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PRELIMINARY DRAFT
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Project Report

HYDROLOGIC CHARACTERIZATION OF LAND TYPES ASSOCIATED WITH IN-SITU OIL SHALE RETORTING

To: Geokinetics, Inc.
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Contract #225

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BACKGROUND

Introduction: This report covers a study carried out for Geokinetics, Inc. by the Utah University Foundation during the summer of 1983. The overall study objective is to characterize the hydrologic properties of several different land conditions of Geokinetics' Seep Ridge oil shale retorting operation. The goals, as amended following original discussions are:

1. To determine point infiltration rates and parameters on two different land types using two different methods. The two land types, as discribed in following sections are: 1) native sagebrush lands, preparatory to clearing and oil retorting operations and 2) prepared retort areas. The two methods are: 1) double ponding ring infiltrometers are 2) modular drop forming infiltrometers

2. To synthesize hydrologic loss rate parameters for the sites from the infiltration data. The loss rate parameters synthesized are runoff curve numbers (CN), used in the curve number method of direct runoff resonse from rainstorms. Infiltration rates measured also function as loss rates.

3. Define associative relationships between sprinkler measured infiltration rates and the ponding ring measured rates.

Other data was also collected (such as runoff water quality and sediment production) but is not treated here.

Site: The location of the study is the Geokinetics Seep Ridge location at Kamp Kerogen, approximately seventy (70) miles south of Vernal in Section 2, T14S, R22E, Uintah County, Utah. The elevation is about 6800 ft. and the native vegetation is mixed pinyon-juniper interspersed with openings of native range dominated by sagebrush. This is formed on a series of sedimentary rock strata of the Green River formation, with fine sandstones and shales predominating. Shale beds containing kerogen (the "Mahogony" zone of the Parachute Creek member) outcrop, and the site is the scene of an active innovative in-situ retorting operating via the "LOFRECO" (Low Front End Cost) process. Average annual precipitation is in the

neighborhood of 13 inches, about half or which occurs as short duration summer thunderstorms. Snow occurs during winter months, though does not form deep long-term snow packs. The area may be generally described as remote, high elevation, semi-arid, and temperate, with a continental climate. Prior to energy developments, the main land use was grazing, with hunting, occasional recreation, and wood gathering seasonally. The area is dissected by a series of deep canyons, providing long vistas.

While active permanent streams are rare, and of low flows, there is ample evidence of intermittent and ephemeral streamflow, usually initiating sediment movement and land erosion. Geomorphically, the area is active in a fluvial sense. Considerable environmental background is given reference 9.

A summary of the rainfall depth-frequency-duration is given in Table 1; which is drawn from the NOAA Atlas for Utah (13). In a national perspective, the expected depths and intensities are indeed modest.

Table 1
Rainfall Depth-Duration-Frequency
Geokinetics Site

Return Period (Yr)	Duration (hrs)					
	1	2	4	6	12	24
2	0.56	0.63	0.73	0.84	0.97	1.16
5	0.81			1.10		1.46
10	0.98	1.06	1.19	1.28	1.47	1.68
25	1.20			1.51		2.06
50	1.39			1.70		2.25
100	1.56	1.56	1.77	1.88	2.13	2.51

Note: Table entries in inches. Taken from NOAA Atlas (13).

The industrial process practiced is of some interest here. Briefly, subterranean oil (Kerogen)-rich shales are rubblized with explosives and ignited. By force-feeding air and providing ventilization, a small portion of the kerogen combusts at a high temperature, initiating melt in adjacent rocks. In a hot, mobile, liquid state, the kerogen is pumped to the surface, and separated from accompanying water. The underground combustion chambers are called "retorts," as are the surface components of them. Hereinafter, "retort" will signify the retort land surface.

In order to minimize the escape of gases during and following the combustion, the retorts are compacted much in the manner of highway subsurfaces. As shall be seen, this imperviousness, which is designed to minimize inadvertent emissions of combustion gases, also results in reduced surface infiltration of rain waters. Operating and planned retorts are on the scale of two to five acres, thus becoming potential runoff source areas. Resulting abnormally high runoff from these coned then impact downstream lands as well as local Geokinetics facilities. Treating the retorts and accommodating runoff then requires knowledge of their hydrology.

Methods: A total of 120 plot infiltrometer runs were made under different combinations of land types ("Sage" or "Retort"), Antecedent moisture ("Dry" or "Wet") and method of measurement ("Ponding" or "Rainfall"). These are as follows:

1. Land Type: The "sage" condition was native untreated sagebrush land which had been designated for preparation as a retort. As shown in Figure 1, the sites were about 1/2 mile south of the present camp. "Retorts" were prepared retorts not yet in operation (Retorts 27 and 28). The land surface is clayey and bare, compacted and driven-upon.

