29	1.21	61	
11-1	.50	.50	80	
11-2	.90	.62	69	
15-1	.57	.49	78	
103-1	.17	1.08	92	
103-2	.09	1.12	96	
111-1	.64	.33	76	
111-2	.93	.30	68	
111-3	.41	.27	83	

TABLE 1 (continued)

Rainfall Losses from HEC-1 optimizations

Code	Initial Loss STRTL inches	Loss Rate CNSTL in/hr	CN for STRTL = .2S
(1)	(2)	(3)	(4)
Wyoming			
WCU1	.62	.07	76
WCU2	.48	.12	81
WC1	.56	.13	78
WC2	.80	.12	72
WDH1	.08	.06	96
WET1	.88	.12	70
WD1	.27	.07	88
WHD1	.97	.12	67
WMB1	.65	.04	75

TABLE 2

Estimation of Initial Loss according to initial abstraction by CN method

$I_a = .2S$

$S = (1000/CN) - 10$

CN (1)	S (2)	$I_a = .2S$ (3)	CN (1)	S (2)	$I_a = .2S$ (3)
100	0.0	0.0	64	5.63	1.13
99	.1	.02	63	5.87	1.17
98	.2	.04	62	6.13	1.23
97	.31	.06	61	6.39	1.28
96	.42	.08	60	6.67	1.33
95	.53	.11	59	6.95	1.39
94	.64	.13	58	7.24	1.45
93	.75	.15	57	7.54	1.51
92	.87	.17	56	7.86	1.57
91	.99	.20	55	8.18	1.64
90	1.11	.22	54	8.52	1.70
89	1.24	.25	53	8.87	1.77
88	1.36	.27	52	9.23	1.85
87	1.49	.30	51	9.61	1.92
86	1.63	.33	50	10.00	2.00
85	1,76	.35	49	10.41	2.08
84	1.90	.38	48	10.83	2.17
83	2.05	.41	47	11.28	2.26
82	2.20	.44	46	11.74	2.35
81	2.35	.47	45	12.22	2.44
80	2.50	.50	44	12.73	2.55
79	2.66	.53	43	13.26	2.65
78	2.82	.56	42	13.81	2.76
77	2.99	.60	41	14.39	2.88
76	3.16	.63	40	15.00	3.00
75	3.33	.67			
74	3.51	.70	35	18.57	3.71
73	3.70	.74			
72	3.89	.78	30	23.33	4.67
71	4.08	.82			
70	4.29	.86	25	30.00	6.00
69	4.49	.90			
68	4.71	.94			
67	4.93	.99			
66	5.15	1.03			
65	5.38	1.08			

23 Sept 88

Summary of Loss Rate Parameter Values
(All values for bare ground. Initial abstractions other than from infiltration must be added if appropriate.)

	Green-Ampt			IL+ULR			
soil	DTHETA	PSIF in.	XKSAT in/hr	STRTL in max	STRTL in mean	STRTL in min	CNSTL in/hr
(1)	(2)	(3)	(4)	(5)			(6)
sand	.05	1.95	4.64	1.55	1.36	0	4.64
loamy sand	.08	2.41	1.18	.58	.29		1.18
sandy loam	.10	4.33	.43	.65	.32		.43
loam	.14	3.50	.26	.50	.25		.26
silty loam	.17	6.57	.13	.85	.59		.13
sandy clay loam	.10	8.60	.06	.56	.33		.06
clay loam	.15	8.22	.04	.68	.47		.04
silty clay loam	.16	10.75	.04	.61	.47		.04
sandy clay	.11	9.41	.02	.37	.18		.02
silty clay	.16	11.50	.02	.28	.12		.02
clay	.14	12.45	.01	.24	.11		.01

IL+ULR

Hydrologic Soil Group	STRTL in.		CNSTL in./hr.	CN for STRTL = .25
(1)	(2) max	mean	(3)	(4)
A	.65	.30	.40	75
B	.55	.25	.25	77
C	.50	.25	.15	80
D	.35	.20	.05	85

GEORGE V. SABOL Ph.D., P.E.
CONSULTING ENGINEER
1351 EAST 141st AVENUE
BRIGHTON, COLORADO 80601
(303) 457-0989

1 November 1988

Mr. Walter Rawls
ARS, U.S. Department of Agriculture
Agr. Res. Center - West
Bldg. 007 Rm. 137
Beltsville, MD 20705

Dear Walter:

I've enclosed copies of pages 53-62 of a 1956 storm drainage report for Phoenix and have noted the references that we talked about today. I will continue trying to locate these in Phoenix. Keep me informed of your progress in locating these potentially valuable reports.

I will send a draft of the Rainfall Losses section of the Maricopa County Hydrology Manual as soon as I get it finished (by the end of November hopefully). I need a good critical review of what I am putting together. This may be the first adoption of the Green and Ampt equation for use in such a manual and I don't want to miss anything. Your offer to provide such a review is appreciated.

Sincerely yours,

George V. Sabol

GVS/jr

Enclosure: pgs. 53-62 of Phoenix Storm Drainage Report

Copy w/o enclosure:
Mr. Joe Rumann, Flood Control District of Maricopa County
Mr. V. Ottozawa-Chatupron, Arizona Transportation Research Center

GEORGE V. SABOL Ph.D., P.E.
1351 EAST 141st AVENUE
BRIGHTON, COLORADO 80601
(303) 457-0989

27 October 1988

Mr. Robin McArthur
Soil Conservation Service
201 E. Indianola Ave.
Suite 200
Phoenix, Arizona 85012

Dear Mr. McArthur:

I spoke to you today about trying to locate two reports in your files on rainfall infiltration. I am enclosing copies of the pages from the engineering report that references these. I'm sure that we would all find the original reports to be of interest and of great value. This information could ultimately be of benefit to both the Flood Control District of Maricopa County and the Arizona Department of Transportation in the preparation of hydrology manuals for both agencies.

Keep me informed of your progress in locating these potentially valuable reports.

Sincerely yours,

George V. Sabol

GVS/jr

Enclosure: pgs. 53-62 of 1956 Phoenix Storm Drainage Report by Yost and Gardner Engineers

Copies w/enclosures: Mr. Joe Rumann, Flood Control District of Maricopa
Mr. V. Ottozawa-Chatupron, Arizona Transportation Research Center

Phone call to Walter Rawls 1 Nov 88

ground ~~&~~ cover – same as rock & litter w/ no canopy

he would review G-A as part of his ARS responsibilities

1. He will try to locate the Phoenix infiltration data by Horton & others that is referenced in the Yost & Gardner 1956 report.
I will send him a copy of what I have.

2. The infiltration adjustments (Infiltration Parameters for Rangeland Soils) can be used for grass.
Don't use canopy cover – treat grass as litter.
% coverages can be estimated from soil surveys unless better information becomes available.

3. He would review the infiltration part of the manual as part of his job. I would get that to him in December or when available.

Yost & Gardner - 2646424

Bob Stevens → called

on 1 Nov 88

[AZ Agri. Ex. Station] - 621 3859 Tucson

21 April 89

Estimates and References for Surface Retention Losses

Condition	Value	Reference
undeveloped areas of Alb. (from rainfall simulator studies)	.1-.2 inch (to ponding) ✓	1
impervious urban areas (from rainfall-runoff data for Albuquerque)	.04 ✓	2
turf	.25 mean ✓ .50 max	3
pavement	.0625 mean ✓ .125 max	3
depression storage losses for intense storms	.20 sand .15 loam ✓ .10 clay	4
impervious drainage area as a function of slope	.11 for 1% slope ✓ .06 for 2.5% slope	5

References

1. Sabol, G.V., Ward, T.J., and Seiger, A.D., 1982, Rainfall infiltration of selected soils in the Albuquerque drainage area: Report to AMAFCA and the City of Albuquerque, Civil Engineering Depart., New Mexico State University, Las Cruces.

2. Hydro Science Engineers, Inc., 1983, Analysis of the urban hydrology program and data for Academy Acres: Report to AMAFCA, Las Cruces, NM.

3. Tholin, A.L., and Kiefer, C.J., 1960, ~~The~~ Hydrology of urban runoff: Trans. ASCE, vol. 125, pp. 1308-1379.

4. Hicks, W.I., 1944, A method of computing urban runoff: Trans. ASCE, vol. 109, pp. 1217-1253.

5. Viessman, W., 1967, A linear model for synthesizing hydrographs for small drainage areas: Amer. Geophysical Union, Forty-eighth Annual Meeting, Washington, D.C.

Ref. NM Rangeland Best Management Data report (Sabol and others, 1982)

Table 4. - Rainfall and runoff statistics for the Tucumcari site.

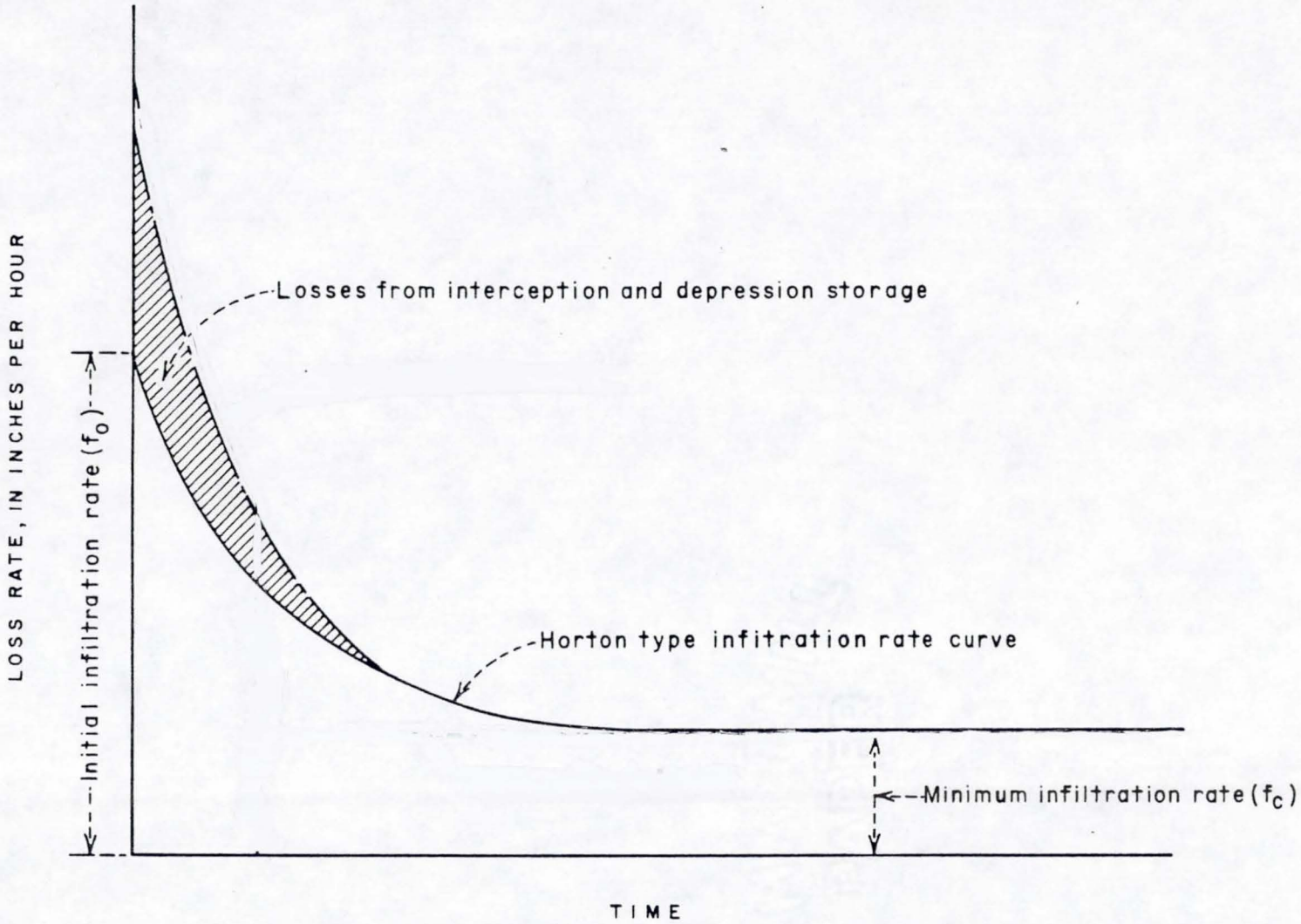
Plot ID (1)	Rain Intensity (in/hr) (2)	Time to Ponding (min) (3)	Time to Runoff (min) (4)	Rainfall Duration (min) (5)	Depth of Rainfall (in) (6)	Depth of Runoff (in) (7)	Surface retention (2)*[(4)-(3)/60]	
T-G-LC-D1	3.296	1.583	6.75	46.25	2.540	.7458		
D2	4.401	2.250	11.00	45.00	3.300	.2391		
D3	4.448	1.000	2.33	45.00	3.336	.4310		
D4	4.305	.533	5.00	45.00	3.229	1.1380		
W1	4.277	.500	4.50	30.00	2.138	.2879	.29	
W2	4.496	.600	4.17	30.00	2.248	.4007	.27	
W3	4.601	.417	2.50	30.00	2.300	.5859	.16	
W4	4.515	.367	6.00	29.375	2.210	.9495	.42	
								.29
T-BG-LC-D1	4.162	.717	8.00	45.625	3.165	1.3603		
D2	4.020	.833	5.50	44.375	2.973	1.2997		
D3	4.601	.667	5.25	46.875	3.594	1.2104		
D4	4.477	.650	2.25	44.375	3.311	.9781		
W1	4.610	.300	3.50	32.50	2.497	1.3401	.25	
W2	4.562	.333	7.00	30.00	2.281	.5892	.51	
W3	4.610	.250	1.83	30.00	2.305	1.1515	.12	
W4	4.505	.250	6.25	30.625	2.300	.9882	.45	
								.33
T-G-QH-D1	4.505	.833	4.50	45.00	3.379	.1953		
D2	3.991	1.000	4.75	45.00	2.993	.4747		
D3	4.610	1.000	9.00	45.00	3.458	.6195		
D4	4.629		15.00	44.375	3.423	.3687		
W1	4.267	.433	3.50	30.00	2.134	.3475	.22	
W2	4.591	.417	4.33	30.00	2.296	.3653	.30	
W3	4.591	.333	4.08	30.00	2.296	.5084	.29	
W4	4.543	.467	7.50	30.00	2.272	.4158	.21	
								.26
T-BG-QH-D1	4.648	1.333	18.00	45.00	3.486	.2104		
D2	4.562	1.250	4.00	45.00	3.422	.2155		
D3	4.562	1.550	9.00	45.00	3.422	.2946		
D4	4.562	.750	3.00	45.625	3.469	.4040		
W1	4.658	.917	13.00	35.00	2.717	.2492	.94	
W2	4.610	.667	13.83	35.00	2.689	.1616	1.01	
W3	4.639	.833	7.50	30.00	2.319	.4108	.52	
W4	4.648	.500	4.00	30.00	2.324	.6532	.27	
								.69
T-MG-QH-D1	4.543	4.333	12.17	45.00	3.408	.3502		
D2	4.629	3.000	11.50	45.00	3.472	.4158		
D3								
D4								
W1	4.477	4.000	9.50	30.00	2.238	.2071	.41	
W2	3.753	3.083	9.00	30.00	1.876	.3569	.37	
W3								
W4								
								.39

average = .39

Table 6. - Rainfall and runoff statistics for the Magdalena site.

Plot ID	Rainfall Intensity (in/hr)	Time to Ponding (min)	Time to Runoff (min)	Rainfall Duration (min)	Depth of Rainfall (in)	Depth of Runoff (in)		
M-HG-D1	4.591	.817	1.67	25.0	1.913	.8929		
D2	4.582	.917	2.05	25.0	1.909	.8485		
D3	4.477	.567	1.75	25.00	1.865	.7919		
D4	4.543	.800	1.97	22.50	1.742	.8889		
W1	4.496	.450	1.33	25.00	1.948	.9172	.07	
W2	4.562	.833	1.50	25.00	1.996	1.1091	.05	
W3	4.658	.417	1.25	25.00	2.038	.9212	.06	
W4	4.553	.667	1.50	25.00	1.954	1.2121	.06	
								.06
M-LG-D1	4.420	1.00	2.33	25.00	1.878	.7354		
D2	4.543	1.333	2.52	25.00	1.950	.5899		
D3	4.524	.867	3.33	25.625	1.961	.4404		
D4	4.629	1.150	3.33	25.00	1.987	.5636		
W1	4.562	.667	2.82	23.75	1.901	.8202	.16	
W2	4.629	.967	3.08	22.50	1.746	.7596	.16	
W3	4.524	.617	2.67	26.25	1.979	.4929	.15	
W4	4.601	.983	2.17	25.00	2.089	.8444	.09	
								.14
M-PJ-D1	4.143	1.233	1.67	25.00	1.726	.6545		
D2	4.582	2.333	3.42	25.625	1.957	.0808		
D3	4.448	2.000	3.50	25.00	2.002	.5414		
D4	4.601	2.167 error	3.87	17.50	1.342	.1131		
W1	4.639	2.667	2.23	25.00	1.993	.4283		
W2	4.496	1.083	1.85	25.00	1.873	.0646	.06	
W3	4.696	2.417	3.00	25.00	1.957	.5111	.05	
W4			5.33	25.00		.0444		.06

XZ+XZ


LOSS RATE, IN INCHES PER HOUR
Initial infiltration rate (f_0)
Losses from interception and depression storage
Horton type infitration rate curve
Minimum infiltration rate (f_c)
TIME

DSD (3rd Edition)

uniform loss rates pgs. 40-41

A	.3-.5
B	.15-.30
C	.05-.15
D	0-.05

DSD (2nd Edition) Appendix A

A	.40	minimum retention loss rate
B	.24	
C	.12	
D	.08	

Musgrave (1955)

A	.30 - .45
B	.15 - .30
C	.05 - .15
D	0 - .05

amDg
22 Aug 88

TABLE 1

Rainfall Losses from HEC-1 optimizations

Code	Initial Loss STRTL inches	Loss Rate CNSTL in/hr	CN for STRTL = .25	
(1)	(2)	(3)	(4)	
Tucson				
THS1	.48	.57	81	
THS2	.48	.28	81	
TAR1	.91	.42	69	
TAR2	1.00	.52	67	
TAR3	.83	.44	71	
TAR4	.62	.32	76	1" antecedent rain
TRR1	.24	.05	98	.6" antecedent rain
TRR2	.52	.26	79	
TAT1	.17	.33	92	
Denver				
DI161	.61	.23	77	
DVI1	.74	.15	73	
DCD1	1.62	.46	55	
DGC1	.61	.04	77	
DSC1	.74	1.33	73	
DSC2	.95	.55	68	
Albuquerque				
AVDØ1	.33	.27	86	
AVDØ2	.56	1.32	78	
AAA1	.44	.11	82	
AAA2	.20	.35	91	
ATR1	.33	.49	86	
ALA1	.69	.47	74	
ALA2	.55	.26	78	
ALA3	.59	.49	77	
ACA1	.36	.35	85	
ACA2	.62	.15	76	
ANCA1	2.15	1.50	48	long duration rainfall
ANCA2	.36	.15	85	
Walnut Gulch				
4-1	.70	.40	74	
4-2	1.13	.76	64	
8-1	.43	.41	82	
8-2	1.29	1.21	61	
11-1	.50	.50	80	
11-2	.90	.62	69	
15-1	.57	.49	78	
103-1	.17	1.08	92	
103-2	.09	1.12	96	
111-1	.64	.33	76	
111-2	.93	.30	68	
111-3	.41	.27	83	
Wyoming				
WCU1	.62	.07	76	
WCU2	.48	.12	81	
WC1	.56	.13	78	
WC2	.80	.12	72	
WDH1	.08	.06	96	
WET1	.88	.12	70	
WD1	.27	.07	88	
WHD1	.97	.12	67	
WMB1	.65	.04	75	

TABLE 2

amDg
22 Aug 88

Estimation of Initial Loss according to initial abstraction by CN method

$$I_a = .2S$$

$$S = \frac{1000}{CN} - 10$$

CN (1)	S (2)	$I_a = .2S$ (3)	CN (1)	S (2)	$I_a = .2S$
100	0.0	0.0	64	5.63	1.13
99	.1	.02	63	5.87	1.17
98	.2	.04	62	6.13	1.23
97	.31	.06	61	6.39	1.28
96	.42	.08	60	6.67	1.33
95	.53	.11	59	6.95	1.39
94	.64	.13	58	7.24	1.45
93	.75	.15	57	7.54	1.51
92	.87	.17	56	7.86	1.57
91	.99	.20	55	8.18	1.64
90	1.11	.22	54	8.52	1.70
89	1.24	.25	53	8.87	1.77
88	1.36	.27	52	9.23	1.85
87	1.49	.30	51	9.61	1.92
86	1.63	.33	50	10.00	2.00
85	1.76	.35	49	10.41	2.08
84	1.90	.38	48	10.83	2.17
83	2.05	.41	47	11.28	2.26
82	2.20	.44	46	11.74	2.35
81	2.35	.47	45	12.22	2.44
80	2.50	.50	44	12.73	2.55
79	2.66	.53	43	13.26	2.65
78	2.82	.56	42	13.81	2.76
77	2.99	.60	41	14.39	2.88
76	3.16	.63	40	15.00	3.00
75	3.33	.67			
74	3.51	.70	35	18.57	3.71
73	3.70	.74			
72	3.89	.78	30	23.33	4.67
71	4.08	.82			
70	4.29	.86	25	30.00	6.00
69	4.49	.90			
68	4.71	.94			
67	4.93	.99			
66	5.15	1.03			
65	5.38	1.08			

green - map 2

Please note:

Copyright pages were not scanned

zmDg
23 Aug 88

Green-Ampt parameters from (Rawls, Brakensiek & Miller, 1983)

Soil Texture class	Total Porosity ϕ	Effective Porosity ϕ_e	Capillary Pressure inches	Hydraulic Conductivity in/hr	W_s ① Gravimetric Soil Moisture at effective saturation, ϕ_e	ϕ_i ② Initial Volumetric Soil Moisture @ $.5W_s$	@ $.75W_s$	$.25W_s$
(1)	(2)	(3)	(4)	(5)	(6)			
sand	.44	.42	1.95	4.64	.12	.20	.30	.10
loamy sand	.44	.40	2.41	1.18	.12	.20	.30	.10
sandy loam	.45	.41	4.33	.43	.13	.21	.32	.10
loam	.46	.43	3.50	.13	.14	.22	.33	.11
silt loam	.50	.49	6.57	.26	.18	.24	.36	.12
sandy clay loam	.40	.33	8.60	.06	.08	.16	.24	.08
clay loam	.46	.31	8.22	.04	.10	.16	.23	.08
silty clay loam	.47	.43	10.75	.04	.14	.21	.31	.10
sandy clay	.43	.32	9.41	.02	.09	.16	.24	.08
silty clay	.48	.42	11.50	.02	.15	.22	.32	.11
clay	.48	.38	12.45	.01	.13	.19	.28	.10

① $W_s = \frac{S * e}{G_s}$, $S = \phi_e$, $e = \frac{\phi}{1-\phi}$, $G_s = 2.65$ $\therefore W_s = \frac{\phi_e * \frac{\phi}{1-\phi}}{2.65}$

② $\phi_i = \frac{W * G_s}{e} = \frac{W * 2.65 * (1-\phi)}{\phi}$

am Dg
25 Aug 88

TABLE A

Summary of rainfall excess for the FCD, 6-hr, nested distribution according to the Green-Ampt equation and initial loss + uniform loss rate

Soil Texture Class	Green-Ampt Parameters (G-A)				IL+ULR			Rainfall Excess inches		Peak intensity (15-min) in/hr	
	Volumetric Soil Moisture		Capillary Pressure inches	Hydraulic Conductivity in/hr	Initial Loss (STRTL) inches		Loss Rate (CNSTL) in/hr				
	Initial	Final						G-A	IL+ULR	G-A	IL+ULR
(1)	(2)	(3)	(4)	(5)	(6)		(7)	(8)	(9)	(10)	(11)
sand	.20	.42	1.95	4.64	1.2	2.4	4.64	.18	.26	.74	1.04
loamy sand	.20	.40	2.41	1.18	.6	1.0	1.18	1.31	1.43	4.46	4.64
sandy loam	.21	.41	4.33	.43	.5	.5	.43	1.89	1.97	5.21	5.40
loam	.22	.43	3.50	.13	.4	.4	.13	2.33	2.39	5.64	5.72
silt loam	.24	.49	6.57	.26	.5	.5	.26	1.96	2.13	5.28	5.60
sandy clay loam	.16	.33	8.60	.06	.3	.4	.06	2.50	2.71	5.72	5.80
clay loam	.16	.31	8.22	.04	.2	.4	.04	2.67	2.85	5.76	5.80
silty clay loam	.21	.43	10.75	.04	.3	.4	.04	2.49	2.78	5.72	5.80
sandy clay	.16	.32	9.41	.02	.2	.2	.02	2.82	2.94	5.80	5.82
silty clay	.22	.42	11.50	.02	.2	.2	.02	2.71	2.94	5.76	5.82
clay	.19	.38	12.45	.01	.2	.2	.01	2.87	2.98	5.80	5.84

$$S = \frac{W * G_s}{e}$$

W - grav.

S - vol.

$G_s = 2.65$

$$W = \frac{S \frac{n}{1-n}}{G}$$

$$e = \frac{n}{1-n}$$

$S = 30$
$W = 11$

$W_{min} = .07$

$W_{max} = 1.0$

$$M_v = \frac{M_g * G_s}{\frac{n}{1-n}}$$

$$S = \frac{W * 2.65}{e = \frac{n}{1-n}}$$

.79

.24

W	S
.07	.24
.10	.34
.13	.42

$\frac{2.2}{.33}$

$$W = \frac{S * e}{G_s}$$

$S = \phi e$

$e = \frac{\phi}{1-\phi}$

6" rim

74.95

136.75 life-time

Dave Woolhiser 18 Aug 88

(1/2)

hydraulic conductivity
range - take published & divide by 2 (Bouwer)
for non-saturated

use infiltration rate

---

initial Abst.
G-A init. abs = total volume inf. until
f

PhD. Freeman Smith - Watershed Management
Holtan → opt. to initial + uniform
for sandy soil

SCS CN → infiltration parameter
"Jim Verden" Morel-Seytoux

Walter Rawls 18 Aug 88

effect. conductivity for infilt. } print
[surface conditions]

TR-55 new CN's

Lane ~~on~~ on loss rates

2 Sept. 88

Phone call to Herman:

½ available water used → reirrigate

% moisture removed	root zone soil depth
40	25%
30	
20	
10	

He does not have any reference on initial soil moistures.

The standard irrigation practice is to irrigate when ½ available water has been used.

↳ = field capacity − wilting point

The soil moisture profile is something like:

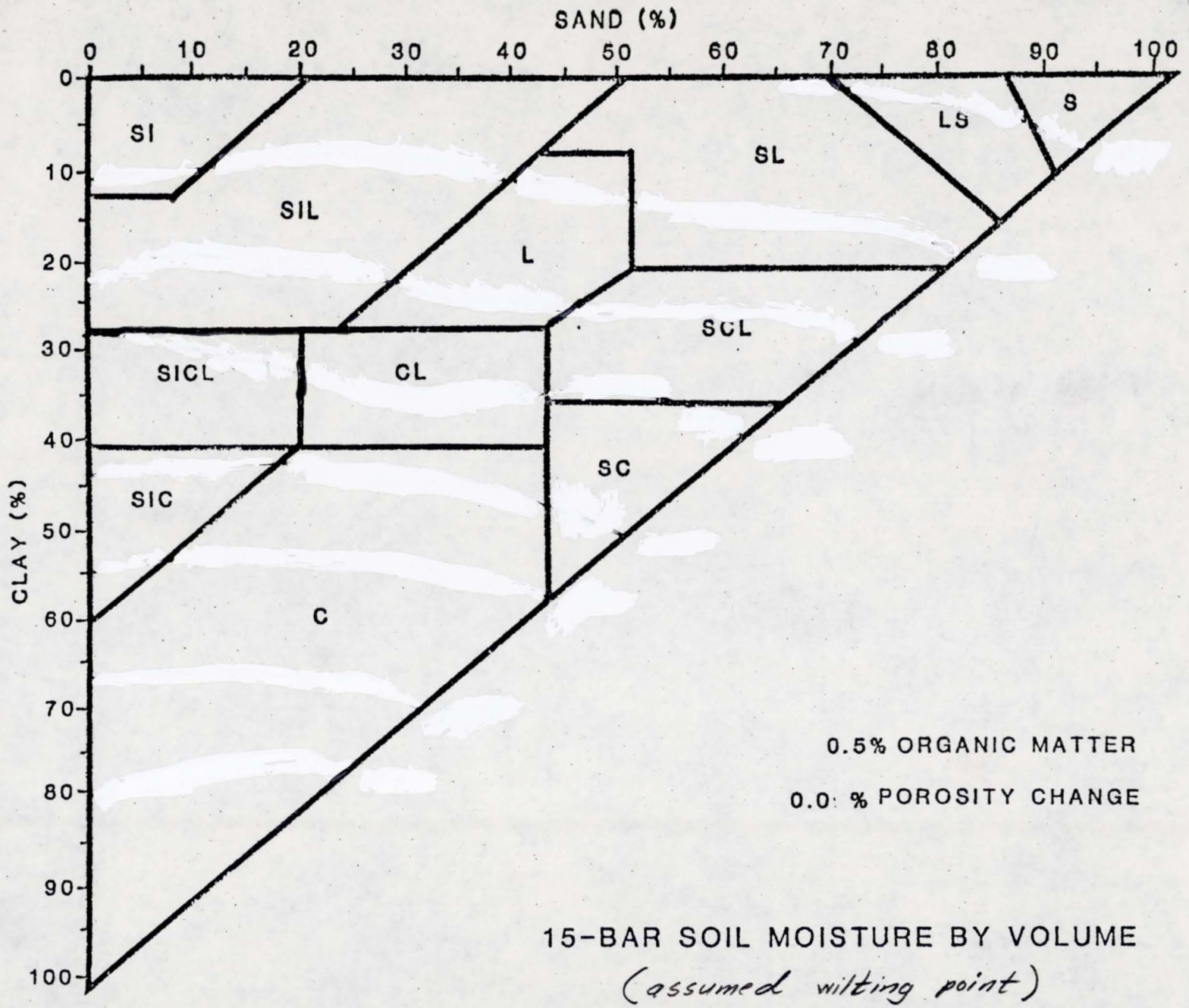
Root zone depth, in %	Soil Moisture Removed, in %
0 - 25	40
25 - 50	30
50 - 75	20
75 - 100	10

He recommended that I talk to Ken Rennard.

23 Sept 88

Estimates of Initial Loss from Green-Ampt method

Soil	Initial Loss, in inches: from 6-hr nested dist.	Initial Loss, in inches: from 5 in/hr uniform dist.	Uniform Loss Rate inches/hour	Hydro. Soil Group
sand	2.41	1.55	4.64	A
loamy sand	.99	.58	1.18	A
sandy loam	.52	.65	.43	A
loam	.43	.50	.13	C
silt loam	.54	.85	.26	B
sandy clay loam	.40	.32	.06	D
clay loam	.40	.45	.04	D
silty clay loam	.41	.37	.04	D
sandy clay	.19	.37	.02	D
silty clay	.15	.28	.02	D
clay	.15	.24	.01	D

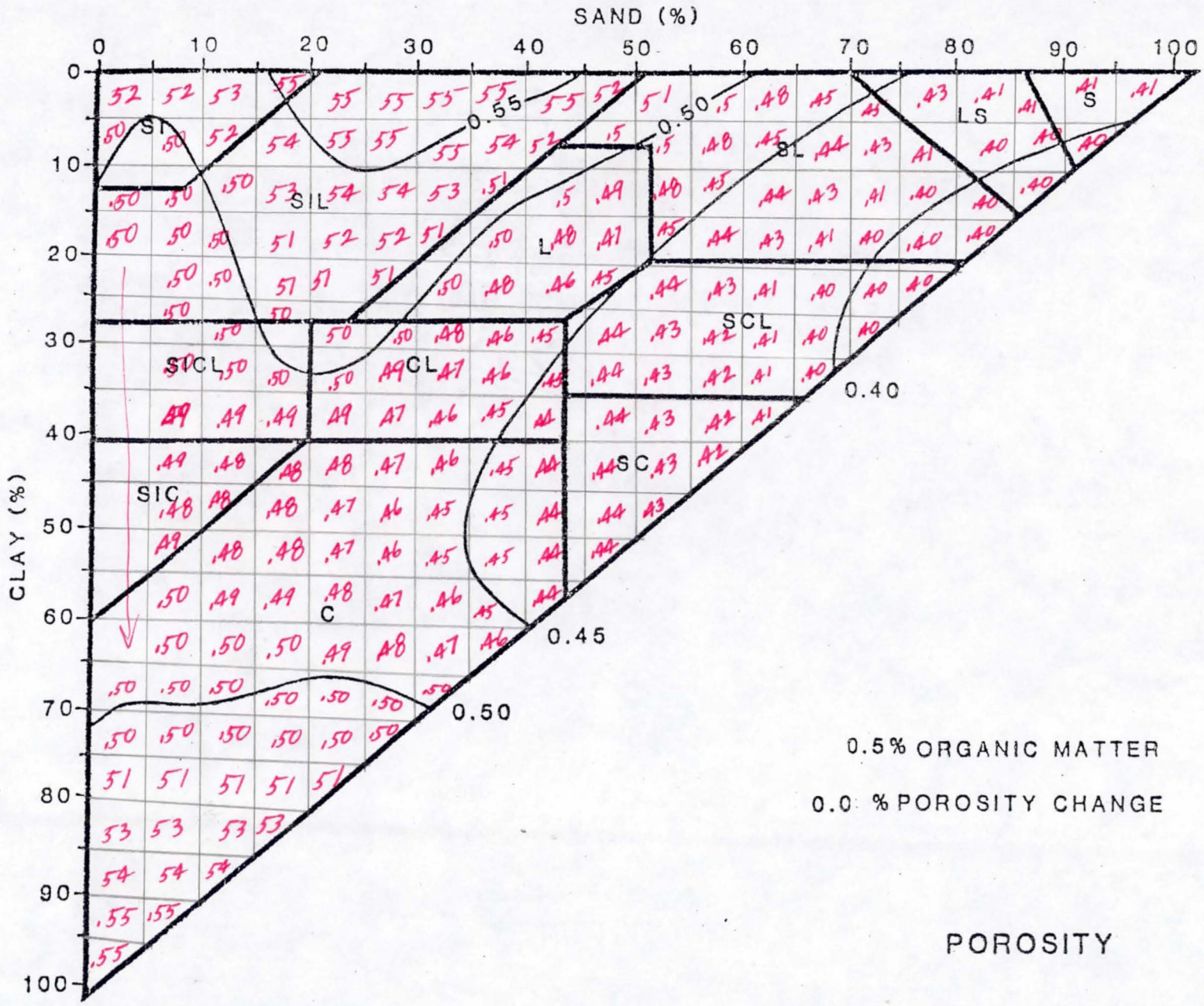


0.5% ORGANIC MATTER

0.0 % POROSITY CHANGE

15-BAR SOIL MOISTURE BY VOLUME

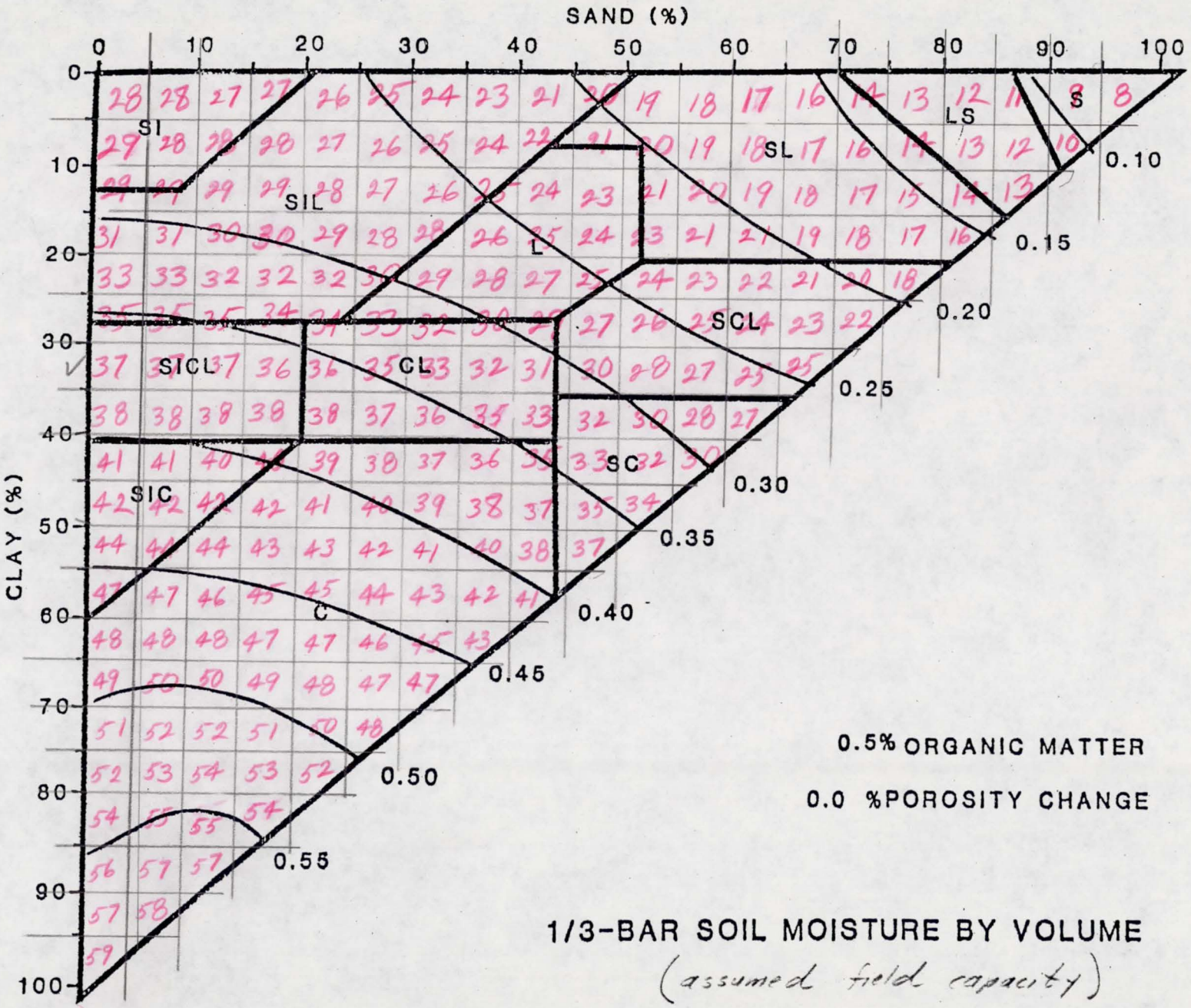
(assumed wilting point)



