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

19 June 1990

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

Subject: Documentation Manual

Dear Joe:

Enclosed is a copy of Part 2 and Part 3 of the Documentation Manual. I also made a copy of this for myself so that I can have the same on record here. The District may wish to have the original records for its files when we are finished with this project. I will maintain the originals until such time that you request them, if desired.

Please review these and provide me comments, suggestion, or remind me of missing parts, if necessary.

Attached to this letter is a copy of my outline for the Documentation Manual that I conveyed to you last December. I found it interesting that I had estimated 50 hours to prepare Parts 2 and 3 and that my records indicate that I spent 49 hours. Lucky guess!

Do you want me to prepare a draft of Part 1 (Design Rainfall Criteria)? If so, I could prepare a draft and then you and Davar could review and supplement my draft. It seems that much of what we developed and adopted is based upon our visit with the LA Corps last year. Please call me and let me know what you want me to do in this area.

I will begin a section (Part 5) on correspondence, review, and comments regarding the <u>development</u> of the manual. We may want a separate section (Part 6) on correspondence, review, and comments concerning the <u>adoption</u> of the manual. It may be best to keep these two separate.

Sincerely yours,

George V. Sabol
George V. Sabol Consulting Engineers, Inc.

PART 2

RAINFALL LOSSES

Development of Procedures

From the inception of the research for and development of the Maricopa County Hydrologic Design Manual, there was a general consensus among the authors that the adopted loss rate method would be the SCS CN method. Although the developers of the manual recognized the deficiencies of this method, it was initially to be adopted because of the wide use in Maricopa County and the general familiarity with the method by the anticipated users.

In July 1988 there arose a concern by the staff of the Flood Control District over the use of the CN method because of the high losses during high intensity rainfall periods using this method (see Interoffice Memorandum 18 July 1988, Appendix 2-A). It was recommended that other loss rate methods be considered, and that the uniform loss rate seemed appropriate.

Efforts started shortly after this to investigate use of the Initial Loss plus Uniform Loss Rate (IL+ULR). Preliminary investigations indicated that references were available for selecting the uniform loss rate (CNSTL) based on hydrologic soil group, however very little information was available to select the value of the initial loss (STRTL). Dr. David Woolhiser suggested that the Green and Ampt infiltration equation could be used to estimate the initial infiltration loss that precedes the uniform loss period. Since the initial loss is a function of the antecedent soil moisture, this led to the question of what soil moisture should be considered for the various soils and land uses in Maricopa County. A letter was written to Dr. Herman Bouwer (Appendix 2-B) describing the potential use of the Green and Ampt equation to estimate the initial loss and asking for information regarding antecedent soil moisture conditions in Maricopa County. Dr. Bouwer responded that such information is not available and the standard practice is to irrigate when one half of the available soil moisture (difference between field capacity and wilting point) has been used.

Available information on IL+ULR parameter values was compiled (Appendix 2-C). This included published values of CNSTL, estimates of CNSTL and STRTL from the previous reconstitution of 48 rainfall-runoff events for unit hydrograph development, and the estimate of STRTL from CN. These values were used as an initial guide in the selection and development of loss rate parameters.

A BASIC program, RAINX, was used to estimate STRTL for the 11 soil texture classes based on Green and Ampt equation parameter values from Rawls, Brakensiek and Miller (1983) (Appendix 2-D). This was performed by calculating the rainfall loss for each of the soil texture classes using the published values of Green and Ampt equation parameters (XKSAT and PSIF) and estimates of soil moisture deficit (DTHETA). The 100-year rainfall (3.22 inches) distributed according to Pattern No. 1 was used. The rainfall loss was accumulated up to the start of rainfall excess and this was used as a first estimate of STRTL. The output from the RAINX program is shown in Appendix 2-E. The RAINX program was then used with the IL+ULR method and the initial estimates of STRTL to estimate rainfall losses as was previously done using the Green and Ampt equation. This resulted in some adjustment to the values of STRTL. The final values of parameter and RAINX output are shown in Appendix 2-F.

A verification that both the Green and Ampt equation and the IL+ULR method gave similar results was performed by modeling a single-basin, 0.126 square mile watershed and running HEC-1 with the same input except using the Green and Ampt equation in one case and the derived values of IL+ULR parameters in the other. The HEC-1 computer output and a summary sheet of results is contained in Appendix 2-G.

During this period of development of the IL+ULR parameters, the U.S. Army Corps of Engineers, Hydrologic Engineering Center released the June 1988 version of HEC-1. This version contains the Green and Ampt equation as one of five options in calculating rainfall losses. Therefore, the decision was made to explore the use of the Green and Ampt equation as a viable method to estimate rainfall losses in Maricopa County.

The Green and Ampt equation as coded into HEC-1 requires three parameter values; hydraulic conductivity (XKSAT), capillary suction (PSIF), and soil moisture deficit (DTHETA). Values of XKSAT and PSIF can be obtained from Appendix 2-D. Values of DTHETA as functions of Dry, Normal, or Saturated soil, as defined in the Hydrologic Design Manual, were developed from information presented by Rawls and Brakensiek (1988) (Appendix 2-H). The work sheets used to develop the DTHETA "Dry" and the DTHETA "Normal" figures in the Manual are presented in Appendix 2-I.

Figure 4-11 of the Manual was derived from information in Brakensiek, Rawls and Stephenson (1984) (Appendix 2-J). The work sheet used to develop that figure is also shown in Appendix 2-J.

The effect of ground cover on infiltration rate was investigated. The equations presented by Rawls, Brakensiek and Savabi (1989) (Appendix 2-K) were investigated (discussion and results in Appendix 2-L). Those equations were not accepted because they yielded inconsistent results across the range of soil textures. Attempts were made to develop a functional relation for hydraulic conductivity as a function of ground cover and canopy cover. Dr. Leonard Lane assisted with the analysis of data that has been published by various researchers. The results of Dr. Lane's work are contained in Appendix 2-M. No satisfactory results were obtained and the lack of an adequately developed and verified procedure for adjusting bare soil infiltration rates for the effects of ground cover and canopy cover remains a major deficiency.

Dr. Tim Ward assisted in providing infiltration data, reviewing work, and as an advisor. Resent research by Ward and others at New Mexico State University and elsewhere indicates that canopy cover can greatly increase the infiltration rate. As a result of those published research results and communication with Dr. Ward, a simplified relation was developed to adjust the bare ground hydraulic conductivity for vegetation cover (Figure 4.10 of the manual).

Reviews

The following individuals have been instrumental in the technical review and/or advising in regard to the rainfall losses section:

Leonard J. Lane, Ph.D., P.E., Arid Lands Watershed Management Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Tucson, Arizona.

Robin McArthur (deceased), Soil Conservation Service, U.S. Department of Agriculture, Phoenix, Arizona.

Walter J. Rawls, Ph.D., Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland.

Kenneth G. Renard, Ph.D., P.E., Arid Lands Watershed Management Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Tucson, Arizona.

Tim J. Ward, Ph.D., P.E., Civil, Agriculture, and Geologic Engineering Department, New Mexico State University, Las Cruces.

David Woolhiser, Ph.D., Arid Lands Watershed Management Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Tucson, Arizona.

APPENDICES

PART 2 - RAINFALL LOSSES

2-A - FCDMC Memorandum, 18 July 1988, on SCS curve numbers vs. Initial and Uniform Loss Rate for estimation of rainfall excess.

2-B - Letter to Dr. Herman Bouwer, 27 August 1988, on Initial Loss plus Uniform Loss Rate parameters derived from the Green and Ampt equation

2-C - Letter to Mr. Joe Rumann, 29 August 1988, on Initial Loss plus Uniform Loss Rate parameters.

2-D - Green-Ampt Infiltration parameters from Soils Data, Rawls, W.J., Brakensiek, D.L., and Miller, N., ASCE Journal of Hydraulic Engineering, Vol. 109, No. 1, Jan. 1983, p. 62-70.

2-E - Computer output on estimation of initial loss for Initial Loss plus Uniform Loss Rate method by use of the Green and Ampt equation.

2-F - Computer output of tests of initial loss values.

2-G - HEC-1 output of verification that the Green and Ampt equation method and the IL+ULR method result in similar estimates of rainfall excess.

2-H - A Procedure to Predict Green and Ampt Infiltration Parameters, Rawls, W.J., and Brakensiek, D.L., Proceedings of ASAE Conference on Advances in Infiltration, Chicago, IL, 1988, p. 102-112.

2-I - Work sheets for the development of the DTHETA figures.

2-J - Modifying SCS Hydrologic Soil Groups and Curve Numbers for Rangeland Soils, Brakensiek, D.L., Rawls, W.J., and Stephenson, G.R., Proceedings of ASAE 1984 Annual Meeting, Kennewick, WA.

2-K - Infiltration parameters for Rangeland Soils, Rawls, W.J., Brakensiek, D.L., and Savabi, M.R., Journal of Range management, Vol. 42, No. 2, March 1989, p. 139-142.

2-L - Notes on Applicability of Infiltration Parameters for Rangeland Soils.

2-M - Correspondence and reports from Dr. Leonard J. Lane on effect of vegetation on hydraulic conductivity (diskette included).

APPENDIX 2-A

FCDMC Memorandum, 18 July 1988, on SCS curve numbers vs. Initial and Uniform Loss Rate for estimation of rainfall excess

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.

APPENDIX 2-B

Letter to Dr. Herman Bouwer, 27 August 1988, on Initial Loss plus Uniform Loss Rate parameters derived from the Green and Ampt equation

GEORGE V. SABOL Ph.D., P.E.
1351 EAST 141st AVENUE
BRIGHTON, COLORADO 80601
(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 retention 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

08-25-1987 10:31:49

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	G-A	IL+ULR	G-A	IL+ULR
	Initial	Final								
(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

APPENDIX 2-C

Letter to Mr. Joe Rumann, 29 August 1988, on Initial Loss plus Uniform Loss Rate parameters.

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

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	Initial Loss STRTL inches	Loss Rate CNSTL in/hr	CN for STRTL = .2S	
(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				
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 = .2S
(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

APPENDIX 2-D

Green-Ampt Infiltration parameters from Soils Data, Rawls, W.J., Brakensiek, D.L., and Miller, N., ASCE Journal of Hydraulic Engineering, Vol. 109, No. 1, Jan. 1983, p. 62-70.

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APPENDIX 2-E

Computer output on estimation of initial loss for Initial Loss plus Uniform Loss Rate method by use of the Green and Ampt equation.

FILENAME IS PN1.DAT
TITLE IS FCDMC 6-HR PATTERN #1
START OF RAINFALL,IN DECIMAL HOUR IS 0
TIME INCREMENT, IN MINUTES IS 15
NUMBER OF RAINFALL INPUTS IS 24

INCREMENT	RAINFALL
1	.02
2	.02
3	.01
4	.04
5	.03
6	.03
7	.03
8	.04
9	.02
10	.04
11	.04
12	.04
13	.04
14	.27
15	.57
16	1.49
17	.27
18	.05
19	.03
20	.04
21	.04
22	.01
23	.02
24	.03

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SAND DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=1.24

INITIAL SOIL MOISTURE CONTENT IS .05
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 1.9 INCHES
HYDRAULIC CONDUCTIVITY IS 4.6 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0000	0.2700	0.0000
210 - 225	0.5700	0.0000	0.5700	0.0000
225 - 240	1.4900	0.1786	1.3114	0.0000
240 - 255	0.2700	0.0000	0.2700	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	0.1786	3.0414	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SAND NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

IA=1.24

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .1
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 1.9 INCHES
HYDRAULIC CONDUCTIVITY IS 4.6 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0000	0.2700	0.0000
210 - 225	0.5700	0.0000	0.5700	0.0000
225 - 240	1.4900	0.2009	1.2891	0.0000
240 - 255	0.2700	0.0000	0.2700	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	0.2009	3.0191	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SAND Saturated

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .4
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 1.9 INCHES
HYDRAULIC CONDUCTIVITY IS 4.6 INCHES PER HOUR

IA=0.0

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0000	0.2700	0.0000
210 - 225	0.5700	0.0000	0.5700	0.0000
225 - 240	1.4900	0.3400	1.1500	0.0000
240 - 255	0.2700	0.0000	0.2700	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	0.3400	2.8800	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

LOAMY SAND DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.67

INITIAL SOIL MOISTURE CONTENT IS .05
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 2.4 INCHES
HYDRAULIC CONDUCTIVITY IS 1.2 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0000	0.2700	0.0000
210 - 225	0.5700	0.1551	0.4149	0.0000
225 - 240	1.4900	1.1109	0.3791	0.0000
240 - 255	0.2700	0.0000	0.2700	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	1.2660	1.9540	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

LOAMY SAND NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.67

INITIAL SOIL MOISTURE CONTENT IS .1
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 2.4 INCHES
HYDRAULIC CONDUCTIVITY IS 1.2 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0000	0.2700	0.0000
210 - 225	0.5700	0.1707	0.3993	0.0000
225 - 240	1.4900	1.1211	0.3689	0.0000
240 - 255	0.2700	0.0000	0.2700	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	1.2917	1.9283	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

LOAMY SAND SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=0.0

INITIAL SOIL MOISTURE CONTENT IS .4
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 2.4 INCHES
HYDRAULIC CONDUCTIVITY IS 1.2 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0000	0.2700	0.0000
210 - 225	0.5700	0.2700	0.3000	0.0000
225 - 240	1.4900	1.1900	0.3000	0.0000
240 - 255	0.2700	0.0000	0.2700	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	1.4600	1.7600	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.40

INITIAL SOIL MOISTURE CONTENT IS .1
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 4.3 INCHES
HYDRAULIC CONDUCTIVITY IS .4 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0387	0.2313	0.0000
210 - 225	0.5700	0.3770	0.1930	0.0000
225 - 240	1.4900	1.3157	0.1743	0.0000
240 - 255	0.2700	0.1073	0.1627	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	1.8386	1.3814	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.40

INITIAL SOIL MOISTURE CONTENT IS .2
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 4.3 INCHES
HYDRAULIC CONDUCTIVITY IS .4 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0730	0.1970	0.0000
210 - 225	0.5700	0.3991	0.1709	0.0000
225 - 240	1.4900	1.3329	0.1571	0.0000
240 - 255	0.2700	0.1216	0.1484	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	1.9265	1.2935	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY LOAM SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

IA=0.0

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .45
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 4.3 INCHES
HYDRAULIC CONDUCTIVITY IS .4 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.1700	0.1000	0.0000
210 - 225	0.5700	0.4700	0.1000	0.0000
225 - 240	1.4900	1.3900	0.1000	0.0000
240 - 255	0.2700	0.1700	0.1000	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	2.2000	1.0200	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.40

INITIAL SOIL MOISTURE CONTENT IS .15
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 3.5 INCHES
HYDRAULIC CONDUCTIVITY IS .15 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.1808	0.0892	0.0000
210 - 225	0.5700	0.4891	0.0809	0.0000
225 - 240	1.4900	1.4147	0.0753	0.0000
240 - 255	0.2700	0.1988	0.0712	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	2.2834	0.9366	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA = A0

INITIAL SOIL MOISTURE CONTENT IS .25
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 3.5 INCHES
HYDRAULIC CONDUCTIVITY IS .15 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.1950	0.0750	0.0000
210 - 225	0.5700	0.5003	0.0697	0.0000
225 - 240	1.4900	1.4241	0.0659	0.0000
240 - 255	0.2700	0.2069	0.0631	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	2.3264	0.8936	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

LOAM SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=0.0

INITIAL SOIL MOISTURE CONTENT IS .5
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 3.5 INCHES
HYDRAULIC CONDUCTIVITY IS .15 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0025	0.0375	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	0.0025	0.0375	0.0000
120 - 135	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0025	0.0375	0.0000
150 - 165	0.0400	0.0025	0.0375	0.0000
165 - 180	0.0400	0.0025	0.0375	0.0000
180 - 195	0.0400	0.0025	0.0375	0.0000
195 - 210	0.2700	0.2325	0.0375	0.0000
210 - 225	0.5700	0.5325	0.0375	0.0000
225 - 240	1.4900	1.4525	0.0375	0.0000
240 - 255	0.2700	0.2325	0.0375	0.0000
255 - 270	0.0500	0.0125	0.0375	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0025	0.0375	0.0000
300 - 315	0.0400	0.0025	0.0375	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	2.4825	0.7375	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SILTY ~~CLAY~~ LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.40

INITIAL SOIL MOISTURE CONTENT IS .1
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 6.6 INCHES
HYDRAULIC CONDUCTIVITY IS .25 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.0463	0.2237	0.0000
210 - 225	0.5700	0.3918	0.1782	0.0000
225 - 240	1.4900	1.3338	0.1562	-0.0000
240 - 255	0.2700	0.1274	0.1426	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	1.8992	1.3208	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SILYT LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA = .40

INITIAL SOIL MOISTURE CONTENT IS .25
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 6.6 INCHES
HYDRAULIC CONDUCTIVITY IS .25 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.1011	0.1689	0.0000
210 - 225	0.5700	0.4270	0.1430	0.0000
225 - 240	1.4900	1.3611	0.1289	0.0000
240 - 255	0.2700	0.1503	0.1197	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	2.0394	1.1806	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SILTY LOAM SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

IA=0.0

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .5
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 6.6 INCHES
HYDRAULIC CONDUCTIVITY IS .25 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.2075	0.0625	0.0000
210 - 225	0.5700	0.5075	0.0625	0.0000
225 - 240	1.4900	1.4275	0.0625	0.0000
240 - 255	0.2700	0.2075	0.0625	0.0000
255 - 270	0.0500	0.0000	0.0500	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0000	0.0400	0.0000
300 - 315	0.0400	0.0000	0.0400	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	2.3500	0.8700	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY CLAY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.40

INITIAL SOIL MOISTURE CONTENT IS .15
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 8.600001 INCHES
HYDRAULIC CONDUCTIVITY IS .06 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.2245	0.0455	0.0000
210 - 225	0.5700	0.5274	0.0426	-0.0000
225 - 240	1.4900	1.4496	0.0404	-0.0000
240 - 255	0.2700	0.2315	0.0385	0.0000
255 - 270	0.0500	0.0130	0.0370	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0052	0.0348	0.0000
300 - 315	0.0400	0.0062	0.0338	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	2.4573	0.7627	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY CLAY LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.32

INITIAL SOIL MOISTURE CONTENT IS .25
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 8.600001 INCHES
HYDRAULIC CONDUCTIVITY IS .06 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0022	0.0378	0.0000
180 - 195	0.0400	0.0044	0.0356	0.0000
195 - 210	0.2700	0.2361	0.0339	0.0000
210 - 225	0.5700	0.5375	0.0325	0.0000
225 - 240	1.4900	1.4587	0.0313	0.0000
240 - 255	0.2700	0.2397	0.0303	0.0000
255 - 270	0.0500	0.0206	0.0294	0.0000
270 - 285	0.0300	0.0013	0.0287	0.0000
285 - 300	0.0400	0.0120	0.0280	0.0000
300 - 315	0.0400	0.0125	0.0275	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0036	0.0264	0.0000
	3.2200	2.5286	0.6914	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY CLAY LOAM SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

IA=0.0

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .4
SATURATED SOIL MOISTURE CONTENT IS .4
SOIL SUCTION HEAD IS 8.600001 INCHES
HYDRAULIC CONDUCTIVITY IS .06 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0050	0.0150	0.0000
15 - 30	0.0200	0.0050	0.0150	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0250	0.0150	0.0000
60 - 75	0.0300	0.0150	0.0150	0.0000
75 - 90	0.0300	0.0150	0.0150	0.0000
90 - 105	0.0300	0.0150	0.0150	0.0000
105 - 120	0.0400	0.0250	0.0150	0.0000
120 - 135	0.0200	0.0050	0.0150	0.0000
135 - 150	0.0400	0.0250	0.0150	0.0000
150 - 165	0.0400	0.0250	0.0150	0.0000
165 - 180	0.0400	0.0250	0.0150	0.0000
180 - 195	0.0400	0.0250	0.0150	0.0000
195 - 210	0.2700	0.2550	0.0150	0.0000
210 - 225	0.5700	0.5550	0.0150	0.0000
225 - 240	1.4900	1.4750	0.0150	-0.0000
240 - 255	0.2700	0.2550	0.0150	0.0000
255 - 270	0.0500	0.0350	0.0150	0.0000
270 - 285	0.0300	0.0150	0.0150	0.0000
285 - 300	0.0400	0.0250	0.0150	0.0000
300 - 315	0.0400	0.0250	0.0150	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0050	0.0150	0.0000
345 - 360	0.0300	0.0150	0.0150	0.0000
	3.2200	2.8700	0.3500	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

CLAY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.32

INITIAL SOIL MOISTURE CONTENT IS .2
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 8.2 INCHES
HYDRAULIC CONDUCTIVITY IS .04 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0028	0.0372	0.0000
180 - 195	0.0400	0.0054	0.0346	0.0000
195 - 210	0.2700	0.2374	0.0326	0.0000
210 - 225	0.5700	0.5390	0.0310	0.0000
225 - 240	1.4900	1.4604	0.0296	0.0000
240 - 255	0.2700	0.2415	0.0285	0.0000
255 - 270	0.0500	0.0225	0.0275	0.0000
270 - 285	0.0300	0.0034	0.0266	0.0000
285 - 300	0.0400	0.0141	0.0259	0.0000
300 - 315	0.0400	0.0148	0.0252	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0060	0.0240	0.0000
	3.2200	2.5473	0.6727	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

CLAY LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.24

INITIAL SOIL MOISTURE CONTENT IS .3
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 8.2 INCHES
HYDRAULIC CONDUCTIVITY IS .04 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0022	0.0378	0.0000
120 - 135	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0082	0.0318	0.0000
150 - 165	0.0400	0.0105	0.0295	0.0000
165 - 180	0.0400	0.0123	0.0277	0.0000
180 - 195	0.0400	0.0137	0.0263	0.0000
195 - 210	0.2700	0.2449	0.0251	0.0000
210 - 225	0.5700	0.5458	0.0242	0.0000
225 - 240	1.4900	1.4666	0.0234	0.0000
240 - 255	0.2700	0.2473	0.0227	0.0000
255 - 270	0.0500	0.0280	0.0220	0.0000
270 - 285	0.0300	0.0085	0.0215	0.0000
285 - 300	0.0400	0.0190	0.0210	0.0000
300 - 315	0.0400	0.0194	0.0206	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0103	0.0197	0.0000
	3.2200	2.6368	0.5832	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

CLAY LOAM SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .45
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 8.2 INCHES
HYDRAULIC CONDUCTIVITY IS .04 INCHES PER HOUR

IA=0.0

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0100	0.0100	0.0000
15 - 30	0.0200	0.0100	0.0100	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0300	0.0100	0.0000
60 - 75	0.0300	0.0200	0.0100	0.0000
75 - 90	0.0300	0.0200	0.0100	0.0000
90 - 105	0.0300	0.0200	0.0100	0.0000
105 - 120	0.0400	0.0300	0.0100	0.0000
120 - 135	0.0200	0.0100	0.0100	0.0000
135 - 150	0.0400	0.0300	0.0100	0.0000
150 - 165	0.0400	0.0300	0.0100	0.0000
165 - 180	0.0400	0.0300	0.0100	0.0000
180 - 195	0.0400	0.0300	0.0100	0.0000
195 - 210	0.2700	0.2600	0.0100	-0.0000
210 - 225	0.5700	0.5600	0.0100	-0.0000
225 - 240	1.4900	1.4800	0.0100	0.0000
240 - 255	0.2700	0.2600	0.0100	0.0000
255 - 270	0.0500	0.0400	0.0100	0.0000
270 - 285	0.0300	0.0200	0.0100	0.0000
285 - 300	0.0400	0.0300	0.0100	0.0000
300 - 315	0.0400	0.0300	0.0100	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0100	0.0100	0.0000
345 - 360	0.0300	0.0200	0.0100	0.0000
	3.2200	2.9800	0.2400	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SILTY CLAY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

IA = .40

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .2
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 10.8 INCHES
HYDRAULIC CONDUCTIVITY IS .04 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0000	0.0400	0.0000
165 - 180	0.0400	0.0000	0.0400	0.0000
180 - 195	0.0400	0.0000	0.0400	0.0000
195 - 210	0.2700	0.2218	0.0482	0.0000
210 - 225	0.5700	0.5256	0.0444	-0.0000
225 - 240	1.4900	1.4484	0.0416	-0.0000
240 - 255	0.2700	0.2307	0.0393	0.0000
255 - 270	0.0500	0.0126	0.0374	0.0000
270 - 285	0.0300	0.0000	0.0300	0.0000
285 - 300	0.0400	0.0054	0.0346	0.0000
300 - 315	0.0400	0.0066	0.0334	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0000	0.0300	0.0000
	3.2200	2.4512	0.7688	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

4

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .35
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 10.8 INCHES
HYDRAULIC CONDUCTIVITY IS .04 INCHES PER HOUR

IA = .28

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0000	0.0400	0.0000
150 - 165	0.0400	0.0029	0.0371	0.0000
165 - 180	0.0400	0.0058	0.0342	0.0000
180 - 195	0.0400	0.0080	0.0320	0.0000
195 - 210	0.2700	0.2397	0.0303	0.0000
210 - 225	0.5700	0.5411	0.0289	0.0000
225 - 240	1.4900	1.4623	0.0277	0.0000
240 - 255	0.2700	0.2433	0.0267	0.0000
255 - 270	0.0500	0.0241	0.0259	0.0000
270 - 285	0.0300	0.0049	0.0251	0.0000
285 - 300	0.0400	0.0155	0.0245	0.0000
300 - 315	0.0400	0.0161	0.0239	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0000	0.0200	0.0000
345 - 360	0.0300	0.0073	0.0227	0.0000
	3.2200	2.5708	0.6492	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SILTY CLAY LOAM SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=0.0

INITIAL SOIL MOISTURE CONTENT IS .5
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 10.8 INCHES
HYDRAULIC CONDUCTIVITY IS .04 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0100	0.0100	0.0000
15 - 30	0.0200	0.0100	0.0100	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0300	0.0100	0.0000
60 - 75	0.0300	0.0200	0.0100	0.0000
75 - 90	0.0300	0.0200	0.0100	0.0000
90 - 105	0.0300	0.0200	0.0100	0.0000
105 - 120	0.0400	0.0300	0.0100	0.0000
120 - 135	0.0200	0.0100	0.0100	0.0000
135 - 150	0.0400	0.0300	0.0100	0.0000
150 - 165	0.0400	0.0300	0.0100	0.0000
165 - 180	0.0400	0.0300	0.0100	0.0000
180 - 195	0.0400	0.0300	0.0100	0.0000
195 - 210	0.2700	0.2600	0.0100	-0.0000
210 - 225	0.5700	0.5600	0.0100	-0.0000
225 - 240	1.4900	1.4800	0.0100	0.0000
240 - 255	0.2700	0.2600	0.0100	0.0000
255 - 270	0.0500	0.0400	0.0100	0.0000
270 - 285	0.0300	0.0200	0.0100	0.0000
285 - 300	0.0400	0.0300	0.0100	0.0000
300 - 315	0.0400	0.0300	0.0100	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0100	0.0100	0.0000
345 - 360	0.0300	0.0200	0.0100	0.0000
	3.2200	2.9800	0.2400	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY CLAY DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA = .18

INITIAL SOIL MOISTURE CONTENT IS .25
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 9.399999 INCHES
HYDRAULIC CONDUCTIVITY IS .02 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0131	0.0269	0.0000
120 - 135	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0172	0.0228	0.0000
150 - 165	0.0400	0.0187	0.0213	0.0000
165 - 180	0.0400	0.0199	0.0201	0.0000
180 - 195	0.0400	0.0209	0.0191	0.0000
195 - 210	0.2700	0.2517	0.0183	0.0000
210 - 225	0.5700	0.5524	0.0176	0.0000
225 - 240	1.4900	1.4731	0.0169	0.0000
240 - 255	0.2700	0.2536	0.0164	0.0000
255 - 270	0.0500	0.0341	0.0159	0.0000
270 - 285	0.0300	0.0145	0.0155	0.0000
285 - 300	0.0400	0.0249	0.0151	0.0000
300 - 315	0.0400	0.0252	0.0148	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0058	0.0142	0.0000
345 - 360	0.0300	0.0160	0.0140	0.0000
	3.2200	2.7413	0.4787	0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY CLAY NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

IA=.05

INITIAL SOIL MOISTURE CONTENT IS .35
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 9.399999 INCHES
HYDRAULIC CONDUCTIVITY IS .02 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0039	0.0361	0.0000
60 - 75	0.0300	0.0037	0.0263	0.0000
75 - 90	0.0300	0.0079	0.0221	0.0000
90 - 105	0.0300	0.0103	0.0197	0.0000
105 - 120	0.0400	0.0220	0.0180	0.0000
120 - 135	0.0200	0.0033	0.0167	0.0000
135 - 150	0.0400	0.0242	0.0158	0.0000
150 - 165	0.0400	0.0250	0.0150	0.0000
165 - 180	0.0400	0.0257	0.0143	0.0000
180 - 195	0.0400	0.0262	0.0138	0.0000
195 - 210	0.2700	0.2567	0.0133	0.0000
210 - 225	0.5700	0.5571	0.0129	-0.0000
225 - 240	1.4900	1.4775	0.0125	0.0000
240 - 255	0.2700	0.2578	0.0122	0.0000
255 - 270	0.0500	0.0381	0.0119	0.0000
270 - 285	0.0300	0.0183	0.0117	0.0000
285 - 300	0.0400	0.0286	0.0114	0.0000
300 - 315	0.0400	0.0288	0.0112	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0091	0.0109	0.0000
345 - 360	0.0300	0.0193	0.0107	0.0000
	3.2200	2.8434	0.3766	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SANDY CLAY SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

IA=0.0

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .45
SATURATED SOIL MOISTURE CONTENT IS .45
SOIL SUCTION HEAD IS 9.399999 INCHES
HYDRAULIC CONDUCTIVITY IS .02 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0150	0.0050	0.0000
15 - 30	0.0200	0.0150	0.0050	0.0000
30 - 45	0.0100	0.0050	0.0050	0.0000
45 - 60	0.0400	0.0350	0.0050	0.0000
60 - 75	0.0300	0.0250	0.0050	0.0000
75 - 90	0.0300	0.0250	0.0050	0.0000
90 - 105	0.0300	0.0250	0.0050	0.0000
105 - 120	0.0400	0.0350	0.0050	0.0000
120 - 135	0.0200	0.0150	0.0050	0.0000
135 - 150	0.0400	0.0350	0.0050	0.0000
150 - 165	0.0400	0.0350	0.0050	0.0000
165 - 180	0.0400	0.0350	0.0050	0.0000
180 - 195	0.0400	0.0350	0.0050	0.0000
195 - 210	0.2700	0.2650	0.0050	0.0000
210 - 225	0.5700	0.5650	0.0050	0.0000
225 - 240	1.4900	1.4850	0.0050	0.0000
240 - 255	0.2700	0.2650	0.0050	-0.0000
255 - 270	0.0500	0.0450	0.0050	0.0000
270 - 285	0.0300	0.0250	0.0050	0.0000
285 - 300	0.0400	0.0350	0.0050	0.0000
300 - 315	0.0400	0.0350	0.0050	0.0000
315 - 330	0.0100	0.0050	0.0050	0.0000
330 - 345	0.0200	0.0150	0.0050	0.0000
345 - 360	0.0300	0.0250	0.0050	0.0000
	3.2200	3.1000	0.1200	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SILTY CLAT DRY

RAINFALL DATA FILENAME IS PN1.DAT

IA = .18

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .3
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 11.5 INCHES
HYDRAULIC CONDUCTIVITY IS .02 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	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	0.0058	0.0342	0.0000
120 - 135	0.0200	0.0000	0.0200	0.0000
135 - 150	0.0400	0.0118	0.0282	0.0000
150 - 165	0.0400	0.0141	0.0259	0.0000
165 - 180	0.0400	0.0159	0.0241	0.0000
180 - 195	0.0400	0.0172	0.0228	0.0000
195 - 210	0.2700	0.2484	0.0216	0.0000
210 - 225	0.5700	0.5493	0.0207	0.0000
225 - 240	1.4900	1.4702	0.0198	-0.0000
240 - 255	0.2700	0.2509	0.0191	0.0000
255 - 270	0.0500	0.0315	0.0185	0.0000
270 - 285	0.0300	0.0120	0.0180	0.0000
285 - 300	0.0400	0.0225	0.0175	0.0000
300 - 315	0.0400	0.0230	0.0170	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0036	0.0164	0.0000
345 - 360	0.0300	0.0140	0.0160	0.0000
	3.2200	2.6903	0.5297	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SILTY CLAY NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

IA=.12

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .4
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 11.5 INCHES
HYDRAULIC CONDUCTIVITY IS .02 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0000	0.0400	0.0000
60 - 75	0.0300	0.0000	0.0300	0.0000
75 - 90	0.0300	0.0034	0.0266	0.0000
90 - 105	0.0300	0.0068	0.0232	0.0000
105 - 120	0.0400	0.0190	0.0210	0.0000
120 - 135	0.0200	0.0007	0.0193	0.0000
135 - 150	0.0400	0.0219	0.0181	0.0000
150 - 165	0.0400	0.0229	0.0171	0.0000
165 - 180	0.0400	0.0237	0.0163	0.0000
180 - 195	0.0400	0.0243	0.0157	0.0000
195 - 210	0.2700	0.2549	0.0151	0.0000
210 - 225	0.5700	0.5554	0.0146	0.0000
225 - 240	1.4900	1.4758	0.0142	-0.0000
240 - 255	0.2700	0.2562	0.0138	0.0000
255 - 270	0.0500	0.0366	0.0134	0.0000
270 - 285	0.0300	0.0169	0.0131	0.0000
285 - 300	0.0400	0.0272	0.0128	0.0000
300 - 315	0.0400	0.0274	0.0126	0.0000
315 - 330	0.0100	0.0000	0.0100	0.0000
330 - 345	0.0200	0.0079	0.0121	0.0000
345 - 360	0.0300	0.0181	0.0119	0.0000
	3.2200	2.7991	0.4209	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

SILTY CLAY SATURATED

RAINFALL DATA FILENAME IS PN1.DAT

IA=0.0

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .5
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 11.5 INCHES
HYDRAULIC CONDUCTIVITY IS .02 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0150	0.0050	0.0000
15 - 30	0.0200	0.0150	0.0050	0.0000
30 - 45	0.0100	0.0050	0.0050	0.0000
45 - 60	0.0400	0.0350	0.0050	0.0000
60 - 75	0.0300	0.0250	0.0050	0.0000
75 - 90	0.0300	0.0250	0.0050	0.0000
90 - 105	0.0300	0.0250	0.0050	0.0000
105 - 120	0.0400	0.0350	0.0050	0.0000
120 - 135	0.0200	0.0150	0.0050	0.0000
135 - 150	0.0400	0.0350	0.0050	0.0000
150 - 165	0.0400	0.0350	0.0050	0.0000
165 - 180	0.0400	0.0350	0.0050	0.0000
180 - 195	0.0400	0.0350	0.0050	0.0000
195 - 210	0.2700	0.2650	0.0050	0.0000
210 - 225	0.5700	0.5650	0.0050	0.0000
225 - 240	1.4900	1.4850	0.0050	0.0000
240 - 255	0.2700	0.2650	0.0050	-0.0000
255 - 270	0.0500	0.0450	0.0050	0.0000
270 - 285	0.0300	0.0250	0.0050	0.0000
285 - 300	0.0400	0.0350	0.0050	0.0000
300 - 315	0.0400	0.0350	0.0050	0.0000
315 - 330	0.0100	0.0050	0.0050	0.0000
330 - 345	0.0200	0.0150	0.0050	0.0000
345 - 360	0.0300	0.0250	0.0050	0.0000
	3.2200	3.1000	0.1200	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

CLAY DRY

RAINFALL DATA FILENAME IS PN1.DAT

IA = .05

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .35
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 12.4 INCHES
HYDRAULIC CONDUCTIVITY IS .01 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0034	0.0366	0.0000
60 - 75	0.0300	0.0041	0.0259	0.0000
75 - 90	0.0300	0.0086	0.0214	0.0000
90 - 105	0.0300	0.0113	0.0187	0.0000
105 - 120	0.0400	0.0231	0.0169	0.0000
120 - 135	0.0200	0.0044	0.0156	0.0000
135 - 150	0.0400	0.0254	0.0146	0.0000
150 - 165	0.0400	0.0262	0.0138	0.0000
165 - 180	0.0400	0.0269	0.0131	0.0000
180 - 195	0.0400	0.0275	0.0125	0.0000
195 - 210	0.2700	0.2580	0.0120	0.0000
210 - 225	0.5700	0.5584	0.0116	-0.0000
225 - 240	1.4900	1.4788	0.0112	0.0000
240 - 255	0.2700	0.2592	0.0108	0.0000
255 - 270	0.0500	0.0395	0.0105	0.0000
270 - 285	0.0300	0.0198	0.0102	0.0000
285 - 300	0.0400	0.0300	0.0100	0.0000
300 - 315	0.0400	0.0302	0.0098	0.0000
315 - 330	0.0100	0.0005	0.0095	0.0000
330 - 345	0.0200	0.0106	0.0094	0.0000
345 - 360	0.0300	0.0208	0.0092	0.0000
	3.2200	2.8669	0.3531	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

CLAY NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

$\pm A = .05$

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .45
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 12.4 INCHES
HYDRAULIC CONDUCTIVITY IS .01 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200	0.0000
15 - 30	0.0200	0.0000	0.0200	0.0000
30 - 45	0.0100	0.0000	0.0100	0.0000
45 - 60	0.0400	0.0241	0.0159	0.0000
60 - 75	0.0300	0.0168	0.0132	0.0000
75 - 90	0.0300	0.0184	0.0116	0.0000
90 - 105	0.0300	0.0194	0.0106	0.0000
105 - 120	0.0400	0.0302	0.0098	0.0000
120 - 135	0.0200	0.0108	0.0092	0.0000
135 - 150	0.0400	0.0313	0.0087	0.0000
150 - 165	0.0400	0.0317	0.0083	0.0000
165 - 180	0.0400	0.0320	0.0080	0.0000
180 - 195	0.0400	0.0323	0.0077	0.0000
195 - 210	0.2700	0.2626	0.0074	-0.0000
210 - 225	0.5700	0.5628	0.0072	-0.0000
225 - 240	1.4900	1.4830	0.0070	0.0000
240 - 255	0.2700	0.2631	0.0069	0.0000
255 - 270	0.0500	0.0433	0.0067	0.0000
270 - 285	0.0300	0.0235	0.0065	0.0000
285 - 300	0.0400	0.0336	0.0064	0.0000
300 - 315	0.0400	0.0337	0.0063	0.0000
315 - 330	0.0100	0.0038	0.0062	0.0000
330 - 345	0.0200	0.0139	0.0061	0.0000
345 - 360	0.0300	0.0240	0.0060	0.0000
	3.2200	2.9943	0.2257	-0.0000

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS GREEN-AMPT EQ'N

CLAY SATURATED

IA=0.0

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 0 INCHES

INITIAL SOIL MOISTURE CONTENT IS .5
SATURATED SOIL MOISTURE CONTENT IS .5
SOIL SUCTION HEAD IS 12.4 INCHES
HYDRAULIC CONDUCTIVITY IS .01 INCHES PER HOUR

TIME INTERVAL MINUTES	RAINFALL INCHES	EXCESS INCHES	INFILTRATION INCHES	INITIAL LOSS INCHES
0 - 15	0.0200	0.0175	0.0025	-0.0000
15 - 30	0.0200	0.0175	0.0025	-0.0000
30 - 45	0.0100	0.0075	0.0025	-0.0000
45 - 60	0.0400	0.0375	0.0025	0.0000
60 - 75	0.0300	0.0275	0.0025	0.0000
75 - 90	0.0300	0.0275	0.0025	0.0000
90 - 105	0.0300	0.0275	0.0025	0.0000
105 - 120	0.0400	0.0375	0.0025	0.0000
120 - 135	0.0200	0.0175	0.0025	0.0000
135 - 150	0.0400	0.0375	0.0025	-0.0000
150 - 165	0.0400	0.0375	0.0025	0.0000
165 - 180	0.0400	0.0375	0.0025	0.0000
180 - 195	0.0400	0.0375	0.0025	0.0000
195 - 210	0.2700	0.2675	0.0025	-0.0000
210 - 225	0.5700	0.5675	0.0025	0.0000
225 - 240	1.4900	1.4875	0.0025	0.0000
240 - 255	0.2700	0.2675	0.0025	-0.0000
255 - 270	0.0500	0.0475	0.0025	0.0000
270 - 285	0.0300	0.0275	0.0025	0.0000
285 - 300	0.0400	0.0375	0.0025	0.0000
300 - 315	0.0400	0.0375	0.0025	0.0000
315 - 330	0.0100	0.0075	0.0025	0.0000
330 - 345	0.0200	0.0175	0.0025	0.0000
345 - 360	0.0300	0.0275	0.0025	0.0000
	3.2200	3.1600	0.0600	0.0000

APPENDIX 2-F

Computer output of tests of initial loss values.

TABLE 4

Initial Loss plus Uniform Loss Rate parameter values for bare ground according to soil texture classification

Soil texture Classification	Uniform Loss Rate CNSTL	Initial Loss, in inches STRTL[1]		
		Dry	Normal	Saturated
(1)	(2)	(3)	(4)	(5)
sand	4.6	1.3	1.3	0.0
loamy sand	1.2	.8	.8	
sandy loam	.4	.7	.6	
loam	.15	.6	.5	
silty loam	.25	.8	.7	
sandy clay loam	.06	.6	.5	
clay loam	.04	.5	.4	
silty clay loam	.04	.6	.5	
sandy clay	.02	.4	.3	
silty clay	.02	.4	.3	
clay	.01	.3	.2	

[1] Selection of STRTL:

Dry - for nonirrigated lands such as desert and rangeland
Normal - for irrigated lawn, turf, and permanent pasture
Saturated - for irrigated agricultural land

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SAND DRY AND NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS 1.3 INCHES
UNIFORM LOSS RATE IS 4.6 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0000	0.2700
210 - 225	0.5700	0.0000	0.5700
225 - 240	1.4900	0.2800	1.2100
240 - 255	0.2700	0.0000	0.2700
255 - 270	0.0500	0.0000	0.0500
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0400	0.0000	0.0400
300 - 315	0.0400	0.0000	0.0400
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0000	0.0200
345 - 360	0.0300	0.0000	0.0300
	3.2200	0.2800	2.9400

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RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

LOAMY SAND DRY AND NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .8 INCHES
UNIFORM LOSS RATE IS 1.2 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0000	0.2700
210 - 225	0.5700	0.1400	0.4300
225 - 240	1.4900	1.1900	0.3000
240 - 255	0.2700	0.0000	0.2700
255 - 270	0.0500	0.0000	0.0500
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0400	0.0000	0.0400
300 - 315	0.0400	0.0000	0.0400
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0000	0.0200
345 - 360	0.0300	0.0000	0.0300
	3.2200	1.3300	1.8900

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RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SANDY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .7 INCHES
UNIFORM LOSS RATE IS .4 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0000	0.2700
210 - 225	0.5700	0.4400	0.1300
225 - 240	1.4900	1.3900	0.1000
240 - 255	0.2700	0.1700	0.1000
255 - 270	0.0500	0.0000	0.0500
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0400	0.0000	0.0400
300 - 315	0.0400	0.0000	0.0400
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0000	0.0200
345 - 360	0.0300	0.0000	0.0300
	3.2200	2.0000	1.2200

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RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SANDY LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .6 INCHES
UNIFORM LOSS RATE IS .4 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0000	0.2700
210 - 225	0.5700	0.4700	0.1000
225 - 240	1.4900	1.3900	0.1000
240 - 255	0.2700	0.1700	0.1000
255 - 270	0.0500	0.0000	0.0500
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0400	0.0000	0.0400
300 - 315	0.0400	0.0000	0.0400
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0000	0.0200
345 - 360	0.0300	0.0000	0.0300
	3.2200	2.0300	1.1900

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RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .6 INCHES
UNIFORM LOSS RATE IS .15 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0325	0.2375
210 - 225	0.5700	0.5325	0.0375
225 - 240	1.4900	1.4525	0.0375
240 - 255	0.2700	0.2325	0.0375
255 - 270	0.0500	0.0125	0.0375
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0400	0.0025	0.0375
300 - 315	0.0400	0.0025	0.0375
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0000	0.0200
345 - 360	0.0300	0.0000	0.0300
	3.2200	2.2675	0.9525

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RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .5 INCHES
UNIFORM LOSS RATE IS .15 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.1325	0.1375
210 - 225	0.5700	0.5325	0.0375
225 - 240	1.4900	1.4525	0.0375
240 - 255	0.2700	0.2325	0.0375
255 - 270	0.0500	0.0125	0.0375
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0400	0.0025	0.0375
300 - 315	0.0400	0.0025	0.0375
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0000	0.0200
345 - 360	0.0300	0.0000	0.0300
	3.2200	2.3675	0.8525

12-29-1988 10:29:57

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SILTY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .8 INCHES
UNIFORM LOSS RATE IS .25 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0000	0.2700
210 - 225	0.5700	0.3775	0.1925
225 - 240	1.4900	1.4275	0.0625
240 - 255	0.2700	0.2075	0.0625
255 - 270	0.0500	0.0000	0.0500
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0400	0.0000	0.0400
300 - 315	0.0400	0.0000	0.0400
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0000	0.0200
345 - 360	0.0300	0.0000	0.0300
	3.2200	2.0125	1.2075

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RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SILTY LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .7 INCHES
UNIFORM LOSS RATE IS .25 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0000	0.2700
210 - 225	0.5700	0.4775	0.0925
225 - 240	1.4900	1.4275	0.0625
240 - 255	0.2700	0.2075	0.0625
255 - 270	0.0500	0.0000	0.0500
270 - 285	0.0300	0.0000	0.0300
285 - 300	0.0400	0.0000	0.0400
300 - 315	0.0400	0.0000	0.0400
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0000	0.0200
345 - 360	0.0300	0.0000	0.0300
	3.2200	2.1125	1.1075

12-29-1988 10:31:01

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SANDY CLAY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .6 INCHES
UNIFORM LOSS RATE IS .06 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0550	0.2150
210 - 225	0.5700	0.5550	0.0150
225 - 240	1.4900	1.4750	0.0150
240 - 255	0.2700	0.2550	0.0150
255 - 270	0.0500	0.0350	0.0150
270 - 285	0.0300	0.0150	0.0150
285 - 300	0.0400	0.0250	0.0150
300 - 315	0.0400	0.0250	0.0150
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0050	0.0150
345 - 360	0.0300	0.0150	0.0150
	3.2200	2.4600	0.7600

12-29-1988 10:31:34

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SANDY CLAY LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .5 INCHES
UNIFORM LOSS RATE IS .06 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.1550	0.1150
210 - 225	0.5700	0.5550	0.0150
225 - 240	1.4900	1.4750	0.0150
240 - 255	0.2700	0.2550	0.0150
255 - 270	0.0500	0.0350	0.0150
270 - 285	0.0300	0.0150	0.0150
285 - 300	0.0400	0.0250	0.0150
300 - 315	0.0400	0.0250	0.0150
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0050	0.0150
345 - 360	0.0300	0.0150	0.0150
	3.2200	2.5600	0.6600

12-29-1988 10:32:03

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

CLAY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .5 INCHES
UNIFORM LOSS RATE IS .04 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.1600	0.1100
210 - 225	0.5700	0.5600	0.0100
225 - 240	1.4900	1.4800	0.0100
240 - 255	0.2700	0.2600	0.0100
255 - 270	0.0500	0.0400	0.0100
270 - 285	0.0300	0.0200	0.0100
285 - 300	0.0400	0.0300	0.0100
300 - 315	0.0400	0.0300	0.0100
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0100	0.0100
345 - 360	0.0300	0.0200	0.0100
	3.2200	2.6100	0.6100

12-29-1988 10:32:31

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

CLAY LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .4 INCHES
UNIFORM LOSS RATE IS .04 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.2600	0.0100
210 - 225	0.5700	0.5600	0.0100
225 - 240	1.4900	1.4800	0.0100
240 - 255	0.2700	0.2600	0.0100
255 - 270	0.0500	0.0400	0.0100
270 - 285	0.0300	0.0200	0.0100
285 - 300	0.0400	0.0300	0.0100
300 - 315	0.0400	0.0300	0.0100
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0100	0.0100
345 - 360	0.0300	0.0200	0.0100
	3.2200	2.7100	0.5100

12-29-1980 10:32:55

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SILTY CLAY LOAM DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .6 INCHES
UNIFORM LOSS RATE IS .04 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.0600	0.2100
210 - 225	0.5700	0.5600	0.0100
225 - 240	1.4900	1.4800	0.0100
240 - 255	0.2700	0.2600	0.0100
255 - 270	0.0500	0.0400	0.0100
270 - 285	0.0300	0.0200	0.0100
285 - 300	0.0400	0.0300	0.0100
300 - 315	0.0400	0.0300	0.0100
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0100	0.0100
345 - 360	0.0300	0.0200	0.0100
	3.2200	2.5100	0.7100

12-29-1980 10:33:32

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SILTY CLAY LOAM NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .5 INCHES
UNIFORM LOSS RATE IS .04 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.1600	0.1100
210 - 225	0.5700	0.5600	0.0100
225 - 240	1.4900	1.4800	0.0100
240 - 255	0.2700	0.2600	0.0100
255 - 270	0.0500	0.0400	0.0100
270 - 285	0.0300	0.0200	0.0100
285 - 300	0.0400	0.0300	0.0100
300 - 315	0.0400	0.0300	0.0100
315 - 330	0.0100	0.0000	0.0100
330 - 345	0.0200	0.0100	0.0100
345 - 360	0.0300	0.0200	0.0100
	3.2200	2.6100	0.6100

12-29-1988 10:34:01

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SANDY CLAY & SILTY CLAY DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .4 INCHES
UNIFORM LOSS RATE IS .02 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0000	0.0400
165 - 180	0.0400	0.0000	0.0400
180 - 195	0.0400	0.0000	0.0400
195 - 210	0.2700	0.2650	0.0050
210 - 225	0.5700	0.5650	0.0050
225 - 240	1.4900	1.4850	0.0050
240 - 255	0.2700	0.2650	0.0050
255 - 270	0.0500	0.0450	0.0050
270 - 285	0.0300	0.0250	0.0050
285 - 300	0.0400	0.0350	0.0050
300 - 315	0.0400	0.0350	0.0050
315 - 330	0.0100	0.0050	0.0050
330 - 345	0.0200	0.0150	0.0050
345 - 360	0.0300	0.0250	0.0050
	3.2200	2.7650	0.4550

12-29-1988 10:34:36

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

SANDY CLAY & SILTY CLAY NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .3 INCHES
UNIFORM LOSS RATE IS .02 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0150	0.0250
165 - 180	0.0400	0.0350	0.0050
180 - 195	0.0400	0.0350	0.0050
195 - 210	0.2700	0.2650	0.0050
210 - 225	0.5700	0.5650	0.0050
225 - 240	1.4900	1.4850	0.0050
240 - 255	0.2700	0.2650	0.0050
255 - 270	0.0500	0.0450	0.0050
270 - 285	0.0300	0.0250	0.0050
285 - 300	0.0400	0.0350	0.0050
300 - 315	0.0400	0.0350	0.0050
315 - 330	0.0100	0.0050	0.0050
330 - 345	0.0200	0.0150	0.0050
345 - 360	0.0300	0.0250	0.0050
	3.2200	2.8500	0.3700

12-29-1988 10:35:23

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

CLAY DRY

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .3 INCHES
UNIFORM LOSS RATE IS .01 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0200	0.0000	0.0200
135 - 150	0.0400	0.0000	0.0400
150 - 165	0.0400	0.0175	0.0225
165 - 180	0.0400	0.0375	0.0025
180 - 195	0.0400	0.0375	0.0025
195 - 210	0.2700	0.2675	0.0025
210 - 225	0.5700	0.5675	0.0025
225 - 240	1.4900	1.4875	0.0025
240 - 255	0.2700	0.2675	0.0025
255 - 270	0.0500	0.0475	0.0025
270 - 285	0.0300	0.0275	0.0025
285 - 300	0.0400	0.0375	0.0025
300 - 315	0.0400	0.0375	0.0025
315 - 330	0.0100	0.0075	0.0025
330 - 345	0.0200	0.0175	0.0025
345 - 360	0.0300	0.0275	0.0025
	3.2200	2.8850	0.3350

12-29-1988 10:35:47

RAINFALL EXCESS BY RAINX PROGRAM MODIFIED APRIL 1986

INITIAL LOSS PLUS UNIFORM RATE METHOD

CLAY NORMAL

RAINFALL DATA FILENAME IS PN1.DAT

INITIAL LOSS IS .2 INCHES
UNIFORM LOSS RATE IS .01 INCHES PER HOUR

TIME INTERVAL MINUTES	INCREMENTAL RAINFALL INCHES	INCREMENTAL RUNOFF INCHES	INCREMENTAL LOSS INCHES
0 - 15	0.0200	0.0000	0.0200
15 - 30	0.0200	0.0000	0.0200
30 - 45	0.0100	0.0000	0.0100
45 - 60	0.0400	0.0000	0.0400
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	0.0175	0.0225
120 - 135	0.0200	0.0175	0.0025
135 - 150	0.0400	0.0375	0.0025
150 - 165	0.0400	0.0375	0.0025
165 - 180	0.0400	0.0375	0.0025
180 - 195	0.0400	0.0375	0.0025
195 - 210	0.2700	0.2675	0.0025
210 - 225	0.5700	0.5675	0.0025
225 - 240	1.4900	1.4875	0.0025
240 - 255	0.2700	0.2675	0.0025
255 - 270	0.0500	0.0475	0.0025
270 - 285	0.0300	0.0275	0.0025
285 - 300	0.0400	0.0375	0.0025
300 - 315	0.0400	0.0375	0.0025
315 - 330	0.0100	0.0075	0.0025
330 - 345	0.0200	0.0175	0.0025
345 - 360	0.0300	0.0275	0.0025
	3.2200	2.9775	0.2425

12-29-1980 10:36:12

IL for Dry Soil

IL+ULR Method
using parameters derived
from Green-Ampt

Input = II
Output = ΦΦ

```
C>
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 09/23/1988 TIME 15:01:40 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X             X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X             X
X    X  X      X    X        X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          SAND
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           IO      0      0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC   .972   .982   .992   1.0
 19           LU   1.55   4.64
 20           UA     0      3      5      8     12     20     43     75     90     96
 21           UA   100
 22           UC   .48    .49
 23           ZZ
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE  09/23/1988  TIME  15:01:40 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                           SAND
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 10 IO        OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME        0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     1    0  ENDING DATE
                  NDTIME        0715  ENDING TIME
                   ICENT         19  CENTURY MARK

             COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
```

```
            **************
            *            *
11 KK       *   SUB-10   *        I-17 SUB-BASIN 10
            *            *
            **************
                                 6-HR DISTRIBUTION

14 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

12 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

15 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

16 PI            INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                    .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                    .01       .01       .01

19 LU          UNIFORM LOSS RATE
                    STRTL        1.55  INITIAL LOSS
                    CNSTL        4.64  UNIFORM LOSS RATE
                    RTIMP         .00  PERCENT IMPERVIOUS AREA

22 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

19 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0

                                                   ***

                                              UNIT HYDROGRAPH PARAMETERS
                                        CLARK   TC=   .48 HR,      R=   .49 HR
                                        SNYDER  TP=   .52 HR,     CP=   .65

                                              UNIT HYDROGRAPH
                                         12 END-OF-PERIOD ORDINATES
                  16.       76.       95.       56.       33.       20.       12.        7.        4.        2.
                   1.        1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	13.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	8.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	4.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	3.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	2.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	1.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	1.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	0.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	0.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.27	.00	0.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.56	.00	0.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	1.25	.23	4.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.27	.00	17.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	21.	1		0715	30	.00	.00	.00	0.

TOTAL RAINFALL = 3.22, TOTAL LOSS = 2.99, TOTAL EXCESS = .23

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 21.	3.50		3.	3.	3.	3.
		(INCHES)	.226	.226	.226	.226
		(AC-FT)	2.	2.	2.	2.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+ HYDROGRAPH AT	SUB-10	21.	3.50	3.	3.	3.	.13		

*** NORMAL END OF HEC-1 ***

C>0

```
1*************************************
 *                                   *
 *  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
 *          FEBRUARY 1981            *
 *        REVISED 01 JUN 88          *
 *                                   *
 * RUN DATE 09/23/1988 TIME 15:06:46 *
 *                                   *
*************************************
```

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*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
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```
X    X  XXXXXXX   XXXXX         X
X    X  X       X    X        XX
X    X  X       X              X
XXXXXXX  XXXX    X       XXXXX  X
X    X  X       X              X
X    X  X       X    X         X
X    X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          LOAMY SAND
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           IO      0      0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC    .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC    .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC    .972   .982   .992   1.0
 19           LU    .58    1.18
 20           UA      0      3      5      8     12     20     43     75     90     96
 21           UA    100
 22           UC    .48    .49
 23           ZZ
```

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1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE  09/23/1988  TIME  15:06:46 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                           LOAMY SAND
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

10 IO         OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME        0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     1    0  ENDING DATE
                  NDTIME        0715  ENDING TIME
                   ICENT         19  CENTURY MARK

             COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

       ENGLISH UNITS
           DRAINAGE AREA        SQUARE MILES
           PRECIPITATION DEPTH  INCHES
           LENGTH, ELEVATION    FEET
           FLOW                 CUBIC FEET PER SECOND
           STORAGE VOLUME       ACRE-FEET
           SURFACE AREA         ACRES
           TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
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            **************
            *            *
11 KK       *   SUB-10   *        I-17 SUB-BASIN 10
            *            *
            **************
                          6-HR DISTRIBUTION

14 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

12 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

15 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

16 PI            INCREMENTAL PRECIPITATION PATTERN
                    .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                    .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                    .01      .01      .01

19 LU          UNIFORM LOSS RATE
                    STRTL         .58  INITIAL LOSS
                    CNSTL        1.16  UNIFORM LOSS RATE
                    RTIMP         .00  PERCENT IMPERVIOUS AREA

22 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

19 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                   100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	75.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	45.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	26.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	16.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	9.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	6.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	3.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	2.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	1.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.27	.00	0.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.30	.27	4.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.29	1.18	40.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.27	.00	115.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	127.	1		0715	30	.00	.00	.00	0.