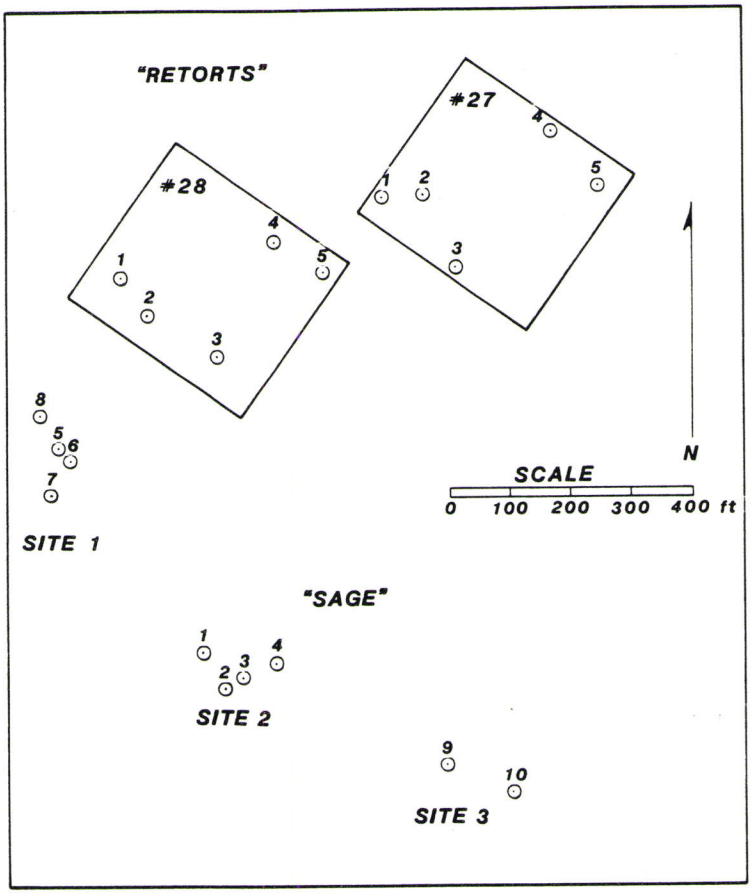


Figure 1. General location of infiltrometer test sites and locations at Geokinetics Seep Ridge site.

2. Antecedent moisture: "Dry" conditions were those in a natural summer moisture status as found. This was usually characterized by a dry and/or dusty surface, with some unknown residual soil moisture. Though several rainstorms occurred during the study period, measurements were deferred for several days following. "Wet" conditions were those found the day following a dry run. That is, a "dry" run was followed the next day with a "wet" run.

3. Method of measurement: "Ponding" runs were measurements made with a double ponding ring infiltrometer. The rings 1/8 inch thick, were 18" and 12 inches in diameter, inserted concentrically to a depth of about 3 inches. The bottoms have a sharpened edge, and the tops a welded rein-

forcing strip to enhance durability and placement. They were operated with a 1 inch (2.54 cm) head of water, maintained with a point gage and inputs measured with a graduated cylinders or (if necessary) a surgical syringe. The timed water budget of the center ring is considered to be infiltration.

"Rainfall" runs were made by simulating rainfall with a drop-forming device, approximately 2 ft. square, with a fall height of about 6 ft. The rain falls on corresponding small catchment defined with steel plate boundaries and a collecting trough. Volumetric measurements of rainfall and runoff over measured time intervals allows determination of apparent infiltration as a difference between the two rates. The rainfall intensity applied varied slightly from run to run, but was assumed uniform throughout the run, and about 5.9-6.3 cm/hr. A more complete description of the drop forming device is given elsewhere (3, 12).

The water used was from the Kamp Kerogen culinary supply from both the ponding and rainfall simulation cases.

5. Sampling Design: The 120 plots were taken as shown in Table 2. The "sage" locations were on three different sites; the "retorts" on two different prepared retorts. Within each type, sampling was further stratified into "locations." A location consisted of a closely associated set of measurements, consisting of 2 ponding ring setups and a rainfall

Table 2

Sampling--Replication Design

	Ponding		Rainfall			
	Dry	Wet	Dry	Wet	:	Total
Sage	20	20	10	10	:	60
Retorts	20	20	10	10	:	60
Total	40	40	20	20	:	120

setup, usually all within about 4-6 feet of each other. Ideally the rings were to be about four feet apart with the rainfall plot between them. These three were then each run wet and dry over a span of no more than two days. Locations were selected as "representative" of the acres sampled, and were no closer than about 100 ft.

6. Sampling Protocol: With few exceptions, runs were for at least 60 minutes duration, with measurements at 2 minute intervals for the first 20 minutes, and every 5 minutes thereafter. Water temperature was taken, as were occasional readings of electrical conductivity. Rainfall runs noted the time runoff began and ended. Plot cover characteristics were noted. Although plot slope was not measured, a consistent modest slope (ca 10%) was a location selection factor.

DATA ANALYSIS

Infiltration Fitting: The raw data from the 120 plot runs were stored on magnetic diskette for ease of access. Analysis of the data was for the coefficients of Horton's infiltration capacity equation

$$f(t) = f_c + (f_o - f_c)e^{-kt}$$

where f_c and f_o are the long term constant rate and the rate at t=0 respectively, and k is a coefficient indicating the rate of approach to f_c. The Horton equation was chosen after some preliminary attempts to fit both the Green-Ampt and Philip equation gave unreasonable negative values of their respective constant rate terms, K_s and A. The driving variable time in Hortons equation is understood to be from the time of ponding, or the beginning of runoff. Thus with the rainfall simulation data, the observed run times were corrected by subtracting the observed time runoff began.

It should be noted that Horton's equation, while flexible and well known, is currently held in low regard because of its lack of original

derivation from physical considerations. The Green-Ampt and/or Philip equations are in vogue. However, as shall be seen, the importance of this distinction fades when only the constant rate term is considered. Results from the Horton fitting agreed well with the data, and the constant rate parameter f_c checked closely with observed end-of-run rates. In addition, only f_c was used in subsequent steps.

The fitting was done via a least squares iteration process. A summary of these fits for all 120 plots (ponding and rainfall) is given separately in the Appendix. Most of the r^2 values were above 90%, and no f_c values were negative.

To account for the temperature-dependent viscosity effects, the f_c values were adjusted to a basis of 55°F (12.78°C) using a viscosity equation provided by Heggen (8). This adjusted value is also shown in the Appendix. This step corrected for the temperature influence (which is not trivial) and made f_c more realistic in terms of the temperature of expected runoff waters. Some background discussion of this concern is given by Klock (11).

Almost all fits gave a high value for the drawdown coefficient "k". Values of 10-20 hr^{-1} were common, indicating a very rapid satisfaction of the transient capillary phase of infiltration. Constant or near-constant infiltration rates were commonly attained after 10-20 minutes. The remainder of the time in the 60 minute runs usually only demonstrated this near-constant rate, with some occasional noise superimposed.

