



TEXAS DEPARTMENT OF WATER RESOURCES  
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REPORT 229

VARIATIONS IN SPECIFIC YIELD IN THE OUTCROP OF THE  
CARRIZO SAND IN SOUTH TEXAS AS ESTIMATED  
BY SEISMIC REFRACTION

By

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April 1979



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# VARIATIONS IN SPECIFIC YIELD IN THE OUTCROP OF THE CARRIZO SAND IN SOUTH TEXAS AS ESTIMATED BY SEISMIC REFRACTION

## SUMMARY

Seismic soundings were made at 84 sites, situated along 20 profiles, on the outcrop of the Carrizo Sand in South Texas. These soundings were made to estimate lateral variations in the aquifer's total porosity and specific yield where the aquifer is under water-table conditions. Compressional wave velocities in the upper unsaturated portion of the aquifer were determined by refraction soundings. Empirical relationships were used to estimate total porosity values from the compressional wave velocities. Estimated specific yields were derived from the estimated total porosities. The porosity values obtained by these empirical methods agree closely with laboratory porosity determinations from core samples taken from seven of the 84 seismic sounding sites.

All of the averaged values for specific yield fall within the range usually specified for unconfined aquifers (5 to 35 percent). Because of depth limitations of equipment used in the soundings, it is probable that the estimated average specific yields from profiles spanning or nearly spanning the outcrop are more nearly representative of the full thickness of the aquifer than are the specific yields from profiles that parallel the strike.

The higher specific yield values are found east of the Frio River and range from 26 to 32 percent. West of the Frio River specific yield values range from 16 to 24 percent.

## INTRODUCTION

### Purpose and Scope

The purpose of the investigation was to obtain estimated lateral variations in total porosity and specific yield in the Carrizo Sand outcrop in South Texas for

refinement of data to be used in the Carrizo aquifer computer model (Klemt and others, 1976). Initial application runs on the computer indicated that the model was very sensitive to specific yield where the aquifer is under water-table conditions. In the Carrizo, water-table conditions occur mainly in the outcrop.

The general scope of the investigation included the following: (a) seismic refraction surveys were made on the Carrizo outcrop to determine lateral variations in compressional wave velocities in the unweathered and unsaturated zone; (b) these compressional wave velocities were used to estimate total porosity in the saturated zone; and (c) the total porosity was used to estimate the specific yield (effective or drainable porosity) of the saturated material through the use of empirical relationships.

## Location

The area of investigation is the Carrizo Sand outcrop in South Texas (Figure 1). This area includes

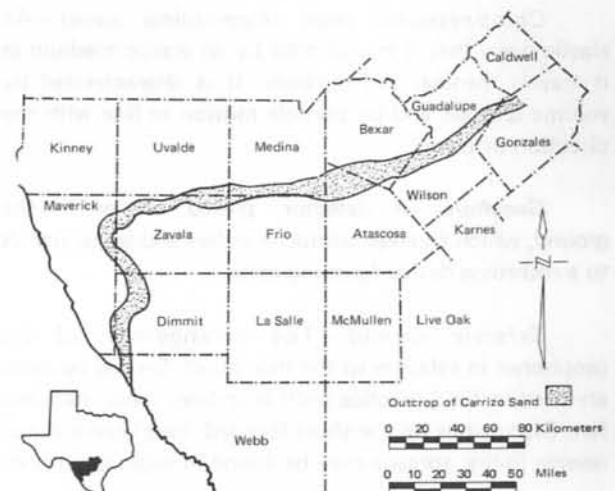


Figure 1.—Location and Extent of Study Area

parts of the following counties: Atascosa, Bexar, Dimmit, Frio, Gonzales, Guadalupe, Maverick, Medina, Uvalde, Webb, Wilson, and Zavala.

### Personnel

This report was prepared under the direct supervision of Dr. Tommy R. Knowles and William B. Klemt. Field work for the study was accomplished by the authors with assistance from James Perdue, James Sansom, Ruben Sanchez, David Jones, and Glenn Marquardt. Eulogio Rodriquez, Jr. assisted in preparation of the report.

### Acknowledgements

The authors acknowledge the cooperation of the Texas Department of Highways and Public Transportation in allowing field work to be conducted on state highway right-of-ways. The authors also appreciate the cooperation of Webb County Judge Alberto A. Santos in granting permission to conduct a seismic investigation on a county road right-of-way in extreme western Webb County.

### Definition of Terms

This section is intended to acquaint the reader with some of the terms as they are used in this report. Most of these definitions were adapted from the *Glossary of Geology and Related Sciences* (American Geological Institute, 1960) and *A Dictionary of Mining, Mineral, and Related Terms* (Thrush and U.S. Bureau of Mines, 1968).

*Compressional wave (longitudinal wave).*—An elastic wave that is transmitted by an elastic medium as it travels through the medium. It is characterized by volume changes and by particle motion in line with the direction of travel.

*Geophone.*—A detector, placed on or in the ground, which receives seismic impulses and sends signals to a recording device (seismograph).

*Seismic spread.*—The arrangement of the geophones in relation to the shot point. Several patterns are used in field practice such as in-line, cross, star, and fan. Discussions on the short forward, long forward, and reverse in-line spreads may be found in subsequent text.

*Seismogram.*—The photographic record made by a seismograph.

*Shot point.*—The point at which an explosive charge is detonated for the generation of seismic energy. In field practice, the shot point includes the hole in which the charge is placed and its immediately surrounding area.

*Specific yield (effective porosity).*—The ratio of (1) the volume of water that an aquifer will yield by gravity if it is first saturated and then allowed to drain to (2) the total volume of the aquifer that is drained. The ratio is expressed as a percentage.

*Time break.*—An indication on a seismogram showing the instant of detonation of a shot or charge. It serves as a zero time reference for determining the travel times of the shock waves.

*Total porosity.*—The ratio of the aggregate volume of interstices (pores) in a rock or soil to its total volume. It is usually stated as a percentage.

## THEORY

The principle of seismic refraction is based on the fact that compressional waves travel at different velocities through materials of different composition. The more dense the material the faster the speed of the compressional wave.

Basically, refraction seismology consists of measuring at known points along the surface of the ground the travel times of artificially produced compressional waves as they travel through the various layers of earth material. The two main variables measured are time and distance. The time measurement is the elapsed time required for the compressional wave to travel from the shot point to each geophone. The distance measurement is the distance between the shot point and each successive geophone. This distance is measured by surveying along the land surface. Figure 2 illustrates diagrammatically the principles of seismic refraction by showing a time-distance plot and associated mathematics, velocity ( $V_1$ ) in an upper weathered zone, velocity ( $V_2$ ) in an unweathered unsaturated zone, and velocity ( $V_3$ ) in the lowermost saturated zone.