TOTAL RAINFALL = 3.22, TOTAL LOSS = 1.77, TOTAL EXCESS = 1.45

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
127.	3.50		20.	16.	16.	16.
		(INCHES)	1.440	1.440	1.440	1.440
		(AC-FT)	10.	10.	10.	10.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	127.	3.50	20.	16.	16.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 09/23/1988 TIME 15:09:22 *
*                                   *
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*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*     DAVIS, CALIFORNIA 95616       *
*        (916) 551-1748             *
*                                   *
*************************************
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```
X    X  XXXXXXX  XXXXX         X
X    X  X       X    X       XX
X    X  X       X            X
XXXXXXX  XXXX    X      XXXXX  X
X    X  X       X            X
X    X  X       X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITIAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          SANDY LOAM
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           ID      0      0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC   .972   .982   .992   1.0
 19           LU   .65    .43
 20           UA     0      3      5      8     12     20     43     75     90     96
 21           UA   100
 22           UC   .48    .49
 23           ZZ
```

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*          FEBRUARY 1981               *
*        REVISED 01 JUN 88             *
*                                      *
* RUN DATE  09/23/1988  TIME  15:09:22 *
*                                      *
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****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                           SANDY LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

10 10         OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME       0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     1    0  ENDING DATE
                  NDTIME       0715  ENDING TIME
                   ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE   7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


          **************
          *            *
 11 KK    *   SUB-10   *       I-17 SUB-BASIN 10
          *            *
          **************
```

6-HR DISTRIBUTION

```
14 IN      TIME DATA FOR INPUT TIME SERIES
               JXMIN        15  TIME INTERVAL IN MINUTES
              JXDATE     1   0  STARTING DATE
              JXTIME         0  STARTING TIME

           SUBBASIN RUNOFF DATA

12 BA      SUBBASIN CHARACTERISTICS
               TAREA       .13  SUBBASIN AREA

           PRECIPITATION DATA

15 PB          STORM      3.22  BASIN TOTAL PRECIPITATION

16 PI      INCREMENTAL PRECIPITATION PATTERN
             .01    .01    .01    .01    .01    .01    .01    .01    .01    .08
             .17    .45    .08    .01    .01    .01    .01    .01    .01    .01
             .01    .01    .01

19 LU      UNIFORM LOSS RATE
              STRTL       .65  INITIAL LOSS
              CNSTL       .43  UNIFORM LOSS RATE
              RTIMP       .00  PERCENT IMPERVIOUS AREA

22 UC      CLARK UNITGRAPH
                TC        .48  TIME OF CONCENTRATION
                 R        .49  STORAGE COEFFICIENT

19 UA      ACCUMULATED-AREA VS. TIME,  11 ORDINATES
             .0     3.0    5.0    8.0   12.0   20.0   43.0   75.0   90.0   96.0
           100.0

                                   ***

                          UNIT HYDROGRAPH PARAMETERS
                     CLARK   TC=   .48 HR,      R=   .49 HR
                    SNYDER   TP=   .52 HR,     CP=   .65

                          UNIT HYDROGRAPH
                     12 END-OF-PERIOD ORDINATES
          16.    76.    95.    56.    33.    20.    12.     7.     4.     2.
           1.     1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	105.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	63.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	37.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	22.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	13.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	8.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	5.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	3.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	1.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.27	.00	0.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.16	.40	7.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.11	1.37	53.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.11	.16	144.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	164.	1		0715	30	.00	.00	.00	0.

TOTAL RAINFALL = 3.22, TOTAL LOSS = 1.29, TOTAL EXCESS = 1.93

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 164.	3.50		26.	22.	22.	22.
		(INCHES)	1.919	1.919	1.919	1.919
		(AC-FT)	13.	13.	13.	13.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	SUB-10	164.	3.50	26.	22.	22.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE (HEC-1)   *
*          FEBRUARY 1981               *
*         REVISED 01 JUN 88            *
*                                      *
* RUN DATE 09/23/1988 TIME 15:12:47    *
*                                      *
****************************************
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```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*        609 SECOND STREET             *
*      DAVIS, CALIFORNIA 95616         *
*        (916) 551-1748                *
*                                      *
****************************************
```

```
X    X  XXXXXXX   XXXXX          X
X    X  X       X    X        XX
X    X  X       X              X
XXXXXXX  XXXX    X       XXXXX  X
X    X  X       X              X
X    X  X       X    X         X
X    X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          LOAM
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           IO      0      0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC   .972   .982   .992   1.0
 19           LU   .50    .13
 20           UA     0      3      5      8     12     20     43     75     90     96
 21           UA   100
 22           UC   .48    .49
 23           ZZ
```

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*          FEBRUARY 1981               *
*        REVISED 01 JUN 88             *
*                                      *
* RUN DATE  09/23/1988  TIME  15:12:47 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                          LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

10 IO         OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT          HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME       0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     1    0  ENDING DATE
                  NDTIME       0715  ENDING TIME
                   ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                  TOTAL TIME BASE   7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

```
            **************
            *            *
 11 KK      *   SUB-10   *       I-17 SUB-BASIN 10
            *            *
            **************
                          6-HR DISTRIBUTION

 14 IN          TIME DATA FOR INPUT TIME SERIES
                     JXMIN          15  TIME INTERVAL IN MINUTES
                    JXDATE     1    0  STARTING DATE
                    JXTIME          0  STARTING TIME

              SUBBASIN RUNOFF DATA

 12 BA          SUBBASIN CHARACTERISTICS
                     TAREA        .13  SUBBASIN AREA

                PRECIPITATION DATA

 15 PB               STORM       3.22  BASIN TOTAL PRECIPITATION

 16 PI            INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                    .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                    .01       .01       .01

 19 LU          UNIFORM LOSS RATE
                     STRTL        .50  INITIAL LOSS
                     CNSTL        .13  UNIFORM LOSS RATE
                     RTIMP        .00  PERCENT IMPERVIOUS AREA

 22 UC          CLARK UNITGRAPH
                       TC        .48  TIME OF CONCENTRATION
                        R        .49  STORAGE COEFFICIENT

 19 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.       76.       95.       56.       33.       20.       12.        7.        4.        2.
                  1.        1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.03	.01	123.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.03	.00	74.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.03	.01	45.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	27.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	16.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	10.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	6.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	3.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	2.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.20	.07	1.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.03	.53	14.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.03	1.44	70.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.03	.24	167.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.03	.01	187.	1		0715	30	.00	.00	.00	0.

TOTAL RAINFALL = 3.22, TOTAL LOSS = .92, TOTAL EXCESS = 2.30

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
187.	3.50		31.	26.	26.	26.
		(INCHES)	2.292	2.292	2.292	2.292
		(AC-FT)	15.	15.	15.	15.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	187.	3.50	31.	26.	26.	.13		

*** NORMAL END OF HEC-1 ***

C)

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE 09/23/1988 TIME 15:15:15 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X       X    X       XX
X    X  X       X            X
XXXXXXX  XXXX    X      XXXXX  X
X    X  X       X            X
X    X  X       X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC16S, HEC10B, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          SILT LOAM
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           ID      0      0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC    .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC    .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC    .972   .982   .992   1.0
 19           LU    .85    .26
 20           UA      0      3      5      8     12     20     43     75     90     96
 21           UA    100
 22           UC    .48    .49
 23           ZZ
```

```
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            FEBRUARY 1981             *
*          REVISED 01 JUN 88           *
*                                      *
*  RUN DATE  09/23/1988  TIME  15:15:15 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*  THE HYDROLOGIC ENGINEERING CENTER   *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 551-1748             *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                           SILT LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 10 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          0  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME       0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                  TOTAL TIME BASE    7.25 HOURS

       ENGLISH UNITS
           DRAINAGE AREA        SQUARE MILES
           PRECIPITATION DEPTH  INCHES
           LENGTH, ELEVATION    FEET
           FLOW                 CUBIC FEET PER SECOND
           STORAGE VOLUME       ACRE-FEET
           SURFACE AREA         ACRES
           TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


         **************
         *            *
 11 KK   *   SUB-10   *       I-17 SUB-BASIN 10
         *            *
         **************
                     6-HR DISTRIBUTION

 14 IN        TIME DATA FOR INPUT TIME SERIES
                  JXMIN         15  TIME INTERVAL IN MINUTES
                 JXDATE     1    0  STARTING DATE
                 JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

 12 BA        SUBBASIN CHARACTERISTICS
                  TAREA        .13  SUBBASIN AREA

            PRECIPITATION DATA

 15 PB            STORM       3.22  BASIN TOTAL PRECIPITATION

 16 PI          INCREMENTAL PRECIPITATION PATTERN
                  .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                  .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                  .01       .01       .01
```

```
19 LU        UNIFORM LOSS RATE
                 STRTL        .85  INITIAL LOSS
                 CNSTL        .26  UNIFORM LOSS RATE
                 RTIMP        .00  PERCENT IMPERVIOUS AREA

22 UC        CLARK UNITGRAPH
                 TC           .48  TIME OF CONCENTRATION
                  R           .49  STORAGE COEFFICIENT

19 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                 .0      3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
               100.0

                                                  ***

                                        UNIT HYDROGRAPH PARAMETERS
                                   CLARK  TC=   .48 HR,      R=   .49 HR
                                  SNYDER  TP=   .52 HR,     CP=   .65

                                        UNIT HYDROGRAPH
                                   12 END-OF-PERIOD ORDINATES
            16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
             1.       1.
```

****

HYDROGRAPH AT STATION SUB-10

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	*	1		0345	16	.04	.04	.00	107.
1		0015	2	.03	.03	.00	0.	*	1		0400	17	.04	.04	.00	64.
1		0030	3	.03	.03	.00	0.	*	1		0415	18	.04	.04	.00	38.
1		0045	4	.03	.03	.00	0.	*	1		0430	19	.03	.03	.00	22.
1		0100	5	.03	.03	.00	0.	*	1		0445	20	.03	.03	.00	13.
1		0115	6	.03	.03	.00	0.	*	1		0500	21	.03	.03	.00	8.
1		0130	7	.04	.04	.00	0.	*	1		0515	22	.03	.03	.00	5.
1		0145	8	.04	.04	.00	0.	*	1		0530	23	.03	.03	.00	3.
1		0200	9	.04	.04	.00	0.	*	1		0545	24	.03	.03	.00	2.
1		0215	10	.04	.04	.00	0.	*	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.27	.00	0.	*	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.30	.26	4.	*	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.06	1.41	43.	*	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.06	.20	135.	*	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	163.	*	1		0715	30	.00	.00	.00	0.

****

TOTAL RAINFALL = 3.22, TOTAL LOSS = 1.35, TOTAL EXCESS = 1.87

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 163.	3.50		25.	21.	21.	21.
		(INCHES)	1.864	1.864	1.864	1.864
		(AC-FT)	13.	13.	13.	13.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	SUB-10	163.	3.50	25.	21.	21.	.13		

*** NORMAL END OF HEC-1 ***

C>
Bad command or file name

C>

```
1****************************************
 *                                      *
 *  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *           FEBRUARY 1981              *
 *          REVISED 01 JUN 88           *
 *                                      *
 * RUN DATE  09/23/1988  TIME  15:17:54 *
 *                                      *
 ****************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X       X    X       XX
X    X  X       X            X
XXXXXXX  XXXX    X      XXXXX X
X    X  X       X            X
X    X  X       X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          SANDY CLAY LOAM
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           IO      0      0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC   .972   .982   .992   1.0
 19           LU   .32    .06
 20           UA     0      3      5      8     12     20     43     75     90     96
 21           UA   100
 22           UC   .48    .49
 23           ZZ
```

```
1*************************************                    *************************************
*                                   *                    *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1) *                    *  U.S. ARMY CORPS OF ENGINEERS     *
*          FEBRUARY 1981            *                    * THE HYDROLOGIC ENGINEERING CENTER *
*        REVISED 01 JUN 88          *                    *        609 SECOND STREET          *
*                                   *                    *      DAVIS, CALIFORNIA 95616      *
* RUN DATE  09/23/1988  TIME  15:17:54 *                  *         (916) 551-1748            *
*                                   *                    *                                   *
*************************************                    *************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                          SANDY CLAY LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 10 IO        OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME        0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     1    0  ENDING DATE
                  NDTIME        0715  ENDING TIME
                   ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


         **************
         *            *
 11 KK   *   SUB-10   *       I-17 SUB-BASIN 10
         *            *
         **************
                        6-HR DISTRIBUTION

 14 IN        TIME DATA FOR INPUT TIME SERIES
                  JXMIN         15  TIME INTERVAL IN MINUTES
                 JXDATE     1    0  STARTING DATE
                 JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

 12 BA        SUBBASIN CHARACTERISTICS
                  TAREA        .13  SUBBASIN AREA

            PRECIPITATION DATA

 15 PB            STORM       3.22  BASIN TOTAL PRECIPITATION

 16 PI          INCREMENTAL PRECIPITATION PATTERN
                  .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                  .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                  .01       .01       .01
```

```
19 LU        UNIFORM LOSS RATE
                 STRTL        .32  INITIAL LOSS
                 CNSTL        .06  UNIFORM LOSS RATE
                 RTIMP        .00  PERCENT IMPERVIOUS AREA

22 UC        CLARK UNITGRAPH
                 TC           .48  TIME OF CONCENTRATION
                 R            .49  STORAGE COEFFICIENT

19 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                 .0      3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
               100.0

                                          ***

                                   UNIT HYDROGRAPH PARAMETERS
                              CLARK  TC=   .48 HR,      R=   .49 HR
                              SNYDER TP=   .52 HR,     CP=   .65

                                   UNIT HYDROGRAPH
                              12 END-OF-PERIOD ORDINATES
          16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
           1.       1.
```

****

HYDROGRAPH AT STATION SUB-10

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	*	1		0345	16	.04	.02	.02	131.
1		0015	2	.03	.03	.00	0.	*	1		0400	17	.04	.02	.02	81.
1		0030	3	.03	.03	.00	0.	*	1		0415	18	.04	.02	.02	51.
1		0045	4	.03	.03	.00	0.	*	1		0430	19	.03	.01	.01	33.
1		0100	5	.03	.03	.00	0.	*	1		0445	20	.03	.02	.02	22.
1		0115	6	.03	.03	.00	0.	*	1		0500	21	.03	.02	.02	15.
1		0130	7	.04	.04	.00	0.	*	1		0515	22	.03	.02	.02	11.
1		0145	8	.04	.04	.00	0.	*	1		0530	23	.03	.02	.02	9.
1		0200	9	.04	.04	.00	0.	*	1		0545	24	.03	.01	.01	7.
1		0215	10	.04	.04	.00	0.	*	1		0600	25	.00	.00	.00	5.
1		0230	11	.27	.03	.24	4.	*	1		0615	26	.00	.00	.00	3.
1		0245	12	.56	.01	.55	28.	*	1		0630	27	.00	.00	.00	2.
1		0300	13	1.47	.01	1.46	89.	*	1		0645	28	.00	.00	.00	1.
1		0315	14	.27	.01	.25	180.	*	1		0700	29	.00	.00	.00	1.
1		0330	15	.04	.02	.02	197.	*	1		0715	30	.00	.00	.00	0.

****

TOTAL RAINFALL = 3.22, TOTAL LOSS = .53, TOTAL EXCESS = 2.69

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 197.	3.50		36.	30.	30.	30.
		(INCHES)	2.678	2.678	2.678	2.678
		(AC-FT)	18.	18.	18.	18.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	SUB-10	197.	3.50	36.	30.	30.	.13		

*** NORMAL END OF HEC-1 ***

C)

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           FEBRUARY 1981              *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  15:20:28 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X    X  XXXXXXX  XXXXX         X
X    X  X       X    X       XX
X    X  X       X            X
XXXXXXX  XXXX    X      XXXXX  X
X    X  X       X            X
X    X  X       X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          CLAY LOAM
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           ID      0      0
```

```
11        KK  SUB-10   I-17 SUB-BASIN 10
12        BA   .126
13        KM     6-HR DISTRIBUTION
14        IN     15
15        PB   3.22
16        PC   .01     .02     .03     .04     .05     .058    .07     .081    .093    .105
17        PC   .188    .361    .014    .897    .909    .921    .932    .944    .952    .962
18        PC   .972    .982    .992    1.0
19        LU   .45     .04
20        UA     0       3       5       8      12      20      43      75      90      96
21        UA   100
22        UC   .48     .49
23        ZZ
```

```
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            FEBRUARY 1981             *
*          REVISED 01 JUN 88           *
*                                      *
*  RUN DATE  09/23/1988  TIME  15:20:28 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*  THE HYDROLOGIC ENGINEERING CENTER   *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                          CLAY LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 10 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          0  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME        0000  STARTING TIME
                     NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME        0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA          SQUARE MILES
            PRECIPITATION DEPTH    INCHES
            LENGTH, ELEVATION      FEET
            FLOW                   CUBIC FEET PER SECOND
            STORAGE VOLUME         ACRE-FEET
            SURFACE AREA           ACRES
            TEMPERATURE            DEGREES FAHRENHEIT
```

*** ***

```
          **************
          *            *
11 KK     *   SUB-10   *       I-17 SUB-BASIN 10
          *            *
          **************
                          6-HR DISTRIBUTION

14 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

12 BA          SUBBASIN CHARACTERISTICS
                    TAREA        .13  SUBBASIN AREA

               PRECIPITATION DATA

15 PB               STORM       3.22  BASIN TOTAL PRECIPITATION

16 PI            INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                    .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                    .01       .01       .01

19 LU          UNIFORM LOSS RATE
                    STRTL        .45  INITIAL LOSS
                    CNSTL        .04  UNIFORM LOSS RATE
                    RTIMP        .00  PERCENT IMPERVIOUS AREA

22 UC          CLARK UNITGRAPH
                      TC        .48  TIME OF CONCENTRATION
                       R        .49  STORAGE COEFFICIENT

19 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0

                                                  ***

                                                UNIT HYDROGRAPH PARAMETERS
                                          CLARK  TC=   .48 HR,      R=   .49 HR
                                          SNYDER TP=   .52 HR,     CP=   .65

                                                UNIT HYDROGRAPH
                                           12 END-OF-PERIOD ORDINATES
                 16.       76.       95.       56.       33.       20.       12.        7.        4.        2.
                  1.        1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.01	.03	130.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.01	.03	81.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.01	.03	52.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.01	.02	34.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.01	.02	23.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.01	.02	16.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.01	.02	13.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.01	.02	10.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.01	.02	9.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	7.
1		0230	11	.27	.15	.12	2.	1		0615	26	.00	.00	.00	5.
1		0245	12	.56	.01	.55	18.	1		0630	27	.00	.00	.00	3.
1		0300	13	1.47	.01	1.46	78.	1		0645	28	.00	.00	.00	2.
1		0315	14	.27	.01	.26	175.	1		0700	29	.00	.00	.00	1.
1		0330	15	.04	.01	.03	194.	1		0715	30	.00	.00	.00	1.

TOTAL RAINFALL = 3.22, TOTAL LOSS = .58, TOTAL EXCESS = 2.64

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
194.	3.50		36.	29.	29.	29.
		(INCHES)	2.622	2.622	2.622	2.622
		(AC-FT)	18.	18.	18.	18.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	194.	3.50	36.	29.	29.	.13		

*** NORMAL END OF HEC-1 ***

C)

1**********
* *
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
* FEBRUARY 1981 *
* REVISED 01 JUN 88 *
* *
* RUN DATE 09/23/1988 TIME 15:22:49 *
* *
****

****
* *
* U.S. ARMY CORPS OF ENGINEERS *
* THE HYDROLOGIC ENGINEERING CENTER *
* 609 SECOND STREET *
* DAVIS, CALIFORNIA 95616 *
* (916) 551-1748 *
* *
****

```
X    X XXXXXXX  XXXXX         X
X    X X       X    X       XX
X    X X       X            X
XXXXXXX XXXX   X      XXXXX  X
X    X X       X            X
X    X X       X    X       X
X    X XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          SILTY CLAY LOAM
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           IO      0      0

 11           KK  SUB-10  I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC   .972   .982   .992   1.0
 19           LU   .37    .04
 20           UA     0      3      5      8     12     20     43     75     90     96
 21           UA   100
 22           UC   .48    .49
 23           ZZ
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE 09/23/1988 TIME 15:22:49 *
*                                   *
*************************************
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*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*     DAVIS, CALIFORNIA 95616       *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                          SILTY CLAY LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

10 IO         OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT          HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME       0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     1    0  ENDING DATE
                  NDTIME       0715  ENDING TIME
                   ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                  TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA          SQUARE MILES
            PRECIPITATION DEPTH    INCHES
            LENGTH, ELEVATION      FEET
            FLOW                   CUBIC FEET PER SECOND
            STORAGE VOLUME         ACRE-FEET
            SURFACE AREA           ACRES
            TEMPERATURE            DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
```

```
            **************
            *            *
11 KK       *   SUB-10   *        I-17 SUB-BASIN 10
            *            *
            **************
                                 6-HR DISTRIBUTION

14 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

12 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

15 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

16 PI            INCREMENTAL PRECIPITATION PATTERN
                   .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                   .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                   .01      .01      .01

19 LU          UNIFORM LOSS RATE
                    STRTL         .37  INITIAL LOSS
                    CNSTL         .04  UNIFORM LOSS RATE
                    RTIMP         .00  PERCENT IMPERVIOUS AREA

22 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

19 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                   100.0

                                                   ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.01	.03	132.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.01	.03	82.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.01	.03	52.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.01	.02	35.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.01	.02	23.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.01	.02	17.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.01	.02	13.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.01	.02	10.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.01	.02	9.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	7.
1		0230	11	.27	.07	.20	3.	1		0615	26	.00	.00	.00	5.
1		0245	12	.56	.01	.55	24.	1		0630	27	.00	.00	.00	3.
1		0300	13	1.47	.01	1.46	85.	1		0645	28	.00	.00	.00	2.
1		0315	14	.27	.01	.26	179.	1		0700	29	.00	.00	.00	1.
1		0330	15	.04	.01	.03	197.	1		0715	30	.00	.00	.00	1.

TOTAL RAINFALL = 3.22, TOTAL LOSS = .51, TOTAL EXCESS = 2.71

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 197.	3.50		37.	30.	30.	30.
		(INCHES)	2.699	2.699	2.699	2.699
		(AC-FT)	18.	18.	18.	18.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+ HYDROGRAPH AT	SUB-10	197.	3.50	37.	30.	30.	.13		

*** NORMAL END OF HEC-1 ***

C)

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE 09/23/1988 TIME 15:25:10 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X       X    X       XX
X    X  X       X            X
XXXXXXX  XXXX    X      XXXXX  X
X    X  X       X            X
X    X  X       X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          SANDY CLAY
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           ID      0      0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC   .972   .982   .992   1.0
 19           LU   .37    .02
 20           UA     0      3      5      8     12     20     43     75     90     96
 21           UA   100
 22           UC   .48    .49
 23           ZZ
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE  09/23/1988  TIME  15:25:10 *
*                                   *
*************************************
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*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*        (916) 551-1748             *
*                                   *
*************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                           SANDY CLAY
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

10 IO         OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME       0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NDDATE     1    0  ENDING DATE
                  NDTIME       0715  ENDING TIME
                   ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                  TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA         SQUARE MILES
            PRECIPITATION DEPTH   INCHES
            LENGTH, ELEVATION     FEET
            FLOW                  CUBIC FEET PER SECOND
            STORAGE VOLUME        ACRE-FEET
            SURFACE AREA          ACRES
            TEMPERATURE           DEGREES FAHRENHEIT
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          **************
          *            *
 11 KK    *   SUB-10   *        I-17 SUB-BASIN 10
          *            *
          **************
                        6-HR DISTRIBUTION

 14 IN        TIME DATA FOR INPUT TIME SERIES
                   JXMIN          15  TIME INTERVAL IN MINUTES
                  JXDATE     1    0  STARTING DATE
                  JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

 12 BA        SUBBASIN CHARACTERISTICS
                   TAREA        .13  SUBBASIN AREA

              PRECIPITATION DATA

 15 PB             STORM       3.22  BASIN TOTAL PRECIPITATION

 16 PI          INCREMENTAL PRECIPITATION PATTERN
                  .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                  .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                  .01      .01      .01

 19 LU        UNIFORM LOSS RATE
                  STRTL        .37  INITIAL LOSS
                  CNSTL        .02  UNIFORM LOSS RATE
                  RTIMP        .00  PERCENT IMPERVIOUS AREA

 22 UC        CLARK UNITGRAPH
                    TC        .48  TIME OF CONCENTRATION
                     R        .49  STORAGE COEFFICIENT

 19 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                   .0      3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                   CLARK  TC=   .48 HR,      R=   .49 HR
                                   SNYDER TP=   .52 HR,      CP=  .65

                                          UNIT HYDROGRAPH
                                   12 END-OF-PERIOD ORDINATES
            16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
             1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.00	.03	133.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.00	.03	84.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.00	.03	54.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.00	.02	36.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.00	.03	25.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.00	.03	18.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.00	.03	14.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.00	.03	12.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.00	.02	10.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	8.
1		0230	11	.27	.06	.21	3.	1		0615	26	.00	.00	.00	6.
1		0245	12	.56	.00	.56	25.	1		0630	27	.00	.00	.00	3.
1		0300	13	1.47	.00	1.47	86.	1		0645	28	.00	.00	.00	2.
1		0315	14	.27	.00	.26	180.	1		0700	29	.00	.00	.00	1.
1		0330	15	.04	.00	.03	198.	1		0715	30	.00	.00	.00	1.

TOTAL RAINFALL = 3.22, TOTAL LOSS = .44, TOTAL EXCESS = 2.78

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
198.	3.50		37.	31.	31.	31.
		(INCHES)	2.767	2.767	2.767	2.767
		(AC-FT)	19.	19.	19.	19.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	198.	3.50	37.	31.	31.	.13		

*** NORMAL END OF HEC-1 ***

C>0

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1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 09/23/1988 TIME 15:27:38 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
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```
X    X  XXXXXXX   XXXXX          X
X    X  X       X    X        XX
X    X  X       X              X
XXXXXXX  XXXX    X       XXXXX  X
X    X  X       X              X
X    X  X       X    X         X
X    X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID          SILTY CLAY
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           ID      0      0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 17           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 18           PC   .972   .982   .992   1.0
 19           LU   .28    .02
 20           UA     0      3      5      8     12     20     43     75     90     96
 21           UA   100
 22           UC   .48    .49
 23           ZZ
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE  09/23/1988  TIME  15:27:38 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                          SILTY CLAY
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

10 IO         OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME        0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NODATE     1    0  ENDING DATE
                  NDTIME        0715  ENDING TIME
                   ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                  TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
             DRAINAGE AREA        SQUARE MILES
             PRECIPITATION DEPTH  INCHES
             LENGTH, ELEVATION    FEET
             FLOW                 CUBIC FEET PER SECOND
             STORAGE VOLUME       ACRE-FEET
             SURFACE AREA         ACRES
             TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
```

```
              **************
              *            *
11 KK         *   SUB-10   *        I-17 SUB-BASIN 10
              *            *
              **************
                                 6-HR DISTRIBUTION

14 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

12 BA          SUBBASIN CHARACTERISTICS
                    TAREA        .13  SUBBASIN AREA

               PRECIPITATION DATA

15 PB                STORM       3.22  BASIN TOTAL PRECIPITATION

16 PI            INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                    .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                    .01       .01       .01

19 LU          UNIFORM LOSS RATE
                   STRTL        .28  INITIAL LOSS
                   CNSTL        .02  UNIFORM LOSS RATE
                   RTIMP        .00  PERCENT IMPERVIOUS AREA

22 UC          CLARK UNITGRAPH
                     TC        .48  TIME OF CONCENTRATION
                      R        .49  STORAGE COEFFICIENT

19 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK  TC=   .48 HR,      R=   .49 HR
                                    SNYDER  TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.       76.       95.       56.       33.       20.       12.        7.        4.        2.
                  1.        1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.00	.03	135.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.00	.03	85.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.00	.03	54.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.00	.02	36.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.00	.03	25.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.00	.03	18.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.00	.03	14.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.00	.03	12.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.00	.02	10.
1		0215	10	.04	.01	.03	0.	1		0600	25	.00	.00	.00	8.
1		0230	11	.27	.00	.26	6.	1		0615	26	.00	.00	.00	6.
1		0245	12	.56	.00	.56	32.	1		0630	27	.00	.00	.00	3.
1		0300	13	1.47	.00	1.47	93.	1		0645	28	.00	.00	.00	2.
1		0315	14	.27	.00	.26	184.	1		0700	29	.00	.00	.00	1.
1		0330	15	.04	.00	.03	200.	1		0715	30	.00	.00	.00	1.

TOTAL RAINFALL = 3.22, TOTAL LOSS = .35, TOTAL EXCESS = 2.87

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 200.	3.50		39.	32.	32.	32.
		(INCHES)	2.852	2.852	2.852	2.852
		(AC-FT)	19.	19.	19.	19.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	SUB-10	200.	3.50	39.	32.	32.	.13		

*** NORMAL END OF HEC-1 ***

C>0

1**********
* *
* FLOOD HYDROGRAPH PACKAGE (HEC-1) *
* FEBRUARY 1981 *
* REVISED 01 JUN 88 *
* *
* RUN DATE 09/23/1988 TIME 15:29:58 *
* *
****

****
* *
* U.S. ARMY CORPS OF ENGINEERS *
* THE HYDROLOGIC ENGINEERING CENTER *
* 609 SECOND STREET *
* DAVIS, CALIFORNIA 95616 *
* (916) 551-1748 *
* *
****

```
X    X XXXXXXX  XXXXX        X
X    X X       X    X       XX
X    X X       X            X
XXXXXXX XXXX   X      XXXXX X
X    X X       X            X
X    X X       X    X       X
X    X XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   INITAL LOSS + UNIFORM LOSS RATE
  3           ID   VALUES FROM GREEN-AMPT ANALYSIS
  4           ID         CLAY
  5           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  6           ID   POINT PRECIPITATION = 3.22
  7           ID   AREA PRECIPITATION = 3.22
  8           ID   DEPTH-AREA RATIO = 1.0
  9           IT     15                    30
 10           IO      0       0

 11           KK  SUB-10   I-17 SUB-BASIN 10
 12           BA   .126
 13           KM     6-HR DISTRIBUTION
 14           IN     15
 15           PB   3.22
 16           PC   .01     .02     .03     .04     .05     .058    .07     .081    .093    .105
 17           PC   .188    .361    .814    .897    .909    .921    .932    .944    .952    .962
 18           PC   .972    .982    .992    1.0
 19           LU   .24     .01
 20           UA     0       3       5       8      12      20      43      75      90      96
 21           UA   100
 22           UC   .48     .49
 23           ZZ
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE 09/23/1988 TIME 15:29:58 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
                    I-17  SUB-BASIN 10
                    INITAL LOSS + UNIFORM LOSS RATE
                    VALUES FROM GREEN-AMPT ANALYSIS
                          CLAY
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

10 IO         OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME       0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NODATE     1    0  ENDING DATE
                  NOTIME       0715  ENDING TIME
                   ICENT         19  CENTURY MARK

             COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

      ENGLISH UNITS
          DRAINAGE AREA        SQUARE MILES
          PRECIPITATION DEPTH  INCHES
          LENGTH, ELEVATION    FEET
          FLOW                 CUBIC FEET PER SECOND
          STORAGE VOLUME       ACRE-FEET
          SURFACE AREA         ACRES
          TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

```
            **************
            *            *
11 KK       *   SUB-10   *       I-17 SUB-BASIN 10
            *            *
            **************
                                 6-HR DISTRIBUTION

14 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

12 BA          SUBBASIN CHARACTERISTICS
                    TAREA        .13  SUBBASIN AREA

               PRECIPITATION DATA

15 PB               STORM       3.22  BASIN TOTAL PRECIPITATION

16 PI            INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                    .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                    .01       .01       .01

19 LU          UNIFORM LOSS RATE
                   STRTL        .24  INITIAL LOSS
                   CNSTL        .01  UNIFORM LOSS RATE
                   RTIMP        .00  PERCENT IMPERVIOUS AREA

22 UC          CLARK UNITGRAPH
                     TC        .48  TIME OF CONCENTRATION
                      R        .49  STORAGE COEFFICIENT

19 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                  100.0

                                                   ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.       76.       95.       56.       33.       20.       12.        7.        4.        2.
                  1.        1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.00	.04	136.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.00	.03	85.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.00	.04	55.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.00	.02	37.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.00	.03	26.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.00	.03	19.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.00	.03	15.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.00	.03	13.
1		0200	9	.04	.01	.03	0.	1		0545	24	.03	.00	.02	11.
1		0215	10	.04	.00	.04	3.	1		0600	25	.00	.00	.00	9.
1		0230	11	.27	.00	.27	10.	1		0615	26	.00	.00	.00	6.
1		0245	12	.56	.00	.56	35.	1		0630	27	.00	.00	.00	4.
1		0300	13	1.47	.00	1.47	95.	1		0645	28	.00	.00	.00	2.
1		0315	14	.27	.00	.27	186.	1		0700	29	.00	.00	.00	1.
1		0330	15	.04	.00	.04	202.	1		0715	30	.00	.00	.00	1.

TOTAL RAINFALL = 3.22, TOTAL LOSS = .28, TOTAL EXCESS = 2.94

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
202.	3.50		40.	33.	33.	33.
		(INCHES)	2.925	2.925	2.925	2.925
		(AC-FT)	20.	20.	20.	20.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	202.	3.50	40.	33.	33.	.13		

*** NORMAL END OF HEC-1 ***

APPENDIX 2-G

HEC-1 output of verification that the Green and Ampt equation method and the IL+ULR method result in similar estimates of rainfall excess.

Summary of HEC-1 results using Green-Ampt

Watershed I-17 sub-basin 10

Point Rainfall 3.22 inches
Depth-Area Ratio 1.0
Distribution 6-hr nested

T_c = .48 hr.
R = .49 hr.
Time-Area = N-D
Interval = 15 min.

Soil	Initial Loss in.	Green-Ampt Parameters IA in.	DTHETA	PSIF in.	XKSAT in./hr.	RTIMP %	Green-Ampt Results Runoff in.	Qp cfs	IL + ULR Results Runoff in.	Qp cfs
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
sand	1.55	0	.05	1.95	4.64	0	.25	23	.23	21
loamy sand	.58		.08	2.41	1.18		1.32	118	1.45	127
sandy loam	.65		.10	4.33	.43		1.85	155	1.93	164
loam	.50		.14	3.50	.13		2.30	183	2.30	187
silt loam	.85		.17	6.57	.26		1.86	157	1.87	163
sandy clay loam	.32		.10	8.60	.06		2.39	189	2.69	197
clay loam	.45		.15	8.22	.04		2.45	190	2.64	194
silty clay loam	.37		.16	10.75	.04		2.37	188	2.71	197
sandy clay	.37		.11	9.41	.02		2.69	196	2.78	198
silty clay	.28		.16	11.50	.02		2.57	193	2.87	200
clay	.24		.14	12.45	.01		2.76	197	2.94	202

```
C)
1****************************************
 *                                      *
 *  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *            FEBRUARY 1981             *
 *          REVISED 01 JUN 88           *
 *                                      *
 * RUN DATE  09/23/1988  TIME  09:24:31 *
 *                                      *
 ****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X       X    X       XX
X    X  X       X            X
XXXXXXX  XXXX    X      XXXXX  X
X    X  X       X            X
X    X  X       X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
      LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

        1           ID   I-17  SUB-BASIN 10
        2           ID   GREEN-AMPT
        3           ID          LOAMY SAND
        4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
        5           ID   POINT PRECIPITATION = 3.22
        6           ID   AREA PRECIPITATION = 3.22
        7           ID   DEPTH-AREA RATIO = 1.0
        8           IT     15                    30
        9           IO      0      0

       10           KK  SUB-10   I-17 SUB-BASIN 10
       11           BA   .126
       12           KM     6-HR DISTRIBUTION
       13           IN     15
       14           PB   3.22
       15           PC    .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
       16           PC    .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
       17           PC    .972   .982   .992   1.0
       18           LG           .08   2.41   1.18
       19           UA      0      3      5      8     12     20     43     75     90     96
       20           UA    100
       21           UC    .48    .49
       22           ZZ
```

```
1*************************************                    *************************************
*                                   *                    *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                    *   U.S. ARMY CORPS OF ENGINEERS    *
*           FEBRUARY 1981           *                    * THE HYDROLOGIC ENGINEERING CENTER *
*         REVISED 01 JUN 88         *                    *        609 SECOND STREET          *
*                                   *                    *      DAVIS, CALIFORNIA 95616      *
* RUN DATE  09/23/1988  TIME  09:24:31 *                    *         (916) 551-1748            *
*                                   *                    *                                   *
*************************************                    *************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                           LOAMY SAND
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

  9 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          0  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME        0000  STARTING TIME
                    NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                NODATE     1    0  ENDING DATE
                NDTIME        0715  ENDING TIME
                 ICENT         19  CENTURY MARK
```

```
          COMPUTATION INTERVAL     .25 HOURS
               TOTAL TIME BASE    7.25 HOURS

     ENGLISH UNITS
         DRAINAGE AREA          SQUARE MILES
         PRECIPITATION DEPTH    INCHES
         LENGTH, ELEVATION      FEET
         FLOW                   CUBIC FEET PER SECOND
         STORAGE VOLUME         ACRE-FEET
         SURFACE AREA           ACRES
         TEMPERATURE            DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


      **************
      *            *
 10 KK  *   SUB-10  *       I-17 SUB-BASIN 10
      *            *
      **************
                    6-HR DISTRIBUTION

 13 IN        TIME DATA FOR INPUT TIME SERIES
                JXMIN          15  TIME INTERVAL IN MINUTES
               JXDATE     1    0  STARTING DATE
               JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

 11 BA        SUBBASIN CHARACTERISTICS
                TAREA        .13  SUBBASIN AREA

              PRECIPITATION DATA

 14 PB          STORM       3.22  BASIN TOTAL PRECIPITATION

 15 PI          INCREMENTAL PRECIPITATION PATTERN
                 .01     .01     .01     .01     .01     .01     .01     .01     .01     .08
                 .17     .45     .08     .01     .01     .01     .01     .01     .01     .01
                 .01     .01     .01

 18 LG        GREEN AND AMPT LOSS RATE
               STRTL        .00  STARTING LOSS
                DTH         .08  MOISTURE DEFICIT
               PSIF        2.41  WETTING FRONT SUCTION
              XKSAT        1.18  HYDRAULIC CONDUCTIVITY
              RTIMP         .00  PERCENT IMPERVIOUS AREA

 21 UC        CLARK UNITGRAPH
                 TC         .48  TIME OF CONCENTRATION
                  R         .49  STORAGE COEFFICIENT

 18 UA        ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                 .0      3.0     5.0     8.0    12.0    20.0    43.0    75.0    90.0    96.0
               100.0

                                          ***

                                   UNIT HYDROGRAPH PARAMETERS
                              CLARK  TC=   .48 HR,      R=   .49 HR
                             SNYDER  TP=   .52 HR,     CP=   .65

                                   UNIT HYDROGRAPH
                          13 END-OF-PERIOD ORDINATES
```

****

HYDROGRAPH AT STATION SUB-10

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	70.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	41.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	25.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	15.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	9.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	5.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	3.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	2.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	1.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.27	.00	0.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.37	.19	3.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.35	1.13	33.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.27	.00	104.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	118.	1		0715	30	.00	.00	.00	0.

loamy sand
$I_a = .99$ in
$f_c = 1.18$ in/hr

****

TOTAL RAINFALL = 3.22, TOTAL LOSS = 1.90, TOTAL EXCESS = 1.32

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
(CFS)	(HR)					
		(CFS)				
118.	3.50		18.	15.	15.	15.
		(INCHES)	1.314	1.314	1.314	1.314
		(AC-FT)	9.	9.	9.	9.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	118.	3.50	18.	15.	15.	.13		

*** NORMAL END OF HEC-1 ***

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           FEBRUARY 1981              *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  09:28:23 *
*                                      *
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```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748              *
*                                      *
****************************************
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```
X    X  XXXXXXX  XXXXX        X
X    X  X       X    X       XX
X    X  X       X             X
XXXXXXX  XXXX    X      XXXXX  X
X    X  X       X             X
X    X  X       X    X        X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          SAND
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10   I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC    .01     .02     .03     .04     .05     .058    .07     .081    .093    .105
 16           PC    .188    .361    .814    .897    .909    .921    .932    .944    .952    .962
 17           PC    .972    .982    .992    1.0
 18           LG            .05    1.95    4.64
 19           UA      0      3       5       8      12      20      43      75      90      96
 20           UA    100
 21           UC    .48     .49
 22           ZZ
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*          REVISED 01 JUN 88        *
*                                   *
* RUN DATE 09/23/1988 TIME 09:28:23 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                          SAND
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 9 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          0  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT        HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME       0000  STARTING TIME
                    NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     1    0  ENDING DATE
                NDTIME       0715  ENDING TIME
                 ICENT         19  CENTURY MARK

            COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

      ENGLISH UNITS
          DRAINAGE AREA         SQUARE MILES
          PRECIPITATION DEPTH   INCHES
          LENGTH, ELEVATION     FEET
          FLOW                  CUBIC FEET PER SECOND
          STORAGE VOLUME        ACRE-FEET
          SURFACE AREA          ACRES
          TEMPERATURE           DEGREES FAHRENHEIT
```

*** ***

```
              **************
              *            *
10 KK         *   SUB-10   *        I-17 SUB-BASIN 10
              *            *
              **************
                                 6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB                STORM        3.22  BASIN TOTAL PRECIPITATION

15 PI            INCREMENTAL PRECIPITATION PATTERN
                   .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                   .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                   .01      .01      .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL         .00  STARTING LOSS
                     DTH         .05  MOISTURE DEFICIT
                    PSIF        1.95  WETTING FRONT SUCTION
                   XKSAT        4.64  HYDRAULIC CONDUCTIVITY
                   RTIMP         .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	14.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	8.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	5.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	3.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	2.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	1.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	1.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	0.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	0.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.27	.00	0.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.56	.00	0.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	1.23	.25	4.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.27	.00	19.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	23.	1		0715	30	.00	.00	.00	0.

Sand
$I_a = 2.41$
$f = 4.64$

TOTAL RAINFALL = 3.22, TOTAL LOSS = 2.97, TOTAL EXCESS = .25

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 23.	3.50		3.	3.	3.	3.
		(INCHES)	.245	.245	.245	.245
		(AC-FT)	2.	2.	2.	2.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	SUB-10	23.	3.50	3.	3.	3.	.13		

*** NORMAL END OF HEC-1 ***

```
C>EDLIN GA.I
End of input file
*0
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE  09/23/1988  TIME  09:31:37 *
*                                   *
*************************************
```

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*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX         X
X    X  X       X    X        XX
X    X  X       X             X
XXXXXXX  XXXX    X       XXXXX  X
X    X  X       X             X
X    X  X       X    X        X
X    X  XXXXXXX  XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                    HEC-1 INPUT                                    PAGE  1

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9.......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          SANDY LOAM
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10   I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 16           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 17           PC   .972   .982   .992   1.0
 18           LG          .10    4.33   .43
 19           UA     0     3      5      8     12     20     43     75     90     96
 20           UA   100
 21           UC    .48   .49
 22           ZZ
```

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*            FEBRUARY 1981             *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  09:31:37 *
*                                      *
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****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                           SANDY LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 9 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          0  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT        HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME       0000  STARTING TIME
                    NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     1    0  ENDING DATE
                NDTIME       0715  ENDING TIME
                 ICENT         19  CENTURY MARK

             COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

       ENGLISH UNITS
           DRAINAGE AREA        SQUARE MILES
           PRECIPITATION DEPTH  INCHES
           LENGTH, ELEVATION    FEET
           FLOW                 CUBIC FEET PER SECOND
           STORAGE VOLUME       ACRE-FEET
           SURFACE AREA         ACRES
           TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

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              **************
              *            *
10 KK         *   SUB-10   *        I-17 SUB-BASIN 10
              *            *
              **************
                                 6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

15 PI            INCREMENTAL PRECIPITATION PATTERN
                   .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                   .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                   .01      .01      .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL         .00  STARTING LOSS
                     DTH         .10  MOISTURE DEFICIT
                    PSIF        4.33  WETTING FRONT SUCTION
                   XKSAT         .43  HYDRAULIC CONDUCTIVITY
                   RTIMP         .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0      3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	98.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	58.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	34.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	20.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	12.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	7.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	4.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	3.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	1.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.22	.05	1.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.18	.38	10.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.17	1.31	55.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.16	.11	140.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	155.	1		0715	30	.00	.00	.00	0.