0.5% ORGANIC MATTER

0.0 % POROSITY CHANGE

POROSITY

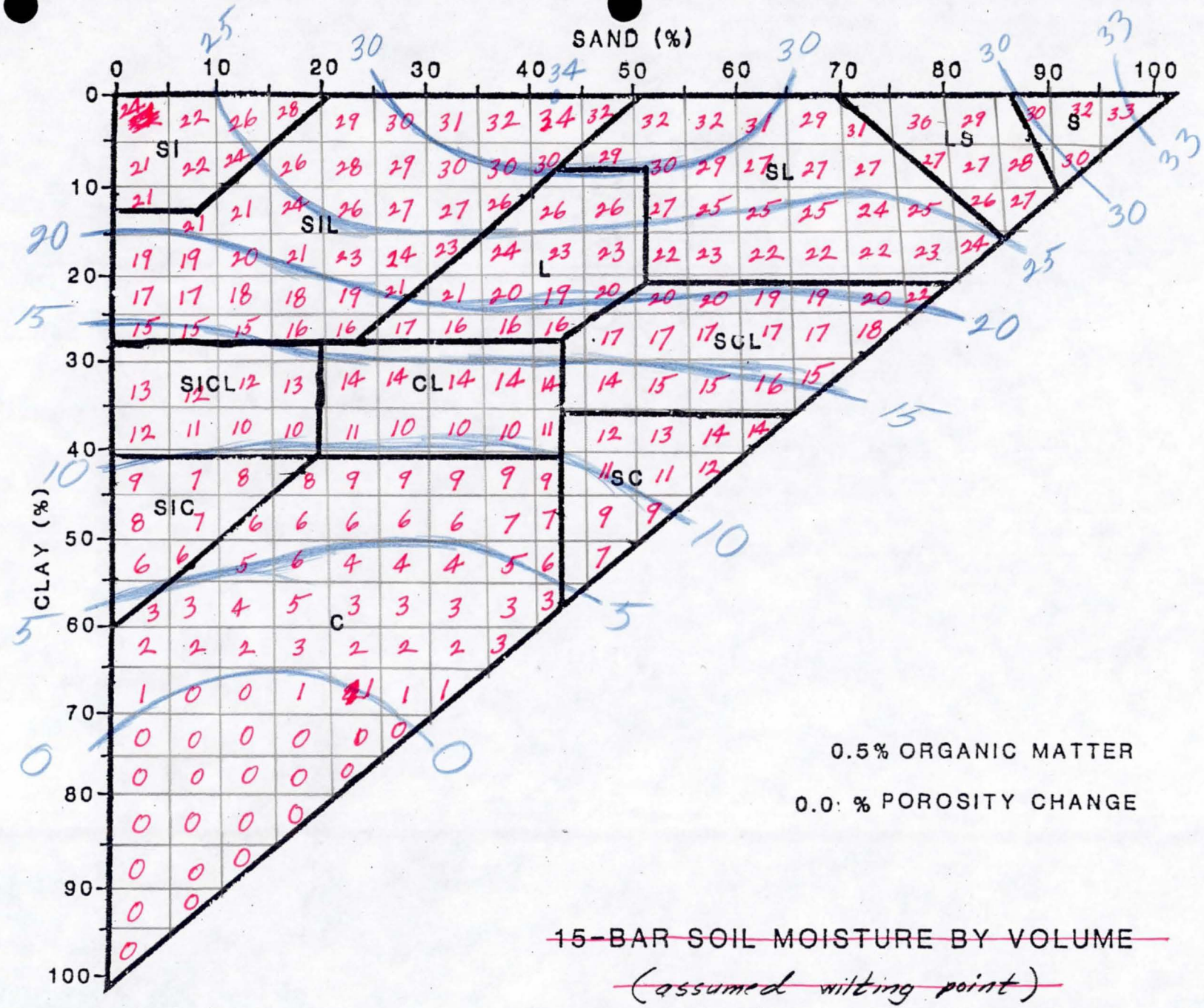


0.5% ORGANIC MATTER

0.0 %POROSITY CHANGE

1/3-BAR SOIL MOISTURE BY VOLUME

(assumed field capacity)



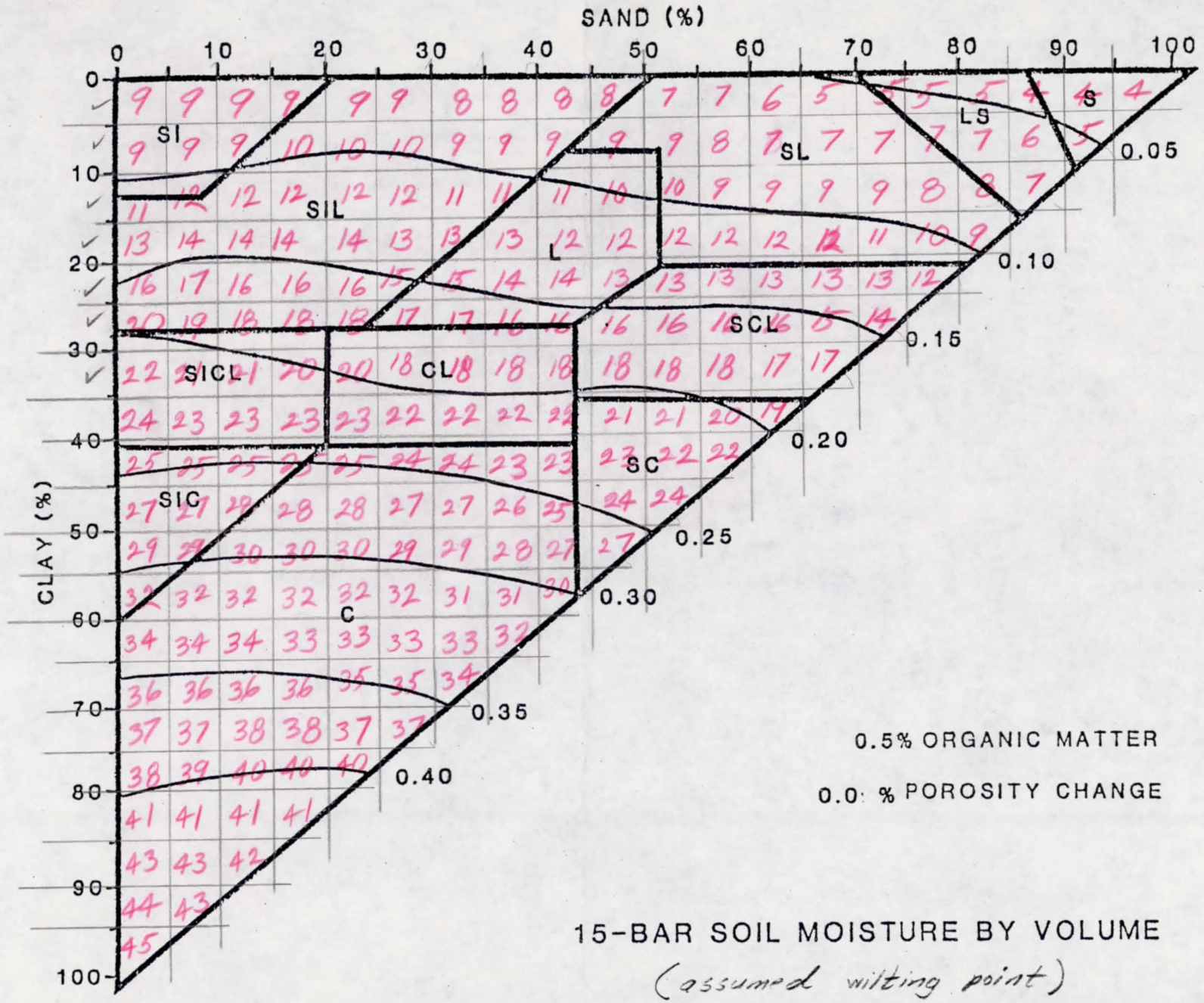
0.5% ORGANIC MATTER

0.0: % POROSITY CHANGE

~~15-BAR SOIL MOISTURE BY VOLUME~~

~~(assumed wilting point)~~

DTHETA for difference between Porosity (saturation) and field capacity



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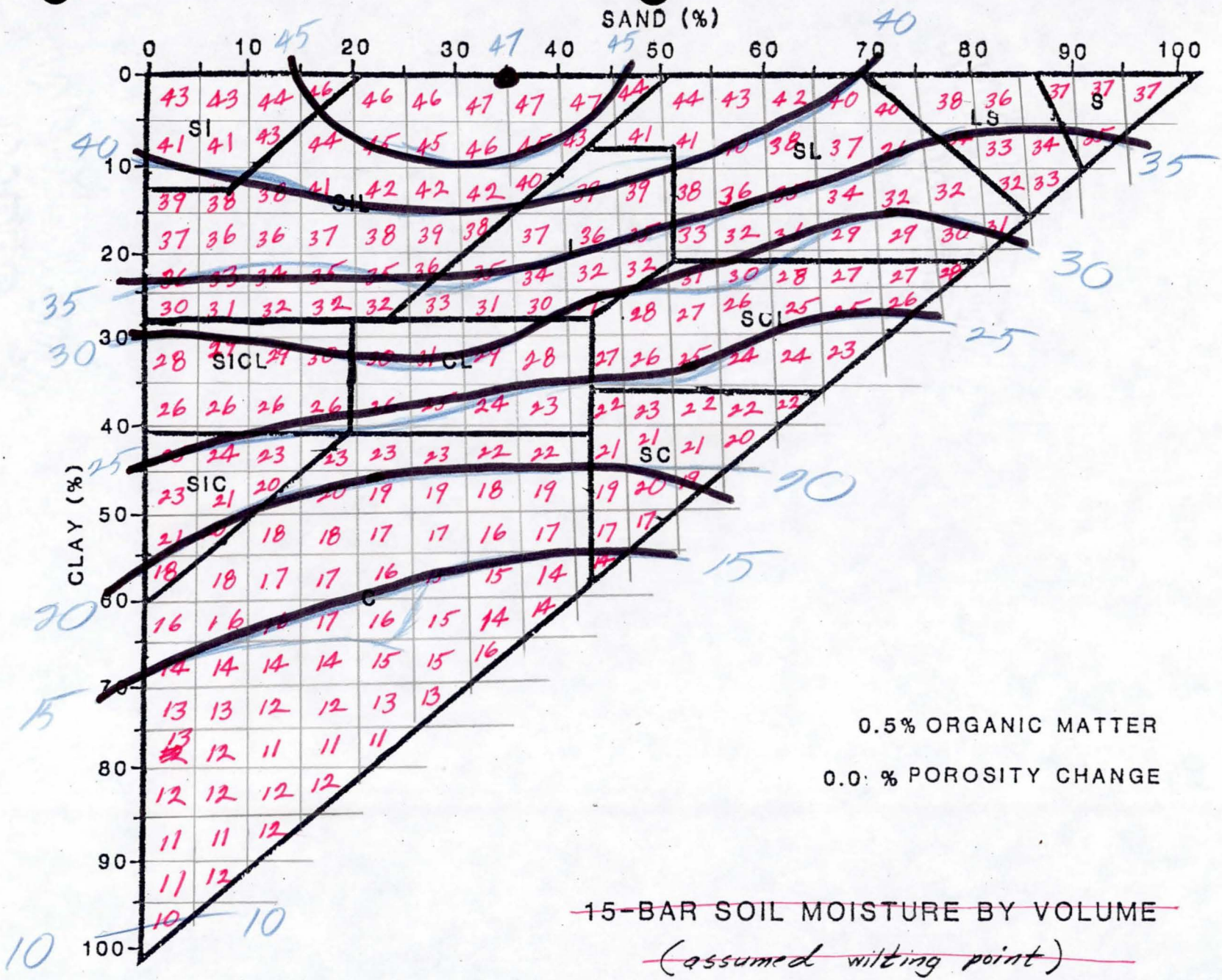
0.0 % POROSITY CHANGE

15-BAR SOIL MOISTURE BY VOLUME

(assumed wilting point)



0.5% ORGANIC MATTER

0.0 % POROSITY CHANGE

~~15-BAR SOIL MOISTURE BY VOLUME~~

~~(assumed wilting point)~~

DTHETA for difference between Porosity (saturation) and wilting point

Gunnery & Ground Guns

28 April 89

Applicability of the hydraulic conductivity equation to incorporate canopy cover & ground cover effects

Reference - "Infiltration parameters for rangeland soils"
Rawls, Brakensiek, Savabi 1989
Journal of Range Management V. 42 No. 2 p. 139-142

Equations 8, 9, and 10 are very sensitive to the value of A.

$$A = \exp(2.82 - .099\,SA + 1.94\,BD) \qquad (Eq.\ 13)$$

SA = % sand
BD = bulk density, g/cm^3

And, therefore this is mainly a function of SA; BD being nearly constant for all soil types.

Eq'n. 13 was developed by regression of data for the following:

	SA, %	BD, g/cm^3	Canopy Cover, %	Ground Cover, %
Hutton (1984)	25-68	.9-1.3	0-65	50-100
Devaurs (1984)	38-59	1.1-1.5	30-52	69-93
Thurow (1985)	27-88	.85-.95	27-57	57-79

Rawls, Brakensiek and Savabi state beneath Eq. 13 that:
1. A was constrained to be > 1.0
2. Eq. 13 will produce extremely high A values for SA < 20%
3. limit the use of Eq. 13 to a maximum A of 18

Table 1A shows the assumed soil properties and values of A, B, and CRC. Notice that:
1. A < 1.0 for sand, loamy sand, and sandy loam
2. A > 18 for silt loam, silty clay loam, silty clay, and clay

A program was written (XKE.BAS) to perform the hyd. conductivity calculation. A copy of this program and results for sandy loam are enclosed. The results are reasonable for this soil, which is predominant in much of Maricopa County.

I wanted to compare the results that would be obtained for various soils. To do this I divided Eq. 10 by the bare soil hydraulic conductivity (XKSAT)

$$RKE = \frac{KE}{XKSAT} = \frac{CAN * KE_c + OP * KE_o}{XKSAT}$$

where RKE is the ratio of the hydraulic conductivity with canopy and ground cover influences to the bare ground hydraulic conductivity. A program was written (RKE.BAS) to perform the calculation. A copy of the program and results are enclosed. Some results are unbelievable (for soils with low SA).

I then plotted the results from RKE.BAS for several soils (enclosed). The results for ~~loam~~ sand and ~~sandy loam~~ loamy sand don't look reasonable; notice that A < 1.0 for these.

The results for sandy loam look reasonable, but A = .811 The results for sandy clay loam also look reasonable (A = 1.61). The results for loam (A = 3.94) and sandy clay (A = 2.65) seem to over compensate for canopy and ground cover.

Finally, I modified the program to set A = 1.0 and the results are shown for sandy loam. Computer output are provided for sandy loam (XKSAT = .40 in/hr), loam (XKSAT = .25 in/hr), and sandy clay loam (XKSAT = .06 in/hr). As seen from the computer output, the graphs from these three soils would all look very much like Figure 7A.

Conclusions

Based on the results that are shown it appears that:

1. The procedure as provided by Rawls, Brakensiek, and Savabi should not be used for many of the soil texture classifications.

2. There is extremely high sensitivity to the value of A.

3. When A=1.0 is used, the ratio of hydraulic conductivities (RKE) converges to a single set of curves (Figure 7A) for sandy loam, loam, and sandy clay loam.

4. The soils for which it was shown that RKE converges have hydraulic conductivities from .06 to .40 in/hr. This is the range of hydraulic conductivities that is normally encountered.

5. Figure 7A demonstrates a range of RKE that compares with the results that Tim Ward is reporting for rainfall simulator studies.

6. Figure 7A is much easier to use than the equations in Rawls, Brakensiek, and Savabi.

7. It is possible that Figure 7A is applicable for most soils.

8. It is possible that A=1.0 for most soils and that A=1.0 should be used rather than Eq. 13.

Question

Can Figure 7A be used for most soils (exclusive of sand, silt, and clay texture classes - all of which are uncommon in nature, and for which there may not be a need to correct the bare soil hydraulic conductivity)?

TABLE 1A

Soil Texture	Bare Soil hyd. conductivity XKSAT in/hr	Sand Content SA %	Bulk Density BD gm/cm³	Soil Crusting Factor SC	A[1]	B[2]	CRC[3]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
sand	4.6	90	1.55	.91	.046	.175	.674
loamy sand	1.2	80	1.55	.89	.123	.147	.626
sandy loam	.40	60	1.5	.86	.811	.102	.530
loam	.25	45	1.55	.82	3.94	.076	.452
silt loam	.15	20	1.25	.81	26.2 *	.051	.362
silt		5	1.40				
sandy clay loam	.06	55	1.60	.85	1.61	.092	.505
clay loam	.04	35	1.45	.82	8.74	.064	.412
silty clay loam	.04	10	1.4	.76	94.2 *	.047	.335
sandy clay	.02	50	1.6	.81	2.65	.084	.471
silty clay	.02	5	1.45	.73	170.4 *	.046	.326
clay	.02	20	1.4	.75	35.0 *	.051	.350

* A > 18 which exceeds the maximum value of A in the data set

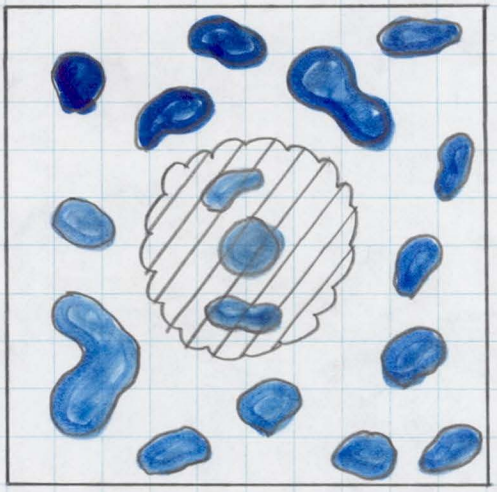
1) $A = \exp\left[2.82 - .099(SA) + 1.94(BD)\right]$

2) $B = .0099 + .0721(TC) + .0000068(SA^2) + .00002(SA^2)(TC) - .000315(SA)(TC^2)$

3) $CRC = \dfrac{L}{\dfrac{L-TC}{SC} + \dfrac{TC}{B}}$

Note: $L = 6$ cm $\quad TC = .5$ cm

Definition sketch of canopy cover and ground cover variables (Rawls, Brakensiek & Savabi, 1989)



canopy is crosshatched

ground cover* is solid

bare ground is unmarked

*ground cover is: rock, litter, and vegetation basal area

Canopy cover - CAN as % of total area

Not under canopy - OP = 100 - CAN

Ground cover = GC is % of total area covered by ground cover

BC = % of bare soil under canopy to total area

$$BC = (100 - GC)(CAN/100)$$

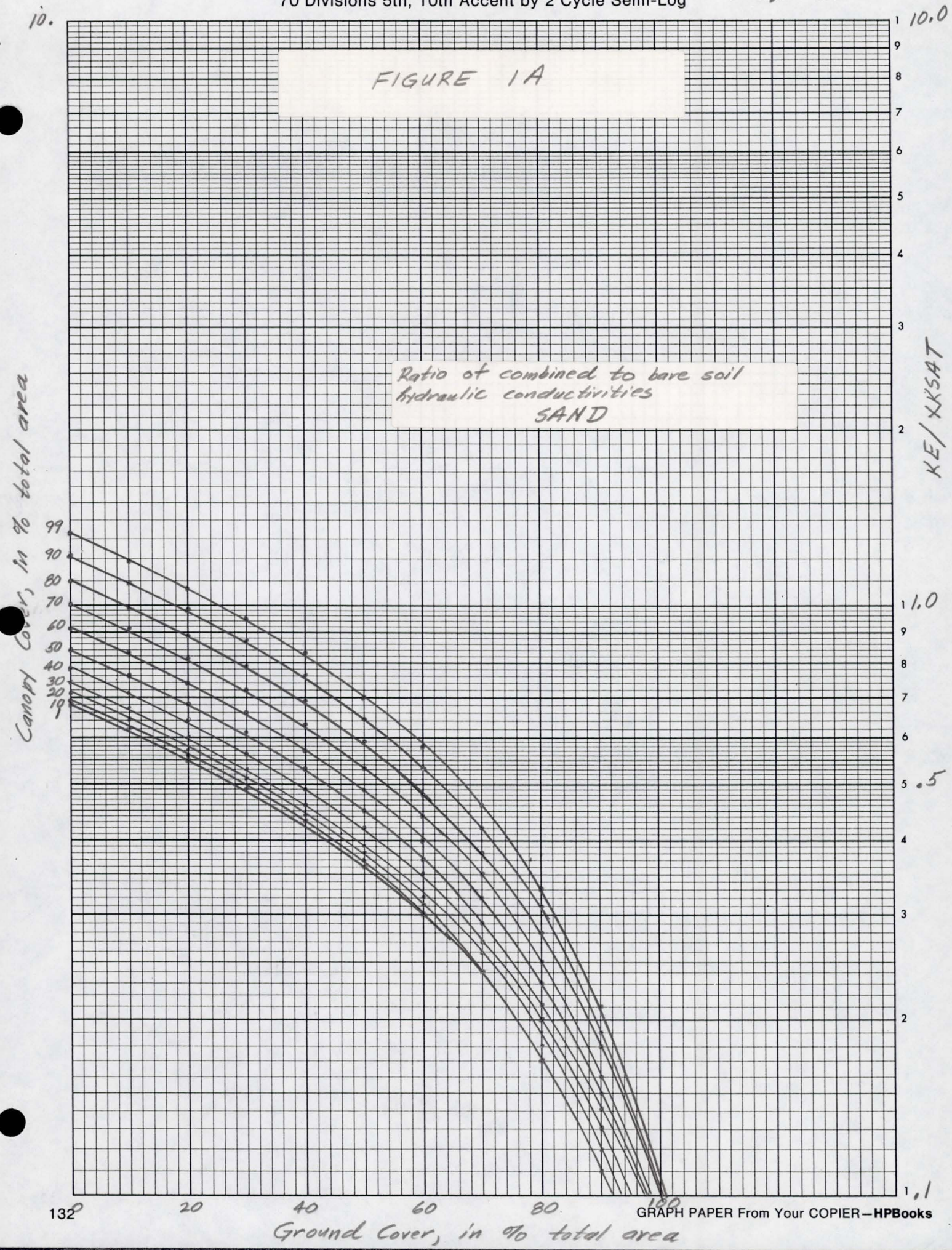
BO = % of bare soil not under canopy to total area

$$BO = (100 - GC)(OP/100)$$

Example: canopy cover = 15 %
ground cover = 20 %

CAN = 15 %
OP = 85 %
BC = (100 − 20)(15/100) = 12 %
BO = (100 − 20)(85/100) = 68 %
80 %

27 April 89



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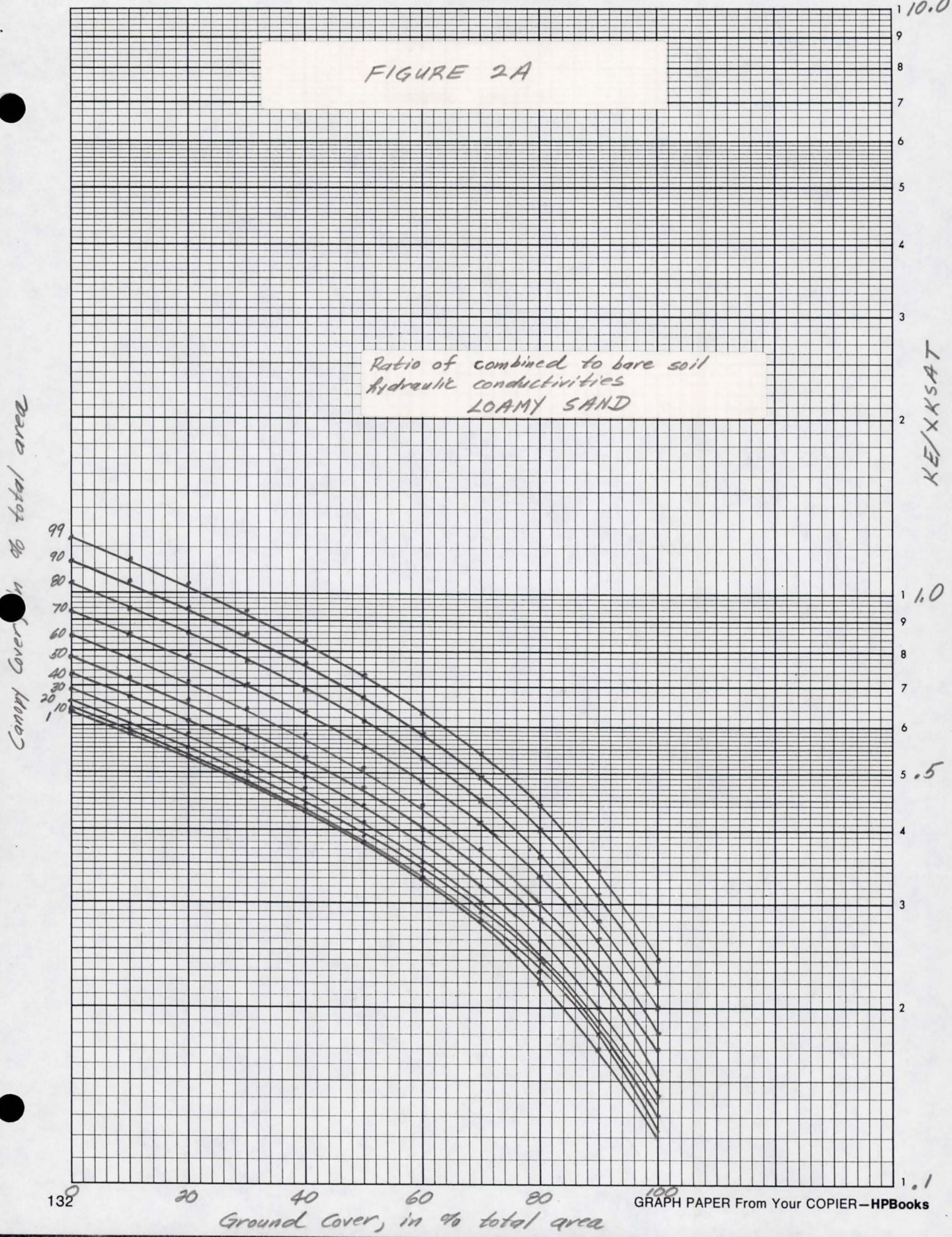

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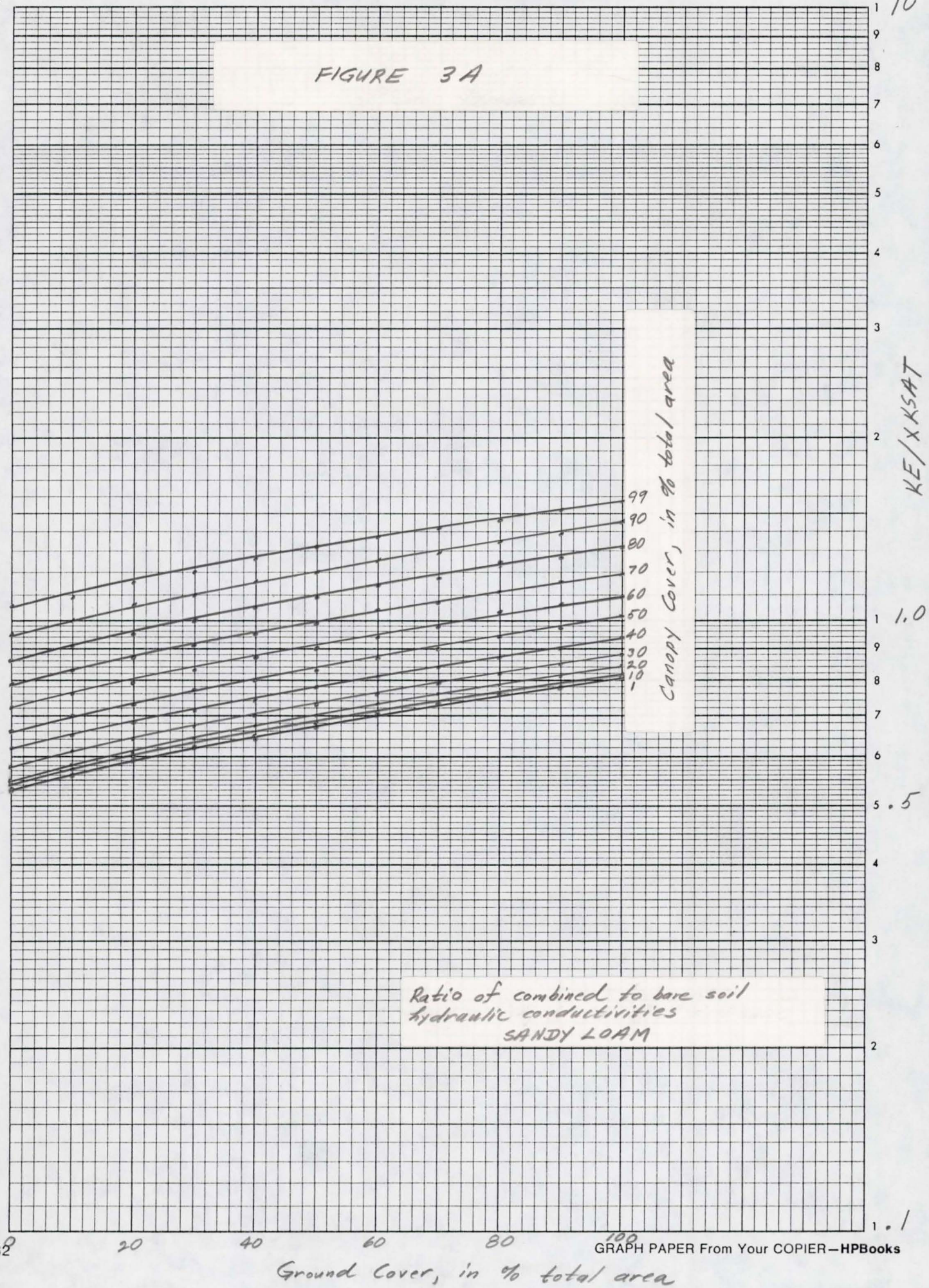

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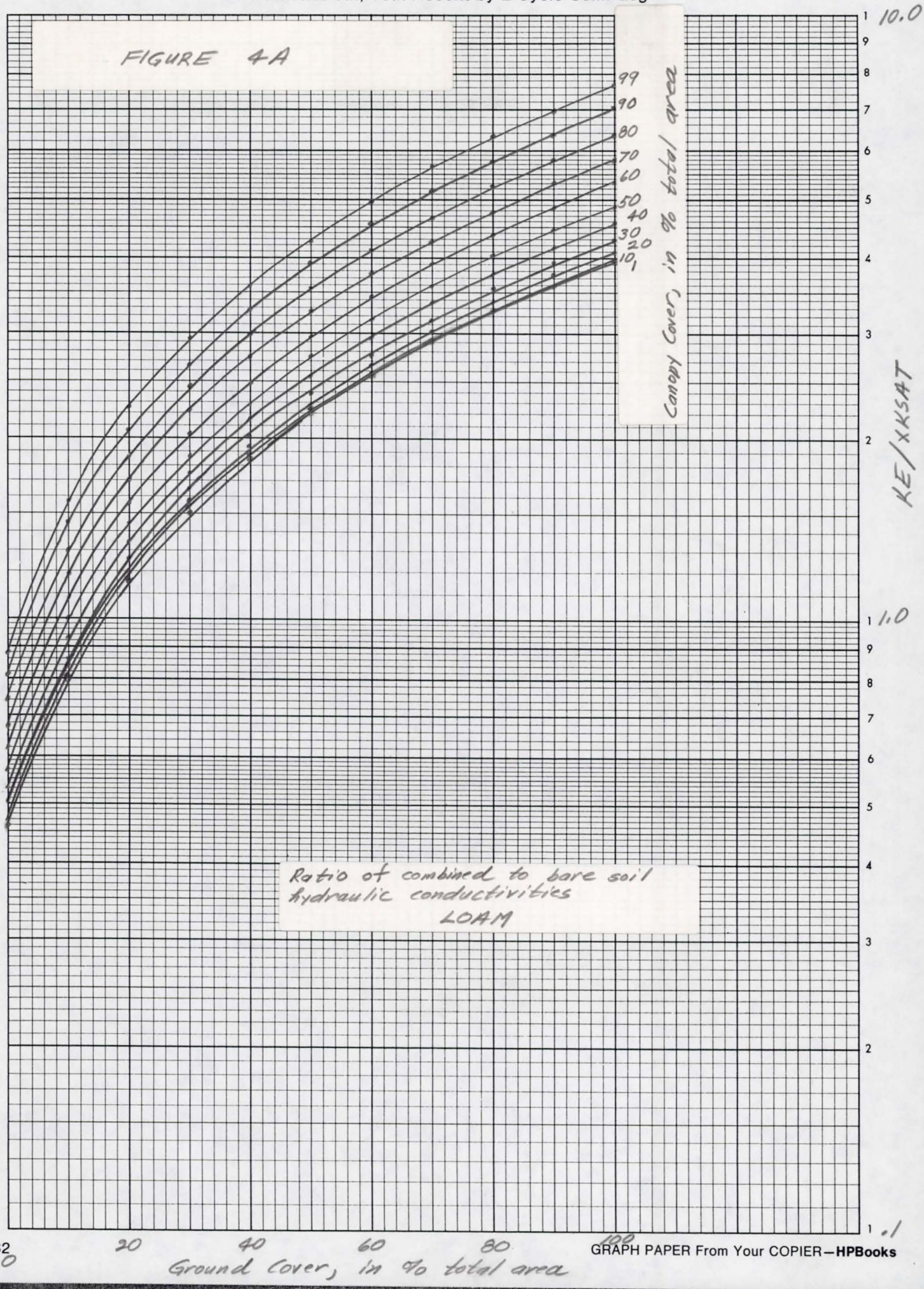