A reverse spread should always be taken to evaluate the possibility of dipping beds and to determine the true velocities of the compressional waves. Reverse shooting simply means detonating the explosive device at both ends of the seismic line in two separate shots so that arrival times at each geophone are measured from both directions. Redpath (1973) gives an excellent discussion on the determination of dip from seismic

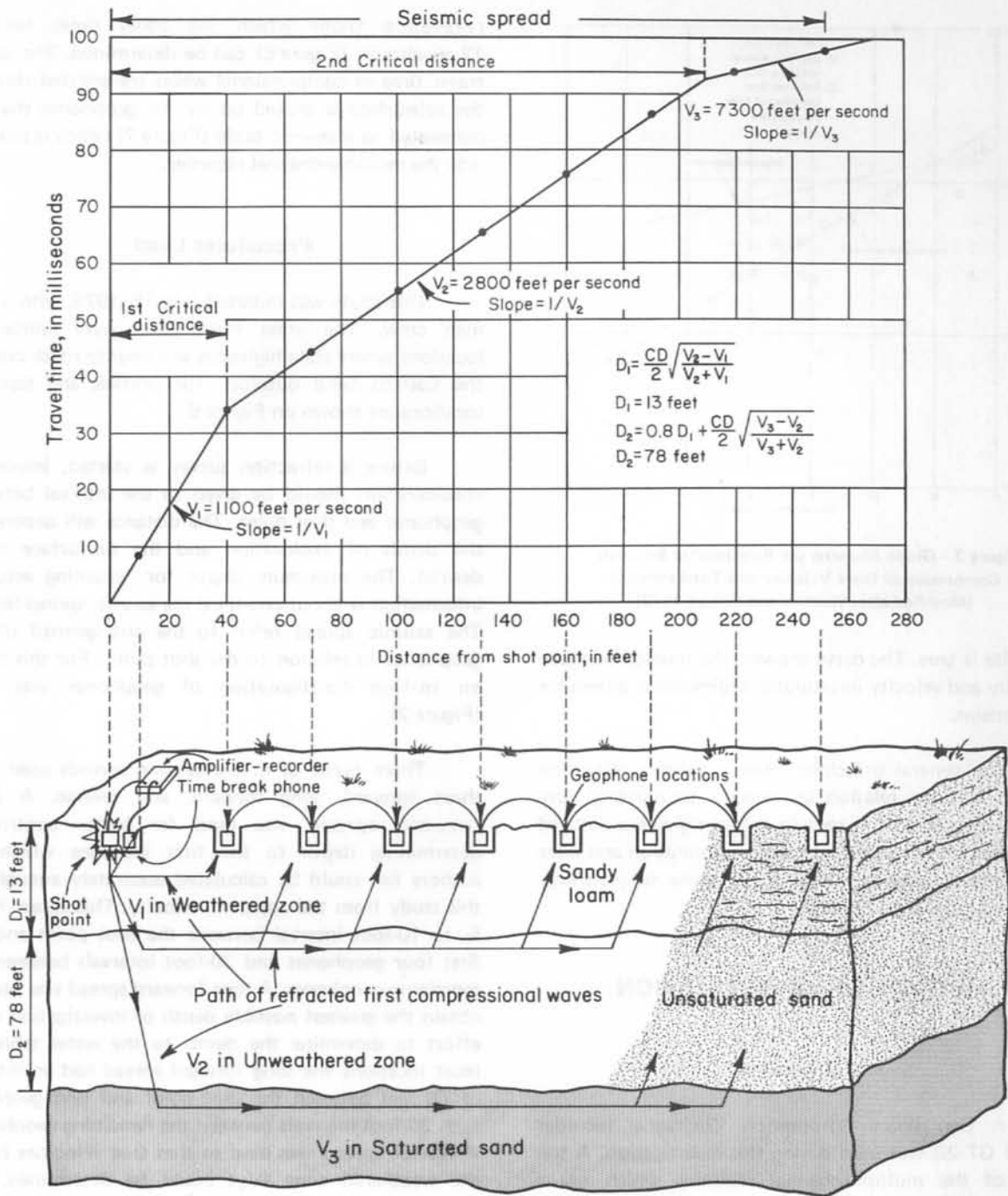


Figure 2.—Principles of Seismic Refraction

refraction methods and the necessary corrections required to obtain true velocities.

Watkins, Walters, and Godson (1972) showed, from seismic studies conducted in Arizona, New Mexico, and California, a direct correlation between porosity and compressional wave velocity of the material being investigated. These studies have shown that porosity is usually the dominant parameter affecting compressional wave velocities in dry or saturated rocks at a given pressure. The data gathered from the studies by Watkins

and others (1972) and results from core samples analyzed by the Department's Material Testing Laboratory were plotted as shown in Figure 3. Because of the limited depth capability of the Department's seismic equipment and the logarithmic response of porosity in saturated sediments to velocity, the porosity of the saturated zone was estimated from the velocity of the unsaturated zone using the graph shown in Figure 3. As an example, a change in velocity of 100 feet per second on the unsaturated curve produces a small difference in porosity but on the saturated curve the

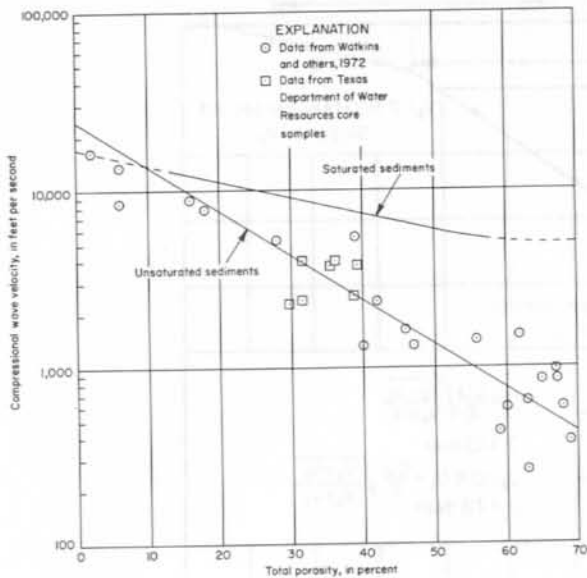


Figure 3.—Graph Showing the Relationship Between Compressional Wave Velocity and Total Porosity (Modified after Watkins and Others 1972)

opposite is true. The curve showing the relation between porosity and velocity in saturated sediments is shown for comparison.