$I_a = .52$
$f = .43$

TOTAL RAINFALL = 3.22, TOTAL LOSS = 1.37, TOTAL EXCESS = 1.85

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 155.	3.50		25.	21.	21.	21.
		(INCHES)	1.844	1.844	1.844	1.844
		(AC-FT)	12.	12.	12.	12.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	SUB-10	155.	3.50	25.	21.	21.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 09/23/1988 TIME 09:34:08 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX         X
X    X  X       X    X       XX
X    X  X       X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X       X            X
X    X  X       X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID         LOAM
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10   I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC    .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 16           PC    .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 17           PC    .972   .982   .992   1.0
 18           LG           .14   3.50    .13
 19           UA      0      3      5      8     12     20     43     75     90     96
 20           UA    100
 21           UC    .48    .49
 22           ZZ
```

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           FEBRUARY 1981              *
*         REVISED 01 JUN 88            *
*                                      *
* RUN DATE  09/23/1988  TIME  09:34:08 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                           LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

  9 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          0  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME       0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

```
            **************
            *            *
10 KK       *   SUB-10   *       I-17 SUB-BASIN 10
            *            *
            **************
                          6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE      1   0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

15 PI            INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                    .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                    .01       .01       .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL         .00  STARTING LOSS
                     DTH         .14  MOISTURE DEFICIT
                    PSIF        3.50  WETTING FRONT SUCTION
                   XKSAT         .13  HYDRAULIC CONDUCTIVITY
                   RTIMP         .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK  TC=   .48 HR,      R=   .49 HR
                                    SNYDER  TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.       76.       95.       56.       33.       20.       12.        7.        4.        2.
                  1.        1.
```

****

HYDROGRAPH AT STATION SUB-10

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	119.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	71.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	42.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	25.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	15.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	9.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	5.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	3.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	2.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.08	.19	3.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.07	.49	23.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.07	1.41	79.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.06	.21	168.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	183.	1		0715	30	.00	.00	.00	0.

Ia = .43
f = .13

****

TOTAL RAINFALL = 3.22, TOTAL LOSS = .92, TOTAL EXCESS = 2.30

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 183.	3.50		31.	26.	26.	26.
		(INCHES)	2.292	2.292	2.292	2.292
		(AC-FT)	15.	15.	15.	15.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	SUB-10	183.	3.50	31.	26.	26.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            FEBRUARY 1981             *
*          REVISED 01 JUN 88           *
*                                      *
*  RUN DATE  09/23/1988  TIME  09:36:59 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*  THE HYDROLOGIC ENGINEERING CENTER   *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 551-1748             *
*                                      *
****************************************
```

```
X    X  XXXXXXX   XXXXX          X
X    X  X       X    X        XX
X    X  X       X             X
XXXXXXX  XXXX    X       XXXXX  X
X    X  X       X             X
X    X  X       X    X        X
X    X  XXXXXXX  XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          SILT LOAM
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10   I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 16           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 17           PC   .972   .982   .992   1.0
 18           LG          .17    6.57   .26
 19           UA     0     3      5      8     12     20     43     75     90     96
 20           UA   100
 21           UC   .48    .49
 22           ZZ
```

```
*                                    *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1) *
*          FEBRUARY 1981             *
*        REVISED 01 JUN 88           *
*                                    *
* RUN DATE  09/23/1988  TIME  09:36:59 *
*                                    *
**************************************
```

```
*                                    *
*   U.S. ARMY CORPS OF ENGINEERS     *
* THE HYDROLOGIC ENGINEERING CENTER  *
*        609 SECOND STREET           *
*      DAVIS, CALIFORNIA 95616       *
*         (916) 551-1748             *
*                                    *
**************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                          SILT LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 9 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          0  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT         HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME        0000  STARTING TIME
                    NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     1    0  ENDING DATE
                NDTIME        0715  ENDING TIME
                 ICENT         19  CENTURY MARK

            COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

       ENGLISH UNITS
           DRAINAGE AREA          SQUARE MILES
           PRECIPITATION DEPTH    INCHES
           LENGTH, ELEVATION      FEET
           FLOW                   CUBIC FEET PER SECOND
           STORAGE VOLUME         ACRE-FEET
           SURFACE AREA           ACRES
           TEMPERATURE            DEGREES FAHRENHEIT
```

*** ***

```
              **************
              *            *
10 KK         *   SUB-10   *        I-17 SUB-BASIN 10
              *            *
              **************
                          6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

15 PI           INCREMENTAL PRECIPITATION PATTERN
                  .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                  .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                  .01      .01      .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL         .00  STARTING LOSS
                     DTH         .17  MOISTURE DEFICIT
                    PSIF        6.57  WETTING FRONT SUCTION
                   XKSAT         .26  HYDRAULIC CONDUCTIVITY
                   RTIMP         .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                    .0       3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                 100.0

                                          ***

                                   UNIT HYDROGRAPH PARAMETERS
                              CLARK   TC=   .48 HR,      R=   .49 HR
                             SNYDER   TP=   .52 HR,     CP=   .65

                                      UNIT HYDROGRAPH
                                 12 END-OF-PERIOD ORDINATES
                16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                 1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	100.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	59.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	35.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	21.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	12.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	7.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	4.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	3.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	1.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.23	.04	1.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.18	.38	9.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.16	1.32	54.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.14	.13	140.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	157.	1		0715	30	.00	.00	.00	0.

$I_a = .54$
$f = .26$

TOTAL RAINFALL = 3.22, TOTAL LOSS = 1.36, TOTAL EXCESS = 1.86

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
157.	3.50		25.	21.	21.	21.
		(INCHES)	1.857	1.857	1.857	1.857
		(AC-FT)	12.	12.	12.	12.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	157.	3.50	25.	21.	21.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 09/23/1988 TIME 09:39:38 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX   XXXXX         X
X    X  X       X    X        XX
X    X  X       X              X
XXXXXXX  XXXX    X       XXXXX  X
X    X  X       X              X
X    X  X       X    X         X
X    X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          SANDY CLAY LOAM
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10  I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC    .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 16           PC    .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 17           PC    .972   .982   .992   1.0
 18           LG           .10    8.60    .06
 19           UA      0     3      5      8     12     20     43     75     90     96
 20           UA    100
 21           UC    .48    .49
 22           ZZ
```

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           FEBRUARY 1981              *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  09:39:38 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*           (916) 551-1748             *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                           SANDY CLAY LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

9 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          0  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

 IT         HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME       0000  STARTING TIME
                    NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                NODATE     1    0  ENDING DATE
                NDTIME       0715  ENDING TIME
                 ICENT         19  CENTURY MARK

            COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

     ENGLISH UNITS
         DRAINAGE AREA        SQUARE MILES
         PRECIPITATION DEPTH  INCHES
         LENGTH, ELEVATION    FEET
         FLOW                 CUBIC FEET PER SECOND
         STORAGE VOLUME       ACRE-FEET
         SURFACE AREA         ACRES
         TEMPERATURE          DEGREES FAHRENHEIT
```

```
*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

          **************
          *            *
10 KK     *   SUB-10   *       I-17 SUB-BASIN 10
          *            *
          **************
                          6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

15 PI            INCREMENTAL PRECIPITATION PATTERN
                   .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                   .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                   .01      .01      .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL         .00  STARTING LOSS
                     DTH         .10  MOISTURE DEFICIT
                    PSIF        8.60  WETTING FRONT SUCTION
                   XKSAT         .06  HYDRAULIC CONDUCTIVITY
                   RTIMP         .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK  TC=   .48 HR,      R=   .49 HR
                                    SNYDER  TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	123.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	73.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	44.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	26.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	16.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	9.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	6.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	3.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	2.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.05	.22	4.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.05	.51	25.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.04	1.43	83.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.04	.23	173.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	189.	1		0715	30	.00	.00	.00	0.

$I_a = .40$
$f = .06$

TOTAL RAINFALL = 3.22, TOTAL LOSS = .83, TOTAL EXCESS = 2.39

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 189.	3.50		32.	27.	27.	27.
		(INCHES)	2.384	2.384	2.384	2.384
		(AC-FT)	16.	16.	16.	16.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+ HYDROGRAPH AT	SUB-10	189.	3.50	32.	27.	27.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           FEBRUARY 1981              *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  09:42:11 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X    X  XXXXXXX  XXXXX         X
X    X  X       X    X       XX
X    X  X       X             X
XXXXXXX  XXXX    X       XXXXX X
X    X  X       X             X
X    X  X       X    X        X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          CLAY LOAM
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10   I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC    .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 16           PC    .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 17           PC    .972   .982   .992   1.0
 18           LG           .15   8.22    .04
 19           UA      0     3      5      8     12     20     43     75     90     96
 20           UA    100
 21           UC    .48    .49
 22           ZZ
```

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           FEBRUARY 1981              *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  09:42:11 *
*                                      *
****************************************
```

```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                          CLAY LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

  9 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          0  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME       0000  STARTING TIME
                    NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     1    0  ENDING DATE
                NDTIME       0715  ENDING TIME
                 ICENT         19  CENTURY MARK

             COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

       ENGLISH UNITS
           DRAINAGE AREA         SQUARE MILES
           PRECIPITATION DEPTH   INCHES
           LENGTH, ELEVATION     FEET
           FLOW                  CUBIC FEET PER SECOND
           STORAGE VOLUME        ACRE-FEET
           SURFACE AREA          ACRES
           TEMPERATURE           DEGREES FAHRENHEIT
```

*** ***

```
              **************
              *            *
10 KK         *   SUB-10   *        I-17 SUB-BASIN 10
              *            *
              **************
                                 6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB                STORM       3.22  BASIN TOTAL PRECIPITATION

15 PI            INCREMENTAL PRECIPITATION PATTERN
                   .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                   .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                   .01      .01      .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL        .00  STARTING LOSS
                     DTH        .15  MOISTURE DEFICIT
                    PSIF       8.22  WETTING FRONT SUCTION
                   XKSAT        .04  HYDRAULIC CONDUCTIVITY
                   RTIMP        .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC        .48  TIME OF CONCENTRATION
                       R        .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0      3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK  TC=   .48 HR,      R=   .49 HR
                                    SNYDER  TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.03	.01	125.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.03	.00	75.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.03	.01	45.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	27.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	17.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	10.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.01	7.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.01	4.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	3.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	1.
1		0230	11	.27	.05	.22	4.	1		0615	26	.00	.00	.00	1.
1		0245	12	.56	.04	.52	25.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.04	1.43	84.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.04	.23	174.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	190.	1		0715	30	.00	.00	.00	0.

$I_a = .40$
$S = .04$

TOTAL RAINFALL = 3.22, TOTAL LOSS = .77, TOTAL EXCESS = 2.45

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
190.	3.50		33.	27.	27.	27.
		(INCHES)	2.440	2.440	2.440	2.440
		(AC-FT)	16.	16.	16.	16.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	190.	3.50	33.	27.	27.	.13		

*** NORMAL END OF HEC-1 ***

C>O

```
1****************************************
 *                                      *
 *  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
 *           FEBRUARY 1981              *
 *          REVISED 01 JUN 88           *
 *                                      *
 * RUN DATE  09/23/1988  TIME  09:44:43 *
 *                                      *
****************************************
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```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X    X  XXXXXXX   XXXXX          X
X    X  X       X    X        XX
X    X  X       X             X
XXXXXXX  XXXX    X       XXXXX  X
X    X  X       X             X
X    X  X       X    X        X
X    X  XXXXXXX   XXXXX        XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          SILTY CLAY LOAM
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10  I-17 SUB-BASIN 10
 11           BA  .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB  3.22
 15           PC   .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 16           PC   .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 17           PC   .972   .982   .992   1.0
 18           LG           .16   10.75   .04
 19           UA     0      3      5      8     12     20     43     75     90     96
 20           UA   100
 21           UC   .48    .49
 22           ZZ
```

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           FEBRUARY 1981              *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  09:44:43 *
*                                      *
****************************************
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****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                          SILTY CLAY LOAM
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

  9 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          0  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                 NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1   0  STARTING DATE
                 ITIME      0000  STARTING TIME
                   NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     1   0  ENDING DATE
                NDTIME      0715  ENDING TIME
                 ICENT         19  CENTURY MARK

             COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

       ENGLISH UNITS
           DRAINAGE AREA          SQUARE MILES
           PRECIPITATION DEPTH    INCHES
           LENGTH, ELEVATION      FEET
           FLOW                   CUBIC FEET PER SECOND
           STORAGE VOLUME         ACRE-FEET
           SURFACE AREA           ACRES
           TEMPERATURE            DEGREES FAHRENHEIT
```

*** ***

```
             **************
             *            *
10 KK        *   SUB-10   *        I-17 SUB-BASIN 10
             *            *
             **************
                                 6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

15 PI            INCREMENTAL PRECIPITATION PATTERN
                    .01       .01       .01       .01       .01       .01       .01       .01       .01       .08
                    .17       .45       .08       .01       .01       .01       .01       .01       .01       .01
                    .01       .01       .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL         .00  STARTING LOSS
                     DTH         .16  MOISTURE DEFICIT
                    PSIF       10.75  WETTING FRONT SUCTION
                   XKSAT         .04  HYDRAULIC CONDUCTIVITY
                   RTIMP         .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                      .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                   100.0

                                                   ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                              UNIT HYDROGRAPH
                                          12 END-OF-PERIOD ORDINATES
                 16.       76.       95.       56.       33.       20.       12.        7.        4.        2.
                  1.        1.
```

****

HYDROGRAPH AT STATION SUB-10

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.04	.00	123.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.04	.00	73.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.04	.00	43.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.03	.00	26.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.03	.00	15.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.03	.00	9.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.03	.00	5.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.03	.00	3.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.03	.00	2.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	0.
1		0230	11	.27	.06	.21	3.	1		0615	26	.00	.00	.00	0.
1		0245	12	.56	.05	.51	24.	1		0630	27	.00	.00	.00	0.
1		0300	13	1.47	.05	1.42	82.	1		0645	28	.00	.00	.00	0.
1		0315	14	.27	.04	.23	172.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.04	.00	188.	1		0715	30	.00	.00	.00	0.

$I_a = .41$
$f = .04$

****

TOTAL RAINFALL = 3.22, TOTAL LOSS = .85, TOTAL EXCESS = 2.37

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 188.	3.50		32.	27.	27.	27.
		(INCHES)	2.363	2.363	2.363	2.363
		(AC-FT)	16.	16.	16.	16.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+ HYDROGRAPH AT	SUB-10	188.	3.50	32.	27.	27.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
1*************************************
 *                                   *
 *  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
 *          FEBRUARY 1981            *
 *        REVISED 01 JUN 88          *
 *                                   *
 * RUN DATE 09/23/1988 TIME 09:47:20 *
 *                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X XXXXXXX  XXXXX        X
X    X X       X    X       XX
X    X X       X             X
XXXXXXX XXXX   X      XXXXX  X
X    X X       X             X
X    X X       X    X        X
X    X XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          SANDY CLAY
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                   30
  9           IO      0      0

 10           KK  SUB-10  I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC    .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 16           PC    .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 17           PC    .972   .982   .992   1.0
 18           LG           .11   9.41    .02
 19           UA      0     3      5      8     12     20     43     75     90     96
 20           UA    100
 21           UC     .48   .49
 22           ZZ
```

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*           FEBRUARY 1981              *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  09:47:20 *
*                                      *
****************************************
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****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                          SANDY CLAY
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 9 IO        OUTPUT CONTROL VARIABLES
                IPRNT          0  PRINT CONTROL
                IPLOT          0  PLOT CONTROL
                QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT         HYDROGRAPH TIME DATA
                NMIN          15  MINUTES IN COMPUTATION INTERVAL
               IDATE     1    0  STARTING DATE
               ITIME        0000  STARTING TIME
                  NQ          30  NUMBER OF HYDROGRAPH ORDINATES
              NDDATE     1    0  ENDING DATE
              NDTIME        0715  ENDING TIME
               ICENT          19  CENTURY MARK

            COMPUTATION INTERVAL     .25 HOURS
                TOTAL TIME BASE    7.25 HOURS

      ENGLISH UNITS
          DRAINAGE AREA          SQUARE MILES
          PRECIPITATION DEPTH    INCHES
          LENGTH, ELEVATION      FEET
          FLOW                   CUBIC FEET PER SECOND
          STORAGE VOLUME         ACRE-FEET
          SURFACE AREA           ACRES
          TEMPERATURE            DEGREES FAHRENHEIT
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*** ***

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              **************
              *            *
10 KK         *   SUB-10   *        I-17 SUB-BASIN 10
              *            *
              **************
                                 6-HR DISTRIBUTION

13 IN            TIME DATA FOR INPUT TIME SERIES
                      JXMIN          15  TIME INTERVAL IN MINUTES
                     JXDATE     1    0  STARTING DATE
                     JXTIME          0  STARTING TIME

               SUBBASIN RUNOFF DATA

11 BA            SUBBASIN CHARACTERISTICS
                      TAREA        .13  SUBBASIN AREA

                 PRECIPITATION DATA

14 PB                 STORM       3.22  BASIN TOTAL PRECIPITATION

15 PI              INCREMENTAL PRECIPITATION PATTERN
                     .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                     .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                     .01      .01      .01

18 LG            GREEN AND AMPT LOSS RATE
                      STRTL        .00  STARTING LOSS
                        DTH        .11  MOISTURE DEFICIT
                       PSIF       9.41  WETTING FRONT SUCTION
                      XKSAT        .02  HYDRAULIC CONDUCTIVITY
                      RTIMP        .00  PERCENT IMPERVIOUS AREA

21 UC            CLARK UNITGRAPH
                         TC        .48  TIME OF CONCENTRATION
                          R        .49  STORAGE COEFFICIENT

18 UA            ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                        .0      3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                     100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.02	.02	130.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.02	.02	80.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.02	.02	50.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.02	.01	32.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.02	.02	21.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.02	.02	14.
1		0130	7	.04	.03	.00	0.	1		0515	22	.03	.02	.02	11.
1		0145	8	.04	.03	.01	0.	1		0530	23	.03	.02	.02	8.
1		0200	9	.04	.03	.01	1.	1		0545	24	.03	.01	.01	7.
1		0215	10	.04	.02	.01	2.	1		0600	25	.00	.00	.00	5.
1		0230	11	.27	.02	.25	7.	1		0615	26	.00	.00	.00	3.
1		0245	12	.56	.02	.54	30.	1		0630	27	.00	.00	.00	2.
1		0300	13	1.47	.02	1.45	90.	1		0645	28	.00	.00	.00	1.
1		0315	14	.27	.02	.25	180.	1		0700	29	.00	.00	.00	1.
1		0330	15	.04	.02	.02	196.	1		0715	30	.00	.00	.00	0.

$I_a = .19$
$f = .02$

TOTAL RAINFALL = 3.22, TOTAL LOSS = .53, TOTAL EXCESS = 2.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
196.	3.50		36.	30.	30.	30.
		(INCHES)	2.681	2.681	2.681	2.681
		(AC-FT)	18.	18.	18.	18.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	196.	3.50	36.	30.	30.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1)    *
*           FEBRUARY 1981              *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE 09/23/1988 TIME 09:49:49    *
*                                      *
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****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*         609 SECOND STREET            *
*      DAVIS, CALIFORNIA 95616         *
*          (916) 551-1748              *
*                                      *
****************************************
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```
X    X XXXXXXX  XXXXX         X
X    X X       X    X       XX
X    X X       X             X
XXXXXXX XXXX   X      XXXXX  X
X    X X       X             X
X    X X       X    X        X
X    X XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1OB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          SILTY CLAY
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10   I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC   .01     .02     .03     .04     .05     .058    .07     .081    .093    .105
 16           PC   .188    .361    .814    .897    .909    .921    .932    .944    .952    .962
 17           PC   .972    .982    .992    1.0
 18           LG           .16   11.50     .02
 19           UA     0      3      5       8      12      20      43      75      90      96
 20           UA   100
 21           UC   .48     .49
 22           ZZ
```

```
1****************************************
*                                      *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            FEBRUARY 1981             *
*          REVISED 01 JUN 88           *
*                                      *
*  RUN DATE  09/23/1988  TIME  09:49:49 *
*                                      *
****************************************
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****************************************
*                                      *
*    U.S. ARMY CORPS OF ENGINEERS      *
*  THE HYDROLOGIC ENGINEERING CENTER   *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                           SILTY CLAY
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

9 IO          OUTPUT CONTROL VARIABLES
                   IPRNT          0  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT          HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME        0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NODATE     1    0  ENDING DATE
                  NOTIME        0715  ENDING TIME
                   ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                  TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA          SQUARE MILES
            PRECIPITATION DEPTH    INCHES
            LENGTH, ELEVATION      FEET
            FLOW                   CUBIC FEET PER SECOND
            STORAGE VOLUME         ACRE-FEET
            SURFACE AREA           ACRES
            TEMPERATURE            DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
```

```
            **************
            *            *
10 KK       *   SUB-10   *       I-17 SUB-BASIN 10
            *            *
            **************
                          6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE      1   0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

15 PI            INCREMENTAL PRECIPITATION PATTERN
                   .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                   .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                   .01      .01      .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL         .00  STARTING LOSS
                     DTH         .16  MOISTURE DEFICIT
                    PSIF       11.50  WETTING FRONT SUCTION
                   XKSAT         .02  HYDRAULIC CONDUCTIVITY
                   RTIMP         .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0       3.0      5.0      8.0     12.0     20.0     43.0     75.0     90.0     96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

HYDROGRAPH AT STATION SUB-10

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.02	.01	128.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.02	.01	78.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.02	.02	48.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.02	.00	30.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.02	.01	19.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.02	.01	12.
1		0130	7	.04	.04	.00	0.	1		0515	22	.03	.02	.01	9.
1		0145	8	.04	.04	.00	0.	1		0530	23	.03	.02	.01	7.
1		0200	9	.04	.04	.00	0.	1		0545	24	.03	.02	.01	5.
1		0215	10	.04	.04	.00	0.	1		0600	25	.00	.00	.00	3.
1		0230	11	.27	.03	.24	4.	1		0615	26	.00	.00	.00	2.
1		0245	12	.56	.03	.53	27.	1		0630	27	.00	.00	.00	1.
1		0300	13	1.47	.03	1.44	87.	1		0645	28	.00	.00	.00	1.
1		0315	14	.27	.03	.24	177.	1		0700	29	.00	.00	.00	0.
1		0330	15	.04	.03	.01	193.	1		0715	30	.00	.00	.00	0.

$I_a = .15$

$f = .02$

TOTAL RAINFALL = 3.22, TOTAL LOSS = .65, TOTAL EXCESS = 2.57

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
193.	3.50		35.	29.	29.	29.
		(INCHES)	2.560	2.560	2.560	2.560
		(AC-FT)	17.	17.	17.	17.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	193.	3.50	35.	29.	29.	.13		

*** NORMAL END OF HEC-1 ***

C>

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*            FEBRUARY 1981             *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  09/23/1988  TIME  09:52:17 *
*                                      *
****************************************
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```
****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X    X  XXXXXXX  XXXXX         X
X    X  X       X    X       XX
X    X  X       X             X
XXXXXXX  XXXX    X      XXXXX  X
X    X  X       X             X
X    X  X       X    X        X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID   I-17  SUB-BASIN 10
  2           ID   GREEN-AMPT
  3           ID          CLAY
  4           ID   RAINFALL DISTRIBUTION =  6-HR NESTED
  5           ID   POINT PRECIPITATION = 3.22
  6           ID   AREA PRECIPITATION = 3.22
  7           ID   DEPTH-AREA RATIO = 1.0
  8           IT     15                    30
  9           IO      0      0

 10           KK  SUB-10   I-17 SUB-BASIN 10
 11           BA   .126
 12           KM     6-HR DISTRIBUTION
 13           IN     15
 14           PB   3.22
 15           PC    .01    .02    .03    .04    .05    .058   .07    .081   .093   .105
 16           PC    .188   .361   .814   .897   .909   .921   .932   .944   .952   .962
 17           PC    .972   .982   .992   1.0
 18           LG           .14   12.45   .01
 19           UA      0     3      5      8     12     20     43     75     90     96
 20           UA    100
 21           UC    .48    .49
 22           ZZ
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE 09/23/1988 TIME 09:52:17 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
                    I-17  SUB-BASIN 10
                    GREEN-AMPT
                           CLAY
                    RAINFALL DISTRIBUTION =  6-HR NESTED
                    POINT PRECIPITATION = 3.22
                    AREA PRECIPITATION = 3.22
                    DEPTH-AREA RATIO = 1.0

 9 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          0  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 QSCAL         0.  HYDROGRAPH PLOT SCALE

  IT         HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME       0000  STARTING TIME
                    NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     1    0  ENDING DATE
                NDTIME       0715  ENDING TIME
                 ICENT         19  CENTURY MARK

            COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

      ENGLISH UNITS
          DRAINAGE AREA        SQUARE MILES
          PRECIPITATION DEPTH  INCHES
          LENGTH, ELEVATION    FEET
          FLOW                 CUBIC FEET PER SECOND
          STORAGE VOLUME       ACRE-FEET
          SURFACE AREA         ACRES
          TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***
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            **************
            *            *
10 KK       *   SUB-10   *        I-17 SUB-BASIN 10
            *            *
            **************
                          6-HR DISTRIBUTION

13 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

             SUBBASIN RUNOFF DATA

11 BA          SUBBASIN CHARACTERISTICS
                    TAREA         .13  SUBBASIN AREA

               PRECIPITATION DATA

14 PB               STORM        3.22  BASIN TOTAL PRECIPITATION

15 PI            INCREMENTAL PRECIPITATION PATTERN
                   .01      .01      .01      .01      .01      .01      .01      .01      .01      .08
                   .17      .45      .08      .01      .01      .01      .01      .01      .01      .01
                   .01      .01      .01

18 LG          GREEN AND AMPT LOSS RATE
                   STRTL         .00  STARTING LOSS
                     DTH         .14  MOISTURE DEFICIT
                    PSIF       12.45  WETTING FRONT SUCTION
                   XKSAT         .01  HYDRAULIC CONDUCTIVITY
                   RTIMP         .00  PERCENT IMPERVIOUS AREA

21 UC          CLARK UNITGRAPH
                      TC         .48  TIME OF CONCENTRATION
                       R         .49  STORAGE COEFFICIENT

18 UA          ACCUMULATED-AREA VS. TIME,  11 ORDINATES
                     .0       3.0       5.0       8.0      12.0      20.0      43.0      75.0      90.0      96.0
                  100.0

                                                  ***

                                          UNIT HYDROGRAPH PARAMETERS
                                     CLARK   TC=   .48 HR,      R=   .49 HR
                                    SNYDER   TP=   .52 HR,     CP=   .65

                                          UNIT HYDROGRAPH
                                     12 END-OF-PERIOD ORDINATES
                 16.      76.      95.      56.      33.      20.      12.       7.       4.       2.
                  1.       1.
```

****

HYDROGRAPH AT STATION SUB-10

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.04	.02	.02	132.
1		0015	2	.03	.03	.00	0.	1		0400	17	.04	.01	.02	81.
1		0030	3	.03	.03	.00	0.	1		0415	18	.04	.01	.02	51.
1		0045	4	.03	.03	.00	0.	1		0430	19	.03	.01	.01	33.
1		0100	5	.03	.03	.00	0.	1		0445	20	.03	.01	.02	22.
1		0115	6	.03	.03	.00	0.	1		0500	21	.03	.01	.02	15.
1		0130	7	.04	.03	.01	0.	1		0515	22	.03	.01	.02	12.
1		0145	8	.04	.02	.01	1.	1		0530	23	.03	.01	.02	9.
1		0200	9	.04	.02	.02	2.	1		0545	24	.03	.01	.01	8.
1		0215	10	.04	.02	.02	3.	1		0600	25	.00	.00	.00	6.
1		0230	11	.27	.02	.25	8.	1		0615	26	.00	.00	.00	4.
1		0245	12	.56	.02	.54	31.	1		0630	27	.00	.00	.00	2.
1		0300	13	1.47	.02	1.46	91.	1		0645	28	.00	.00	.00	1.
1		0315	14	.27	.02	.25	181.	1		0700	29	.00	.00	.00	1.
1		0330	15	.04	.02	.02	197.	1		0715	30	.00	.00	.00	0.

$I_a = .15$

$f = .01$

****

TOTAL RAINFALL = 3.22, TOTAL LOSS = .46, TOTAL EXCESS = 2.76

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
		(CFS)				
197.	3.50		37.	31.	31.	31.
		(INCHES)	2.748	2.748	2.748	2.748
		(AC-FT)	18.	18.	18.	18.

CUMULATIVE AREA = .13 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	SUB-10	197.	3.50	37.	31.	31.	.13		

*** NORMAL END OF HEC-1 ***

APPENDIX 2-H

A Procedure to Predict Green and Ampt Infiltration Parameters, Rawls, W.J., and Brakensiek, D.L., Proceedings of ASAE Conference on Advances in Infiltration, Chicago, IL, p. 102-112.

Proc. ASAE Conference on Advances in Infiltration, Chicago, IL, pp. 102-112 1983

Rec'd from Rawls 1 Sept 88

A PROCEDURE TO PREDICT GREEN AND AMPT INFILTRATION PARAMETERS

W. J. Rawls
Member ASAE

D. L. Brakensiek
Member ASAE

If a physically based infiltration model is to be useful in operational hydrology, procedures must be developed for estimating the model parameters based on readily available data such as soil survey and agronomic information.

Since the Green-Ampt (Green and Ampt, 1911) infiltration model has been shown to have wide applicabiltiy for modeling the infiltration process (Mein and Larson 1971 and Smith and Parlange 1978), it is the purpose of this paper to present a procedure for estimating the Green and Ampt infiltration parameters. Also, the Green and Ampt model parameters can be easily modified to apply to other physically based infiltration models such as the Philip (1957) and the Smith and Parlange (1978) models.

APPROACH

The Green-Ampt infiltration rate equation is

$$f = K\left(1 + \frac{n\psi_f}{F}\right) \tag{1}$$

and its integrated form is

$$F - n\psi_f \ln\left(1 + \frac{F}{n\psi_f}\right) = Kt \tag{2}$$

where K is hydraulic conductivity, cm/hr; ψ_f is Green-Ampt capillary pressure head, cm; and n is available porosity., Equation variables are infiltration rate, f, cm/hr; infiltration amount, F, cm; and time, t, hr.

The Green and Ampt parameters have been estimated from soil water retention data using the Brooks-Corey water retention equation (Brakensiek et al. 1981). The Brooks and Corey equation (1964) is written as

$$S_e = (\psi_b/\psi)^{\lambda} \tag{3}$$

where

$$S_e \text{ (effective saturation)} = \frac{\theta-\theta_r}{\phi-\theta_r}$$

and θ is soil water content cm^3/cm^3; θ_r is residual saturation, cm^3/cm^3; ϕ is total porosity, cm^3/cm^3; ψ_b is bubbling pressure, cm; ψ is capillary pressure, cm; and λ is the pore-size distribution index. The Green-Apmt capillary pressure head, ψ_f is calculated by (Brakensiek 1977):

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$$\psi_f = \frac{2 + 3\lambda}{1 + 3\lambda} \quad \frac{\psi_b}{2} \tag{4}$$

where ψ_b is divided by 2 to correspond to an air exit value (Bouwer 1969). The available porosity (n) is calculated as:

$$n = \theta_e - ASW \tag{5}$$

where

$$\theta_e \text{ (effective porosity)} = (\phi - \theta_r) \tag{6}$$

and ASW is the antecedent soil water, cm^3/cm^3. The Green and Ampt hydraulic conductivity parameter (K), based on Bouwer's (1969) work, is one-half the saturated hydraulic conductivity, K_s.

$$K = K_s/2 \tag{7}$$

and the saturated conductivity (K_s) is calculated by an equation derived by Brutsaert (1967)

$$K_s = a \left(\frac{\theta_e}{\psi_b}\right)^2 \frac{\lambda^2}{(\lambda + 1)(\lambda + 2)} \tag{8}$$

Calibration of equation (8) with measured K_s (cm/sec) values gave an empirical value of "a" = 21 (Rawls et al. 1982).

Based on analysis reported by Brakensiek et. al. (1982) the final saturated conductivity for a soil crusted layer is

$$K_{Sc} = \frac{Z_c}{\psi_{1f} + Z_c} (SC) (K_s) \tag{9}$$

where K_{Sc} = saturated crust conductivity (cm/hr), Z_c = crust thickness (cm), ψ_{1f} = steady state capillary potential at crust subcrust interface (cm), SC = reduction factor for subcrust partial saturation, and K_s = saturated conductivity for the original uncrusted soil. Since saturated hydraulic conductivity values are used to determine crust conductivities, we will report saturated hydraulic conductivities in this paper rather than the Green-Ampt hydraulic conductivity.

In summary, the Green-Ampt parameters needed for application are θ_e, effective porosity, Green-Ampt capillary pressure head ψ_f, and saturated hydraulic conductivity, K_s.

PROCEDURE

Alternate procedures for specifying the Green-Ampt infiltration parameters based on available soils and agronomic information is presented in Fig. 1.

Soils

The soils data needed are particle size distribution (percent sand and clay), percent organic matter, and bulk density. Soil survey descriptions can be used to estimate the above soil properties if measured values are not available (Rawls et al. 1983). Also, Fig. 2 can be used with estimated or measured particle size distribution and organic matter to estimate bulk density (Rawls 1983).

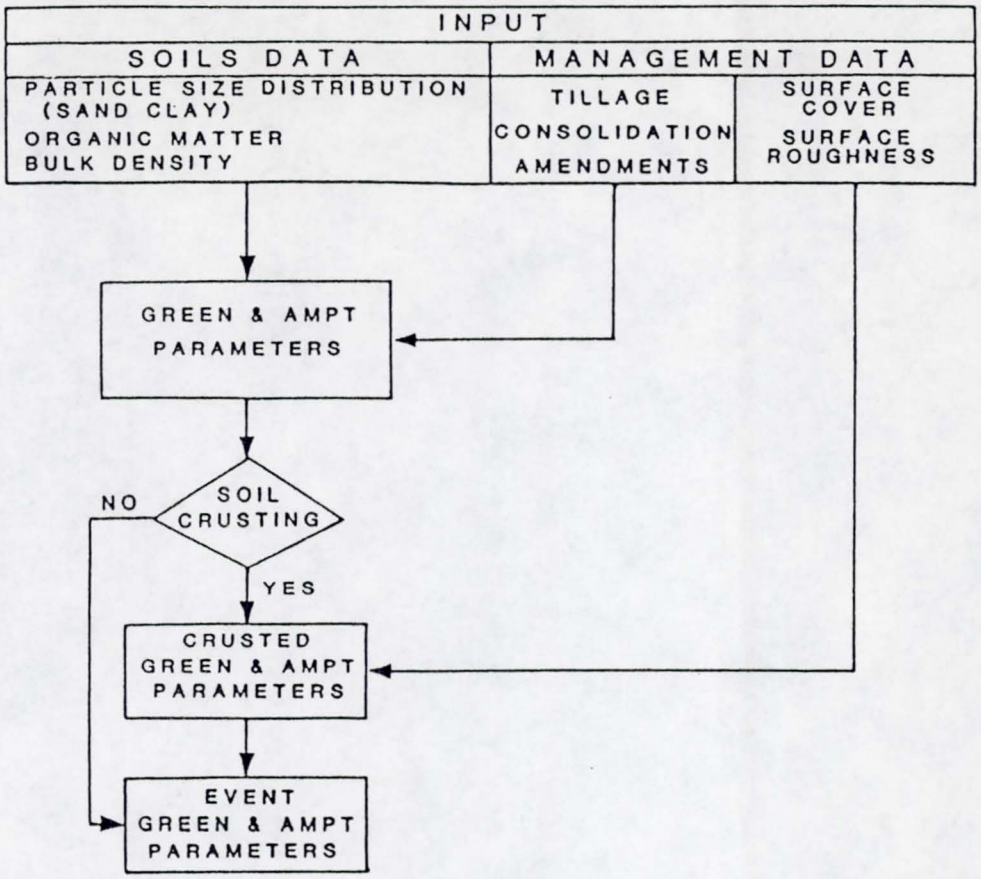

Fig. 1. Procedure to Estimate Green and Ampt Infiltration Parameters

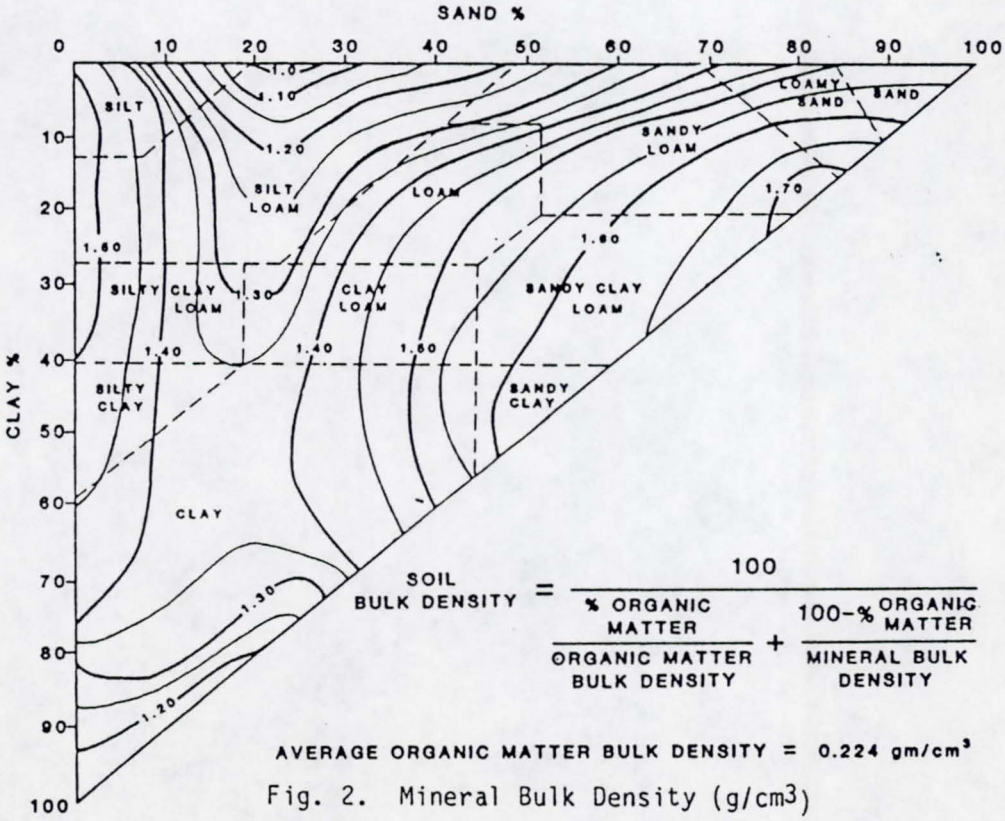

Fig. 2. Mineral Bulk Density (g/cm3)

The influence of tillage, additions of organic matter and soil modification are represented as changes in total porosity (Brakensiek et al. 1982). Figure 3 shows the percent porosity change due to moldboard tillage according to soil texture. A porosity change for other tillage practices can be determined by multiplying the porosity change caused by plowing, given in Fig. 3, by the factor given in Table 1 for the specific tillage practice. Values given in Table 1 can also be used in conjunction with experience to determine porosity changes for new tillage methods.

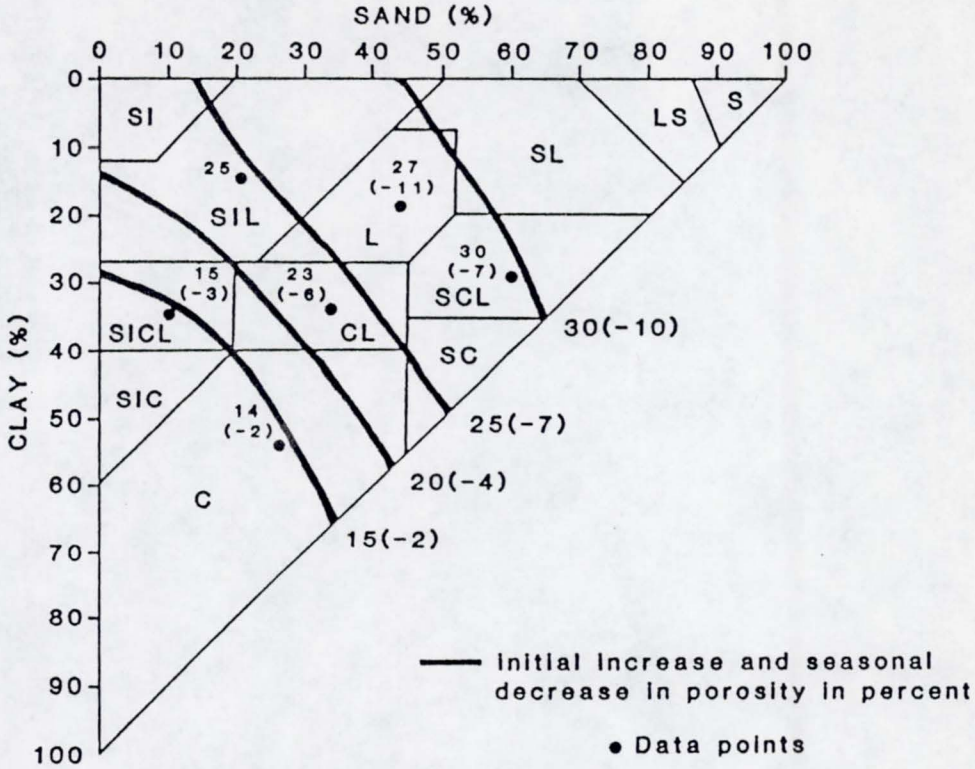

Fig. 3. Porosity Changes Caused by Plowing

Table 1.

Tillage System	Ratio $\frac{\text{Tillage Porosity}}{\text{Plow Porosity}}$
Chisel	1.02
Plow-Disk-Harrow	0.97
Rotary	0.95
Plow and Pack	0.82

GREEN-AMPT PARAMETERS

To quantify the soils and management effects on the Green-Ampt parameters, water retention regression equations with sand, clay, organic matter, and bulk density as input (Rawls et al. 1982a) were used to predict the soil water held at 9 tensions between 0.2 bar and 15 bar. The Brooks-Corey equation (Eq. 3) was fitted to the estimated water retention curve using a non-linear optimization scheme and the Green-Ampt parameters (θ_e, ψ_f, K_s) were determined from the optimized Brooks-Corey parameters using equations 4, 6, 7, and 8.

Using porosity values calculated from the bulk density values obtained from Fig. 2, the set of base value Green-Ampt parameter charts given in Figs. 4, 5, and 6 were developed by simulation for 0.5 percent organic matter. Also included in Figs. 4, 5, and 6 are Green and Ampt parameter charts for various levels of porosity change ranging from -20 to 30 percent change of the base value porosity (Fig. 7).

In the case where bulk density and organic matter cannot be determined and soil texture is the only soils data available, then the soil texture centroid values of sand and clay are used to enter the base value charts in Figs. 4, 5, and 6 to determine the Green-Ampt parameters. Additionally, soil texture modifiers can be used to indicate the portion of the soil texture to be entered. In the case where the bulk density is known or estimated from Fig. 2 with a known amount of organic matter, Fig. 7 is used to determine the porosity level which matches the porosity calculated from the bulk density for the given sand and clay percentages. If the value falls between two charts, linear interpolation can be used. Using the porosity level determined, along with the percent sand and clay, the Green-Ampt parameters can be determined from Figs. 4, 5 and 6.

Texture charts representing the 1/3 and 15 bar soil water retention shown in Fig. 8 were developed similarly to the Green-Ampt parameter charts and can be used to estimate antecedent soil water content (ASW) for wet and dry conditions if measured values are not available.

CRUSTED GREEN-AMPT PARAMETERS

If the soil is susceptable to crusting (most cultivated soils) input about the surface cover and surface roughness is needed (Brakensiek et al. 1982). Using the appropriate matric potential drop across the surface seal and subcrust partial saturation conductivity reduction factors given in Table 2, and an assumed crust thickness, the final saturated curst conductivity can be determined using equation 9. The transient crust saturated conductivity can be determined by methods given in Brakensiek et al. 1982.

Table 2. Crust Parameters

Soil texture	Steady state capillary potential across a crust subcrust interface ψ_{1f} (cm)	Partial saturation reduction factor for subcrust conductivity (SC)
Sand	2	0.91
Loamy sand	3	0.89
Sandy loam	6	0.86
Loam	7	0.82
Silt loam	10	0.81
Sandy clay loam	5	0.85
Clay loam	8	0.82
Silty clay loam	10	0.76
Sandy clay	6	0.80
Silty clay	11	0.73
Clay	9	0.75

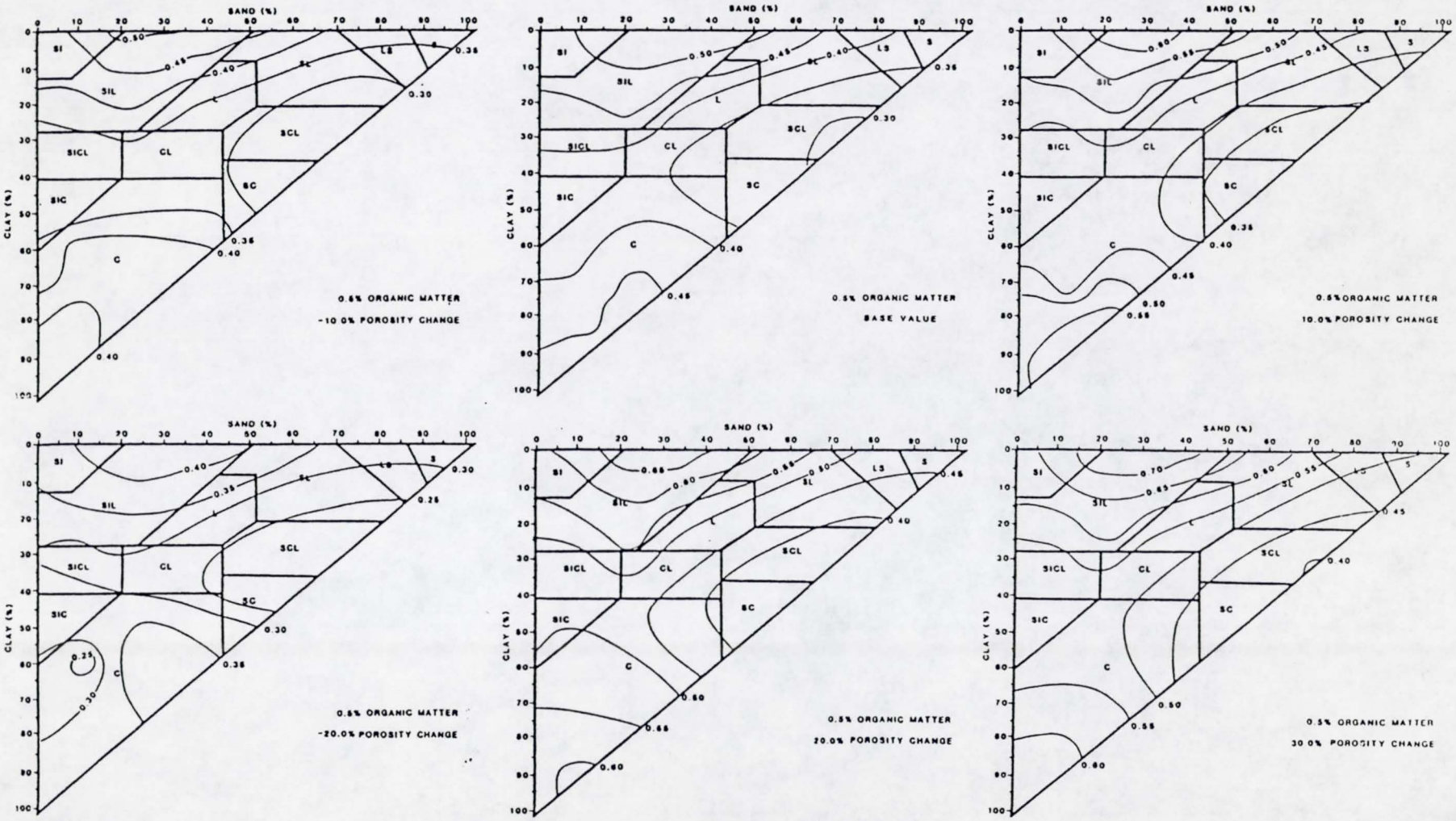

FIG. 4. EFFECTIVE POROSITY ,(θ_e), cm^3/cm^3

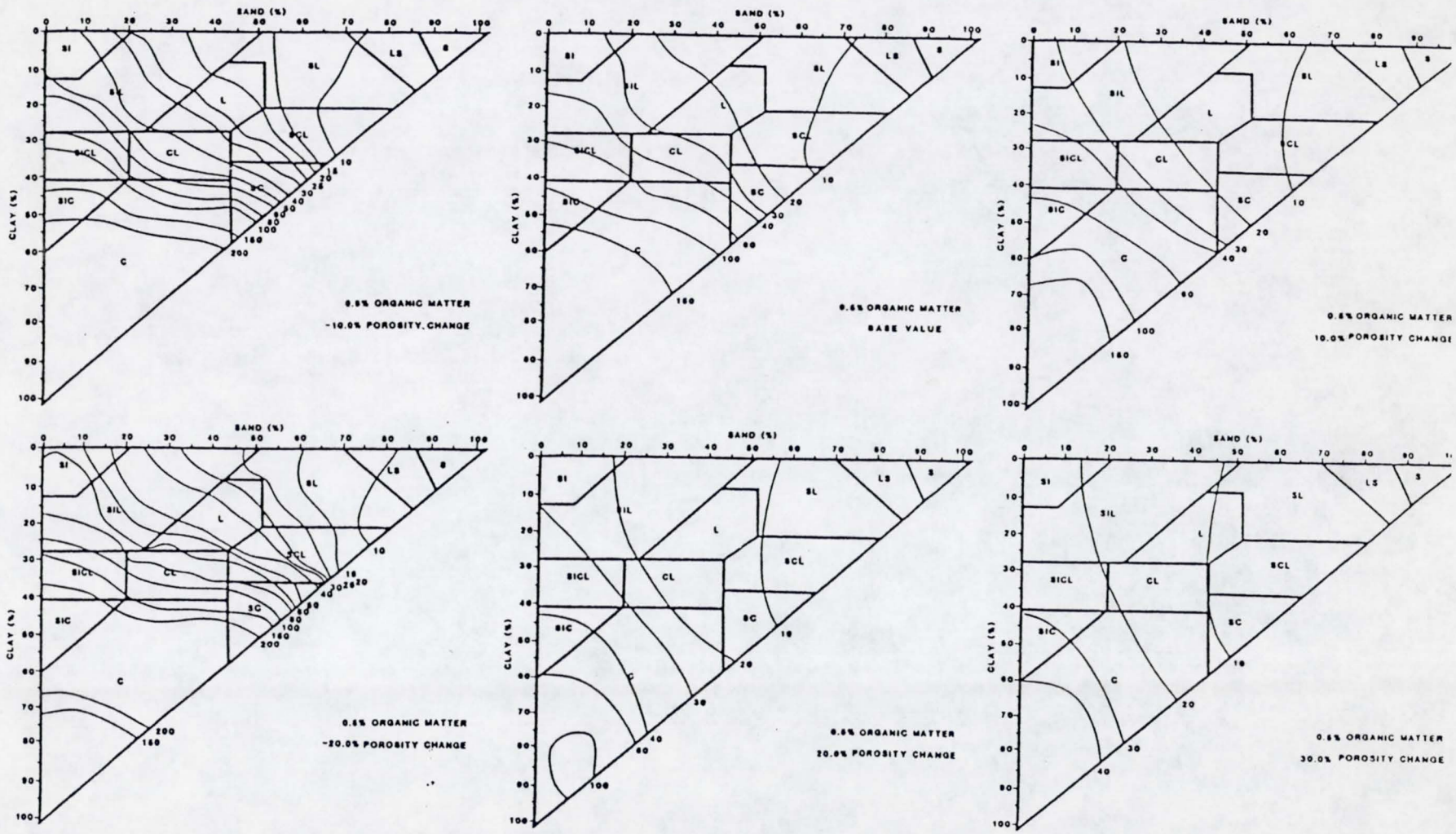

FIG. 5. GREEN-AMPT CAPILLARY PRESSURE HEAD, (Ψ_f), cm.