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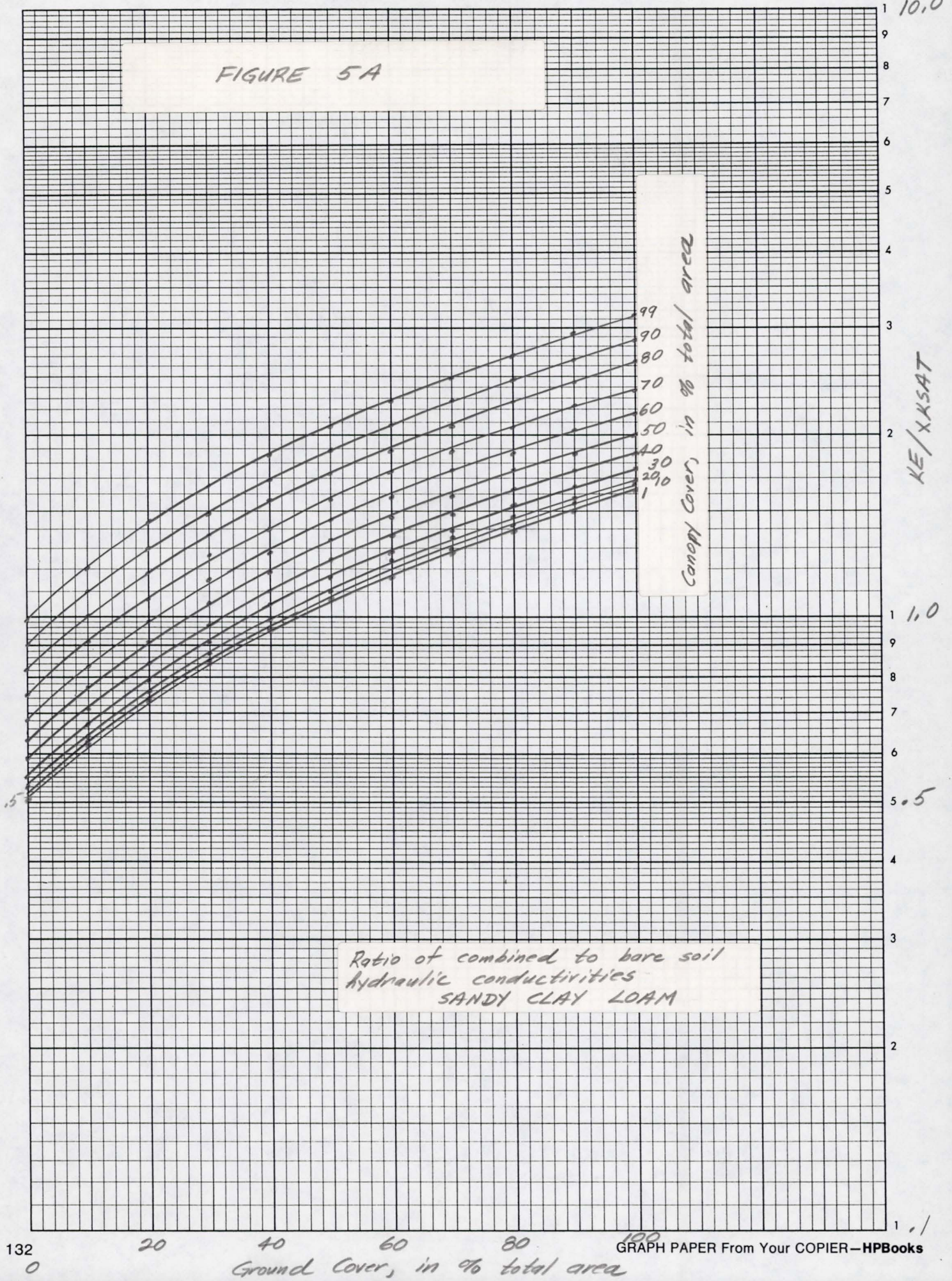

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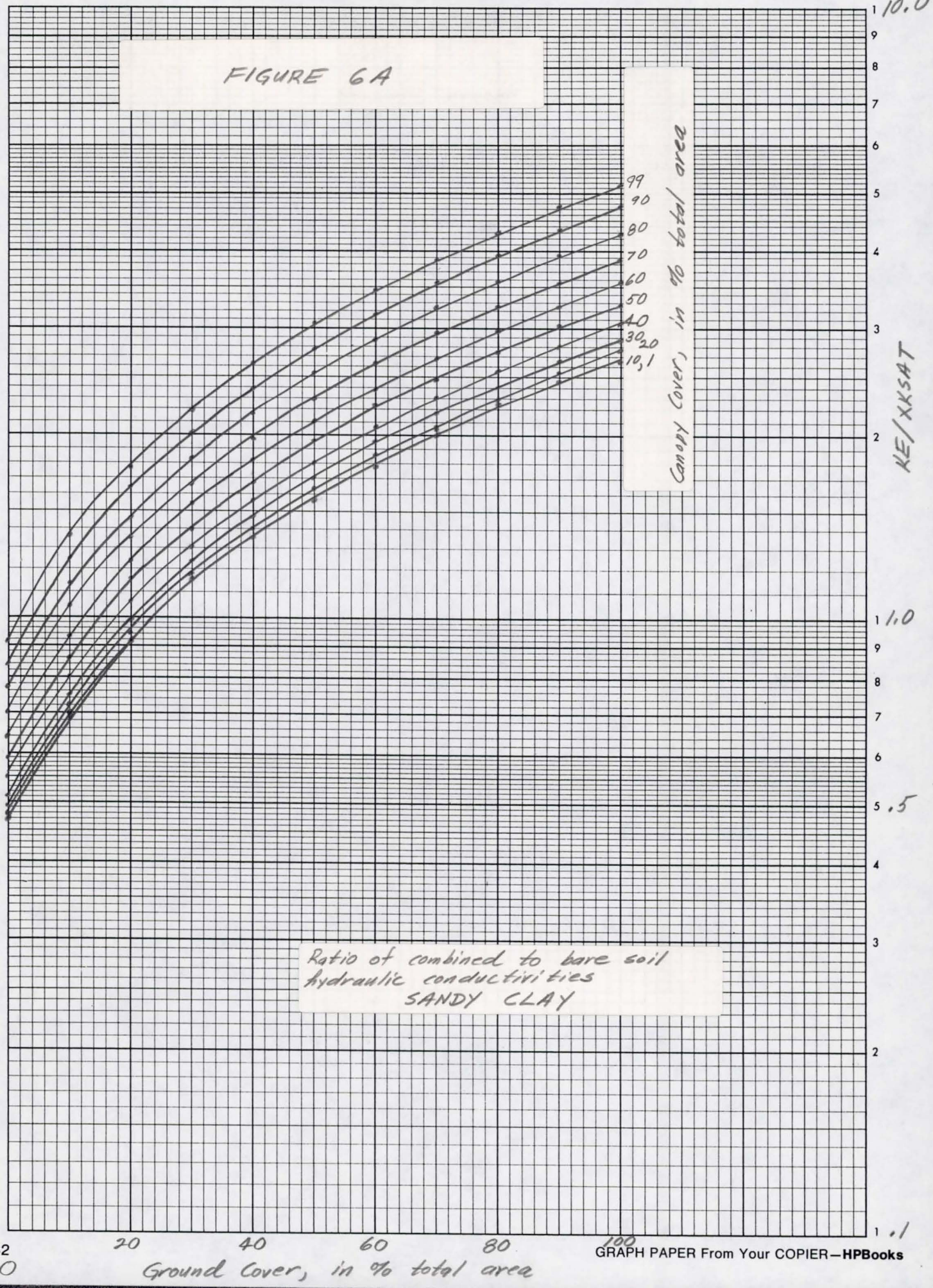

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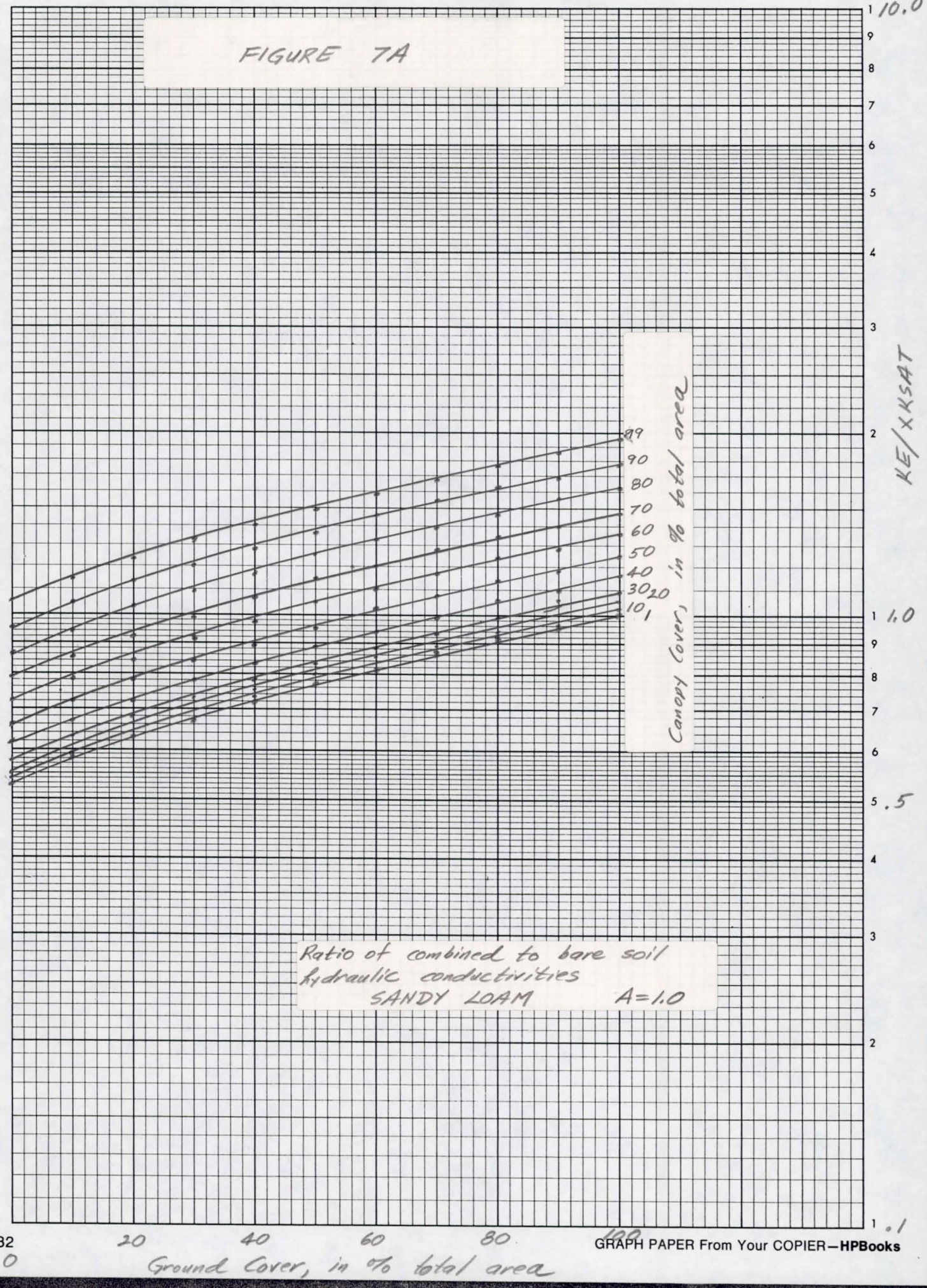

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TO: GEORGE SABOL RE HIS 28 APRIL CORRESPONDENCE

SUBJECT: PROPOSED FIGURE 7A AS A METHOD OF ADJUSTING VALUES OF BARE SOIL HYDRAULIC CONDUCTIVITY Ks0 TO REFLECT CANOPY COVER AND GROUND COVER

FROM: L. J. LANE

George:

I think we are close to solving the problem of how to derive simplified means of estimating Ks to use in the Green-Ampt infiltration equation.

I must confess, I am still somewhat confused by the complicated regression equations from Rawls, et al. But, I have a proposal for you which may help clear up the confusion.

If you could clean up and document a straight forward way to account for coarse fragments in the soil, crusting, and bulk density changes affecting Ks, I can take care of canopy cover and ground cover effects.

Consider an equation of the form:

$$Ks = Ks0*(\exp(Acc*cc5))*(\exp(Agc*gc\%))$$

where: Ks = Adjusted Ks for use in Green-Ampt eq. (mm/h),
Ks0 = Bare soil Ks incorporating coarse fragments in the profile, crusting, and changes in bulk density (mm/h),
Acc = Coefficient expressing influence of canopy cover,
cc% = Percent canopy cover (%),
Agc = Coefficient expressing influence of ground cover, and
gc% = Percent ground cover (%).

If you could develop procedures to get estimates of Ks0, I have some ideas for the canopy cover and ground cover effects.

In the following Analysis Notes, I derive first order estimates of Acc and Agc for data from 32 rainfall simulator plots in Arizona, Nevada, and New Mexico.

But first a question for you. In your Fig. 7A, why is the value of KE/XKSAT less than one (~0.53) for values of 0.0 ground cover and 0.0 canopy cover? I thought the bare soil Ks0 was the minimum value and Ks increased with addition of canopy cover and ground cover. This is why I do not understand why we don't require KE/XKSAT >=1.0?

In any event, please read through my Analysis notes and let me know what the next step is. Perhaps we should set down at a desk together for half to a full day together to clear up any misunderstandings, reach a decision on how to proceed, and to outline a publication if such is warranted. If you should decide we need to get together, I have a den with computer, printer, typewriter, phone, and answering machine.

The problem is my crazy schedule. I will be travelling to Kansas City, Honolulu, Newark, Edmonton, and West Lafayette over the next two and a half months. Following are some proposed dates should you agree on the need for some personal discussions. We should probably count on a full day to accomplish the tasks outlined above.

June: 1. Sat 6/17 (Note Sunday June 18 is Father's Day)

July: 1. Mon 7/3 (Note Tues is July 4)
2. Fri 7/7
3. Sat 7/8

Again, please consider the need for a meeting and let me know if any of the above dates would be convenient for you. You can call and leave a message on my machine at home (602-575-8009) if we wind up missing calls back and forth.

Thanks,

Leonard

Leonard J. Lane

ANALYSIS NOTES

Re: PROPOSED FIGURE 7A AS A METHOD OF ADJUSTING Ks IN THE GREEN-AMPT INFILTRATION EQUATION FOR THE MARICOPA COUNTY HYDROLOGY MANUAL

I. SELECTION AND PRELIMINARY ANALYSIS OF DATA

My personal library and the University of Arizona Science Library were consulted to find appropriate reports and papers meeting the following criteria.

1. Dealing with rainfall simulator studies in the Southwest
2. Studies reporting some soils information including surface soil texture, or providing sufficient information in the text to allow estimation of apparent surface soil texture.
3. Studies reporting percent canopy cover, percent ground cover, and measured final infiltration rate Kf as a statistic representing a field-measured estimate of Ks.

My quick literature search and quick trip to the library turned up four key references listing data on 32 experimental plots (Table 1). The soils on the sites listed in Table 1 were all poorly described in the text with textures given as sand, gravelly loamy sand, gravelly sandy loam, fine sandy loam, and sandy loam. From narrative descriptions given in the texts of the papers, I classified the soils as sand (Sa), Loamy Sand (LSa), Sandy Loam (SaL), and Loam (L) in the last column of Table 1. Those classified as Loam probably are Sandy Loam near the Sandy Loam--Loam border. In any event, my textural classifications are not rigorous but are more "apparent" based on my reading of the texts, my knowledge of the sites, and the grouping of the resulting Kf values. I am far from satisfied with these classifications or groupings. But, as long as our soils colleagues continue to use such descriptive and qualitative descriptions of soils and concentrate their efforts on profile properties as opposed to surface and near surface properties, we in the West will suffer from poor soils information.

The quantitative data from the publications are summarized in Table 2. Of the four textural classes in Table 2 (Sa, LSa, SaL, and L), LSa and SaL could probably be combined based on the statistics of the measured Kf values shown in the last column. But, I suggest we keep them separate for now as we don't know how really representative the values are of all possible Loamy Sands and Sandy Loams.

II. ANALYSIS & PREDICTION OF Ks FROM Ks0, CC%, AND GC%

An equation of the following form was hypothesized as a means of adjusting Ks0 for canopy and ground cover effects. Because I had trouble understanding how to get coarse fragments, crusting, etc. into the estimate of Ks0, I decided to get estimates of it by optimization.

The proposed equation is an exponential form which has some

desirable properties such as robustness and known properties in the limits. The proposed equation is

$$Ks = Ks0*[\exp(Acc*cc\%))*(\exp(Agc*gc\%))] \qquad (1)$$

where: Ks = Adjusted Ks value to use in Green-Ampt eq. (mm/h),
Ks0 = Bare soil Ks value adjusted for crusting, etc. (mm/h),
Acc = Coefficient for canopy cover effects,
cc% = Percent canopy cover,
Agc = Coefficient for ground cover effects, and
gc% = Percent ground cover.

A least squares program was written to read in observed Kf data from Table 2, assume initial values of Ks0, Acc, and Agc, calculate corresponding values of Ks from Equation 1, and find the least squares or best estimates of Ks0, Acc, and Agc. Except for the Sand, it looked like 0.01 provided a reasonable (not optimal as I have not done a complete analysis) value for Acc and Agc. For Sand, I assumed Acc = 0.005 because canopy effects seem to diminish for the sandier soils. Of course, these somewhat arbitrary selections for Acc and Agc no doubt affect the optimal value of Ks0. This is a problem for a subsequent multivariable optimization study. I do not have the appropriate software available. However if you have a statistical package which can do multiple regression, we could take the log transform of Equation 1 and estimate all three parameters by least squares regression. I did not think you wanted me to take the large amount of time to write such a program and, in fact, you probably already have one we can use if we get together.

Table 3 lists the Ks0, Acc, and Agc values used for each of the four apparent textural classes and the final column of table 3 shows the estimated Ks values. As you will see, these predictions are quite close to the measured Kf values considering the data were collected over a 20+ year period by a variety of investigators using many different techniques.

Table 4 contains data summarizing how well the Ks values correlate with the measured Kf values by class and for all data. The corresponding Kf and Ks values and the regression line between them is shown in Fig. 1. My conclusion is that if you can get the right Ks0 value, then the proposed equation and the parameter values shown in Table 4 can be used to estimate Ks values sufficiently accurate for practical applications.

Figure 2 shows Ks/Ks0 vs ground cover and canopy cover for the Sand and similar results are shown for the other texture classes in Figure 3.

If you compare Figure 3 with your Figure 7A, you will notice the following:

1. Fig. 3 suggests the range of influence of ground cover is from exp(0.0) = 1.0 to exp(1.0) = 2.718 as is the influence of canopy cover so long as Acc=Agc=0.01. Your Fig. 7A

suggests about a factor of 2 correction for canopy cover and also for ground cover. Again, I don't know why KE/XKSAT is not 1.0 when canopy cover and ground cover are both zero.

2. The corrections to Ks0 due to canopy cover and ground cover are exponential and thus transform to "nice" straight lines on semilog paper as shown in Fig. 3. This makes for easy interpolation.

3. Figure 3 incorporates optimal or least squares estimates for Ks0. How does Ks0 enter in your Fig. 7A?

III. SUGGESTIONS

1. Please go through my notes and analysis to make sure they are correct and that I did not misinterpret your results.

2. Assuming no problems from step 1, please consider combining your work on Ks0 and my work on canopy and ground cover influences as the first practical procedure to estimate Ks on sandy soils in the desert Southwest. We could propose it as a documented procedure, clearly explained, and thus amenable to further testing, evaluation, and refining. Perhaps we could suggest some carefully conducted experiments to evaluate Ks0, Acc, and Agc as well as the form of Eq. 1. In any event, Eq. 1 is the simplest I could come up with which is robust and has reasonable, easily apparent limits, yet fits the data so well. But again we need to use log transformations and a multiple regression program to find the true optimal values.

Please let me know what you think of these suggestions. I think we are getting close but are not quite there yet.

L. J. Lane
Tucson

Table 1. Selected referenced with data on canopy cover, ground cover, and final infiltration rates.

Reference	Plot Identification In Reference	Plot Identification Here
Bach, L. B. 1984. Determination of infiltration, runoff, and erosional characteristics of a small watershed using rainfall simulation data. Unpublished MS Thesis, New Mexico State Univ., Las Cruces, NM, 69 pp.	UV	Sa1
	UI	Sa2
	MV	Sa3
	MI	Sa4
	LI	SaL1
Kincaid, D. R., J. L. Gardner, and H. A. Schreiber. 1964. Soil and vegetation parameters affecting infiltration under semiarid conditions. Bull. IASH 65:440-453.	E3	LSa1
	E2	LSa2
	E4	LSa3
	LH-3	LSa4
	E1	LSa5
	K-10	SaL2
Lane, L. J., J. R. Simanton, T. E. Hakonson, and E. M. Romney. 1987. Large-plot infiltration studies in desert and semiarid rangeland areas of the Southwestern U.S.A. Proc. Intrl. Conf. on Infiltration Development and Application., Water Res. Res. Center, Univ. of Hawaii at Manoa, Honolulu, HI, pp.365-376.	BN	LSa6
	BC	LSa7
	BB	LSa8
	A11N	LSa9
	A11C	LSa10
	A11B	LSa11
	CN	SaL3
	CC	SaL4
	CB	SaL5
	HN	SaL6
	HC	SaL7
	HB	SaL8
	MN	L1
	MC	L2
	MB	L3
Ward, T. J. 1986. A study of runoff and erosion processes using large and small area rainfall simulators. New Mexico State Univ. Water Res. Res. Center, Report No. 215, 71p.	WS2	SaL9
	WS3	SaL10
	WS2	Sa111
	WS3	L4
	NMSU	LSa12
	NMSU	LSa13

Table 2. Summary of canopy cover, ground cover, and final infiltration rates for selected data in Table 1.

Plot ID	"Apparent" Textural Class of Surface Soil	% Canopy Cover (%)	% Ground Cover (%)	Final Infil. Rate Kf (mm/h)
Sa1	Sand or Loamy Sand	57.0	35.0	45.8
Sa2	"	25.0	70.4	60.7
Sa3	"	41.2	57.8	75.6
Sa4	"	17.0	82.7	81.0
LSa1	Loamy Sand or Gravelly	44.4	26.7	35.6e
LSa2	Loamy Sand	35.2	27.2	17.3
LSa3	"	32.1	10.5	20.3
LSa4	"	20.3	17.6	14.7
LSa5	"	26.0	14.7	17.0
LSa6	"	65.2	57.3	35.3
LSa7	"	0.0	62.4	21.0
LSa8	"	0.0	23.6	13.7
LSa9	"	21.2	78.4	33.7
LSa10	"	0.0	70.8	29.4
LSa11	"	0.0	16.8	16.3
LSa12	"	5.0	52.7	25.9
LSa13	"	12.0	50.0e	22.1
SaL1	Sandy Loam or Gravelly	23.5	1.9	12.0
SaL2	Sandy Loam	20.0e	17.7	13.2
SaL3	"	34.7	57.9	26.3
SaL4	"	0.0	59.4	15.0
SaL5	"	0.0	18.8	11.6
SaL6	"	48.7	63.9	31.6
SaL7	"	0.0	65.0	19.3
SaL8	"	0.0	21.9	12.4
SaL9	"	23.0	2.1	18.8
SaL10	"	12.0	1.2	14.7
SaL11	"	26.0	2.0e	16.0
L1	Sandy Loam to Loam	22.0	76.5	20.5
L2	"	0.0	78.1	7.3
L3	"	0.0	16.6	4.8
L4	"	22.0	1.0e	7.1

The symbol e represents estimated values using information from the text of the references cited in Table 1.

Table 3. Summary of Ks estimating equations, canopy cover, ground cover, measured final infiltration rates, and estimated Ks values. Estimating equation is Ks = Ks0(exp(Acc*cc%))*(exp(Agc*gc%)) where Ks0 is the bare soil Ks value, cc% is the percent canopy cover, and gc% is percent ground cover. The coefficients are Acc and Agc.

Plot ID	Parameters Ks0 (mm/h)	Acc (--)	Agc (--)	% Canopy Cover (%)	% Ground Cover (%)	Final Infil. Rate Kf (mm/h)	Est. Ks (mm/h)
Sa1	30.0	.005	.01	57.0	35.0	45.8	56.6
Sa2		"		25.0	70.4	60.7	68.7
Sa3		"		41.2	57.8	75.6	65.7
Sa4		"		17.0	82.7	81.0	74.7
LSa1	12.0	.01	.01	44.4	26.7	35.6e	24.4
LSa2		"		35.2	27.2	17.3	22.4
LSa3		"		32.1	10.5	20.3	18.4
LSa4		"		20.3	17.6	14.7	17.5
LSa5		"		26.0	14.7	17.0	18.0
LSa6		"		65.2	57.3	35.3	40.8
LSa7		"		0.0	62.4	21.0	22.4
LSa8		"		0.0	23.6	13.7	15.2
LSa9		"		21.2	78.4	33.7	32.5
LSa10		"		0.0	70.8	29.4	24.4
LSa11		"		0.0	16.8	16.3	14.2
LSa12		"		5.0	52.7	25.9	21.4
LSa13		"		12.0	50.0e	22.1	22.3
SaL1	10.3	.01	.01	23.5	1.9	12.0	13.3
SaL2		"		20.0e	17.7	13.2	15.0
SaL3		"		34.7	57.9	26.3	26.0
SaL4		"		0.0	59.4	15.0	18.7
SaL5		"		0.0	18.8	11.6	12.3
SaL6		"		48.7	63.9	31.6	31.8
SaL7		"		0.0	65.0	19.3	19.7
SaL8		"		0.0	21.9	12.4	12.8
SaL9		"		23.0	2.1	18.8	13.2
SaL10		"		12.0	1.2	14.7	11.8
SaL11		"		26.0	2.0e	16.0	13.6
L1	5.7	.01	.01	22.0	76.5	20.5	15.3
L2		"		0.0	78.1	7.3	12.4
L3		"		0.0	16.6	4.8	6.7
L4		"		22.0	1.0e	7.1	7.2

The symbol e represents estimated values using information from the text of the references cited in Table 1.

Table 4. Comparison of measured Kf and estimated Ks values for the four "apparent" textural classes shown in Tables 2 and 3.

Plot ID	"Apparent" Textural Class of Surface Soil	Regression Results for: Ks = A + B*Kf		
		A	B	R Squared
Sa1	Sand or Loamy Sand	39.9	0.40	0.72
Sa2	"			
Sa3	"			
Sa4	"			
LSa1	Loamy Sand or Gravelly	5.1	0.75	0.68
LSa2	Loamy Sand			
LSa3	"			
LSa4	"			
LSa5	"			
LSa6	"			
LSa7	"			
LSa8	"			
LSa9	"			
LSa10	"			
LSa11	"			
LSa12	"			
LSa13	"			
SaL1	Sandy Loam or Gravelly	0.84	0.94	0.85
SaL2	Sandy Loam			
SaL3	"			
SaL4	"			
SaL5	"			
SaL6	"			
SaL7	"			
SaL8	"			
SaL9	"			
SaL10	"			
SaL11	"			
L1	Sandy Loam to Loam	5.6	0.49	0.70
L2	"			
L3	"			
L4	"			

For all data: N = 32, Ks = 1.3 + 0.94*Kf, R Squared = 0.93

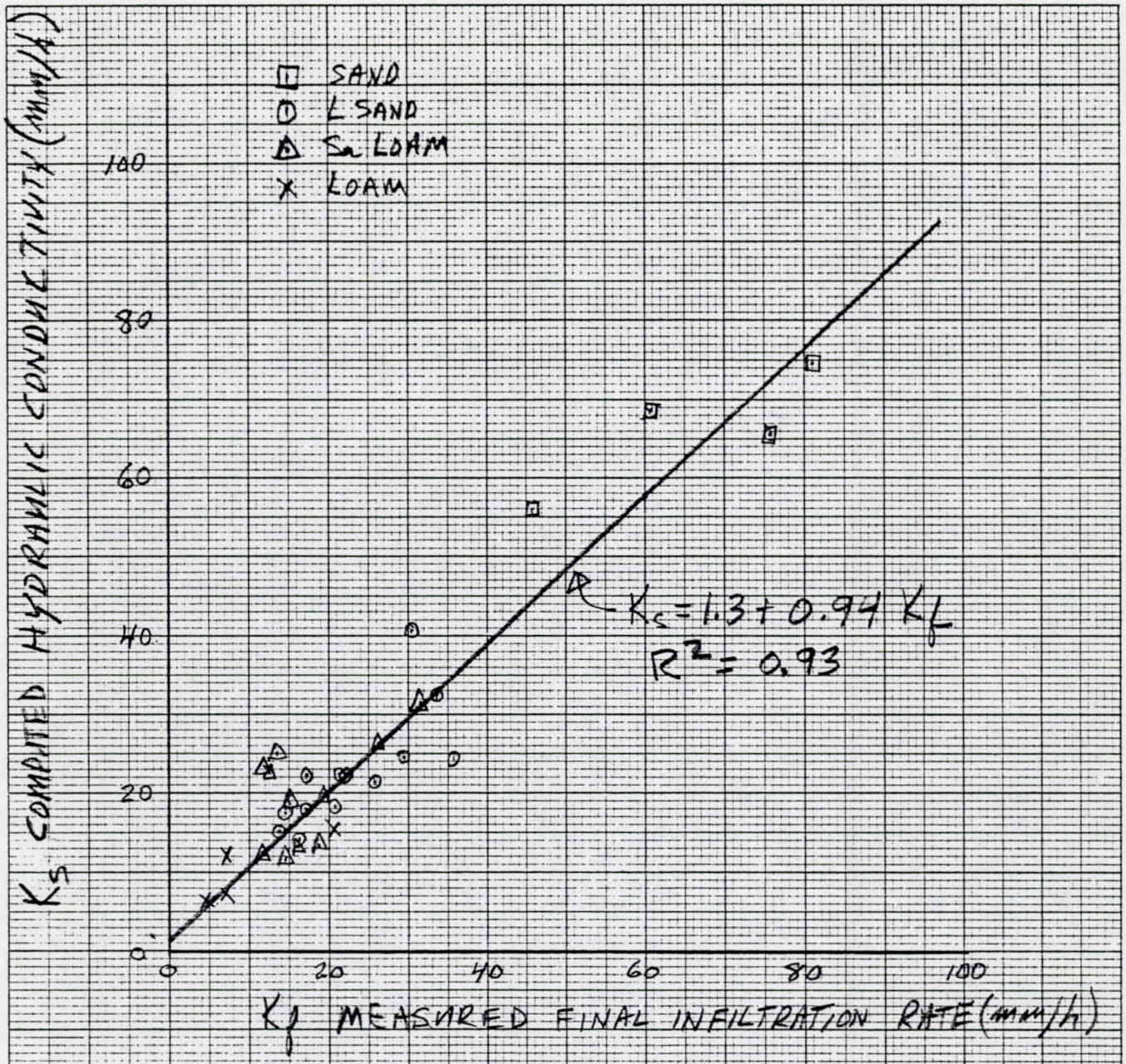


FIGURE 1. RELATIONSHIP BETWEEN MEASURED K_f AND COMPUTED K_s. DATA FROM TABLES 3 & 4.

GRAPH PAPER GRAPHIC CONTROLS CORPORATION Buffalo New York Printed in U.S.A. SQUARE 10 X 10 TO THE HALF INCH AS 0813-60

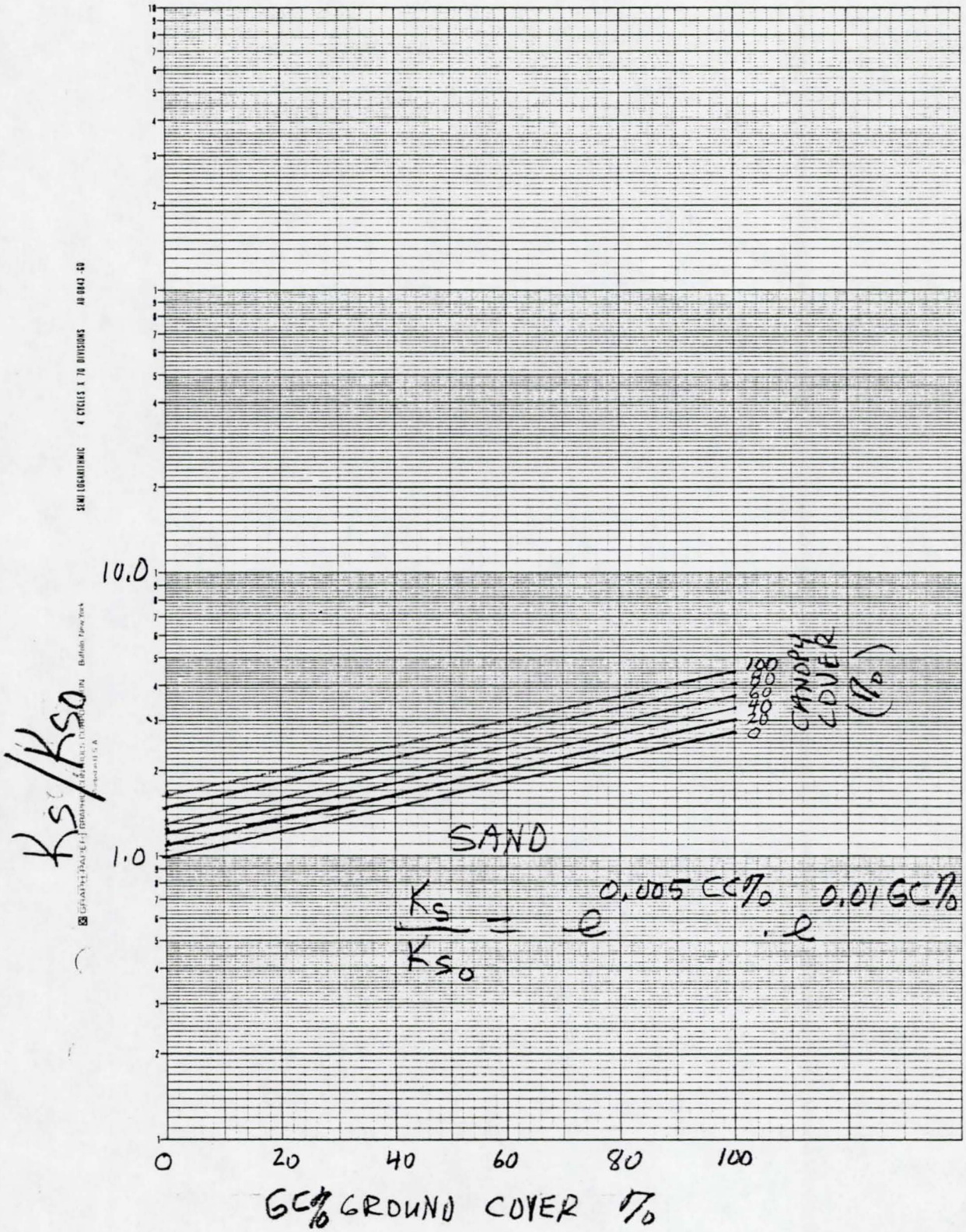


FIGURE 2. RELATIONSHIP BETWEEN CANOPY COVER, GROUND COVER AND ADJUSTMENT IN Ks FOR TEXTURAL CLASS "SAND."