Statistical Analysis: The temperature-viscosity corrected results of the above described fittings are shown in Figure 2, demonstrating the relative magnitudes of infiltration and the rankings for the land types (sage and retorts), moisture conditions (dry and wet), and the method

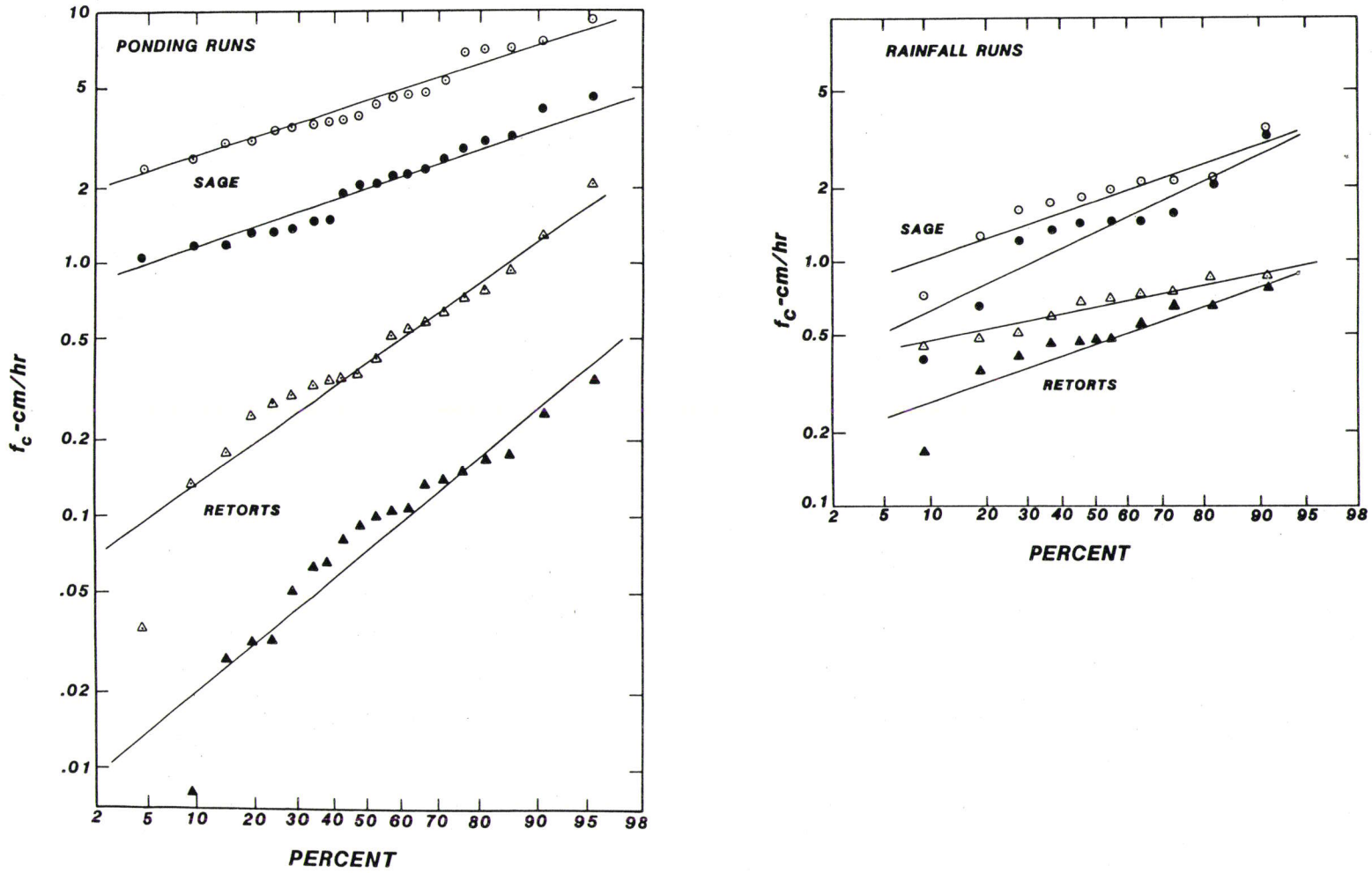


Figure 2. Frequency arrays of infiltration capacities f_c (corrected for temperature-viscosity effects). Straight lines shown are moment fits to log-normal distributions.

(ponding and rainfall), and their relative positions. The data is also summarized in statistical moment form as given in Table 3.

Differences are obvious between the land types and the moisture conditions. An analysis of variance is shown in Table 4. The contrast between ponding measurement and rainfall simulation measurements is in accord with general expectations on the sage sites, but more muddled on the retorts. The dry conditions provide indistinguishable results, but the wet runs show higher infiltration rates with rainfall measurements. This may be attributed to any of a number of factors: 1) observed incomplete coverage of the plot with the rainfall simulator, 2) splash losses, 3) measurement noise combined with the subtraction of two near-equal quantities, or 4) a genuine unappreciated physical process associated with rainfall. In any case, while the finding is disturbing, it is not crucial to the steps that follow.