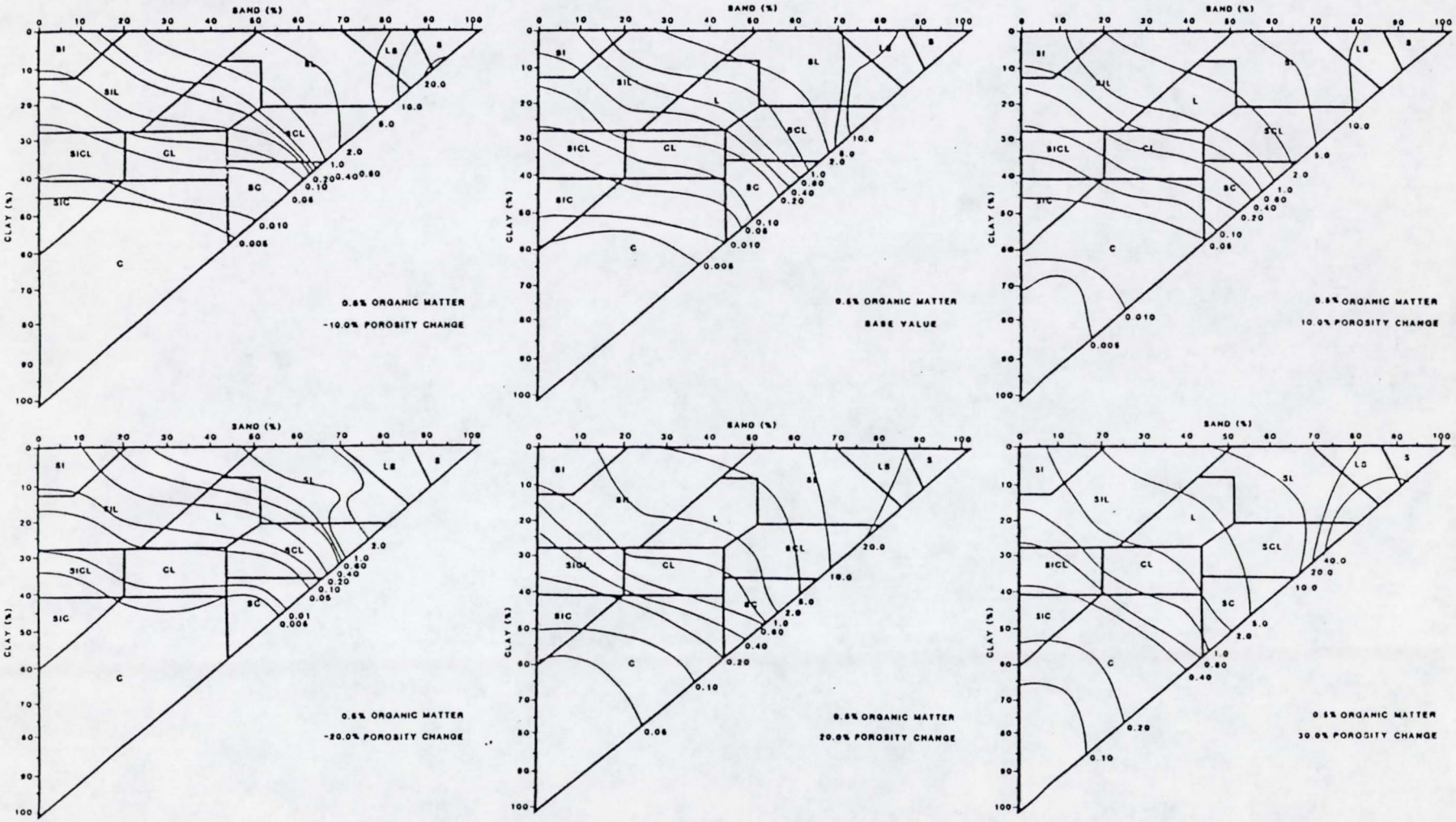

FIG. 6. SATURATED HYDRAULIC CONDUCTIVITY, (K_s), cm/hr

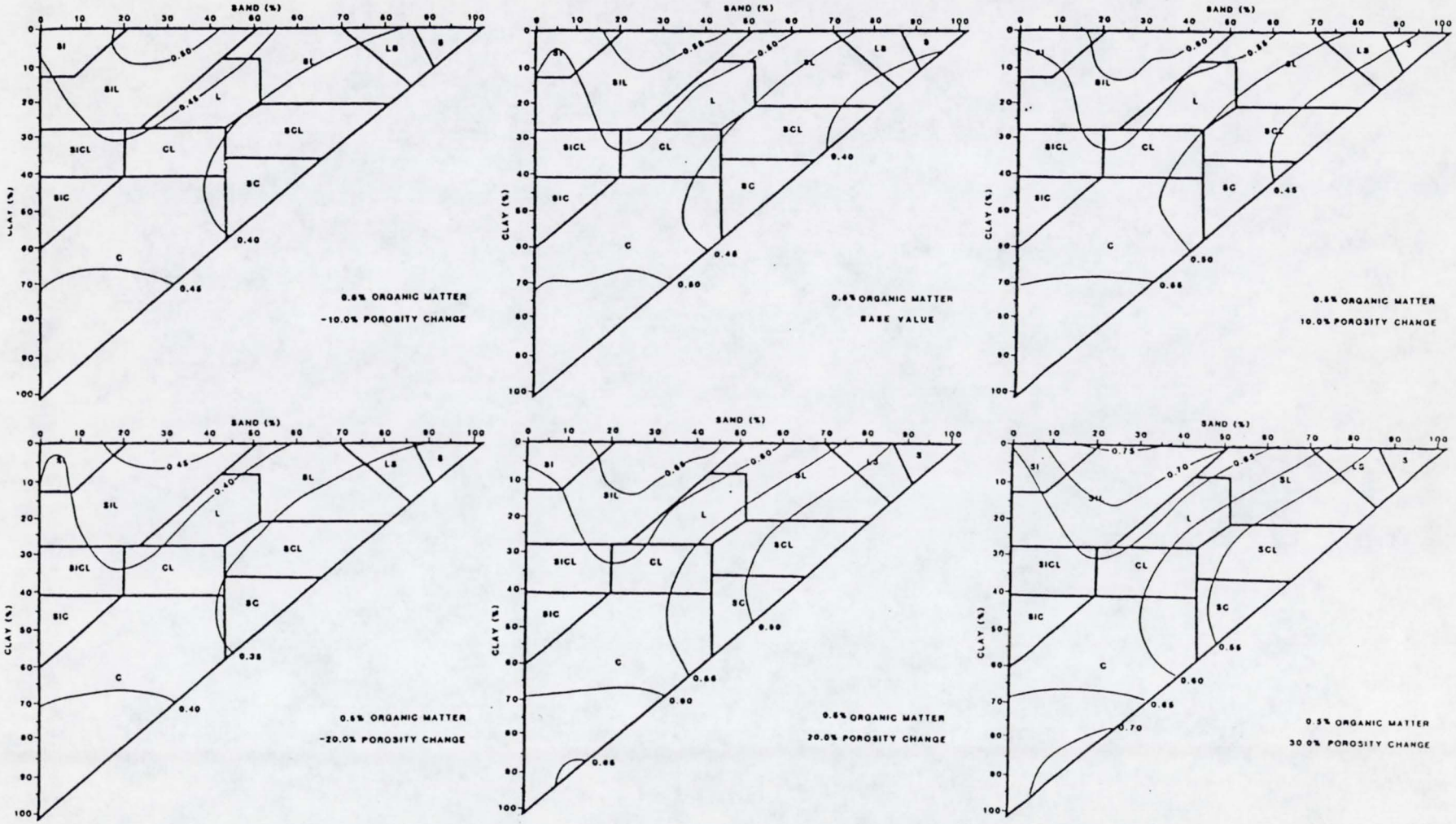

FIG. 7. POROSITY, (Ø), cm^3/cm^3

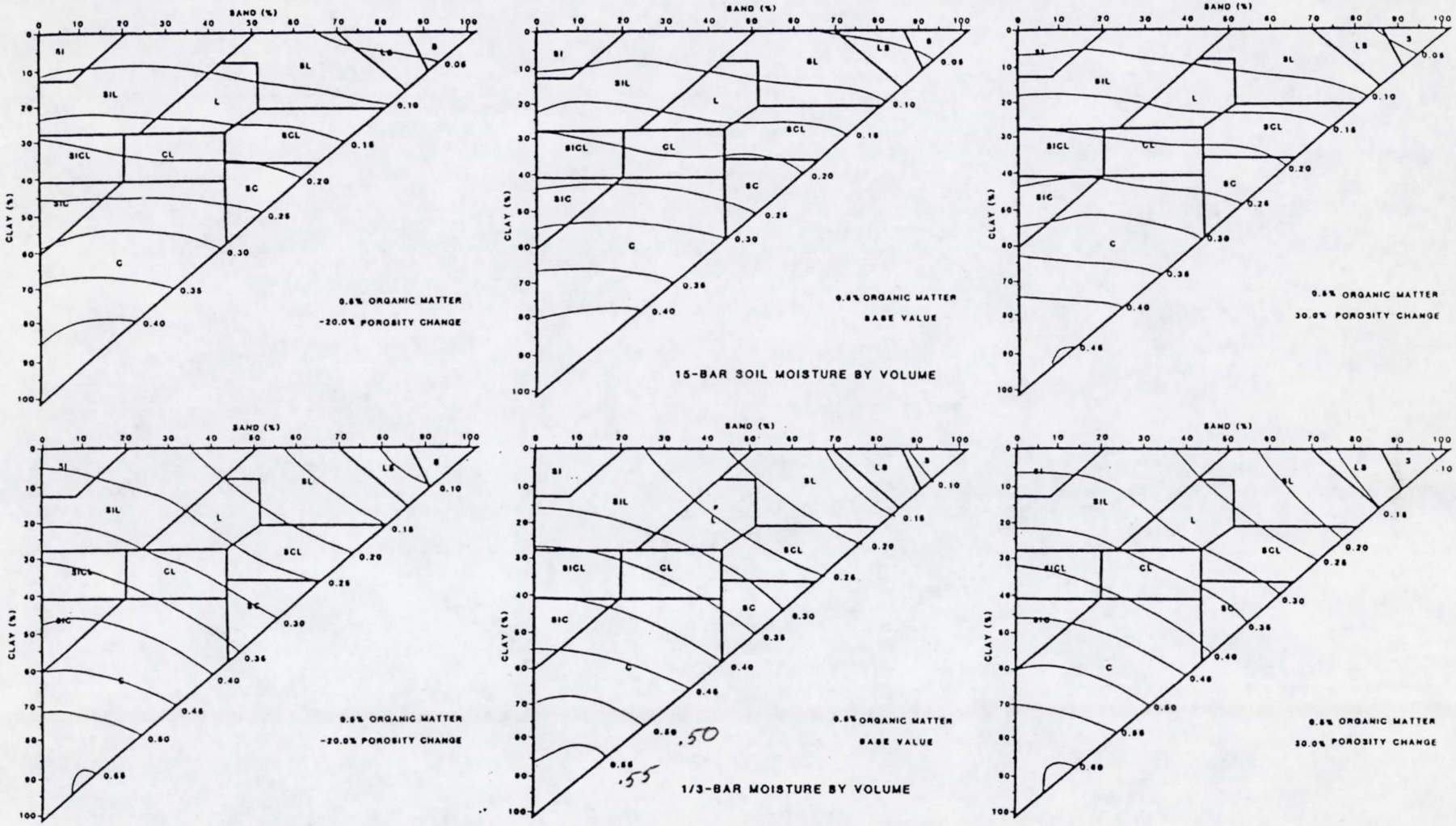

FIG. 8. 1/3 BAR AND 15 BAR WATER RETENTION, cm^3/cm^3

CONCLUSION

A procedure with the necessary tables and graphs have been presented for estimating Green-Ampt infiltration parameters based on readily available soils and agronomic data. This procedure allows an infiltration based rainfall runoff model to be used in ungaged areas (Brakensiek et al. 1982).

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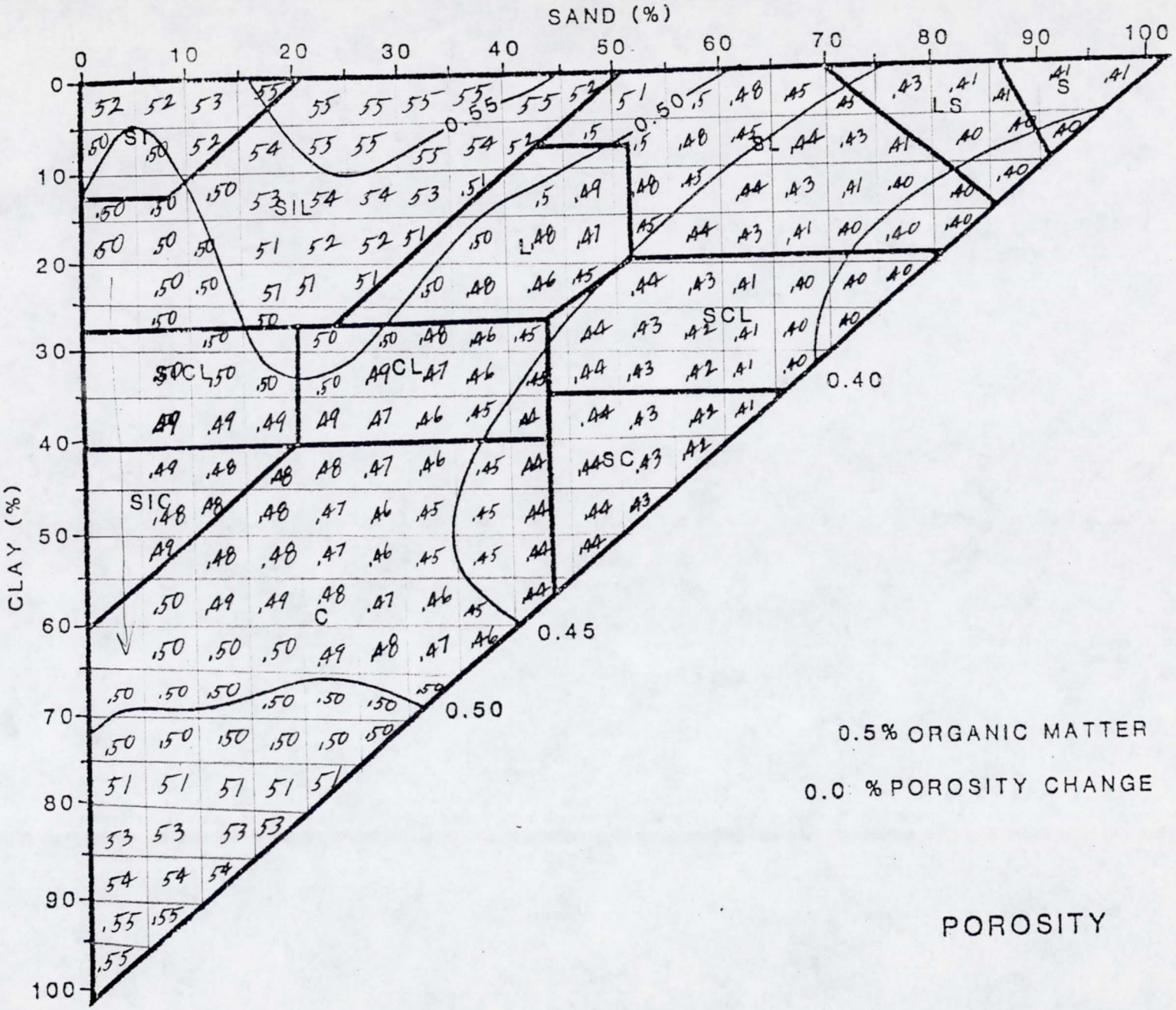
APPENDIX 2-I

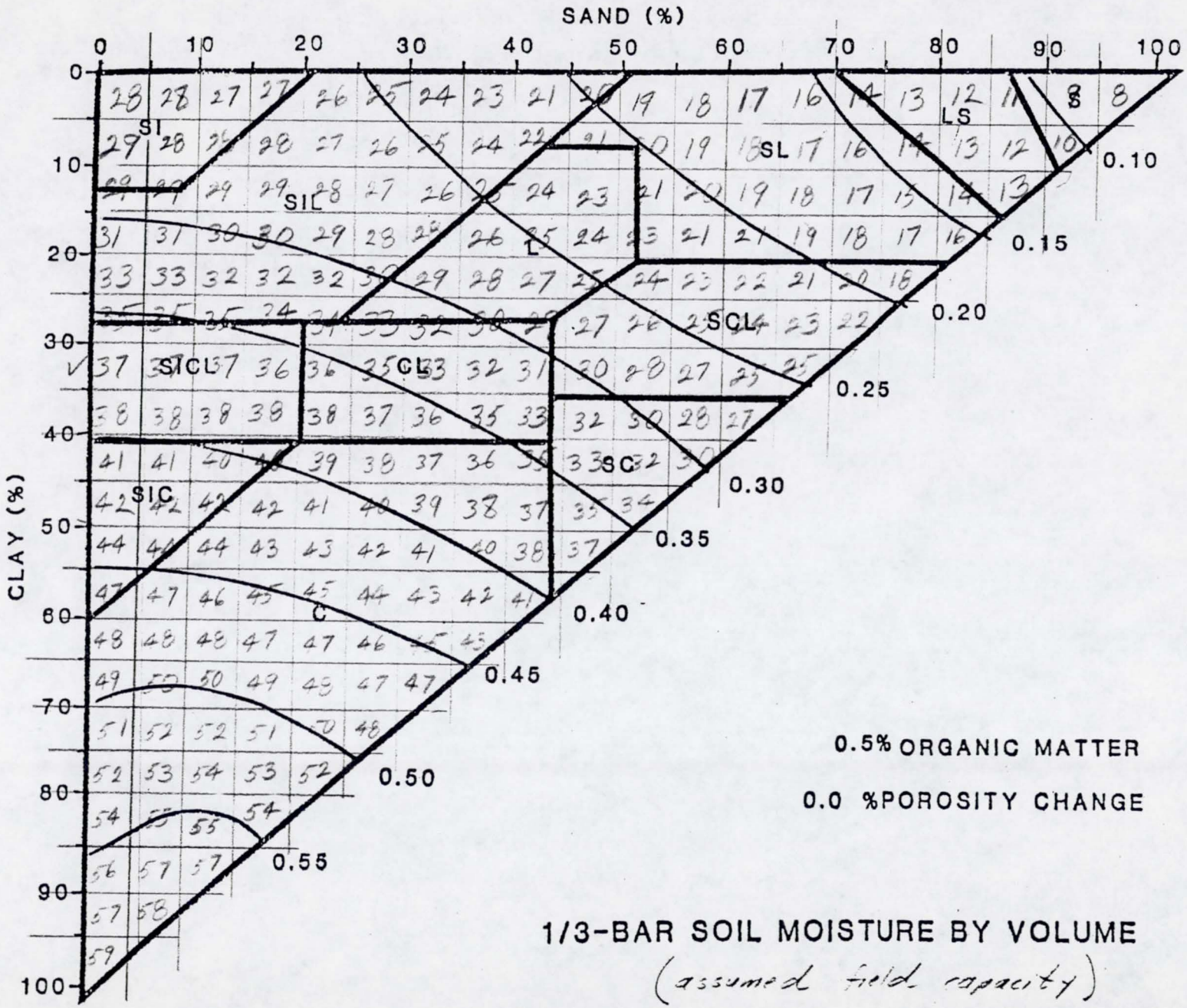
Work sheets for the development of the DTHETA figures.



0.5% ORGANIC MATTER

0.0 % POROSITY CHANGE

POROSITY

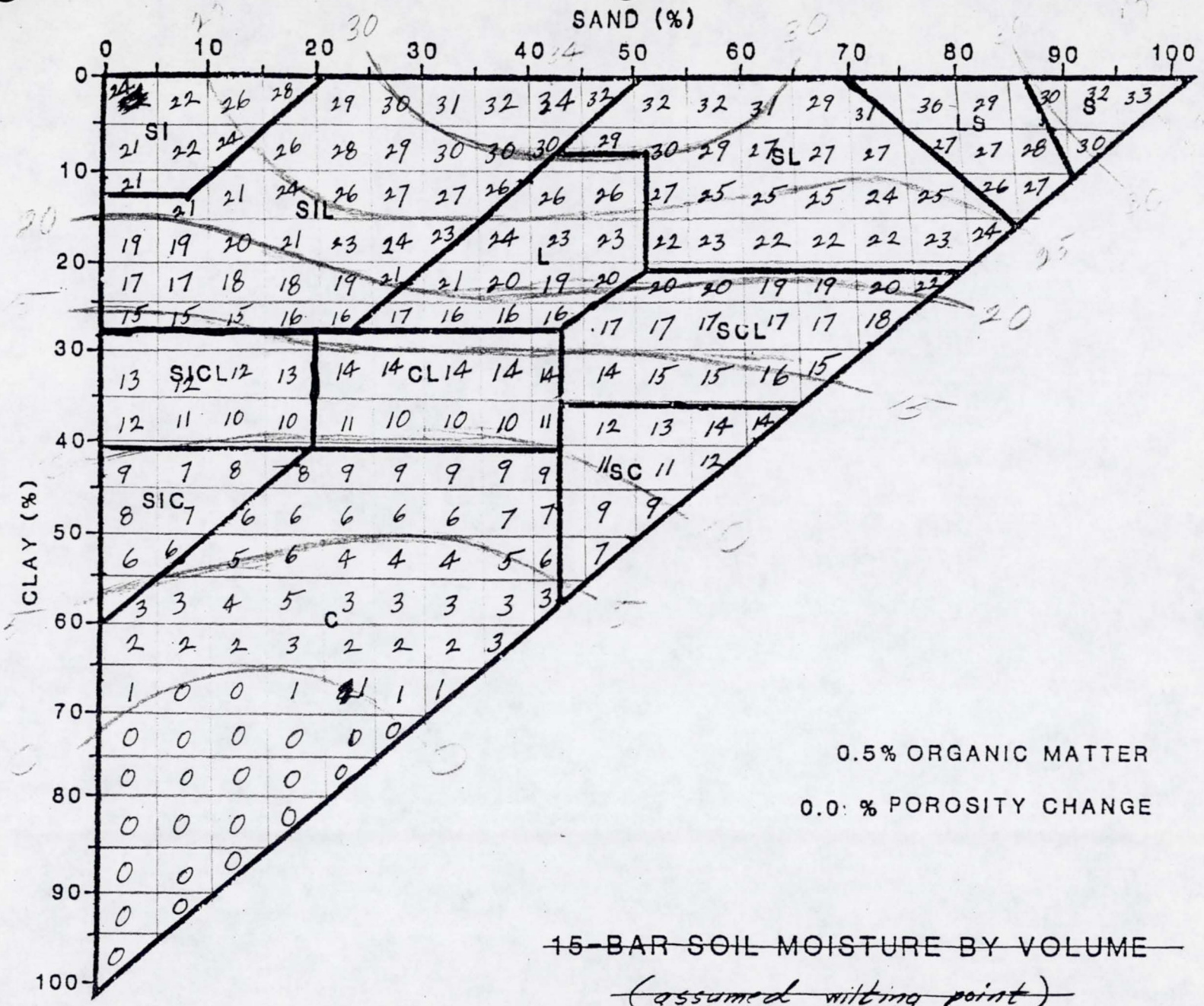


0.5% ORGANIC MATTER

0.0 %POROSITY CHANGE

1/3-BAR SOIL MOISTURE BY VOLUME

(assumed field capacity)



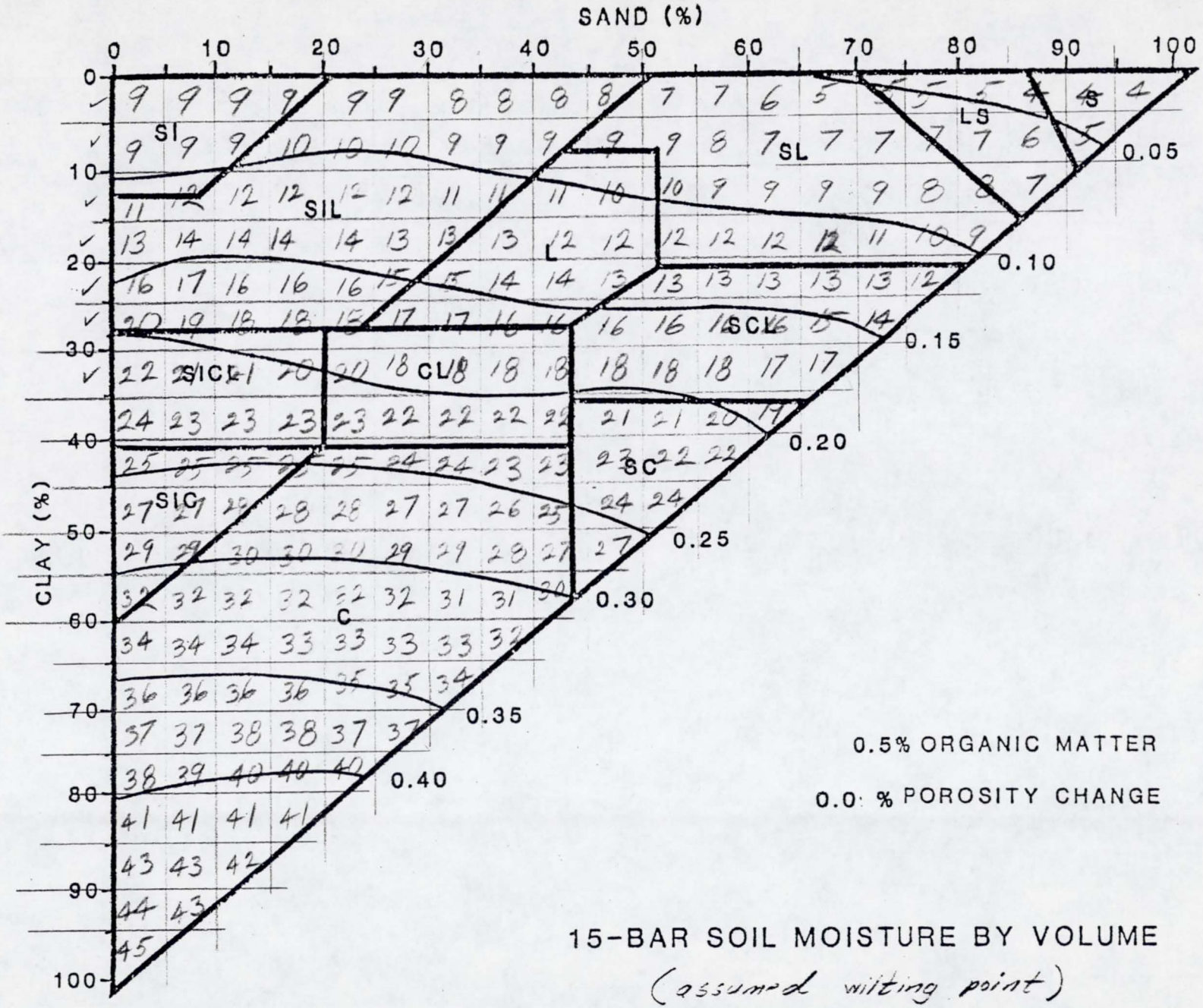
0.5% ORGANIC MATTER

0.0 % POROSITY CHANGE

~~15-BAR SOIL MOISTURE BY VOLUME~~

~~(assumed wilting point)~~

DTHETA for difference between Porosity (saturation) and field capacity

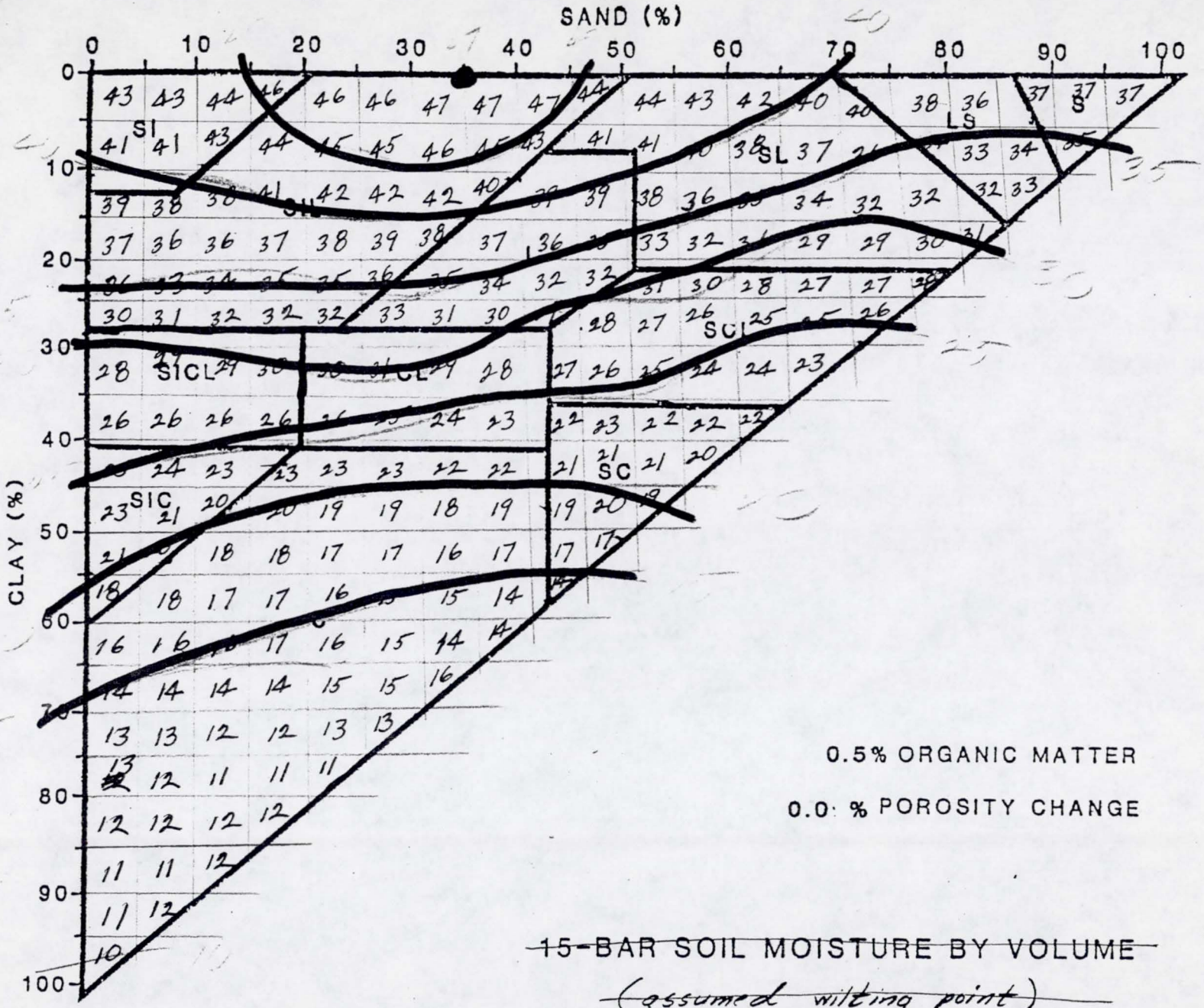


0.5% ORGANIC MATTER

0.0 % POROSITY CHANGE

15-BAR SOIL MOISTURE BY VOLUME

(assumed wilting point)



0.5% ORGANIC MATTER

0.0 % POROSITY CHANGE

~~15-BAR SOIL MOISTURE BY VOLUME~~

~~(assumed wilting point)~~

DTHETA for difference between Porosity (saturation) and wilting point

APPENDIX 2-J

Modifying SCS Hydrologic Soil Groups and Curve Numbers for Rangeland Soils, Brakensiek, D.L., Rawls, W.J., and Stephenson, G.R., Proceedings of ASAE 1984 Annual Meeting, Kennewick, WA.

PAPER NO. PNR-84-203

MODIFYING SCS HYDROLOGIC SOIL GROUPS AND CURVE NUMBERS FOR RANGELAND SOILS

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SUMMARY:

Procedures are proposed for determining SCS hydrologic soil groups and curve numbers for rangeland soils. The procedures utilize the SCS Soils-5 data base and previously developed infiltration research results. An example for the USDA-ARS Reynolds Creek research watershed in Idaho is presented.

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Modifying SCS Hydrologic Soil Groups and Curve Numbers for Rangeland Soils[1]

D. L. Brakensiek, W. J. Rawls, and G. R. Stephenson[2]

Alternative determinations of SCS hydrologic soil groups (HSG) and runoff curve numbers (CN) procedures are presented along with examples. The procedure utilizes the SCS Soils-5 data base. Use of this data base is facilitated by SIRS (Soils Information Retrieval Systems) facilites use of this data base.

SOILS DATA

The SCS Soils-5 file represents the largest and most available U.S. soils data bank. SIRS has now greatly facilitated access to Soils-5. Since the Soils-5 data file does not include certain soil water properties such as percent sand, R. B. Grossman of the National Soils Survey Laboratory, SCS, Lincoln, Nebraska, developed expressions for calculating these quantities from the Soils-5 data. He cautions that the exactness of the approximations may vary and that they should only be used if measurements for particular properties are unavailable.

Table 1 presents Soils-5 property entries from SIRS for the Searla soil series (found on the Reynolds Creek watershed in Idaho). We have added a letter code for reference to the following calculations. Necessary soil properties which we require but are not available on SOILS 5 are: Z1, the percent of fragments < 250 mm, > 2 mm by weight, and Z5, the percent sand.

These can be calculated from the Grossman expressions as,

$$Z1 = E + \left[\left(1 - \frac{E}{100}\right)(100 - G)\right], \qquad (1)$$

where

E = percent fraction greater than 3 inches (E),
G = percent material less than 3 inches passing sieve #10 (G),
and

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TABLE 1. SOILS-5 FILE FOR SEARLA SOIL SERIES

--*-*-*-*-*-*-*-*-*

searla (id0929)cool

mlra(s): 25
rev. th,ghl , 12-82
calcic argixerolls, loamy-skeletal, mixed, frigid

the searla series consists of very deep well drained soils that formed in colluvium from sedimentary rocks on mountains. elevation is 5500 to 6900 feet. aap is 14 to 16 ihes. mast is 42 to 45 f. ffs is 50 to 70 days. vegetation is mountain big sagebrush and bluebunch wheatgrass. typically the surface layer is brown gravelly loam 15 inches thick. the subsoil is yellowish brown very gravelly clay loam to 32 inches. the substratum is white very gravelly loam and very pale brown very gravelly sandy loam to 60 inches. slopes are 30 to 60 percent.

--*-*-*-*-*-*-*-*-*

searla (id0929)cool

A depth (in.)	B texture	C unified	D aashto	E fract > 3in (pct)	F percent of material less than 3 in passing sieve no. 4	G 10	H 40	I 200	J liquid limit	K plast'y index	M clay %<2mm	N moist bulk density (g/cm3)
0-15	gr-l	sm-sc,gm-gc	a-4	5-10	65-85	60-80	45-60	35-50	25-30	5-10	12-20	1.40-1.50
15-32	grv-cl	gc	a-2	5-15	45-60	35-50	25-40	20-35	30-40	10-15	27-35	1.40-1.50
32-60	grv-l,grv-sl	gm-gc	a-1,a-2	0-15	35-60	25-50	15-35	10-30	25-30	5-10	10-22	1.50-1.60

O permea- bility (in/hr)	P available water (in/in)	Q soil reaction (ph)	R salinity mmhos/cm	S shrink- swell	T erosion factors k	U t	V wind erod. group	W organic matter (pct)
0.6-2.0	0.13-0.16	6.6-7.3	-	low	.15	2	6	2-4
0.2-0.6	0.10-0.13	6.6-7.3	-	low	.10			
0.6-2.0	0.05-0.07	7.4-8.4	< 2	low	.05			

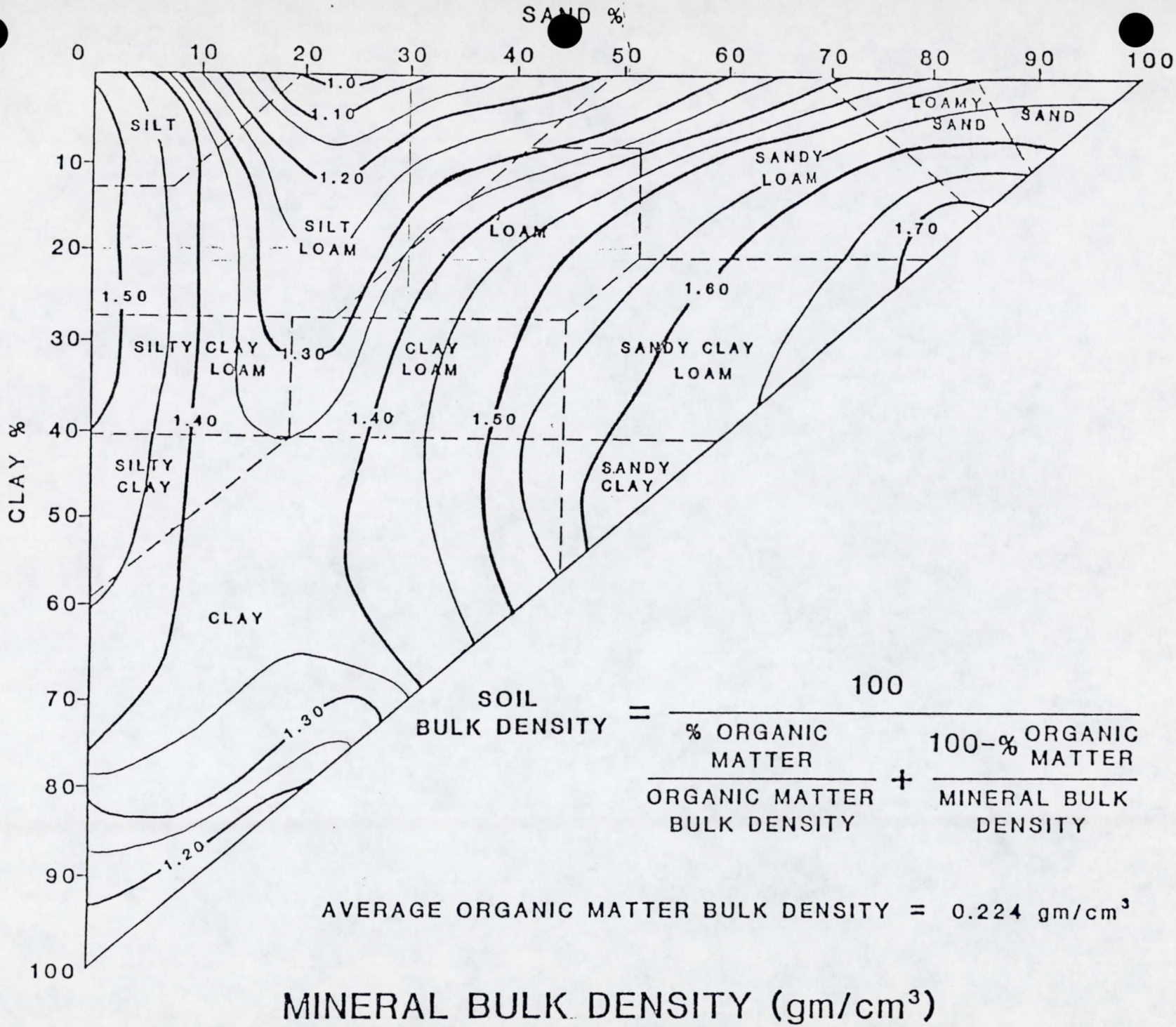

Fig. 1--Determination of soil bulk density.

TABLE 2. PROGRAM TO FIND SOIL PARAMETERS

POR = POROSITY PS = PERCENT SAND = % SAND PC = PERCENT CLAY = % CLAY

```
      REAL*4 Ks,Yf,Qe,Qr,Yb,LAM
      CHARACTER*1 ANS
10    WRITE(6,20)
20    FORMAT(/,/,5X,'$ ENTER THE POROSITY: ',$)
      ACCEPT*, POR
      IF(POR .LT. 0.0 .OR. POR .GT. 1.0) GO TO 150
30    WRITE(6,40)
40    FORMAT(/,5X,'$ ENTER THE % OF SAND: ',$)
      ACCEPT*, SAND
      IF(SAND .LT. 5.0 .OR. SAND .GT. 70.0) GO TO 170
50    WRITE(6,60)
60    FORMAT(/,5X,'$ ENTER THE % OF CLAY: ',$)
      ACCEPT*, CLAY
      IF(CLAY .LT. 5.0 .OR. CLAY .GT. 60.0) GO TO 190
      PS=SAND
      PC=CLAY

    EQUATIONS DESCRIBING GREEN-AMPT PARAMETER CHARTS

      Qe=0.01162-0.001473*PS-0.002236*PC+0.98402*POR+0.0000987*PC**2
     1+0.003616*PS*POR-0.010859*PC*POR-0.000096*PC**2*POR-0.002437*
     2POR**2*PS+0.0115395*POR**2*PC

      Yf=6.5309-7.32561*POR+0.001583*PC**2+3.809479*POR**2+0.000344*
     1PS*PC-0.049837*PS*POR+0.001608*PS**2*POR**2+0.001602*PC**2*
     2POR**2-0.0000136*PS**2*PC-0.003479*PC**2*POR-0.000799*PS**2*POR

      Yf = EXP(Yf)

      Ks=19.52348*POR-8.96847-0.028212*PC+0.00018107*PS**2-0.0094125*
     1PC**2-8.395215*POR**2+0.077718*PS*POR-0.00298*PS**2*POR**2-
     20.019492*PC**2*POR**2+0.0000173*PS**2*PC+0.02733*PC**2*POR+
     30.001434*PS**2*POR-0.0000035*PC**2*PS

      Ks = EXP(Ks)

      Qr=-0.0182482+0.00087269*PS+0.00513488*PC+0.02939286*POR
     1-0.00015395*PC**2-0.0010827*PS*POR-0.00018233*(PC**2)*
     2(POR**2)+0.00030703*(PC**2)*POR-0.0023584*(POR**2)*PC

      LAM=-0.7842831+0.0177544*PS-1.062498*POR-0.00005304*PS**2
     1-0.00273493*PC**2+1.11134946*POR**2-0.03088295*PS*POR
     2+0.00026587*(PS**2)*(POR**2)-0.00610522*(PC**2)*(POR**2)
     3-0.00000235*(PS**2)*PC+0.00798746*(PC**2)*POR-0.00674491
     4*(POR**2)*PC

      LAM = EXP(LAM)
```

TABLE 2. PROGRAM TO FIND SOIL PARAMETERS (CONT.)

```
      Yb=5.3396738+0.1845038*PC-2.48394546*POR-0.00213853*
      1PC**2-0.04356349*PS*POR-0.61745089*PC*POR+0.00143598
      2*(PS**2)*(POR**2)-0.00855375*(PC**2)*(POR**2)-0.00001282*
      3(PS**2)*PC+0.00895359*(PC**2)*POR-0.00072472*(PS**2)*POR
      4+0.0000054*(PC**2)*PS+0.50028060*(POR**2)*PC

      Yb = EXP(Yb)
---------------
      BARTHD=.1535-.0018*PS+.0039*PC+.1943*POR
      BAR15 =.0370-.0004*PS+.0044*PC+.0482*POR

    OUTPUT SECTION

      WRITE(6,70) POR,SAND,CLAY
 70   FORMAT(/,/,/,12X,'POROSITY',5X,'% SAND',5X,'% CLAY',/,
      112X,F7.5,6X,F6.2,5X,F6.2)
      WRITE(6,80) Qe
 80   FORMAT(/,/,5X,'EFFECTIVE POROSITY = ',F7.4)
      WRITE(6,85) LAM
 85   FORMAT(/,5X,'POROSITY INDEX      = ',F7.4)
      WRITE(6,90) Yf
 90   FORMAT(/,5X,'WETTING FRONT CAPILLARY PRESSURE = ',F10.4,' cm')
      WRITE(6,100) Ks
 100  FORMAT(/,5X,'SATURATED HYDRAULIC CONDUCTIVITY = ',F10.5,' cm/hr')
      WRITE(6,110) BARTHD
110   FORMAT(/,5X,'ONE THIRD BAR WATER CONTENT      = ',F10.4)
      WRITE(6,120) BAR15
120   FORMAT(/,5X,'15 BAR WATER CONTENT             = ',F10.4)
      WRITE(6,125) Qr
125   FORMAT(/,5X,'RESIDUAL WATER CONTENT           = ',F10.4)
      WRITE(6,126) Yb
126   FORMAT(/,5X,'BUBBLING PRESURE                 = ',F10.4,' cm')
      WRITE(6,130)
 130  FORMAT(/,/,/,5X,'$ WOULD YOU LIKE TO CALCULATE ANY MORE?(y/n) ',$)
      READ(5,140) ANS
 140  FORMAT(A1)
      IF(ANS .EQ. 'Y' .OR. ANS .EQ. 'y') GO TO 10
      STOP

    ERROR CHECKING

 150  WRITE(6,160)
 160  FORMAT(/,/,5X,'ERROR IN POROSITY,  value must be > 0 and < 1')
      GO TO 10
 170  WRITE(6,180)
 180  FORMAT(/,/,5X,'ERROR IN PERCENTAGE OF SAND, value must be > 5 and
      1 < 70')
      GO TO 30
 190  WRITE(6,200)
 200  FORMAT(/,/,5X,'ERROR IN PERCENTAGE OF CLAY, value must be > 5 and
      1 < 60')
      GO TO 50
      END
```

TABLE 3. SAMPLE OUTPUT

```
RUN SOILS

   $ ENTER THE POROSITY: 0.45

   $ ENTER THE % OF SAND: 39

   $ ENTER THE % OF CLAY: 16


         POROSITY      % SAND      % CLAY
         0.45000        39.00       16.00

   EFFECTIVE POROSITY =  0.3788

   POROSITY INDEX     =  0.3460 (GREEN AND AMPT λ)

   WETTING FRONT CAPILLARY PRESSURE =    21.1312 cm (GREEN AND AMPT ψf)

   SATURATED HYDRAULIC CONDUCTIVITY =    0.59637 cm/hr

   ONE THIRD BAR WATER CONTENT      =     0.2331

   15 BAR WATER CONTENT             =     0.1135

   RESIDUAL WATER CONTENT           =     0.0710 (GREEN AND AMPT Θr)

   BUBBLING PRESURE                 =    27.4790 cm


   $ WOULD YOU LIKE TO CALCULATE ANY MORE?(y/n) N

FORTRAN STOP
```

Table 4.--SCS hydrologic soil groups for saturated conductivity (KS) classes.

HSG (KS cm/hr)	Description
A (0.76-1.14)[1]	(Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.
B (0.38-0.76)	Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
C (0.13-0.38)	Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer than impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
D (0.0-0.13)	(High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

[1] It is assumed that a KS greater than 1.14 cm/hr is an "A" soil.

$$\phi_c = (1 - \frac{Z1}{100}) / (\frac{1}{\phi} - \frac{Z1}{100}) \quad (3)$$

where

ϕ_c = the bulk soil porosity (with coarse fragments),
ϕ = fine earth fabric, < 2 mm, porosity, and
Z1 = percent by weight of the soil material > 2 mm and < 250 mm,

where Z1 is calculated from Soils-5 data by equation (3). The value of ϕ is the porosity determined from Fig. 1 by the procedure described in the text or taken from the Soils-5 data file.

Equation (4) was also derived from the results of Bouwer and Rice (1983). The saturated conductivity can be calculated for the soil containing coarse fragments, K_c, from the conductivity of the fine earth fraction, KS, and the percent by weight of coarse fragments, Z1. If Z1 is not known it is calculated by equation (1).

$$K_c = (1 - \frac{Z1}{100}) KS \quad (4)$$

The value of K_c is entered in Table 4 and a hydrologic soil group is determined for the bulk soil. The computer program in Table 2 can be entered with ϕ_c to determine bulk soil properties other than the saturated hydraulic conductivity, which is determined by equation (4). Equation (4) is also similar to one derived by Peck and Watson[3]. Additional research on gravels in soils is presented by Dunn and Mehuys (1984).

Compacted Soils

Soil bulk densities can change as a function of land use which induce compaction. As the bulk density increases the bulk soil porosity will decrease, which may change the HSG. Our procedure is simply to change the original bulk density by the percent change and compute a new porosity. The program in Table 2 is entered with a new porosity, and the calculated KS value is used in Table 4 to determine the HSG.

FROZEN SOILS

Frozen soil conditions frequently occur on rangelands. The following procedure was developed by Lee (1983) from his study of a frozen soil. He related the ratio of the frozen soil saturated conductivity $(KS)_f$ to the unfrozen soil KS as a function of antecedent soil water content. We have expressed his

[3] Peck, A. J., and J. D. Watson. 1979. Hydraulic conductivity and flow in non-uniform soil. Unpublished paper, presented at the Workshop on Soil Physics and Field Heterogeneity, Canberra, Australia, p. 31-36.

antecedent soil water factor as a percent of field capacity. One-third bar water contents are also estimated in our computer program. Equations (5a,b) present Lee's relationships,

$$(KS)_f/KS = 1.89 - 0.023\ (\%\ \text{of FC}), \quad \%FC < 78 \tag{5a}$$

and

$$= 0.1 \qquad , \quad \%F > 78. \tag{5b}$$

For example, if it is estimated that the antecedent soil water content when the ground is frozen was 50 percent of field capacity, then by equation (5a)

$$(KS)_f/KS = 0.74.$$

Thus, if the original hydrologic soil group was "B", KS = 0.45 cm/hr, then

$$(KS)_f = 0.33 \text{ cm/hr}$$

and the HSG determined from Table 4 would be reduced to a "C" soil. Equations (5a,b) should be used very cautiously, since they are based on laboratory tests of only one soil texture. However, they do indicate the hydrologic importance of frozen soils.

SURFACE ROCK COVER

A thesis study by Dadkhah (1979) indicated that rock cover on the soil surface, from 0 percent to 20 percent, decreased the SCS curve number by nearly 10 percent. Apparently surface rock cover is a signficant factor to consider on rangeland curve number hydrology, but more research is needed to quantify its effect. The same thesis study also investigated the interactions of rock cover, vegetation cover, and soil compaction.

RANGELAND RUNOFF CURVE NUMBERS

Standard SCS procedures for determining rangeland CN's are given in Tables 8.1, 8.2, and 9.1 of their Hydrology Guide (SCS 1972). Inputs are land use treatment or practice, hydrologic condition, and hydrologic soil group (HSG). The HSG can be estimated by our procedure.

We propose an alternative procedure which uses the KS parameter directly, rather than the hydrologic soil group. We developed Fig. 2 by combining Tables 8.1, 8.2, and 9.1, and our Table 4. Fig. 2 would be entered with the estimated KS value and with an estimated hydrologic condition (HC), i.e., cover class. We are suggesting that HC can be estimated from percent cover. Based on SCS Table 8.2, the cover classes were defined as shown in Fig. 2 for bare, poor, fair, and good cover. The lines in Fig. 2 were oriented with the four points in their Table 9.1 representing the curve numbers for a bare, poor, fair and good HC plotted versus the mid-point KS for each HSG. For interpretation between classes, we developed the following equation assuming the average cover percent shown in Fig. 2 for each class.

$$CN = 96.38 - 0.158C - 19.84K - 0.397KC \tag{6}$$

where

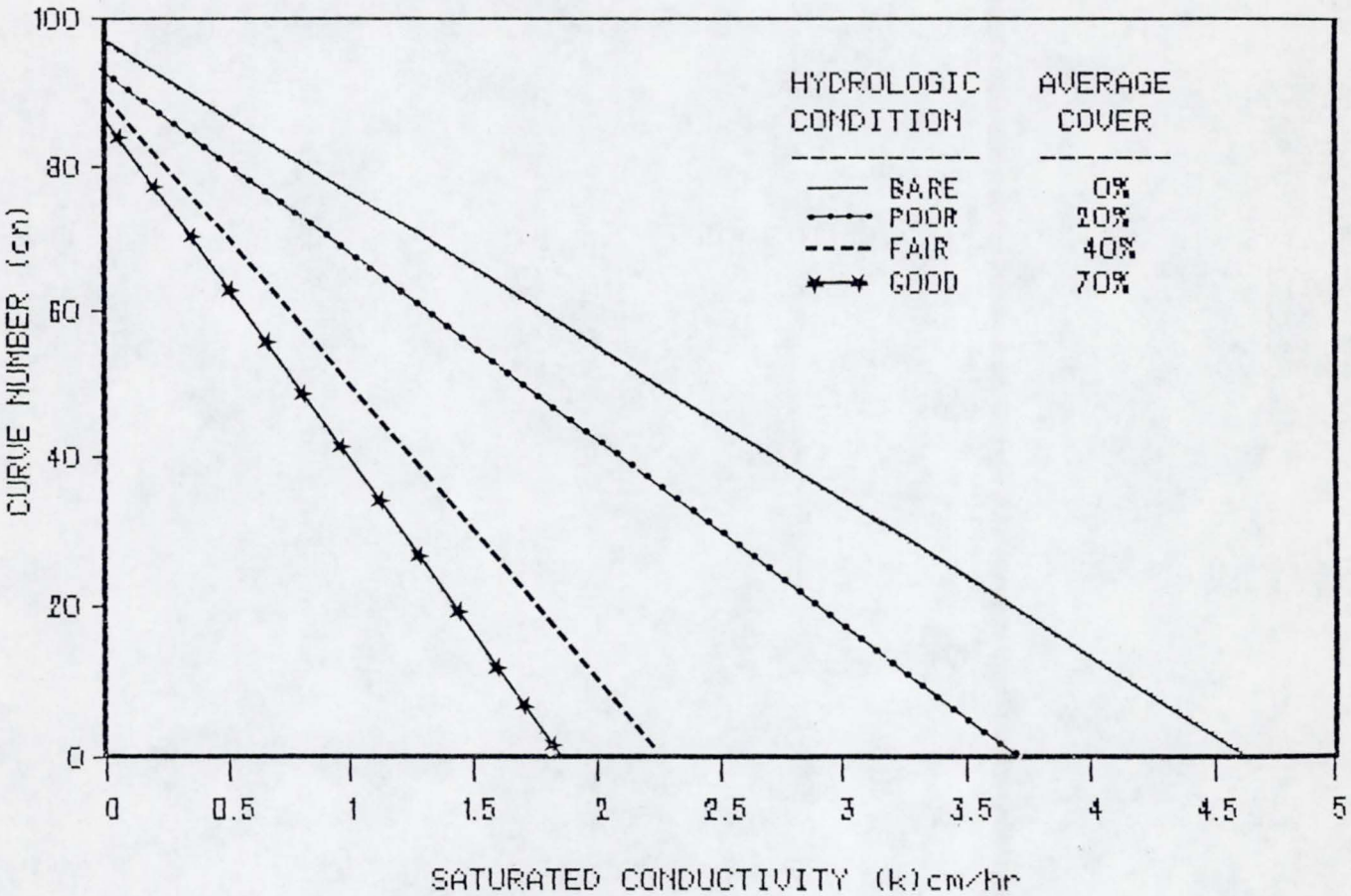

Fig. 2--Rangeland curve numbers as a function of saturated conductivity for cover classes.

CN = Curve Number,
C = total cover in percent, and
K = saturated conductivity, cm/hr.

EXAMPLES

Given: Reynolds Creek Soils-5 data for Searla (id0929) cool

(1) Find - percent sand

Sand (%) = Z5 = 100 - 100 I/G

I = percent material < 3" passing #200 sieve = 35 - 50 percent
G = percent material < 3" passing #10 sieve = 60 - 80 percent.

Using the midpoint value for I and G

Sand (%) = 100 - 100 (42.5/70)
= 39 percent.

(2) Find - percent by weight of material > 2 mm and < 250 mm = Z1

$$Z1 = E + \left[\left(1 - \frac{E}{100}\right)(100-G)\right]$$

E = percent fraction > 3 inches
G = percent material < 3 inches passing the #10 sieve.

From Soils-5

E = 5 - 10 percent
G = 60 - 80 percent

$$Z1 = 7.5 + \left[\left(1 - \frac{7.5}{100}\right)(100 - 70)\right]$$

Z1 = 35 percent.

(3) Find - Hydrologic Soil Group

From the Soils-5, the percent clay (M) is 12 - 20 with the mid-value of 16 percent and the percent of sand (Z5) is 39 percent.

The measured moist bulk density (N) is 1.4 - 1.5 with a mid-value of 1.45.

From our computer program

KS = 0.60 cm/hr.

Referring to Table 4, this soil is Hydrologic Soil Group B.

If we assume a total cover of 30 percent cover, the calculated curve number is

CN = 72.

REFERENCES

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3. Dunn, A. J., and G. R. Mehuys. 1984. Relationship between gravel content of soils and saturated hydraulic conductivity in laboratory tests. In Erosion and Productivity of Soils Containing Rock Fragments, p.55-63. SSSA Spec. Pub. No. 13.

4. Lee, H. W. 1983. Determination of infiltration characteristics of a frozen Palouse silt loam soil under simulated rainfall. Ph.D. Dissertation, University of Idaho, Moscow, ID. (Unpublished).