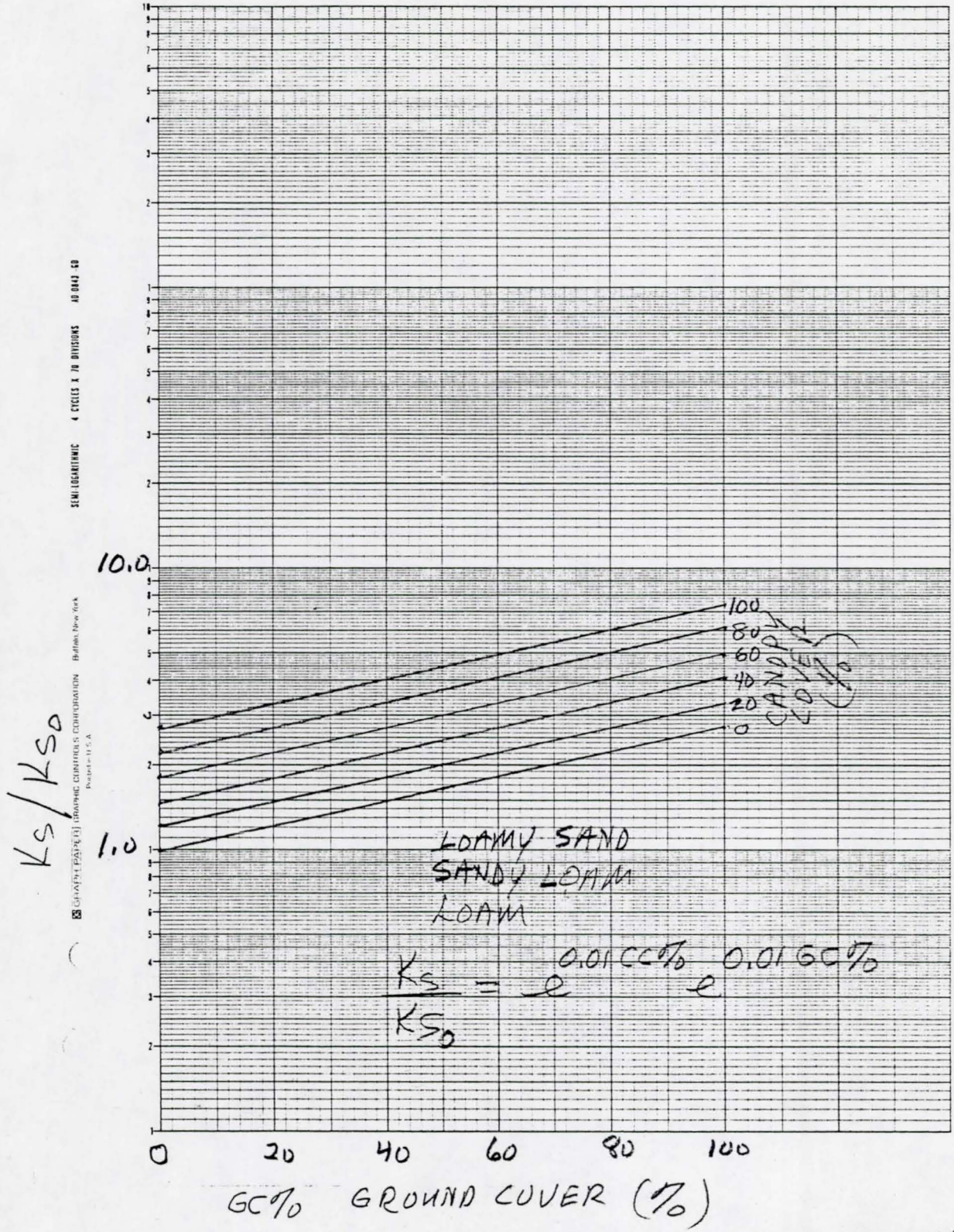


FIGURE 3. RELATION BETWEEN CANOPY COVER, GROUND COVER, AND ADJUSTMENT IN Ks FOR LOAMY SAND, SANDY LOAM, & LOAM

L. J. Lane
Hydrologist
411 E. Suffolk Dr.
Tucson, AZ 85704
602-575-8009

DATE: August 13, 1989

TO: Dr. George V. Sabol
1351 East 141st Ave.
Brighton, CO 80601
303-457-0989

SUBJECT: Report on Analyses of Infiltration Data

Enclosed is a report on my subsequent analyses of the infiltration data as suggested during your visit here on July 7, 1989.

I think I have done about all I can do with the basic data set (which is enclosed in hard copy and on a disk). Please examine the material carefully and let me know how you decide to proceed. I suggest you look at Table 4 and 4a enclosed and consider a procedure such as this.

Enclosed are the following documents/items:

1. Invoice for June, July and August
2. The interpreted infiltration data
3. Listings of the raw data files which I used in the 2 variable regression through the origin analyses
4. Listings of the regression results
5. Documentation and a listing of the 2 variable regression program
6. A disk containing the input and regression output data, source and exe code for the regression program, the program documentation, and a read.me file to help you sort out the information on the disk.

With the enclosed information and invoice, I will not do any more work on the project until you have had a chance to examine the enclosed material in detail and until we have discussed the project.

Leonard

Leonard J. Lane

enclosures

(2) INTERPRETED DATA

Table 1. Selected referenced with data on canopy cover, ground cover, and final infiltration rates.

Reference	Plot Identification In Reference	Plot Identification Here
Bach, L. B. 1984. Determination of infiltration, runoff, and erosional characteristics of a small watershed using rainfall simulation data. Unpublished MS Thesis, New Mexico State Univ., Las Cruces, NM, 69 pp.	UV	LSa1
	UI	LSa2
	MV	LSa3
	MI	LSa4
	LI	SaL1
Kincaid, D. R., J. L. Gardner, and H. A. Schreiber. 1964. Soil and vegetation parameters affecting infiltration under semiarid conditions. Bull. IASH 65:440-453.	E3	SaL2
	E2	SaL3
	E4	SaL4
	LH-3	SaL5
	E1	SaL6
	K-10	SaL7
Lane, L. J., J. R. Simanton, T. E. Hakonson, and E. M. Romney. 1987. Large-plot infiltration studies in desert and semiarid rangeland areas of the Southwestern U.S.A. Proc. Intrl. Conf. on Infiltration Development and Application., Water Res. Res. Center, Univ. of Hawaii at Manoa, Honolulu, HI, pp.365-376.	BN	LSa5
	BC	LSa6
	BB	LSa7
	A11N	LSa8
	A11C	LSa9
	A11B	LSa10
	CN	SaL8
	CC	SaL9
	CB	SaL10
	HN	SaL11
	HC	SaL12
	HB	SaL13
	MN	L1
	MC	L2
	MB	L3
Ward, T. J. 1986. A study of runoff and erosion processes using large and small area rainfall simulators. New Mexico State Univ. Water Res. Res. Center, Report No. 215, 71p.	WS2	SaL14
	WS3	SaL15
	WS2	SaL16
	WS3	L4
	NMSU	LSa11
	NMSU	LSa12
Ward, T. J. and S. B. Bolin. 1989. Determination of hydrologic parameters for selected soils in Arizona and New Mexico utilizing rainfall simulation. New Mexico State Univ. Water Res. Center, Report No. 243, 84p.	BH3B	LSa13
	BH6L	LSa14
	BH6H	LSa15
	HB2B	LSa16
	HB4L	LSa17
	HB4H	LSa18
	LK2L	LSa19
	LK2H	LSa20

Table 2. Summary of canopy cover, ground cover, and final infiltration rates for selected data in Table 1.

Plot ID	"Apparent" Textural Class of Surface Soil	% Canopy Cover (%)	% Ground Cover (%)	Final Infil. Rate Kf (mm/h)
LSa1	Loamy Sand or Gravelly	57.0	35.0	45.8
LSa2	Loamy Sand	25.0	70.4	60.7
LSa3	"	41.2	57.8	75.6
LSa4	"	17.0	82.7	81.0
LSa5	"	65.2	57.3	35.3
LSa6	"	0.0	62.4	21.0
LSa7	"	0.0	23.6	13.7
LSa8	"	21.2	78.4	33.7
LSa9	"	0.0	70.8	29.4
LSa10	"	0.0	16.8	16.3
LSa11	"	5.0	52.7	25.9
LSa12	"	12.0	50.0e	22.1
LSa13	"	0.0	0.0	16.3
LSa14	"	9.3	78.9	18.3
LSa15	"	19.6	78.5	33.3
LSa16	"	0.0	0.0	6.4
LSa17	"	18.0	59.7	23.2
LSa18	"	12.3	69.0	25.3
LSa19	"	36.7	67.4	31.2
LSa20	"	39.3	76.6	27.9
SaL1	Sandy Loam or Gravelly	23.5	1.9	12.0
SaL2	Sandy Loam	44.4	26.7	35.6e
SaL3	"	35.2	27.2	17.3
SaL4	"	32.1	10.5	20.3
SaL5	"	20.3	17.6	14.7
SaL6	"	26.0	14.7	17.0
SaL7	"	20.0e	17.7	13.2
SaL8	"	34.7	57.9	26.3
SaL9	"	0.0	59.4	15.0
SaL10	"	0.0	18.8	11.6
SaL11	"	48.7	63.9	31.6
SaL12	"	0.0	65.0	19.3
SaL13	"	0.0	21.9	12.4
SaL14	"	23.0	2.1	18.8
SaL15	"	12.0	1.2	14.7
SaL16	"	26.0	2.0e	16.0
L1	Loam or Loam near	22.0	76.5	20.5
L2	Sandy Loam	0.0	78.1	7.3
L3	"	0.0	16.6	4.8
L4	"	22.0	1.0e	7.1

The symbol e represents estimated values using information from the text of the references cited in Table 1.

Table 3. Summary of Ks0 base values, canopy cover, ground cover, measured final infiltration rates, and normalized, Kf/Ks0, values.

Plot ID	Base Ks0 Values (mm/h)	% Canopy Cover (%)	% Ground Cover (%)	Final Infil. Rate Kf (mm/h)	Normalized Kf/Ks0 (--)
LSa1	30.	57.0	35.0	45.8	1.52
LSa2	"	25.0	70.4	60.7	2.02
LSa3	"	41.2	57.8	75.6	2.52
LSa4	"	17.0	82.7	81.0	2.70
LSa5	"	65.2	57.3	35.3	1.18
LSa6	" 1.2 in/hr	0.0	62.4	21.0	0.70
LSa7	"	0.0	23.6	13.7	0.46
LSa8	"	21.2	78.4	33.7	1.12
LSa9	"	0.0	70.8	29.4	0.98
LSa10	"	0.0	16.8	16.3	0.54
LSa11	"	5.0	52.7	25.9	0.86
LSa12	"	12.0	50.0	22.1	0.74
LSa13	"	0.0	0.0	16.3	0.54
LSa14	"	9.3	78.9	18.3	0.61
LSa15	"	19.6	78.5	33.3	1.11
LSa16	"	0.0	0.0	6.4	0.21
LSa17	"	18.0	59.7	23.2	0.77
LSa18	"	12.3	69.0	25.3	0.84
LSa19	"	36.7	67.4	31.2	1.04
LSa20	"	39.3	76.6	27.9	0.93
SaL1	10.	23.5	1.9	12.0	1.20
SaL2	"	44.4	26.7	35.6	3.56
SaL3	"	35.2	27.2	17.3	1.73
SaL4	"	32.1	10.5	20.3	2.03
SaL5	"	20.3	17.6	14.7	1.47
SaL6	" .4 in/hr	26.0	14.7	17.0	1.70
SaL7	"	20.0	17.7	13.2	1.32
SaL8	"	34.7	57.9	26.3	2.63
SaL9	"	0.0	59.4	15.0	1.50
SaL10	"	0.0	18.8	11.6	1.16
SaL11	"	48.7	63.9	31.6	3.16
SaL12	"	0.0	65.0	19.3	1.93
SaL13	"	0.0	21.9	12.4	1.24
SaL14	"	23.0	2.1	18.8	1.88
SaL15	"	12.0	1.2	14.7	1.47
SaL16	"	26.0	2.0	16.0	1.60
L1	6.4 .25 in/hr	22.0	76.5	20.5	3.20
L2	"	0.0	78.1	7.3	1.14
L3	"	0.0	16.6	4.8	0.75
L4	"	22.0	1.0	7.1	1.11

Table 3a. Summary of Ks0 base values, canopy cover, ground cover, measured final infiltration rates, and normalized, Kf/Ks0, values. Ks0 values adjusted for gravel in profile by Ks0adj = Ks0*(1.0 - fraction of gravel in profile).

Plot ID	Base Ks0 Values (mm/h)	% Canopy Cover (%)	% Ground Cover (%)	Final Infil. Rate Kf (mm/h)	Normalized Kf/Ks0 (--)
LSa1	30.	57.0	35.0	45.8	1.52
LSa2	30.	25.0	70.4	60.7	2.02
LSa3	30.	41.2	57.8	75.6	2.52
LSa4	30.	17.0	82.7	81.0	2.70
LSa5	17.	65.2	57.3	35.3	2.08
LSa6	17.	0.0	62.4	21.0	1.24
LSa7	17.	0.0	23.6	13.7	0.81
LSa8	27.	21.2	78.4	33.7	1.25
LSa9	27.	0.0	70.8	29.4	1.09
LSa10	27.	0.0	16.8	16.3	0.60
LSa11	25.	5.0	52.7	25.9	1.04
LSa12	25.	12.0	50.0	22.1	0.88
LSa13	24.	0.0	0.0	16.3	0.68
LSa14	23.	9.3	78.9	18.3	0.80
LSa15	22.	19.6	78.5	33.3	1.51
LSa16	18.	0.0	0.0	6.4	0.36
LSa17	16.	18.0	59.7	23.2	1.45
LSa18	17.	12.3	69.0	25.3	1.49
LSa19	22.	36.7	67.4	31.2	1.42
LSa20	22.	39.3	76.6	27.9	1.27
SaL1	10.	23.5	1.9	12.0	1.20
SaL2	6.1	44.4	26.7	35.6	5.84
SaL3	6.1	35.2	27.2	17.3	2.84
SaL4	6.1	32.1	10.5	20.3	3.33
SaL5	6.1	20.3	17.6	14.7	2.41
SaL6	6.1	26.0	14.7	17.0	2.79
SaL7	8.6	20.0	17.7	13.2	1.53
SaL8	5.0	34.7	57.9	26.3	5.26
SaL9	5.0	0.0	59.4	15.0	3.00
SaL10	5.0	0.0	18.8	11.6	2.32
SaL11	4.0	48.7	63.9	31.6	7.90
SaL12	4.0	0.0	65.0	19.3	4.82
SaL13	4.0	0.0	21.9	12.4	3.10
SaL14	10.0	23.0	2.1	18.8	1.88
SaL15	10.0	12.0	1.2	14.7	1.47
SaL16	10.0	26.0	2.0	16.0	1.60
L1	5.8	22.0	76.5	20.5	3.53
L2	5.8	0.0	78.1	7.3	1.26
L3	5.8	0.0	16.6	4.8	0.83
L4	6.4	22.0	1.0	7.1	1.11

Table 4. Summary of regression results for influence of percent canopy cover (cc%) and percent ground cover (gc%) on hydraulic conductivity.

Model: $y = (Kf/Ks0) - 1 = a*cc\% + b*gc\%$

or

$Kf/Ks0 = 1.0 + a*cc\% + b*gc\%$

Where: Kf = measured final infiltration rate in mm/h

Ks0= base value of hydraulic conductivity in mm/h

Soil Texture	N	Coefficient a	Coefficient b	R**2
Loamy Sand	20	0.011	0.0	0.17
Sandy Loam	16	0.028	0.011	0.72
Loam	4	0.036	0.009	0.60

Table 4a. Summary of regression results for influence of percent canopy cover (cc%) and percent ground cover (gc%) on hydraulic conductivity.

Model: $y = (Kf/Ks0adj) - 1 = a*cc\% + b*gc\%$

or $Kf/Ks0adj = 1.0 + a*cc\% + b*gc\%$

Where: Kf = measured final infiltration rate in mm/h

Ks0adj = base value of hydraulic conductivity in mm/h adjusted for gravel content in the profile

Soil Texture	N	Coefficient a	Coefficient b	R**2
Loamy Sand	20	0.013	0.003	0.42
Sandy Loam	16	0.043	0.055	0.78
Loam	4	0.039	0.012	0.62

ORIGINAL DATA LSAND.DAT

③ DATA FILES (INPUT DATA)

	Ksd	CC%	GC%	Kf	$\frac{Kf}{Ksd} - 1$
LSa1	30.	57.0	35.0	45.8	0.52
LSa2	"	25.0	70.4	60.7	1.02
LSa3	"	41.2	57.8	75.6	1.52
LSa4	"	17.0	82.7	81.0	1.70
LSa5	"	65.2	57.3	35.3	0.18
LSa6	"	0.0	62.4	21.0	-0.30
LSa7	"	0.0	23.6	13.7	-0.54
LSa8	"	21.2	78.4	33.7	0.12
LSa9	"	0.0	70.8	29.4	-0.02
LSa10	"	0.0	16.8	16.3	-0.46
LSa11	"	5.0	52.7	25.9	-0.14
LSa12	"	12.0	50.0	22.1	-0.26
LSa13	"	0.0	0.0	16.3	-0.46
LSa14	"	9.3	78.9	18.3	-0.39
LSa15	"	19.6	78.5	33.3	0.11
LSa16	"	0.0	0.0	6.4	-0.79
LSa17	"	18.0	59.7	23.2	-0.23
LSa18	"	12.3	69.0	25.3	-0.16
LSa19	"	36.7	67.4	31.2	0.04
LSa20	"	39.3	76.6	27.9	-0.07

DATA ADJUSTED FOR GRAVEL IN PROFILE LSANDA.DAT

	KsdADJ				$\frac{Kf}{KsdADJ} - 1$
LSa1	30.	57.0	35.0	45.8	0.52
LSa2	"	25.0	70.4	60.7	1.02
LSa3	"	41.2	57.8	75.6	1.52
LSa4	"	17.0	82.7	81.0	1.70
LSa5	17.	65.2	57.3	35.3	1.08
LSa6	"	0.0	62.4	21.0	0.24
LSa7	"	0.0	23.6	13.7	-0.19
LSa8	27.	21.2	78.4	33.7	0.25
LSa9	"	0.0	70.8	29.4	0.09
LSa10	"	0.0	16.8	16.3	-0.40
LSa11	25.	5.0	52.7	25.9	0.04
LSa12	"	12.0	50.0	22.1	-0.12
LSa13	24.	0.0	0.0	16.3	-0.32
LSa14	23.	9.3	78.9	18.3	-0.20
LSa15	22.	19.6	78.5	33.3	0.51
LSa16	18.	0.0	0.0	6.4	-0.64
LSa17	16.	18.0	59.7	23.2	0.45
LSa18	17.	12.3	69.0	25.3	0.49
LSa19	22.	36.7	67.4	31.2	0.42
LSa20	22.	39.3	76.6	27.9	0.27

FORMAT

(20X, 2F11.1, 11X, F11.1) FOR CC%, GC% & $\frac{Kf}{Ksd} - 1$

ORIGINAL DATA SALOAM.DAT

SaL1	10.	23.5	1.9	12.0	0.20
SaL2	"	44.4	26.7	35.6	2.56
SaL3	"	35.2	27.2	17.3	0.73
SaL4	"	32.1	10.5	20.3	1.03
SaL5	"	20.3	17.6	14.7	0.47
SaL6	"	26.0	14.7	17.0	0.70
SaL7	"	20.0	17.7	13.2	0.32
SaL8	"	34.7	57.9	26.3	1.63
SaL9	"	0.0	59.4	15.0	0.50
SaL10	"	0.0	18.8	11.6	0.16
SaL11	"	48.7	63.9	31.6	2.16
SaL12	"	0.0	65.0	19.3	0.93
SaL13	"	0.0	21.9	12.4	0.24
SaL14	"	23.0	2.1	18.8	0.88
SaL15	"	12.0	1.2	14.7	0.47
SaL16	"	26.0	2.0	16.0	0.60

DATA ADJUSTED FOR GRAVEL IN PROFILE SALOAMA.DAT

SaL1	10.	23.5	1.9	12.0	0.20
SaL2	6.1	44.4	26.7	35.6	4.84
SaL3	"	35.2	27.2	17.3	1.84
SaL4	"	32.1	10.5	20.3	2.33
SaL5	"	20.3	17.6	14.7	1.41
SaL6	"	26.0	14.7	17.0	1.79
SaL7	8.6	20.0	17.7	13.2	0.53
SaL8	5.0	34.7	57.9	26.3	4.26
SaL9	"	0.0	59.4	15.0	2.00
SaL10	"	0.0	18.8	11.6	1.32
SaL11	4.0	48.7	63.9	31.6	6.90
SaL12	"	0.0	65.0	19.3	3.82
SaL13	"	0.0	21.9	12.4	2.10
SaL14	10.0	23.0	2.1	18.8	0.88
SaL15	"	12.0	1.2	14.7	0.47
SaL16	"	26.0	2.0	16.0	0.60

ORIGINAL DATA

LOAM.DAT

L1	6.4	22.0	76.5	20.5	2.20
L2	"	0.0	78.1	7.3	0.14
L3	"	0.0	16.6	4.8	-0.25
L4	"	22.0	1.0	7.1	0.11

DATA ADJUSTED
FOR GRAVEL IN PROFILE

LOAMA.DAT

L1	5.8	22.0	76.5	20.5	2.53
L2	"	0.0	78.1	7.3	0.26
L3	"	0.0	16.6	4.8	-0.17
L4	6.4	22.0	1.0	7.1	0.11

Loamy sand data, 8/13/89, x1=cc%, x2=gc%, y = (Kf/KS0) - 1

(4) REGRESSION RESULTS

Regression through the origin for
y = a*x1 + b*x2

a = .011 b = -.000

$$\frac{K_f}{K_{S0}} = 1 + 0.011\,CC\%$$

With Rsquared = .172

Data Listing

i	x1(i)	x2(i)	y(i)	ypred(i)
1	57.000	35.000	.520	.599
2	25.000	70.400	1.020	.244
3	41.200	57.800	1.520	.422
4	17.000	82.700	1.700	.155
5	65.200	57.300	.180	.680
6	.000	62.400	-.300	-.021
7	.000	23.600	-.540	-.008
8	21.200	78.400	.120	.201
9	.000	70.800	-.020	-.024
10	.000	16.800	-.460	-.006
11	5.000	52.700	-.140	.036
12	12.000	50.000	-.260	.112
13	.000	.000	-.460	.000
14	9.300	78.900	-.390	.073
15	19.600	78.500	.110	.184
16	.000	.000	-.790	.000
17	18.000	59.700	-.230	.173
18	12.300	69.000	-.160	.109
19	36.700	67.400	.040	.371
20	39.300	76.600	-.070	.396

-----End of Data Listing-----

Sandy loam data, 8/13/89, x1=cc%, x2=gc%, y = (Kf/KS0) -1

Regression through the origin for
y = a*x1 + b*x2

a = .028 b = .011

$$\frac{K_f}{K_{S_0}} = 1.0 + 0.028\,CC\% + 0.011\,GC\%$$

With Rsquared = .720

Data Listing

i	x1(i)	x2(i)	y(i)	ypred(i)
1	23.500	1.900	.200	.679
2	44.400	26.700	2.560	1.547
3	35.200	27.200	.730	1.295
4	32.100	10.500	1.030	1.018
5	20.300	17.600	.470	.769
6	26.000	14.700	.700	.895
7	20.000	17.700	.320	.761
8	34.700	57.900	1.630	1.631
9	.000	59.400	.500	.678
10	.000	18.800	.160	.215
11	48.700	63.900	2.160	2.091
12	.000	65.000	.930	.742
13	.000	21.900	.240	.250
14	23.000	2.100	.880	.667
15	12.000	1.200	.470	.349
16	26.000	2.000	.600	.750

-----End of Data Listing-----

25x

Loam data, 8/13/89, x1=cc%, x2=gc%, y = (Kf/KS0) -1

Regression through the origin for
y = a*x1 + b*x2

$$\frac{K_f}{K_{S0}} = 1.0 + 0.036\,CC\% + 0.009\,GC\%$$

a = .036 b = .009

With Rsquared = .605

Data Listing

i	x1(i)	x2(i)	y(i)	ypred(i)
1	22.000	76.500	2.200	1.506
2	.000	78.100	.140	.725
3	.000	16.600	-.250	.154
4	22.000	1.000	.110	.804

-----End of Data Listing-----

Loamy sand data, 8/13/89, adj for gravel, x1=cc%, x2=gc%, y=Kf/KS0 -1

Regression through the origin for
y = a*x1 + b*x2

a = .013 b = .003

$$\frac{K_f}{K_{S0ADJ}} = 1.0 + 0.013\,CC\% + 0.003\,GC\%$$

With Rsquared = .420

Data Listing

i	x1(i)	x2(i)	y(i)	ypred(i)
1	57.000	35.000	.520	.878
2	25.000	70.400	1.020	.556
3	41.200	57.800	1.520	.735
4	17.000	82.700	1.700	.486
5	65.200	57.300	1.080	1.058
6	.000	62.400	.240	.194
7	.000	23.600	-.190	.073
8	21.200	78.400	.250	.529
9	.000	70.800	.090	.220
10	.000	16.800	-.400	.052
11	5.000	52.700	.040	.231
12	12.000	50.000	-.120	.317
13	.000	.000	-.320	.000
14	9.300	78.900	-.200	.370
15	19.600	78.500	.510	.508
16	.000	.000	-.640	.000
17	18.000	59.700	.450	.428
18	12.300	69.000	.490	.380
19	36.700	67.400	.420	.704
20	39.300	76.600	.270	.768

-----End of Data Listing-----

Sandy loam data, 813/89, adj for gravel, x1=cc%, x2=gc%, y=Kf/KS0 -1

Regression through the origin for
y = a*x1 + b*x2

a = .043 b = .055

$$\frac{K_f}{K_{SO\,ADJ}} = 1.0 + 0.043\,CC\% + 0.055\,GC\%$$

With Rsquared = .783

Data Listing

i	x1(i)	x2(i)	y(i)	ypred(i)
1	23.500	1.900	.200	1.121
2	44.400	26.700	4.840	3.385
3	35.200	27.200	1.840	3.014
4	32.100	10.500	2.330	1.965
5	20.300	17.600	1.410	1.843
6	26.000	14.700	1.790	1.931
7	20.000	17.700	.530	1.836
8	34.700	57.900	4.260	4.675
9	.000	59.400	2.000	3.256
10	.000	18.800	1.320	1.030
11	48.700	63.900	6.900	5.610
12	.000	65.000	3.820	3.562
13	.000	21.900	2.100	1.200
14	23.000	2.100	.880	1.111
15	12.000	1.200	.470	.585
16	26.000	2.000	.600	1.235

-----End of Data Listing-----

Loam, 8/13/89, adj for gravel, x1=cc%, x2=gc%, y = Kf/KS0 - 1

Regression through the origin for
y = a*x1 + b*x2

a = .039 b = .012

With Rsquared = .625

Data Listing

i	x1(i)	x2(i)	y(i)	ypred(i)
1	22.000	76.500	2.530	1.765
2	.000	78.100	.260	.921
3	.000	16.600	-.170	.196
4	22.000	1.000	.110	.875

-----End of Data Listing-----

(5) PROGRAM DOCUMENTATION & PROGRAM LISTING

PROGRAM DOCUMENTATION

PROGRAM: REGORGN2

PURPOSE: Two perform regression through the origin for two independent variables:

```
Model:    y = a*x1 + b*x2
Solution: Estimates of a and b and  R squared
```

LANGUAGE: FORTRAN 77

```
Input units: * keyboard, 1 input files
Output Units: * screen, 99 output file

Input Information: 1. title, FORMAT 510
                   2. fmt,   FORMAT 510
                      fmt is the variable format for
                      the input data.
                   3. filen, FORMAT 510
                      filen is the filename for the
                      input data x1(i) x2(i) y(i) read
                      in under the format fmt
                   4. fname, FORMAT 510
                      fname is the filename for all
                      file output
                   5. temp1,temp2,temp3  FORMAT fmt
                      x1(i) = temp1
                      x2(i) = temp2
                      y(i)  = temp3
                      for i = 1 to i = nx

Output Information: 1. title, FORMAT 510
                       Output to screen and fname
                    2. Heading, FORMAT 600
                       Output to screen and fname
                    3. Equation, FORMAT 610
                       Output to screen and fname
                    4. a and b, FORMAT 620
                       Output to screen and fname
                    5. rsqrd, FORMAT 630
                       Output to screen and fname
                    6. Heading, FORMAT 635
                       Output to fname only
                    7. Heading, FORMAT 640
                       Output to fname only
                    8. i,x1(i),x2(i),y(i),yhat(i)
                              FORMAT 650
                       Output to fname only
                    9. Heading, FORMAT 660
                       Output to fname only
```

EXAMPLE:

Suppose you have a problem with the following.

```
Title: Test run for two vars
fmt: (20x,3f10.2)  This is the format for the x1,x2,y data
filen: test1.dat   This is file name for input data
fname: test1.out   This is file name for output data
```

To run the program you would enter the following data in response to the program prompts.

Prompt	User Input
Enter Job Title	Test run for two vars
Enter format for data (?x,fnn.n,fnn.n,fnn.n)	(20x,3f10.2)
Enter file name for input data	test1.dat
Enter file name for output	test1.dat

At this point the program will read in the data from the file called test1.dat. The file test1.dat looks like this: Note that the first three rows below are for illustrative purposes and are not in the data file. The data file would only contain the lines labeled actual data below. That is, the data file test1.dat would consist of six rows of data.

```
Column in data file
123456789112345678921234567893123456789412345678951234567 89
         0         0         0         0         0
   actual data            1.20      2.22      3.55
   actual data            3.33      4.44      7.32
   actual data            8.00    100.50    125.90
   actual data            0.50      0.50      1.10
   actual data            3.21     55.90     75.00
   actual data           50.00      1.95     82.00
```

The output data (in file fname) would look like the following.

```
 Test run for two vars


      Regression through the origin for
      y = a*x1 + b*x2

      a =       1.588  b =       1.154

    With Rsquared =        .997

    Data Listing

    i          x1(i)        x2(i)        y(i)       ypred(i)

    1          1.200        2.220       3.550         4.469
    2          3.330        4.440       7.320        10.415
    3          8.000      100.500     125.900       128.733
    4           .500         .500       1.100         1.371
    5          3.210       55.900      75.000        69.635
    6         50.000        1.950      82.000        81.660

-----End of Data Listing-----
```

```
      program regorgn2
c               Program to perform regression analysis
c               through the origin for two independent variables
c               y = ax1 + bx2
c         L. J. Lane, July 1989

c
                character*80 title
                character*80 fmt
                character*1 ans1
                character*12 filen
                character*12 fname
                common x1(1000),x2(1000),y(1000),yhat(1000)

c     section to input job info

                write (*,500)
500             format(' Enter Job Title ')
                read (*,510) title
510             format(a)
                write (*,505)
505       format(' Enter format for data (?x,fnn.n,fnn.n,fnn.n) ')
                read(*,510)fmt
                write(*,520)
520             format(' Enter file name for input data ')
                read (*,510) filen
                open(1,file=filen,status='old')
c
                write(*,560)
560             format(' Enter file name for output ')
                read(*,510)fname
                open(unit=99,file=fname,status='new')
                nx = 0
c
c               read in data x1(i),x2(i),y(i), i=1 to nx
c
10              read(1,fmt,end=20) temp1,temp2,temp3
                nx = nx + 1
                x1(nx) = temp1
                x2(nx) = temp2
                y(nx)  = temp3
                go to 10
20              rewind 1
                nx = nx
                xnum = nx
c
c               initialize variables
c
            sumx1 = 0.0
            sumx2 = 0.0
            sumy  = 0.0
            sumx1y = 0.0
            sumx1x2 = 0.0
            sumx2y = 0.0
            sumx1sq = 0.0
            sumx2sq = 0.0
```

```
c
          do 30 i =1,nx
            sumx1 = sumx1 + x1(i)
            sumx2 = sumx2 + x2(i)
            sumy = sumy + y(i)
            sumx1y = sumx1y + x1(i)*y(i)
            sumx1x2 = sumx1x2 + x1(i)*x2(i)
            sumx2y = sumx2y + x2(i)*y(i)
            sumx1sq = sumx1sq + x1(i)*x1(i)
            sumx2sq = sumx2sq + x2(i)*x2(i)
30        continue
c
c           calculate regression coefficients
c
            b = sumx1y*sumx1x2 - sumx1sq*sumx2y
            b = b/((sumx1x2*sumx1x2) - sumx1sq*sumx2sq)
            a = (sumx2y - b*sumx2sq)/(sumx1x2)
c
c           calculate estimated y values
c
           sse = 0.0
           ssy = 0.0
           ybar = sumy/nx
         do 40 i = 1,nx
           yhat(i) = a*x1(i) + b*x2(i)
           sse = sse + (y(i)-yhat(i))*(y(i)-yhat(i))
           ssy = ssy + (y(i)-ybar)*(y(i)-ybar)
40       continue
           rsqrd = 1.0 - (sse/ssy)
c
c          section to write out results
c
         write(*,510)title
         write(99,510)title
         write(*,600)
         write(99,600)
600      format(//,5x,' Regression through the origin for ')
         write(*,610)
         write(99,610)
610      format(5x,' y = a*x1 + b*x2 ')
         write(*,620)a,b
         write(99,620)a,b
620      format(/,'       a = ',f10.3,'  b = ',f10.3)
         if((rsqrd.gt.0.0).and.(rsqrd.le.1.0)) then
         write(*,630)rsqrd
         write(99,630)rsqrd
         else
         endif
630      format(/,'    With Rsquared = ',f10.3,)
c
         write(99,635)
635      format(/,'    Data Listing ')
         write(99,640)
```

```
640     format(/,'     i          x1(i)          x2(i)          y(i)
     1  ypred(i)    ',/)
        do 50 i=1,nx
         write(99,650)i,x1(i),x2(i),y(i),yhat(i)
50      continue
650     format(i5,4x,f10.3,3x,f10.3,1x,f10.3,7x,f12.3)
        write(99,660)
660     format(/,'-----End of Data Listing-----',///)
        end
```

L. J. LANE
JULY 8, 1989

$$y = ax_1 + bx_2$$

$$G = \sum \left[y - (ax_1 + bx_2) \right]^2$$

$$G = \sum \; y^2 - 2y(ax_1 + bx_2) + (ax_1 + bx_2)^2 \Big]$$

$$G = \sum \left[y^2 - 2ax_1y - 2bx_2y + a^2x_1^2 + 2abx_1x_2 + b^2x_2^2 \right]$$

$$\frac{\partial G}{\partial a} = \sum \left[-2x_1y + 2ax_1^2 + 2bx_1x_2 \right]$$

$$\frac{\partial G}{\partial a} = -\cancel{2} \sum x_1y + \cancel{2}a \sum x_1^2 + \cancel{2}b \sum x_1x_2 = 0$$

$$\Rightarrow \frac{\partial G}{\partial a} = -\sum x_1y + a \sum x_1^2 + b \sum x_1x_2 = 0$$

$$\frac{\partial G}{\partial b} = \sum \left[-2x_2y + 2ax_1x_2 + 2bx_2^2 \right]$$

$$\frac{\partial G}{\partial b} = -\cancel{2} \sum x_2y + \cancel{2}a \sum x_1x_2 + \cancel{2}b \sum x_2^2 = 0$$

$$\frac{\partial G}{\partial b} = -\sum x_2y + a \sum x_1x_2 + b \sum x_2^2 = 0$$

$$\begin{cases} a \sum x_1^2 + b \sum x_1x_2 - \sum x_1y = 0 & (1) \\ a \sum x_1x_2 + b \sum x_2^2 - \sum x_2y = 0 & (2) \end{cases}$$

FROM (2)

$$a \Sigma x_1 x_2 = \Sigma x_2 y - b \Sigma x_2^2$$

$$\Rightarrow \boxed{a = \frac{\Sigma x_2 y - b \Sigma x_2^2}{\Sigma x_1 x_2}}$$

SUBSTITUTE INTO (1)

$$\Sigma x_1^2 \left(\frac{\Sigma x_2 y - b \Sigma x_2^2}{\Sigma x_1 x_2} \right) + b \Sigma x_1 x_2 - \Sigma x_1 y = 0$$

$$\Sigma x_1^2 \Sigma x_2 y - \cancel{\Sigma x_1^2 b \Sigma x_2^2} + \cancel{b \Sigma x_1 x_2 \Sigma x_1 x_2} - \Sigma x_1 y \Sigma x_1 x_2 = 0$$

$$\Rightarrow b \left((\Sigma x_1 x_2)^2 - \Sigma x_1^2 \Sigma x_2^2 \right) + \Sigma x_1^2 \Sigma x_2 y - \Sigma x_1 y \Sigma x_1 \Sigma x_2 = 0$$

$$\Rightarrow b (\qquad\qquad) = \Sigma x_1 y \Sigma x_1 \Sigma x_2 - \Sigma x_1^2 \Sigma x_2 y$$

$$\Rightarrow \boxed{\begin{aligned} b &= \frac{\Sigma x_1 y \Sigma x_1 \Sigma x_2 - \Sigma x_1^2 \Sigma x_2 y}{(\Sigma x_1 x_2)^2 - \Sigma x_1^2 \Sigma x_2^2} \\ a &= \frac{\Sigma x_2 y - b \Sigma x_2^2}{\Sigma x_1 x_2} \end{aligned}}$$

ALL DATA

Regression through the origin for
y = a*x1 + b*x2

a = .021 b = .001

With Rsquared = .275

Data Listing

i	x1(i)	x2(i)	y(i)	ypred(i)
1	23.500	1.900	.200	.502
2	44.400	26.700	2.560	.979
3	35.200	27.200	.730	.784
4	32.100	10.500	1.030	.696
5	20.300	17.600	.470	.455
6	26.000	14.700	.700	.572
7	20.000	17.700	.320	.448
8	34.700	57.900	1.630	.815
9	.000	59.400	.500	.080
10	.000	18.800	.160	.025
11	48.700	63.900	2.160	1.120
12	.000	65.000	.930	.087
13	.000	21.900	.240	.029
14	23.000	2.100	.880	.491
15	12.000	1.200	.470	.256
16	26.000	2.000	.600	.555
17	57.000	35.000	.520	1.257
18	25.000	70.400	1.020	.626
19	41.200	57.800	1.520	.953
20	17.000	82.700	1.700	.472
21	65.200	57.300	.180	1.461
22	.000	62.400	-.300	.084
23	.000	23.600	-.540	.032
24	21.200	78.400	.120	.556
25	.000	70.800	-.020	.095
26	.000	16.800	-.460	.023
27	5.000	52.700	-.140	.177
28	12.000	50.000	-.260	.322
29	.000	.000	-.460	.000
30	9.300	78.900	-.390	.304
31	19.600	78.500	.110	.522
32	.000	.000	-.790	.000
33	18.000	59.700	-.230	.463
34	12.300	69.000	-.160	.354
35	36.700	67.400	.040	.870
36	39.300	76.600	-.070	.938
37	22.000	76.500	2.200	.570
38	.000	78.100	.140	.105
39	.000	16.600	-.250	.022
40	22.000	1.000	.110	.468

-----End of Data Listing-----

$$K_f/K_{so} = 1 + \overset{.02}{.021}\,CC + \overset{.01}{.001}\,GC$$

CC \ GC	0	10	20	30	40	50	60	70	80	90	100
0	1.00	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10
10	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31
20	1.42	1.43	1.44	1.45	1.46	1.47	1.48	1.49	1.50	1.51	1.52
30	1.63										
40	1.84										
50	2.05										
60	2.26										
70	2.47										
80	2.68										
90	2.89										
100	3.10	3.11	3.12	3.13	3.14	3.15	3.16	3.17	3.18	3.19	3.20

30 Aug 89

$$K_s / K_{so} = 1.0 + a(cc) + b(gc)$$

	a	b
loamy sand	.011	0.0
sandy loam	.028	.011
Loam	.036	.009

loamy sand

cc \ gc	0	10	20	30	40	50	60	70	80	90	100
0	1.00										
10	1.11										
20	1.22										
30	1.33										
40	1.44										
50	1.55										
60	1.66										
70	1.77										
80	1.88										
90	1.99										
100	2.10										

sandy loam

cc \ gc	0	10	20	30	40	50	60	70	80	90	100
0	1.00										2.10
10	1.28										
20	1.58										
30	1.84										
40	2.12										
50	2.40										
60	2.68										
70	2.96										
80	3.24										
90	3.52										
100	3.80	3.91	4.02	4.13	4.24	4.35	4.46	4.57	4.68	4.79	4.90

27 July 89

Tim,

I've calculated the loss rates from the simulator data for the NM rangeland project. For this, I have calculated the loss rate by the following:

$$f = i - r$$

where f is loss rate, in in/hr,
i is raintall intensity, in in/hr, and
r is runoff rate, in in/hr.