Table 4

ANOVA Table

Source of Var.	SS	DF	MS	F	Signif.
Main Effects	230.214	3	76.738	85.296	0
Veg. Type	179.772	1	179.772	199.822	0
Meas. Meth.	14.546	1	14.546	16.186	0
Moisture	35.896	1	35.896	39.899	0
Two-Way Int.	52.063	3	17.354	19.290	0
Type-Meth.	26.144	1	26.144	29.060	0
Type-Moist.	16.363	1	16.363	18.188	0
Meth-Moist.	9.566	1	9.556	10.622	.001
Three-Way Int.	5.667	1	5.667	6.310	.013
Type-Meth-Moist.	5.667	1	5.667	6.310	.013
Explained	287.954	7	41.136	45.724	0
Residual	100.762	112	0.900		
TOTAL	388.716	119	3.267		

Table 3
SUMMARY OF INFILTRATION DATA

I PONDING RUNS

	DRY			WET		
	Mean	Stdv	Skew	Mean	Stdv	Skew
Sage	4.70	1.88	0.94	2.16	0.97	1.05
Retorts	0.55	0.47	2.14	0.11	0.09	1.33

II RAINFALL RUNS

	DRY			WET		
	Mean	Stdv	Skew	Mean	Stdv	Skew
Sage	1.91	0.73	0.83	1.54	0.77	1.40
Retorts	0.67	0.15	-0.12	0.50	0.17	-0.32

Notes: Data in cm/hr

SUMMARY OF INFILTRATION DATA
(Logarithmic)

I PONDING RUNS

	DRY			WET		
	Mean	Stdv	Skew	Mean	Stdv	Skew
Sage	1.48	0.38	0.40	0.69	0.43	0.31
Retorts	-0.90	0.86	-0.84	-2.82	1.73	-2.86[1]

II RAINFALL RUNS

	DRY			WET		
	Mean	Stdv	Skew	Mean	Stdv	Skew
Sage	0.58	0.41	-0.87	0.32	0.54	-0.95
Retorts	-0.42	0.23	-0.39	-0.77	0.43	-0.56

Notes: Logarithms to natural base of data in cm/hr
1. Includes one point of zero infiltration set to a value of 0.0001 cm/hr for calculation purposes.

Ponding vs Rainfall: Comparisons were made between the ponding-measured and the rainfall-measured infiltration rates. This was facilitated by the study design, which placed two ponding ring runs and a single rainfall simulation run in clustered proximity. In practice, the two ponding runs were made no more than 5 ft. apart, and the rainfall run as close as possible, preferably between the two rings.

Data were reduced to an X-Y array by locations, using an average f_c for the two ponding ring runs (X) and the single f_c from the rainfall run (Y). These results are shown plotted in Figure 3. Despite the scatter, the r^2 value of 0.58 indicates at least an associative relationship for the pooled data (significant at α=.05). For lower infiltration situations (< about .8 cm/hr, ponding) the rainfall measurement gives higher results. The low slope (0.30) could be artifact of an upper limit, constrained by the rainfall intensity used in the runs, about 6 cm/hr. That is, no infiltration rate can be measured in excess of the intensity used. Because of this, the relationship found should be viewed as specific to the conditions.

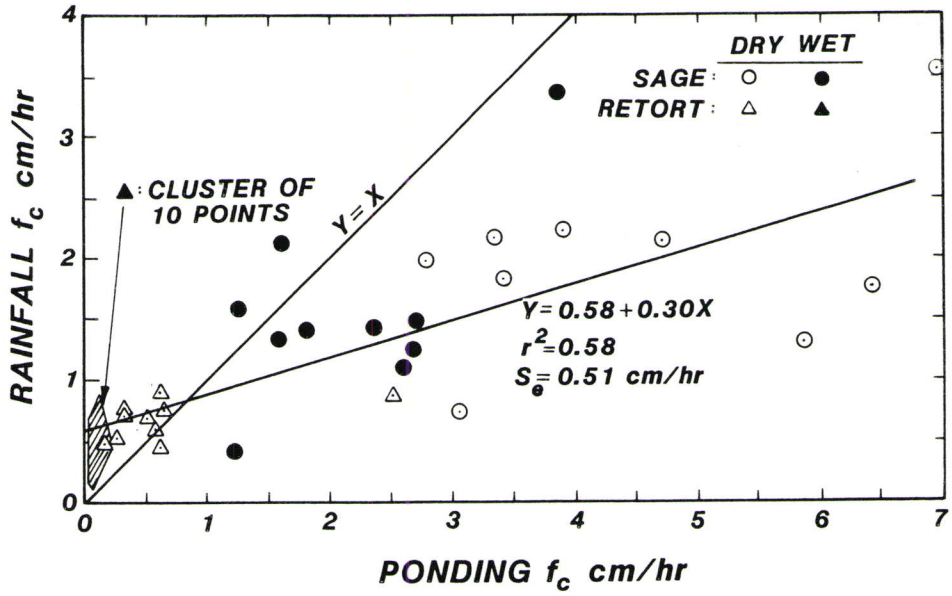


Figure 3. Relationship between ponding and rainfall determined f_c (corrected for temperature-viscosity effects).

For the general mass of sagebrush site data, the relationship is not far from a general rule-of-thumb sometimes used that rainfall results will be "about half of ponding results". In fact, using only the sage data and and forcing the fit through the origin gives a ratio (slope) of 0.44.

CURVE NUMBER SYNTHESIS

General: Both point infiltration rates and runoff curve numbers (CN) represent losses of rainfall in the generation of watershed runoff. Thus, it is compelling to make a connection between the two. In addition, infiltration measurement is relatively convenient, while CNs can only otherwise be determined from long-term small watershed data, or estimated from descriptive handbook tables.

A basic problem in the task is the lack of time considerations (rainfall intensity or duration, or infiltration velocities) in the CN technique. The CN method deals with storm and runoff depths and site storage (e.g., inches), whereas the infiltration-intensity approach was rates (e.g., inches/hr). Thus some time descriptor must be introduced, and exact or consistent matching cannot be routinely expected.

Briefly, the creation of CNs from infiltration here is done by generating rainfall excess from design storms of given intensity distribution and depth, thru superposition of inteval intensities on strips of interacting infiltrating points. Runoff rates are converted to depths, and summed over a storm's duration. These runoff depths are then used to define curve number for the rainfall depth. The rationale and steps are outlined in the following sections.

1. Moisture Status: The use of the curve numbers will be to calculate storm runoff from extreme events, which suggests <u>wet</u> antecedent

conditions. The wet condition also suggests a satisfied depression storage situation.