The general principles used in seismic refraction surveys and the relation of velocity to porosity have been presented in this section without giving a detailed discussion on the theory of elastic deformation and wave propagation. Detailed discussions on these subjects may be found in Heiland (1946).

## METHOD OF INVESTIGATION

### Equipment

A Geo Space Corporation 12-channel recorder model GT-2B was used during this investigation. A top view of the multiple-channel recorder which has a polaroid camera that photographs a permanent record (seismogram) is shown in Figure 4. The energy source used at each shot point contains approximately 20 grams (0.7 ounces) of photographic flash powder encased with an electric match in a plastic container (Figure 5). The multiple-channel recorder has a built-in blaster with a safety switch which ignites the electric match causing the powder to burn. A time-break phone connected to the recorder is inserted in the ground near the shot point (Figure 2). The time-break phone sends an impulse to the recorder causing a time break to appear on the seismogram at the instant the explosive device is detonated. The time-break curve provides a zero-time

reference from which the travel times for the 12 geophones (Figure 6) can be determined. The actual travel time of compressional waves transmitted through the subsurface is picked up by the geophones that are connected to a seismic cable (Figure 7) which is plugged into the multiple-channel recorder.

### Procedures Used

This study was initiated July 16, 1975, with a four man crew. The areas investigated were limited to locations where state highways and county roads crossed the Carrizo Sand outcrop. The profiles and test site locations are shown on Figure 9.

Before a refraction survey is started, important consideration should be given to the interval between geophones and shot point. The distance will depend on the depth of exploration and the subsurface detail desired. The maximum depth for obtaining accurate information is about one-third the seismic spread length. The seismic spread refers to the arrangement of the geophones in relation to the shot point. For this study an in-line configuration of geophones was used (Figure 2).

Three types of in-line seismic spreads used were short forward, long forward, and reverse. A short forward spread was used for better control in determining depth to the first interface which the authors felt could be calculated accurately enough for this study from the apparent velocity. This spread had a 5- to 10-foot interval between the shot point and the first four geophones and 30-foot intervals between the remaining geophones. A long forward spread was used to obtain the greatest possible depth of investigation in an effort to determine the depth to the water table. At most locations the long forward spread had an interval of 60 feet between the shot point and first geophone with 30-foot intervals between the remaining geophones. A reverse spread was used so that true velocities below the weathered zone ( $V_1$ ) could be determined. The reverse spread had the same distance between shot point and geophones as the long forward spread. The best approximations of true velocities in unsaturated sand ( $V_2$ ) and in saturated sand ( $V_3$ ) were calculated by using the harmonic mean formula

$$V = 2 \frac{A \times B}{A + B}$$

where

A = long forward spread velocity and

B = reverse spread velocity.