5. Musgrave, G. W. 1955. How much of the rain enters the soil. In "Water," The Yearbook of Agriculture. p. 151-159.

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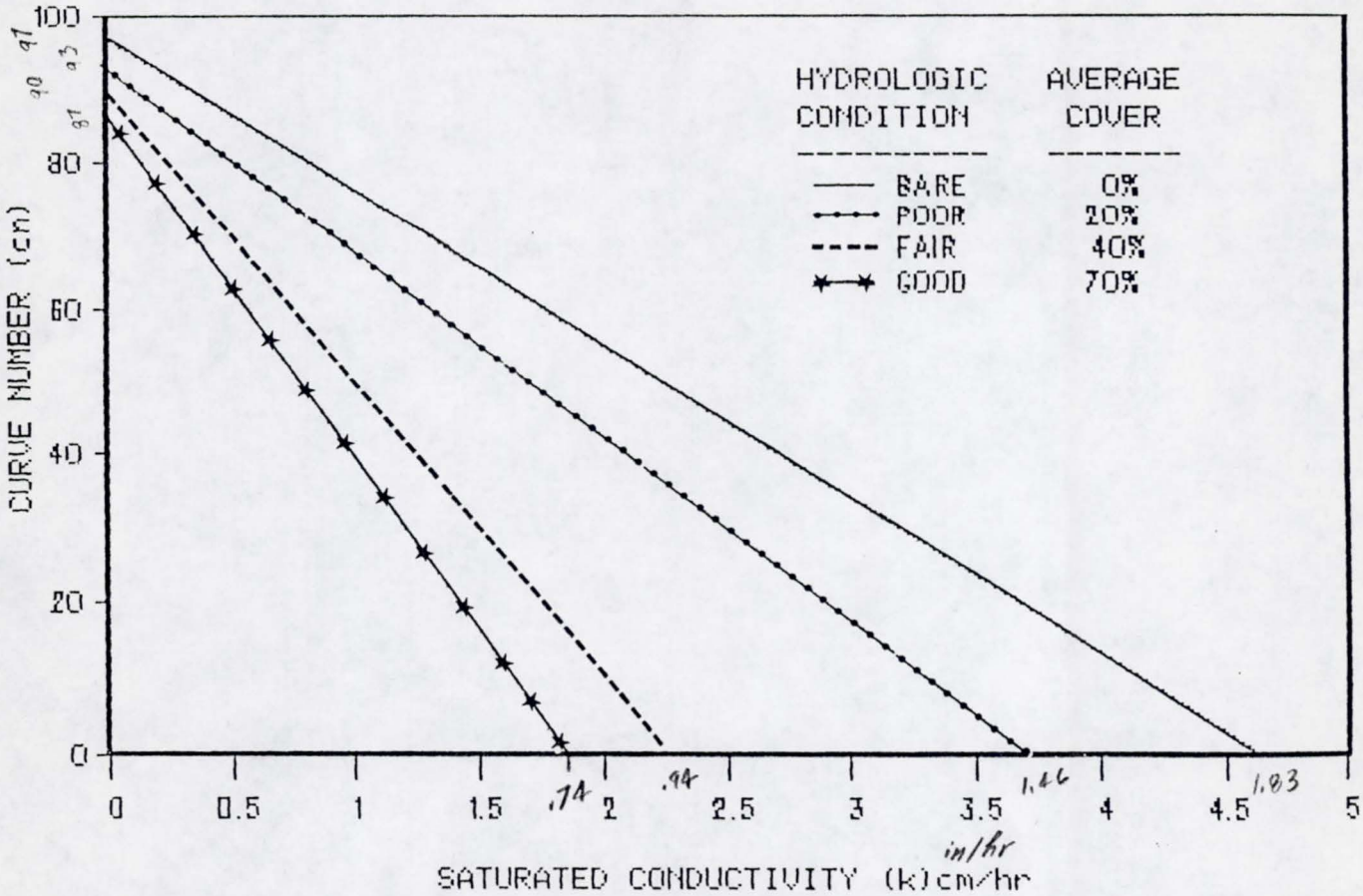
7. Wood, K. and W. Blackburn. 1984. An evaluation of the hydrologic soil groups as used in the SCS runoff method on rangelands. Water Resour. Bull. 20 (3):379-389.

Ref – Brakensiek, Rawls, Stephenson, 1984

Used to develop Figure 11 of the Rainfall Losses Section



~~Fig. 2~~ –Rangeland curve numbers as a function of saturated conductivity for cover classes.

hydr. conductivity (XKSAT) = 1/2 saturated conductivity

APPENDIX 2-K

Infiltration parameters for Rangeland Soils, Rawls, W.J., Brakensiek, D.L., and Savabi, M.R., Journal of Range management, Vol. 42, No. 2, March 1989, p. 139-142.

Infiltration parameters for rangeland soils

W.J. RAWLS, D.L. BRAKENSIEK, AND M.R. SAVABI

Abstract

Important to the management of rangelands is knowledge of the water intake properties of their soils and the effect of soil surface and canopy cover. Using a data base of rangeland infiltration runs covering a wide range of soil and cover conditions, a procedure incorporating the effects of soil properties, soil surface cover, and vegetative canopy on the Green-Ampt hydraulic conductivity parameter was developed. Test results indicate that the estimated Green-Ampt parameters provided good predictions of the mean final infiltration rates and volumes for a variety of soil-cover situations.

Key Words: Green-Ampt, infiltration rates, soil properties

The importance of ground and canopy cover on rangeland infiltration characteristics has long been recognized (Gifford 1984). Generally, it has been shown that as ground cover or canopy cover increase, infiltration amounts increase while increases in bare ground decreases infiltration amounts (Gifford 1984). Most recently Hutten and Gifford (1988) showed that Green-Ampt parameters estimated from soil texture data alone do not adequately model rangeland infiltration. Mehan (1986) showed that infiltration increases with increases in surface rock for a range of soil textures. Also, Lane et al. (1987) conducted infiltration studies on 5 soils in Arizona and Nevada where rainfall simulation experiments were run on plots with natural cover canopy removed and bare plots where the canopy and most of the surface rock and litter were removed. They found that infiltration was greatest for the natural condition, declining when canopy was removed and further declining when surface rock and litter were removed.

At present there are methods for predicting parameters for the Green-Ampt infiltration model based on soil properties (Rawls and Brakensiek, 1983, 1985); however, there is no method for incorporating the effects of rangeland ground cover and canopy cover on infiltration parameters. Therefore, it is the purpose of this paper to develop procedures for incorporating the effects of ground cover and canopy cover into the Green-Ampt infiltration parameters, which may alleviate some of the problems identified by Hutten and Gifford (1988).

The Green-Ampt infiltration rate equation is

$$f = K \left(1 + \frac{(\phi_c - ASW)\ \Psi_f}{F} \right) \qquad [1]$$

and its integrated form is

$$K(T) = F - (\phi_c - ASW)\ \Psi_f \ln \left(1 + \frac{F}{(\phi_c - ASW)\ \Psi_f} \right) \qquad [2]$$

where
- f = infiltration rate (cm/hr)
- F = infiltration amount (cm)
- T = time (hrs)
- K = hydraulic conductivity (cm/hr)
- Ψ = wetting front capillary potential (cm)
- ϕ_c = corrected porosity (total porosity corrected for rocks and air) (vol)
- ASW = antecedent soil water (vol)

Authors are hydrologist, USDA-ARS Hydrology Laboratory, Beltsville, Md.; research engineer, Dept. of Civil Engineering, University of Maryland, College Park, Md.; and research associate, Dept. of Agronomy, University of Maryland, College Park, respectively.

Without the cooperation of those investigators who provided data given in Table 1, this study would not have been possible.

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In order to predict infiltration with equations [1] or [2], the antecedent soil water (ASW) needs to be inputted and hydraulic conductivity (K), wetting front capillary potential (Ψ_f) and the porosity corrected for rocks and entrapped air (ϕ_c) need to be estimated. The following are equations used for predicting the parameters based only on soil properties:

Effective Porosity (ϕ_c)

$$\phi_c = \phi = (CFC)\ (EAC) \qquad [3]$$

where
- ϕ = total porosity (vol) = (2.65) - BD)/2.65
- CFC = Correction for coarse fragments (Brakensiek et al. 1986) = ((100 - VCF)/100)
- EAC = correction for entrapped air (Rawls and Baumer 1989) = $1.0 - (3.8 + 0.00019\ (CL^2) - 0.337\ (SA) + 0.126\ (CEC)\ (CL) + OM\ (SA/200)^2)/100$
- BD = 33 KPa bulk density of the fine earth soil (<2 mm) g/cm³
- OM = % organic matter
- CL = % clay
- SA = % sand
- CEC = cation exchange capacity/%clay (ranges 0–1)
- VCF = % volume coarse fragments (>2 mm) computed from Brakensiek et al. 1986
- VCF = ((WCF/2.65) * 100)/((100–WCF/BD + WCF/2.65))
- WCF = %weight of coarse fragements (>2 mm)

Wetting Front Capillary Potential (Ψ_f)

$$\Psi_f = e^x \qquad [4]$$

where $x = 5.34 + 0.185\ (CL^2) - 2.484\ (\phi) - 0.0021\ (CL^2) - 0.0436\ (SA)\ (\phi) - 0.6175\ (CL)\ (\phi) + 0.00144\ (SA^2)\ (\phi^2) - 0.00855\ (CL^2)\ (\phi^2) - 0.000013\ (CL)\ (SA^2) + 0.009\ (\phi)\ (CL^2) - 0.00073\ (\phi)\ (SA^2) + 0.000005\ (SA)\ (CL^2) + 0.5003\ (CL)\ (\phi^2)$ (Rawls and Brakensiek, 1985)

Hydraulic Conductivity (K)

$$K = K_s\ (FGC)\ (CFC) \qquad [5]$$

where K_s = saturated hydraulic conductivity (Rawls and Baumer 1989)

$$= \left(\frac{(\phi_c - \Theta_r)^3}{(1 - \phi_c)^2} \right) \left(\frac{BD}{\Theta_r} \right)^2 \left(.0002\ (C^2) \right)$$

- FGC = frozen ground correction (Lee 1983) = 2 - .019 * PFC
- Θ_r = residual soil water (vol) (Rawls and Baumer 1989) = $0.2 + 0.1\ (OM) + 0.25\ (CL)\ (CEC^{0.45})\ (BD/100)\ (BD/100)\ (EAC)\ (CFC)$
- C = $-0.17 + 0.181\ (CL) - 0.00000069\ (SA^2)\ (CL^2) - 0.00000041\ (SA^2)\ (SI^2) + 0.000118\ (SA^2)\ (BD^2) + 0.00069\ (CL^2)\ (BD^2) + 0.000049\ (SA^2)\ (CL) - 0.000085\ (SI)\ (CL^2)$
- SI = percent silt.
- PFC = soil water at freezing (% vol)/soil water held at 33 KPa (% vol). If PFC ≥ 1, then FGC = .1 (Lee 1983).

Brakensiek and Rawls (1983) developed a factor for reducing the saturated hydraulic conductivity for an established soil crust. The crust factor is

$$CRC = \frac{L}{\frac{L - TC}{SC} + \frac{TC}{B}} \quad [6]$$

where CRC = soil crust correction (Brakensiek and Rawls, 1983)
L = wetting front depth (cm) (assume 6 cm)
TC = crust thickness (cm) (assume 0.5 cm)
$B = 0.0099 + 0.0721\,(TC) + 0.0000068\,(SA^2) + 0.000021\,(SA^2)\,(TC) - 0.000315\,(SA)\,(TC^2)$
SC = correction factor for partial saturation of the subcrust soil (Brakensiek and Rawls 1983)

Management changes are reflected in the above parameters only by changes in the bulk density of the soil.

Methods

An extensive data search was performed to compile infiltration data sets which included detailed soils, ground cover, and canopy cover information. The physical characteristics of the data sets located are summarized in Table 1.

Table 1. Summary description of data sets.

Study reference	State	General description
Devaurs (1984)	ID	3 soil series, grazed and non-grazed sites and 2 soil water levels; 38–59% sand; 9–18% clay; bulk density 1.1–1.5 g/cm³; 30–52% canopy; and 7–32% bare ground.
Hutten (1984)	UT	5 soil sites with 2 management practices (plowed and unplowed); 25–68% sand; 15–33% clay; bulk density 0.9–1.3 g/cm³; 0.65% canopy; and 0–50% bare ground.
Lane et al. (1987)	AZ NV	Natural, clipped and bare range cover at 3 sites in AZ and 2 sites in NV; 66–84% sand; 1–9% clay; 0–75% canopy; and 0–41% bare ground.
Thurow (1985)	TX	27–88% sand; 7–42% clay; bulk density 0.85–0.95 g/cm³; 27–57% canopy; and 21–43% bare ground.
Ward and Wood (1982)	NM	Grazing levels, pinyon-juniper mgt, sagebrush mgt and others at 3 sites; 32–90% sand; 14–33% clay; 1–90% canopy; and 3–89% bare ground.
Williams (1969)	UT	4 chained pinyon-juniper sites; 16–65% sand, 16–33% clay; bulk density .9–1.6 g/cm³; 0.20% canopy; and 38–97% bare ground.
Wood[1]	NM	Dry and wet soil water levels on one range site; 29% sand; 44% clay; and 35% canopy.

[1]Personal communication

For each infiltration test we calculated the effective conductivity using an approximation to the Green-Ampt equation derived by Li et al. (1976),

$$KE = 2(FR) - (F/T) \quad [7]$$

where KE = effective conductivity (cm/hr)
FR = final infiltration rate (cm/hr)
F = total infiltration at the final infiltration rate (CM)
T = accumulated time corresponding to the final rate and infiltration amount (hr)

Since the studies contained various replications at each site, we used the mean site value for soil—ground cover, canopy cover, and the geometric mean effective conductivity which represents an area integrated value—for the analyses.

Parameter Development

Past research (Moore 1981) has shown that the wetting front capillary potential parameter is relatively insensitive in comparison with the hydraulic conductivity parameter. It was thus assumed that ground cover and canopy cover affect only the hydraulic conductivity parameters. Since rangeland conditions reflect long-term climate, cover, and land use patterns, we assumed that all bare soil is crusted and that the bare or covered soil under a canopy has a higher conductivity than the bare or covered soil in the interspace area. In addition, the covered soil has a higher effective conductivity than the uncovered soil surface whether under a canopy or in the interspace area. These assumptions reflect that canopy, ground cover, litter, or surface rocks reduce crust formation. Further, they enhance macroporosity caused by biotic activity and other processes especially in the soil under or around the litter rock soil interface.

We incorporated the canopy and ground cover effect into a simple weighting by the proportions of the unit area composed of canopy and open space and by the proportion of the canopy space and open space in which the soil surface was covered or bare. For the portion of unit area under canopy cover we estimate the effective conductivity parameter, $(KE)_c$, as

$$KE_c = (CF)\,[(BC/CAN)(CRC) + A(1-(BC/CAN))]\,(K) \quad [8]$$

and for the portion of the unit area outside of canopy cover we estimated the effective conductivity (KE_O) as

$$KE_O = [(BO/OP)(CRC)+A(1-(BO/OP))]\,(K) \quad [9]$$

where
KE_c = effective conductivity under canopy (cm/hr)
KE_O = effective conductivity outside of canopy (cm/hr)
CF = canopy factor
BC = bare area under canopy (%)
CAN = canopy area (%)
OP = open area outside canopy (%)
BO = bare area in open space (%)
CRC = crust factor (equation [6])
A = macro-porosity factor
K = hydraulic conductivity of soil (cm/hr) (equation [5])

Combining equations [8] and [9] for the total unit area consisting of canopy covered area (CAN) and open area (OP), we have

$$KE = (CAN)KE_c + (OP)KE_O \quad [10]$$

or

$$KE = (CF)\,[(A)(CAN-BC) + CRC(BC)](K) + [(A)(OP-BO) + CRC(BO)](K) \quad [11]$$

The canopy factor (CF) and macroporosity factor (A) are the only unknown parameters in equation [11]. In the following sections estimators for these parameters will be developed.

Canopy Factor

The canopy factor (CF) is defined as the ratio of effective conductivity under canopy (KE_c) to effective conductivity without canopy (KE_{nc}).

The Hutten (1984) data set was chosen to develop the canopy factor because it covered a wide range of soil texture, ground cover, and canopy cover conditions (Table 1) and included infiltration runs with and without canopy. A geometric mean KE without canopy was determined for the 4 soils and used to determine CF for each of the 12 treatments. Using the data the following equation was developed relating canopy to CF

$$CF = \frac{KE_c}{KE_{nc}} = \left(1 + 0.96\frac{CAN}{100}\right) \quad r^2 = 0.88 \quad n = 13; \qquad [12]$$

where CAN = canopy (%)

Macroporosity Factor

The macroporosity factor (A) in equation [11] is assumed to represent an enhancement of the infiltration potential of soil that is covered by rocks or litter (Mehan 1986). The Hutten (1984), Devaurs (1984) and Thurou (1985) data sets were chosen for evaluating the macroporosity factor because they covered a range of soil conditions including bulk density and ground cover conditions. Using the previously developed CF predictor equation [12] we solved equation [11] for a mean A for each treatment and then using regression techniques related to A to soil properties resulting in the following prediction equation:

$$A = e^{(2.82 - 0.099\,SA + 1.94\,BD)} \quad r^2 = .88 \quad n = 41 \qquad [13]$$

where

SA = % sand

BD = 33 KPa bulk density of fine earth soil (<2 mm) g/cm³

In fitting equation [13], A was constrained to be greater than one because macroporosity was assumed to only increase hydraulic conductivity. Also, since the data did not include soils with less than 20 % sand, and the form of equation [13] will produce extremely high A values for soils with less than 20% sand, we would limit the equation to a maximum A value of 18 which was the largest value in the data set.

Testing

We used the Lane et al. (1987), Ward and Wood (1982), Williams (1969) and Wood data sets (Table 1) to test equations [11, 12 and 13] because these data sets were not used in parameter development. Since each data set had different run durations, we predicted the final infiltration rate, total infiltration amount, and the average measured antecedent soil moisture using the Green-Ampt infiltration model equation [1] from equations [3,4,5,6,11,12, and 13]. The predicted infiltration values were compared with the mean and standard deviations of the observed values for each site. The results of the testing are summarized in Table 2.

Lane et al. (1987) reported infiltration results from studies on large rangeland plots in Arizona and Nevada under simulated rainfall. At each of the 5 sites they had 2 plots evaluated spring and fall for several consecutive years with the following designated treatments:

natural – natural site conditions

clipped – all vegetation cut and removed

bare – canopy and nonembedded (>5 mm) surface matrial removed

They reported mean final infiltration rates and amounts for the 30 minute very wet run at each site. As they did not measure bulk density it was calculated with the equation reported by Rawls (1983). Rock, litter, bare soil, under and outside canopy were measured for each AZ plot. The proportion of bare ground beneath the canopy and outside of the canopy was estimated for

Table 2. Summary of test results.

				Infiltration final rate and volume			
				Measured		Predicted	
Study reference	Site	Treatment	Sample size	Final rate* cm/hr	Volume* cm	Final rate cm/hr	Volume cm
Lane et al. (1987)	Bernardino	Natural	8	3.53 ± 0.77	1.96 ± 0.82	3.87	2.19
		Clipped	8	2.10 ± 0.75	1.24 ± 0.65	2.69	1.67
		Bare	8	1.37 ± 0.62	.73 ± 0.60	1.79	1.21
	Cave	Natural	8	2.63 ± 0.70	1.49 ± 0.77	1.96	1.32
		Clipped	8	1.50 ± 0.62	.88 ± 0.80	1.81	1.23
		Bare	8	1.16 ± 0.60	.65 ± 0.65	1.08	0.81
	Hathaway	Natural	8	3.16 ± 0.99	1.72 ± 0.85	2.65	1.62
		Clipped	8	1.93 ± 0.85	1.04 ± 0.80	2.16	1.38
		Bare	8	1.24 ± 0.52	.74 ± 0.58	1.32	0.92
	Mercury	Natural	4	2.05 ± 0.48	1.08 ± 0.98	1.97	1.32
		Clipped	4	.73 ± 0.55	.50 ± 0.70	1.93	1.29
		Bare	4	.48 ± 0.30	.25 ± 0.46	1.04	.77
	Area 11	Natural	4	3.37 ± 1.30	1.85 ± 0.75	2.55	1.60
		Clipped	4	2.94 ± 0.75	1.75 ± 1.00	2.18	1.42
		Bare	4	1.63 ± 0.48	.98 ± 0.48	1.31	0.94
Williams (1969)	Intermediate sandy soils (30–45%)		8	4.4 ± 0.98	1.88 ± 0.59	2.25	1.71
	High sand soils (50–65%)		8	4.98 ± 2.61	1.61 ± 0.82	5.32	3.19
Wood		Dry	24	6.94 ± 0.32	6.28 ± 0.12	7.08	6.21
		Wet	21	4.60 ± 0.45	5.34 ± 0.20	5.66	5.28
Ward and Wood (1982)	Grazing	Dry	6	8.56 ± 1.13	5.91 ± 0.73	7.62	5.90
		Wet		7.63 ± 1.85	4.25 ± 0.80	7.50	4.34
	Sagebrush	Dry	5	6.35 ± 2.21	4.15 ± 1.10	7.88	4.81
		Wet		5.81 ± 1.79	2.96 ± 0.73	4.83	2.79
	Pinyon/Juniper	Dry	5	7.50 ± 2.29	4.6 ± 1.53	11.3	6.20
		Wet		7.30 ± 1.65	3.86 ± 0.72	9.5	5.00

* ± value is the standard deviation for each measured mean.

the NV sites. Soil rock was estimated from their soil report.

Table 2 compares the predicted Green-Ampt final infiltration rates and total infiltration amount with the measured mean final infiltration rate and amount at each site and treatment. As shown in Table 2, predictions for all sites except Mercury bare and clipped were within ± 1 standard deviation of the measured mean. Since Lane's sites had very high sand (>65) the macroporosity factor derived from equation [11] becomes 1; thus this study gives an independent test of the crust and canopy factors in equation [11]. The natural plots test our procedures for predicting the canopy and crust factors. The clipped plots test our procedure for predicting surface cover factors, while the bare soil plots tested our procedures for predicting crusted soil hydraulic conductivity. The bare plots independently tested the crust factor since the soil surface was primarily bare.

Williams (1969) conducted a number of infiltration tests in Utah on pinyon juniper sites in 1967 and 1968. We stratified the Williams data into 2 groups, intermediate sand and high sand, and the results are shown in Table 2. The predicted rates and amounts are within the 95% confidence intervals; however, the confidence intervals are very wide and absolute error is up to 100% for the high sand total infiltration. The high sand tests the effect of the canopy and crust factors while the intermediate sand soils incorporates the crust, canopy and macroporosity factors.

Wood conducted infiltration tests on a clay loam soil in New Mexico. We ran predictions on the dry and wet treatments; all predictions except the dry final rate, which could be a result of antecedent soil water conditions, were within the 95% confidence intervals.

Ward and Wood (1982) conducted 4 replicate infiltration tests at 17 sites. We subdivided the sites according to cover (grazing sagebrush and pinyon juniper) and dry or wet treatments. The predicted final infiltration rates and amounts were within 95% confidence intervals; however, the standard deviation of the means are very large (Table 2). The numerical error in the pinyon/juniper estimates are 30–50% high.

Regression analysis was performed on the mean measured final infiltration rate versus the predicted final infiltration rate given in Table 2 and the mean measured total infiltration volume versus the predicted infiltration volume given in Table 2. This analysis indicated that the intercepts and slopes were not significantly different from 0 and 1, respectively, at the 0.05 significance level. This indicates that the model predicts accurate and unbiased estimates of the mean final infiltration rate and total infiltration volume.

Conclusion

A method was developed for incorporating readily available rangeland soil, surface cover, and canopy cover properties into the predictions of the Green-Ampt hydraulic conductivity parameter. The method was evaluated on ten diverse independent rangeland areas and generally predicted the mean final infiltration rate and amount within one standard deviation of the measured mean, indicating that our assumptions and parameter estimators are acceptable. Since the development and testing of data sets did not include high silt soils and grass-dominated vegetative cover, using the proposed procedure may yield questionable results. Also, the proposed procedure yields one of the first quantitative methods for evaluating the relative effects of rangeland treatments on infiltration.

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APPENDIX 2-L

Notes on Applicability of Infiltration Parameters for Rangeland Soils.

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 raintall 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

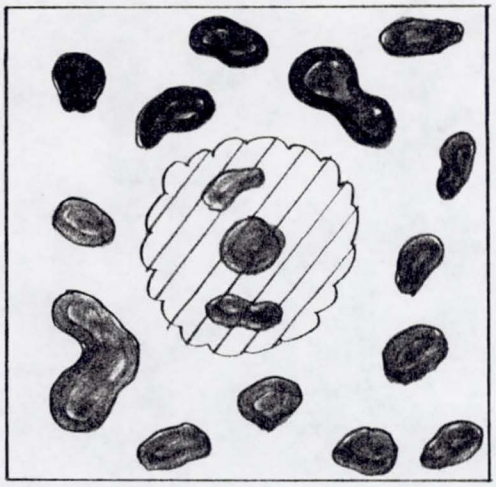
1) $A = \exp\left[2.82 - .099(SA) + 1.94(BD)\right]$

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 crosshatch

ground cover* is solid

bare ground is unmar

*ground cover is: rocks, 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

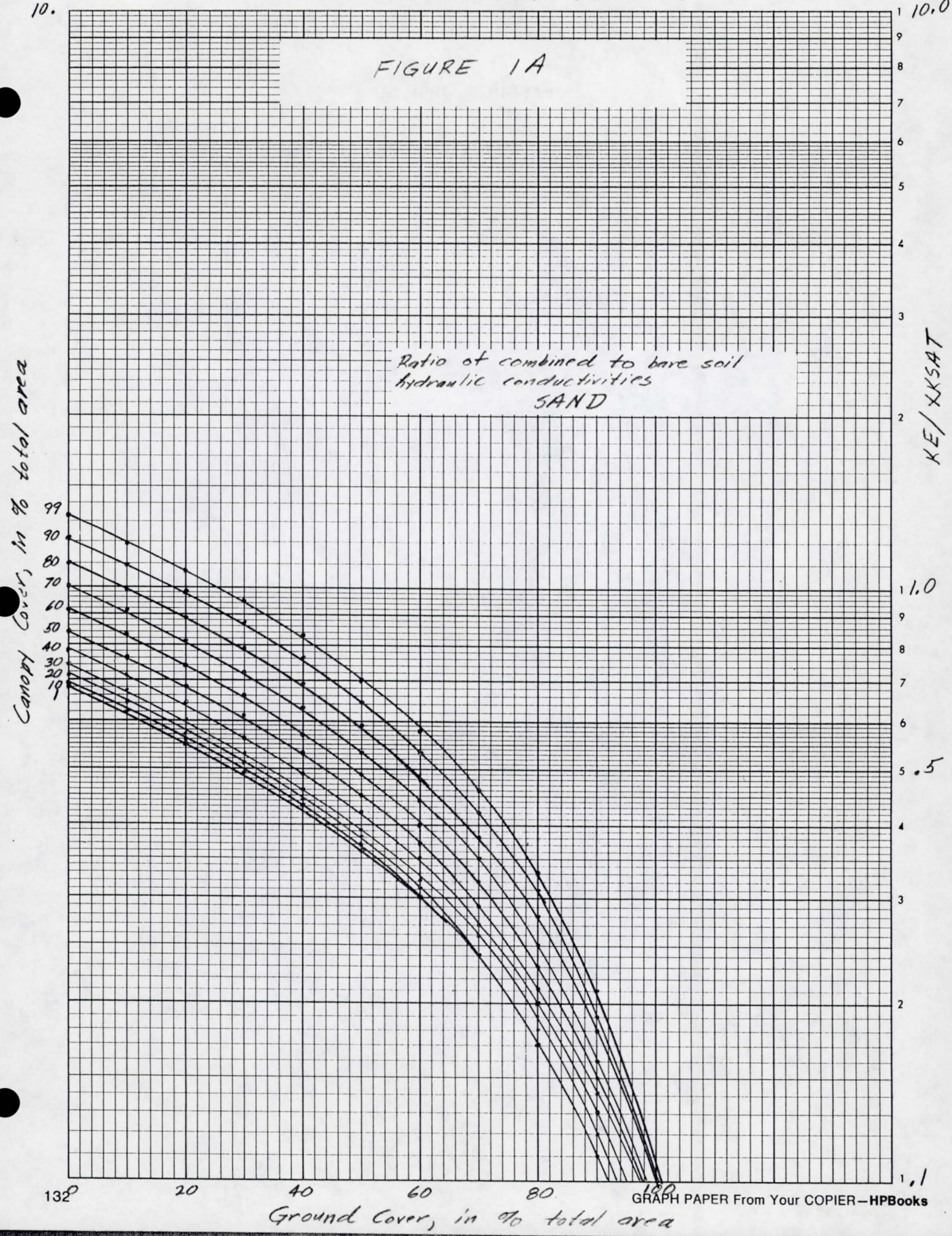
BC = % of bare soil under canopy to total area
$BC = (100 - GC)(CAN/100)$

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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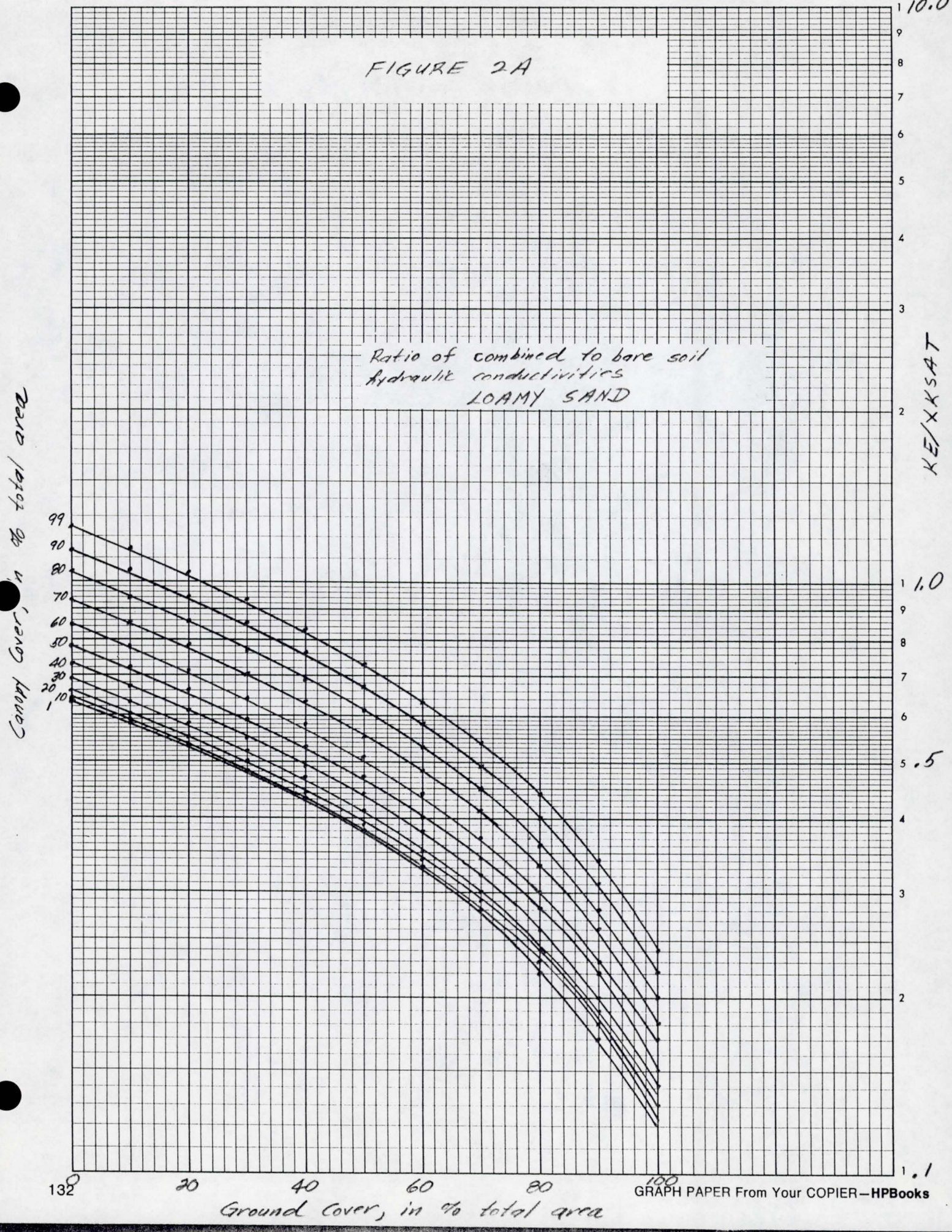
27 April 84



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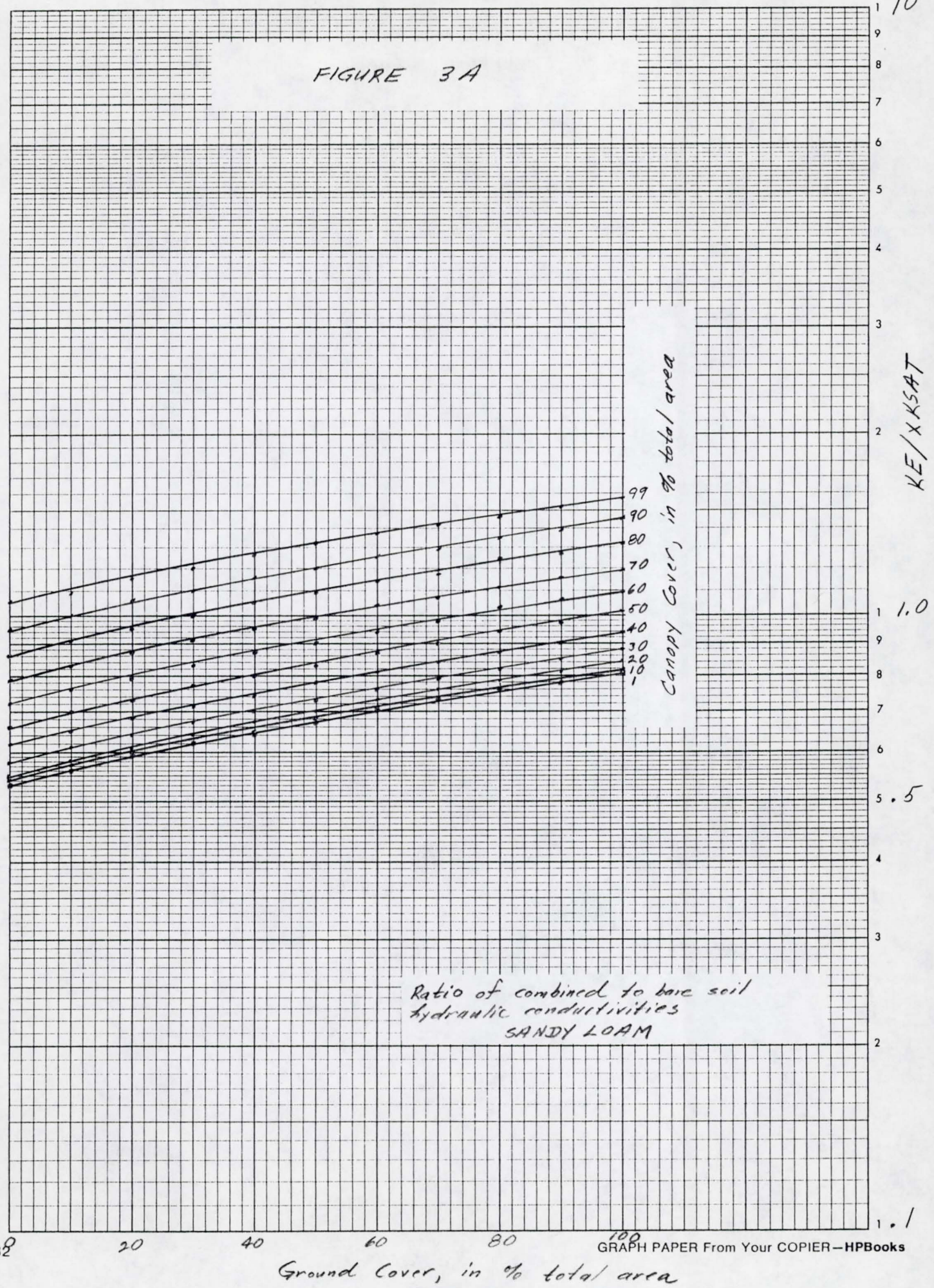
70 Divisions 5th, 10th Accent by 2 Cycle Semi-Log



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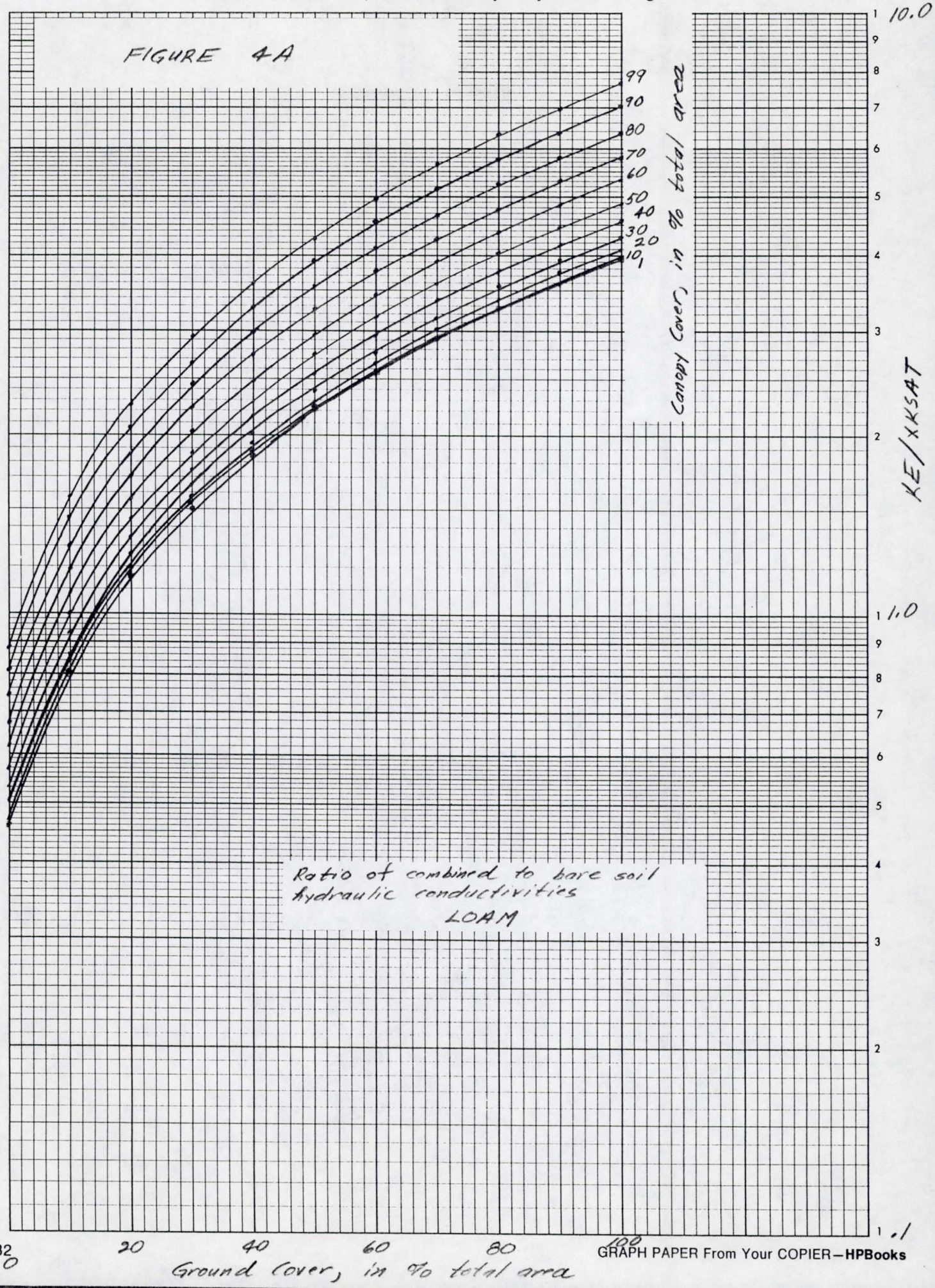

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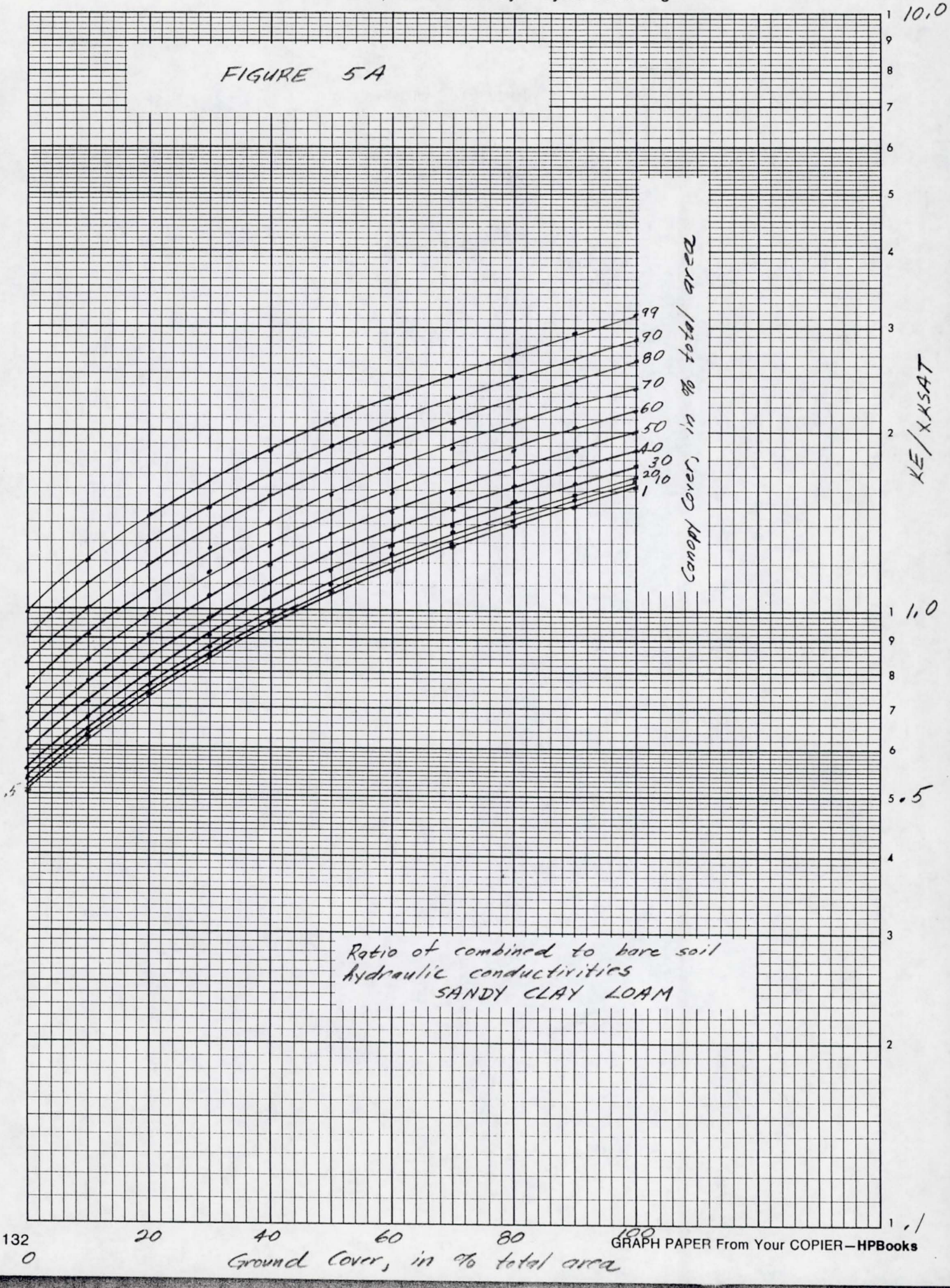

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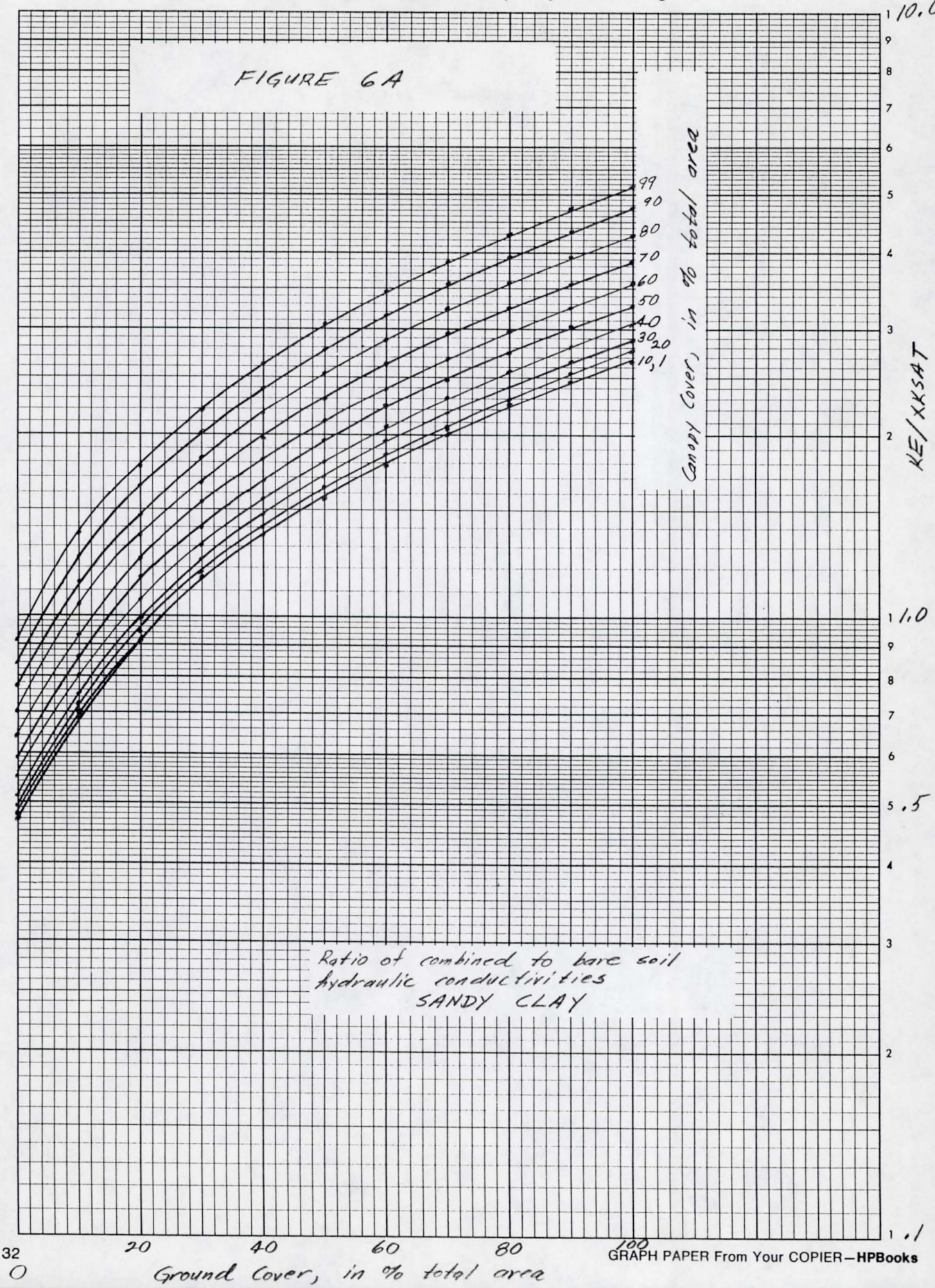

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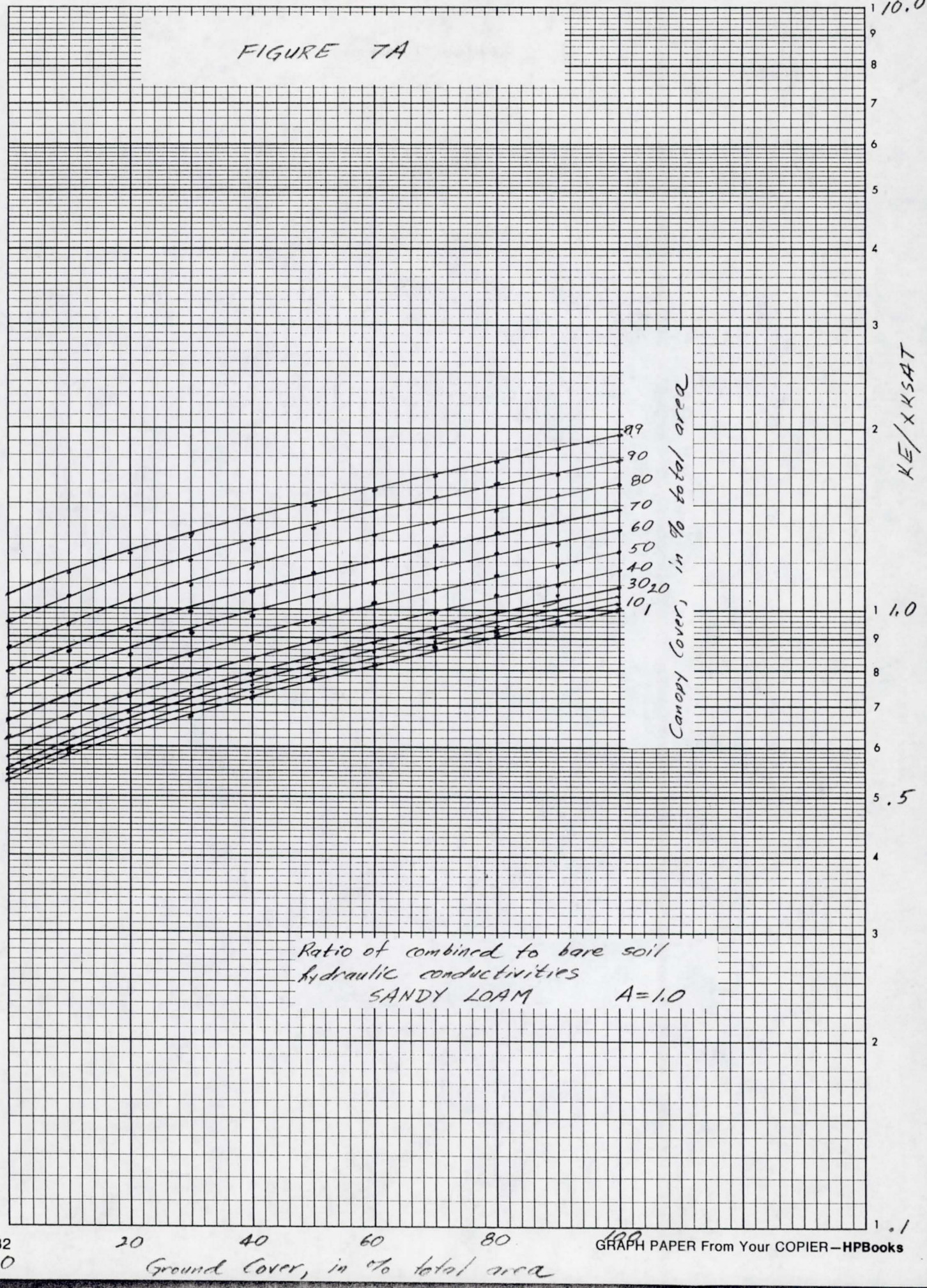
28 April 87



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APPENDIX 2-M

Correspondence and reports from Dr. Leonard J. Lane on effect of vegetation on hydraulic conductivity (diskette included).

TO: GEORGE SABOL RE HIS 28 APRIL CORRESPONDENCE

SUBJECT: PROPOSED FIGURE 7A AS A METHOD OF ADJUSTING VALUES OF BARE SOIL HYDRAULIC CONDUCTIVITY KsO 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 [illegible] of canopy cover and ground cover effects.

6 B-M
(3) copies
(Return)

Consider an equation [illegible]

$$Ks = KsO*(exp[illegible](Agc gc\%))$$

where: Ks = Adju[illegible] use in Green-Ampt eq. (mm/h),
KsO = 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 KsO, 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 KsO 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.

