

EXAMPLE OF HISTOGRAM USE

TO ASSIST IN SELECTION OF "NET PAY CUTOFF"

Introduction

In most reservoirs, selected lower limits of porosity and permeability are designated as "net pay cutoff". All samples with physical properties that fall below these limits are considered to have a negligible effect on reservoir behavior and are excluded from subsequent calculations. In some cases an appreciable or total loss of oil saturation is observed on the core analysis when permeability or porosity decrease to some low level. When this occurs, the saturation data are helpful in selecting the "cutoff" values. In other cases, oil saturation is found for the complete range of porosity observed, but much of the rock has permeability so low it will contribute only slightly to hydrocarbon flow. In this case, excluding the low permeability rock may mean not counting as net pay a large number of feet of core, but because of its low permeability only a small percentage of the total flow capacity may be lost.

Histogram Use

There is often no clean-cut method to select "net pay cutoff" values. However, one helpful approach that can be applied is to use statistical core data as an aid. These statistical data give you a picture of the overall distribution of porosity and permeability for quick comparison with other wells and allow you to assess (1) how much footage and storage capacity is lost, and (2) how much footage and flow capacity is lost for any selected cutoff.

There is an interrelation of porosity and permeability cutoff values, and one should not be selected without consideration of the effect of the selected value on the other. The tie between the two variables is expressed on the plot of permeability versus porosity which is also attached.

Example

It is necessary to select (often based on experience or knowledge of the area) some lower limit of permeability or porosity as a starting point. Let us assume experience in this area indicates a permeability of 1 millidarcy should be considered as the "net pay cutoff". Entering the permeability histogram with this value, and moving vertically upward to intersect the dashed "cumulative capacity lost" line indicates less than 1% of the total flow capacity would be lost by this permeability selection. This sounds good. Continuing vertically upward to intersect the solid "cumulative frequency" line indicates that approximately 27% of the total number of samples have one milli-

darcy permeability or less and would not be counted as net pay. This may be acceptable, but before deciding we must examine the influence of our selection on the storage capacity that will be lost.

Entering the porosity vs. permeability plot at 1 millidarcy furnishes an average porosity of 10 percent. We return to the histogram plot and enter with a porosity of 10 percent. Moving vertically upward to intersect the dashed "cumulative capacity lost" curve indicates that with a porosity cutoff of 10%, 26% of the total storage capacity would be ignored. Continuing vertically upward to the solid "cumulative frequency" curve indicates that 38% of the total number of samples would be discarded. The 26% would likely be an excessive loss of storage capacity. This would certainly be excessive if capillary pressure studies indicated that the reservoir water saturation was low (resulting in high oil saturation) in the 10% and less porosity rock, but might be acceptable if the 10% porosity rock of 1 millidarcy and lower contained a high water saturation.

Study of these plots indicates that a cutoff of 6% porosity might be a more acceptable selection. This cutoff would yield a loss of only 5% of the total storage capacity, and only 13% of the total footage. Six percent porosity corresponds to a permeability of between 0.01 and 0.08 millidarcies depending on the drawing of the permeability versus porosity plot. Using 0.08 as the maximum permeability value would result in a cutoff of less than 1% of the total flow capacity, and a loss of approximately 15% of the total footage. This would likely be a suitable compromise, although the cutoff porosity could be reduced to 4% with little additional loss of storage and flow capacity.

Definitions (Applicable when each sample represents one foot of core)

Arithmetic Mean Porosity: $\frac{\text{Sum of All Porosities}}{\text{Number of Samples}}$

Geometric Mean Permeability: Antilog $\left[\frac{\text{Sum of Logarithm of Each Permeability}}{\text{Number of Samples}} \right]$

Median Value: 50% of the samples have values greater than the median value, and 50% have values less than the median value.

Frequency: $\frac{\text{Number of Samples in Any Range}}{\text{Total Number of Samples}}$

Cumulative Frequency: Sum of frequency from lowest range to any higher permeability or porosity value.