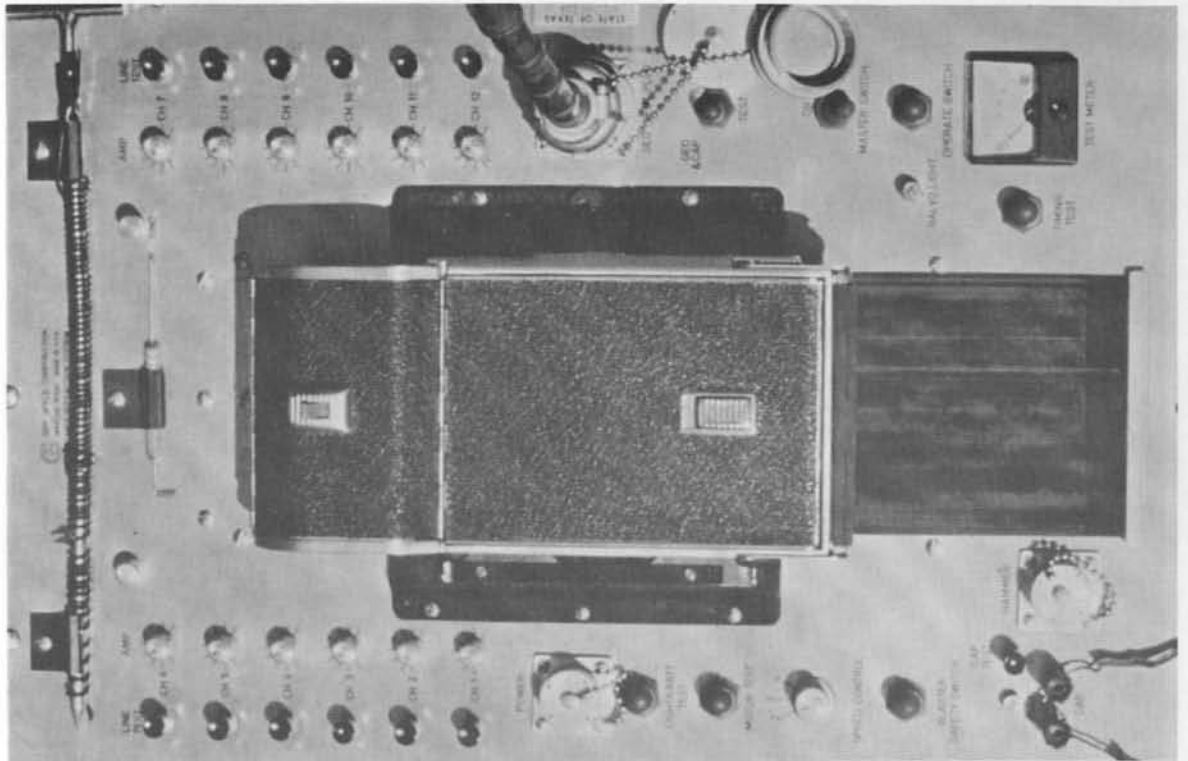


Figure 4.—Multiple-Channel Recorder Model GT-2B

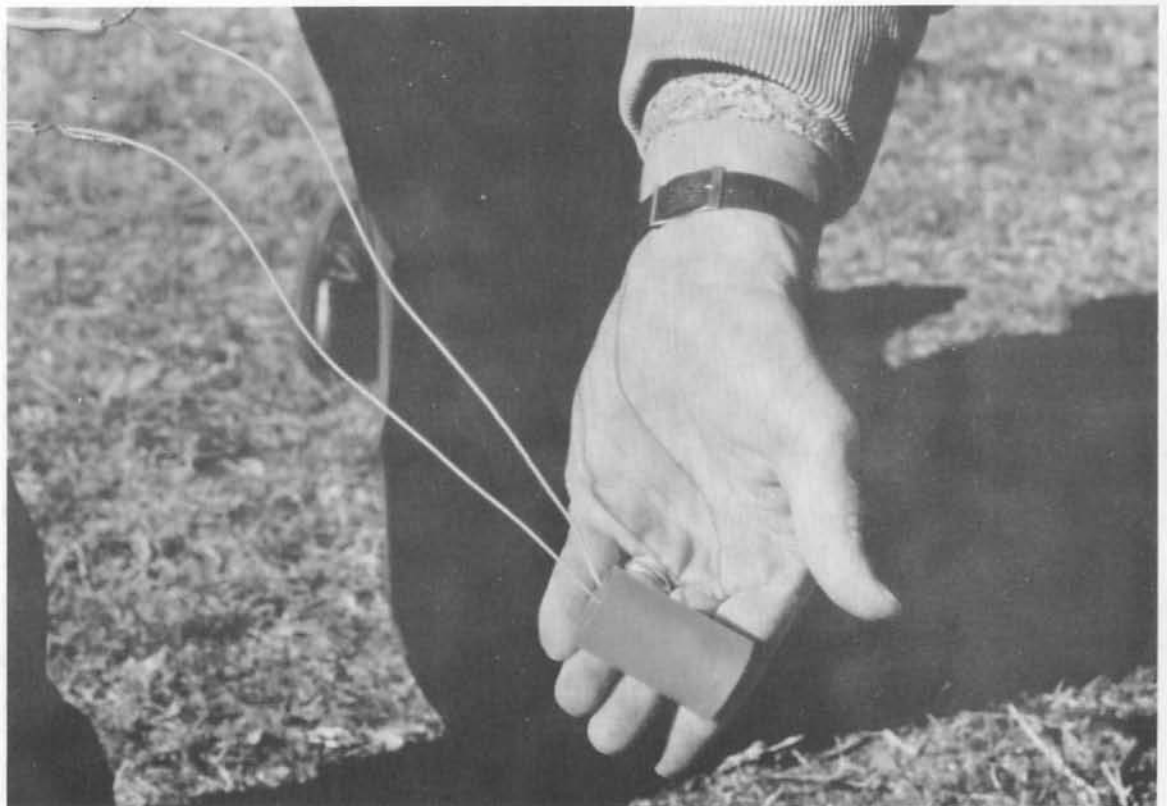


Figure 5.—Plastic Explosive Container

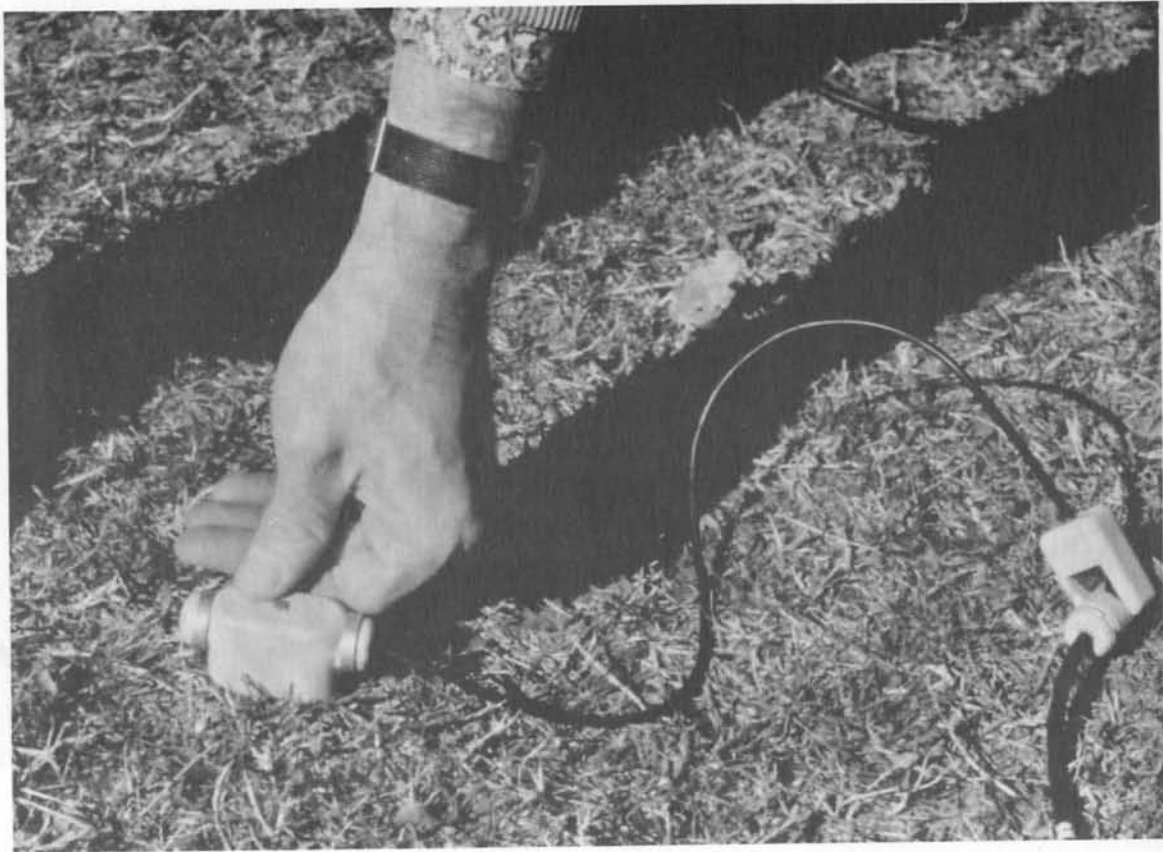


Figure 6.—Geophone

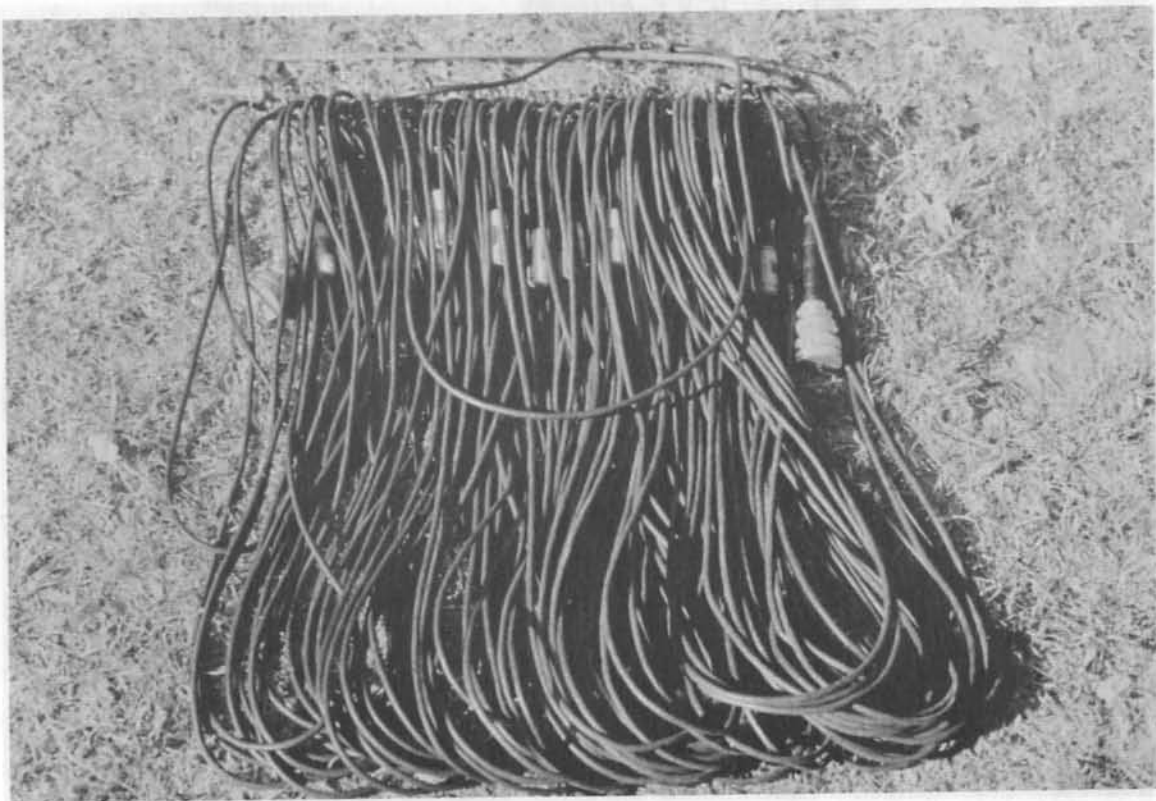


Figure 7.—Seismic Cable

The interval distance between geophones shown separately and cumulatively and the compressional wave travel times for each test site are shown in Table 1. Data in Table 1 were used to calculate the compressional wave velocities in Table 2. An average compressional wave velocity was calculated for each profile from individual unsaturated sand compressional wave velocities ( $V_2$ ) in Table 2. The average compressional wave velocity ( $V_2$ ) for each profile was used in conjunction with Figure 3 to obtain estimated average total porosities shown in Table 2. The estimated average total porosities obtained from Figure 3 were used in conjunction with Figure 8 to obtain estimated average specific yields shown in Table 2 and Figure 9.

The unsaturated rather than the saturated sediments curve in Figure 3 was used in relating velocity to estimated total porosity because the depth capability of the seismic equipment was too limited to reach the saturated sediments at each test site. Because of this equipment limitation, the authors decided that a single, averaged specific yield value for each profile would reflect a more realistic evaluation of the data collected. Therefore, in this report, estimated specific yields from profiles extending across or nearly across the outcrop, parallel to the dip, probably are more representative than the estimated specific yields from profiles that are aligned parallel to the strike.

To verify the relationship derived by Watkins and others (1972), a gasoline driven auger was used to obtain core samples from the Carrizo outcrop at selected seismic test sites. The core samples were analyzed by the Department's Materials Testing Laboratory to determine percent moisture and porosity. Moisture, by weight, ranged from 5.1 to 12.2 percent and porosities, by volume, ranged from 29.7 to 39.4 percent. A tabulation of the laboratory results is in Table 3. Watkins and others (1972) did not consider the effects of partial saturation and saturant-matrix interaction to be too significant in the velocity-porosity relationship. Therefore, it was considered unnecessary to make adjustments in velocity for partial saturation during this study. The porosities in Table 3 and the unsaturated sand compressional wave velocities ( $V_2$ ) in Table 2 from the same site locations were plotted on the graph in Figure 3.