2. Measurement Device: The ponding infiltrometer results were used as representative infiltration rates in CN generation to avoid the partial area problems known (and observed herein) with rainfall simulators. The problem is one of intensity-specific results arising from diversity of infiltration characteristics over the plot area. This problem has been previously described with examples (5), and was observed in one trial run on sagebrush sites here.

3. Infiltration Capacities: Values of f_c were used as time-invariant point loss rates. Use of f_c is justified considering the wet condition, and the high k coefficient or rapid approach of f(t) to f_c. This latter consideration becomes less important as the storm duration becomes longer. This essentially casts the infiltration rates as point ϕ-indexes.

These rates were then adjusted by a factor of 0.9 to account for lateral outflow in the ponding rings. A similar approach is used by Khanbilvardi et al. (10), which draws from a study by Tricker (14).

4. Strip Arrays.

A. Using the logarithmic statistical moment information given in Table 3, a file of 2000 infiltration rates was created by data synthesis techniques. The mean, standard deviation, and skewness were targeted for preservation. The results of this synthesis are given in Table 5, and compared to the target values.

B. The above arrays were subdivided into forty 50 point groups, each assumed to be a serial display of point infiltration, or infiltrating points on a flow path 50 units long. Because the data was drawn from 12" rings, this can be roughly interpreted as a 50 ft of overland flow distance, representative of the observed scale of field conditions. In preliminary runs, the choice of 50 points (and 50 ft) rather than, say, 100 points was not found to be crucial.

Table 5

Data Generation Comparisons

	SAGE			RETORTS		
	mean	stdv	skew	mean	stdv	skew
Target	2.17	0.97	1.04	0.11	0.09	1.33
Simulated	2.17	0.98	1.42	0.11	0.09	1.19

Notes: data in cm/hr. Simulations on 2000 points by Logarithmic transformed moments.

C. Rate Relationships. The forty strips were used as samples of overland flow paths for the two land types. A rainfall-runoff rate relationship was then generated for each of the 40 strips, and averaged for further use. This was done by the following assumptions and procedure.

1) A rainfall burst is at constant intensity.

2) The outflow from a strip it at equilibrium. That is, the rising limb of the outflow hydrograph has been passed, and the outflow rate is constant.

3) Strip outflow rate is then calculated by determining the cumulative value of (i-f), with the constraint that it not fall below zero. In this event, the sum is reset to zero. The effective strip outflow rate is then this sum divided by 50 (the number of strip points).

In equation form, this calculation is

$$q = \sum_{j=k}^{NP} (i-f_j)/NP$$

Where k is the counter for the last zero sum point, and NP is the number of strip points. This procedure gives a relationship between the rainfall intensity, i, (in/hr) and the runoff intensity ,q, (in/hr) for each land type. A variety of this approach has been used previously (1). The relationship was determined over a wide array of rainfall intensities. The results are given in Table 6.

Table 6
Intensity-Runoff Rate Relationships
Geokinetics Sites

Intensity in/hr	Runoff Rate - in/hr	
	Sage	Retorts
0	0	0
0.05	0	.01185
0.10	0	.06138
0.15	0	.11134
0.20	0	.16134**
0.25	0	**
0.30	0	**
0.35	0	**
0.40	.00006	**
0.45	.00018	**
0.50	.00050	**
0.55	.00126	**
0.60	.00287	**
0.65	.00543	**
0.70	.01146	**
0.75	.02642	**
0.80	.05413	**
0.85	.09264	**
0.90	.13715	**
0.95	.18486	**
1.00	.23378	**
1.05	.28309	**
1.10	.33257	**
1.15	.38236	**
1.20	.43221	**
1.25	.48212	**
1.30	.53207	**
1.35	.58202	**
1.40	.63197	**
1.45	.68192	**
1.50	.73187	**
1.55	.78182	**
1.60	.83177	**
1.65	.88172	**
1.70	.93167	**
1.75	.98162	**
1.80	1.03157	**
1.85	1.08152	**
1.90	1.13149	**
1.95	1.18148	**
2.00	1.23148*	**

Notes: * For i>2.00 in/hr, q=i-0.76852 ** For i>0.20 in/hr, q=i-0.03866

5. Design Storms: Two different design storm distributions were used: The NEH-4 type "B" (15), a widely-use distribution taken originally from the U.S. Soil Conservation Service; and the Farmer-Fletcher distribution, which was developed for use in northern and central Utah (2). They are shown in cumulative form in Figure 4. Durations used were: 1 hr., 2 hr., 4 hr., 6 hr., 12 hr., and 24 hr., and depths for these durations covered the range from the 10 yr. to 100 yr. return period, as shown in Table 1.

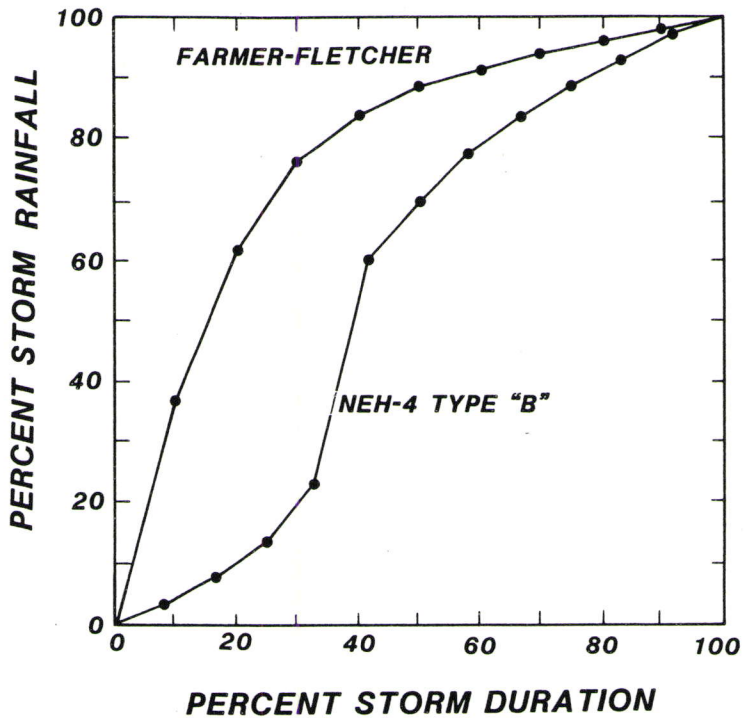


Figure 4. Dimensionless expression of the storm rainfall distributions.