Porosity Capacity: Porosity x Sample Length = Porosity Feet of Storage Space

Cumulative Porosity Capacity: Sum of porosity capacity from lowest porosity value included to any higher porosity

Total Porosity Capacity: The sum of porosity capacity from the lowest to the highest porosity values included in the analysis

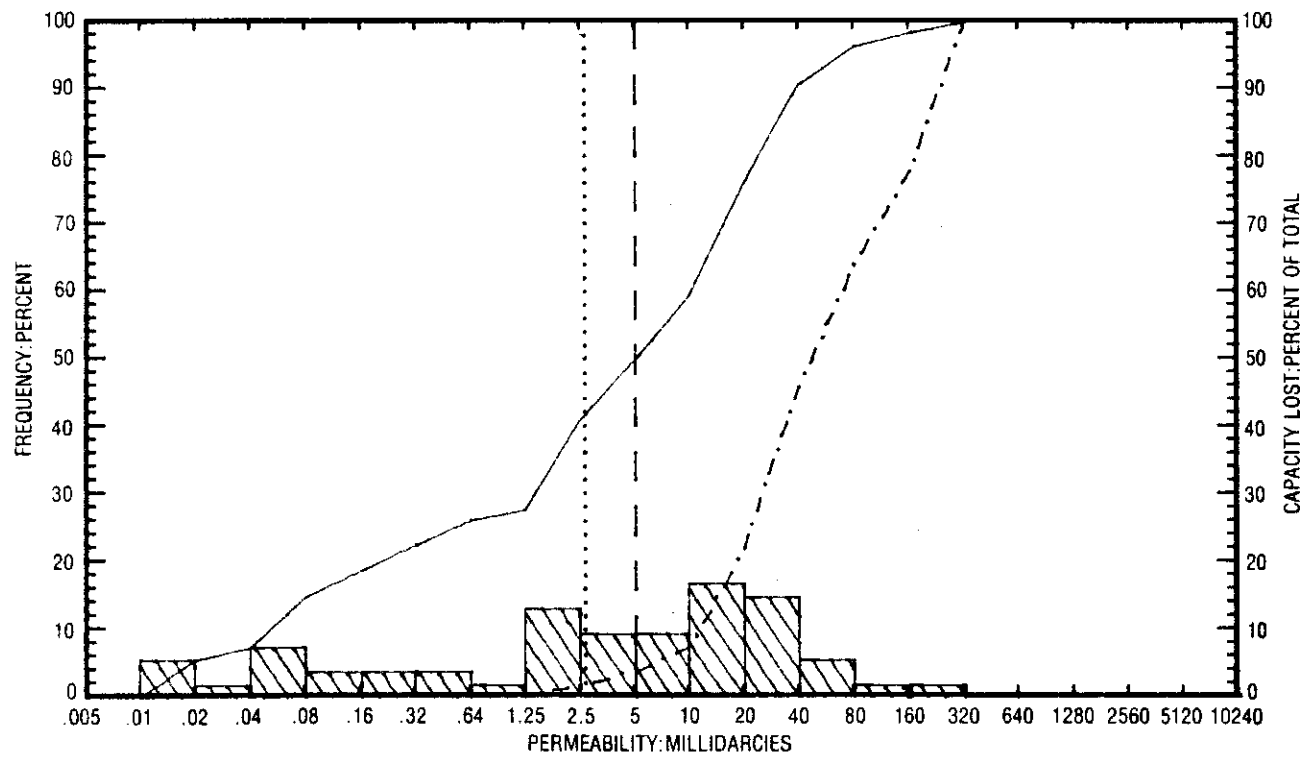
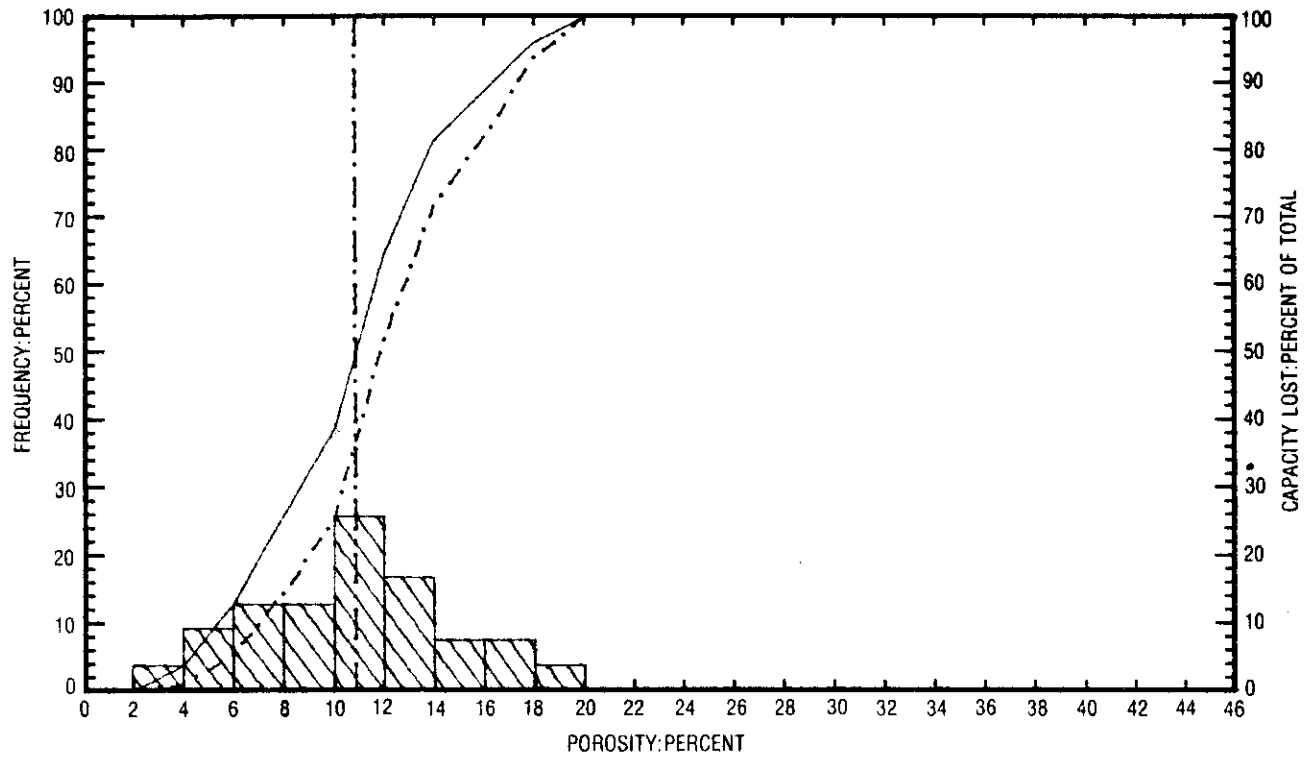
Cumulative Porosity Capacity Lost
(% of Total): This is the cumulative porosity capacity (storage capacity) lost for any selected porosity cutoff, divided by the total porosity capacity. This quotient is multiplied by 100 to yield percent.