### LIMITATIONS AND PROBLEMS

The seismic refraction method can be used to identify the dense layers that are to be found at lower depths. Usually, density increases as depth is increased. Layers of higher porosity (low velocity) overlain by layers of lower porosity (high velocity) cannot be

identified by seismic refraction. This is commonly known as the "hidden layer problem".

At many of the seismic site locations, thin sandstones or claystones probably masked the underlying layers. Thus, any porosities obtained from the seismic analysis under these conditions would be conservative.

The porosity of the saturated layer ( $V_3$ ) could not be determined in most cases and therefore could not be compared with the porosity obtained from the overlying layer ( $V_2$ ). This comparison could have been used to ascertain if the "hidden layer problem" did exist at the site in question. The length of the seismic cable and the recording time capability of the seismic recorder were the equipment limitations which restricted the depth of the investigation.

### RECOMMENDATIONS

The results of this investigation should be incorporated into an integrated geophysical investigation of the Carrizo Sand in South Texas. Additional geophysical work should include (a) surface electrical resistivity surveys; (b) use of calibrated radiological logging tools; and (c) downhole seismic surveys. It is important to note that each of the above are sensitive to different properties of the subsurface materials, and therefore through their use problems such as the "hidden layer problem" can be eliminated and speed, economy, and reliability achieved.

The surface electrical resistivity survey should be most useful with respect to the Carrizo in South Texas. This type of investigation should be able to determine (a) depth to water; (b) location of large shale or sandstone beds within the Carrizo; and (c) porosity and permeability estimates. Archie (1942) related porosity and permeability of subsurface materials to surface-measured resistivity in the formula

$$F = \frac{R_0}{R_w}$$

where

- F = the formation resistivity factor,
- $R_0$  = the resistivity of rock that is 100 percent saturated with formation water, and
- $R_w$  = the resistivity of the formation water.