5. Runoff generation: For a given intensity distribution storm depth, and intensity-runoff relationship (specific to land type, either sage or retorts) the runoff depth was calculated. The runoff rate for a storm interval was simply interpolated using Table 6. The runoff depth for the interval was then $q\Delta t$, and the storm runoff depth the sum

$$Q = \sum_{j=1}^{n} q_j \Delta t$$

Where n is the number of intervals. Twelve (12) intervals were used with the NEH-Type "B" distribution, and 10 for the Farmer-Fletcher distribution.

6. Curve Number Calculation: With the storm runoff depth in hand, and the rainfall depth already available, the curve number was calculated via the equations

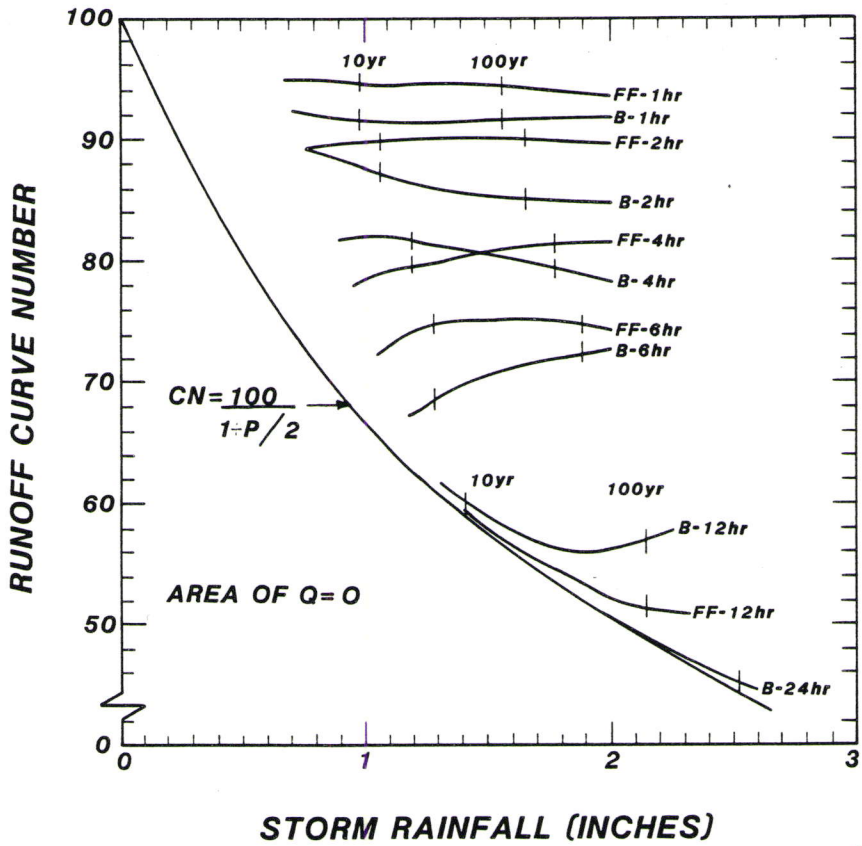
$$S = 5(P+2Q-\sqrt{4Q^2 + 5PQ})$$

$$\text{and } CN = 1000/(10+S)$$

Results: The summarized outcome of these calculations are shown in Tables 7. A graphical display for the sage sites is shown in Figure 5.

The results indicate curve number varying with storm duration, return period (storm rainfall), and land type. The latter is expected. The influence of distribution and depth may be best understood as arising because of fundamental differences between the two methods of calculating storm runoff. The CNs calculated here are for specific storm distributions (not naturally observed site data), very specific land types, and a loss rate approach.

The fundamental definition of CN springs from the notion of small watershed rainfall-runoff, observed over a number of years, and defined on annual floods. Such events might arise from a variety of storm distributions, durations, and depths not presumed here. With this in mind, "consensus" curve numbers are given in Table 8. There are merely the arithmetic averages of 10 and 100 yr, Farmer-Fletcher and "B" distribution for the durations shown. As averages, they should be used with the critical storm duration judged appropriate. Shorter storms of thunderstorm origin seem to dominate in the area, suggesting design using perhaps a four (4) hour design duration for extreme events.



Sagebrush

Figure 5. Runoff curve numbers for various durations, distributions, and depths.

Table 7. Curve Number Summary

"SAGE"

Storm Duration (hr)	RP=10 yr P (in)	RP=10 yr CN FF	RP=10 yr CN B	RP=100 yr P (in)	RP=100 yr CN FF	RP=100 yr CN B
1	0.98	94.6	91.7	1.56	94.1	91.5
2	1.06	89.6	87.3	1.65	90.0	85.2
4	1.19	79.4	81.7	1.77	81.3	79.2
6	1.28	68.5	74.7	1.88	72.4	74.6
12	1.47	58.3	59.2	2.13	51.5	57.2
24	1.68	*	*	2.51	*	45.2

Notes: *Q=0.CN indeterminate

"RETORTS"

Storm Duration (hr)	RP=10 yr P (in)	RP=10 yr CN FF	RP=10 yr CN B	RP=100 yr P (in)	RP=100 yr CN FF	RP=100 yr CN B
1	0.98	99.7	99.7	1.56	99.7	99.7
2	1.06	99.3	99.3	1.65	99.3	99.3
4	1.19	98.6	98.6	1.77	98.7	98.7
6	1.28	97.9	97.8	1.88	97.9	97.9
12	1.47	96.4	95.3	2.13	96.0	95.7
24	1.68	94.1	91.4	2.51	93.5	90.9

Table 8

Consensus Curve Numbers
Geokinetics Site

Sagebrush

Storm Duration (hr)	CURVE NUMBER Sage	Retorts
1	93.0	99.7
2	88.0	99.3
4	80.4	98.7
6	72.6	97.9
12	56.6	95.8
24	*	92.5

*Indeterminate.Q=0

93-99 for Retort

High # – High runoff
55-95
normal curve #'s.