Raintall (sprinkler) intensity (i) is provided in Tables 3-6 of the data report.

Runoff rate was calculated from the data in Appendix A as:

$$r = \frac{\Delta \text{ depth}}{\Delta \text{ time}} * 60$$

where Δ depth is the incremental runoff depth, in inches, and
Δ time is the incremental time between measurements, in minutes.

I only used the <u>wet</u> runs for these calculations. The results for each wet run are enclosed. The final loss rates are extremely high.

An enclosed table shows the results for the Fort Stanton (FS) data. The Avg. Final Loss Rate is the average of the final loss rates for all replicates. These loss rates are 2 to 4 inches/hour. Can this be correct, or have I made an error in interpreting or analyzing the data?

I'll give you a call after 18 August. Any help that you can lend would be appreciated.

I called Leonard Lane last night. He would like you to call him, 602-575 8009 (home).

Thanks for your help.

Leo

Copy: L. Lane w/ enclosures

Plot ID No.	Gradation Sand %	Gradation Silt %	Gradation Clay %	Texture Class	Cover Plant %	Cover Total %	Avg. Final Loss Rate in/hr
FS-MC	43.4	28.3	28.3	L, CL, SCL	43.7	50.6	1.87
FS-HC	42.6	28.1	29.4	CL	42.7	53.3	2.63
FS-EX	39.9	29.1	31.1	CL	52.3	75.3	3.79
FS-H-PH	42.1	31.4	26.5	L	15.3	95.1	3.92
FS-H-MG	38.2	36.2	25.7	L	44.1	49.1	2.62
FS-M-PJ	38.5	36.0	25.5	L	23.6	85.4	3.81
FS-H-LG	36.8	33.3	30.0	CL	71.3	76.5	3.54
FS-F	41.6	33.5	25.0	L	54.7	58.6	2.69
FS-FC	43.4	34.2	22.5	L	38.0	41.8	1.76

FS-MC-W3

RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.75	0.0000	0.0000	0.0000
11.25	0.0485	0.4477	4.0483
11.88	0.0808	3.0762	1.4198
13.75	0.1479	2.1529	2.3431
16.25	0.1596	0.2808	4.2152
17.50	0.2020	2.0352	2.4608
23.75	0.3778	1.6877	2.8083
30.00	0.6869	2.9674	1.5286

FS-MC-W4

RAINFALL INTENSITY 4.639 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.13	0.0000	0.0000	0.0000
3.75	0.0236	2.2839	2.3551
5.00	0.1010	3.7152	0.9238
11.88	0.2828	1.5855	3.0535
13.13	0.3047	1.0512	3.5878
14.38	0.3670	2.9904	1.6486
17.50	0.4646	1.8769	2.7621
20.00	0.5135	1.1736	3.4654
21.88	0.5943	2.5787	2.0603
26.88	0.7605	1.9944	2.6446
29.38	0.8502	2.1528	2.4862
30.00	0.8754	2.4387	2.2003

FS-HC-W1

RAINFALL INTENSITY 4.626 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.67	0.0000	0.0000	0.0000
5.00	0.0242	0.6232	4.0028
7.50	0.0343	0.2424	4.3836
10.63	0.0747	0.7744	3.8516
14.38	0.1535	1.2608	3.3652
17.50	0.2323	1.5154	3.1106
20.63	0.3212	1.7042	2.9218
23.75	0.4040	1.5923	3.0337
27.50	0.5172	1.8112	2.8148

FS-HC-W2

RAINFALL INTENSITY 4.362 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.92	0.0000	0.0000	0.0000
8.13	0.0970	0.9372	3.4248
10.63	0.1677	1.6968	2.6652
13.13	0.2586	2.1816	2.1804
17.50	0.4020	1.9689	2.3931
20.63	0.5293	2.4403	1.9217
23.13	0.6384	2.6184	1.7436
26.25	0.7535	2.2135	2.1485
30.00	0.8848	2.1008	2.2612

FS-HC-W3

RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.00	0.0000	0.0000	0.0000
6.25	0.0141	0.2603	4.2357
8.75	0.0323	0.4368	4.0592
10.63	0.0727	1.2894	3.2066
13.13	0.1131	0.9696	3.5264
15.63	0.1535	0.9696	3.5264
17.50	0.1960	1.3636	3.1324
20.63	0.2404	0.8511	3.6449
23.75	0.2970	1.0885	3.4075
26.25	0.3434	1.1136	3.3824
30.00	0.4687	2.0048	2.4912

FS-HC-W4

RAINFALL INTENSITY 4.658 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.83	0.0000	0.0000	0.0000
5.00	0.0545	1.0315	3.6265
7.50	0.1333	1.8912	2.7668
10.00	0.2101	1.8432	2.8148
12.50	0.2747	1.5504	3.1076
15.00	0.3636	2.1336	2.5244
17.50	0.4485	2.0376	2.6204
20.00	0.5394	2.1816	2.4764
23.75	0.6566	1.8752	2.7828
26.88	0.7515	1.8192	2.8388
31.25	0.8768	1.7204	2.9376

FS-EX-W1

RAINFALL INTENSITY 4.543 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
12.25	0.0000	0.0000	0.0000
23.50	0.0121	0.0645	4.4785
34.00	0.0283	0.0926	4.4504

FS-EX-W2

RAINFALL INTENSITY 4.124 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.50	0.0000	0.0000	0.0000
32.50	0.0000	0.0000	4.1240
0.00	0.0000	0.0000	4.1240

FS-EX-W2

RAINFALL INTENSITY 4.124 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.00	0.0000	0.0000	0.0000
4.50	0.0242	0.9680	3.1560
32.50	0.1212	0.2079	3.9161

FS-EX-W3

RAINFALL INTENSITY 3.886 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
7.00	0.0000	0.0000	0.0000
10.00	0.0469	0.9380	2.9480
15.00	0.1010	0.6492	3.2368
23.25	0.2222	0.8815	3.0045

FS-H-PJ-W1

RAINFALL INTENSITY 4.143 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
13.00	0.0000	0.0000	0.0000
16.88	0.0040	0.0619	4.0811
20.63	0.0182	0.2272	3.9158
26.25	0.0364	0.1943	3.9487
30.63	0.0566	0.2767	3.8663

FS-H-PJ-W3

RAINFALL INTENSITY 4.543 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.00	0.0000	0.0000	0.0000
4.38	0.0081	0.3522	4.1908
8.13	0.0505	0.6784	3.8646
11.25	0.0848	0.6596	3.8834
16.88	0.1414	0.6032	3.9398
21.25	0.1778	0.4998	4.0432
25.00	0.2162	0.6144	3.9286
30.00	0.2586	0.5088	4.0342

FS-H-PJ-W4

RAINFALL INTENSITY 4.020 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.67	0.0000	0.0000	0.0000
5.00	0.0020	0.3636	3.6564
8.75	0.0081	0.0976	3.9224
11.88	0.0121	0.0767	3.9433
17.50	0.0162	0.0438	3.9762
21.88	0.0202	0.0548	3.9652
26.25	0.0222	0.0275	3.9925
30.00	0.0323	0.1616	3.8584

FS-H-MG-W1

RAINFALL INTENSITY 4.591 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.47	0.0000	0.0000	0.0000
5.00	0.0222	0.5265	4.0645
8.75	0.0485	0.4208	4.1702
11.88	0.0768	0.5425	4.0485
15.63	0.1030	0.4192	4.1718
18.75	0.1253	0.4288	4.1622
23.13	0.1515	0.3589	4.2321
26.25	0.1758	0.4673	4.1237
30.00	0.2101	0.5488	4.0422

FS-H-MG-W2

RAINFALL INTENSITY 4.591 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.67	0.0000	0.0000	0.0000
4.38	0.0505	1.7719	2.8191
7.50	0.1030	1.0096	3.5814
11.25	0.1838	1.2928	3.2982
14.38	0.2505	1.2786	3.3124
18.13	0.3232	1.1632	3.4278
21.88	0.4162	1.4880	3.1030
25.63	0.5091	1.4864	3.1046
29.38	0.6141	1.6800	2.9110
30.00	0.6465	3.1355	1.4555

FS-H-MG-W3

RAINFALL INTENSITY 4.458 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.50	0.0000	0.0000	0.0000
2.50	0.0202	1.2120	3.2460
5.00	0.0747	1.3080	3.1500
8.13	0.1596	1.6275	2.8305
10.63	0.2485	2.1336	2.3244
15.00	0.3939	1.9963	2.4617
18.13	0.4949	1.9361	2.5219
21.88	0.6444	2.3920	2.0660
26.25	0.8162	2.3588	2.0992
30.75	0.9939	2.3693	2.0887

FS-H-MG-W4

RAINFALL INTENSITY 4.639 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.33	0.0000	0.0000	0.0000
3.13	0.0040	0.1333	4.5057
6.50	0.0424	0.6837	3.9553
8.75	0.1051	1.6720	2.9670
11.88	0.1737	1.3150	3.3240
16.25	0.2828	1.4979	3.1411
19.38	0.3758	1.7827	2.8563
23.00	0.4889	1.8746	2.7644
27.50	0.6202	1.7507	2.8883
31.75	0.7434	1.7393	2.8997

FS-M-PJ-W1

RAINFALL INTENSITY 4.629 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.08	0.0000	0.0000	0.0000
7.50	0.0081	0.1421	4.4869
10.63	0.0525	0.8511	3.7779
13.75	0.0929	0.7769	3.8521
18.13	0.1455	0.7205	3.9085
21.25	0.1838	0.7365	3.8925
25.00	0.2343	0.8080	3.8210
29.00	0.2747	0.6060	4.0230

FS-M-PJ-W2

RAINFALL INTENSITY 4.524 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.50	0.0000	0.0000	0.0000
6.88	0.0465	1.1723	3.3517
10.00	0.1051	1.1269	3.3971
13.75	0.1737	1.0976	3.4264
17.59	0.2424	1.0734	3.4506
21.25	0.3192	1.2590	3.2650
25.00	0.4000	1.2928	3.2312
30.00	0.5010	1.2120	3.3120

FS-M-PJ-W3

RAINFALL INTENSITY 4.601 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
14.00	0.0000	0.0000	0.0000
19.38	0.0061	0.0680	4.5330
23.55	0.0404	0.4935	4.1075
27.52	0.0768	0.5501	4.0509
30.00	0.0970	0.4887	4.1123

FS-H-LG-W1

RAINFALL INTENSITY 4.639 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
10.75	0.0000	0.0000	0.0000
15.63	0.0024	0.0295	4.6095
20.63	0.0065	0.0492	4.5898
26.88	0.0182	0.1123	4.5267
30.00	0.0234	0.1000	4.5390

FS-H-LG-W2

RAINFALL INTENSITY 4.324 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
5.00	0.0000	0.0000	0.0000
7.50	0.0303	0.7272	3.5968
13.13	0.1293	1.0551	3.2689
16.25	0.1762	0.9019	3.4221
21.25	0.2667	1.0860	3.2380
27.50	0.3798	1.0858	3.2382
30.30	0.4364	1.2129	3.1111

FS-H-LG-W3

RAINFALL INTENSITY 4.648 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.33	0.0000	0.0000	0.0000
5.63	0.0364	0.6618	3.9862
8.13	0.1010	1.5504	3.0976
10.63	0.1778	1.8432	2.8048
14.38	0.2828	1.6800	2.9680
17.50	0.4101	2.4481	2.1999
20.63	0.5253	2.2083	2.4397
23.13	0.6222	2.3256	2.3224
26.26	0.7313	2.0914	2.5566
30.00	0.8646	2.1385	2.5095

FS-H-LG-W4

RAINFALL INTENSITY 4.210 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
0.00	0.0000	0.0000	0.0000
5.00	0.0012	0.0144	4.1956
7.50	0.0020	0.0192	4.1908
10.63	0.0121	0.1936	4.0164
13.75	0.0202	0.1558	4.0542
17.50	0.0364	0.2592	3.9508
20.00	0.0444	0.1920	4.0180
22.50	0.0586	0.3408	3.8692
26.25	0.0747	0.2576	3.9524
30.00	0.0889	0.2272	3.9828

FS-F-W1

RAINFALL INTENSITY 4.562 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.75	0.0000	0.0000	0.0000
10.00	0.0061	0.0586	4.5034
14.38	0.0444	0.5247	4.0373
19.38	0.0869	0.5100	4.0520
22.50	0.1131	0.5038	4.0582
30.00	0.1455	0.2592	4.3028
31.25	0.1616	0.7728	3.7892

FS-F-W2

RAINFALL INTENSITY 4.591 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.33	0.0000	0.0000	0.0000
7.50	0.2485	2.4165	2.1745
12.50	0.4424	2.3268	2.2642
17.50	0.6263	2.2068	2.3842
21.25	0.7798	2.4560	2.1350
30.00	1.1051	2.2306	2.3604

FS-F-W3

RAINFALL INTENSITY 4.458 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.75	0.0000	0.0000	0.0000
6.50	0.0040	0.0640	4.3940
12.50	0.2384	2.3440	2.1140
26.25	0.7596	2.2743	2.1837
32.50	1.0020	2.3270	2.1310

FS-F-W4

RAINFALL INTENSITY 4.020 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.50	0.0000	0.0000	0.0000
5.63	0.0444	0.6450	3.3750
11.88	0.1818	1.3190	2.7010
16.25	0.3596	2.4412	1.5788
21.25	0.5010	1.6968	2.3232
28.25	0.6828	1.5583	2.4617
31.00	0.7531	1.5338	2.4862

FS-FC-W1

RAINFALL INTENSITY 4.362 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.92	0.0000	0.0000	0.0000
7.50	0.0081	0.0871	4.2749
13.13	0.0545	0.4945	3.8675
18.13	0.1212	0.8004	3.5616
23.75	0.2121	0.9705	3.3915
28.25	0.4303	2.9093	1.4527

FS-FC-W2

RAINFALL INTENSITY 4.515 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.50	0.0000	0.0000	0.0000
8.75	0.1212	1.3851	3.1299
15.00	0.3030	1.7453	2.7697
20.00	0.4848	2.1816	2.3334
25.00	0.6545	2.0364	2.4786
31.50	0.9414	2.6483	1.8667

FS-FC-W3

RAINFALL INTENSITY 4.648 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.33	0.0000	0.0000	0.0000
5.88	0.0788	1.0391	3.6089
10.88	0.3051	2.7156	1.9324
15.88	0.5313	2.7144	1.9336
19.63	0.7192	3.0064	1.6416
23.38	0.9192	3.2000	1.4480
27.13	1.1475	3.6528	0.9952
30.58	1.3091	2.8104	1.8376

FS-FC-W4

RAINFALL INTENSITY 4.458 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
0.91	0.0000	0.0000	0.0000
5.00	0.0889	1.3042	3.1538
10.63	0.3152	2.4117	2.0463
15.63	0.5657	3.0060	1.4520
18.75	0.7192	2.9519	1.5061
23.13	0.9131	2.6562	1.8018
27.50	1.1919	3.8279	0.6301
30.25	1.3111	2.6007	1.8573

T-G-LC-W1

RAINFALL INTENSITY 4.277 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.50	0.0000	0.0000	0.0000
13.13	0.0185	0.1286	4.1484
16.88	0.0623	0.7008	3.5762
20.00	0.1128	0.9712	3.3058
23.75	0.1768	1.0240	3.2530
27.50	0.2424	1.0496	3.2274
30.00	0.2879	1.0920	3.1850

T-G-LC-W2

RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.17	0.0000	0.0000	0.0000
6.25	0.0034	0.0981	4.3979
7.50	0.0118	0.4032	4.0928
9.38	0.0269	0.4819	4.0141
12.50	0.0724	0.8750	3.6210
16.25	0.1364	1.0240	3.4720
19.38	0.1936	1.0965	3.3995
23.13	0.2643	1.1312	3.3648
27.50	0.3451	1.1094	3.3866
30.00	0.4007	1.3344	3.1616

Y-G-LC-W3

RAINFALL INTENSITY 4.601 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.50	0.0000	0.0000	0.0000
7.50	0.0640	0.7680	3.8330
10.63	0.1145	0.9681	3.6329
17.50	0.2391	1.0882	3.5128
20.63	0.3569	2.2581	2.3429
25.00	0.4562	1.3634	3.2376
30.00	0.5859	1.5564	3.0446

T-G-LC-W4

RAINFALL INTENSITY 4.515 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
6.00	0.0000	0.0000	0.0000
7.50	0.0051	0.2040	4.3110
10.63	0.0724	1.2901	3.2249
16.88	0.3266	2.4403	2.0747
20.00	0.5522	4.3385	0.1765
24.38	0.7273	2.3986	2.1164
29.38	0.9495	2.6664	1.8486

T-BG-LC-W1

RAINFALL INTENSITY 4.610 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.50	0.0000	0.0000	0.0000
6.88	0.0051	0.0905	4.5195
10.00	0.1263	2.3308	2.2792
13.25	0.3350	3.8529	0.7571
16.88	0.4899	2.5603	2.0497
20.00	0.6481	3.0423	1.5677
23.13	0.8300	3.4869	1.1231
26.25	0.9714	2.7192	1.8908
29.50	1.1579	3.4431	1.1669
32.50	1.3401	3.6440	0.9660

T-BG-LC-W2

RAINFALL INTENSITY 4.562 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
7.00	0.0000	0.0000	0.0000
8.75	0.0320	1.0971	3.4649
13.13	0.1330	1.3836	3.1784
15.63	0.1869	1.2936	3.2684
19.38	0.2559	1.1040	3.4580
21.88	0.3081	1.2528	3.3092
24.38	0.3620	1.2936	3.2684
27.50	0.4377	1.4558	3.1062
30.00	0.5892	3.6360	0.9260

T-BG-LC-W3

RAINFALL INTENSITY 4.610 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.83	0.0000	0.0000	0.0000
11.88	0.2027	1.2101	3.3999
17.50	0.4646	2.7961	1.8139
20.63	0.6902	4.3246	0.2854
26.88	0.9747	2.7312	1.8788
30.00	1.1515	3.4000	1.2100

T-BG-LC-W4

RAINFALL INTENSITY 4.505 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
6.25	0.0000	0.0000	0.0000
13.75	0.1970	1.5760	2.9290
17.50	0.3939	3.1504	1.3546
24.38	0.6919	2.5988	1.9062
28.75	0.9057	2.9355	1.5695
30.63	0.9882	2.6330	1.8720

T-G-QH-W1

RAINFALL INTENSITY 4.267 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.50	0.0000	0.0000	0.0000
15.00	0.0808	0.4216	3.8454
23.50	0.2141	0.9409	3.3261
28.00	0.2949	1.0773	3.1897
30.00	0.3475	1.5780	2.6890

T-G-QH-W2

RAINFALL INTENSITY 4.591 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.33	0.0000	0.0000	0.0000
10.00	0.0253	0.2677	4.3233
15.00	0.1094	1.0092	3.5818
22.50	0.2306	0.9696	3.6214
28.13	0.3165	0.9155	3.6755
30.00	0.3653	1.5658	3.0252

T-G-QH-W3

RAINFALL INTENSITY 4.591 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.08	0.0000	0.0000	0.0000
10.00	0.0455	0.4611	4.1299
12.50	0.0976	1.2504	3.3406
20.63	0.2811	1.3542	3.2368
26.25	0.4192	1.4744	3.1166
30.00	0.5084	1.4272	3.1638

T-G-QH-W4

RAINFALL INTENSITY 4.543 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
7.50	0.0000	0.0000	0.0000
9.38	0.0034	0.1085	4.4345
10.63	0.0152	0.5664	3.9766
13.13	0.0471	0.7656	3.7774
20.63	0.1886	1.1320	3.4110
26.25	0.3249	1.4552	3.0878
30.00	0.4158	1.4544	3.0886

T-BG-QH-W1
RAINFALL INTENSITY 4.658 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
13.00	0.0000	0.0000	0.0000
19.38	0.0556	0.5229	4.1351
25.63	0.1279	0.6941	3.9639
31.25	0.2003	0.7730	3.8850
35.00	0.2492	0.7824	3.8756

T-BG-QH-W2
RAINFALL INTENSITY 4.610 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
13.83	0.0000	0.0000	0.0000
24.00	0.0808	0.4767	4.1333
30.00	0.1253	0.4450	4.1650
35.00	0.1616	0.4356	4.1744

T-BG-QH-W3
RAINFALL INTENSITY 4.639 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
7.50	0.0000	0.0000	0.0000
12.50	0.0370	0.4440	4.1950
16.88	0.1195	1.1301	3.5089
21.88	0.2323	1.3536	3.2854
26.88	0.3418	1.3140	3.3250
30.00	0.4108	1.3269	3.3121

T-BG-QH-W4
RAINFALL INTENSITY 4.648 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
4.00	0.0000	0.0000	0.0000
10.63	0.1111	1.0054	3.6426
16.88	0.2475	1.3094	3.3386
22.50	0.4125	1.7616	2.8864
26.88	0.5522	1.9137	2.7343
30.00	0.6532	1.9423	2.7057

T-MG-QH-W1
RAINFALL INTENSITY 4.477 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
9.50	0.0000	0.0000	0.0000
26.88	0.1532	0.5289	3.9481
30.00	0.2071	1.0365	3.4405

T-MG-QH-W2

RAINFALL INTENSITY 3.753 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
9.00	0.0000	0.0000	0.0000
16.88	0.0303	0.2307	3.5223
20.00	0.0808	0.9712	2.7818
24.38	0.1835	1.4068	2.3462
27.50	0.2845	1.9423	1.8107
30.00	0.3569	1.7376	2.0154

C-CPJ-W1

RAINFALL INTENSITY 4.591 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr	
0.83	0.0000	0.0000	0.0000	
2.60	0.0556	1.8847	2.7063	
9.38	0.3030	2.1894	2.4016	
? 10.00	0.4175	%11.08064556121826		%-6.489645481109619
13.13	0.5892	3.2914	1.2996	
17.50	0.7879	2.7281	1.8629	
20.63	0.9731	3.5502	1.0408	
25.00	1.1448	2.3574	2.2336	
27.50	1.2795	3.2328	1.3582	
30.00	1.4529	4.1616	0.4294	

C-CPJ-W2

RAINFALL INTENSITY 4.448 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.50	0.0000	0.0000	0.0000
5.63	0.0061	0.1169	4.3311
8.13	0.0586	1.2600	3.1880
10.63	0.1071	1.1640	3.2840
14.38	0.1737	1.0656	3.3824
18.13	0.2263	0.8416	3.6064
21.25	0.2929	1.2808	3.1672
25.63	0.3636	0.9685	3.4795
28.13	0.4040	0.9696	3.4784
31.00	0.4606	1.1833	3.2647

C-CPJ-W3

RAINFALL INTENSITY 4.429 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.08	0.0000	0.0000	0.0000
2.60	0.0438	1.7289	2.7001
6.25	0.1852	2.3244	2.1046
10.63	0.3636	2.4438	1.9852
14.38	0.5623	3.1792	1.2498
18.75	0.7539	2.6307	1.7983
21.88	0.9276	3.3297	1.0993
23.75	1.0236	3.0802	1.3488
25.00	1.1044	3.8784	0.5506
27.50	1.1919	2.1000	2.3290
29.25	1.2525	2.0777	2.3513

C-CPJ-W4

RAINFALL INTENSITY 4.086 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.33	0.0000	0.0000	0.0000
3.13	0.0303	1.0100	3.0760
6.88	0.1414	1.7776	2.3084
11.25	0.2889	2.0252	2.0608
16.88	0.4808	2.0451	2.0409
20.63	0.6586	2.8448	1.2412
23.75	0.8323	3.3404	0.7456
26.25	0.9414	2.6184	1.4676
27.50	0.9939	2.5200	1.5660
30.25	1.1232	2.8211	1.2649

C-CWPJ-W1

RAINFALL INTENSITY 4.210 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.00	0.0000	0.0000	0.0000
5.00	0.1354	2.0310	2.1790
10.00	0.3232	2.2536	1.9564
15.00	0.5697	2.9580	1.2520
20.00	0.8162	2.9580	1.2520
24.75	1.0707	3.2147	0.9953
28.25	1.2784	3.5606	0.6494
30.50	1.3859	2.8667	1.3433

~~4.2102~~

C-CWPJ-W2

RAINFALL INTENSITY 4.505 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.08	0.0000	0.0000	0.0000
6.25	0.1152	1.3369	3.1681
11.50	0.2768	1.8469	2.6581
16.25	0.4929	2.7297	1.7753
21.00	0.6909	2.5011	2.0039
26.00	0.9051	2.5704	1.9346
30.50	1.0747	2.2613	2.2437
33.50	1.1879	2.2640	2.2410

C-CWPJ-W3

RAINFALL INTENSITY 4.639 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr	
1.08	0.0000	0.0000	0.0000	
5.00	0.1152	1.7633	2.8757	
10.00	0.3071	2.3028	2.3362	
15.00	0.5091	2.4240	2.2150	
20.00	0.6990	2.2788	2.3602	~~53125~~
24.38	0.9091	2.8781	1.7609	~~286875~~
30.00	1.1677	2.7609	1.8781	

C-CWPJ-W4

RAINFALL INTENSITY 4.639 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr	
1.50	0.0000	0.0000	0.0000	
5.00	0.0444	0.7611	3.8779	
10.00	0.2101	1.9884	2.6506	
15.00	0.4101	2.4000	2.2390	
19.38	0.6020	2.6288	2.0102	
24.38	0.8040	2.4240	2.2150	
29.50	1.0012	2.3109	2.3281	~~1636~~
31.20	1.0659	2.2835	2.3555	

C-PJ-W2

RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.33	0.0000	0.0000	0.0000
11.88	0.1859	1.3046	3.1914
15.00	0.2909	2.0192	2.4768
18.75	0.3838	1.4864	3.0096
21.88	0.4747	1.7425	2.7535
24.38	0.5535	1.8912	2.6048
28.13	0.6646	1.7776	2.7184

C-PJ-W3

RAINFALL INTENSITY 4.583 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.25	0.0000	0.0000	0.0000
3.75	0.0707	1.6968	2.8862
6.88	0.2101	2.6722	1.9108
10.00	0.3596	2.8750	1.7080
13.13	0.4848	2.4000	2.1830
16.25	0.6141	2.4865	2.0965
20.00	0.7980	2.9424	1.6406
22.50	0.9313	3.1992	1.3838
25.63	1.1535	4.2594	0.3236
30.00	1.2424	1.2206	3.3624

C-PJ-W4

RAINFALL INTENSITY 4.505 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.67	0.0000	0.0000	0.0000
5.00	0.0848	1.5279	2.9771
8.13	0.1374	1.0083	3.4967
12.50	0.2202	1.1368	3.3682
15.63	0.2990	1.5105	2.9945
20.00	0.3960	1.3318	3.1732
25.00	0.5071	1.3332	3.1718
27.50	0.5939	2.0832	2.4218
30.00	0.6606	1.6008	2.9042

4.5056

C-SB-W1

RAINFALL INTENSITY 4.562 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
0.33	0.0000	0.0000	0.0000
1.25	0.0202	1.3174	3.2446
3.75	0.1354	2.7648	1.7972
7.50	0.3677	3.7168	0.8452
11.25	0.5737	3.2960	1.2660
15.00	0.7737	3.2000	1.3620
20.00	1.0303	3.0792	1.4828
22.50	1.1798	3.5880	0.9740

C-SB-W2

RAINFALL INTENSITY 4.658 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
0.50	0.0000	0.0000	0.0000
1.88	0.0283	1.2304	3.4276
4.38	0.1293	2.4240	2.2340
8.13	0.2667	2.1984	2.4596
11.25	0.3919	2.4077	2.2503
15.00	0.4525	0.9696	3.6884
20.63	0.6000	1.5719	3.0861
23.13	0.7192	2.8608	1.7972
25.63	0.8101	2.1816	2.4764

C-SB-W3

RAINFALL INTENSITY 4.601 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
0.58	0.0000	0.0000	0.0000
3.75	0.0606	1.1470	3.4540
7.00	0.1859	2.3132	2.2878
13.25	0.3879	1.9392	2.6618
17.00	0.5333	2.3264	2.2746
20.63	0.7131	2.9719	1.6291
24.83	0.8566	2.0500	2.5510
26.25	0.9374	3.4141	1.1869

C-SB-W4

RAINFALL INTENSITY 4.582 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
0.58	0.0000	0.0000	0.0000
2.50	0.0727	2.2719	2.3101
5.00	0.2101	3.2976	1.2844
12.50	0.4606	2.0040	2.5780
15.63	0.6263	3.1764	1.4056
20.00	0.8202	2.6622	1.9198
23.75	1.0303	3.3616	1.2204
25.63	1.1212	2.9011	1.6809

C-TSB-W1

RAINFALL INTENSITY 4.543 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.83	0.0000	0.0000	0.0000
6.88	0.0061	0.0904	4.4526
12.50	0.1495	1.5310	3.0120
15.63	0.2505	1.9361	2.6069
18.75	0.3434	1.7865	2.7565
21.88	0.4646	2.3233	2.2197
25.00	0.5697	2.0212	2.5218

C-TSB-W2

RAINFALL INTENSITY 4.410 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.17	0.0000	0.0000	0.0000
6.88	0.1374	1.7503	2.6597
11.88	0.3374	2.4000	2.0100
15.63	0.5455	3.3296	1.0804
18.75	0.6909	2.7962	1.6138
22.50	0.8808	3.0384	1.3716
25.00	1.0263	3.4920	0.9180

C-TSB-W3

RAINFALL INTENSITY 4.648 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.08	0.0000	0.0000	0.0000
6.88	0.1212	1.2538	3.3942
11.88	0.2869	1.9884	2.6596
15.63	0.4283	2.2624	2.3856
21.88	0.6707	2.3270	2.3210
24.38	0.7758	2.5224	2.1256
25.63	0.8485	3.4896	1.1584

C-TSB-W4

RAINFALL INTENSITY 3.934 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.67	0.0000	0.0000	0.0000
6.25	0.0606	0.7939	3.1401
11.25	0.2141	1.8420	2.0920
15.00	0.3475	2.1344	1.7996
21.25	0.5859	2.2886	1.6454
24.38	0.7192	2.5553	1.3787
25.00	0.7515	3.1258	0.8082

C-TCP-W1

RAINFALL INTENSITY 4.277 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr	
2.25	0.0000	0.0000	0.0000	
6.25	0.0707	1.0605	3.2165	
10.63	%2808	%38464.78515625		%-38460.5078125
15.00	0.0000	%-38553.77734375		%38558.0546875
16.88	0.0000	0.0000	4.2770	
20.63	0.0000	0.0000	4.2770	

C-TSB-W1

RAINFALL INTENSITY 4.277 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.25	0.0000	0.0000	0.0000
6.25	0.0707	1.0605	3.2165
10.63	0.2808	2.8781	1.3989
15.00	0.4586	2.4412	1.8358
16.88	0.5677	3.4819	0.7951
20.63	0.7030	2.1648	2.1122

C-TSB-W2
RAINFALL INTENSITY 4.524 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.92	0.0000	0.0000	0.0000
6.25	0.0323	0.5820	3.9420
10.63	0.0889	0.7753	3.7487
14.38	0.1535	1.0336	3.4904
18.75	0.2182	0.8883	3.6357
20.63	0.2586	1.2894	3.2346

C-TCP-W3
RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
0.75	0.0000	0.0000	0.0000
6.88	0.0141	0.1380	4.3580
9.38	0.0545	0.9696	3.5264
12.50	0.1253	1.3615	3.1345
15.63	0.2000	1.4319	3.0641
18.13	0.2566	1.3584	3.1376
20.63	0.3394	1.9872	2.5088

C-TSB-W4
RAINFALL INTENSITY 4.610 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.08	0.0000	0.0000	0.0000
4.38	0.0774	2.0191	2.5909
8.13	0.1970	1.9136	2.6964
10.63	0.3047	2.5848	2.0252
15.00	0.4562	2.0801	2.5299
17.50	0.5185	1.4952	3.1148
20.63	0.6198	1.9419	2.6681

C-BSB-W1
RAINFALL INTENSITY 4.372 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.15	0.0000	0.0000	0.0000
5.63	0.0384	0.5143	3.8577
10.00	0.1051	0.9158	3.4562
14.38	0.1737	0.9397	3.4323
18.13	0.2626	1.4224	2.9496
22.50	0.3475	1.1657	3.2063
30.00	0.4848	1.0984	3.2736