Quantitative analysis of nuclear logs in terms of porosity can be made only if the logging equipment is

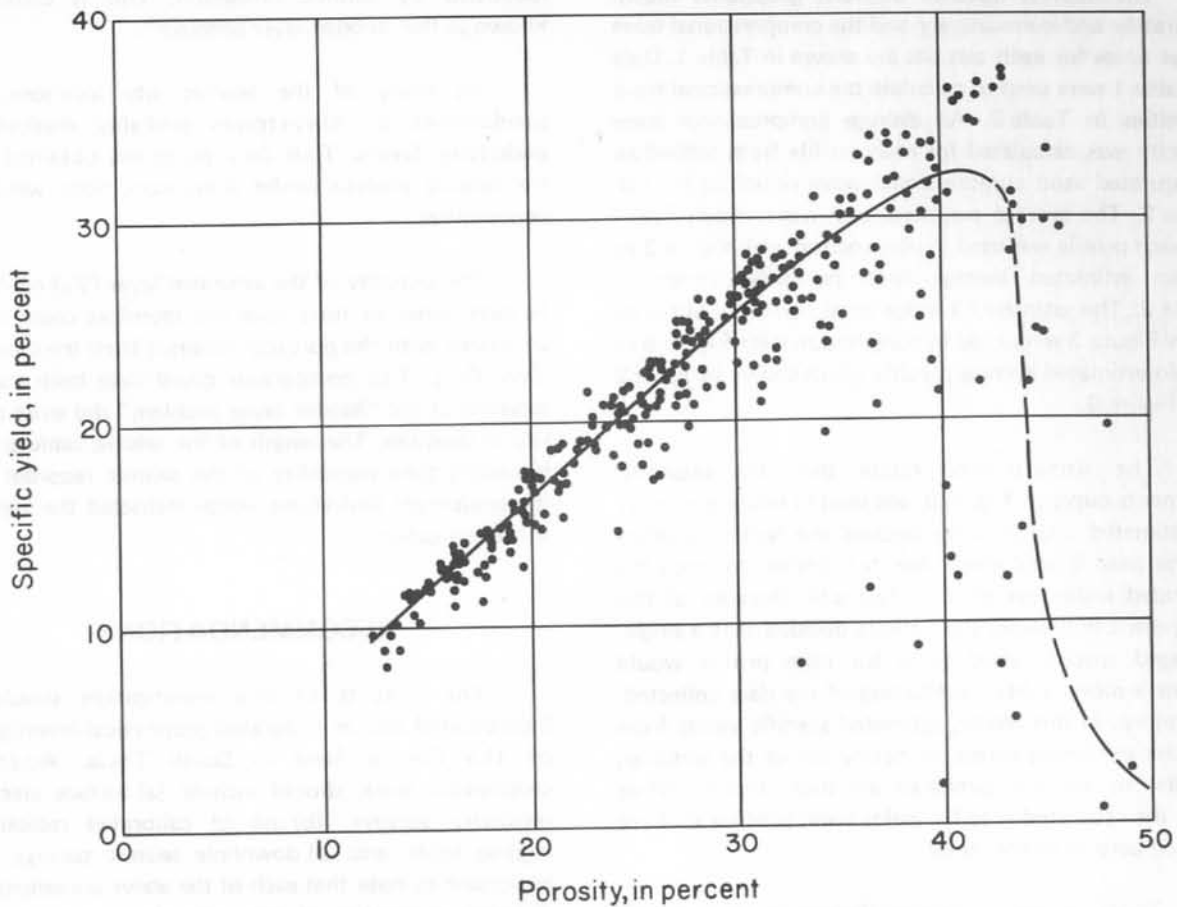


Figure 8.—Relationship of Specific Yield and Porosity (After Preuss and Todd, 1963)

calibrated by using laboratory analyses of core samples from a logged hole or by using a model. The API Limestone pits in Houston, Texas, are the only readily available models for calibrating logging tools. The Department's radioactive logging tools have been calibrated there. These calibrated tools can be used in drilled holes to obtain estimates of porosity at depth. These estimates can then be correlated with seismic velocities over a wide area.

Generally, the seismic downhole survey is a record of the transit time of an acoustic pulse between the surface of the ground and some point in a drilled borehole. In practice the receiver is lowered down the hole, an impulse is set off at the surface, and the transit time is recorded. The results can be graphed as shown in Figure 2 and the "hidden layer" identified more readily. This method is limited in that the compressional wave velocity in the vertical direction may be different than in the horizontal direction. Also, this method is very time consuming and dependent upon good drill equipment.

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Table 1.--Geophone Intervals and Compressional Wave Travel Times

<u>Test Site 1-A</u>				<u>Test Site 2-A</u>			
Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)
<u>Short Spread</u>				<u>Short Spread</u>			
SP- 1	5	5	4	SP- 1	10	10	11
1- 2	5	10	11	1- 2	5	15	13
2- 3	5	15	14	2- 3	5	20	15
3- 4	5	20	19	3- 4	30	50	27
4- 5	30	50	44	4- 5	30	80	41
5- 6	30	80	52	5- 6	30	110	51
6- 7	30	110	59	6- 7	30	140	54
7- 8	30	140	69	7- 8	30	170	62
8- 9	30	170	77	8- 9	30	200	70
9-10	30	200	84	9-10	30	230	73
10-11	30	230	95	10-11	30	260	78
11-12	30	260	104	11-12	30	290	83
<u>Long Spread</u>				<u>Long Spread</u>			
SP- 1	10	10	11	A spread was not run at this site.			
1- 2	20	30	33				
2- 3	20	50	43				
3- 4	30	80	54				
4- 5	30	110	62				
5- 6	30	140	70				
6- 7	30	170	78				
7- 8	30	200	88				
8- 9	30	230	97				
9-10	30	260	--				
10-11	30	290	--				
11-12	30	320	--				
<u>Reverse Spread</u>				<u>Reverse Spread</u>			
SP-12	10	10	6	SP-12	10	10	9
12-11	30	40	25	12-11	30	40	22
11-10	30	70	39	11-10	30	70	33
10- 9	30	100	50	10- 9	30	100	43
9- 8	30	130	59	9- 8	30	130	49
8- 7	30	160	71	8- 7	30	160	53
7- 6	30	190	79	7- 6	30	190	57
6- 5	30	220	93	6- 5	30	220	67
5- 4	30	250	103	5- 4	30	250	72
4- 3	30	280	--	4- 3	30	280	78
3- 2	30	310	--	3- 2	30	310	83
2- 1	30	340	--	2- 1	30	340	89