Permeability Capacity: $\text{Permeability} \times \text{Sample Length} = \text{Millidarcy Feet of Flow Capacity}$

Cumulative Permeability Capacity: Sum of permeability capacity from lowest permeability value included to any higher permeability

Total Permeability Capacity: The sum of permeability capacity from the lowest to the highest permeability values included in the analysis

Cumulative Permeability Capacity Lost
(% of Total): This is the cumulative permeability capacity (flow capacity) lost for a selected permeability cutoff, divided by the total permeability capacity. This quotient is then multiplied by 100 to yield percent.

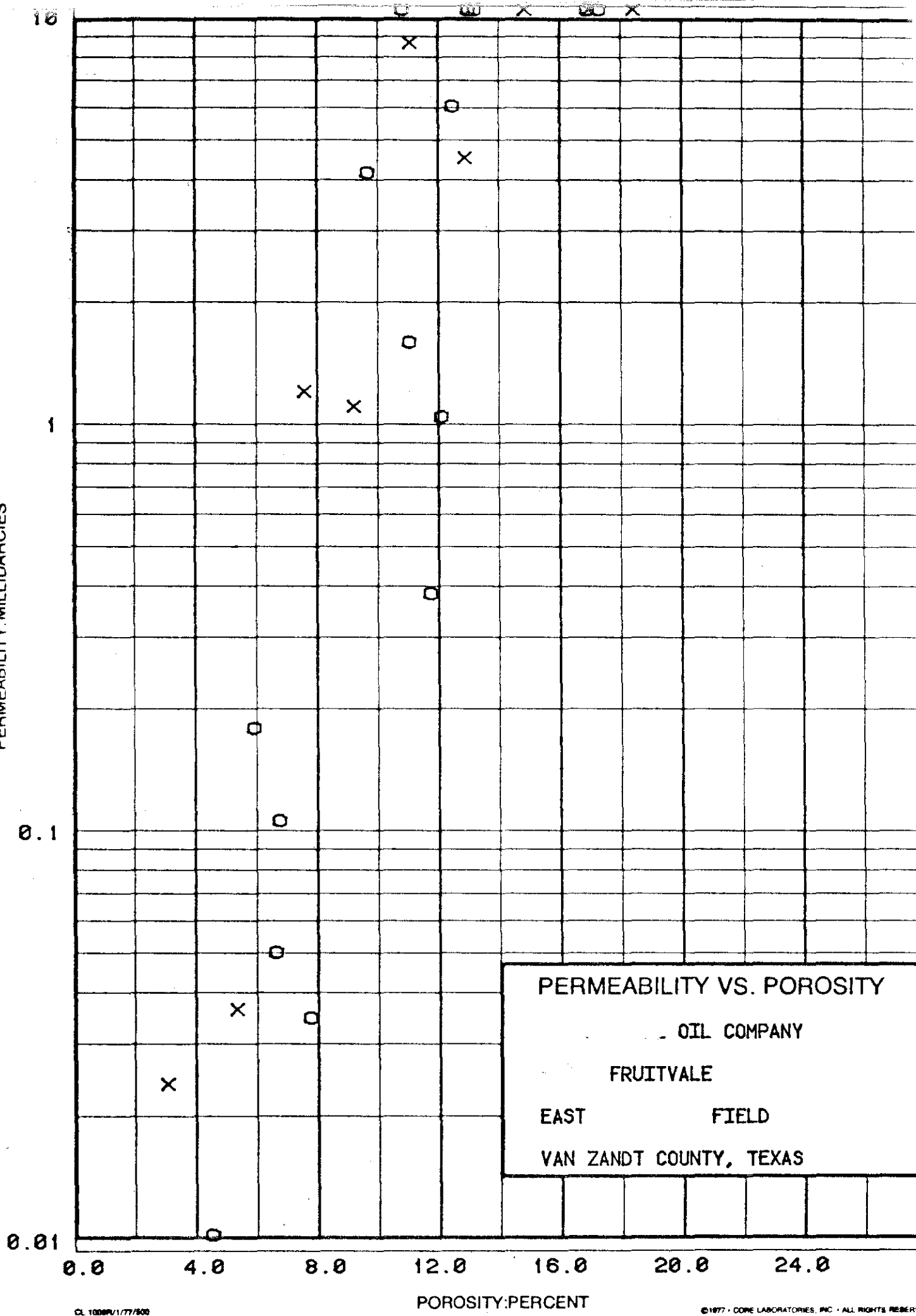


PERMEABILITY AND POROSITY HISTOGRAMS

OIL COMPANY
 FRUITVALE
 EAST FIELD
 VAN ZANDT COUNTY, TEXAS

LEGEND
 ARITHMETIC MEAN POROSITY
 GEOMETRIC MEAN PERMEABILITY
 MEDIAN VALUE - - - - -
 CUMULATIVE FREQUENCY _____
 CUMULATIVE CAPACITY LOST - . - . - .