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	Sal11
	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

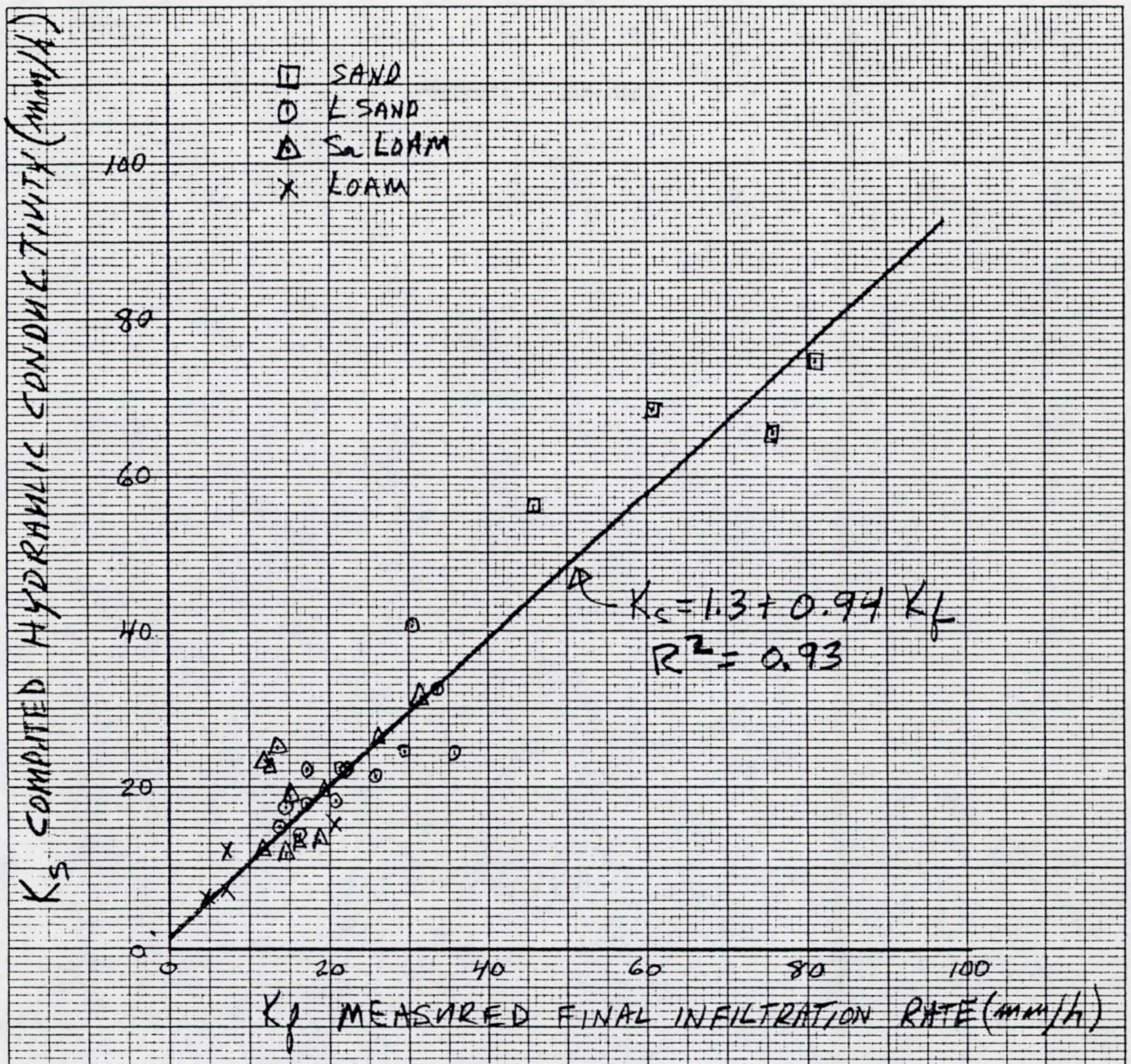

FIGURE 1. RELATIONSHIP BETWEEN MEASURED K_f AND COMPUTED K_s. DATA FROM TABLES 3 & 4.

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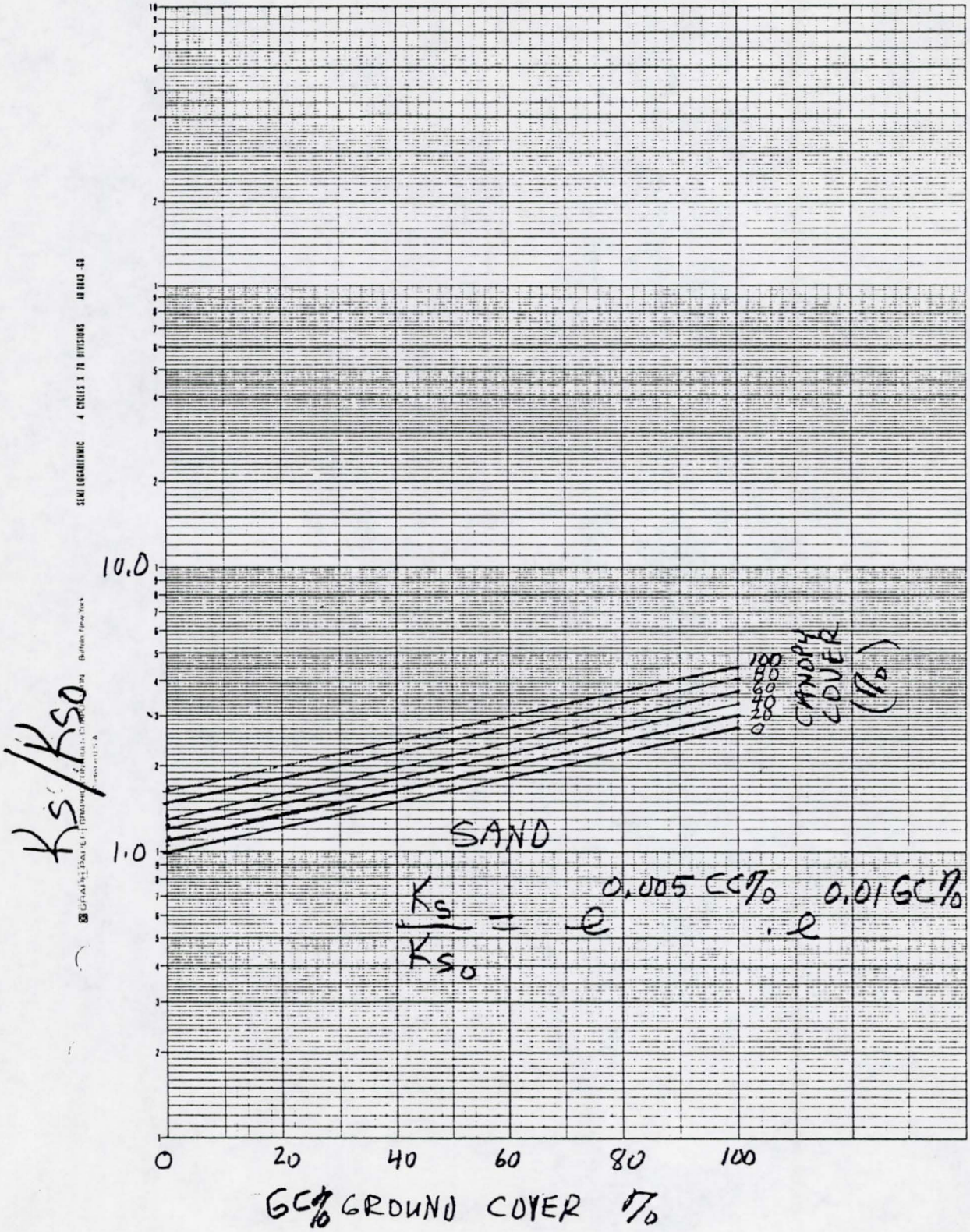

FIGURE 2. RELATIONSHIP BETWEEN CANOPY COVER, GROUND COVER AND ADJUSTMENT IN K_s FOR TEXTURAL CLASS "SAND."

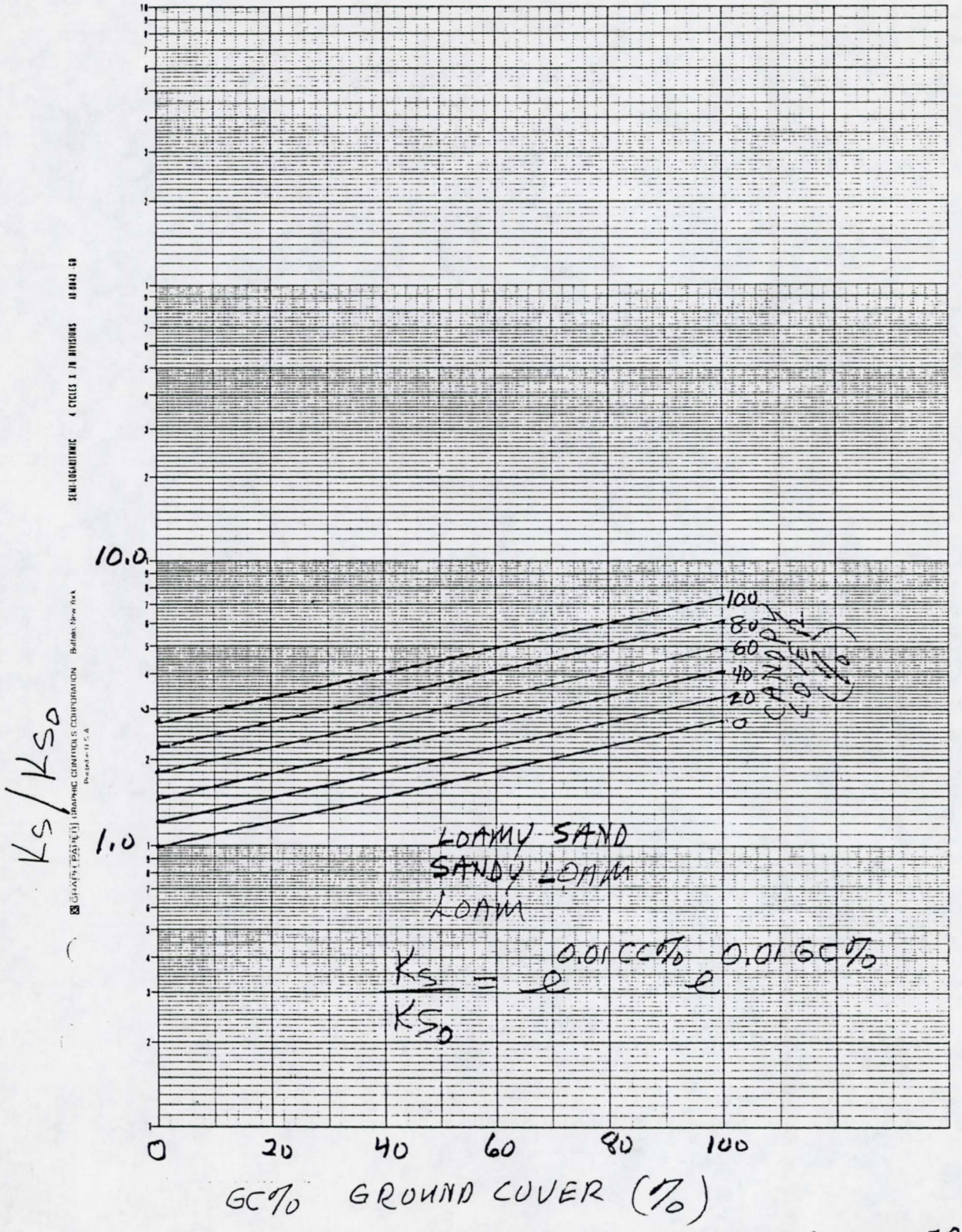

FIGURE 3. RELATION BETWEEN CANOPY COVER, GROUND COVER, AND ADJUSTMENT IN Ks FOR LOAMY SAND, SANDY LOAM, & LOAM

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)

	K_{SO}	CC%	GC%	K_f	$\frac{K_f}{K_{SO}} - 1$
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

	$K_{SO\,ADJ}$				$\frac{K_f}{K_{SO\,ADJ}} - 1$
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% & $\frac{K_f}{K_{SO}} - 1$

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

1	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

$$\frac{K_f}{K_{S_0}} = 1.0 + 0.036\,CC\% + 0.009\,GC\%$$

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

$$\frac{K_f}{K_{S0\,ADJ}} = 1.0 + 0.043\,CC\% + 0.055\,GC\%$$

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. LAINE
JULY 8, 1989

$$y = ax_1 + bx_2$$

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

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

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

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

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

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

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

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

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

$$\left\{ \begin{array}{l} a\sum x_1^2 + b\sum x_1x_2 - \sum x_1y = 0 \\ a\sum x_1x_2 + b\sum x_2^2 - \sum x_2y = 0 \end{array} \right\} \begin{array}{l} (1) \\ (2) \end{array}$$

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)

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

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

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

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

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

TECHNICAL MEMORANDUM

TO: Joe Rumann, FCDMC
FROM: G.V. Sabol
SUBJECT: Areal Averaging Green and Ampt Parameters
DATE: 29 April 1991

Presently, use of the Green and Ampt infiltration equation has included area weighted averaging of the individual parameter values (XKSAT, PSIF and DTHETA). At our recent review meetings (16-17 April), it was decided that we should determine the area weighted average of XKSAT and then determine the representative values of PSIF and DTHETA from graphs of XKSAT versus PSIF and DTHETA. Use of such graphs is to reduce the computation effort. I recently performed some computational comparisons that indicate that large error could be introduced by arithmetically averaging the XKSAT values. Much greater accuracy is achieved by using the area weighted average of the logarithms of the XKSAT values. Both methods used the same procedure to estimate PSIF and DTHETA from the calculated value of XKSAT. The procedure and results of my comparison is enclosed.

PROCEDURE

Four soil distributions (% of drainage area being comprised of various percentages of each soil texture) were created from three soil textures as shown below:

	% of Drainage Area			
	Soil Distribution			
Soil Texture	A	B	C	D
loamy sand	33 1/3	60	25	15
loam	33 1/3	25	60	25
clay	33 1/3	15	15	60

Two graphs were prepared of XKSAT versus PSIF and DTHETA (dry) from Table 4.2 (Figure 1). The area weighted values of XKSAT were calculated for these soil

distributions based on the arithmetic values of XKSAT and log XKSAT. Corresponding values of PSIF and DTHETA were taken from Figure 1 in both cases. The area weighted values of the Green and Ampt parameters are shown in Table 1.

The runoff volumes were calculated by three methods:

1. The "actual" runoff volume was estimated by calculating the rainfall excess for each portion of the total area that contains a single soil texture. The volume is the sum of the runoff volumes from each soil texture type. The depths of rainfall excess for four different drainage areas and the three soil textures are shown in Table 2. These rainfall excess depths were calculated with HEC-1.
2. The runoff volumes were then calculated by using the area weighted average arithmetic values of XKSAT and related PSIF and DTHETA (shown in Table 1). This is the procedure that is presently used.
3. The runoff volumes were then calculated by using the area weighted average log values of XKSAT and related PSIF and DTHETA (shown in Table 1).

RESULTS

The results are shown in Table 3 for four drainage areas. The drainage areas were selected such that they corresponded to Pattern Nos:

0.5 sq. mi. - Pattern No. 1
2.8 sq. mi. - Pattern No. 2
16 sq. mi. - Pattern No. 3
100 sq. mi. - Pattern No. 4.07 (area limit of procedure)

The results from Table 3 are shown in Figures 2 and 3. Notice that the presently used method always results in an underestimation of the runoff volume. The log method of averaging provides very close estimates of runoff volume to the actual volume.

The % error using each procedure is shown in Table 4. The method of arithmetic averaging becomes worse with increasing drainage area size. The log averaging method shows some small overestimation for small to medium sized areas, and underestimation for large areas.

CONCLUSIONS

1. Area weighting of arithmetic parameters will generally (maybe always) result in underestimation of runoff volumes. The error seems to grow increasingly worse as drainage area size increases.
2. This underestimation of rainfall excess also affects the calculation of T_c. This error is partially responsible for the problem in using the Clark unit hydrograph method wherein the duration of rainfall excess is often too short.
3. It appears that the area weighting of log XKSAT is a preferred method.
4. Area averaging of parameters should be avoided for large watersheds if there is a large range of XKSAT for the subareas. The limit for averaging of XKSAT (by any method) may be around 16 sq. mi.
5. We need to check the log averaging procedure for some real watersheds. I will check the procedure for the Agua Fria R. trib. and the Tucson Arroyo.
6. This appears to be a <u>critical</u> concern. We need to carefully review this and make more comparisons before making a decision.

TABLE 1 - Calculation of area weighted XKSAT and related PSIF & DTHETA.

	XKSAT in/hr	PSIF in	DTHETA	% Total Area Soil Distribution A	B	C	D
loamy sand	1.2	2.4	.35	33 1/3	60	25	15
loam	.25	3.5	.35	33 1/3	25	60	25
clay	.01	12.4	.15	33 1/3	15	15	60
	XKSAT - area wt'd. (arith.)			.49	.78	.45	.25
	PSIF *			3.7	3.1	3.9	5.0
	DTHETA *			.35	.35	.35	.35
	XKSAT - area wt'd (log)			.14	.40 **	.23	.046
	PSIF *			6.4	4.1	5.2	9.3
	DTHETA *			.40	.35	.35	.26

* PSIF & DTHETA from the attached graph of XKSAT vs PSIF & DTHETA

** Calculation of $\overline{XKSAT}$ = antilog (.60 log 1.2 + .25 log .25 + .15 log .01)

= antilog (.60 × .0792 + .25 × -.6021 + .15 × -2.0)

= antilog (-.4030) = .40

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TABLE 2 - Depths of rainfall excess for each soil texture and each drainage area <u>without</u> area weighted averaging.

Rainfall Excess, inches

Area sq. mi.	Rainfall, inches Point	Rainfall, inches Areal	Soil: loamy sand	Soil: loam	Soil: clay
		XKSAT	1.2	.25	.01
		PSIF	2.4	3.5	12.4
		DTHETA	.35	.35	.15
.5	3.22	3.20	.99	1.82	2.73
2.8	3.22	3.14	.41	1.56	2.67
16	3.22	2.97	.14	1.23	2.48
100	3.22	2.58	0.0	.77	2.08

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TABLE 3 - Results

Soil Distribution ①	Parameter Method ②	Runoff Volume, in ac-ft — Total Area, sq. mi. .5	2.8	16	100
A	I	49.2	231.0	1,095.1	5,066.7
A	II	37.6	153.8	614.4	1,653.3
A	III	49.3	243.4	1,117.9	4,533.3
B	I	38.9	154.8	651.5	2,690.7
B	II	31.7	113.5	358.4	320.0
B	III	40.3	173.2	708.3	2,133.3
C	I	46.6	214.9	977.1	4,128.0
C	II	38.7	164.3	648.5	1,813.3
C	III	45.9	218.0	964.3	3,573.3
D	I	59.8	306.7	1,550.1	7,682.7
D	II	45.3	212.1	930.1	3,360.0
D	III	59.5	316.6	1,587.2	7,573.3

① Soil Distribution:

A -	33⅓ % loamy sand	33⅓ % loam	33⅓ % clay
B -	60 %	25 %	15 %
C -	25 %	60 %	15 %
D -	15 %	25 %	60 %

② Parameter Method:

I - soil specific parameters for <u>each</u> subbasin

II - XKSAT from area wt'd. arith. avg.

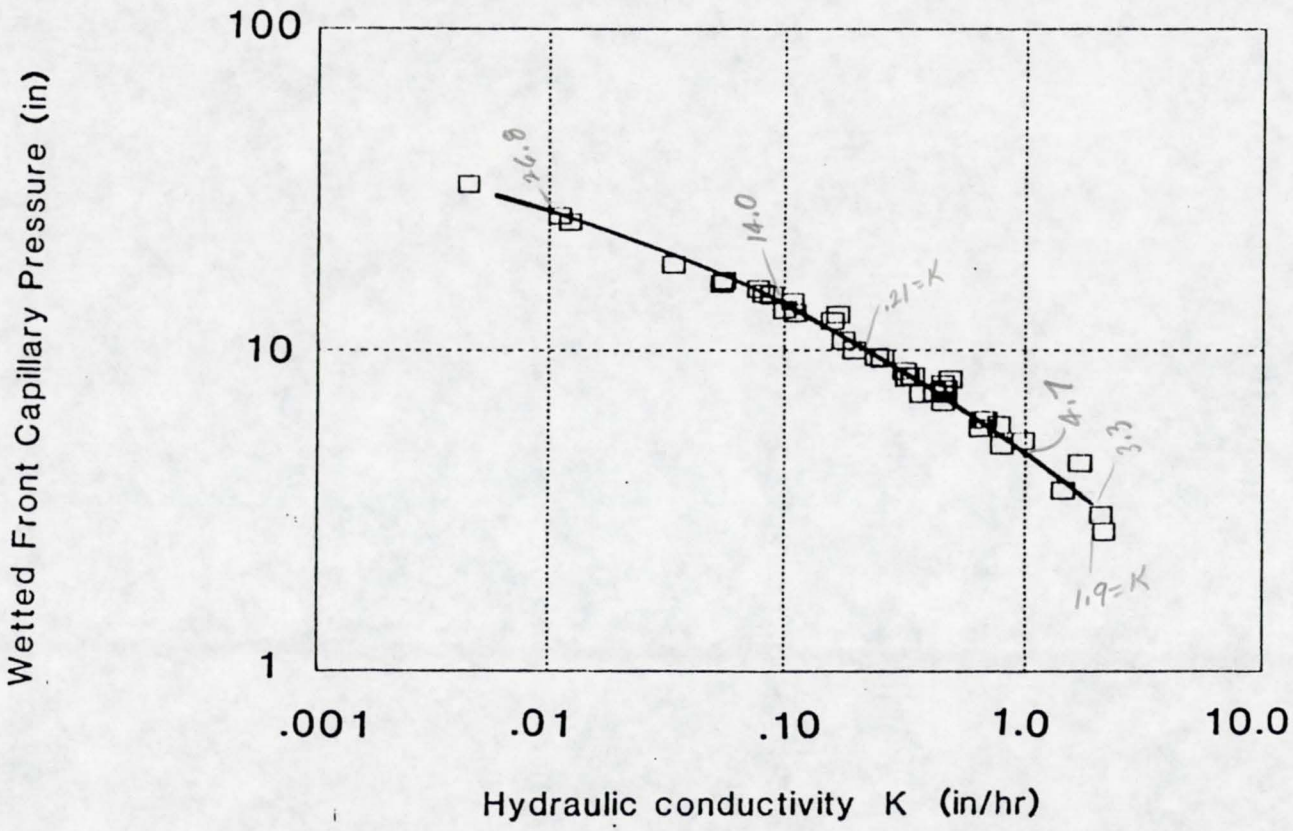
III - XKSAT from area wt'd. log. avg.

TABLE 4 - Error in runoff volumes by each method of averaging XKSAT.

Soil Distribution	% Error in Runoff Volume — Total Area, sq. mi. 0.5	2.8	16	100
	By Arith. Avg. of XKSAT			
A	-23.6	-33.4	-43.9	-67.4
B	-18.5	-26.7	-45.0	-88.1
C	-17.0	-23.5	-33.6	-56.1
D	-24.2	-30.8	-40.0	-56.3
avg.	-20.8	-28.6	-40.6	-67.0
	By Log. Avg. of XKSAT			
A	0.2	5.4	2.1	-10.5
B	3.6	11.9	8.7	-20.7
C	-1.5	1.4	-1.3	-13.4
D	-0.5	3.2	2.4	-1.4
avg.	0.5	5.5	3.0	-11.5

from Van Mullem's MS thesis

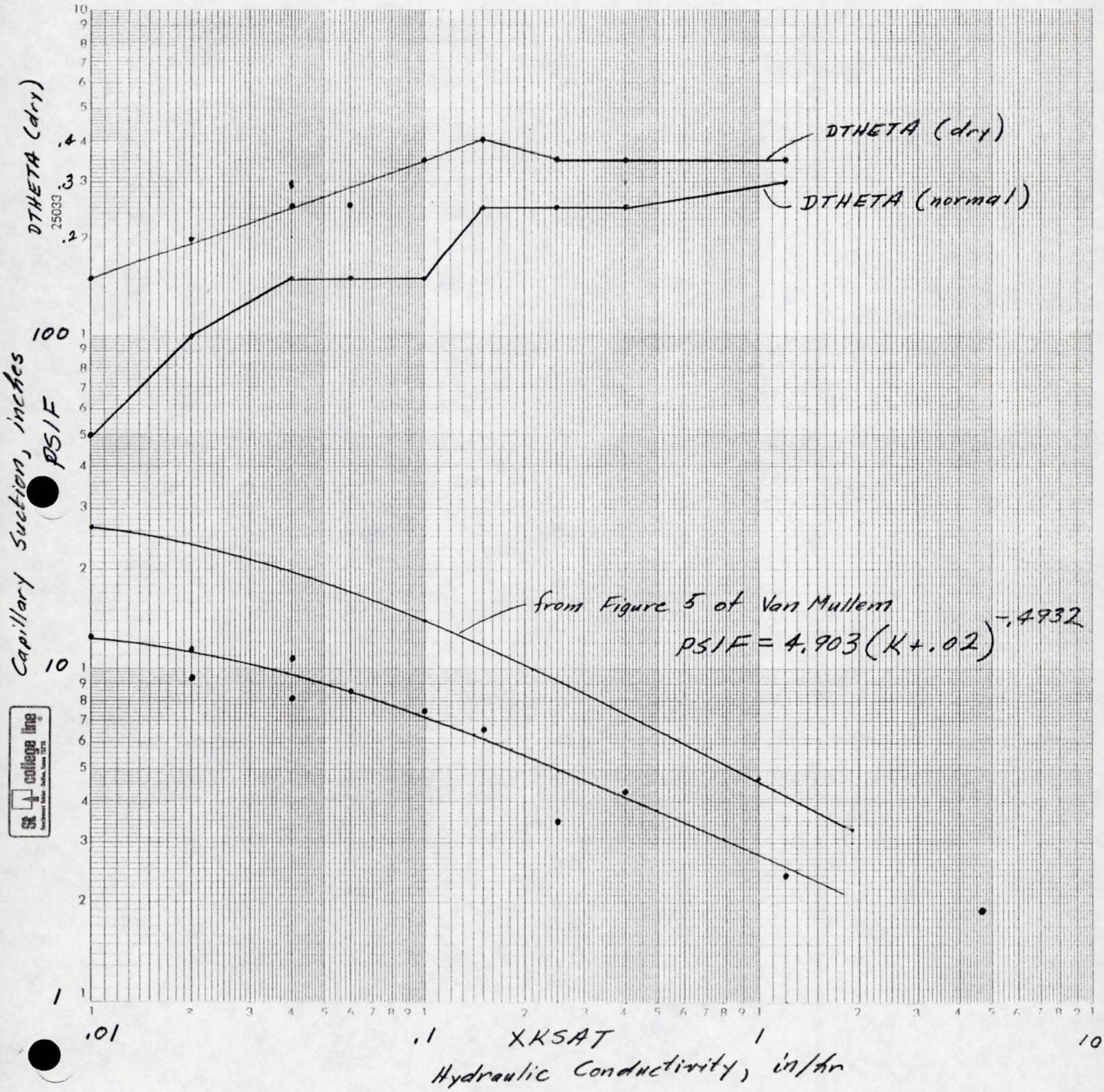
Figure 5. Capillary pressure vs hydraulic conductivity



am Dg
25 April 91

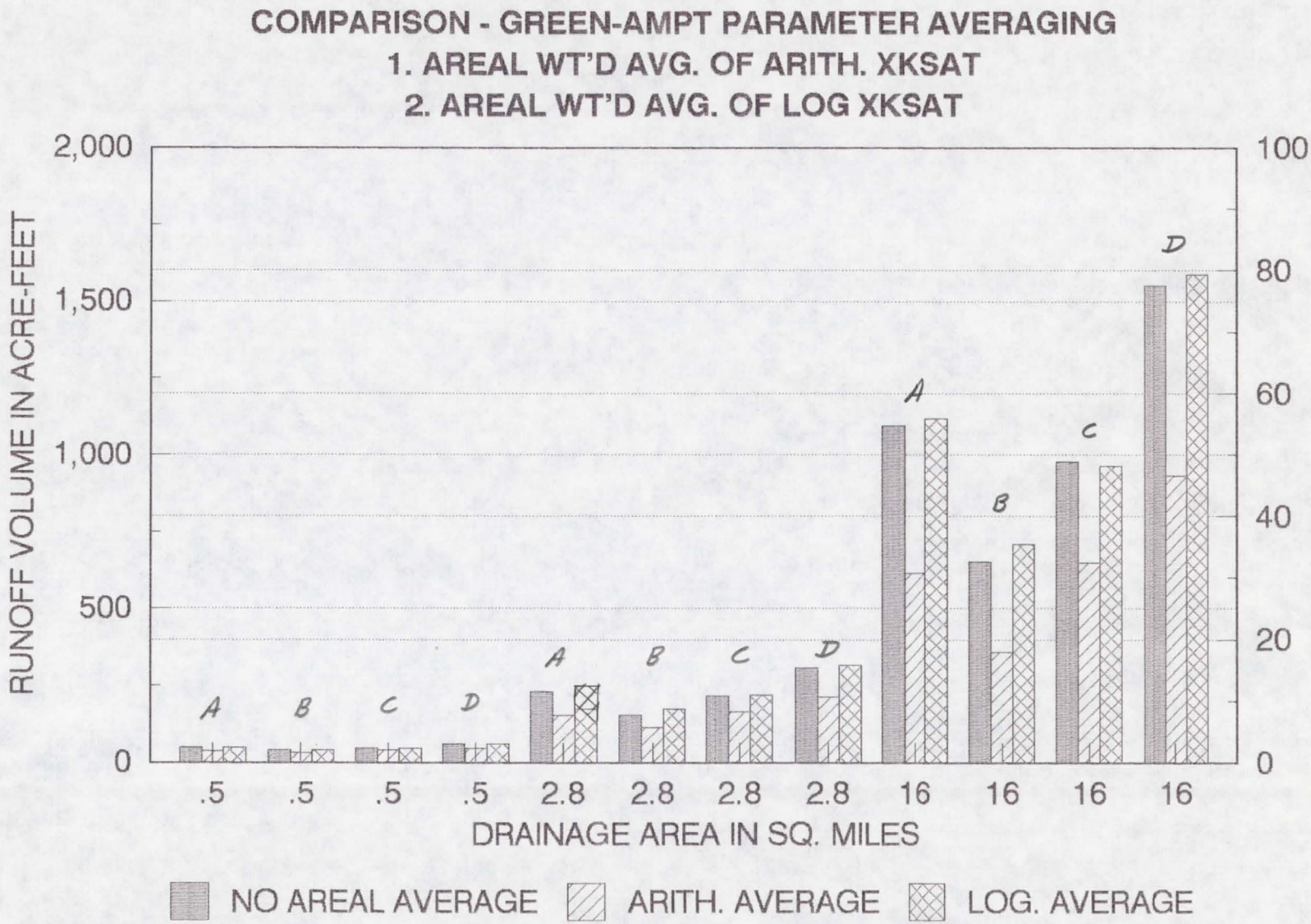
FIGURE 1

Comparison of XKSAT vs PSIF from Table 4.2 and the relation by Van Mullem (1989)



Logarithmic 3 X 3 Cycles

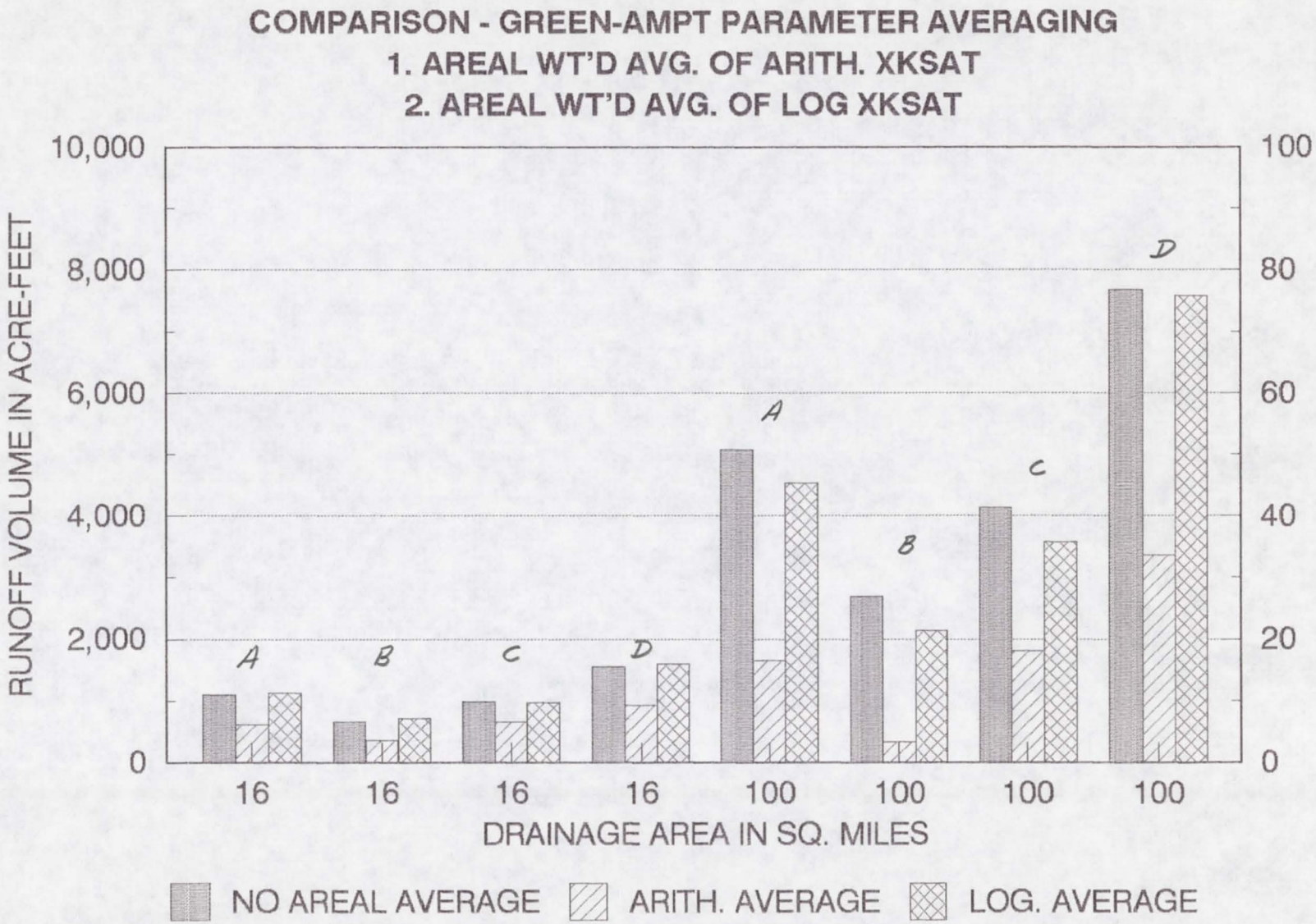
FIGURE 2



(4) SOIL DISTRIBUTIONS
(3) DRAINAGE AREAS

File: ARITH3

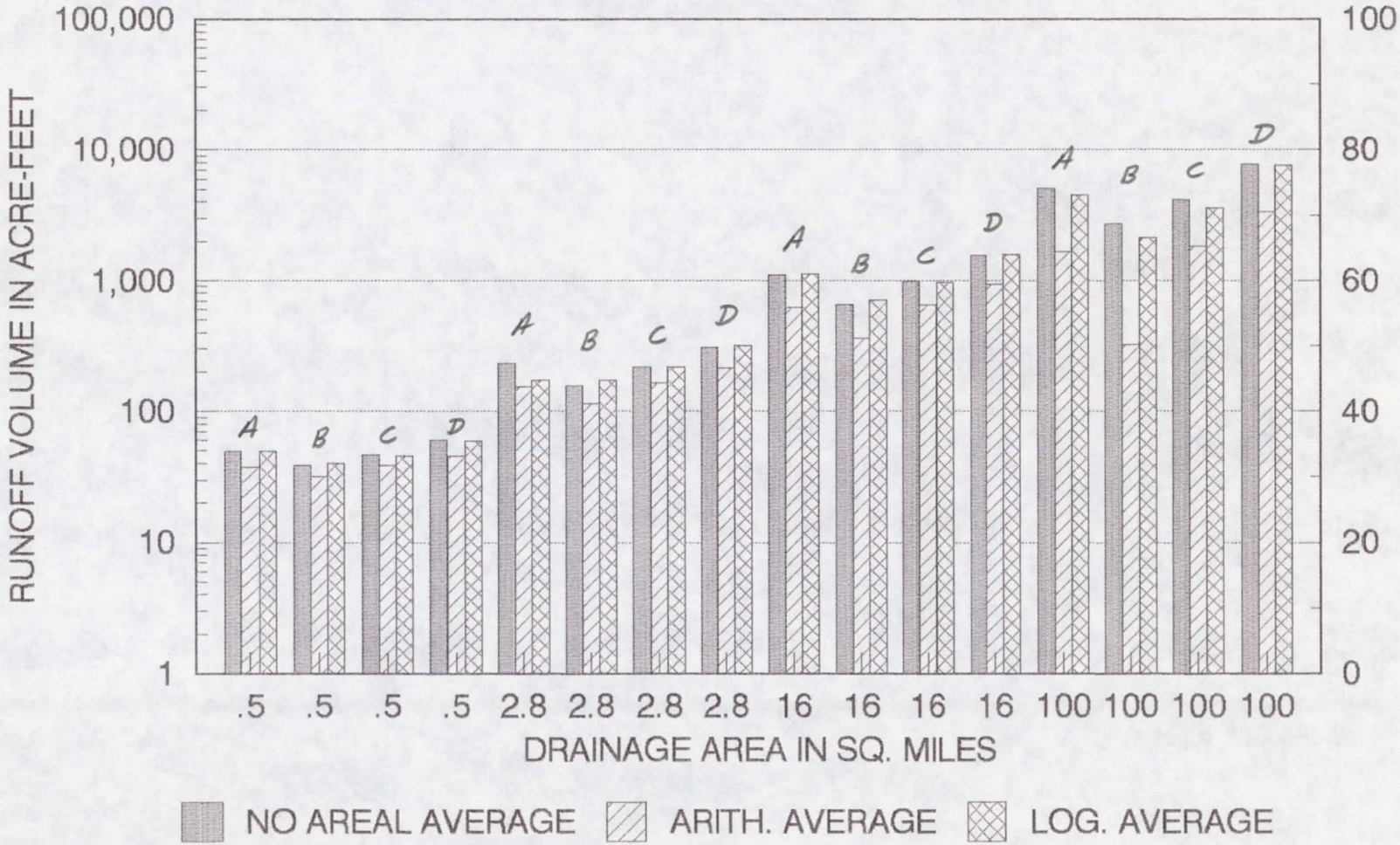
FIGURE 3



(4) SOIL DISTRIBUTIONS
(2) DRAINAGE AREAS

File: ARITH2

COMPARISON - GREEN-AMPT PARAMETER AVERAGING
1. AREAL WT'D AVG. OF ARITH. XKSAT
2. AREAL WT'D AVG. OF LOG XKSAT



(4) SOIL DISTRIBUTIONS
(4) DRAINAGE AREA SIZES

File : ALLLOG

GEORGE V. SABOL CONSULTING ENGINEERS, INC.

SHEET 1 OF

CLIENT FCDMC

DATE 29 April 91

PROJECT Hydro. Manual

BY GVS

SUBJECT Agua Fria R. trib.

PROJECT NO. 5-5-F

Area Wt.d Avg. log XKSAT

% area	XKSAT
50	.25
35	.40
15	.01

$\overline{XKSAT}$ = antilog [.50 log .25 + .35 log .40 + .15 log .01]

= .18 in/hr

Related PSIF & DTHETA (normal) from attached figure

PSIF = 5.8 in.
DTHETA = .25

Comparison of previously used parameters to log. avg. values:

	Arith. Avg. Values	log Avg. Values
XKSAT, in/hr	.27	.18
PSIF, in.	5.1	5.8
DTHETA	.22	.25

Other parameters remain unchanged.

GEORGE V. SABOL CONSULTING ENGINEERS, INC.

SHEET 2 OF

CLIENT

DATE 29 April 91

PROJECT

BY GVS

SUBJECT

PROJECT NO. 5-5-F

HEC-1 model results for Green and Ampt parameters based on area wt'd log XKSAT.

Model input changes:

	Previous Value	New Value
XKSAT	.27	.18
PSIF	5.1	5.8
DTHETA	.22	.25

Revised Model Results:

Return Period	6-hr Point Rain	Rainfall Excess	T_c	R	Q_p	T_p
years	inches	inches	hr	hr	cfs	hr
100	3.21	2.20	.73	.85	123	4.42
50	2.85	1.88	.82	.96	95	4.42
25	2.50	1.58	.90	1.07	73	4.50
10	2.04	1.19	1.05	1.27	48	4.58
5	1.70	.91	1.18	1.45	32	4.67
2	1.19	.55	1.40	1.75	16	4.83

Discussion:

Use of the log XKSAT procedure for determining the Green and Ampt parameters resulted in about an 8% increase in Q_p for the 100-yr flood and about a 7% increase for the 2-yr flood. Therefore, the previous verification results are not greatly affected.

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SHEET 8 OF

CLIENT

DATE

PROJECT

BY

SUBJECT HEC-1 model input & results

PROJECT NO.

Watershed input:

A = .13 sq. mi.
L = 1.023 mi.
S = 5.8 ft/mi
K_b = .028

Time-Area relation = urban

IA = .15 in
DTHETA = .22
PSIF = 5.1 in
XKSAT = .27 in/hr
RTIMP = 25 %

Verification results of March 1991 using the September 1990 version of the Manual

Computation Interval = 5 min.

Return Period	6-hr Point Rain	Rainfall Excess	T_c	R	Q_p	T_p
years	inches	inches	hr	hr	cfs	hr
100	3.21	2.12	.77	.90	114	4.42
50	2.85	1.81	.83	.99	90	4.42
25	2.50	1.51	.93	1.12	68	4.50
10	2.04	1.12	1.08	1.32	43	4.58
5	1.70	.87	1.20	1.48	30	4.67
2	1.19	.52	1.40	1.75	15	4.83

GEORGE V. SABOL CONSULTING ENGINEERS, INC.

SHEET ____ OF ____

CLIENT FCDMC

DATE 29 April 91

PROJECT Hydro. Manual

BY GVS

SUBJECT Tucson Arroyo

PROJECT NO. 5-5-F

Area wt'd Avg. log XKSAT

% area	XKSAT
60	.25
20	.40
20	.15

$XKSAT = \text{antilog}\left[.60 \log .25 + .20 \log .40 + .20 \log .15\right]$

$= .25$ in/hr

Related PSIF & DTHETA (normal) from attached figure

PSIF = 5.0 in.
DTHETA = .25

Comparison of previously used parameters to log avg. values

	Arith. Avg. Values	log Avg. Values
XKSAT, in/hr	.26	.25
PSIF, in	4.3	5.0
DTHETA	.25	.25

Results & comparison w/ previous analysis for 100-yr flood:

	Previous Results	Present Results
HEC-1 file	VT100	VT100L
Rain Excess, in.	1.97	1.94
T_C, hr	.93	.93
R, hr	.45	.45
Q_p, cfs	7,520	7,445
T_p, hr	4.50	4.50

PC Shell Version 6 Directory Print TD - None

Path=B:\

Name	Ext	Size	#Clu	Date	Time	Attributes
W1	DAT	605	1	4/26/91	4:03p	A
W1	OUT	13512	14	4/26/91	4:03p	A
W2	DAT	605	1	4/26/91	4:05p	A
W2	OUT	13512	14	4/26/91	4:05p	A
W3	DAT	605	1	4/26/91	4:07p	A
W3	OUT	13512	14	4/26/91	4:07p	A
X1	DAT	687	1	4/26/91	4:08p	A
X1	OUT	13761	14	4/26/91	4:09p	A
X2	DAT	687	1	4/26/91	4:10p	A
X2	OUT	13761	14	4/26/91	4:10p	A
X3	DAT	687	1	4/26/91	4:11p	A
X3	OUT	13761	14	4/26/91	4:12p	A
Y1	DAT	769	1	4/26/91	4:13p	A
Y1	OUT	14010	14	4/26/91	4:13p	A
Y2	DAT	769	1	4/26/91	4:14p	A
Y2	OUT	14010	14	4/26/91	4:14p	A
Y3	DAT	769	1	4/26/91	4:15p	A
Y3	OUT	14010	14	4/26/91	4:16p	A
Z1	DAT	1507	2	4/26/91	4:17p	A
Z1	OUT	15992	16	4/26/91	4:17p	A
Z2	DAT	1507	2	4/26/91	4:18p	A
Z2	OUT	15992	16	4/26/91	4:18p	A
Z3	DAT	1507	2	4/26/91	4:19p	A
Z3	OUT	15992	16	4/26/91	4:20p	A
WA	DAT	605	1	4/27/91	11:44a	A
WA	OUT	13512	14	4/27/91	11:44a	A
WB	DAT	605	1	4/27/91	11:26a	A
WB	OUT	13512	14	4/27/91	11:26a	A
WC	DAT	605	1	4/27/91	11:27a	A
WC	OUT	13512	14	4/27/91	11:27a	A
WD	DAT	605	1	4/27/91	11:28a	A
WD	OUT	13512	14	4/27/91	11:28a	A
XA	DAT	687	1	4/27/91	11:30a	A
XA	OUT	13761	14	4/27/91	11:31a	A
XB	DAT	687	1	4/27/91	11:31a	A
XB	OUT	13761	14	4/27/91	11:32a	A
XC	DAT	687	1	4/27/91	11:32a	A
XC	OUT	13761	14	4/27/91	11:33a	A
XD	DAT	687	1	4/27/91	11:34a	A
XD	OUT	13761	14	4/27/91	11:34a	A
YA	DAT	769	1	4/27/91	11:35a	A
YA	OUT	14010	14	4/27/91	11:35a	A
YB	DAT	769	1	4/27/91	11:36a	A
YB	OUT	14010	14	4/27/91	11:36a	A

used to calculate the "actual" runoff volumes without area wt. avg. of parameters

W = .5 sq. mi.
X = 2.8 sq. mi.
Y = 16 sq. mi.
Z = 100 sq. mi.

1 = loamy sand
2 = loam
3 = clay

Area wt'd. arith. avg. of XKSAT

Area

	.5 W	2.8 X	16 Y	100 Z
A	WA	XA	YA	ZA
B	WB			
C	WC			
D	WD			

etc

Distribution

YC	DAT	769	1	4/27/91	11:37a	A
YC	OUT	14010	14	4/27/91	11:37a	A
YD	DAT	769	1	4/27/91	11:38a	A
YD	OUT	14010	14	4/27/91	11:38a	A
ZA	DAT	1507	2	4/27/91	11:39a	A
ZA	OUT	15992	16	4/27/91	11:39a	A
ZB	DAT	1507	2	4/27/91	11:40a	A
ZB	OUT	15992	16	4/27/91	11:40a	A
ZC	DAT	1507	2	4/27/91	11:41a	A
ZC	OUT	15992	16	4/27/91	11:41a	A
ZD	DAT	1507	2	4/27/91	11:42a	A
ZD	OUT	15992	16	4/27/91	11:42a	A
LWA	DAT	606	1	4/27/91	11:45a	A
LWA	OUT	13512	14	4/27/91	11:46a	A
LWB	DAT	606	1	4/27/91	11:46a	A
LWB	OUT	13512	14	4/27/91	11:47a	A
LWC	DAT	606	1	4/27/91	11:47a	A
LWC	OUT	13512	14	4/27/91	11:48a	A
LWD	DAT	606	1	4/27/91	11:48a	A
LWD	OUT	13512	14	4/27/91	11:49a	A
LXA	DAT	688	1	4/29/91	8:34a	A
LXA	OUT	13761	14	4/29/91	8:34a	A
LXB	DAT	688	1	4/27/91	11:50a	A
LXB	OUT	13761	14	4/27/91	11:51a	A
LXC	DAT	688	1	4/27/91	11:52a	A
LXC	OUT	13761	14	4/27/91	11:52a	A
LXD	DAT	688	1	4/27/91	11:53a	A
LXD	OUT	13761	14	4/27/91	11:53a	A
LYA	DAT	770	1	4/27/91	11:54a	A
LYA	OUT	14010	14	4/27/91	11:54a	A
LYB	DAT	770	1	4/27/91	11:55a	A
LYB	OUT	14010	14	4/27/91	11:55a	A
LYC	DAT	770	1	4/27/91	11:56a	A
LYC	OUT	14010	14	4/27/91	11:56a	A
LYD	DAT	770	1	4/27/91	11:57a	A
LYD	OUT	14010	14	4/27/91	11:57a	A
LZA	DAT	1508	2	4/27/91	11:58a	A
LZA	OUT	15992	16	4/27/91	11:58a	A
LZB	DAT	1508	2	4/27/91	11:59a	A
LZB	OUT	15992	16	4/27/91	11:59a	A
LZC	DAT	1508	2	4/27/91	12:00p	A
LZC	OUT	15992	16	4/27/91	12:00p	A
LZD	DAT	1508	2	4/27/91	12:01p	A
LZD	OUT	15992	16	4/27/91	12:02p	A

Watershed Sol D WS

Area wt'd avg. of log XKSAT

Same notation as above except addition of "L"

88 files LISTed 669,289 bytes 88 files in sub-dir = 669,289 bytes
0 files SELECTed 0 bytes Available on volume = 20,480 bytes

runs to calculate the depths of raintall excess
as a function of drainage area for 4 sizes of areas

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC 1)   *
*            FEBRUARY 1981              *
*          REVISED 01 JUN 00            *
*                                       *
*  RUN DATE  04/26/1991  TIME  16:03:45 *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*  THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*          (916) 551 1748               *
*                                       *
*****************************************
```

```
*    *  *******   *****          *
*    *  *      *    *        **
*    *  *      *              *
*******  ****   *      *****  *
*    *  *      *              *
*    *  *      *    *         *
*    *  *******   *****        ***
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC 1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES RTIMP AND RTIOR HAVE CHANGED FROM THOSE USED WITH THE 1973 STYLE INPUT STRUCTURE.
THE DEFINITION OF AMSKK ON RM CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 01. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                    HEC 1 INPUT                                    PAGE  1

     LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

       1           ID
       2           ID
       3           ID
       4           IT     15                  30
       5           IO      1

       6           KK
       7           KM   SUB BASIN W1
       8           BA    .50
       9           IN     15
      10           PB   3.20
      11           PC    .000    .000    .016    .025    .033    .041    .050    .058    .066    .074
      12           PC    .087    .099    .110    .130    .216    .377    .034    .011    .031    .050
```

```
        13        PC   .062   .072   .903   .991  1.000
        14        LC   .00    .35   2.10   1.20    .00
        15        UI   33.   122.   101.   306.   262.   177.   105.    10.    27.     9.
        16        UI    0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
        17        UI    0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
        18        ZZ
1****************************************                                  ************************************
*                                      *                                  *                                  *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                  *   U.S. ARMY CORPS OF ENGINEERS   *
*            FEBRUARY 1981             *                                  * THE HYDROLOGIC ENGINEERING CENTER *
*          REVISED 01 JUN 88           *                                  *        609 SECOND STREET         *
*                                      *                                  *     DAVIS, CALIFORNIA 95616      *
* RUN DATE  04/26/1991  TIME  16:03:45 *                                  *        (916) 551-1748            *
*                                      *                                  *                                  *
****************************************                                  ************************************

  5 IO        OUTPUT CONTROL VARIABLES
                   IPRNT          1  PRINT CONTROL
                   IPLOT          0  PLOT CONTROL
                   QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                    NMIN         15  MINUTES IN COMPUTATION INTERVAL
                   IDATE     1    0  STARTING DATE
                   ITIME        0000  STARTING TIME
                      NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                  NQDATE     1    0  ENDING DATE
                  NQTIME        0715  ENDING TIME
                  ICENT          19  CENTURY MARK

                COMPUTATION INTERVAL     .25 HOURS
                    TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


          **************
          *            *
  6 KK    *            *
          *            *
          **************
                   SUB-BASIN W1

  9 IN        TIME DATA FOR INPUT TIME SERIES
                  JXMIN         15  TIME INTERVAL IN MINUTES
                 JXDATE     1    0  STARTING DATE
                 JXTIME          0  STARTING TIME
```

SUBBASIN RUNOFF DATA

8 BA SUBBASIN CHARACTERISTICS

TAREA .50 SUBBASIN AREA

PRECIPITATION DATA

10 PB STORM 3.20 BASIN TOTAL PRECIPITATION

11 PI INCREMENTAL PRECIPITATION PATTERN

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.02	.02	.08	.16	.46	.08	.02	.02	.01
.01	.01	.01	.01						

14 LG GREEN AND AMPT LOSS RATE

STRTL .00 STARTING LOSS

DTH .35 MOISTURE DEFICIT

PSIF 2.40 WETTING FRONT SUCTION

XKSAT 1.20 HYDRAULIC CONDUCTIVITY

RTIMP .00 PERCENT IMPERVIOUS AREA

14 UI INPUT UNITGRAPH, 11 ORDINATES, VOLUME = .99

33.0	122.0	184.0	306.0	262.0	177.0	105.0	48.0	27.0	9.0
9.0									

***

****

HYDROGRAPH AT STATION

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	*	1		0345	16	.52	.51	.00	0.
1		0015	2	.03	.03	.00	0.	*	1		0400	17	1.46	.48	.99	33.
1		0030	3	.03	.03	.00	0.	*	1		0415	18	.25	.25	.00	120.
1		0045	4	.03	.03	.00	0.	*	1		0430	19	.06	.06	.00	182.
1		0100	5	.03	.03	.00	0.	*	1		0445	20	.06	.06	.00	302.
1		0115	6	.03	.03	.00	0.	*	1		0500	21	.04	.04	.00	259.
1		0130	7	.03	.03	.00	0.	*	1		0515	22	.03	.03	.00	175.
1		0145	8	.03	.03	.00	0.	*	1		0530	23	.04	.04	.00	104.
1		0200	9	.03	.03	.00	0.	*	1		0545	24	.03	.03	.00	47.
1		0215	10	.03	.03	.00	0.	*	1		0600	25	.03	.03	.00	27.
1		0230	11	.04	.04	.00	0.	*	1		0615	26	.00	.00	.00	9.
1		0245	12	.04	.04	.00	0.	*	1		0630	27	.00	.00	.00	9.
1		0300	13	.06	.06	.00	0.	*	1		0645	28	.00	.00	.00	0.
1		0315	14	.06	.06	.00	0.	*	1		0700	29	.00	.00	.00	0.
1		0330	15	.25	.25	.00	0.	*	1		0715	30	.00	.00	.00	0.

****

TOTAL RAINFALL = 3.20, TOTAL LOSS = 2.21, TOTAL EXCESS = .99

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 302.	4.75		53.	44.	44.	44.
		(INCHES)	.980	.980	.980	.980
		(AC-FT)	26.	26.	26.	26.

CUMULATIVE AREA = .50 SQ MI

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		302.	4.75	53.	44.	44.	.50		

*** NORMAL END OF HEC-1 ***

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            FEBRUARY 1981          *
*          REVISED 01 JUN 88        *
*                                   *
* RUN DATE  04/26/1991  TIME  16:05:51 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                    HEC-1 INPUT                                    PAGE  1

      LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

        1           ID
        2           ID
        3           ID
        4           IT     15                   30
        5           IO      1

        6           KK
        7           KM   SUB-BASIN W2
        8           BA    .50
        9           IN     15
       10           PB   3.20
       11           PC    .000    .008    .016    .025    .033    .041    .050    .058    .066    .074
       12           PC    .087    .099    .118    .138    .216    .377    .834    .911    .931    .950
```

```
        13        PC   .962   .972   .983   .991  1.000
        14        LG   .00    .35   3.50    .25    .00
        15        UI   33.   122.   184.   306.   262.   177.   105.    48.    27.     9.
        16        UI    9.     0.     0.     0.     0.     0.     0.     0.     0.     0.
        17        UI    0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
        18        ZZ
1*************************************                                  *************************************
*                                   *                                  *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                *   U.S. ARMY CORPS OF ENGINEERS    *
*          FEBRUARY 1981            *                                * THE HYDROLOGIC ENGINEERING CENTER *
*        REVISED 01 JUN 88          *                                *        609 SECOND STREET          *
*                                   *                                *      DAVIS, CALIFORNIA 95616      *
* RUN DATE  04/26/1991  TIME  16:05:51 *                              *         (916) 551-1748            *
*                                   *                                *                                   *
*************************************                                  *************************************

  5 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          1  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  OSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NO         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME       0715  ENDING TIME
                 ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE   7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


          **************
          *            *
  6 KK    *            *
          *            *
          **************
                   SUB-BASIN W2

  9 IN        TIME DATA FOR INPUT TIME SERIES
                  JXMIN         15  TIME INTERVAL IN MINUTES
                 JXDATE     1    0  STARTING DATE
                 JXTIME          0  STARTING TIME
```

SUBBASIN RUNOFF DATA

8 BA SUBBASIN CHARACTERISTICS

TAREA .50 SUBBASIN AREA

PRECIPITATION DATA

10 PB STORM 3.20 BASIN TOTAL PRECIPITATION

11 PI INCREMENTAL PRECIPITATION PATTERN

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.02	.02	.08	.16	.46	.08	.02	.02	.01
.01	.01	.01	.01						

14 LG GREEN AND AMPT LOSS RATE

STRTL .00 STARTING LOSS

DTH .35 MOISTURE DEFICIT

PSIF 3.50 WETTING FRONT SUCTION

XKSAT .25 HYDRAULIC CONDUCTIVITY

RTIMP .00 PERCENT IMPERVIOUS AREA

14 UI INPUT UNITGRAPH, 11 ORDINATES, VOLUME = .99

33.0	122.0	184.0	306.0	262.0	177.0	105.0	48.0	27.0	9.0
9.0									

***

****

HYDROGRAPH AT STATION

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
								*								
1		0000	1	.00	.00	.00	0.	*	1		0345	16	.52	.17	.35	17.
1		0015	2	.03	.03	.00	0.	*	1		0400	17	1.46	.15	1.31	94.
1		0030	3	.03	.03	.00	0.	*	1		0415	18	.25	.14	.11	242.
1		0045	4	.03	.03	.00	0.	*	1		0430	19	.06	.06	.00	373.
1		0100	5	.03	.03	.00	0.	*	1		0445	20	.06	.06	.00	521.
1		0115	6	.03	.03	.00	0.	*	1		0500	21	.04	.04	.00	444.
1		0130	7	.03	.03	.00	0.	*	1		0515	22	.03	.03	.00	300.
1		0145	8	.03	.03	.00	0.	*	1		0530	23	.04	.04	.00	175.
1		0200	9	.03	.03	.00	0.	*	1		0545	24	.03	.03	.00	84.
1		0215	10	.03	.03	.00	0.	*	1		0600	25	.03	.03	.00	44.
1		0230	11	.04	.04	.00	0.	*	1		0615	26	.00	.00	.00	18.
1		0245	12	.04	.04	.00	0.	*	1		0630	27	.00	.00	.00	13.
1		0300	13	.06	.06	.00	0.	*	1		0645	28	.00	.00	.00	1.
1		0315	14	.06	.06	.00	0.	*	1		0700	29	.00	.00	.00	0.
1		0330	15	.25	.20	.05	2.	*	1		0715	30	.00	.00	.00	0.
								*								

****

TOTAL RAINFALL = 3.20, TOTAL LOSS = 1.38, TOTAL EXCESS = 1.82

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 521.	4.75		97.	80.	80.	80.
		(INCHES)	1.804	1.804	1.804	1.804
		(AC-FT)	48.	48.	48.	48.