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 3-A				Test Site 3-B			
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)		Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	
<u>Short Spread</u>				<u>Short Spread</u>			
SP- 1	10	10	9	SP- 1	10	10	9
1- 2	5	15	14	1- 2	5	15	15
2- 3	5	20	17	2- 3	5	20	19
3- 4	5	25	23	3- 4	5	25	22
4- 5	5	30	26	4- 5	30	55	37
5- 6	30	60	37	5- 6	30	85	47
6- 7	30	90	48	6- 7	30	115	57
7- 8	30	120	57	7- 8	30	145	73
8- 9	30	150	73	8- 9	30	175	87
9-10	30	180	89	9-10	30	205	103
10-11	30	210	105	10-11	30	235	112
11-12	30	240	116	11-12	30	265	127
<u>Long Spread</u>				<u>Long Spread</u>			
A spread was not run at this site.				A spread was not run at this site.			
<u>Reverse Spread</u>				<u>Reverse Spread</u>			
SP-12	10	10	7	SP-12	10	10	7
12-11	30	40	30	12-11	30	40	30
11-10	30	70	38	11-10	30	70	50
10- 9	30	100	53	10- 9	30	100	63
9- 8	30	130	62	9- 8	30	130	70
8- 7	30	160	70	8- 7	30	160	77
7- 6	30	190	104	7- 6	30	190	88
6- 5	30	220	106	6- 5	30	220	100
5- 4	30	250	115	5- 4	30	250	116
4- 3	30	280	123	4- 3	30	280	130
3- 2	30	310	129	3- 2	30	310	137
2- 1	30	340	149	2- 1	30	340	149

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 4-A			Test Site 4-B				
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)		
<u>Short Spread</u>			<u>Short Spread</u>				
SP- 1	10	10	9	SP- 1	10	10	9
1- 2	10	20	15	1- 2	5	15	12
2- 3	10	30	18	2- 3	5	20	16
3- 4	10	40	21	3- 4	5	25	19
4- 5	30	70	31	4- 5	30	55	26
5- 6	30	100	39	5- 6	30	85	32
6- 7	30	130	48	6- 7	30	115	39
7- 8	30	160	58	7- 8	30	145	49
8- 9	30	190	66	8- 9	30	175	55
9-10	30	220	76	9-10	30	205	62
10-11	30	250	85	10-11	30	235	74
11-12	30	280	96	11-12	30	265	80
<u>Long Spread</u>			<u>Long Spread</u>				
SP- 1	10	10	9	SP- 1	10	10	8
1- 2	30	40	27	1- 2	30	40	19
2- 3	30	70	32	2- 3	30	70	26
3- 4	30	100	41	3- 4	30	100	35
4- 5	30	130	48	4- 5	30	130	42
5- 6	30	160	57	5- 6	30	160	52
6- 7	30	190	66	6- 7	30	190	58
7- 8	30	220	76	7- 8	30	220	66
8- 9	30	250	86	8- 9	30	250	74
9-10	30	280	95	9-10	30	280	80
10-11	30	310	104	10-11	30	310	89
11-12	30	340	119	11-12	30	340	98
<u>Reverse Spread</u>			<u>Reverse Spread</u>				
SP-12	10	10	8	SP-12	10	10	10
12-11	30	40	25	12-11	30	40	24
11-10	30	70	34	11-10	30	70	30
10- 9	30	100	42	10- 9	30	100	38
9- 8	30	130	49	9- 8	30	130	44
8- 7	30	160	56	8- 7	30	160	52
7- 6	30	190	64	7- 6	30	190	58
6- 5	30	220	71	6- 5	30	220	66
5- 4	30	250	84	5- 4	30	250	73
4- 3	30	280	91	4- 3	30	280	80
3- 2	30	310	102	3- 2	30	310	92
2- 1	30	340	114	2- 1	30	340	98



Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 4-C			Test Site 4-D		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	4	SP- 1	10 10	8
1- 2	5 15	7	1- 2	5 15	9
2- 3	5 20	8	2- 3	5 20	10
3- 4	30 50	18	3- 4	5 25	11
4- 5	30 80	25	4- 5	30 55	20
5- 6	30 110	33	5- 6	30 85	36
6- 7	30 140	43	6- 7	30 115	46
7- 8	30 170	55	7- 8	30 145	65
8- 9	30 200	65	8- 9	30 175	75
9-10	30 230	73	9-10	30 205	86
10-11	30 260	89	10-11	30 235	97
11-12	30 290	98	11-12	30 265	114
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	10 10	6	SP- 1	10 10	10
1- 2	30 40	16	1- 2	30 40	24
2- 3	30 70	23	2- 3	30 70	33
3- 4	30 100	31	3- 4	30 100	48
4- 5	30 130	39	4- 5	30 130	63
5- 6	30 160	52	5- 6	30 160	73
6- 7	30 190	60	6- 7	30 190	78
7- 8	30 220	73	7- 8	30 220	88
8- 9	30 250	77	8- 9	30 250	102
9-10	30 280	90	9-10	30 280	109
10-11	30 310	97	10-11	30 310	121
11-12	30 340	104	11-12	30 340	137
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	10 10	7	SP-12	10 10	12
12-11	30 40	20	12-11	30 40	33
11-10	30 70	26	11-10	30 70	41
10- 9	30 100	34	10- 9	30 100	54
9- 8	30 130	43	9- 8	30 130	67
8- 7	30 160	51	8- 7	30 160	77
7- 6	30 190	62	7- 6	30 190	88
6- 5	30 220	71	6- 5	30 220	104
5- 4	30 250	88	5- 4	30 250	--
4- 3	30 280	93	4- 3	30 280	109
3- 2	30 310	101	3- 2	30 310	134
2- 1	30 340	105	2- 1	30 340	145

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 4-E			Test Site 4-F		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	4	SP- 1	10 10	8
1- 2	5 15	7	1- 2	5 15	11
2- 3	5 20	8	2- 3	5 20	12
3- 4	5 25	10	3- 4	5 25	13
4- 5	30 55	17	4- 5	30 55	22
5- 6	30 85	24	5- 6	30 85	32
6- 7	30 115	30	6- 7	30 115	40
7- 8	30 145	43	7- 8	30 145	50
8- 9	30 175	57	8- 9	30 175	--
9-10	30 205	67	9-10	30 205	--
10-11	30 235	74	10-11	30 235	93
11-12	30 265	84	11-12	30 265	97
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	10 10	5	SP- 1	10 10	11
1- 2	30 40	16	1- 2	30 40	22
2- 3	30 70	23	2- 3	30 70	32
3- 4	30 100	30	3- 4	30 100	37
4- 5	30 130	38	4- 5	30 130	48
5- 6	30 160	52	5- 6	30 160	63
6- 7	30 190	63	6- 7	30 190	74
7- 8	30 220	80	7- 8	30 220	91
8- 9	30 250	88	8- 9	30 250	103
9-10	30 280	97	9-10	30 280	106
10-11	30 310	104	10-11	30 310	115
11-12	30 340	120	11-12	30 340	125
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	10 10	6	SP-12	10 10	6
12-11	30 40	17	12-11	30 40	18
11-10	30 70	25	11-10	30 70	23
10- 9	30 100	33	10- 9	30 100	33
9- 8	30 130	41	9- 8	30 130	51
8- 7	30 160	49	8- 7	30 160	59
7- 6	30 190	58	7- 6	30 190	68
6- 5	30 220	68	6- 5	30 220	80
5- 4	30 250	94	5- 4	30 250	91
4- 3	30 280	103	4- 3	30 280	96
3- 2	30 310	113	3- 2	30 310	105
2- 1	30 340	120	2- 1	30 340	113