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APPENDIX

On the following page, the columns are

1. Cover or Type
2. Measurement Method
3. Site Number
4. Plot Number
5. Moisture Condition
6. f_c-best fit, cm/hr
7. Coefficient of determination, r^2
8. Standard error of estimate, cm/hr
9. Water Temperature, ^oC
10. f_c-corrected for viscosity, cm/hr

	1	2	3	4	5	6	7	8	9	10
1	SAGE	POND	1	1	DRY	3.46	.9676	.785	17.5	3.065
2	SAGE	POND	1	1	WET	1.53	.9304	.3352	18.5	1.322
3	SAGE	POND	1	2	DRY	4.58	.9495	1.3125	22	3.637
4	SAGE	POND	1	2	WET	2.5	.9781	.3386	24	1.894
5	SAGE	POND	1	3	DRY	3.87	.9601	.7183	23	3.001
6	SAGE	POND	1	3	WET	1.76	.9314	.2918	24	1.333
7	SAGE	POND	1	4	DRY	3.44	.9672	.3802	24	2.606
8	SAGE	POND	1	4	WET	1.57	.9769	.2267	24	1.189
9	SAGE	POND	1	5	DRY	4.15	.9547	1.1528	17	3.722
10	SAGE	POND	1	5	WET	1.79	.7905	1.451	21	1.455
11	SAGE	POND	1	6	DRY	2.75	.9558	1.0158	18	2.406
12	SAGE	POND	1	6	WET	1.28	.9712	.2825	21	1.041
13	SAGE	POND	1	7	DRY	8.36	.96	1.7687	20	6.965
14	SAGE	POND	1	7	WET	3.93	.8547	1.4645	21	3.196
15	SAGE	POND	1	8	DRY	8.63	.9603	1.8862	21	7.018
16	SAGE	POND	1	8	WET	5.66	.9715	.8981	21.5	4.548
17	SAGE	POND	2	1	DRY	5.95	.9603	1.8662	17	5.337
18	SAGE	POND	2	1	WET	2.63	.7122	.4804	19	2.245
19	SAGE	POND	2	2	DRY	8.49	.9136	1.9366	17	7.616
20	SAGE	POND	2	2	WET	3.44	.9374	.4052	18	3.009
21	SAGE	POND	2	3	DRY	4.27	.9527	1.2078	17	3.830
22	SAGE	POND	2	3	WET	1.58	.6914	.6989	18	1.382
23	SAGE	POND	2	4	DRY	12.26	.9843	1.0216	25	9.077
24	SAGE	POND	2	4	WET	4.98	.9212	.9901	21	4.050
25	SAGE	POND	2	5	DRY	5.25	.8578	1.5379	29	3.553
26	SAGE	POND	2	5	WET	1.49	.9027	.2541	22	1.183
27	SAGE	POND	2	6	DRY	5.8	.9576	1.5364	25	4.294
28	SAGE	POND	2	6	WET	2.53	.9192	.6382	22	2.009
29	SAGE	POND	2	7	DRY	5.12	.9266	1.4069	16.5	4.651
30	SAGE	POND	2	7	WET	2.69	.9718	.32	15.5	2.506
31	SAGE	POND	2	8	DRY	4.93	.9388	1.4645	14	4.774
32	SAGE	POND	2	8	WET	2.35	.9525	.538	15	2.217
33	SAGE	POND	3	1	DRY	10.34	.9538	1.1545	28	7.154
34	SAGE	POND	3	1	WET	4.18	.909	.5746	28	2.892
35	SAGE	POND	3	2	DRY	6.78	.9361	1.1485	29	4.588
36	SAGE	POND	3	2	WET	3.44	.9672	.3802	29	2.328
37	SAGE	POND	3	3	DRY	4.38	.943	1.3674	22	3.478
38	SAGE	POND	3	3	WET	2.7	.9726	.5822	23	2.094
39	SAGE	POND	3	4	DRY	4.25	.9385	1.2531	22	3.375
40	SAGE	POND	3	4	WET	1.9	.9735	.2982	23	1.473
41	RTRT	POND	27	1	DRY	.28	.9326	.6183	17	.2511
42	RTRT	POND	27	1	WET	.15	.0824	.2272	17	.1345
43	RTRT	POND	27	2	DRY	.32	.9937	.1723	18	.2799
44	RTRT	POND	27	2	WET	.17	.875	.1917	18	.1487
45	RTRT	POND	27	3	DRY	.89	.926	.7906	21	.7238
46	RTRT	POND	27	3	WET	.04	.1656	.2659	22	.0317
47	RTRT	POND	27	4	DRY	.6	.9616	.8303	27	.4245
48	RTRT	POND	27	4	WET	.23	.6095	.345	25	.1703
49	RTRT	POND	27	5	DRY	.26	.9585	.2146	28	.1799
50	RTRT	POND	27	5	WET	.14	.973	.0982	26	.1013
51	RTRT	POND	27	6	DRY	.2	.9668	.2351	29	.1353
52	RTRT	POND	27	6	WET	.07	.9118	.0814	26	.0506
53	RTRT	POND	27	7	DRY	.34	.9306	.6693	18	.2974
54	RTRT	POND	27	7	WET	.38	.9969	.1425	16	.3496
55	RTRT	POND	27	8	DRY	2.41	.9332	1.0309	18.5	2.082
56	RTRT	POND	27	8	WET	.07	.9833	.0636	17	.0627
57	RTRT	POND	27	9	DRY	.61	.9733	.3908	20	.5082
58	RTRT	POND	27	9	WET	.34	.8413	.3203	25	.2517
59	RTRT	POND	27	10	DRY	.74	.8553	.5859	25	.5479
60	RTRT	POND	27	10	WET	.01	.9493	.0318	21	.0081