CUMULATIVE AREA = .50 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		521.	4.75	97.	80.	80.	.50		

*** NORMAL END OF HEC-1 ***

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 04/26/1991 TIME 16:07:21 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX      XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1         ID
  2         ID
  3         ID
  4         IT     15                  30
  5         IO      1

  6         KK
  7         KM   SUB-BASIN W3
  8         BA    .50
  9         IN     15
 10         PB   3.20
 11         PC    .000    .008    .016    .025    .033    .041    .050    .058    .066    .074
 12         PC    .087    .099    .118    .138    .216    .377    .834    .911    .931    .950
```

```
13        PC   .962   .972   .983   .991  1.000
14        LG   .00    .15   12.40   .01    .00
15        UI   33.   122.   184.   306.   262.   177.   105.    48.    27.     9.
16        UI    9.     0.     0.     0.     0.     0.     0.     0.     0.     0.
17        UI    0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
18        ZZ
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE 04/26/1991 TIME 16:07:21 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
 5 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          1  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 OSCAL         0.  HYDROGRAPH PLOT SCALE

   IT        HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME        0000  STARTING TIME
                    NO         30  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     1    0  ENDING DATE
                NDTIME        0715  ENDING TIME
                 ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE   7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

```
         **************
         *            *
 6 KK    *            *
         *            *
         **************
                  SUB-BASIN W3

 9 IN        TIME DATA FOR INPUT TIME SERIES
                 JXMIN         15  TIME INTERVAL IN MINUTES
                JXDATE     1    0  STARTING DATE
                JXTIME          0  STARTING TIME
```

SUBBASIN RUNOFF DATA

8 BA SUBBASIN CHARACTERISTICS

TAREA .50 SUBBASIN AREA

PRECIPITATION DATA

10 PB STORM 3.20 BASIN TOTAL PRECIPITATION

11 PI INCREMENTAL PRECIPITATION PATTERN

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.02	.02	.08	.16	.46	.08	.02	.02	.01
.01	.01	.01	.01						

14 LG GREEN AND AMPT LOSS RATE

STRTL .00 STARTING LOSS

DTH .15 MOISTURE DEFICIT

PSIF 12.40 WETTING FRONT SUCTION

XKSAT .01 HYDRAULIC CONDUCTIVITY

RTIMP .00 PERCENT IMPERVIOUS AREA

14 UI INPUT UNITGRAPH, 11 ORDINATES, VOLUME = .99

33.0	122.0	184.0	306.0	262.0	177.0	105.0	48.0	27.0	9.0
9.0									

***

****

HYDROGRAPH AT STATION

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.52	.02	.50	75.
1		0015	2	.03	.03	.00	0.	1		0400	17	1.46	.02	1.45	182.
1		0030	3	.03	.03	.00	0.	1		0415	18	.25	.02	.23	370.
1		0045	4	.03	.03	.00	0.	1		0430	19	.06	.01	.05	524.
1		0100	5	.03	.03	.00	0.	1		0445	20	.06	.01	.05	672.
1		0115	6	.03	.03	.00	0.	1		0500	21	.04	.01	.02	582.
1		0130	7	.03	.03	.00	0.	1		0515	22	.03	.01	.02	409.
1		0145	8	.03	.03	.00	0.	1		0530	23	.04	.01	.02	259.
1		0200	9	.03	.03	.00	0.	1		0545	24	.03	.01	.01	145.
1		0215	10	.03	.02	.00	0.	1		0600	25	.03	.01	.02	88.
1		0230	11	.04	.02	.02	1.	1		0615	26	.00	.00	.00	51.
1		0245	12	.04	.02	.02	4.	1		0630	27	.00	.00	.00	37.
1		0300	13	.06	.02	.04	8.	1		0645	28	.00	.00	.00	19.
1		0315	14	.06	.02	.05	17.	1		0700	29	.00	.00	.00	11.
1		0330	15	.25	.02	.23	32.	1		0715	30	.00	.00	.00	6.

****

TOTAL RAINFALL = 3.20, TOTAL LOSS = .47, TOTAL EXCESS = 2.73

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 672.	4.75		145.	120.	120.	120.
		(INCHES)	2.704	2.704	2.704	2.704
		(AC-FT)	72.	72.	72.	72.

CUMULATIVE AREA = .50 SQ MI

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		672.	4.75	145.	120.	120.	.50		

*** NORMAL END OF HEC-1 ***

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 04/26/1991 TIME 16:09:09 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*     DAVIS, CALIFORNIA 95616       *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1         ID
  2         ID
  3         ID
  4         IT     15                  30
  5         IO      1

  6         KK
  7         KM   SUB-BASIN X1
  8         BA    2.80
  9         IN      15
 10         PB    3.14
 11         PC    .000    .009    .016    .025    .034    .042    .051    .059    .067    .076
 12         PC    .087    .100    .120    .163    .252    .451    .694    .837    .900    .938
```

```
        13        PC   .950   .963   .975   .988  1.000
        14        LG    .00    .35   2.40   1.20    .00
        15        UI    79.   107.   291.   390.   467.   565.   727.   988.   810.   660.
        16        UI   546.   445.   356.   235.   138.   129.    81.    72.    24.    24.
        17        UI    24.    24.    24.     0.     0.     0.     0.     0.     0.     0.
        18        UI     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
        19        ZZ
1*************************************                                  *************************************
*                                   *                                  *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                *   U.S. ARMY CORPS OF ENGINEERS    *
*           FEBRUARY 1981           *                                  * THE HYDROLOGIC ENGINEERING CENTER *
*         REVISED 01 JUN 88         *                                  *        609 SECOND STREET          *
*                                   *                                  *     DAVIS, CALIFORNIA 95616       *
* RUN DATE  04/26/1991  TIME  16:09:09 *                               *         (916) 551-1748            *
*                                   *                                  *                                   *
*************************************                                  *************************************
```

```
  5 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          1  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  OSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME        0000  STARTING TIME
                     NO         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME        0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE    7.25 HOURS

       ENGLISH UNITS
           DRAINAGE AREA        SQUARE MILES
           PRECIPITATION DEPTH  INCHES
           LENGTH, ELEVATION    FEET
           FLOW                 CUBIC FEET PER SECOND
           STORAGE VOLUME       ACRE-FEET
           SURFACE AREA         ACRES
           TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

```
          **************
          *            *
  6 KK    *            *
          *            *
          **************
                   SUB-BASIN X1

  9 IN        TIME DATA FOR INPUT TIME SERIES
                  JXMIN         15  TIME INTERVAL IN MINUTES
                 JXDATE     1    0  STARTING DATE
```

JXTIME 0 STARTING TIME

SUBBASIN RUNOFF DATA

8 BA SUBBASIN CHARACTERISTICS

TAREA 2.80 SUBBASIN AREA

PRECIPITATION DATA

10 PB STORM 3.14 BASIN TOTAL PRECIPITATION

11 PI INCREMENTAL PRECIPITATION PATTERN

.01	.01	.01	.01	.01	.01	.01	.01	.01	.01
.01	.02	.04	.09	.20	.24	.14	.06	.04	.01
.01	.01	.01	.01						

14 LG GREEN AND AMPT LOSS RATE

STRTL .00 STARTING LOSS

DTH .35 MOISTURE DEFICIT

PSIF 2.40 WETTING FRONT SUCTION

XKSAT 1.20 HYDRAULIC CONDUCTIVITY

RTIMP .00 PERCENT IMPERVIOUS AREA

14 UI INPUT UNITGRAPH, 23 ORDINATES, VOLUME = 1.00

79.0	107.0	291.0	390.0	467.0	565.0	727.0	988.0	810.0	660.0
546.0	445.0	356.0	235.0	138.0	129.0	81.0	72.0	24.0	24.0
24.0	24.0	24.0							

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HYDROGRAPH AT STATION

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	*	1		0345	16	.62	.54	.08	7.
1		0015	2	.03	.03	.00	0.	*	1		0400	17	.76	.46	.30	33.
1		0030	3	.02	.02	.00	0.	*	1		0415	18	.45	.43	.02	59.
1		0045	4	.03	.03	.00	0.	*	1		0430	19	.20	.20	.00	123.
1		0100	5	.03	.03	.00	0.	*	1		0445	20	.12	.12	.00	164.
1		0115	6	.03	.03	.00	0.	*	1		0500	21	.04	.04	.00	197.
1		0130	7	.03	.03	.00	0.	*	1		0515	22	.04	.04	.00	242.
1		0145	8	.03	.03	.00	0.	*	1		0530	23	.04	.04	.00	315.
1		0200	9	.03	.03	.00	0.	*	1		0545	24	.04	.04	.00	383.
1		0215	10	.03	.03	.00	0.	*	1		0600	25	.04	.04	.00	322.
1		0230	11	.03	.03	.00	0.	*	1		0615	26	.00	.00	.00	264.
1		0245	12	.04	.04	.00	0.	*	1		0630	27	.00	.00	.00	217.
1		0300	13	.06	.06	.00	0.	*	1		0645	28	.00	.00	.00	177.
1		0315	14	.14	.14	.00	0.	*	1		0700	29	.00	.00	.00	137.
1		0330	15	.28	.28	.00	0.	*	1		0715	30	.00	.00	.00	91.

****

TOTAL RAINFALL = 3.14, TOTAL LOSS = 2.73, TOTAL EXCESS = .41

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 383.	5.75		112.	93.	93.	93.
		(INCHES)	.372	.372	.372	.372
		(AC-FT)	55.	55.	55.	55.

CUMULATIVE AREA = 2.80 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		383.	5.75	112.	93.	93.	2.80		

*** NORMAL END OF HEC-1 ***

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE  04/26/1991  TIME  16:10:42 *
*                                   *
*************************************
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*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

   1          ID
   2          ID
   3          ID
   4          IT     15                  30
   5          IO      1

   6          KK
   7          KM   SUB-BASIN X2
   8          BA    2.80
   9          IN      15
  10          PB    3.14
  11          PC    .000    .009    .016    .025    .034    .042    .051    .059    .067    .076
  12          PC    .087    .100    .120    .163    .252    .451    .694    .837    .900    .938
```

```
          13        PC   .950   .963   .975   .988  1.000
          14        LG    .00    .35   3.50    .25    .00
          15        UI    79.   107.   291.   390.   467.   565.   727.   988.   810.   660.
          16        UI   546.   445.   356.   235.   138.   129.    81.    72.    24.    24.
          17        UI    24.    24.    24.     0.     0.     0.     0.     0.     0.     0.
          18        UI     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
          19        ZZ
1*************************************                                  *************************************
*                                   *                                  *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                *   U.S. ARMY CORPS OF ENGINEERS    *
*           FEBRUARY 1981           *                                  * THE HYDROLOGIC ENGINEERING CENTER *
*         REVISED 01 JUN 88         *                                  *        609 SECOND STREET          *
*                                   *                                  *      DAVIS, CALIFORNIA 95616      *
* RUN DATE  04/26/1991  TIME  16:10:42 *                               *         (916) 551-1748            *
*                                   *                                  *                                   *
*************************************                                  *************************************

  5 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          1  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  OSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NO         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME       0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


          *************
          *           *
  6 KK    *           *
          *           *
          *************
                  SUB-BASIN X2

  9 IN        TIME DATA FOR INPUT TIME SERIES
                  JXMIN         15  TIME INTERVAL IN MINUTES
                 JXDATE     1    0  STARTING DATE
```

```
                JXTIME          0  STARTING TIME

          SUBBASIN RUNOFF DATA

 8 BA        SUBBASIN CHARACTERISTICS
                 TAREA        2.80  SUBBASIN AREA

             PRECIPITATION DATA

10 PB            STORM        3.14  BASIN TOTAL PRECIPITATION

11 PI          INCREMENTAL PRECIPITATION PATTERN
                 .01      .01      .01      .01      .01      .01      .01      .01      .01      .01
                 .01      .02      .04      .09      .20      .24      .14      .06      .04      .01
                 .01      .01      .01      .01

14 LG        GREEN AND AMPT LOSS RATE
                 STRTL         .00  STARTING LOSS
                   DTH         .35  MOISTURE DEFICIT
                  PSIF        3.50  WETTING FRONT SUCTION
                 XKSAT         .25  HYDRAULIC CONDUCTIVITY
                 RTIMP         .00  PERCENT IMPERVIOUS AREA

14 UI        INPUT UNITGRAPH,  23 ORDINATES,  VOLUME = 1.00
                 79.0     107.0     291.0     390.0     467.0     565.0     727.0     988.0     810.0     660.0
                546.0     445.0     356.0     235.0     138.0     129.0      81.0      72.0      24.0      24.0
                 24.0      24.0      24.0

                                                   ***
```

****

HYDROGRAPH AT STATION

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.62	.16	.46	46.
1		0015	2	.03	.03	.00	0.	1		0400	17	.76	.14	.62	125.
1		0030	3	.02	.02	.00	0.	1		0415	18	.45	.13	.32	261.
1		0045	4	.03	.03	.00	0.	1		0430	19	.20	.13	.07	443.
1		0100	5	.03	.03	.00	0.	1		0445	20	.12	.12	.00	608.
1		0115	6	.03	.03	.00	0.	1		0500	21	.04	.04	.00	761.
1		0130	7	.03	.03	.00	0.	1		0515	22	.04	.04	.00	951.
1		0145	8	.03	.03	.00	0.	1		0530	23	.04	.04	.00	1193.
1		0200	9	.03	.03	.00	0.	1		0545	24	.04	.04	.00	1316.
1		0215	10	.03	.03	.00	0.	1		0600	25	.04	.04	.00	1220.
1		0230	11	.03	.03	.00	0.	1		0615	26	.00	.00	.00	1028.
1		0245	12	.04	.04	.00	0.	1		0630	27	.00	.00	.00	843.
1		0300	13	.06	.06	.00	0.	1		0645	28	.00	.00	.00	681.
1		0315	14	.14	.14	.00	0.	1		0700	29	.00	.00	.00	521.
1		0330	15	.28	.19	.09	7.	1		0715	30	.00	.00	.00	365.

****

TOTAL RAINFALL = 3.14, TOTAL LOSS = 1.58, TOTAL EXCESS = 1.56

	PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+	(CFS)	(HR)					
			(CFS)				
+	1316.	5.75		425.	351.	351.	351.
			(INCHES)	1.410	1.410	1.410	1.410
			(AC-FT)	211.	211.	211.	211.

CUMULATIVE AREA = 2.80 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		1316.	5.75	425.	351.	351.	2.80		

*** NORMAL END OF HEC-1 ***

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*          REVISED 01 JUN 88        *
*                                   *
* RUN DATE 04/26/1991 TIME 16:12:08 *
*                                   *
*************************************
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```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX      XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID
  2           ID
  3           ID
  4           IT     15                   30
  5           IO      1

  6           KK
  7           KM   SUB-BASIN X3
  8           BA    2.80
  9           IN      15
 10           PB    3.14
 11           PC    .000    .009    .016    .025    .034    .042    .051    .059    .067    .076
 12           PC    .087    .100    .120    .163    .252    .451    .694    .837    .900    .938
```

```
        13        PC   .950   .963   .975   .988  1.000
        14        LG   .00    .15   12.40   .01    .00
        15        UI   79.   107.   291.   390.   467.   565.   727.   988.   810.   660.
        16        UI   546.  445.   356.   235.   138.   129.   81.   72.   24.   24.
        17        UI   24.   24.    24.    0.     0.     0.     0.    0.    0.    0.
        18        UI   0.    0.     0.     0.     0.     0.     0.    0.    0.    0.
        19        ZZ
1*************************************                    *************************************
*                                   *                    *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                    *   U.S. ARMY CORPS OF ENGINEERS    *
*           FEBRUARY 1981           *                    * THE HYDROLOGIC ENGINEERING CENTER *
*         REVISED 01 JUN 88         *                    *        609 SECOND STREET          *
*                                   *                    *      DAVIS, CALIFORNIA 95616      *
* RUN DATE  04/26/1991  TIME  16:12:08 *                  *         (916) 551-1748            *
*                                   *                    *                                   *
*************************************                    *************************************
```

```
 5 IO        OUTPUT CONTROL VARIABLES
                 IPRNT          1  PRINT CONTROL
                 IPLOT          0  PLOT CONTROL
                 OSCAL         0.  HYDROGRAPH PLOT SCALE

  IT         HYDROGRAPH TIME DATA
                  NMIN         15  MINUTES IN COMPUTATION INTERVAL
                 IDATE     1    0  STARTING DATE
                 ITIME        0000  STARTING TIME
                    NO         30  NUMBER OF HYDROGRAPH ORDINATES
                NDDATE     1    0  ENDING DATE
                NDTIME        0715  ENDING TIME
                 ICENT         19  CENTURY MARK

            COMPUTATION INTERVAL     .25 HOURS
                 TOTAL TIME BASE    7.25 HOURS

      ENGLISH UNITS
          DRAINAGE AREA        SQUARE MILES
          PRECIPITATION DEPTH  INCHES
          LENGTH, ELEVATION    FEET
          FLOW                 CUBIC FEET PER SECOND
          STORAGE VOLUME       ACRE-FEET
          SURFACE AREA         ACRES
          TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

```
        **************
        *            *
 6 KK   *            *
        *            *
        **************
                 SUB-BASIN X3

 9 IN        TIME DATA FOR INPUT TIME SERIES
                 JXMIN         15  TIME INTERVAL IN MINUTES
                JXDATE     1    0  STARTING DATE
```

```
                    JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

 8 BA          SUBBASIN CHARACTERISTICS
                    TAREA        2.80  SUBBASIN AREA

               PRECIPITATION DATA

10 PB               STORM        3.14  BASIN TOTAL PRECIPITATION

11 PI            INCREMENTAL PRECIPITATION PATTERN
                     .01       .01       .01       .01       .01       .01       .01       .01       .01       .01
                     .01       .02       .04       .09       .20       .24       .14       .06       .04       .01
                     .01       .01       .01       .01

14 LG          GREEN AND AMPT LOSS RATE
                    STRTL         .00  STARTING LOSS
                      DTH         .15  MOISTURE DEFICIT
                     PSIF       12.40  WETTING FRONT SUCTION
                    XKSAT         .01  HYDRAULIC CONDUCTIVITY
                    RTIMP         .00  PERCENT IMPERVIOUS AREA

14 UI          INPUT UNITGRAPH,  23 ORDINATES,  VOLUME = 1.00
                    79.0      107.0      291.0      390.0      467.0      565.0      727.0      988.0      810.0      660.0
                   546.0      445.0      356.0      235.0      138.0      129.0       81.0       72.0       24.0       24.0
                    24.0       24.0       24.0

                                                   ***

*****************************************************************************************************************************

                                                HYDROGRAPH AT STATION

*****************************************************************************************************************************
                                                                  *
     DA MON HRMN  ORD    RAIN    LOSS  EXCESS    COMP Q          *     DA MON HRMN  ORD    RAIN    LOSS  EXCESS    COMP Q
                                                                  *
      1    0000    1     .00     .00     .00        0.           *      1    0345   16     .62     .02     .61      148.
      1    0015    2     .03     .03     .00        0.           *      1    0400   17     .76     .02     .75      293.
      1    0030    3     .02     .02     .00        0.           *      1    0415   18     .45     .02     .43      505.
      1    0045    4     .03     .03     .00        0.           *      1    0430   19     .20     .01     .18      771.
      1    0100    5     .03     .03     .00        0.           *      1    0445   20     .12     .01     .11     1035.
      1    0115    6     .03     .03     .00        0.           *      1    0500   21     .04     .01     .02     1294.
      1    0130    7     .03     .03     .00        0.           *      1    0515   22     .04     .01     .03     1576.
      1    0145    8     .03     .03     .00        0.           *      1    0530   23     .04     .01     .02     1857.
      1    0200    9     .03     .03     .00        0.           *      1    0545   24     .04     .01     .03     1989.
      1    0215   10     .03     .02     .00        0.           *      1    0600   25     .04     .01     .03     1881.
      1    0230   11     .03     .02     .01        2.           *      1    0615   26     .00     .00     .00     1655.
      1    0245   12     .04     .02     .02        4.           *      1    0630   27     .00     .00     .00     1411.
      1    0300   13     .06     .02     .04       11.           *      1    0645   28     .00     .00     .00     1159.
      1    0315   14     .14     .02     .12       27.           *      1    0700   29     .00     .00     .00      920.
      1    0330   15     .28     .02     .26       63.           *      1    0715   30     .00     .00     .00      697.
                                                                  *
*****************************************************************************************************************************

   TOTAL RAINFALL =    3.14, TOTAL LOSS =     .47, TOTAL EXCESS =    2.67

 PEAK FLOW    TIME                          MAXIMUM AVERAGE FLOW
                                      6-HR       24-HR      72-HR     7.25-HR
+  (CFS)      (HR)
                          (CFS)
+   1989.     5.75                   706.       585.       585.       585.
                          (INCHES)  2.345      2.345      2.345      2.345
                          (AC-FT)   350.       350.       350.       350.
```

CUMULATIVE AREA = 2.80 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		1989.	5.75	706.	585.	585.	2.80		

*** NORMAL END OF HEC-1 ***

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*           FEBRUARY 1981           *
*          REVISED 01 JUN 88        *
*                                   *
* RUN DATE  04/26/1991  TIME  16:13:29 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX         X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID
  2           ID
  3           ID
  4           IT     15                  30
  5           IO      1

  6           KK
  7           KM   SUB-BASIN Y1
  8           BA   16.00
  9           IN     15
 10           PB    2.97
 11           PC    .000    .015    .020    .030    .048    .063    .076    .090    .105    .119
 12           PC    .135    .152    .175    .222    .304    .472    .670    .796    .868    .912
```

```
          13        PC   .946   .960   .973   .987  1.000
          14        LG    .00    .35   2.40   1.20    .00
          15        UI   299.   299.   463.  1049.  1310.  1535.  1726.  1945.  2225.  2592.
          16        UI  3337.  3870.  3208.  2747.  2442.  2154.  1873.  1635.  1425.  1145.
          17        UI   805.   530.   507.   492.   313.   299.   264.    92.    92.    92.
          18        UI    92.    92.    92.    92.    92.     0.     0.     0.     0.     0.
          19        UI     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
          20        ZZ
1*************************************                                  *************************************
*                                   *                                  *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                *   U.S. ARMY CORPS OF ENGINEERS    *
*           FEBRUARY 1981           *                                *  THE HYDROLOGIC ENGINEERING CENTER *
*         REVISED 01 JUN 88         *                                *         609 SECOND STREET         *
*                                   *                                *      DAVIS, CALIFORNIA 95616      *
* RUN DATE  04/26/1991  TIME  16:13:29 *                              *          (916) 551-1748           *
*                                   *                                *                                   *
*************************************                                  *************************************

  5 IO         OUTPUT CONTROL VARIABLES
                    IPRNT          1  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    OSCAL         0.  HYDROGRAPH PLOT SCALE

   IT          HYDROGRAPH TIME DATA
                     NMIN         15  MINUTES IN COMPUTATION INTERVAL
                    IDATE     1    0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NO         30  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE     1    0  ENDING DATE
                   NDTIME       0715  ENDING TIME
                    ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL     .25 HOURS
                     TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


          *************
          *           *
  6 KK    *           *
          *           *
          *************
                   SUB-BASIN Y1

  9 IN         TIME DATA FOR INPUT TIME SERIES
                    JXMIN         15  TIME INTERVAL IN MINUTES
```

```
                JXDATE     1    0  STARTING DATE
                JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

  8 BA        SUBBASIN CHARACTERISTICS
                TAREA       16.00  SUBBASIN AREA

              PRECIPITATION DATA

 10 PB            STORM       2.97  BASIN TOTAL PRECIPITATION

 11 PI          INCREMENTAL PRECIPITATION PATTERN
                  .01      .00      .01      .02      .02      .01      .01      .01      .01      .02
                  .02      .02      .05      .08      .17      .20      .13      .07      .04      .03
                  .01      .01      .01      .01

 14 LG        GREEN AND AMPT LOSS RATE
                STRTL        .00  STARTING LOSS
                  DTH        .35  MOISTURE DEFICIT
                 PSIF       2.40  WETTING FRONT SUCTION
                XKSAT       1.20  HYDRAULIC CONDUCTIVITY
                RTIMP        .00  PERCENT IMPERVIOUS AREA

 14 UI        INPUT UNITGRAPH,  35 ORDINATES,  VOLUME = 1.00
                299.0    299.0    463.0   1049.0   1310.0   1535.0   1726.0   1945.0   2225.0   2592.0
               3337.0   3870.0   3208.0   2747.0   2442.0   2154.0   1873.0   1635.0   1425.0   1145.0
                805.0    530.0    507.0    492.0    313.0    299.0    264.0     92.0     92.0     92.0
                 92.0     92.0     92.0     92.0     92.0

                                                   ***

*****************************************************************************************************************

                                          HYDROGRAPH AT STATION

*****************************************************************************************************************
                                                     *
    DA MON HRMN  ORD    RAIN    LOSS  EXCESS    COMP Q    *    DA MON HRMN  ORD    RAIN    LOSS  EXCESS    COMP Q
                                                     *
     1   0000    1     .00     .00     .00        0.    *     1   0345   16     .50     .50     .00        1.
     1   0015    2     .04     .04     .00        0.    *     1   0400   17     .59     .46     .13       40.
     1   0030    3     .01     .01     .00        0.    *     1   0415   18     .37     .37     .00       41.
     1   0045    4     .03     .03     .00        0.    *     1   0430   19     .21     .21     .00       64.
     1   0100    5     .05     .05     .00        0.    *     1   0445   20     .13     .13     .00      142.
     1   0115    6     .04     .04     .00        0.    *     1   0500   21     .10     .10     .00      178.
     1   0130    7     .04     .04     .00        0.    *     1   0515   22     .04     .04     .00      208.
     1   0145    8     .04     .04     .00        0.    *     1   0530   23     .04     .04     .00      234.
     1   0200    9     .04     .04     .00        0.    *     1   0545   24     .04     .04     .00      264.
     1   0215   10     .04     .04     .00        0.    *     1   0600   25     .04     .04     .00      302.
     1   0230   11     .05     .05     .00        0.    *     1   0615   26     .00     .00     .00      352.
     1   0245   12     .05     .05     .00        0.    *     1   0630   27     .00     .00     .00      453.
     1   0300   13     .07     .07     .00        0.    *     1   0645   28     .00     .00     .00      521.
     1   0315   14     .14     .14     .00        0.    *     1   0700   29     .00     .00     .00      432.
     1   0330   15     .24     .24     .00        0.    *     1   0715   30     .00     .00     .00      371.
                                                     *
*****************************************************************************************************************

   TOTAL RAINFALL =    2.97, TOTAL LOSS =    2.83, TOTAL EXCESS =     .14

 PEAK FLOW    TIME                        MAXIMUM AVERAGE FLOW
                                     6-HR       24-HR      72-HR     7.25-HR
+  (CFS)      (HR)
                          (CFS)
+    521.     6.75                  142.       118.       118.       118.
                          (INCHES)  .083       .083       .083       .083
```

```
                    (AC-FT)      71.        71.        71.        71.

                    CUMULATIVE AREA =   16.00 SQ MI

1
                                          RUNOFF SUMMARY
                                     FLOW IN CUBIC FEET PER SECOND
                                   TIME IN HOURS,  AREA IN SQUARE MILES

                                 PEAK  TIME OF    AVERAGE FLOW FOR MAXIMUM PERIOD     BASIN   MAXIMUM   TIME OF
        OPERATION      STATION   FLOW   PEAK                                          AREA    STAGE   MAX STAGE
+                                                 6-HOUR     24-HOUR     72-HOUR

        HYDROGRAPH AT
+                                 521.   6.75       142.        118.        118.     16.00


*** NORMAL END OF HEC-1 ***
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 04/26/1991 TIME 16:14:53 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX      XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID
  2           ID
  3           ID
  4           IT     15                  30
  5           IO      1

  6           KK
  7           KM   SUB-BASIN Y2
  8           BA   16.00
  9           IN     15
 10           PB    2.97
 11           PC    .000    .015    .020    .030    .048    .063    .076    .090    .105    .119
 12           PC    .135    .152    .175    .222    .304    .472    .670    .796    .868    .912
```

```
        13        PC   .946   .960   .973   .987  1.000
        14        LG    .00    .35   3.50    .25    .00
        15        UI   299.   299.   463.  1049.  1310.  1535.  1726.  1945.  2225.  2592.
        16        UI  3337.  3870.  3208.  2747.  2442.  2154.  1873.  1635.  1425.  1145.
        17        UI   805.   530.   507.   492.   313.   299.   264.    92.    92.    92.
        18        UI    92.    92.    92.    92.    92.     0.     0.     0.     0.     0.
        19        UI     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
        20        ZZ
1*************************************                                  *************************************
*                                   *                                  *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                *   U.S. ARMY CORPS OF ENGINEERS    *
*           FEBRUARY 1981           *                                  * THE HYDROLOGIC ENGINEERING CENTER *
*         REVISED 01 JUN 88         *                                  *        609 SECOND STREET          *
*                                   *                                  *      DAVIS, CALIFORNIA 95616      *
* RUN DATE  04/26/1991  TIME  16:14:53 *                               *         (916) 551-1748            *
*                                   *                                  *                                   *
*************************************                                  *************************************

  5 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          1  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  OSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NO         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME       0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE    7.25 HOURS

       ENGLISH UNITS
           DRAINAGE AREA        SQUARE MILES
           PRECIPITATION DEPTH  INCHES
           LENGTH, ELEVATION    FEET
           FLOW                 CUBIC FEET PER SECOND
           STORAGE VOLUME       ACRE-FEET
           SURFACE AREA         ACRES
           TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


         *************
         *           *
  6 KK   *           *
         *           *
         *************
                   SUB-BASIN Y2

  9 IN        TIME DATA FOR INPUT TIME SERIES
                  JXMIN         15  TIME INTERVAL IN MINUTES
```

```
                JXDATE     1    0  STARTING DATE
                JXTIME          0  STARTING TIME

          SUBBASIN RUNOFF DATA

 8 BA        SUBBASIN CHARACTERISTICS
                TAREA       16.00  SUBBASIN AREA

             PRECIPITATION DATA

10 PB              STORM       2.97  BASIN TOTAL PRECIPITATION

11 PI          INCREMENTAL PRECIPITATION PATTERN
                 .01      .00      .01      .02      .02      .01      .01      .01      .01      .02
                 .02      .02      .05      .08      .17      .20      .13      .07      .04      .03
                 .01      .01      .01      .01

14 LG        GREEN AND AMPT LOSS RATE
                STRTL        .00  STARTING LOSS
                  DTH        .35  MOISTURE DEFICIT
                 PSIF       3.50  WETTING FRONT SUCTION
                XKSAT        .25  HYDRAULIC CONDUCTIVITY
                RTIMP        .00  PERCENT IMPERVIOUS AREA

14 UI        INPUT UNITGRAPH,  35 ORDINATES,  VOLUME = 1.00
               299.0    299.0    463.0   1049.0   1310.0   1535.0   1726.0   1945.0   2225.0   2592.0
              3337.0   3870.0   3208.0   2747.0   2442.0   2154.0   1873.0   1635.0   1425.0   1145.0
               805.0    530.0    507.0    492.0    313.0    299.0    264.0     92.0     92.0     92.0
                92.0     92.0     92.0     92.0     92.0

                                                   ***
```

****

HYDROGRAPH AT STATION

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.50	.15	.35	128.
1		0015	2	.04	.04	.00	0.	1		0400	17	.59	.14	.45	276.
1		0030	3	.01	.01	.00	0.	1		0415	18	.37	.13	.25	453.
1		0045	4	.03	.03	.00	0.	1		0430	19	.21	.12	.09	781.
1		0100	5	.05	.05	.00	0.	1		0445	20	.13	.12	.01	1199.
1		0115	6	.04	.04	.00	0.	1		0500	21	.10	.10	.00	1571.
1		0130	7	.04	.04	.00	0.	1		0515	22	.04	.04	.00	1877.
1		0145	8	.04	.04	.00	0.	1		0530	23	.04	.04	.00	2150.
1		0200	9	.04	.04	.00	0.	1		0545	24	.04	.04	.00	2448.
1		0215	10	.04	.04	.00	0.	1		0600	25	.04	.04	.00	2836.
1		0230	11	.05	.05	.00	0.	1		0615	26	.00	.00	.00	3397.
1		0245	12	.05	.05	.00	0.	1		0630	27	.00	.00	.00	3988.
1		0300	13	.07	.07	.00	0.	1		0645	28	.00	.00	.00	4182.
1		0315	14	.14	.14	.00	0.	1		0700	29	.00	.00	.00	3903.
1		0330	15	.24	.17	.08	23.	1		0715	30	.00	.00	.00	3462.

****

TOTAL RAINFALL = 2.97, TOTAL LOSS = 1.74, TOTAL EXCESS = 1.23

	PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+	4182.	6.75	(CFS)	1289.	1067.	1067.	1067.
			(INCHES)	.749	.749	.749	.749

```
                    (AC-FT)      639.       639.       639.       639.

                    CUMULATIVE AREA =   16.00 SQ MI

1
                                          RUNOFF SUMMARY
                                     FLOW IN CUBIC FEET PER SECOND
                                   TIME IN HOURS,  AREA IN SQUARE MILES

                                 PEAK  TIME OF    AVERAGE FLOW FOR MAXIMUM PERIOD     BASIN    MAXIMUM    TIME OF
        OPERATION      STATION   FLOW   PEAK                                          AREA     STAGE    MAX STAGE
+                                                 6-HOUR     24-HOUR     72-HOUR

        HYDROGRAPH AT
+                                4182.   6.75      1289.       1067.       1067.     16.00


 *** NORMAL END OF HEC-1 ***
```

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*           FEBRUARY 1981           *
*          REVISED 01 JUN 88        *
*                                   *
* RUN DATE  04/26/1991  TIME  16:16:10 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID
  2           ID
  3           ID
  4           IT     15                   30
  5           IO      1

  6           KK
  7           KM   SUB-BASIN Y3
  8           BA   16.00
  9           IN     15
 10           PB    2.97
 11           PC    .000    .015    .020    .030    .048    .063    .076    .090    .105    .119
 12           PC    .135    .152    .175    .222    .304    .472    .670    .796    .868    .912
```

```
        13        PC   .946   .960   .973   .987  1.000
        14        LG    .00    .15  12.40    .01    .00
        15        UI   299.   299.   463.  1049.  1310.  1535.  1726.  1945.  2225.  2592.
        16        UI  3337.  3870.  3208.  2747.  2442.  2154.  1873.  1635.  1425.  1145.
        17        UI   805.   530.   507.   492.   313.   299.   264.    92.    92.    92.
        18        UI    92.    92.    92.    92.    92.     0.     0.     0.     0.     0.
        19        UI     0.     0.     0.     0.     0.     0.     0.     0.     0.     0.
        20        ZZ
1*************************************                                  *************************************
*                                   *                                  *                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *                                *   U.S. ARMY CORPS OF ENGINEERS    *
*           FEBRUARY 1981           *                                 * THE HYDROLOGIC ENGINEERING CENTER *
*         REVISED 01 JUN 88         *                                 *         609 SECOND STREET         *
*                                   *                                 *      DAVIS, CALIFORNIA 95616      *
* RUN DATE  04/26/1991  TIME  16:16:10 *                              *         (916) 551-1748            *
*                                   *                                 *                                   *
*************************************                                 *************************************

  5 IO         OUTPUT CONTROL VARIABLES
                    IPRNT          1  PRINT CONTROL
                    IPLOT          0  PLOT CONTROL
                    QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT         HYDROGRAPH TIME DATA
                     NMIN         15  MINUTES IN COMPUTATION INTERVAL
                    IDATE     1    0  STARTING DATE
                    ITIME       0000  STARTING TIME
                       NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                   NDDATE     1    0  ENDING DATE
                   NDTIME       0715  ENDING TIME
                    ICENT         19  CENTURY MARK

                COMPUTATION INTERVAL     .25 HOURS
                    TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


          *************
          *           *
  6 KK    *           *
          *           *
          *************
                   SUB-BASIN Y3

  9 IN         TIME DATA FOR INPUT TIME SERIES
                    JXMIN         15  TIME INTERVAL IN MINUTES
```

```
                JXDATE     1    0  STARTING DATE
                JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

  8 BA        SUBBASIN CHARACTERISTICS
                  TAREA      16.00  SUBBASIN AREA

              PRECIPITATION DATA

 10 PB            STORM       2.97  BASIN TOTAL PRECIPITATION

 11 PI          INCREMENTAL PRECIPITATION PATTERN
                   .01       .00       .01       .02       .02       .01       .01       .01       .01       .02
                   .02       .02       .05       .08       .17       .20       .13       .07       .04       .03
                   .01       .01       .01       .01

 14 LG        GREEN AND AMPT LOSS RATE
                  STRTL        .00  STARTING LOSS
                    DTH        .15  MOISTURE DEFICIT
                   PSIF      12.40  WETTING FRONT SUCTION
                  XKSAT        .01  HYDRAULIC CONDUCTIVITY
                  RTIMP        .00  PERCENT IMPERVIOUS AREA

 14 UI        INPUT UNITGRAPH,  35 ORDINATES,  VOLUME = 1.00
                 299.0     299.0     463.0    1049.0    1310.0    1535.0    1726.0    1945.0    2225.0    2592.0
                3337.0    3870.0    3208.0    2747.0    2442.0    2154.0    1873.0    1635.0    1425.0    1145.0
                 805.0     530.0     507.0     492.0     313.0     299.0     264.0      92.0      92.0      92.0
                  92.0      92.0      92.0      92.0      92.0

                                                          ***
```

****

HYDROGRAPH AT STATION

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		0345	16	.50	.02	.48	623.
1		0015	2	.04	.04	.00	0.	1		0400	17	.59	.01	.57	954.
1		0030	3	.01	.01	.00	0.	1		0415	18	.37	.01	.36	1350.
1		0045	4	.03	.03	.00	0.	1		0430	19	.21	.01	.20	1917.
1		0100	5	.05	.04	.01	3.	1		0445	20	.13	.01	.12	2583.
1		0115	6	.04	.03	.01	6.	1		0500	21	.10	.01	.09	3208.
1		0130	7	.04	.03	.01	11.	1		0515	22	.04	.01	.03	3773.
1		0145	8	.04	.02	.02	23.	1		0530	23	.04	.01	.03	4329.
1		0200	9	.04	.02	.02	40.	1		0545	24	.04	.01	.03	4942.
1		0215	10	.04	.02	.02	60.	1		0600	25	.04	.01	.03	5628.
1		0230	11	.05	.02	.03	89.	1		0615	26	.00	.00	.00	6388.
1		0245	12	.05	.02	.03	125.	1		0630	27	.00	.00	.00	7077.
1		0300	13	.07	.02	.05	174.	1		0645	28	.00	.00	.00	7298.
1		0315	14	.14	.02	.12	254.	1		0700	29	.00	.00	.00	6976.
1		0330	15	.24	.02	.23	383.	1		0715	30	.00	.00	.00	6435.

****

TOTAL RAINFALL = 2.97, TOTAL LOSS = .49, TOTAL EXCESS = 2.48

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 7298.	6.75		2559.	2118.	2118.	2118.
		(INCHES)	1.487	1.487	1.487	1.487

(AC-FT) 1269. 1269. 1269. 1269.

CUMULATIVE AREA = 16.00 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		7298.	6.75	2559.	2118.	2118.	16.00		

*** NORMAL END OF HEC-1 ***

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 04/26/1991 TIME 16:17:31 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


```
LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1         ID
  2         ID
  3         ID
  4         IT     15                  30
  5         IO      1

  6         KK
  7         KM   SUB-BASIN Z1
  8         BA  100.00
  9         IN     15
 10         PB   2.58
 11         PC    .000    .021    .035    .051    .071    .088    .106    .126    .144    .162
 12         PC    .181    .203    .234    .283    .367    .501    .656    .771    .839    .887
```

13	PC	.926	.944	.963	.982	1.000					
14	LG	.00	.35	2.40	1.20	.00					
15	UI	561.	561.	561.	561.	561.	561.	561.	561.	561.	1587.
16	UI	1844.	1844.	2151.	2151.	2409.	2581.	2680.	2746.	2930.	3002.
17	UI	3148.	3206.	3309.	3452.	3552.	3688.	3893.	4062.	4213.	4326.
18	UI	4451.	4780.	5132.	5576.	6023.	6761.	6720.	7525.	7390.	6884.
19	UI	6392.	6045.	5744.	5481.	5249.	5044.	4861.	4698.	4552.	4421.
20	UI	4302.	4033.	3862.	3720.	3585.	3412.	3329.	3227.	2992.	2926.
21	UI	2746.	2720.	2581.	2512.	2151.	2151.	1742.	1613.	1613.	1266.
22	UI	993.	993.	993.	993.	967.	922.	922.	922.	922.	922.
23	UI	648.	561.	561.	561.	561.	561.	561.	561.	561.	343.
24	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	172.
25	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	172.
26	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	0.
27	UI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	UI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	ZZ										

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE 04/26/1991 TIME 16:17:31 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
  5 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          1  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NQ         30  NUMBER OF HYDROGRAPH ORDINATES
                 NQDATE     1    0  ENDING DATE
                 NQTIME       0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                   TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

```
            **************
            *            *
 6 KK       *            *
            *            *
            **************
                      SUB-BASIN Z1

 9 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN        15  TIME INTERVAL IN MINUTES
                   JXDATE     1   0  STARTING DATE
                   JXTIME         0  STARTING TIME

            SUBBASIN RUNOFF DATA

 8 BA          SUBBASIN CHARACTERISTICS
                    TAREA    100.00  SUBBASIN AREA

               PRECIPITATION DATA

10 PB               STORM      2.58  BASIN TOTAL PRECIPITATION

11 PI            INCREMENTAL PRECIPITATION PATTERN
                    .02      .01      .02      .02      .02      .02      .02      .02      .02      .02
                    .02      .03      .05      .08      .13      .16      .12      .07      .05      .04
                    .02      .02      .02      .02

14 LG          GREEN AND AMPT LOSS RATE
                   STRTL       .00  STARTING LOSS
                     DTH       .35  MOISTURE DEFICIT
                    PSIF      2.40  WETTING FRONT SUCTION
                   XKSAT      1.20  HYDRAULIC CONDUCTIVITY
                   RTIMP       .00  PERCENT IMPERVIOUS AREA

14 UI          INPUT UNITGRAPH, 119 ORDINATES,  VOLUME = 1.00
                  561.0    561.0    561.0    561.0    561.0    561.0    561.0    561.0    561.0   1587.0
                 1844.0   1844.0   2151.0   2151.0   2409.0   2581.0   2680.0   2746.0   2930.0   3002.0
                 3148.0   3206.0   3309.0   3452.0   3552.0   3688.0   3893.0   4062.0   4213.0   4326.0
                 4451.0   4780.0   5132.0   5576.0   6023.0   6761.0   6720.0   7525.0   7390.0   6884.0
                 6392.0   6045.0   5744.0   5481.0   5249.0   5044.0   4861.0   4698.0   4552.0   4421.0
                 4302.0   4033.0   3862.0   3720.0   3585.0   3412.0   3329.0   3227.0   2992.0   2926.0
                 2746.0   2720.0   2581.0   2512.0   2151.0   2151.0   1742.0   1613.0   1613.0   1266.0
                  993.0    993.0    993.0    993.0    967.0    922.0    922.0    922.0    922.0    922.0
                  648.0    561.0    561.0    561.0    561.0    561.0    561.0    561.0    561.0    343.0
                  172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0
                  172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0
                  172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0

                                                   ***

*****************************************************************************************************************

                                          HYDROGRAPH AT STATION

*****************************************************************************************************************
                                                                 *
   DA MON HRMN  ORD    RAIN    LOSS  EXCESS     COMP Q          *     DA MON HRMN  ORD    RAIN    LOSS  EXCESS     COMP Q
                                                                 *
    1    0000    1     .00     .00     .00         0.          *      1    0345   16     .35     .35     .00         0.
    1    0015    2     .05     .05     .00         0.          *      1    0400   17     .40     .40     .00         0.
    1    0030    3     .04     .04     .00         0.          *      1    0415   18     .30     .30     .00         0.
    1    0045    4     .04     .04     .00         0.          *      1    0430   19     .18     .18     .00         0.
    1    0100    5     .05     .05     .00         0.          *      1    0445   20     .12     .12     .00         0.
    1    0115    6     .04     .04     .00         0.          *      1    0500   21     .10     .10     .00         0.
    1    0130    7     .05     .05     .00         0.          *      1    0515   22     .05     .05     .00         0.
    1    0145    8     .05     .05     .00         0.          *      1    0530   23     .05     .05     .00         0.
    1    0200    9     .05     .05     .00         0.          *      1    0545   24     .05     .05     .00         0.
```

1	0215	10	.05	.05	.00	0.	*	1	0600	25	.05	.05	.00	0.
1	0230	11	.05	.05	.00	0.	*	1	0615	26	.00	.00	.00	0.
1	0245	12	.06	.06	.00	0.	*	1	0630	27	.00	.00	.00	0.
1	0300	13	.08	.08	.00	0.	*	1	0645	28	.00	.00	.00	0.
1	0315	14	.13	.13	.00	0.	*	1	0700	29	.00	.00	.00	0.
1	0330	15	.22	.22	.00	0.	*	1	0715	30	.00	.00	.00	0.
							*							

****

TOTAL RAINFALL = 2.58, TOTAL LOSS = 2.58, TOTAL EXCESS = .00

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 0.	.25		0.	0.	0.	0.
		(INCHES)	.000	.000	.000	.000
		(AC-FT)	0.	0.	0.	0.

CUMULATIVE AREA = 100.00 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		0.	.25	0.	0.	0.	100.00		

*** NORMAL END OF HEC-1 ***

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)  *
*            FEBRUARY 1981          *
*          REVISED 01 JUN 88        *
*                                   *
* RUN DATE  04/26/1991  TIME  16:18:52 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*          (916) 551-1748           *
*                                   *
*************************************
```

```
X    X  XXXXXXX  XXXXX         X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX       XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
1                                    HEC-1 INPUT                                    PAGE  1

      LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

        1           ID
        2           ID
        3           ID
        4           IT     15                   30
        5           IO      1

        6           KK
        7           KM   SUB-BASIN Z2
        8           BA  100.00
        9           IN     15
       10           PB    2.58
       11           PC    .000    .021    .035    .051    .071    .088    .106    .126    .144    .162
       12           PC    .181    .203    .234    .283    .367    .501    .656    .771    .839    .887
```

13	PC	.926	.944	.963	.982	1.000					
14	LG	.00	.35	3.50	.25	.00					
15	UI	561.	561.	561.	561.	561.	561.	561.	561.	561.	1587.
16	UI	1844.	1844.	2151.	2151.	2409.	2581.	2680.	2746.	2930.	3002.
17	UI	3148.	3206.	3309.	3452.	3552.	3688.	3893.	4062.	4213.	4326.
18	UI	4451.	4780.	5132.	5576.	6023.	6761.	6720.	7525.	7390.	6884.
19	UI	6392.	6045.	5744.	5481.	5249.	5044.	4861.	4698.	4552.	4421.
20	UI	4302.	4033.	3862.	3720.	3585.	3412.	3329.	3227.	2992.	2926.
21	UI	2746.	2720.	2581.	2512.	2151.	2151.	1742.	1613.	1613.	1266.
22	UI	993.	993.	993.	993.	967.	922.	922.	922.	922.	922.
23	UI	648.	561.	561.	561.	561.	561.	561.	561.	561.	343.
24	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	172.
25	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	172.
26	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	0.
27	UI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	UI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	ZZ										

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*          FEBRUARY 1981            *
*        REVISED 01 JUN 88          *
*                                   *
* RUN DATE 04/26/1991 TIME 16:18:52 *
*                                   *
*************************************
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*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*        609 SECOND STREET          *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
  5 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          1  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  QSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NO         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME       0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                  TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

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             **************
             *            *
 6 KK        *            *
             *            *
             **************
                       SUB-BASIN Z2

 9 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN        15  TIME INTERVAL IN MINUTES
                   JXDATE     1   0  STARTING DATE
                   JXTIME         0  STARTING TIME