C-BSB-W2
RAINFALL INTENSITY 4.610 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.67	0.0000	0.0000	0.0000
8.75	0.0061	0.0720	4.5380
14.38	0.0343	0.3005	4.3095
18.13	0.0747	0.6464	3.9636
22.50	0.1172	0.5835	4.0265
30.00	0.1657	0.3880	4.2220

C-NSB-W1

RAINFALL INTENSITY 4.648 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.13	0.0000	0.0000	0.0000
3.75	0.0444	1.0168	3.6312
6.88	0.1131	1.3169	3.3311
11.88	0.2182	1.2612	3.3868
16.25	0.3010	1.1368	3.5112
20.00	0.3798	1.2608	3.3872
25.00	0.5051	1.5036	3.1444

C-NSB-W2

RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.83	0.0000	0.0000	0.0000
4.38	0.0626	1.4729	3.0231
7.50	0.2101	2.8365	1.6595
13.13	0.4687	2.7560	1.7400
16.88	0.6707	3.2320	1.2640
21.00	0.8889	3.1777	1.3183
26.00	1.1556	3.2004	1.2956

C-NSB-W3

RAINFALL INTENSITY 4.505 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
0.50	0.0000	0.0000	0.0000
2.50	0.0545	1.6350	2.8700
5.63	0.1939	2.6722	1.8328
9.38	0.4121	3.4912	1.0138
13.75	0.6606	3.4119	1.0931
17.50	0.8768	3.4592	1.0458
21.25	1.0707	3.1024	1.4026
26.00	1.3293	3.2665	1.2385

M-HG-W1

RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.33	0.0000	0.0000	0.0000
5.00	0.0909	1.4861	3.0099
9.38	0.2163	1.7178	2.7782
12.50	0.3495	2.5615	1.9345
15.63	0.4646	2.2064	2.2896
18.13	0.5758	2.6688	1.8272
21.25	0.7253	2.8750	1.6210
23.13	0.7899	2.0617	2.4343
26.00	0.9172	2.6613	1.8347

M-HG-W2

RAINFALL INTENSITY 4.562 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.50	0.0000	0.0000	0.0000
6.25	0.1657	2.0931	2.4689
9.38	0.2970	2.5169	2.0451
12.50	0.4606	3.1462	1.4158
15.50	0.5960	2.7080	1.8540
18.13	0.7414	3.3171	1.2449
22.00	0.9192	2.7566	1.8054
23.13	0.9818	3.3239	1.2381
26.25	1.1091	2.4481	2.1139

M-HG-W3

RAINFALL INTENSITY 4.658 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.25	0.0000	0.0000	0.0000
7.50	0.1596	1.5322	3.1258
10.00	0.2566	2.3280	2.3300
15.00	0.4465	2.2788	2.3792
20.00	0.6525	2.4720	2.1860
22.50	0.7616	2.6184	2.0396
26.25	0.9212	2.5536	2.1044

M-HG-W4

RAINFALL INTENSITY 4.553 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.50	0.0000	0.0000	0.0000
3.75	0.0545	1.4533	3.0997
7.50	0.2242	2.7152	1.8378
10.63	0.3616	2.6339	1.9191
15.75	0.6364	3.2203	1.3327
20.00	0.9131	3.9064	0.6466
22.75	1.0505	2.9978	1.5552
25.75	1.2121	3.2320	1.3210

M-LG-W1

RAINFALL INTENSITY 4.143 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.82	0.0000	0.0000	0.0000
4.38	0.0485	1.8654	2.2776
8.13	0.1778	2.0688	2.0742
12.50	0.3253	2.0252	2.1178
16.25	0.4727	2.3584	1.7846
20.00	0.6303	2.5216	1.6214
22.00	0.7030	2.1810	1.9620
25.00	0.8202	2.3440	1.7990

M-LG-W2

RAINFALL INTENSITY 4.582 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.08	0.0000	0.0000	0.0000
3.13	0.0586	1.7151	2.8669
7.50	0.1758	1.6092	2.9728
11.25	0.3253	2.3920	2.1900
15.00	0.4707	2.3264	2.2556
18.75	0.6081	2.1984	2.3836
20.25	0.6667	2.3440	2.2380
22.63	0.7596	2.3420	2.2400

M-LG-W3

RAINFALL INTENSITY 4.448 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
2.67	0.0000	0.0000	0.0000
7.50	0.1030	1.2795	3.1685
16.25	0.2263	0.8455	3.6025
21.88	0.3717	1.5496	2.8984
23.75	0.4121	1.2963	3.1517
26.25	0.4929	1.9392	2.5088

M-LG-W4

RAINFALL INTENSITY 4.601 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
7.50	0.0000	0.0000	0.0000
9.38	0.0768	2.4511	2.1499
15.00	0.2848	2.2206	2.3804
18.13	0.4525	3.2147	1.3863
21.25	0.5899	2.6423	1.9587
23.00	0.6869	3.3257	1.2753
27.25	0.8444	2.2235	2.3775

M-PJ-W1

RAINFALL INTENSITY 4.639 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE. in/hr
2.23	0.0000	0.0000	0.0000
6.25	0.0444	0.6627	3.9763
11.88	0.1152	0.7545	3.8845
16.25	0.2040	1.2192	3.4198
20.63	0.3152	1.5233	3.1157
24.38	0.4000	1.3568	3.2822
25.00	0.4283	2.7387	1.9003

M-PJ-W2

RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
1.85	0.0000	0.0000	0.0000
6.25	0.0061	0.0832	4.4128
11.88	0.0242	0.1929	4.3031
16.25	0.0384	0.1950	4.3010
20.63	0.0505	0.1658	4.3302
25.00	0.0646	0.1936	4.3024

M-PJ-W3

RAINFALL INTENSITY 4.496 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr
3.00	0.0000	0.0000	0.0000
5.00	0.0101	0.3030	4.1930
7.50	0.0768	1.6008	2.8952
11.88	0.1798	1.4110	3.0850
15.00	0.2747	1.8250	2.6710
18.75	0.3475	1.1648	3.3312
21.88	0.4202	1.3936	3.1024
25.00	0.5111	1.7481	2.7479

M-PJ-W4

RAINFALL INTENSITY 0.000 IN/HR

TIME minutes	DEPTH inches	RUNOFF RATE in/hr	LOSS RATE in/hr

Table 13. - Texture based on hydrometer analysis and organic content of Ft. Stanton samples.

Plot ID No.	Texture, in %			Organic content in %
	Sand	Silt	Clay	
FS-MC-1	45.6	27.8	26.6	4.95
2	43.4	29.2	27.4	5.10
3	42.0	28.4	29.6	4.79
4	42.6	27.8	29.6	5.96
FS-HC-1	39.2	30.0	30.8	5.26
2	44.0	24.0	32.0	4.40
3	42.8	29.0	28.2	5.55
4	44.2	29.2	26.6	5.15
FS-EX-1	43.4	28.0	28.6	4.47
2	40.4	28.6	31.0	5.15
3	36.4	31.2	32.4	4.05
4	39.2	28.4	32.4	4.98
FS-H-PH-1	39.6	32.4	28.0	11.56
2	42.8	31.8	25.4	9.78
3	46.0	29.4	24.6	12.45
4	40.0	32.0	28.0	10.93
FS-H-MG-1	39.4	33.4	27.2	6.69
2	40.2	33.8	26.0	4.54
3	32.0	42.6	25.4	8.59
4	41.2	34.8	24.0	6.32
FS-M-PJ-1	38.0	33.8	28.2	8.88
2	36.0	33.8	30.2	8.88
3	40.0	39.6	20.4	10.37
4	40.0	36.8	23.2	11.27
FS-H-LG-1	37.8	30.0	32.3	6.39
2	35.4	32.0	32.6	6.32
3	36.4	32.6	31.0	7.03
4	37.4	38.4	24.2	11.03
FS-F-1	37.2	34.8	28.0	4.40
2	40.0	31.0	29.0	5.38
3	45.0	34.0	21.0	4.32
4	44.0	34.0	22.0	3.22
FS-FC-1	38.4	33.6	28.0	3.16
2	42.6	32.8	24.6	2.96
3	45.6	36.4	18.0	2.81
4	47.0	33.8	19.2	2.33

Table 14. - Texture based on hydrometer analysis and organic content of Tucumcari samples.

Plot ID NO.	Texture, in %			Organic content, in %
	Sand	Silt	Clay	
T-G-LC-1	42.0	41.0	17.0	3.37
2	48.0	39.0	13.0	2.65
3	43.0	41.0	16.0	2.31
4	45.0	38.0	17.0	2.41
T-BG-LC-1	48.0	36.0	16.0	1.44
2	48.0	37.8	14.2	1.69
3	46.0	39.0	15.0	1.61
4	52.0	34.0	14.0	1.69
T-G-QH-1	58.8	23.2	18.0	1.74
2	56.8	23.8	19.4	1.69
3	50.8	27.6	21.6	1.95
4	54.8	27.6	17.6	1.35
T-BG-QH-1	50.8	25.8	23.4	3.43
2	56.8	21.8	21.4	2.64
3	56.0	27.0	17.0	1.66
4	65.6	20.2	14.2	1.19
T-MG-QH-1	59.2	19.6	21.5	2.59
2	60.8	19.6	19.6	1.28
3	64.8	17.8	17.4	2.18
4	64.8	20.0	15.2	1.69

Table 15. - Texture based on hydrometer analysis and organic content of Cuba samples.

Plot ID No.	Texture, in %			Organic content, in %
	Sand	Silt	Clay	
C-CPJ-1	63.4	22.2	14.4	3.82
2	60.0	26.0	14.0	4.38
3	72.6	16.2	11.2	4.17
4	75.4	14.6	10.0	1.12
C- CWPJ-1	68.2	17.0	14.8	1.59
2	70.0	16.4	13.6	2.62
3	70.4	15.6	14.0	1.27
4	69.4	18.0	12.6	2.00
C-PJ- 1	66.0	19.6	14.4	4.66
2	70.8	15.0	14.2	3.29
3	85.6	6.2	8.2	0.92
4	90.0	8.0	2.0	2.32
C-SB -1	56.0	25.0	19.0	5.23
2	56.0	23.6	20.4	2.77
3	69.0	16.6	14.4	2.49
4	57.4	22.6	20.0	2.99
C-TSB-1	47.0	24.2	28.8	2.61
2	48.8	22.6	28.6	3.78
3	53.6	23.2	23.2	3.42
4	50.4	23.6	26.0	4.30
C-TCP-1	82.4	7.6	10.0	1.45
2	76.6	9.4	14.0	1.68
3	66.2	17.2	16.6	4.04
4	82.6	5.4	12.0	0.73
C-BSB-1	49.6	30.4	20.0	1.51
2	70.0	20.0	10.0	0.71
3	32.6	36.8	30.6	3.01
4	32.0	38.0	30.0	4.82
C-NSB-1	38.8	34.2	27.0	6.35
2	49.6	36.6	13.8	1.80
3	44.0	32.6	23.4	3.22
4	39.0	38.6	22.4	2.53

Table 16. - Texture based on hydrometer analysis and organic content of Magdalena samples.

Plot ID No.	Texture, in %			Organic content, in %
	Sand	Silt	Clay	
M-HG-1	57.6	22.0	20.4	2.75
2	62.0	19.0	19.0	2.59
3	58.0	21.6	20.4	2.84
4	62.8	21.0	16.2	2.51
M-LG-1	59.0	19.8	21.1	7.29
2	61.6	18.4	20.0	4.10
3	48.0	29.2	22.8	7.28
4	50.4	32.2	17.4	6.08
M-PH-1	56.0	23.8	20.2	9.03
2	58.0	21.4	20.6	5.93
3	62.4	17.2	20.4	7.04
4	68.4	15.4	16.2	2.67

Table 21. - Ground cover and production within the plots of Ft. Stanton.

Plot ID No.	Cover in %						Production in Kg/ha		
	Plant	Grass	Forb	Litter	Rock	Total	Grass	Forb	Litter
FS-MC-1	25.36	24.42	0.94	2.92	2.92	31.2	271.7	15.4	310.6
2	47.81	46.25	1.56	2.81	0.52	51.14	307.6	15.4	417.2
3	53.85	46.56	7.29	7.71	3.65	65.21	249.1	228.6	228.6
4	47.91	46.35	1.56	2.81	4.06	54.78	275.8	37.9	189.7
FS-HC-1	42.18	13.85	28.33	8.23	2.60	53.01	125.1	419.3	1694.6
2	41.98	34.58	7.40	2.81	6.46	51.25	241.9	163.0	414.2
3	55.21	47.19	8.02	10.10	1.56	66.87	1111.3	174.3	550.5
4	31.36	12.92	18.44	8.12	2.50	41.98	263.5	424.4	838.6
FS-EX-1	64.68	60.10	4.58	18.13	0.52	83.33	1549.0	78.9	1609.5
2	58.44	55.73	2.71	6.15	1.04	65.63	1594.1	89.2	792.5
3	40.63	8.65	31.98	26.88	4.58	72.09	209.1	491.1	1939.6
4	45.52	20.52	25.00	33.33	1.15	80.00	733.0	431.6	3266.2
FS-H-PJ-1	20.52	16.98	3.54	77.54	1.46	99.52	238.9	261.4	11261.3
2	13.12	9.79	3.33	85.27	0.52	98.91	220.4	164.0	8349.9
3	9.69	6.88	2.81	78.02	5.00	92.71	301.4	162.0	1266.1
4	17.71	15.31	2.40	70.31	1.15	89.17	272.7	164.0	6344.7
FS-H-MG-1	39.79	36.25	3.54	7.08	2.19	49.06	461.3	216.3	562.8
2	43.23	43.23	0.00	0.21	3.23	46.67	414.2	0.0	149.7
3	54.48	46.56	7.92	6.15	0.00	60.63	57.1	280.9	338.3
4	38.75	34.69	4.06	0.52	0.94	40.21	477.7	246.0	168.1
FS-M-PJ-1	25.94	23.65	2.29	56.04	0.63	82.61	266.5	151.7	9603.7
2	19.59	15.63	3.96	46.46	0.31	66.36	205.0	184.5	9419.1
3	25.00	21.77	3.23	67.50	1.25	93.75	271.7	146.6	2385.5
4	24.06	17.71	6.35	74.69	0.00	98.75	266.5	188.6	7374.0
FS-H-LG-1	90.94	86.88	4.06	5.73	0.00	96.67	1986.8	313.7	801.7
2	73.02	68.75	4.27	3.33	1.99	78.34	1045.7	220.4	349.6
3	58.43	43.33	15.10	3.96	1.25	63.64	993.4	424.4	908.3
4	62.82	59.17	3.65	0.42	4.27	67.51	981.1	284.0	543.3
FS-F-1	64.38	57.71	6.67	2.29	0.00	66.67	708.4	258.3	210.2
2	51.14	47.60	3.54	4.06	0.00	55.20	535.1	268.6	339.3
3	60.73	58.65	2.08	2.71	0.00	63.44	840.6	167.1	243.0
4	42.40	40.63	1.77	6.77	0.00	49.17	687.9	198.9	538.2
FS-FC-1	44.32	44.11	0.21	1.46	2.40	48.18	404.9	164.0	159.9
2	42.61	40.94	1.67	4.27	3.33	50.21	615.1	184.5	166.1
3	31.36	29.38	2.08	2.60	0.00	34.06	448.0	225.5	179.4
4	33.65	30.00	3.65	1.04	0.00	34.69	396.7	240.9	166.1

Table 22. - Ground cover and production within the plots at Tucumcari.

Plot ID No.	Cover, in %						Production, in Kg/ha		
	Plant	Grass	Forb	Litter	Rock	Total	Grass	Forb	Litter
T-G-LC-1	52.0	51.2	0.8	4.7	0.0	56.7	995	17.0	696*
2	61.9	61.9	0.0	0.8	0.0	62.7	946	1.0	700*
3	60.9	60.0	0.9	0.9	0.0	61.8	1145	13.0	552*
4	41.5	41.5	0.0	1.9	0.0	43.4	632	2.0	157*
T-BG-LC-1	28.3	28.3	0.0	0.3	0.0	28.6	201	<1.0	22
2	28.8	28.8	0.0	0.0	0.0	28.8	273	<1.0	38
3	25.5	25.5	0.0	0.0	0.0	25.5	310	3.0	6.0
4	21.4	21.2	0.2	0.4	0.0	21.8	272	1.0	59
T-G-QH-1	37.8	36.1	1.7	26.6	0.0	64.4	862	17.0	1545*
2	42.2	42.2	0.0	11.6	0.0	53.8	951	0.0	881*
3							802	18.0	489*
4	35.2	35.2	0.0	11.9	0.0	47.1	721	7.0	310*
T-BG-QH-1	64.4	63.4	1.0	13.2	0.0	77.6	614	18.0	941*
2	53.0	48.1	4.9	7.8	0.0	60.8	761	68.0	952*
3	64.9	63.0	1.9	5.7	0.0	70.6	978	16.0	668*
4	41.9	41.9	0.0	4.9	0.0	46.8	535	0.0	267*
T-MG-QH-1	35.0	28.8	6.2	55.6	0.0	90.6	355	5.0	987
2	27.0	27.0	0.0	46.8	0.0	73.8	219	0.0	1158
3	6.7	6.7	0.0	90.0	0.0	96.7	98	0.0	5818
4	24.4	24.0	0.4.	61.2	0.0	85.6	269	3.0	7527

*includes standing dead material.

Table 23. - Ground cover and production within the plots at Cuba.

Plot ID No.	Cover, in %						Production, in Kg/ha		
	Plant	Grass	Forb	Litter	Rock	Total	Grass	Forb	Litter
C-CPJ-1	0.94	0.42	0.52	7.08	0.00	8.02	2.1	2.1	1005.4
2	1.25	0.21	1.04	48.33	0.00	49.58	3.1	7.2	31591.0
3	2.71	2.71	0.00	32.29	0.00	34.50	9.3	0.0	2614.7
4	10.52	2.19	8.33	11.88	0.00	22.40	11.4	109.4	964.1
C-CWPJ-1	33.23	32.92	0.31	4.37	0.00	37.60	595.6	8.3	997.2*
2	54.48	54.17	0.31	6.99	0.00	61.47	1193.3	7.2	1446.2*
3	32.08	25.73	6.35	12.60	0.00	44.68	415.0	160.0	1511.2*
4	31.88	30.73	1.15	12.19	0.00	44.07	639.0	16.5	3146.3**
C-PJ-1	2.81	2.50	0.31	97.02	0.00	99.83	26.8	7.2	?
2	0.84	0.21	0.63	89.48	0.00	90.32	5.2	23.7	56155.0
3	2.92	1.98	0.94	90.42	0.0	93.34	14.5	8.3	23238.0
4	3.65	1.98	1.67	22.08	0.0	25.73	7.2	35.1	3282.6
C-SB-1	5.21	4.17	1.04	5.73	0.0	10.94	19.6	11.4	1253.2
2	1.25	1.25	0.0	12.60	0.0	13.85	15.5	0.0	3194.0**
3	9.37	3.85	5.52	6.25	0.0	15.62	26.8	107.4	2032.5**
4	4.06	4.06	0.0	15.42	0.0	19.48	31.0	4.1	1750.7**
C-TSB-1	46.98	46.98	0.0	14.17	0.0	61.15	1909.7	7.2	1203.6*
2	44.17	44.17	0.0	8.23	0.0	52.40	862.0	22.7	894.0*
3	35.62	33.02	2.60	23.13	0.0	58.75	388.1	42.3	3391.0*
4	51.78	48.13	3.65	15.00	0.0	66.78	1058.1	40.3	756.6
C-TCP-1	63.17	51.54	11.63	2.26	0.0	65.43	720.5	127.0	2775.7**
2	38.22	38.62	7.60	1.04	0.0	39.26	775.2	68.1	625.6*
3	47.70	37.60	10.10	0.42	0.0	48.12	825.8	130.1	603.9*
4	42.39	38.07	4.32	2.26	0.0	44.65	695.7	33.0	515.1
C-BSB-1	46.66	44.79	1.87	2.29	0.0	48.95	1189.2	90.8	709.2
2	55.72	53.33	2.39	7.19	0.0	62.91	1103.0	107.4	813.4
3	65.21	56.98	8.23	7.92	0.0	68.13	1627.9	206.5	815.5
4	48.44	44.69	3.75	25.63	0.00	74.07	1560.8	37.2	2171.9*
C-NSB-1	0.73	0.73	0.00	57.40	0.00	58.13	26.8	5.2	16789.0
2	39.79	37.60	2.19	9.37	0.00	49.16	325.2	83.6	1581.4
3	6.98	16.15	0.83	10.42	0.00	27.40	171.4	16.5	1577.3
4	10.93	8.85	2.08	10.00	0.0	20.93	173.4	32.0	2279.2

*includes standing dead material

**branches

Table 24. - Ground cover and production within the plots of Magdalena.

Plot ID No.	Cover, in %						Production in Kg/ha		
	Plant	Grass	Forb	Litter	Rock	Total	Grass	Forb	Litter
M-HG-1	23.96	22.19	1.77	0.00	2.60	26.56	84.1	95.3	19.5
2	25.83	25.83	0.00	0.00	3.23	29.06	158.9	15.4	28.7
3	37.29	37.29	0.00	0.00	18.96	56.25	128.2	7.2	5.1
4	26.67	18.75	7.92	0.42	4.69	31.78	133.3	*155.8	59.5
M-LG-1	44.89	40.83	4.06	0.00	4.79	49.68	637.7	85.1	152.8
2	33.55	33.13	0.42.	5.10	13.13	51.78	321.9	23.6	27.7
3	37.29	37.29	0.00	0.00	11.88	49.17	362.9	14.4	13.3
4	60.95	56.91	4.04	0.00	0.00	60.95	1722.3	157.9	44.1
M-PJ-1	6.67	6.67	0.00	83.44	2.50	92.61	40.0	-	28,376
2	6.98	4.79	2.19	75.21	3.44	85.68	27.7	34.9	32,763
3	0.83	0.62	0.21	96.61	1.96	99.4	3.1	6.2	44,775
4	1.03	0.93	0.10	93.62	0.72	95.37	10.3	1.0	69,641

11 July 89

Phone call w/ Tim Ward

He will send WRRI Report No. 241
He is finishing (in print) another WRRI report
& will send it.

I will send him our data set.

I may ask him to do the data reduction
for us.

30 Aug. 89

Tim will send Report No. 241 & 243.
Look @ data in these. Bare ground data also.

GEORGE V. SABOL Ph.D., P.E.
CONSULTING ENGINEER
1351 EAST 141st AVENUE
BRIGHTON, COLORADO 80601
(303) 457-0989

28 April 1989

Mr. Joe Rumann
Hydrologist
Flood Control District of Maricopa County
3335 West Durango
Phoenix, Arizona 85009

Dear Joe:

I have been working on the review comments by Leonard Lane and Walter Rawls. I have been using a paper by Rawls, Brakensiek, and Savabi (1989) in trying to determine a way to correct hydraulic conductivity to account for canopy and ground cover influences.

Leonard had pointed out some computational problems in using this method in his review. This was mainly due to a misunderstanding on my part of the definition of some of the cover terms (BC and BO), and I also had some errors in the equations in my draft of the manual. I have talked to Walter and I have the definition of terms sorted out (see attached definition sketch), and I have corrected the equations in the manual. However, there still are problems with the method.

I have included a copy of some analyses that I have performed and have sent this to Leonard and Tim Ward for their comments. If further analysis and comments by Leonard and Tim are supportive, then Figure 7A (attached) would be superior to the equations that are in the present draft of the manual.

You don't need to spend any time reviewing this because it is preliminary; however, I want to send it out to Leonard and Tim to get their comments and suggestions.

Sincerely yours,

George V. Sabol

Enclosures:
1. Copy of Rawls, Brakensiek, and Savabi (1989)
2. handwritten notes, table, and figures
3. definition sketch
4. computer output

Copies w/enclosures: Dr. Leonard Lane, ARS
Dr. Tim Ward, NMSU

28 April 89

Leonard,

Could you look at the enclosed.
What do you think of Figure 7A of the enclosed?
Call me with your comments.

Do you think that there is the basis for a technical paper here? Are you interested in co-authoring?

Ken

I sent this to Tim Ward also.

28 April 89

Tim,

You might be interested in this. Of course, I would value your comments and suggestions, as always!

I have enclosed a copy of the first draft of the Raintall Losses section of the Maricopa County Hydrology Manual. I am presently working on trying to incorporate canopy and ground cover influences into the Green-Ampt hydraulic conductivity.

What do you think of Figure 7A of the enclosed?

Call me if you have comments.

Do you think that there is the basis of a technical paper here? Are you interested in co-authoring?

Leo

I have sent this to Leonard also.

GEORGE V. SABOL Ph.D., P.E.
1351 EAST 141st AVENUE
BRIGHTON, COLORADO 80601
(303) 457-0989

6 September 1988

Mr. Walter J. Rawls
Hydrologist
USDA-ARS, Hydrology Laboratory
Bldg. 007, BARC - West
Beltsville, MD 20705

301-3443745

Dear Walter:

I did receive the package of papers that you sent to me. I don't have any suggestion as to why the Postal Service couldn't find this address the first time that you tried. All of my bills arrive without any delay! Although it has been the observation of some of my clients that their payment checks to me definately travel slowly by mail! This is a first for scientific papers.

I am working on a Hydrology Manual for the Flood Control District of Maricopa County, Arizona, and we are presently evaluating rainfall loss procedures and parameter estimation techniques. Now that Green-Ampt is available in HEC-1 (version released in July 88), this has become a viable alternative for our use. Copies of the instruction sheets for coding the HEC-1 Green-Ampt function are enclosed for your convenience. I am using the procedures that you, Brakensiek, and others have recommended for parameter estimation. I will keep you informed of the results of our tests and selection of recommended procedures.

I would like your comment on a procedure that I have adapted from some of your work in regard to estimating the volumetric moisture deficit (DTHETA according to HEC-1 nomenclature). I used the 1/3-bar and 15-bar soil moisture graphs from Figure 8 of Rawls and Brakensick (1983), A procedure to predict Green and Ampt infiltration parameters to prepare a similar graph of the difference between these two soil moistures. I have enclosed a copy of this figure. I believe that this represents the available water content of the soil and also the maximum value of DTHETA (for bare ground). Some adjustments may be necessary depending upon soil cover and land-use practices. This figure does seem to be a convenient aid for estimating DTHETA. What are your comments on this?

I notice in your manuscript titled Infiltration parameters for rangeland soils (to be published in Range Management) that you reference a research report by Ward and Wood (1982). It seems that this is a data report that I wrote for a research project at New Mexico State University, and as you

probably only had the data you may choose to expand the citation. This multi-disciplinary project had Co-Principal Investigators from three departments; Dr. Karl Wood from Animal and Range Science, Dr. Garrey Carruthers from Agricultural Economics, and me from Civil Engineering. As a point of interest, Dr. Carruthers is now New Mexico's Governor Carruthers. I have enclosed a copy of the report cover and Acknowledgement page indicating authorship. Although I have no particularly great pride of authorship of the report, the project itself did involve a great deal of effort by many people and a significant financial commitment by the State of New Mexico. I would suggest, however, that the reference include that the research was performed for the New Mexico Soil and Water Conservation Division, Natural Resources Department and that authorship be as indicated in the Acknowledgement. I would also think that the report was "published" by New Mexico Sate University.

I'm glad to see that this data could be put to use. A rainfall simulator was used in another project for the City of Albuquerque and I should have this data available somewhere, if you're ever interested.

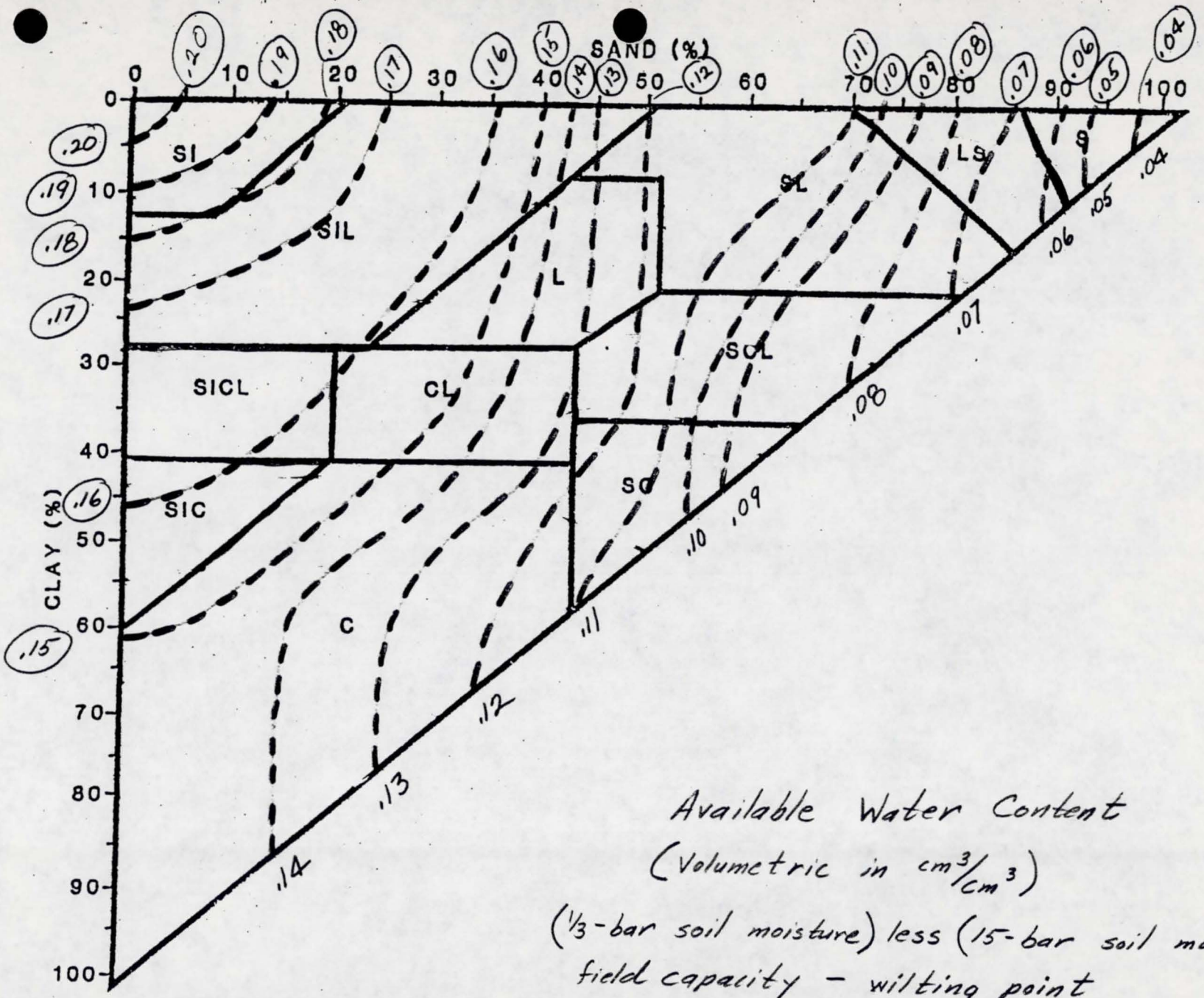
I'll call you next week to solicite your comment on the DTHETA figure. I appreciate your help, thanks.

Sincerely yours,

George V. Sabol

GVS/jr

Enclosures:
1. Copy of HEC-1, Green-Ampt coding instructions
2. Copy of DTHETA figure
3. Report title page and acknowledgement page of research data report.



Available Water Content

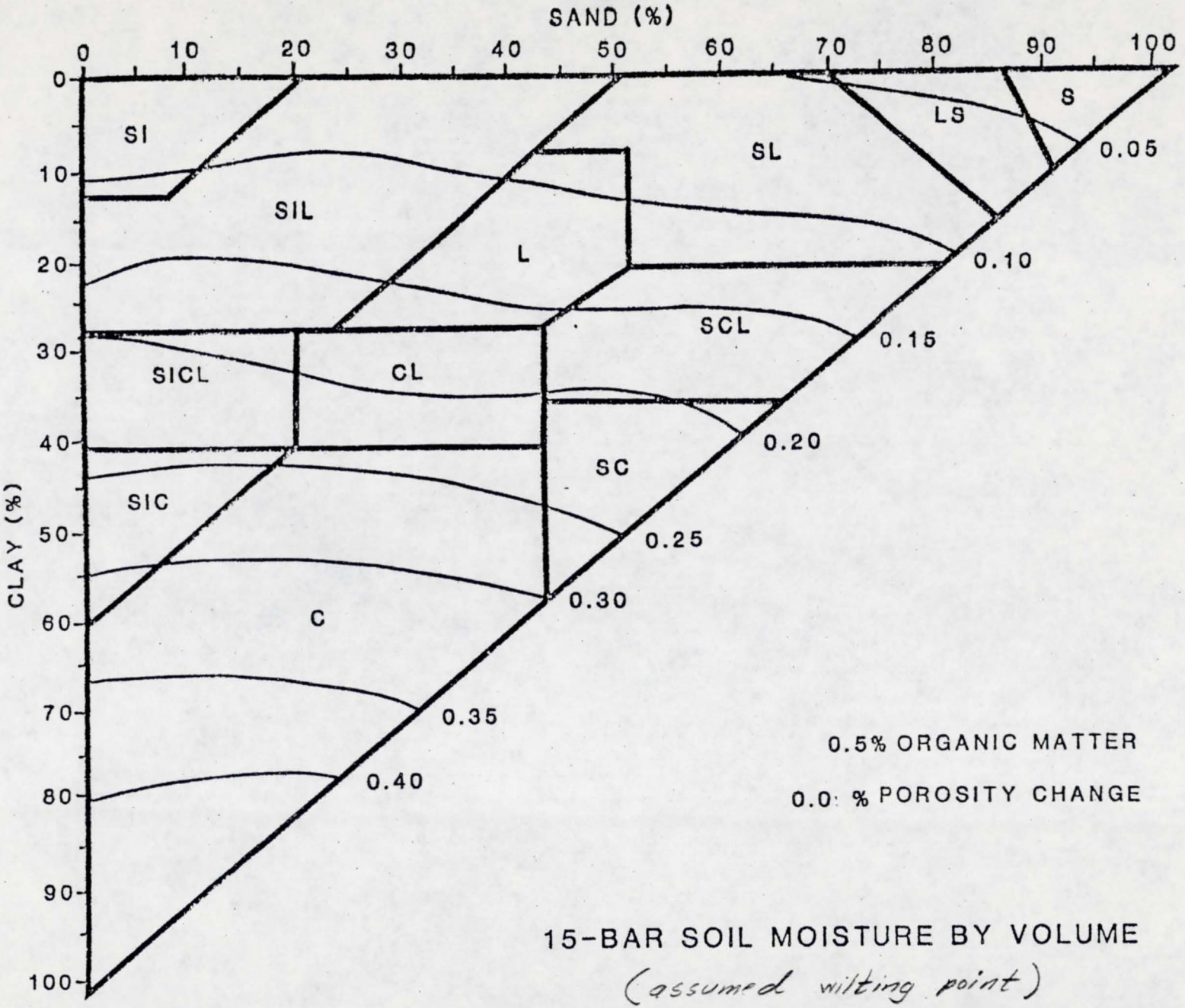
(Volumetric in cm^3/cm^3)

(1/3-bar soil moisture) less (15-bar soil moisture)

field capacity - wilting point

Maximum DTHETA in HEC-1, Green-Ampt Loss Rate Function

G.V.S. 6 Sept. 88

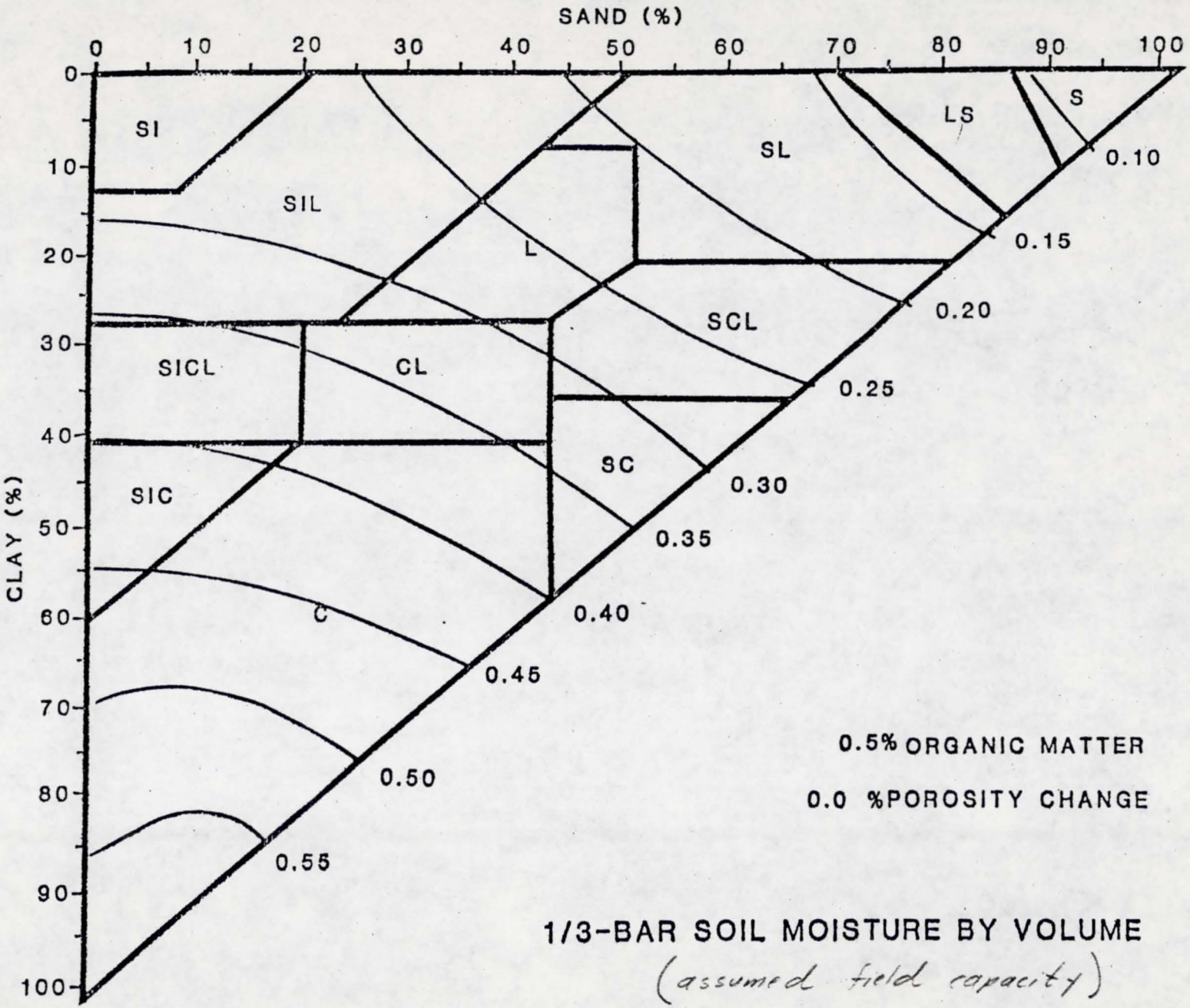


0.5% ORGANIC MATTER

0.0 % POROSITY CHANGE

15-BAR SOIL MOISTURE BY VOLUME

(assumed wilting point)



0.5% ORGANIC MATTER

0.0 %POROSITY CHANGE

1/3-BAR SOIL MOISTURE BY VOLUME

(assumed field capacity)

Research Report Submitted to:

New Mexico Soil and Water Conservation Divison
Natural Resourses Department

EVALUATION OF RANGELAND BEST MANAGEMENT PRACTICES TO CONTROL NON-POINT POLLUTION

DATA REPORT

By

Civil Engineering Department

and

Animal and Range Science Department

New Mexico State University
Las Cruces, NM 88003

April 1982

ACKNOWLEDGEMENT

The data reported herein is a result of a research project conducted for the New Mexico Soil and Water Conservation Division of the Natural Resources Department. The research was a joint effort of the Agricultural Economics and Agricultural Business Departments, Animal and Range Science, Civil Engineering, and Cooperative Extension Service.