PERMEABILITY: MILLIDARCIES



STATISTICAL DATA FOR POROSITY AND PERMEABILITY HISTOGRAM

COMPANY: OIL COMPANY WELL : FRUITVALE
FIELD : EAST FIELD COUNTY, STATE: VAN ZANDT COUNTY, TEXAS

AIR PERMEABILITY : MD. (HORIZONTAL) RANGE USED 0.010 TO 12000.
POROSITY : PERCENT (FLUID SATURATION) RANGE USED 0.0 TO 46.0

(PERMEABILITY UNCORRECTED FOR SLIPPAGE)

DEPTH LIMITS : 8261.0 - 13720.0 INTERVAL LENGTH : 5459.0
FEET ANALYZED IN ZONE : 178.0 LITHOLOGY EXCLUDED : DOL

DATA SUMMARY

POROSITY AVERAGE	PERMEABILITY AVERAGES		
	ARITHMETIC	HARMONIC	GEOMETRIC
10.8	17.	0.12	2.6

STATISTICAL DATA FOR POROSITY AND PERMEABILITY HISTOGRAM

COMPANY: OIL COMPANY WELL : FRUITVALE
 FIELD : EAST FIELD COUNTY, STATE: VAN ZANDT COUNTY, TEXAS

GROUPING BY POROSITY RANGES

POROSITY RANGE	FEET IN RANGE	AVERAGE POROSITY	AVERAGE PERM. (GEOM.)	AVERAGE PERM. (ARITH)	FREQUENCY (PERCENT)	CUMULATIVE FREQUENCY (%)
2.0 - 4.0	2.0	3.0	0.024	0.032	3.7	3.7
4.0 - 6.0	5.0	5.3	0.037	0.066	9.3	13.0
6.0 - 8.0	7.0	7.5	1.2	9.8	13.0	25.9
8.0 - 10.0	7.0	9.2	1.1	5.7	13.0	38.9
10.0 - 12.0	14.0	11.1	8.6	15.	25.9	64.8
12.0 - 14.0	9.0	12.9	4.5	14.	16.7	81.5
14.0 - 16.0	4.0	14.9	15.	15.	7.4	88.9
16.0 - 18.0	4.0	17.0	43.	88.	7.4	96.3
18.0 - 20.0	2.0	18.4	12.	17.	3.7	100.0

TOTAL NUMBER OF FEET = 54.0

STATISTICAL DATA FOR POROSITY AND PERMEABILITY HISTOGRAM

COMPANY: OIL COMPANY WELL : FRUITVALE
 FIELD : EAST FIELD COUNTY, STATE: VAN ZANDT COUNTY, TEXAS

GROUPING BY PERMEABILITY RANGES

PERMEABILITY RANGE	FEET IN RANGE	AVERAGE PERM. (GEOM.)	AVERAGE PERM. (ARITH)	AVERAGE POROSITY	FREQUENCY (PERCENT)	CUMULATIVE FREQUENCY (%)
0.010 - 0.020	3.0	0.010	0.010	4.4	5.6	5.6
0.020 - 0.039	1.0	0.035	0.035	7.7	1.9	7.4
0.039 - 0.078	4.0	0.051	0.051	6.6	7.4	14.8
0.078 - 0.156	2.0	0.106	0.108	6.7	3.7	18.5
0.156 - 0.312	2.0	0.180	0.180	5.8	3.7	22.2
0.312 - 0.625	2.0	0.383	0.384	11.7	3.7	25.9
0.625 - 1.250	1.0	1.0	1.0	12.1	1.9	27.8
1.250 - 2.500	7.0	1.6	1.6	11.0	13.0	40.7
2.500 - 5.000	5.0	4.1	4.2	9.6	9.3	50.0
5.- 10.	5.0	6.0	6.1	12.5	9.3	59.3
10.- 20.	9.0	14.	15.	13.0	16.7	75.9
20.- 40.	8.0	26.	27.	13.2	14.8	90.7
40.- 80.	3.0	54.	54.	10.8	5.6	96.3
80.- 160.	1.0	122.	122.	16.9	1.9	98.1
160.- 320.	1.0	200.	200.	17.3	1.9	100.0