            SUBBASIN RUNOFF DATA

 8 BA          SUBBASIN CHARACTERISTICS
                    TAREA    100.00  SUBBASIN AREA

               PRECIPITATION DATA

10 PB                STORM      2.58  BASIN TOTAL PRECIPITATION

11 PI            INCREMENTAL PRECIPITATION PATTERN
                    .02      .01      .02      .02      .02      .02      .02      .02      .02      .02
                    .02      .03      .05      .08      .13      .16      .12      .07      .05      .04
                    .02      .02      .02      .02

14 LG          GREEN AND AMPT LOSS RATE
                    STRTL       .00  STARTING LOSS
                      DTH       .35  MOISTURE DEFICIT
                     PSIF      3.50  WETTING FRONT SUCTION
                    XKSAT       .25  HYDRAULIC CONDUCTIVITY
                    RTIMP       .00  PERCENT IMPERVIOUS AREA

14 UI          INPUT UNITGRAPH, 119 ORDINATES,  VOLUME = 1.00
                  561.0    561.0    561.0    561.0    561.0    561.0    561.0    561.0    561.0   1587.0
                 1844.0   1844.0   2151.0   2151.0   2409.0   2581.0   2680.0   2746.0   2930.0   3002.0
                 3148.0   3206.0   3309.0   3452.0   3552.0   3688.0   3893.0   4062.0   4213.0   4326.0
                 4451.0   4780.0   5132.0   5576.0   6023.0   6761.0   6720.0   7525.0   7390.0   6884.0
                 6392.0   6045.0   5744.0   5481.0   5249.0   5044.0   4861.0   4698.0   4552.0   4421.0
                 4302.0   4033.0   3862.0   3720.0   3585.0   3412.0   3329.0   3227.0   2992.0   2926.0
                 2746.0   2720.0   2581.0   2512.0   2151.0   2151.0   1742.0   1613.0   1613.0   1266.0
                  993.0    993.0    993.0    993.0    967.0    922.0    922.0    922.0    922.0    922.0
                  648.0    561.0    561.0    561.0    561.0    561.0    561.0    561.0    561.0    343.0
                  172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0
                  172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0
                  172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0    172.0

                                                                  ***

*****************************************************************************************************************

                                                HYDROGRAPH AT STATION

*****************************************************************************************************************
                                                                  *
   DA MON HRMN  ORD    RAIN    LOSS  EXCESS     COMP Q           *     DA MON HRMN  ORD    RAIN    LOSS  EXCESS     COMP Q
                                                                  *
    1    0000    1     .00     .00     .00         0.           *      1    0345   16     .35     .14     .20      147.
    1    0015    2     .05     .05     .00         0.           *      1    0400   17     .40     .13     .27      297.
    1    0030    3     .04     .04     .00         0.           *      1    0415   18     .30     .13     .17      394.
    1    0045    4     .04     .04     .00         0.           *      1    0430   19     .18     .12     .06      425.
    1    0100    5     .05     .05     .00         0.           *      1    0445   20     .12     .11     .01      430.
    1    0115    6     .04     .04     .00         0.           *      1    0500   21     .10     .10     .00      430.
    1    0130    7     .05     .05     .00         0.           *      1    0515   22     .05     .05     .00      430.
    1    0145    8     .05     .05     .00         0.           *      1    0530   23     .05     .05     .00      430.
    1    0200    9     .05     .05     .00         0.           *      1    0545   24     .05     .05     .00      491.
```

1	0215	10	.05	.05	.00	0.	*	1	0600	25	.05	.05	.00	715.
1	0230	11	.05	.05	.00	0.	*	1	0615	26	.00	.00	.00	1042.
1	0245	12	.06	.06	.00	0.	*	1	0630	27	.00	.00	.00	1305.
1	0300	13	.08	.08	.00	0.	*	1	0645	28	.00	.00	.00	1469.
1	0315	14	.13	.13	.00	0.	*	1	0700	29	.00	.00	.00	1590.
1	0330	15	.22	.16	.06	33.	*	1	0715	30	.00	.00	.00	1708.
							*							

****

TOTAL RAINFALL = 2.58, TOTAL LOSS = 1.81, TOTAL EXCESS = .77

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 1708.	7.25		437.	362.	362.	362.
		(INCHES)	.041	.041	.041	.041
		(AC-FT)	217.	217.	217.	217.

CUMULATIVE AREA = 100.00 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		1708.	7.25	437.	362.	362.	100.00		

*** NORMAL END OF HEC-1 ***

```
1****************************************
*                                      *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*            FEBRUARY 1981             *
*          REVISED 01 JUN 88           *
*                                      *
* RUN DATE  04/26/1991  TIME  16:20:08 *
*                                      *
****************************************
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****************************************
*                                      *
*   U.S. ARMY CORPS OF ENGINEERS       *
* THE HYDROLOGIC ENGINEERING CENTER    *
*          609 SECOND STREET           *
*       DAVIS, CALIFORNIA 95616        *
*          (916) 551-1748              *
*                                      *
****************************************
```

```
X    X  XXXXXXX  XXXXX        X
X    X  X      X    X       XX
X    X  X      X            X
XXXXXXX  XXXX   X      XXXXX  X
X    X  X      X            X
X    X  X      X    X       X
X    X  XXXXXXX  XXXXX      XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

1 HEC-1 INPUT PAGE 1

```
LINE        ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1         ID
  2         ID
  3         ID
  4         IT     15                  30
  5         IO      1

  6         KK
  7         KM   SUB-BASIN Z3
  8         BA  100.00
  9         IN     15
 10         PB    2.58
 11         PC    .000    .021    .035    .051    .071    .088    .106    .126    .144    .162
 12         PC    .181    .203    .234    .283    .367    .501    .656    .771    .839    .887
```

13	PC	.926	.944	.963	.982	1.000					
14	LG	.00	.15	12.40	.01	.00					
15	UI	561.	561.	561.	561.	561.	561.	561.	561.	561.	1587.
16	UI	1844.	1844.	2151.	2151.	2409.	2581.	2680.	2746.	2930.	3002.
17	UI	3148.	3206.	3309.	3452.	3552.	3688.	3893.	4062.	4213.	4326.
18	UI	4451.	4780.	5132.	5576.	6023.	6761.	6720.	7525.	7390.	6884.
19	UI	6392.	6045.	5744.	5481.	5249.	5044.	4861.	4698.	4552.	4421.
20	UI	4302.	4033.	3862.	3720.	3585.	3412.	3329.	3227.	2992.	2926.
21	UI	2746.	2720.	2581.	2512.	2151.	2151.	1742.	1613.	1613.	1266.
22	UI	993.	993.	993.	993.	967.	922.	922.	922.	922.	922.
23	UI	648.	561.	561.	561.	561.	561.	561.	561.	561.	343.
24	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	172.
25	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	172.
26	UI	172.	172.	172.	172.	172.	172.	172.	172.	172.	0.
27	UI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	UI	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	ZZ										

```
1*************************************
*                                   *
*  FLOOD HYDROGRAPH PACKAGE (HEC-1) *
*           FEBRUARY 1981           *
*         REVISED 01 JUN 88         *
*                                   *
* RUN DATE 04/26/1991 TIME 16:20:08 *
*                                   *
*************************************
```

```
*************************************
*                                   *
*   U.S. ARMY CORPS OF ENGINEERS    *
* THE HYDROLOGIC ENGINEERING CENTER *
*         609 SECOND STREET         *
*      DAVIS, CALIFORNIA 95616      *
*         (916) 551-1748            *
*                                   *
*************************************
```

```
  5 IO        OUTPUT CONTROL VARIABLES
                  IPRNT          1  PRINT CONTROL
                  IPLOT          0  PLOT CONTROL
                  OSCAL         0.  HYDROGRAPH PLOT SCALE

   IT         HYDROGRAPH TIME DATA
                   NMIN         15  MINUTES IN COMPUTATION INTERVAL
                  IDATE     1    0  STARTING DATE
                  ITIME       0000  STARTING TIME
                     NO         30  NUMBER OF HYDROGRAPH ORDINATES
                 NDDATE     1    0  ENDING DATE
                 NDTIME       0715  ENDING TIME
                  ICENT         19  CENTURY MARK

              COMPUTATION INTERVAL     .25 HOURS
                  TOTAL TIME BASE    7.25 HOURS

        ENGLISH UNITS
            DRAINAGE AREA        SQUARE MILES
            PRECIPITATION DEPTH  INCHES
            LENGTH, ELEVATION    FEET
            FLOW                 CUBIC FEET PER SECOND
            STORAGE VOLUME       ACRE-FEET
            SURFACE AREA         ACRES
            TEMPERATURE          DEGREES FAHRENHEIT
```

*** ***

```
            **************
            *            *
 6 KK       *            *
            *            *
            **************
                      SUB-BASIN Z3

 9 IN          TIME DATA FOR INPUT TIME SERIES
                    JXMIN          15  TIME INTERVAL IN MINUTES
                   JXDATE     1    0  STARTING DATE
                   JXTIME          0  STARTING TIME

            SUBBASIN RUNOFF DATA

 8 BA          SUBBASIN CHARACTERISTICS
                    TAREA      100.00  SUBBASIN AREA

               PRECIPITATION DATA

10 PB                STORM       2.58  BASIN TOTAL PRECIPITATION

11 PI            INCREMENTAL PRECIPITATION PATTERN
                    .02       .01       .02       .02       .02       .02       .02       .02       .02       .02
                    .02       .03       .05       .08       .13       .16       .12       .07       .05       .04
                    .02       .02       .02       .02

14 LG          GREEN AND AMPT LOSS RATE
                   STRTL        .00  STARTING LOSS
                     DTH        .15  MOISTURE DEFICIT
                    PSIF      12.40  WETTING FRONT SUCTION
                   XKSAT        .01  HYDRAULIC CONDUCTIVITY
                   RTIMP        .00  PERCENT IMPERVIOUS AREA

14 UI          INPUT UNITGRAPH, 119 ORDINATES,  VOLUME = 1.00
                 561.0     561.0     561.0     561.0     561.0     561.0     561.0     561.0     561.0    1587.0
                1844.0    1844.0    2151.0    2151.0    2409.0    2581.0    2680.0    2746.0    2930.0    3002.0
                3148.0    3206.0    3309.0    3452.0    3552.0    3688.0    3893.0    4062.0    4213.0    4326.0
                4451.0    4780.0    5132.0    5576.0    6023.0    6761.0    6720.0    7525.0    7390.0    6884.0
                6392.0    6045.0    5744.0    5481.0    5249.0    5044.0    4861.0    4698.0    4552.0    4421.0
                4302.0    4033.0    3862.0    3720.0    3585.0    3412.0    3329.0    3227.0    2992.0    2926.0
                2746.0    2720.0    2581.0    2512.0    2151.0    2151.0    1742.0    1613.0    1613.0    1266.0
                 993.0     993.0     993.0     993.0     967.0     922.0     922.0     922.0     922.0     922.0
                 648.0     561.0     561.0     561.0     561.0     561.0     561.0     561.0     561.0     343.0
                 172.0     172.0     172.0     172.0     172.0     172.0     172.0     172.0     172.0     172.0
                 172.0     172.0     172.0     172.0     172.0     172.0     172.0     172.0     172.0     172.0
                 172.0     172.0     172.0     172.0     172.0     172.0     172.0     172.0     172.0
```

***

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HYDROGRAPH AT STATION

****

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
								*								
1		0000	1	.00	.00	.00	0.	*	1		0345	16	.35	.01	.33	576.
1		0015	2	.05	.05	.00	0.	*	1		0400	17	.40	.01	.39	833.
1		0030	3	.04	.04	.00	0.	*	1		0415	18	.30	.01	.28	1030.
1		0045	4	.04	.04	.00	0.	*	1		0430	19	.18	.01	.16	1166.
1		0100	5	.05	.03	.02	10.	*	1		0445	20	.12	.01	.11	1282.
1		0115	6	.04	.03	.02	19.	*	1		0500	21	.10	.01	.09	1397.
1		0130	7	.05	.03	.02	31.	*	1		0515	22	.05	.01	.03	1513.
1		0145	8	.05	.02	.03	47.	*	1		0530	23	.05	.01	.04	1691.
1		0200	9	.05	.02	.03	61.	*	1		0545	24	.05	.01	.04	1978.

1	0215	10	.05	.02	.03	76.	*	1	0600	25	.05	.01	.03	2433.
1	0230	11	.05	.02	.03	94.	*	1	0615	26	.00	.00	.00	2977.
1	0245	12	.06	.02	.04	116.	*	1	0630	27	.00	.00	.00	3468.
1	0300	13	.08	.02	.06	151.	*	1	0645	28	.00	.00	.00	3870.
1	0315	14	.13	.02	.11	232.	*	1	0700	29	.00	.00	.00	4242.
1	0330	15	.22	.02	.20	365.	*	1	0715	30	.00	.00	.00	4607.
							*							

****

TOTAL RAINFALL = 2.58, TOTAL LOSS = .50, TOTAL EXCESS = 2.08

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	7.25-HR
+ (CFS)	(HR)					
		(CFS)				
+ 4607.	7.25		1331.	1102.	1102.	1102.
		(INCHES)	.124	.124	.124	.124
		(AC-FT)	660.	660.	660.	660.

CUMULATIVE AREA = 100.00 SQ MI

1

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT		4607.	7.25	1331.	1102.	1102.	100.00		

*** NORMAL END OF HEC-1 ***

Rec'd from S.D. Waters
23 Aug 91

LOGARTHMIC AREAL AVERAGING OF THE GREEN & AMPT SATURATED HYDRAULIC CONDUCTIVITY PARAMETER (XKSAT) ON FOUR DESERT WATERSHEDS IN MARICOPA COUNTY, ARIZONA

Purpose

The Green & Ampt loss rate method is currently recommended for use in hydrologic analyses by the Hydrologic Design Manual for Maricopa County (manual). The established procedure for developing the average saturated hydraulic conductivity parameter (XKSAT) for a subbasin involves linear (arithmetic) averaging of first the conductivity for each soil texture within a soil map unit, then for the various map units within a subbasin. The Wetting Front Capillary Suction (PSIF) and Volumetric Soil Moisture Deficit (DTHETA) values for the subbasin are then chosen from a graph (Figure 1) based on the average XKSAT.

Users of the manual have expressed concern with the present method. Subbasin average parameters seem to be biased toward higher infiltration rates when soils of high conductivity (say a loamy sand, XKSAT = 1.20 in/hr) are averaged with soils of low conductivity (say a sandy clay loam, XKSAT = 0.06 in/hr). Since some research in this area has already been done (Sabol, 1991; Van Mullen, 1989) this paper will investigate the results of logarithmically averaging the XKSAT parameter, within both the map unit and the subbasin.

Procedure

Four subbasins, ranging in size from 0.42 to 9.78 square miles were chosen for this analysis, without regard to the types of soils they contained. The subbasins were part of previous hydrologic analyses by the Flood Control District and Burgess & Niple, with soil map unit percentages already delineated. All subbasins are located within the boundaries of the Soil

Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona, because it contains the most detailed soil texture data of the three available soil surveys in Maricopa County.

Map units (designated by numbers) were described for each subbasin. XKSAT values for each major and minor soil were assigned from Appendix A in the manual. Each minor soil was given equal weight in the averaging process. Two average XKSAT values were calculated for each map unit, one using the arithmetic average of the individual XKSATs times the partial areas, and one using the log of the individual XKSATs times the partial areas, with the antilog taken at the end of the calculation. At this point, the average XKSAT value for the subbasin was calculated in four ways:

1. A/A - (Arithmetic/Arithmetic): The arithmetically averaged map unit XKSAT values are averaged arithmetically (this procedure is currently recommended by the manual).
2. A/L - (Arithmetic/Log): The logarithmically averaged map unit XKSAT values are averaged arithmetically.
3. L/A - (Log/Arithmetic): The arithmetically averaged map unit XKSAT values are averaged logarithmically.
4. L/L - (Log/Log): The logarithmically averaged map unit XKSAT values are averaged logarithmically.

Appendix 1 contains all of the calculations used in the averaging process.

To develop the Modeled Runoff quantities, values of PSIF and DTHETA (dry) were read from Figure 1 for each of the four XKSAT values, and the loss parameters became input to an HEC-1 model for each subbasin on the LG card. Table 2 lists the loss parameters for the different subbasins and methods of areal averaging. Also included in the HEC-1 input were the following constants:

1. 6-hour rainfall from the manual, pattern number and areal reduction are based on the area of each subbasin.

2. A rainfall depth of 3 inches (a typical 100-year, 6-hour design rainfall depth in Maricopa County).

3. A five-minute hydrograph timestep.

The model was run four times for each subbasin, and after each run the value of total excess rainfall was converted to a runoff volume in acre-feet. The Modeled Runoff values are listed in Table 1.

As a comparison to the Modeled Runoff values, an attempt was made to quantify the Expected Runoff volume for each watershed by separating the soil textures, running an HEC-1 model for each using the same constant inputs, then summing the totals. A key assumption here is that all the individual soil textures contribute runoff to the outlet, i.e. runoff from an area of clay loam does not traverse an area of sandy loam and infiltrate en-route. This seems to be a reasonable assumption for low frequency design rainfall events because rainfall rates are generally greater than saturated conductivity rates and soils are nearly saturated at the point in the storm when large quantities of runoff begin. The Expected Runoff values are listed in Table 1.

Results

The results of the HEC-1 analyses are presented in Table 1.

Conclusions (from Table 1)

1. The present method of arithmetically averaging the XKSAT parameter (A/A) generally results in a large (12-31%) underestimation of the true runoff volume. Since rainfall excess is underestimated, the time of

concentration parameter in the Clark Unit Hydrograph method will be overestimated, resulting in underestimation of the peak discharge.

2. The Log/Log (L/L) method of averaging XKSAT seems to yield the best results when compared to the Expected Runoff, even for large basins and differing soil texture compositions.

Recommendations

If the Youngtown and Tucson Arroyo testing by GVS yields similar results, incorporate the Log/Log method of areal averaging the XKSAT parameter into the Hydrologic Design Manual. Include a detailed example of the procedure in the manual. Provide the weighted XKSAT values for each map unit in Appendicies similar to the current ones using the procedures developed herein. Provide guidance on developing an alternative map unit XKSAT for small drainage areas which might be dominated by one or more major or minor soils or a particular geomorphic regime.

TABLE 1

SUMMARY OF LOG AREAL AVERAGING TESTING RESULTS

SUBBASIN NUMBER	AREA (sq.mi)	DOMINANT SOIL TEXTURES (approx. percentage)	EXPECTED RUNOFF (ac-ft)	MODELED RUNOFF (% error) (ac-ft)			
				A/A	A/L	L/A	L/L
LD4	0.42	Sandy Loam (45) Sandy Clay Loam (39) Loamy Sand (13)	32.1	28.2 (-12.1)	30.2 (-5.9)	30.5 (-5.0)	32.5 (+1.2)
CF5	1.12	Sandy Clay Loam (65) Sandy Loam (28)	91.4	77.2 (-15.5)	86.8 (-5.0)	77.2 (-15.5)	87.4 (-4.4)
JR6	6.74	Sandy Loam (70) Sandy Clay Loam (11) Loamy Sand (11)	296.	262. (-11.5)	291. (-1.7)	266. (-10.1)	306. (+3.4)
TW8	9.78	Sandy Clay Loam (37) Sandy Loam (34) Loamy Sand (26)	461.	318. (-31.0)	386. (-16.3)	412. (-10.6)	475. (+3.0)
		Average Error (absolute value) ---------->		17.5 %	7.2 %	10.3 %	3.0 %

TABLE 2

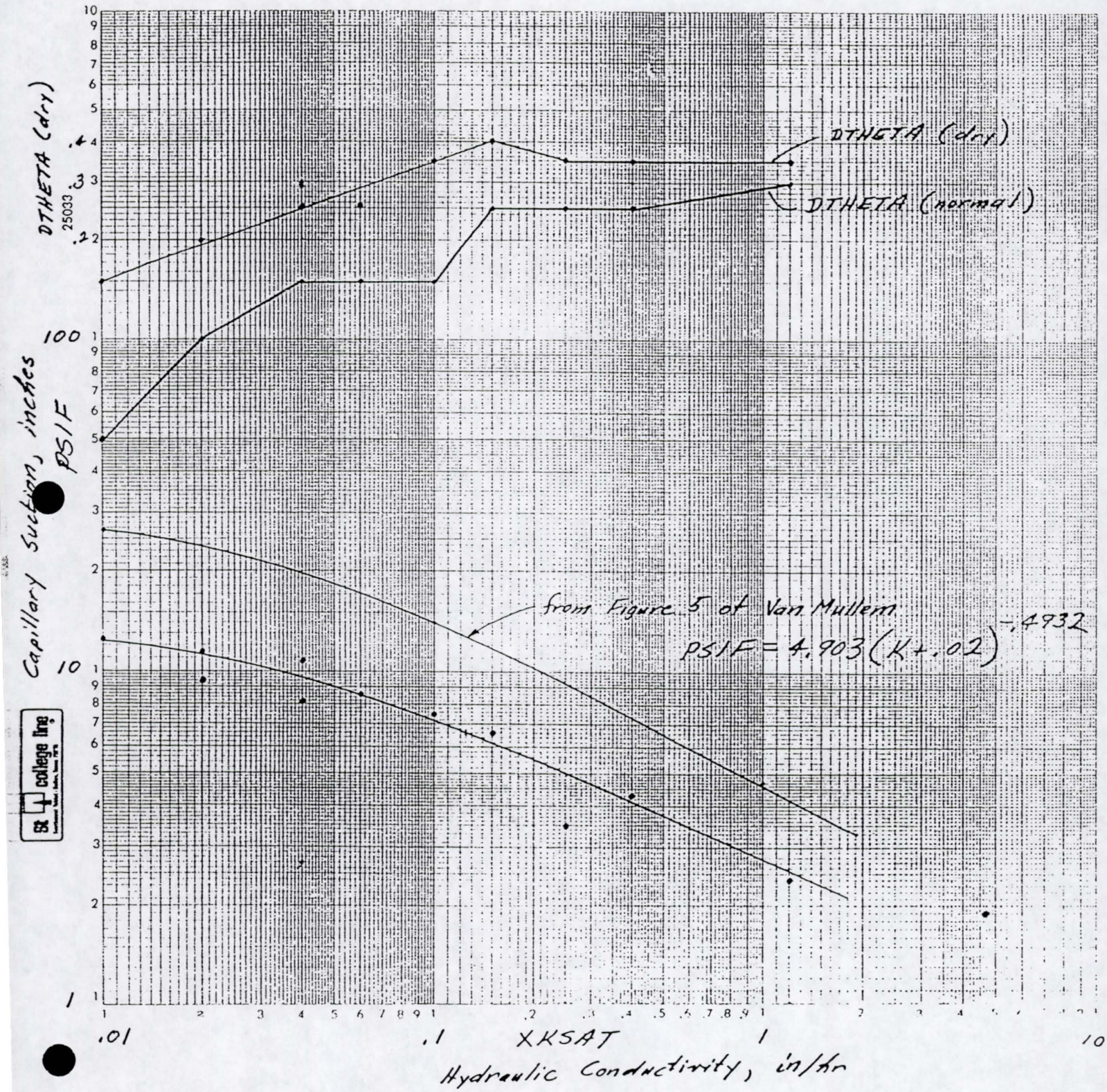
SUBBASIN LOSS PARAMETERS

Subbasin	Averaging Method (subbasin/map unit)	XKSAT (in/hr)	PSIF (in)	DTHETA (in)
LD4	A/A	.367	4.30	.350
	A/L	.301	4.65	.350
	L/A	.295	4.70	.350
	L/L	.217	5.35	.365
CF5	A/A	.234	5.20	.355
	A/L	.127	6.55	.380
	L/A	.232	5.20	.360
	L/L	.125	6.60	.375
JR6	A/A	.431	3.95	.350
	A/L	.362	4.30	.350
	L/A	.423	4.00	.350
	L/L	.344	4.30	.350
TW8	A/A	.476	3.85	.350
	A/L	.370	4.25	.350
	L/A	.337	4.40	.350
	L/L	.260	4.95	.350

am Vg
25 April 91

FIGURE 1

Comparison of XKSAT vs PSIF from Table 4.2 and the relation by Van Mullem (1989)



Logarithmic 3 X 3 Cycles

APPENDIX 1

LOST DOG #4

AREA = 0.42 mi^2

MAP UNITS:			
#10	13.3%	=	.056 mi^2
#31	34.0%	=	.143 mi^2
#44	9.6%	=	.040 mi^2
#52	43.1%	=	.181 mi^2

SOIL DESCRIPTIONS:

#10 Brios - Carrizo Complex			XKSAT
40%	Brios Loamy Sand		1.20
40%	Carrizo Sand		1.20
20%	Antho (5%)	Benches	.40
	Gilman (5%)	Benches	.25
	Maripo (5%)	Benches	.40
	Vint (5%)	Benches	.40

XKSAT (ARITH) = .80(1.2) + .15(.40) + .05(.25) = 1.033 in/hr

XKSAT (Log) = [.8(log 1.2) + .15(log .40) + .05(log .25)] ALOG = 0.941 in/hr

#31 DIXALETA COMPLEX			XKSAT
84.6%	Dixaleta Extremely Channery Sandy Loam		.40
15.4%	Ohaco (2.567% ea.)	FAN Terraces	.06
	Nickel (2.567% ea.)	FAN Terraces	.40
	Cave (2.567% ea.)	FAN Terraces	.25
	Eba (2.567% ea.)	FAN Terraces	.40
	Gran (2.567% ea.)	Mtn. Slopes	.06
	Lehmans (2.567% ea.)	Mtn. Slopes	.06

XKSAT (ARITH) = .89734 (.40) + .02567(.25) + .07701(.06) = .370 in/hr

XKSAT (Log) = Alog [.89734(log .40) + .02567(log .25) + .07701(log .06)] = .341 in/hr

# 44 EBON VERY GRAVELLY LOAM			XKSAT
80%	Ebon Sandy Clay Loam		.06
20%	Cipriano	(2.857% ea.) FAN TERRACES	.06
	Contine		.04
	Beardsley		.25
	Luke		.06
	Gunsight		.40
	MOHALL		.25
	Pinamt		.06

XKSAT (ARITH) = .02857(.40) + .05714 (.25) + .88571 (.06) + .02857 (.04) = .080 in/hr

XKSAT (Log) = ALOG [.02857 (log .40) + .05714 (log .25) + .88571 (log .06) + .02857 (log .04)] = .068 in/hr

#52 Gachado - Lomitas Complex			XKSAT
56.3%	Gachado Very Gravelly Sandy Clay Loam		.06
25%	Lomitas Gravelly Sandy Loam		.40
18.7%	Carrizo	(2.671% ea.) Fan Terraces	1.20
	Cherioni		1.20
	Ebon		.06
	Gunsight		.40
	Pinamt		.06
	Shenco	Hillslopes	.06
	Vaiva		.40

XKSAT = .05343 (1.20) + .30342 (.40) + .64313 (.06) = .224 in/hr

XKSAT (Log) = ALOG [.05343 (log 1.20) + .30342 (log .40) + .64313 (log .06)] = .125 in/hr

SUBBASIN RUNOFF FROM INDIVIDUAL SOIL TEXTURES

#10 → 13.3% OF Subbasin

Loamy Sand → 80% (13.3) = 10.64% OF Subbasin

Sandy Loam → 15% (13.3) = 1.995%

Loam → 5% (13.3) = 0.665%

#31 → 34.0% OF Subbasin

Sandy Loam → 89.734% (34) = 30.510% OF Subbasin

Loam → 2.567% (34) = 0.873%

Sandy Clay Loam → 7.701% (34) = 2.618%

#44 → 9.6% OF SUBBASIN

Sandy Loam → 2.857% (9.6) = .274% OF Subbasin

Loam → 5.714% (9.6) = .549%

Sandy Clay Loam → 88.571% (9.6) = 8.503%

Clay Loam → 2.857% (9.6) = .274%

#52 → 43.1% OF Subbasin

Loamy Sand → 5.343 (43.1) = 2.303% OF Subbasin

Sandy Loam → 30.342 (43.1) = 13.077%

Sandy Clay Loam → 64.313 (43.1) = 27.719%

TOTALS FOR THE SUBBASIN

Loamy Sand →	12.943%	=	.054 mi^2
Sandy Loam →	45.856%	=	.193 mi^2
Loam →	2.087%	=	.009 mi^2
Sandy Clay Loam →	38.840%	=	.163 mi^2
Clay Loam →	.274%	=	.001 mi^2
	100.000%		.420 mi^2

RUNOFF BY SOIL TEXTURE

LOAMY SAND (LD4LS.DAT)	P_e = .84 in	V = 2.419 ac-ft
Sandy Loam (LD4SL.DAT)	P_e = 1.21 in	V = 12.455 ac-ft
Loam (LD4L.DAT)	P_e = 1.53 in	V = .734 ac-ft
Sandy Clay Loam (LD4SCL.DAT)	P_e = 1.89 in	V = 16.430 ac-ft
Clay Loam (LD4CL.DAT)	P_e = 2.02 in	V = .108 ac-ft

TOTAL RUNOFF = 32.146 ac-ft

MODELED SUBBASIN RUNOFF

AVERAGED LOSSES: (XKSAT)

ARITH/ARITH : .133 (1.033) + .340(.370) + .096(.08) + .431(.224) = .367 in/hr

ARITH/Log : .133 (.941) + .340 (.341) + .096 (.068) + .431 (.125) = .301 in/hr

Log/ARITH : [.133 (log 1.033) + .340 (log .370) + .096 (log .08) + .431 (log .224)] ALOG

= .295 in/hr

Log/Log : [.133 (log .941) + .340 (log .341) + .096 (log .068) + .431 (log .125)] ALOG

= .217 in/hr

RUNS (Subbasin, Map Unit)

1. LD4AA.DAT XKSAT = .367 in/hr, PSIF = 4.3 in, $d\theta$ = .35 in
2. LD4AL.DAT XKSAT = .301 in/hr, PSIF = 4.65 in, $d\theta$ = .35 in
3. LD4LA.DAT XKSAT = .295 in/hr, PSIF = 4.7 in, $d\theta$ = .35 in
4. LD4LL.DAT XKSAT = .217 in/hr, PSIF = 5.35 in $d\theta$ = .365 in

RUN RESULTS

1. LD4AA.DAT	P_e = 1.26 in	V = 28.224 ac-ft
2. LD4AL.DAT	P_e = 1.35 in	V = 30.240 ac-ft
3. LD4LA.DAT	P_e = 1.36 in	V = 30.464 ac-ft
4. LD4LL.DAT	P_e = 1.45 in	V = 32.480 ac-ft

JACKRABBIT WASH #6D

AREA = 6.74 mi^2

MAP UNIT	% AREA		mi^2
#3	0.742	4.896	.05
#4	4.154		.28
#30	62.315		4.20
#56	4.599		.31
#91	2.671		.18
#99	2.671		.18
#108	0.593		.04
#117	22.255		1.50

SOIL DESCRIPTIONS

#s 3 & 4:	ANTHO - Carrizo - Maripo Complex		XKSAT
35%	ANTHO Sandy Loam		.40
30%	Carrizo Very Gravelly Sand		1.20
20%	Maripo Sandy Loam		.40
15%	BRIOS	Drainageways	1.20
	Gilman	Floodplains	.25
	Vint	Floodplains	.40
	Denure	Stream Terraces	.40
	Momoli	Stream Terraces	.40
	Carrizo	Stream Terraces	.40

(2.5% ea.)

XKSAT (ARITH) = .325(1.20) + .65(.40) + .025(.25) = 0.656 in/hr

XKSAT (Log) = ALOG[.325(log 1.20) + .65(log .40) + .025(log .25) = .565 in/hr

#30	DENURE - MOMOLI - Carrizo Complex		XKSAT
40%	DENURE Gravelly Sandy Loam		.40
30%	MOMOLI Gravelly Sandy Loam		.40
20%	Carrizo Gravelly Sandy Loam		.40
10%	GILMAN (3.33% ea.)	FLOODPLAINS	.25
	Maripo		.40
	Carrizo		1.20

XKSAT (ARITH) = .9333 (.40) + .0333 (.25) + .0333 (1.20) = .422 in/hr

XKSAT (Log) = [.9333 (log .40) + .0333 (log .25) + .0333 (log 1.20)] Alog = .408 in/hr

#56	GILMAN LOAMS		XKSAT
80%	GILMAN Loam		.25
20%	ANTHO	Drainageways	.40
	Carrizo		1.20
	ESTRELLA	Throughout	.25
	Glenbar (2.5% ea.)		.15
	Vint		.40
	Denure	Fan Terraces	.40
	Momoli		.40
	Carrizo		.40

XKSAT (ARITH) = .825(.25) + .125 (.40) + .025 (1.20) + .025 (.15) = .290 in/hr

XKSAT (Log) = Alog [.825 (log .25) + .125 (log .40) + .025 (log 1.20) + .025 (log .15)] = .272 in/hr

#91	Momoli - Carrizo Complex			XKSAT
45%	Momoli Very Gravelly Loam			.40
35%	Carrizo Very Gravelly Sandy Loam			1.20
20%	Mohall	(2.5% ea.)	High Terraces	.25
	Tremant			.40
	Gunsight			.06
	Chuckawalla			.06
	Denure		Throughout	.40
	GILMAN		Drainageways	.25
	Maripo			.40
	Carrizo			1.20

XKSAT (ARITH) = .375(1.20) + .525(.40) + .05(.25) + .05(.06) = .676 in/hr

XKSAT (Log) = ALOG[(.375(log 1.20) + .525(log .40) + .05(log .25) + .05(log .06)] = .537 in/hr

#99	Pinamt - Tremant Complex			XKSAT
45%	Pinamt Very Gravelly Sandy Clay Loam			.06
35%	Tremant Gravelly Loam			.40
20%	Carrizo		Drainageways	1.20
	Chuckawalla	(4% ea.)	FAN Terraces	.06
	Ebon			.06
	Gunsight			.40
	Rillito			.40

XKSAT (ARITH) = .04(1.2) + .43(.40) + .53(.06) = .252 in/hr

XKSAT (Log) = [.04 (log 1.2) + .43 (log .40) + .53 (log .06)] ALOG = .153 in/hr

#108	SHENCO COMPLEX			XKSAT
71.4 %	SHENCO			.06
28.6%	Antho		Drainageways	.40
	Beardsley	(2.86 % ea.)	Fan Terraces	.25
	Cherioni			.40
	Cipriano			.06
	Ebon			.06
	Gunsight			.40
	Sun City			.06
	Gachado		Hillslopes	.06
	Quilotosa		Throughout	1.20
	Vaiva			.40

XKSAT (ARITH) = .0286 (1.20) + .1144 (.40) + .0286 (.25) + .8284 (.06) = .137 in/hr

XKSAT (Log) = ALOG[.0286 (log 1.2) + .0858 (log .40) + .0286 (log .25) + .8284 (log .06)]
= .087 in/hr

# 117	TREMANT - GUNSIGHT - RILLITO COMPLEX			XKSAT
30%	Tremant			.06
20%	Gunsight			1.20
20%	RILLITO			.40
30%	Cipriano	(4.286 % ea.)	Terraces	.06
	Pinamt			.06
	Mohall			.25
	Contine			.04
	Antho		Alluvial Fans Drainageways	.40
	Carrizo			1.20
	GILMAN			.25

XKSAT (ARITH) = .24286 (1.2) + .24286 (.40) + .08572 (.25) + .38572 (.06) + .04286 (.04) = .435 in/hr

XKSAT (LOG) = ALOG[.24286 (log 1.2) + .24286 (log .40) + .08572 (log .25) + .38572 (log .06) + .04286 (log .04)] = .219 in/hr

SUBBASIN RUNOFF FROM INDIVIDUAL SOIL TEXTURES

JR6D

#3 & 4 → 4.9% of Subbasin

Loamy Sand → 32.5% (4.9) = 1.59% of Subbasin

Sandy Loam → 65% (4.9) = 3.19%

Loam → 2.5% (4.9) = 0.12%

#30 → 62.3% of SUBBASIN

Loamy Sand → 3.33% (62.3) = 2.07% of Subbasin

Sandy Loam → 93.33% (62.3) = 58.14%

Loam → 3.33% (62.3) = 2.07%

#56 4.6% of SUBBASIN

Loamy Sand → 2.5% (4.6) = 0.12% of Subbasin

Sandy Loam → 12.5% (4.6) = 0.58%

Loam → 82.5% (4.6) = 3.80%

SILTY Loam → 2.5% (4.6) = 0.12%

#91 2.7% of SUBBASIN

Loamy Sand → 37.5% (2.7) = 1.01% of Subbasin

Sandy Loam → 52.5% (2.7) = 1.42%

Loam → 5% (2.7) = .14%

Sandy Clay Loam → 5% (2.7) = .14%

#99 2.7% of SUBBASIN

Loamy Sand → 4% (2.7) = .11% of Subbasin

Sandy Loam → 43% (2.7) = 1.16%

Sandy Clay Loam → 53% (2.7) = 1.43%

#108 0.6 % of Subbasin

Loamy Sand → 2.86 % (.6) = .02 % of Subbasin
Sandy Loam → 11.44 % (.6) = .07 %
Loam → 2.86 % (.6) = .02 %
Sandy Clay Loam → 82.84% (.6) = .50 %

#117 22.3 % of Subbasin

Loamy Sand → 24.286%(22.3) = 5.42 % of Subbasin
Sandy Loam → 24.286%(22.3) = 5.42 %
Loam → 8.572%(22.3) = 1.91 %
Sandy Clay Loam → 38.572%(22.3) = 8.60 %
Clay Loam → 4.286% (22.3) = 0.96 %

TOTALS FOR THE SUBBASIN (A = 6.74 mi^2)

LOAMY SAND →	10.34 %	=	.697 mi^2
Sandy Loam →	69.98 %	=	4.717 mi^2
Loam →	8.06 %	=	.543 mi^2
SILTY Loam →	.12 %	=	.008 mi^2
Sandy Clay Loam →	10.67%	=	.719 mi^2
Clay Loam →	.96%	=	.065 mi^2
	100.13%		6.749 mi^2

RUNOFF BY SOIL TEXTURE

LOAMY SAND	(JRLS.DAT)	P_e = .14 in,	V = 5.20 ac-ft
SANDY LOAM	(JRSL.DAT)	P_e = .75	V = 188.68
LOAM	(JRL.DAT)	P_e = 1.12	V = 32.44
SILTY LOAM	(JRSLL.DAT)	P_e = 1.12	V = 0.48
SANDY Clay Loam	(JRSCL.DAT)	P_e = 1.64	V = 62.89
Clay Loams	(JRCL.DAT)	P_e = 1.81	V = 6.28

TOTAL RUNOFF = 295.97 ac-ft

MODELED SUBBASIN RUNOFF

AVERAGED LOSSES (XKSAT)

Subbasin Map Unit

ARITH / ARITH : .04896(.656) + .62315(.422) + .04599(.290) + .02671(.676) + .02671(.252) + .00593(.137) + .22255(.435) = .431 in/hr

PSIF = 3.95 in $d\theta$ = .35 in

ARITH / LOG : .04896(.565) + .62315(.408) + .04599(.272) + .02671(.537) + .02671(.153) + .00593(.087) + .22255(.219) = .362 in/hr

PSIF = 4.3 in $d\theta$ = .35 in

LOG / ARITH = ALOG[.04896(log .656) + .62315(log .422) + .04599(log .290) + .02671(log .676) + .02671(log .252) + .00593(log .137) + .22255(log .435)]

= .423 in/hr PSIF = 4.0 $d\theta$ = .35 in

LOG / LOG = ALOG[.04896(log .565) + .62315(log .408) + .04599(log .272) + .02671(log .537) + .02671(log .153) + .00593(log .087) + .22255(log .219)]

= .344 in/hr PSIF = 4.3 in $d\theta$ = .35 in

RUN RESULTS

	P_e (in)	V (ac-ft)
1. JRAA.DAT	.73	262.4
2. JRAL.DAT	.81	291.2
3. JRLA.DAT	.74	266.0
4. JRLL.DAT	.85	305.5

Carefree Subbasin #5

AGUILA - CAREFREE SOIL SURVEY

DRAINAGE AREA: 1.122 mi^2

MAP UNITS:

#41	3%	=	.034 mi^2
#61	4%	=	.045 mi^2
#63	21%	=	.236 mi^2
#72	72%	=	.808 mi^2

SOIL DESCRIPTIONS (MAP UNIT LOSSES)

#41 Eba - Pinaleno Complex

			XKSAT
45%	Eba very gravelly loam		.40
35%	Pinaleno very gravelly clay loam		.06
20%	Ohaco (5%)	THROUGHOUT	.04
	Tres Hermanos (5%)		.06
	ANTHONY (5%)	DRAINAGEWAYS	1.20
	ARIZO (5%)		1.20

XKSAT (ARITH) = .45(.40) + .40(.06) + .05(.04) + .10(1.20) = .326 in/hr

XKSAT (Log) = [.45(log .40) + .40(log .06) + .05(log .04) + .10(log 1.20)] ALOG

= .186 in/hr

#61

Gran - Wickenburg Complex, 1-10% SLOPES

40%	Gran very gravelly sandy clay loam		(.06)
35%	Wickenburg gravelly sandy loam		(.40)
25%	Eba (8⅓%)	Toe Slopes	(.40)
	Pinaleno (8⅓%)		(.06)
	Arizo (8⅓%)	Drainageways	(1.20)

XKSAT (Arith) = .483(.06) + .433(.40) + .083(1.20) = .302 in/hr

XKSAT (Log) = ALOG [.483(log .06) + .433(log .40) + .083(log 1.20)] = .175 in/hr

#63

Gran - Wickenburg Complex, 10-65% Slopes

40%	Gran very gravelly sandy clay loam			(.06)
33%	Wickenburg gravelly sandy loam			(.40)
27%	Dixaleta		Mtn Slopes	(.40)
	Lehmans			(.06)
	Eba	5.4% ea	Toe Slopes	(.40)
	Pinaleno			(.06)
	Arizo		Drainageways	(1.20)

XKSAT (ARITH) .438(.40) + .508 (.06) + .054 (1.20) = .270 in/hr

XKSAT (Log) ALOG [.438(log .40) + .508(log .06) + .054(log 1.20)] = .162 in/hr

#72 LEHMANS Complex

64%	Lehmans very gravelly clay loam			(.06)
36%	ARIZO		Drainageways	(1.20)
	Eba		foot slopes	(.40)
	Pinaleno	7.2% ea.		(.06)
	Greycagle		Gentle Slopes	(.40)
	Nickel			(.40)

XKSAT (ARITH) = .712(.06) + .072(1.20) + .216(.40) = .216 in/hr

XKSAT (Log) = ALOG [.712(log .06) + .072(log 1.2) + .216(log .40)] = .112 in/hr

CAREFREE #5 SUBBASIN LOSSES

1. ARITH / ARITH

$XKSAT = .03(.326) + .04(.302) + .21(.270) + .72(.216) = .234$ in/hr

2. ARITH / Log

$XKSAT = .03(.186) + .04(.175) + .21(.162) + .72(.112) = .127$ in/hr

3. Log / ARITH

$XKSAT = ALOG[.03(\log .326) + .04(\log .302) + .21(\log .270) + .72(\log .216)]$
$= .232$ in/hr

4. Log / Log

$XKSAT = ALOG[.03(\log .186) + .04(\log .175) + .21(\log .162) + .72(\log .112)]$
$= .125$ in/hr

---

1. CF5AA.DAT → XKSAT = .234 in/hr PSIF = 5.2 in $d\theta$ = .355 in
2. CF5AL.DAT → XKSAT = .127 in/hr PSIF = 6.55 in $d\theta$ = .38 in
3. CF5LA.DAT → XKSAT = .232 in/hr PSIF = 5.2 in $d\theta$ = .36 in
4. CF5LL.DAT → XKSAT = .125 in/hr PSIF = 6.6 in $d\theta$ = .375 in

TIGER WASH SUB 8

DRAINAGE AREA : 9.78 mi^2

SOIL SURVEY : Aguila - Carefree

MAP UNITS :	#19, 20	38.6 %	=	3.775 mi^2
	# 92	50.1 %	=	4.900 mi^2
	# 100	11.3 %	=	1.105 mi^2

SOIL DESCRIPTIONS (MAP UNIT LOSSES)

#19,20

CHUCKAWALLA - GUNSIGHT COMPLEX

				XKSAT
45%	CHUCKAWALLA Very Gravelly Sandy Clay Loam			.06
35%	GUNSIGHT Very Gravelly Loam			.06
20%	Sal	(2.857 % ea.)	FAN TERRACES	.06
	Pinamt			.06
	Tremant			.40
	RILLITO		Side Slopes	.40
	ANTHO		FLOODPLAINS	.40
	Gilman			.25
	Maripo			.40

XKSAT (ARITH) = .85714 (.06) + .114 (.40) + .02857 (.25) = .104 in/hr

XKSAT (LOG) = ALOG[.85714 (log .06) + .114 (log .40) + .02857 (log .25)] = .078 in/hr

92

MOMOLI - CARRIZO COMPLEX			XKSAT
45%	MOMOLI Very Gravelly Loam		.40
35%	CARRIZO Very Gravelly Sandy Loam		1.20
20%	MOHALL	High Terraces	.25
	Tremant		.40
	Gunsight		.06
	Chuckawalla		.06
	DENURE (2.5% each)	Throughout	.40
	GILMAN	Drainageways	.25
	Maripo		.40
	Carrizo		1.20

XKSAT (ARITH) = .375 (1.20) + .525 (.40) + .05 (.25) + .05 (.06) = .676 in/hr

XKSAT (Log) = ALOG[.375(log 1.2) + .525 (log .40) + .05 (log .25) + .05 (log .06)] = .537 in/hr

100

QUILOTOSA - VAIVA COMPLEX			XKSAT
62.5%	Quilotosa Extremely Gravelly Loam		1.20
25%	VAIVA Very gravelly Loam		.40
12.5%	Schenco	Mtn. Slopes	.06

XKSAT (ARITH) = .625 (1.20) + .25 (.40) + .125 (.06) = .858 in/hr

XKSAT (Log) = ALOG[.625 (log 1.20) + .25 (log .40) + .125 (log .06)] = .627 in/hr

TIGER WASH #8

SUBBASIN LOSSES

Subbasin / MAP UNIT

ARITH / ARITH

XKSAT = .386(.104) + .501(.676) + .113(.858) = .476 in/hr

ARITH / LOG

XKSAT = .386(.078) + .501(.537) + .113(.627) = .370 in/hr

LOG / ARITH

XKSAT = ALOG[.386(log .104) + .501(log .676) + .113(log .858)] = .337 in/hr

LOG / LOG

XKSAT = ALOG[.386(log .078) + .501(log .537) + .113(log .627)] = .260 in/hr

1. TWAA.DAT → XKSAT = .476 in/hr PSIF = 3.85 in dθ = .35 in
2. TWAL.DAT → XKSAT = .370 in/hr PSIF = 4.25 in dθ = .35 in
3. TWLA.DAT → XKSAT = .337 in/hr PSIF = 4.4 in dθ = .35 in
4. TWLL.DAT → XKSAT = .260 in/hr PSIF = 4.95 in dθ = .35 in

VOLUME RUNS

CAREFREE #5

HEC-1 MODEL :

RAINFALL → DEPTH = 3.0 in , IA = .25 in

DISTR. → 6-hour, Pattern based on 1.122 mi^2

RUNOFF FROM MAP UNITS

ARITH LOSSES

#41 →	(CF541A.DAT)	P_e = 1.17 in ,	V = 2.122 ac-ft
#61 →	(CF561A.DAT)	P_e = 1.20 in ,	V = 2.880 ac-ft
#63 →	(CF563A.DAT)	P_e = 1.24 in ,	V = 15.607 ac-ft
#72 →	(CF572A.DAT)	P_e = 1.30 in ,	V = 56.021 ac-ft

TOTAL RUNOFF = 76.630 ac-ft

LOG LOSSES

#41 →	(CF541L.DAT)	P_e = 1.34 in,	V = 2.430 ac-ft
#61 →	(CF561L.DAT)	P_e = 1.35 in,	V = 3.240 ac-ft
#63 →	(CF563L.DAT)	P_e = 1.37 in,	V = 17.240 ac-ft
#72 →	(CF572L.DAT)	P_e = 1.52 in,	V = 65.502 ac-ft

TOTAL RUNOFF = 88.412 ac-ft

SUBBASIN RUNOFF

(CF5AA.DAT)	P_e = 1.29 in,	V = 77.194 ac-ft
(CF5AL.DAT)	P_e = 1.45 in,	V = 86.768 ac-ft
(CF5LA.DAT)	P_e = 1.29 in,	V = 77.194 ac-ft
(CF5LL.DAT)	P_e = 1.46 in,	V = 87.366 ac-ft

MAP UNIT AVE.

Subbasin AVE.

SUBBASIN RUNOFF FROM INDIVIDUAL SOIL TEXTURES

#41 → 3% OF SUBBASIN

45%	Sandy Loam
40%	Sandy Clay Loam
10%	Loamy Sand
5%	Sandy Clay

% of Subbasin:

Loamy Sand → .10(3) = .3%

Sandy Loam → .45(3) = 1.35%

Sandy Clay Loam → .40(3) = 1.2%

Clay Loam → .05(3) = .15%

#61 → 4% OF SUBBASIN

8.33%	Loamy Sand
43.33%	Sandy Loam
48.33%	Sandy Clay Loam

% OF Subbasin:

Loamy Sand → .0833(4) = .333%

Sandy Loam → .4333(4) = 1.733%

Sandy Clay Loam → .4833(4) = 1.933%

#63 → 21% OF Subbasin

5.4%	Loamy Sand
43.8%	Sandy Loam
50.8%	Sandy Clay Loam

% OF SUBBASIN:

Loamy Sand → .054(21) = 1.134%

Sandy Loam → .438(21) = 9.198%

Sandy Clay Loam → .508(21) = 10.668%

#72 → 72% OF SUBBASIN

7.2% Loamy Sand
21.6% Sandy Loam
71.2% Sandy Clay Loam

% OF SUBBASIN:

Loamy Sand → .072 (72) = 5.184 %
Sandy Loam → .216 (72) = 15.552 %
Sandy Clay Loam → .712 (72) = 51.264 %

TOTALS FOR THE SUBBASIN

Loamy Sand →	6.951 %	=	.078 mi^2
Sandy Loam →	27.833 %	=	.312 mi^2
Sandy Clay Loam →	65.065 %	=	.730 mi^2
Sandy Clay →	.150 %	=	.002 mi^2
	99.999 %		1.122 mi^2

RUNOFF BY SOIL TEXTURE:

Loamy Sand →	(CF5LS.DAT)	P_e = .55 in	V = 2.288 ac-ft
Sandy Loam →	(CF5SL.DAT)	P_e = 1.06 in	V = 17.638 ac-ft
Sandy Clay Loam →	(CF5SCL.DAT)	P_e = 1.83 in	V = 71.248 ac-ft
Clay Loam →	(CF5CL.DAT)	P_e = 1.97 in	V = 0.210 ac-ft

TOTAL RUNOFF = 91.384 ac-ft

TIGER WASH SUB 8

SUBBASIN RUNOFF FROM INDIVIDUAL SOIL TEXTURES

#19,20 → 38.6 % OF Subbasin

11.43 % Sandy Loam
2.86 % Loam
85.71 % Sandy Clay Loam

% OF Subbasin

SANDY Loam → .1143 (38.6) = 4.412 %
Loam → .0286 (38.6) = 1.104 %
Sandy Clay Loam → .8571 (38.6) = 33.084 %

#92 → 50.1 % OF SUBBASIN

Loamy Sand → 37.5 % (50.1) = 18.788 % of Subbasin
Sandy Loam → 52.5 % (50.1) = 26.303 %
Loam → 5 % (50.1) = 2.505 %
Sandy Clay Loam → 5 % (50.1) = 2.505 %

#100 → 11.3 % OF Subbasin

Loamy Sand → 62.5 % (11.3) = 7.063 % OF Subbasin
Sandy Loam → 25 % (11.3) = 2.825 %
Sandy Clay Loam → 12.5 % (11.3) = 1.413 %

TOTALS FOR THE SUBBASIN

LOAMY SAND	→	25.851 %	=	2.528 mi^2
Sandy Loam	→	33.540 %	=	3.280 mi^2
Loam	→	3.609 %	=	.353 mi^2
Sandy Clay Loam	→	37.002 %	=	3.619 mi^2
		100.002 %		9.780 mi^2

RUNOFF BY SOIL TEXTURE

Loamy Sand →	(TW8LS.DAT)	P_e = .10 in	V = 13.483 ac-ft
Sandy Loam →	(TW8SL.DAT)	P_e = .68 in	V = 118.955 ac-ft
Loam →	(TW8L.DAT)	P_e = 1.06 in	V = 19.956 ac-ft
Sandy Clay Loam →	(TW8SCL.DAT)	P_e = 1.60 in	V = 308.821 ac-ft

TOTAL RUNOFF = 461.215 ac-ft

MODELED SUBBASIN RUNOFF

(TW8AA.DAT)	P_e = .61 in	V = 318.2 ac-ft
(TW8AL.DAT)	P_e = .74 in	V = 386.0 ac-ft
(TW8LA.DAT)	P_e = .79 in	V = 412.1 ac-ft
(TW8LL.DAT)	P_e = .91 in	V = 474.7 ac-ft

Subbasin MAP UNIT