This report was prepared under the direction of Dr. George V. Sabol, Associate Professor of Civil Engineering. Other Civil Engineering Department personnel that participated on this report are Dr. Tim J. Ward, Associate Professor, and Mr. Larry Coons and Mr. Andy Seiger Research Assistants. Personnel from the Animal and Range Science Department that participated in this effort are Dr. M. Karl Wood, Assistant Professor, and Mr. James Wood. Dr. John Tromble, Jornada Experiment Range, USDA-SEA provided valuable assistance throughout the project.

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19 Sept 88

phone call to Walter Rawls,

He emphasized that the figure that I provided would be <u>maximum</u> DTHETA. I noted that that was what was on my figure.

We talked about the assumption to be made about the initial soil moisture. He thought that one should start from <u>wet</u> soil for flood hydrology. I pointed out that we would probably use a 6-hr rainfall dist. with peak intensitres in the 3-4 hour range & that by then we should have satisfied initial soil moisture requirements. He agreed.

He will make the reference change that I noted.

$$KE = CF\left[A*(CAN-BC) + CRC*BC\right]K + \left[A*(OP-BO) + CRC*BO\right]K$$

CAN = % total area that is under canopy

OP = % total area that is not under canopy

$$CAN + OP = 100$$

BC = % total area under canopy and not covered by rock or litter

BO = % total area not under canopy and not covered by rock or litter (subject to crusting)

→ CF = canopy factor

$$CF = 1 + 0.96\,\frac{CAN}{100}$$

→ A = macroporosity factor

$$A = e^{(2.82 - 0.099\,SA + 1.94\,BD)}$$

SA = % sand

BD = bulk density (g/cm^3)

CRC = crust factor

$$CRC = \frac{L}{\frac{L-TC}{SC} + \frac{TC}{B}}$$

L = wetting front depth (assume 2.4 inches)

TC = crust thickness (assume 0.2 inches)

need reference

SC = correction factor for partial saturation of crust

$$B = 0.0099 + 0.0721*TC + 0.0000068*SA^2 + 0.000021*SA^2*TC - 0.000315*SA*TC^2$$

effective porosity θ_e

$$\theta_e = \phi - \theta_r$$

ϕ = total porosity cm^3/cm^3

θ_r = residual saturation cm^3/cm^3

effective saturation S_e

$$S_e = \frac{\theta - \theta_r}{\phi - \theta_r} = \frac{\theta - \theta_r}{\theta_e}$$

θ = soil water content cm^3/cm^3

capillary pressure head

$$\psi_f = \frac{2+3\lambda}{1+3\lambda} \frac{\psi_b}{2} \qquad cm$$

24 Dec 88

Green & Ampt equation
Hydraulic Conductivity - correction for ground cover and canopy cover

Reference - "Infiltration Parameters for Rangeland Soils" by Rawls, Brakensiek and Savabi (unpublished)

$$KE = CAN * KE_C + OP * KE_O \qquad (1)$$

KE_C = effective hyd. cond. of soil under canopy
KE_O = effective hyd. cond. of soil outside of canopy cover
CAN = ratio of area under canopy cover to total area
OP = ratio of area outside of canopy cover to total area

$$KE_C = K * CF * \left[\frac{BC}{CAN} * CRC + A\left(1 - \frac{BC}{CAN}\right) \right] \qquad (2)$$

$$KE_O = K * \left[\frac{BO}{OP} * CRC + A\left(1 - \frac{BO}{OP}\right) \right] \qquad (3)$$

where

CF is canopy factor

$$CF = 1 + .96 * CAN \qquad (4)$$

A is macroporosity factor

$$A = e^{(2.82 - 0.0995A + 1.94\,BD)} \qquad (5)$$

CRC is crust factor

$$CRC = \frac{L}{\frac{L - TC}{SC} + \frac{TC}{B}} \qquad (6)$$

BC = ratio of bare soil (no rock, litter or vegetation ground cover) that is under canopy to total area

BO = ratio of bare soil that is outside of canopy cover to total area

SA = percent sand

BD = bulk density of soil (g/cm^3)

L = wetting front depth (assume 6 cm)

TC = crust thickness (assume 0.5 cm)

SC = correction factor for partial saturation of the subcrust soil (see Table 3)

(1) $$B = 0.0099 + 0.0721\,\sqrt{TC} + 0.0000068\,\sqrt{SA}^{\,2} + 0.000021\,\sqrt{SA}^{\,2}\sqrt{TC} - 0.000315\,SA\,\sqrt{TC}^{\,2}$$

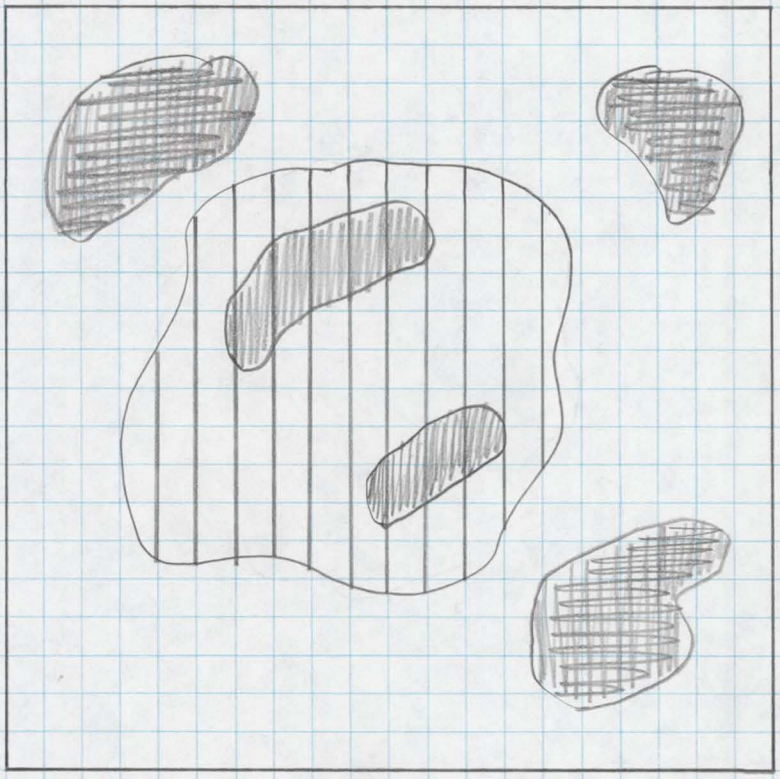
For Lawns

$CAN = 0.0$ $\qquad$ $BC = 0$

$OP = 1.0$ $\qquad$ $BO = 0$

$$KE_0 = K * \left[\frac{\overset{0}{BO}}{OP} * CRC + A \left(1 - \frac{\overset{0}{BO}}{OP}\right) \right]$$

$$KE_0 = K * A$$



A = total area

AC = area under canopy cover

AO = area outside of canopy cover

ABC = area of bare soil under canopy cover

ABO = area of bare soil outside of canopy cover

AC + AO = A

CAN = AC / A

OP = AO / A

BC = ABC / A

BO = ABO / A

TELEPHONE LOG

PROJECT: FCD

TO/~~FROM~~: Tim Ward

DATE: 21 April 89

ORGANIZATION: NMSU

TOPICS: correction to G-A eq'n. for ground cover

CITY: Las Cruces

PHONE NO: 505-646 3232

Susan Bolin 646 3512

ITEMS DISCUSSED:

1. They have developed a hyd. conductivity eq'n. based on their simulator studies

$\log K_w (mm/hr) = 1.16 + .77$ relative roughness (cm) $- .01$ antecedent moisture content (% dry soil wt.) $+ .004$ organic ground cover $R = .71$

2. studies on bare ground indicate that final infiltration rate (f_c) varies with cover

cover > 50% then $f_c = 3.3\ f_c$ bare ground

cover < 50% " " $= 2.2$ "

bare ground w/ screen " " $= 1.9$ "

3. on pinion-juniper soils & initially dry soil

high cover 61 mm/hr

low cover 36 mm/hr

bare w/ screen 33 mm/hr

bare 18.6 mm/hr

wet soil is 25-50% less

FURTHER ACTIONS REQUIRED:

27 April 89

Sandy loam

XKSAT = .40 in/hr

SA = 60 %

BD = 1.5 gm/cm^3

SC = .86

Canopy Cover = 20%

CAN = 20 %

OP = 80 %

Ground Cover (Basal, Litter, Rock) = 30%

TC = .5 cm

L = 6 cm

K = XKSAT * 2.54

= 1.016 cm/hr

BC = (100-30)(20/100) = 14 %

BO = (100-30)(80/100) = 56 %

Bare soil 70 %

$$B = .0099 + .0721(TC) + .0000068(SA^2) + .000021(SA^2)(TC) - .000315(SA)(TC)^2$$

$$= .0099 + .0721(.5) + .0000068(60^2) + .000021(60^2)(.5) - .000315(60)(.5^2)$$

$$= .10351$$

$$A = \exp\left[2.82 - .099(SA) + 1.94(BD)\right]$$

$$= \exp\left[2.82 - .099(60) + 1.94(1.5)\right]$$

$$= .81058$$

$$CRC = \frac{L}{\frac{L-TC}{SC} + \frac{TC}{B}}$$

$$= \frac{6}{\frac{6-.5}{.86} + \frac{.5}{.10531}}$$

$$= .53844$$

$$CF = 1 + .96\,\frac{CAN}{100}$$

$$= 1 + .96\,\frac{20}{100}$$

$$= 1.192$$

$$KE_C = (K)(CF)\left[\frac{(BC)(CRC)}{CAN} + A\left(1 - \frac{BC}{CAN}\right)\right]$$

$$= (1.016)(1.192)\left[\frac{(14)(.53844)}{20} + .81\left(1 - \frac{14}{20}\right)\right]$$

$$= .75076$$

$$KE_O = (K)\left[\frac{(BO)(CRC)}{OP} + A\left(1 - \frac{BO}{OP}\right)\right]$$

$$= (1.016)\left[\frac{(56)(.53844)}{80} + (.81058)\left(1 - \frac{56}{80}\right)\right]$$

$$= .63000$$

$$KE = \left[CAN(KE_C) + OP(KE_O)\right]/100$$

$$\left[(20)(.75) + (80)(.63)\right]/100$$

$KE = .65$ cm/hr $= .257$ in/hr

	SANDY LOAM
HYDAULIC CONDUCTIVITY	0.40 in/hr
SAND CONTENT	60 %
BULK DENSITY	1.50 gm/cc
SOIL CRUSTING FACTOR	.86

CANOPY COVER %	GROUND COVER %	EFFECTIVE HYDRAULIC CONDUCTIVITY in/hr
20	30	0.26

```
LPRINTLPRINTLPRINTLPRINTLPRINTCLS
INPUT "SOIL TEXTURE CLASSIFICATION";SOIL$
INPUT "HYDRAULIC CONDUCTIVITY, IN in/hr";XKSAT
INPUT "SAND CONTENT, IN %";SA
INPUT "BULK DENSITY, IN gm/cubic cm";BD
INPUT "SOIL CRUST FACTOR";SC
FMT2$="HYDAULIC CONDUCTIVITY          #.## in/hr"
FMT3$="SAND CONTENT                    ### %"
FMT4$="BULK DENSITY                   #.## gm/cc"
FMT5$="SOIL CRUSTING FACTOR            .##"
LPRINT TAB(30); SOIL$
LPRINT USING FMT2$;XKSAT
LPRINT USING FMT3$;SA
LPRINT USING FMT4$;BD
LPRINT USING FMT5$;SC
LPRINT
LPRINT
LPRINT "   CANOPY COVER   GROUND COVER   EFFECTIVE HYDRAULIC CONDUCTIVITY"
LPRINT "         %              %                    in/hr"
LPRINT "      ______         ______                 _______"
FMT1$= "        ###            ###                  #.## "
CLS
INPUT "CANOPY COVER, IN % TOTAL AREA";CAN
INPUT "GROUND COVER, IN % TOTAL AREA";GC
CALC:
OP = 100-CAN
BC = (100-GC)*CAN/100
BO = (100-GC)*OP/100
TC = .5
L = 6.0
K = 2.54 * XKSAT
B = .0099 + .0721*TC + .0000068*SA^2 + .000021*SA^2*TC - .000315*SA*TC^2
A = EXP(2.82 - .099*SA + 1.94*BD)
CRC =L/((L-TC)/SC + TC/B)
CF = 1 + .96*CAN/100
KEO = K*(BO*CRC/OP + A*(1 - BO/OP))/2.54
KEC = K*CF*(BC*CRC/CAN + A*(1 - BC/CAN))/2.54
XKE = (CAN*KEC + OP*KEO)/100
LPRINT USING FMT1$;CAN,GC,XKE
CLS
PRINT "          SELECT:"
PRINT "                1 - INPUT OTHER COVER FACTORS"
PRINT "                2 - EXIT"
INPUT "          ENTER CHOICE";DECIS
IF DECIS=1 GOTO 1
IF DECIS=2 GOTO 2
1 CLS
INPUT "CANOPY COVER";CAN
INPUT "GROUND COVER";GC
GOSUB CALC
2 PRINT "END OF RUN"
END
```

RKE.BAS

```
GOSUB CALCCLS
INPUT "SOIL TEXTURE CLASSIFICATION";SOIL$
INPUT "HYDRAULIC CONDUCTIVITY, IN in/hr";XKSAT
INPUT "SAND CONTENT, IN %";SA
INPUT "BULK DENSITY, IN gm/cubic cm";BD
INPUT "SOIL CRUST FACTOR";SC
FMT2$="HYDRAULIC CONDUCTIVITY          #.## in/hr"
FMT3$="SAND CONTENT                    ### %"
FMT4$="BULK DENSITY                   #.## gm/cc"
FMT5$="SOIL CRUSTING FACTOR            .##"
LPRINT TAB(30); SOIL$
LPRINT USING FMT2$;XKSAT
LPRINT USING FMT3$;SA
LPRINT USING FMT4$;BD
LPRINT USING FMT5$;SC
LPRINT
LPRINT
LPRINT "   CANOPY COVER   GROUND COVER   HYDRAULIC CONDUCTIVITY FACTOR"
LPRINT "         %              %                      "
LPRINT "      _______        _______                  _________"
FMT1$= "        ###            ###                    #.## "
FOR I=1 TO 11
IF I=1 THEN GOTO 10 ELSE GOTO 20
10 CAN = 1
GOTO 50
20 IF I=11 THEN GOTO 30 ELSE GOTO 40
30 CAN = 99
GOTO 50
40 CAN =(I-1)*10
50 FOR J=0 TO 10
GC = J*10
OP = 100-CAN
BC = (100-GC)*CAN/100
BO = (100-GC)*OP/100
TC = .5
L = 6.0
K = 2.54 * XKSAT
B = .0099 + .0721*TC + .0000068*SA^2 + .000021*SA^2*TC - .000315*SA*TC^2
A = EXP(2.82 - .099*SA + 1.94*BD)
CRC =L/((L-TC)/SC + TC/B)
CF = 1 + .96*CAN/100
KEO = K*(BO*CRC/OP + A*(1 - BO/OP))/2.54
KEC = K*CF*(BC*CRC/CAN + A*(1 - BC/CAN))/2.54
XKE = (CAN*KEC + OP*KEO)/100
RKE = XKE/XKSAT
LPRINT USING FMT1$;CAN,GC,RKE
NEXT J
NEXT I
END
```

Results from XKE.BAS

	SANDY LOAM
HYDRAULIC CONDUCTIVITY	0.40 in/hr
SAND CONTENT	60 %
BULK DENSITY	1.50 gm/cc
SOIL CRUSTING FACTOR	.86

CANOPY COVER %	GROUND COVER %	EFFECTIVE HYDRAULIC CONDUCTIVITY in/hr
1	1	0.21
1	10	0.22
1	25	0.24
1	50	0.27
1	75	0.30
1	99	0.32
10	1	0.22
10	10	0.23
10	25	0.24
10	50	0.27
10	75	0.30
10	99	0.33
25	1	0.23
25	10	0.24
25	25	0.26
25	50	0.29
25	75	0.31
25	99	0.34
50	1	0.27
50	10	0.28
50	25	0.30
50	50	0.33
50	75	0.37
50	99	0.40
75	1	0.33
75	10	0.35
75	25	0.37
75	50	0.41
75	75	0.46
75	99	0.50
99	1	0.42
99	10	0.44
99	25	0.47
99	50	0.52
99	75	0.58
99	99	0.63

XKE.BAS

```
CLS
INPUT "SOIL TEXTURE CLASSIFICATION";SOIL$
INPUT "HYDRAULIC CONDUCTIVITY, IN in/hr";XKSAT
INPUT "SAND CONTENT, IN %";SA
INPUT "BULK DENSITY, IN gm/cubic cm";BD
INPUT "SOIL CRUST FACTOR";SC
FMT2$="HYDRAULIC CONDUCTIVITY          #.## in/hr"
FMT3$="SAND CONTENT                    ### %"
FMT4$="BULK DENSITY                   #.## gm/cc"
FMT5$="SOIL CRUSTING FACTOR            .##"
LPRINT TAB(30); SOIL$
LPRINT USING FMT2$;XKSAT
LPRINT USING FMT3$;SA
LPRINT USING FMT4$;BD
LPRINT USING FMT5$;SC
LPRINT
LPRINT
LPRINT "   CANOPY COVER   GROUND COVER   EFFECTIVE HYDRAULIC CONDUCTIVITY"
LPRINT "         %              %                     in/hr"
LPRINT "      _______        _______                 ________"
FMT1$= "        ###            ###                   #.## "
CLS
INPUT "CANOPY COVER, IN % TOTAL AREA";CAN
INPUT "GROUND COVER, IN % TOTAL AREA";GC
CALC:
OP = 100-CAN
BC = (100-GC)*CAN/100
BO = (100-GC)*OP/100
TC = .5
L = 6.0
K = 2.54 * XKSAT
B = .0099 + .0721*TC + .0000068*SA^2 + .000021*SA^2*TC - .000315*SA*TC^2
A = EXP(2.82 - .099*SA + 1.94*BD)
CRC =L/((L-TC)/SC + TC/B)
CF = 1 + .96*CAN/100
KEO = K*(BO*CRC/OP + A*(1 - BO/OP))/2.54
KEC = K*CF*(BC*CRC/CAN + A*(1 - BC/CAN))/2.54
XKE = (CAN*KEC + OP*KEO)/100
LPRINT USING FMT1$;CAN,GC,XKE
CLS
PRINT "          SELECT:"
PRINT "                1 - INPUT OTHER COVER FACTORS"
PRINT "                2 - EXIT"
INPUT "          ENTER CHOICE";DECIS
IF DECIS=1 GOTO 1
IF DECIS=2 GOTO 2
1 CLS
INPUT "CANOPY COVER";CAN
INPUT "GROUND COVER";GC
```

CLAY

HYDRAULIC CONDUCTIVITY	0.02 in/hr
SAND CONTENT	20 %
BULK DENSITY	1.40 gm/cc
SOIL CRUSTING FACTOR	.75

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.35
1	10	3.82
1	20	7.29
1	30	%10.7537670135498
1	40	%14.22125625610352
1	50	%17.68874359130859
1	60	%21.15623474121094
1	70	%24.62372016906738
1	80	%28.09121131896973
1	90	%31.55869674682617
1	100	%35.02618408203125
10	0	0.35
10	10	3.86
10	20	7.36
10	30	%10.8559627532959
10	40	%14.35640144348145
10	50	%17.85684204101562
10	60	%21.3572826385498
10	70	%24.85772323608398
10	80	%28.35816192626953
10	90	%31.85860252380371
10	100	%35.35903930664062
20	0	0.36
20	10	3.97
20	20	7.57
20	30	%11.16564178466797
20	40	%14.76593494415283
20	50	%18.36623001098633
20	60	%21.96652412414551
20	70	%25.56681632995605
20	80	%29.1671142578125
20	90	%32.76740646362305
20	100	%36.36769866943359
30	0	0.38
30	10	4.15
30	20	7.92
30	30	%11.68177223205566
30	40	%15.44849014282227
30	50	%19.21520805358887
30	60	%22.98192596435547
30	70	%26.74864387512207
30	80	%30.51536178588867
30	90	%34.28207778930664
30	100	%38.04879760742188
40	0	0.41
40	10	4.40
40	20	8.40
40	30	%12.40435600280762
40	40	%16.40406608581543
40	50	%20.40377807617188
40	60	%24.40348815917969
40	70	%28.40320014953613
40	80	%32.40290832519531
40	90	%36.40261840820312
40	100	%40.40232849121094
50	0	0.44
50	10	4.73
50	20	9.03
50	30	%13.33339214324951
50	40	%17.63266563415527
50	50	%21.93193817138672
50	60	%26.2312126159668
50	70	%30.53048324584961
50	80	%34.82975769042969
50	90	%39.1290283203125
50	100	%43.42830276489258
60	0	0.47
60	10	5.14
60	20	9.80
60	30	%14.46888160705566
60	40	%19.13428497314453
60	50	%23.79969024658203
60	60	%28.4650936126709
60	70	%33.13049697875977
60	80	%37.79590225219727
60	90	%42.46130752563477
60	100	%47.12671279907227
70	0	0.52
70	10	5.61
70	20	%10.71271800994873
70	30	%15.81082344055176
70	40	%20.9089298248291
70	50	%26.00703620910645
70	60	%31.10514068603516
70	70	%36.20324325561523
70	80	%41.30134963989258
70	90	%46.39945602416992
70	100	%51.49756240844727
80	0	0.57
80	10	6.16
80	20	%11.76184177398682
80	30	%17.35921669006348
80	40	%22.95659446716309
80	50	%28.55396842956543
80	60	%34.15134811401367
80	70	%39.74872207641602
80	80	%45.34609603881836
80	90	%50.9434700012207
80	100	%56.54084777832031
90	0	0.62
90	10	6.79
90	20	%12.95084857940674
90	30	%19.11406326293945
90	40	%25.27727890014648
90	50	%31.44049453735352
90	60	%37.60371017456055
90	70	%43.76692581176758
90	80	%49.93014148974609
90	90	%56.09335327148438
90	100	%62.25656890869141
99	0	0.68
99	10	7.41
99	20	%14.1405553817749
99	30	%20.86994171142578
99	40	%27.59932899475098
99	50	%34.32871627807617
99	60	%41.05810546875
99	70	%47.78749465942383
99	80	%54.51688385009766
99	90	%61.24627304077148
99	100	%67.97566223144531

SILTY CLAY

HYDRAULIC CONDUCTIVITY	0.02 in/hr
SAND CONTENT	5 %
BULK DENSITY	1.45 gm/cc
SOIL CRUSTING FACTOR	.73

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.33
1	10	%17.33251190185547
1	20	%34.33901596069336
1	30	%51.34551620483398
1	40	%68.35202026367188
1	50	%85.35853576660156
1	60	%102.3650283813477
1	70	%119.3715362548828
1	80	%136.3780364990234
1	90	%153.3845520019531
1	100	%170.3910522460938
10	0	0.33
10	10	%17.49722099304199
10	20	%34.66534042358398
10	30	%51.83345794677734
10	40	%69.00157928466797
10	50	%86.16970062255859
10	60	%103.3378143310547
10	70	%120.5059280395508
10	80	%137.6740417480469
10	90	%154.8421783447266
10	100	%172.0102996826172
20	0	0.34
20	10	%17.9963493347168
20	20	%35.65420913696289
20	30	%53.31206512451172
20	40	%70.96993255615234
20	50	%88.62778472900391
20	60	%106.28564453125
20	70	%123.9435119628906
20	80	%141.6013641357422
20	90	%159.2592315673828
20	100	%176.9170837402344
30	0	0.35
30	10	%18.8282299041748
30	20	%37.30232620239258
30	30	%55.77641296386719
30	40	%74.25051116943359
30	50	%92.72460174560547
30	60	%111.1986999511719
30	70	%129.6727905273438
30	80	%148.1468811035156
30	90	%166.6209716796875
30	100	%185.0950775146484
40	0	0.38
40	10	%19.99286270141602
40	20	%39.60968399047852
40	30	%59.22650146484375
40	40	%78.84333038330078
40	50	%98.46014404296875
40	60	%118.0769577026367
40	70	%137.6937866210938
40	80	%157.3106079101562
40	90	%176.9274291992188
40	100	%196.5442504882812
50	0	0.40
50	10	%21.4902458190918
50	20	%42.57629013061523
50	30	%63.66232681274414
50	40	%84.74837493896484
50	50	%105.8344116210938
50	60	%126.9204635620117
50	70	%148.0065002441406
50	80	%169.0925445556641
50	90	%190.1785888671875
50	100	%211.2646179199219
60	0	0.44
60	10	%23.32038497924805
60	20	%46.20214080810547
60	30	%69.08389282226562
60	40	%91.96565246582031
60	50	%114.847412109375
60	60	%137.7291717529297
60	70	%160.6109161376953
60	80	%183.49267578125
60	90	%206.3744354248047
60	100	%229.2561798095703
70	0	0.48
70	10	%25.48327445983887
70	20	%50.48723983764648
70	30	%75.49120330810547
70	40	%100.4951629638672
70	50	%125.4991302490234
70	60	%150.5030975341797
70	70	%175.507080078125
70	80	%200.5110321044922
70	90	%225.5149841308594
70	100	%250.5189666748047
80	0	0.53
80	10	%27.97891616821289
80	20	%55.43158340454102
80	30	%82.88424682617188
80	40	%110.3369140625
80	50	%137.7895812988281
80	60	%165.2422485351562
80	70	%192.6949157714844
80	80	%220.1475677490234
80	90	%247.6002197265625
80	100	%275.0529174804688
90	0	0.58
90	10	%30.80730819702148
90	20	%61.0351676940918
90	30	%91.26303100585938
90	40	%121.4908981323242
90	50	%151.7187652587891
90	60	%181.9466094970703
90	70	%212.1744842529297
90	80	%242.40234375
90	90	%272.6301879882812
90	100	%302.8580627441406
99	0	0.63
99	10	%33.63737106323242
99	20	%66.64206695556641
99	30	%99.646728515625
99	40	%132.6514282226562
99	50	%165.6561126708984
99	60	%198.6608123779297
99	70	%231.6654968261719
99	80	%264.6701965332031
99	90	%297.6748657226562
99	100	%330.6795654296875

	SANDY CLAY
HYDRAULIC CONDUCTIVITY	0.02 in/hr
SAND CONTENT	50 %
BULK DENSITY	1.60 gm/cc
SOIL CRUSTING FACTOR	.81

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.47
1	10	0.69
1	20	0.91
1	30	1.13
1	40	1.34
1	50	1.56
1	60	1.78
1	70	2.00
1	80	2.21
1	90	2.43
1	100	2.65
10	0	0.48
10	10	0.70
10	20	0.92
10	30	1.14
10	40	1.36
10	50	1.58
10	60	1.80
10	70	2.02
10	80	2.23
10	90	2.45
10	100	2.67
20	0	0.49
20	10	0.72
20	20	0.94
20	30	1.17
20	40	1.40
20	50	1.62
20	60	1.85
20	70	2.07
20	80	2.30
20	90	2.52
20	100	2.75
30	0	0.52
30	10	0.75
30	20	0.99
30	30	1.22
30	40	1.46
30	50	1.70
30	60	1.93
30	70	2.17
30	80	2.40
30	90	2.64
30	100	2.88
40	0	0.55
40	10	0.80
40	20	1.05
40	30	1.30
40	40	1.55
40	50	1.80
40	60	2.05
40	70	2.30
40	80	2.55
40	90	2.80
40	100	3.06
50	0	0.59
50	10	0.86
50	20	1.13
50	30	1.40
50	40	1.67
50	50	1.94
50	60	2.21
50	70	2.48
50	80	2.74
50	90	3.01
50	100	3.28
60	0	0.64
60	10	0.93
60	20	1.22
60	30	1.52
60	40	1.81
60	50	2.10
60	60	2.39
60	70	2.69
60	80	2.98
60	90	3.27
60	100	3.56
70	0	0.70
70	10	1.02
70	20	1.34
70	30	1.66
70	40	1.98
70	50	2.30
70	60	2.62
70	70	2.94
70	80	3.25
70	90	3.57
70	100	3.89
80	0	0.77
80	10	1.12
80	20	1.47
80	30	1.82
80	40	2.17
80	50	2.52
80	60	2.87
80	70	3.22
80	80	3.57
80	90	3.92
80	100	4.28
90	0	0.84
90	10	1.23
90	20	1.62
90	30	2.00
90	40	2.39
90	50	2.78
90	60	3.16
90	70	3.55
90	80	3.93
90	90	4.32
90	100	4.71
99	0	0.92
99	10	1.34
99	20	1.76
99	30	2.19
99	40	2.61
99	50	3.03
99	60	3.45
99	70	3.87
99	80	4.30
99	90	4.72
99	100	5.14

SILTY CLAY LOAM

HYDRAULIC CONDUCTIVITY	0.04 in/hr
SAND CONTENT	10 %
BULK DENSITY	1.40 gm/cc
SOIL CRUSTING FACTOR	.76

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.34
1	10	9.73
1	20	%19.12092971801758
1	30	%28.51376533508301
1	40	%37.90661239624023
1	50	%47.29945755004883
1	60	%56.69230270385742
1	70	%66.08514404296875
1	80	%75.47799682617188
1	90	%84.87083435058594
1	100	%94.26367950439453
10	0	0.34
10	10	9.82
10	20	%19.30263328552246
10	30	%28.78473854064941
10	40	%38.266845703125
10	50	%47.74894714355469
10	60	%57.23105621337891
10	70	%66.71315765380859
10	80	%76.19526672363281
10	90	%85.6773681640625
10	100	%95.15947723388672
20	0	0.35
20	10	%10.10066986083984
20	20	%19.85326385498047
20	30	%29.60585784912109
20	40	%39.35844802856445
20	50	%49.11104563740234
20	60	%58.8636360168457
20	70	%68.61623382568359
20	80	%78.36882781982422
20	90	%88.12141418457031
20	100	%97.87400817871094
30	0	0.36
30	10	%10.56757259368896
30	20	%20.7709789276123
30	30	%30.97438621520996
30	40	%41.17779159545898
30	50	%51.38120269775391
30	60	%61.5846061706543
30	70	%71.78800964355469
30	80	%81.99141693115234
30	90	%92.19482421875
30	100	%102.3982315063477
40	0	0.39
40	10	%11.22123718261719
40	20	%22.05578231811523
40	30	%32.89032745361328
40	40	%43.72487258911133
40	50	%54.55941772460938
40	60	%65.39395904541016
40	70	%76.22850799560547
40	80	%87.06304931640625
40	90	%97.89759063720703
40	100	%108.7321395874023
50	0	0.42
50	10	%12.0616626739502
50	20	%23.70767211914062
50	30	%35.35367965698242
50	40	%46.99969100952148
50	50	%58.64569854736328
50	60	%70.29170989990234
50	70	%81.93772125244141
50	80	%93.58373260498047
50	90	%105.229736328125
50	100	%116.8757476806641
60	0	0.45
60	10	%13.08884906768799
60	20	%25.72664642333984
60	30	%38.36444473266602
60	40	%51.00224685668945
60	50	%63.64004135131836
60	60	%76.27783966064453
60	70	%88.91563415527344
60	80	%101.5534286499023
60	90	%114.1912384033203
60	100	%126.8290328979492
70	0	0.49
70	10	%14.3027982711792
70	20	%28.11271095275879
70	30	%41.92262268066406
70	40	%55.73253631591797
70	50	%69.54244995117188
70	60	%83.35236358642578
70	70	%97.16227722167969
70	80	%110.9721908569336
70	90	%124.782096862793
70	100	%138.5920257568359
80	0	0.54
80	10	%15.70350551605225
80	20	%30.86585998535156
80	30	%46.02821350097656
80	40	%61.1905632019043
80	50	%76.35291290283203
80	60	%91.51527404785156
80	70	%106.677619934082
80	80	%121.8399810791016
80	90	%137.0023345947266
80	100	%152.1646728515625
90	0	0.60
90	10	%17.29097747802734
90	20	%33.98609161376953
90	30	%50.68120956420898
90	40	%67.37632751464844
90	50	%84.07144927978516
90	60	%100.7665557861328
90	70	%117.4616851806641
90	80	%134.1567840576172
90	90	%150.8519134521484
90	100	%167.5470275878906
99	0	0.65
99	10	%18.87938499450684
99	20	%37.10817337036133
99	30	%55.33694076538086
99	40	%73.56572723388672
99	50	%91.79451751708984
99	60	%110.0233001708984
99	70	%128.2520751953125
99	80	%146.4808807373047
99	90	%164.7096557617188
99	100	%182.9384307861328