	1	2	3	4	5	6	7	8	9	10
61	RTRT	POND	28	1	DRY	.48	.4281	.4482	27	.3396
62	RTRT	POND	28	1	WET	.15	.9808	.1459	26.5	.1073
63	RTRT	POND	28	2	DRY	1.04	.9654	.5848	17.5	.9213
64	RTRT	POND	28	2	WET	.1	.8801	.0806	15	.0943
65	RTRT	POND	28	3	DRY	.39	.9873	.1917	17	.3498
66	RTRT	POND	28	3	WET	.03	.9923	.0577	15.5	.0279
67	RTRT	POND	68	4	DRY	.39	.9873	.1917	19.5	.3288
68	RTRT	POND	28	4	WET	0	.9495	.0317	18	0
69	RTRT	POND	28	5	DRY	.47	.9809	.2642	22.5	.3688
70	RTRT	POND	28	5	WET	.08	.9405	.0983	20.5	.0658
71	RTRT	POND	28	6	DRY	.92	.9723	.4308	20	.7664
72	RTRT	POND	28	6	WET	.2	.9617	.2884	18	.1749
73	RTRT	POND	28	7	DRY	.05	.9918	.1835	26	.0361
74	RTRT	POND	28	7	WET	.04	.5259	.0624	22	.0317
75	RTRT	POND	28	8	DRY	1.67	.8276	.0178	23	1.295
76	RTRT	POND	28	8	WET	.13	.9759	.0367	22	.1032
77	RTRT	POND	28	9	DRY	.83	.951	.2145	23	.6437
78	RTRT	POND	28	9	WET	.16	.7815	.1023	18	.14
79	RTRT	POND	28	10	DRY	.78	.9708	.1888	24	.5910
80	RTRT	POND	28	10	WET	.11	.9766	.069	25	.0814
81	SAGE	RAIN	1	10	DRY	2.9	.8585	.3152	25	2.147
82	SAGE	RAIN	1	10	WET	2.88	.883	.3018	25	2.132
83	SAGE	RAIN	1	9	DRY	2.56	.9064	.2827	23	1.985
84	SAGE	RAIN	1	9	WET	2.03	.9795	.147	23	1.574
85	SAGE	RAIN	1	7	DRY	1.12	.9765	.1937	31	.7257
86	SAGE	RAIN	1	7	WET	.59	.9582	.2727	28.5	.4037
87	SAGE	RAIN	1	8	DRY	5.58	.5751	.1465	32	3.539
88	SAGE	RAIN	1	8	WET	5.08	.8707	.1071	30	3.363
89	SAGE	RAIN	2	5	DRY	2.29	.9932	.0907	24	1.735
90	SAGE	RAIN	2	5	WET	1.54	.9814	.1679	22	1.222
91	SAGE	RAIN	2	6	DRY	2.28	.9613	.188	27	1.613
92	SAGE	RAIN	2	6	WET	1.92	.962	.198	24	1.454
93	SAGE	RAIN	2	4	DRY	3.06	.9493	.1994	26	2.214
94	SAGE	RAIN	2	4	WET	1.78	.9358	.2651	24.5	1.333
95	SAGE	RAIN	2	3	DRY	2.97	.8797	.2797	26.5	2.125
96	SAGE	RAIN	2	3	WET	1.86	.9885	.1212	23	1.442
97	SAGE	RAIN	3	1	DRY	1.47	.9812	.2065	18	1.286
98	SAGE	RAIN	3	1	WET	.81	.9861	.1369	21	.6587
99	SAGE	RAIN	3	2	DRY	2.13	.95	.2439	19	1.818
100	SAGE	RAIN	3	2	WET	1.78	.9696	.1849	22	1.413
101	RTRT	RAIN	27	1	DRY	.72	.9385	.3515	27	.5094
102	RTRT	RAIN	27	1	WET	.67	.9484	.3302	27	.4740
103	RTRT	RAIN	27	2	DRY	.87	.9187	.3365	28	.6019
104	RTRT	RAIN	27	2	WET	.49	.9528	.315	26	.3546
105	RTRT	RAIN	27	3	DRY	.56	.9156	.4008	18	.4899
106	RTRT	RAIN	27	3	WET	.55	.8422	.5338	18.5	.4753
107	RTRT	RAIN	27	4	DRY	1.01	.8919	.4156	19	.8622
108	RTRT	RAIN	27	4	WET	.8	.991	.1308	21	.6506
109	RTRT	RAIN	27	5	DRY	.95	.9764	.2177	26	.6875
110	RTRT	RAIN	27	5	WET	.52	.9847	.1648	22.5	.4080
111	RTRT	RAIN	28	1	DRY	1.24	.8909	1.2633	34	.7539
112	RTRT	RAIN	28	1	WET	.25	.9792	.2223	30	.165
113	RTRT	RAIN	28	2	DRY	1.26	.9758	.2152	36	.7351
114	RTRT	RAIN	28	2	WET	.71	.9933	.1142	31	.4600
115	RTRT	RAIN	28	3	DRY	.92	.9857	.1557	23	.7135
116	RTRT	RAIN	28	3	WET	.88	.9808	.1784	18	.7699
117	RTRT	RAIN	28	4	DRY	1.18	.9239	.3461	25	.8737
118	RTRT	RAIN	28	4	WET	.76	.9936	.1063	19	.6488
119	RTRT	RAIN	28	5	DRY	.59	.9795	.1974	23.5	.4522
120	RTRT	RAIN	28	5	WET	.66	.9629	.2744	20	.5498