TOTAL NUMBER OF FEET = 54.0

STATISTICAL DATA FOR POROSITY AND PERMEABILITY HISTOGRAM

COMPANY: OIL COMPANY WELL : FRUITVALE
 FIELD : EAST FIELD COUNTY, STATE: VAN ZANDT COUNTY, TEXAS

POROSITY-FEET OF STORAGE CAPACITY LOST FOR SELECTED POROSITY CUT OFF

POROSITY CUT OFF	FEET LOST	CAPACITY LOST (%)	FEET REMAINING	CAPACITY REMAINING (%)	ARITH MEAN	MEDIAN
0.0	0.0	0.0	54.0	100.0	10.8	10.9
2.0	0.0	0.0	54.0	100.0	10.8	10.9
4.0	2.0	1.0	52.0	99.0	11.1	11.0
6.0	7.0	5.5	47.0	94.5	11.8	11.4
8.0	14.0	14.5	40.0	85.5	12.5	11.9
10.0	21.0	25.5	33.0	74.5	13.2	12.6
12.0	35.0	52.1	19.0	47.9	14.8	14.2
14.0	44.0	71.9	10.0	28.1	16.4	16.5
16.0	48.0	82.1	6.0	17.9	17.5	
18.0	52.0	93.7	2.0	6.3	18.4	
20.0	54.0	100.0	0.0	0.0		

TOTAL STORAGE CAPACITY IN POROSITY-FEET = 584.7

STATISTICAL DATA FOR POROSITY AND PERMEABILITY HISTOGRAM

COMPANY: OIL COMPANY WELL : FRUITVALE
 FIELD : EAST FIELD COUNTY, STATE: VAN ZANDT COUNTY, TEXAS

MILLIDARCY-FEET OF FLOW CAPACITY LOST FOR SELECTED PERMEABILITY CUT OFF

PERMEABILITY CUT OFF	FEET LOST	CAPACITY LOST (%)	FEET REMAINING	CAPACITY REMAINING (%)	GEOM MEAN	MEDIAN
0.005	0.0	0.0	54.0	100.0	2.65	5.00
0.010	0.0	0.0	54.0	100.0	2.96	5.00
0.020	3.0	0.0	51.0	100.0	3.67	6.16
0.039	4.0	0.0	50.0	100.0	4.03	6.60
0.078	8.0	0.0	46.0	100.0	5.89	8.71
0.156	10.0	0.1	44.0	99.9	7.07	10.00
0.312	12.0	0.1	42.0	99.9	8.42	10.80
0.625	14.0	0.2	40.0	99.8	9.83	11.67
1.250	15.0	0.3	39.0	99.7	10.41	12.12
2.500	22.0	1.6	32.0	98.4	15.72	15.87
5.	27.0	3.9	27.0	96.1	20.13	19.24
10.	32.0	7.3	22.0	92.7	26.48	23.78
20.	41.0	22.0	13.0	78.0	40.70	
40.	49.0	45.9	5.0	54.1	82.26	
80.	52.0	64.0	2.0	36.0	156.21	160.00
160.	53.0	77.6	1.0	22.4	200.00	
320.	54.0	100.0	0.0	0.0		

TOTAL FLOW CAPACITY IN MILLIDARCY-FEET (ARITHMETIC) = 894.46