	CLAY LOAM
HYDRAULIC CONDUCTIVITY	0.04 in/hr
SAND CONTENT	35 %
BULK DENSITY	1.45 gm/cc
SOIL CRUSTING FACTOR	.82

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.41
1	10	1.25
1	20	2.08
1	30	2.91
1	40	3.75
1	50	4.58
1	60	5.41
1	70	6.24
1	80	7.08
1	90	7.91
1	100	8.74
10	0	0.42
10	10	1.26
10	20	2.10
10	30	2.94
10	40	3.78
10	50	4.62
10	60	5.46
10	70	6.30
10	80	7.14
10	90	7.98
10	100	8.82
20	0	0.43
20	10	1.30
20	20	2.16
20	30	3.02
20	40	3.89
20	50	4.75
20	60	5.62
20	70	6.48
20	80	7.35
20	90	8.21
20	100	9.08
30	0	0.45
30	10	1.35
30	20	2.26
30	30	3.16
30	40	4.07
30	50	4.97
30	60	5.88
30	70	6.78
30	80	7.69
30	90	8.59
30	100	9.50
40	0	0.48
40	10	1.44
40	20	2.40
40	30	3.36
40	40	4.32
40	50	5.28
40	60	6.24
40	70	7.20
40	80	8.16
40	90	9.12
40	100	%10.08337020874023
50	0	0.51
50	10	1.55
50	20	2.58
50	30	3.61
50	40	4.64
50	50	5.68
50	60	6.71
50	70	7.74
50	80	8.77
50	90	9.81
50	100	%10.83857440948486
60	0	0.56
60	10	1.68
60	20	2.80
60	30	3.92
60	40	5.04
60	50	6.16
60	60	7.28
60	70	8.40
60	80	9.52
60	90	%10.64122486114502
60	100	%11.76160144805908
70	0	0.61
70	10	1.83
70	20	3.06
70	30	4.28
70	40	5.51
70	50	6.73
70	60	7.96
70	70	9.18
70	80	%10.40387725830078
70	90	%11.62816429138184
70	100	%12.85245132446289
80	0	0.67
80	10	2.01
80	20	3.36
80	30	4.70
80	40	6.05
80	50	7.39
80	60	8.73
80	70	%10.07856941223145
80	80	%11.42275428771973
80	90	%12.76694011688232
80	100	%14.11112403869629
90	0	0.74
90	10	2.22
90	20	3.70
90	30	5.18
90	40	6.66
90	50	8.14
90	60	9.62
90	70	%11.09741401672363
90	80	%12.57748317718506
90	90	%14.05755138397217
90	100	%15.53761959075928
99	0	0.80
99	10	2.42
99	20	4.04
99	30	5.65
99	40	7.27
99	50	8.88
99	60	%10.50082588195801
99	70	%12.11685752868652
99	80	%13.73289109276367
99	90	%15.3489236831665
99	100	%16.96495628356934

SANDY CLAY LOAM

HYDRAULIC CONDUCTIVITY	0.06 in/hr
SAND CONTENT	55 %
BULK DENSITY	1.60 gm/cc
SOIL CRUSTING FACTOR	.85

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.51
1	10	0.62
1	20	0.73
1	30	0.84
1	40	0.95
1	50	1.06
1	60	1.17
1	70	1.28
1	80	1.39
1	90	1.50
1	100	1.61
10	0	0.51
10	10	0.63
10	20	0.74
10	30	0.85
10	40	0.96
10	50	1.07
10	60	1.18
10	70	1.30
10	80	1.41
10	90	1.52
10	100	1.63
20	0	0.53
20	10	0.64
20	20	0.76
20	30	0.87
20	40	0.99
20	50	1.10
20	60	1.22
20	70	1.33
20	80	1.45
20	90	1.56
20	100	1.68
30	0	0.55
30	10	0.67
30	20	0.79
30	30	0.91
30	40	1.03
30	50	1.15
30	60	1.27
30	70	1.39
30	80	1.51
30	90	1.63
30	100	1.75
40	0	0.59
40	10	0.71
40	20	0.84
40	30	0.97
40	40	1.10
40	50	1.22
40	60	1.35
40	70	1.48
40	80	1.61
40	90	1.73
40	100	1.86
50	0	0.63
50	10	0.77
50	20	0.91
50	30	1.04
50	40	1.18
50	50	1.32
50	60	1.45
50	70	1.59
50	80	1.73
50	90	1.86
50	100	2.00
60	0	0.68
60	10	0.83
60	20	0.98
60	30	1.13
60	40	1.28
60	50	1.43
60	60	1.58
60	70	1.73
60	80	1.87
60	90	2.02
60	100	2.17
70	0	0.75
70	10	0.91
70	20	1.07
70	30	1.24
70	40	1.40
70	50	1.56
70	60	1.72
70	70	1.89
70	80	2.05
70	90	2.21
70	100	2.37
80	0	0.82
80	10	1.00
80	20	1.18
80	30	1.36
80	40	1.54
80	50	1.71
80	60	1.89
80	70	2.07
80	80	2.25
80	90	2.43
80	100	2.61
90	0	0.90
90	10	1.10
90	20	1.30
90	30	1.49
90	40	1.69
90	50	1.89
90	60	2.08
90	70	2.28
90	80	2.48
90	90	2.67
90	100	2.87
99	0	0.99
99	10	1.20
99	20	1.42
99	30	1.63
99	40	1.85
99	50	2.06
99	60	2.28
99	70	2.49
99	80	2.70
99	90	2.92
99	100	3.13

SILT LOAM

HYDRAULIC CONDUCTIVITY	0.15 in/hr
SAND CONTENT	20 %
BULK DENSITY	1.25 gm/cc
SOIL CRUSTING FACTOR	.81

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.36
1	10	2.94
1	20	5.53
1	30	8.11
1	40	%10.69075489044189
1	50	%13.27273273468018
1	60	%15.85471057891846
1	70	%18.43668937683105
1	80	%21.01866722106934
1	90	%23.60064506530762
1	100	%26.1826229095459
10	0	0.37
10	10	2.97
10	20	5.58
10	30	8.19
10	40	%10.79235076904297
10	50	%13.39886474609375
10	60	%16.00538063049316
10	70	%18.61189460754395
10	80	%21.21841049194336
10	90	%23.82492446899414
10	100	%26.43144035339355
20	0	0.38
20	10	3.06
20	20	5.74
20	30	8.42
20	40	%11.10021495819092
20	50	%13.78108310699463
20	60	%16.46195220947266
20	70	%19.14282035827637
20	80	%21.82369041442871
20	90	%24.50455856323242
20	100	%27.18542671203613
30	0	0.39
30	10	3.20
30	20	6.00
30	30	8.81
30	40	%11.61332130432129
30	50	%14.41811370849609
30	60	%17.2229061126709
30	70	%20.02769660949707
30	80	%22.83248901367188
30	90	%25.63728141784668
30	100	%28.44207382202148
40	0	0.42
40	10	3.40
40	20	6.38
40	30	9.35
40	40	%12.3316707611084
40	50	%15.30995655059814
40	60	%18.28824043273926
40	70	%21.26652336120605
40	80	%24.24480819702148
40	90	%27.22309303283691
40	100	%30.20137405395508
50	0	0.45
50	10	3.65
50	20	6.85
50	30	%10.05391883850098
50	40	%13.25526523590088
50	50	%16.45660972595215
50	60	%19.65795516967773
50	70	%22.85930252075195
50	80	%26.06064605712891
50	90	%29.26199150085449
50	100	%32.46334075927734
60	0	0.49
60	10	3.96
60	20	7.44
60	30	%10.91012382507324
60	40	%14.38410091400146
60	50	%17.85807609558105
60	60	%21.33205223083496
60	70	%24.80602836608887
60	80	%28.28000259399414
60	90	%31.75398063659668
60	100	%35.22795486450195
70	0	0.53
70	10	4.33
70	20	8.13
70	30	%11.92200183868408
70	40	%15.71817779541016
70	50	%19.51435279846191
70	60	%23.3105297088623
70	70	%27.1067066192627
70	80	%30.90288352966309
70	90	%34.69905853271484
70	100	%38.49523544311523
80	0	0.59
80	10	4.75
80	20	8.92
80	30	%13.0895528793335
80	40	%17.25749969482422
80	50	%21.42544364929199
80	60	%25.5933895111084
80	70	%29.76133155822754
80	80	%33.92927932739258
80	90	%38.09722518920898
80	100	%42.26516723632812
90	0	0.64
90	10	5.23
90	20	9.82
90	30	%14.41277885437012
90	40	%19.0020637512207
90	50	%23.59134674072266
90	60	%28.18062973022461
90	70	%32.76991271972656
90	80	%37.35919952392578
90	90	%41.94848251342773
90	100	%46.53776168823242
99	0	0.70
99	10	5.72
99	20	%10.72591400146484
99	30	%15.73678112030029
99	40	%20.74765205383301
99	50	%25.75852203369141
99	60	%30.76939392089844
99	70	%35.7802619934082
99	80	%40.79113388061523
99	90	%45.802001953125
99	100	%50.81287002563477

	LOAM
HYDRAULIC CONDUCTIVITY	0.25 in/hr
SAND CONTENT	45 %
BULK DENSITY	1.55 gm/cc
SOIL CRUSTING FACTOR	.82

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.46
1	10	0.80
1	20	1.15
1	30	1.50
1	40	1.85
1	50	2.20
1	60	2.55
1	70	2.90
1	80	3.25
1	90	3.59
1	100	3.94
10	0	0.46
10	10	0.81
10	20	1.16
10	30	1.52
10	40	1.87
10	50	2.22
10	60	2.57
10	70	2.92
10	80	3.28
10	90	3.63
10	100	3.98
20	0	0.47
20	10	0.84
20	20	1.20
20	30	1.56
20	40	1.92
20	50	2.28
20	60	2.65
20	70	3.01
20	80	3.37
20	90	3.73
20	100	4.09
30	0	0.50
30	10	0.87
30	20	1.25
30	30	1.63
30	40	2.01
30	50	2.39
30	60	2.77
30	70	3.15
30	80	3.53
30	90	3.91
30	100	4.28
40	0	0.53
40	10	0.93
40	20	1.33
40	30	1.73
40	40	2.14
40	50	2.54
40	60	2.94
40	70	3.34
40	80	3.74
40	90	4.15
40	100	4.55
50	0	0.57
50	10	1.00
50	20	1.43
50	30	1.86
50	40	2.29
50	50	2.73
50	60	3.16
50	70	3.59
50	80	4.02
50	90	4.46
50	100	4.89
60	0	0.61
60	10	1.08
60	20	1.55
60	30	2.02
60	40	2.49
60	50	2.96
60	60	3.43
60	70	3.90
60	80	4.37
60	90	4.84
60	100	5.31
70	0	0.67
70	10	1.18
70	20	1.70
70	30	2.21
70	40	2.72
70	50	3.23
70	60	3.75
70	70	4.26
70	80	4.77
70	90	5.29
70	100	5.80
80	0	0.74
80	10	1.30
80	20	1.86
80	30	2.42
80	40	2.99
80	50	3.55
80	60	4.11
80	70	4.68
80	80	5.24
80	90	5.80
80	100	6.37
90	0	0.81
90	10	1.43
90	20	2.05
90	30	2.67
90	40	3.29
90	50	3.91
90	60	4.53
90	70	5.15
90	80	5.77
90	90	6.39
90	100	7.01
99	0	0.88
99	10	1.56
99	20	2.24
99	30	2.92
99	40	3.59
99	50	4.27
99	60	4.95
99	70	5.62
99	80	6.30
99	90	6.98
99	100	7.65

	SANDY LOAM
HYDAULIC CONDUCTIVITY	0.40 in/hr
SAND CONTENT	60 %
BULK DENSITY	1.50 gm/cc
SOIL CRUSTING FACTOR	.86

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.53
1	10	0.56
1	20	0.59
1	30	0.62
1	40	0.64
1	50	0.67
1	60	0.70
1	70	0.73
1	80	0.76
1	90	0.78
1	100	0.81
10	0	0.54
10	10	0.57
10	20	0.60
10	30	0.62
10	40	0.65
10	50	0.68
10	60	0.71
10	70	0.73
10	80	0.76
10	90	0.79
10	100	0.82
20	0	0.55
20	10	0.58
20	20	0.61
20	30	0.64
20	40	0.67
20	50	0.70
20	60	0.73
20	70	0.76
20	80	0.78
20	90	0.81
20	100	0.84
30	0	0.58
30	10	0.61
30	20	0.64
30	30	0.67
30	40	0.70
30	50	0.73
30	60	0.76
30	70	0.79
30	80	0.82
30	90	0.85
30	100	0.88
40	0	0.62
40	10	0.65
40	20	0.68
40	30	0.71
40	40	0.74
40	50	0.78
40	60	0.81
40	70	0.84
40	80	0.87
40	90	0.90
40	100	0.94
50	0	0.66
50	10	0.70
50	20	0.73
50	30	0.77
50	40	0.80
50	50	0.83
50	60	0.87
50	70	0.90
50	80	0.94
50	90	0.97
50	100	1.01
60	0	0.72
60	10	0.76
60	20	0.79
60	30	0.83
60	40	0.87
60	50	0.90
60	60	0.94
60	70	0.98
60	80	1.02
60	90	1.05
60	100	1.09
70	0	0.79
70	10	0.83
70	20	0.87
70	30	0.91
70	40	0.95
70	50	0.99
70	60	1.03
70	70	1.07
70	80	1.11
70	90	1.15
70	100	1.19
80	0	0.86
80	10	0.91
80	20	0.95
80	30	1.00
80	40	1.04
80	50	1.09
80	60	1.13
80	70	1.17
80	80	1.22
80	90	1.26
80	100	1.31
90	0	0.95
90	10	1.00
90	20	1.05
90	30	1.10
90	40	1.15
90	50	1.20
90	60	1.24
90	70	1.29
90	80	1.34
90	90	1.39
90	100	1.44
99	0	1.04
99	10	1.09
99	20	1.14
99	30	1.20
99	40	1.25
99	50	1.31
99	60	1.36
99	70	1.41
99	80	1.47
99	90	1.52
99	100	1.57

LOAMY SAND

HYDRAULIC CONDUCTIVITY	1.20 in/hr
SAND CONTENT	80 %
BULK DENSITY	1.55 gm/cc
SOIL CRUSTING FACTOR	.89

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.63
1	10	0.58
1	20	0.53
1	30	0.48
1	40	0.43
1	50	0.38
1	60	0.33
1	70	0.28
1	80	0.22
1	90	0.17
1	100	0.12
10	0	0.64
10	10	0.59
10	20	0.53
10	30	0.48
10	40	0.43
10	50	0.38
10	60	0.33
10	70	0.28
10	80	0.23
10	90	0.18
10	100	0.12
20	0	0.66
20	10	0.60
20	20	0.55
20	30	0.50
20	40	0.44
20	50	0.39
20	60	0.34
20	70	0.29
20	80	0.23
20	90	0.18
20	100	0.13
30	0	0.69
30	10	0.63
30	20	0.58
30	30	0.52
30	40	0.47
30	50	0.41
30	60	0.35
30	70	0.30
30	80	0.24
30	90	0.19
30	100	0.13
40	0	0.73
40	10	0.67
40	20	0.61
40	30	0.55
40	40	0.49
40	50	0.44
40	60	0.38
40	70	0.32
40	80	0.26
40	90	0.20
40	100	0.14
50	0	0.78
50	10	0.72
50	20	0.66
50	30	0.59
50	40	0.53
50	50	0.47
50	60	0.40
50	70	0.34
50	80	0.28
50	90	0.22
50	100	0.15
60	0	0.85
60	10	0.78
60	20	0.71
60	30	0.64
60	40	0.58
60	50	0.51
60	60	0.44
60	70	0.37
60	80	0.30
60	90	0.23
60	100	0.17
70	0	0.93
70	10	0.85
70	20	0.78
70	30	0.70
70	40	0.63
70	50	0.55
70	60	0.48
70	70	0.41
70	80	0.33
70	90	0.26
70	100	0.18
80	0	1.02
80	10	0.94
80	20	0.86
80	30	0.77
80	40	0.69
80	50	0.61
80	60	0.53
80	70	0.45
80	80	0.36
80	90	0.28
80	100	0.20
90	0	1.12
90	10	1.03
90	20	0.94
90	30	0.85
90	40	0.76
90	50	0.67
90	60	0.58
90	70	0.49
90	80	0.40
90	90	0.31
90	100	0.22
99	0	1.23
99	10	1.13
99	20	1.03
99	30	0.93
99	40	0.83
99	50	0.73
99	60	0.63
99	70	0.54
99	80	0.44
99	90	0.34
99	100	0.24

Results from RKE.BAS

	SAND
HYDRAULIC CONDUCTIVITY	4.60 in/hr
SAND CONTENT	90 %
BULK DENSITY	1.55 gm/cc
SOIL CRUSTING FACTOR	.91

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.68
1	10	0.62
1	20	0.55
1	30	0.49
1	40	0.43
1	50	0.36
1	60	0.30
1	70	0.24
1	80	0.17
1	90	0.11
1	100	0.05
10	0	0.69
10	10	0.62
10	20	0.56
10	30	0.49
10	40	0.43
10	50	0.37
10	60	0.30
10	70	0.24
10	80	0.17
10	90	0.11
10	100	0.05
20	0	0.71
20	10	0.64
20	20	0.57
20	30	0.51
20	40	0.44
20	50	0.38
20	60	0.31
20	70	0.24
20	80	0.18
20	90	0.11
20	100	0.05
30	0	0.74
30	10	0.67
30	20	0.60
30	30	0.53
30	40	0.46
30	50	0.39
30	60	0.32
30	70	0.26
30	80	0.19
30	90	0.12
30	100	0.05
40	0	0.78
40	10	0.71
40	20	0.64
40	30	0.56
40	40	0.49
40	50	0.42
40	60	0.35
40	70	0.27
40	80	0.20
40	90	0.13
40	100	0.05
50	0	0.84
50	10	0.76
50	20	0.68
50	30	0.61
50	40	0.53
50	50	0.45
50	60	0.37
50	70	0.29
50	80	0.21
50	90	0.14
50	100	0.06
60	0	0.91
60	10	0.83
60	20	0.74
60	30	0.66
60	40	0.57
60	50	0.49
60	60	0.40
60	70	0.32
60	80	0.23
60	90	0.15
60	100	0.06
70	0	1.00
70	10	0.91
70	20	0.81
70	30	0.72
70	40	0.63
70	50	0.53
70	60	0.44
70	70	0.35
70	80	0.25
70	90	0.16
70	100	0.07
80	0	1.10
80	10	0.99
80	20	0.89
80	30	0.79
80	40	0.69
80	50	0.59
80	60	0.48
80	70	0.38
80	80	0.28
80	90	0.18
80	100	0.07
90	0	1.21
90	10	1.09
90	20	0.98
90	30	0.87
90	40	0.76
90	50	0.64
90	60	0.53
90	70	0.42
90	80	0.31
90	90	0.19
90	100	0.08
99	0	1.32
99	10	1.19
99	20	1.07
99	30	0.95
99	40	0.83
99	50	0.70
99	60	0.58
99	70	0.46
99	80	0.33
99	90	0.21
99	100	0.09

SANDY CLAY LOAM A = 1.0

HYDRAULIC CONDUCTIVITY 0.06 in/hr
SAND CONTENT 55 %
BULK DENSITY 1.60 gm/cc
SOIL CRUSTING FACTOR .85

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.51
1	10	0.56
1	20	0.61
1	30	0.66
1	40	0.71
1	50	0.75
1	60	0.80
1	70	0.85
1	80	0.90
1	90	0.95
1	100	1.00
10	0	0.51
10	10	0.56
10	20	0.61
10	30	0.66
10	40	0.71
10	50	0.76
10	60	0.81
10	70	0.86
10	80	0.91
10	90	0.96
10	100	1.01
20	0	0.53
20	10	0.58
20	20	0.63
20	30	0.68
20	40	0.73
20	50	0.78
20	60	0.83
20	70	0.89
20	80	0.94
20	90	0.99
20	100	1.04
30	0	0.55
30	10	0.61
30	20	0.66
30	30	0.71
30	40	0.77
30	50	0.82
30	60	0.87
30	70	0.93
30	80	0.98
30	90	1.03
30	100	1.09
40	0	0.59
40	10	0.64
40	20	0.70
40	30	0.76
40	40	0.81
40	50	0.87
40	60	0.93
40	70	0.98
40	80	1.04
40	90	1.10
40	100	1.15
50	0	0.63
50	10	0.69
50	20	0.75
50	30	0.81
50	40	0.87
50	50	0.94
50	60	1.00
50	70	1.06
50	80	1.12
50	90	1.18
50	100	1.24
60	0	0.68
60	10	0.75
60	20	0.82
60	30	0.88
60	40	0.95
60	50	1.02
60	60	1.08
60	70	1.15
60	80	1.21
60	90	1.28
60	100	1.35
70	0	0.75
70	10	0.82
70	20	0.89
70	30	0.96
70	40	1.04
70	50	1.11
70	60	1.18
70	70	1.25
70	80	1.33
70	90	1.40
70	100	1.47
80	0	0.82
80	10	0.90
80	20	0.98
80	30	1.06
80	40	1.14
80	50	1.22
80	60	1.30
80	70	1.38
80	80	1.46
80	90	1.54
80	100	1.61
90	0	0.90
90	10	0.99
90	20	1.08
90	30	1.17
90	40	1.25
90	50	1.34
90	60	1.43
90	70	1.52
90	80	1.60
90	90	1.69
90	100	1.78
99	0	0.99
99	10	1.08
99	20	1.18
99	30	1.27
99	40	1.37
99	50	1.46
99	60	1.56
99	70	1.65
99	80	1.75
99	90	1.85
99	100	1.94

	LOAM A = 1.0
HYDRAULIC CONDUCTIVITY	0.25 in/hr
SAND CONTENT	45 %
BULK DENSITY	1.55 gm/cc
SOIL CRUSTING FACTOR	.82

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.46
1	10	0.51
1	20	0.56
1	30	0.62
1	40	0.67
1	50	0.73
1	60	0.78
1	70	0.84
1	80	0.89
1	90	0.95
1	100	1.00
10	0	0.46
10	10	0.52
10	20	0.57
10	30	0.62
10	40	0.68
10	50	0.73
10	60	0.79
10	70	0.84
10	80	0.90
10	90	0.95
10	100	1.01
20	0	0.47
20	10	0.53
20	20	0.59
20	30	0.64
20	40	0.70
20	50	0.76
20	60	0.81
20	70	0.87
20	80	0.93
20	90	0.98
20	100	1.04
30	0	0.50
30	10	0.55
30	20	0.61
30	30	0.67
30	40	0.73
30	50	0.79
30	60	0.85
30	70	0.91
30	80	0.97
30	90	1.03
30	100	1.09
40	0	0.53
40	10	0.59
40	20	0.65
40	30	0.71
40	40	0.78
40	50	0.84
40	60	0.90
40	70	0.97
40	80	1.03
40	90	1.09
40	100	1.15
50	0	0.57
50	10	0.63
50	20	0.70
50	30	0.77
50	40	0.84
50	50	0.90
50	60	0.97
50	70	1.04
50	80	1.11
50	90	1.17
50	100	1.24
60	0	0.61
60	10	0.69
60	20	0.76
60	30	0.83
60	40	0.91
60	50	0.98
60	60	1.05
60	70	1.13
60	80	1.20
60	90	1.27
60	100	1.35
70	0	0.67
70	10	0.75
70	20	0.83
70	30	0.91
70	40	0.99
70	50	1.07
70	60	1.15
70	70	1.23
70	80	1.31
70	90	1.39
70	100	1.47
80	0	0.74
80	10	0.82
80	20	0.91
80	30	1.00
80	40	1.09
80	50	1.18
80	60	1.26
80	70	1.35
80	80	1.44
80	90	1.53
80	100	1.61
90	0	0.81
90	10	0.91
90	20	1.00
90	30	1.10
90	40	1.20
90	50	1.29
90	60	1.39
90	70	1.49
90	80	1.58
90	90	1.68
90	100	1.78
99	0	0.88
99	10	0.99
99	20	1.10
99	30	1.20
99	40	1.31
99	50	1.41
99	60	1.52
99	70	1.62
99	80	1.73
99	90	1.84
99	100	1.94

Sandy Loam

A = 1.0

HYDRAULIC CONDUCTIVITY	0.40 in/hr
SAND CONTENT	60 %
BULK DENSITY	1.50 gm/cc
SOIL CRUSTING FACTOR	.86

CANOPY COVER %	GROUND COVER %	HYDRAULIC CONDUCTIVITY FACTOR
1	0	0.53
1	10	0.58
1	20	0.63
1	30	0.67
1	40	0.72
1	50	0.77
1	60	0.81
1	70	0.86
1	80	0.91
1	90	0.95
1	100	1.00
10	0	0.54
10	10	0.59
10	20	0.63
10	30	0.68
10	40	0.73
10	50	0.77
10	60	0.82
10	70	0.87
10	80	0.92
10	90	0.96
10	100	1.01
20	0	0.55
20	10	0.60
20	20	0.65
20	30	0.70
20	40	0.75
20	50	0.80
20	60	0.85
20	70	0.89
20	80	0.94
20	90	0.99
20	100	1.04
30	0	0.58
30	10	0.63
30	20	0.68
30	30	0.73
30	40	0.78
30	50	0.83
30	60	0.88
30	70	0.93
30	80	0.99
30	90	1.04
30	100	1.09
40	0	0.62
40	10	0.67
40	20	0.72
40	30	0.78
40	40	0.83
40	50	0.89
40	60	0.94
40	70	0.99
40	80	1.05
40	90	1.10
40	100	1.15
50	0	0.66
50	10	0.72
50	20	0.78
50	30	0.84
50	40	0.89
50	50	0.95
50	60	1.01
50	70	1.07
50	80	1.12
50	90	1.18
50	100	1.24
60	0	0.72
60	10	0.78
60	20	0.84
60	30	0.91
60	40	0.97
60	50	1.03
60	60	1.10
60	70	1.16
60	80	1.22
60	90	1.28
60	100	1.35
70	0	0.79
70	10	0.85
70	20	0.92
70	30	0.99
70	40	1.06
70	50	1.13
70	60	1.20
70	70	1.27
70	80	1.33
70	90	1.40
70	100	1.47
80	0	0.86
80	10	0.94
80	20	1.01
80	30	1.09
80	40	1.16
80	50	1.24
80	60	1.31
80	70	1.39
80	80	1.46
80	90	1.54
80	100	1.61
90	0	0.95
90	10	1.03
90	20	1.12
90	30	1.20
90	40	1.28
90	50	1.36
90	60	1.45
90	70	1.53
90	80	1.61
90	90	1.69
90	100	1.78
99	0	1.04
99	10	1.13
99	20	1.22
99	30	1.31
99	40	1.40
99	50	1.49
99	60	1.58
99	70	1.67
99	80	1.76
99	90	1.85
99	100	1.94

CNE

```
1 CLS
2 LOCATE 5
10 PRINT "                    CALCULATION OF EFFECTIVE CN FOR URBAN LAND"
19 LOCATE 10
20 PRINT TAB(25) "INPUT THE RATIO OF "
30 PRINT TAB(16) "DIRECTLY CONNECTED AREA TO TOTAL AREA"
31 PRINT :PRINT :PRINT :PRINT :PRINT
35 INPUT "                                          RIMP =";RIMP
40 CLS
41 LOCATE 10
42 PRINT TAB(10) "INPUT THE PERVIOUS AREA CN"
43 PRINT :PRINT :PRINT TAB(10)"THE CN FOR IMPERVIOUS AREA IS ASSUMED TO BE 95"
44 PRINT :PRINT :PRINT :PRINT :PRINT
45 INPUT "                                            CN =";CN
46 CLS
47 LOCATE 10
50 PRINT TAB(10) "INPUT THE PRECIPITATION DEPTH, IN INCHES"
51 PRINT :PRINT :PRINT :PRINT :PRINT
52 INPUT "                                             P =";P
54 CLS
130 S=(1000/CN)-10
132 TEST=.2*S
133 LOCATE 10
134 IF P>TEST GOTO 140
136 PRINT TAB(20) "INITIAL ABSTRACTION EXCEEDS PRECIPITATION AMOUNT"
137 LOCATE 10
138 GOTO 600
140 Q=(P-.2*S)^2/(P+.8*S)
200 CNI = 95
210 SI=(1000/CNI)-10
212 TEST=.2*SI
214 IF P>TEST GOTO 220
215 LOCATE 10
216 PRINT TAB(20) "INITIAL ABSTRACTION EXCEEDS PRECIPITATION ON IMPERVIOUS AREA"

218 GOTO 600
220 QI=(P-.2*SI)^2/(P+.8*SI)
230 QT=Q*(1-RIMP)+QI*RIMP
300 D=.4*P+.8*QT
310 E=.16*P*(P-QT)
320 F=SQR(D^2-E)
340 SE=(D-F)/.08
360 CNE=1000/(SE+10)
390 LOCATE 10
400 PRINT TAB(20) "EFFECTIVE CN =";CNE
600 END
```

CNETBL

```
10 FORMAT$ = "   ##          ##.#       ##.#       ##.#        ##.#       ##.#"
20 INPUT "RIMP";RIMP
30 LPRINT "                    CN impervious = 95"
32 LPRINT "          Ratio of impervious to total area (RIMP) = ", RIMP
33 LPRINT:LPRINT
34 LPRINT "                                CN effective"
36 LPRINT "              ----------------------------------------------------"
38 LPRINT "CN pervious  P=1.0 in.  P=2.0 in.  P=3.0 in.  P=4.0 in.  P=5.0 in."
40 LPRINT "-----------  ---------  ---------  ---------  ---------  ---------"
42 LPRINT "    (1)         (2)        (3)        (4)        (5)        (6)"
44 LPRINT
55 FOR I=1 TO 6
60 CN=30+10*I
65 FOR P=1 TO 5
130 S=(1000/CN)-10
132 TEST=.2*S
133 IF P>TEST GOTO 140
134 CNE(P)=0!
136 GOTO 400
140 Q=(P-.2*S)^2/(P+.8*S)
200 CNI = 95
210 SI=(1000/CNI)-10
212 TEST=.2*SI
214 IF P>TEST GOTO 220
216 CNE(P)=-1!
218 GOTO 400
220 QI=(P-.2*SI)^2/(P+.8*SI)
230 QT=Q*(1-RIMP)+QI*RIMP
300 D=.4*P+.8*QT
310 E=.16*P*(P-QT)
320 F=SQR(D^2-E)
340 SE=(D-F)/.08
360 CNE(P)=1000/(SE+10)
400 NEXT P
412 LPRINT USING FORMAT$;CN,CNE(1),CNE(2),CNE(3),CNE(4),CNE(5)
500 NEXT I
550 LPRINT:LPRINT:LPRINT:LPRINT:LPRINT
600 END
```

check

RIMP = .20

CN impervious = 95

CN pervious = 70

$CN = 70$ $\qquad S = \frac{1000}{CN} - 10 \qquad$ $CN = 95$

$S = 4.29''$ $\qquad\qquad$ $S = .53''$

$$Q_p = \frac{(P - .2S)^2}{P + .8S}$$

$$= \frac{(4 - .2(4.29))^2}{4 + .8(4.29)} \qquad\qquad Q_p = \frac{(4 - .2(.53))^2}{4 + .8(.53)}$$

$$= 1.33'' \qquad\qquad = 3.43''$$

$$1.33(.8) + 3.43(.2) = 1.75''$$

for $CN = 76.2$

$S = 3.12''$

$$Q = \frac{(4 - .2(3.12))^2}{4 + .8(3.12)}$$

$Q = 1.75''$ <u>OK</u>

CN impervious = 95
Ratio of impervious to total area (RIMP) = .05

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	46.9	45.1
50	0.0	0.0	55.6	54.0	53.3
60	0.0	64.8	63.2	62.6	62.3
70	75.3	72.4	71.9	71.6	71.5
80	81.6	81.1	80.9	80.9	80.8
90	90.3	90.3	90.3	90.3	90.3

CN impervious = 95
Ratio of impervious to total area (RIMP) = .1

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	51.8	49.3
50	0.0	0.0	59.8	57.5	56.4
60	0.0	68.4	66.0	65.0	64.4
70	78.2	74.5	73.6	73.2	72.9
80	83.0	82.1	81.9	81.7	81.6
90	90.6	90.6	90.5	90.5	90.5

CN impervious = 95
Ratio of impervious to total area (RIMP) = .15

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	55.9	53.0
50	0.0	0.0	63.3	60.7	59.3
60	0.0	71.3	68.6	67.3	66.5
70	80.4	76.4	75.3	74.7	74.3
80	84.2	83.1	82.8	82.6	82.5
90	90.9	90.8	90.8	90.8	90.8

CN impervious = 95
Ratio of impervious to total area (RIMP) = .2

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	59.5	56.5
50	0.0	0.0	66.4	63.6	62.0
60	0.0	73.8	70.9	69.5	68.6
70	82.1	78.1	76.8	76.2	75.7
80	85.2	84.1	83.6	83.4	83.3
90	91.2	91.1	91.1	91.0	91.0

CN impervious = 95
Ratio of impervious to total area (RIMP) = .25

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	62.8	59.7
50	0.0	0.0	69.2	66.4	64.6
60	0.0	76.1	73.1	71.5	70.6
70	83.6	79.7	78.3	77.6	77.1
80	86.2	85.0	84.5	84.2	84.0
90	91.5	91.4	91.3	91.3	91.3

CN impervious = 95
Ratio of impervious to total area (RIMP) = .3

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	65.8	62.7
50	0.0	0.0	71.8	68.9	67.1
60	0.0	78.1	75.1	73.5	72.5
70	84.9	81.2	79.8	79.0	78.4
80	87.1	85.8	85.3	85.0	84.8
90	91.8	91.6	91.6	91.6	91.5

CN impervious = 95
Ratio of impervious to total area (RIMP) = .4

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	71.2	68.4
50	0.0	0.0	76.3	73.7	71.8
60	0.0	81.6	78.9	77.2	76.1
70	87.1	83.9	82.4	81.6	81.0
80	88.7	87.4	86.9	86.6	86.4
90	92.3	92.2	92.1	92.1	92.0

CN impervious = 95
Ratio of impervious to total area (RIMP) = .5

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	76.1	73.6
50	0.0	0.0	80.3	77.9	76.2
60	0.0	84.5	82.2	80.7	79.6
70	89.0	86.2	84.9	84.1	83.6
80	90.1	88.9	88.4	88.1	87.9
90	92.8	92.7	92.6	92.6	92.5

CN impervious = 95
Ratio of impervious to total area (RIMP) = .6

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	80.5	78.4
50	0.0	0.0	83.9	81.9	80.4
60	0.0	87.1	85.2	83.9	83.0
70	90.5	88.3	87.2	86.5	86.0
80	91.3	90.3	89.8	89.5	89.4
90	93.3	93.2	93.1	93.1	93.0

CN impervious = 95
Ratio of impervious to total area (RIMP) = .7

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	84.6	82.3
50	0.0	0.0	87.0	85.5	84.3
60	0.0	89.4	88.0	86.9	86.2
70	91.9	90.2	89.3	88.8	88.3
80	92.4	91.6	91.2	91.0	90.8
90	93.8	93.6	93.6	93.6	93.5

CN impervious = 95
Ratio of impervious to total area (RIMP) = .8

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	88.3	87.2
50	0.0	0.0	89.9	88.9	88.1
60	0.0	91.5	90.5	89.8	89.2
70	93.0	92.0	91.4	90.9	90.5
80	93.3	92.9	92.5	92.4	92.2
90	94.2	94.1	94.1	94.0	94.0

CN impervious = 95
Ratio of impervious to total area (RIMP) = .9

CN pervious	CN effective P=1.0 in.	P=2.0 in.	P=3.0 in.	P=4.0 in.	P=5.0 in.
(1)	(2)	(3)	(4)	(5)	(6)
40	0.0	0.0	0.0	91.8	91.2
50	0.0	0.0	92.6	92.0	91.6
60	0.0	93.3	92.8	92.5	92.2
70	94.1	93.5	93.2	93.0	92.8
80	94.2	93.9	93.8	93.7	93.6
90	94.6	94.6	94.5	94.5	94.5