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 5-A			Test Site 5-B		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
A spread was not run at this site.			SP- 1	5 5	7
			1- 2	5 10	9
			2- 3	5 15	10
			3- 4	5 20	11
			4- 5	30 50	21
			5- 6	30 80	30
			6- 7	30 110	57
			7- 8	30 140	66
			8- 9	30 170	69
			9-10	30 200	74
			10-11	30 230	81
			11-12	30 260	87
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	10 10	9	SP- 1	60 60	24
1- 2	30 40	34	1- 2	30 90	33
2- 3	30 70	43	2- 3	30 120	38
3- 4	30 100	54	3- 4	30 150	62
4- 5	30 130	74	4- 5	30 180	69
5- 6	30 160	80	5- 6	30 210	75
6- 7	30 190	86	6- 7	30 240	80
7- 8	30 220	93	7- 8	30 270	86
8- 9	30 250	98	8- 9	30 300	91
9-10	30 280	102	9-10	30 330	95
10-11	30 310	112	10-11	30 360	100
11-12	30 340	124	11-12	30 390	107
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	10 10	9	SP-12	60 60	26
12-11	30 40	34	12-11	30 90	44
11-10	30 70	48	11-10	30 120	53
10- 9	30 100	57	10- 9	30 150	64
9- 8	30 130	66	9- 8	30 180	71
8- 7	30 160	77	8- 7	30 210	76
7- 6	30 190	83	7- 6	30 240	82
6- 5	30 220	92	6- 5	30 270	88
5- 4	30 250	98	5- 4	30 300	92
4- 3	30 280	104	4- 3	30 330	98
3- 2	30 310	107	3- 2	30 360	101
2- 1	30 340	110	2- 1	30 390	107

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 5-C			Test Site 5-D		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	5 5	4	SP- 1	5 5	1
1- 2	5 10	7	1- 2	5 10	5
2- 3	5 15	8	2- 3	5 15	8
3- 4	5 20	10	3- 4	5 20	12
4- 5	30 50	24	4- 5	30 50	26
5- 6	30 80	40	5- 6	30 80	42
6- 7	30 110	62	6- 7	30 110	54
7- 8	30 140	72	7- 8	30 140	68
8- 9	30 170	75	8- 9	30 170	84
9-10	30 200	83	9-10	30 200	102
10-11	30 230	92	10-11	30 230	114
11-12	30 260	98	11-12	30 260	120
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	22	SP- 1	60 60	34
1- 2	30 90	31	1- 2	30 90	50
2- 3	30 120	62	2- 3	30 120	60
3- 4	30 150	69	3- 4	30 150	76
4- 5	30 180	78	4- 5	30 180	87
5- 6	30 210	80	5- 6	30 210	102
6- 7	30 240	84	6- 7	30 240	117
7- 8	30 270	88	7- 8	30 270	125
8- 9	30 300	95	8- 9	30 300	133
9-10	30 330	101	9-10	30 330	139
10-11	30 360	109	10-11	30 360	142
11-12	30 390	114	11-12	30 390	150
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	28	SP-12	60 60	33
12-11	30 90	47	12-11	30 90	47
11-10	30 120	65	11-10	30 120	75
10- 9	30 150	71	10- 9	30 150	89
9- 8	30 180	78	9- 8	30 180	99
8- 7	30 210	83	8- 7	30 210	110
7- 6	30 240	89	7- 6	30 240	115
6- 5	30 270	100	6- 5	30 270	122
5- 4	30 300	105	5- 4	30 300	124
4- 3	30 330	113	4- 3	30 330	129
3- 2	30 360	115	3- 2	30 360	139
2- 1	30 390	116	2- 1	30 390	144

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 5-E			Test Site 6-A		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	5 5	2	SP- 1	5 5	2
1- 2	5 10	6	1- 2	5 10	6
2- 3	5 15	9	2- 3	5 15	11
3- 4	5 20	16	3- 4	5 20	14
4- 5	30 50	28	4- 5	30 50	27
5- 6	30 80	43	5- 6	30 80	37
6- 7	30 110	61	6- 7	30 110	50
7- 8	30 140	80	7- 8	30 140	82
8- 9	30 170	88	8- 9	30 170	93
9-10	30 200	96	9-10	30 200	98
10-11	30 230	103	10-11	30 230	102
11-12	30 260	110	11-12	30 260	109
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	38	SP- 1	60 60	32
1- 2	30 90	48	1- 2	30 90	41
2- 3	30 120	64	2- 3	30 120	53
3- 4	30 150	86	3- 4	30 150	83
4- 5	30 180	88	4- 5	30 180	88
5- 6	30 210	95	5- 6	30 210	95
6- 7	30 240	97	5- 7	30 240	104
7- 8	30 270	107	7- 8	30 270	111
8- 9	30 300	112	8- 9	30 300	114
9-10	30 330	122	9-10	30 330	121
10-11	30 360	126	10-11	30 360	130
11-12	30 390	135	11-12	30 390	132
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	40 40	22	SP-12	30 30	29
12-11	30 70	32	12-11	30 60	42
11-10	30 100	44	11-10	30 90	59
10- 9	30 130	78	10- 9	30 120	76
9- 8	30 160	87	9- 8	30 150	96
8- 7	30 190	93	8- 7	30 180	102
7- 6	30 220	97	7- 6	30 210	108
6- 5	30 250	105	6- 5	30 240	112
5- 4	30 280	114	5- 4	30 270	116
4- 3	30 310	117	4- 3	30 300	121
3- 2	30 340	119	3- 2	30 330	125
2- 1	30 370	--	2- 1	30 360	132

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 6-B			Test Site 7-A		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	6	SP- 1	10 10	6
1- 2	5 15	12	1- 2	5 15	11
2- 3	5 20	14	2- 3	5 20	15
3- 4	5 25	16	3- 4	5 25	18
4- 5	30 55	28	4- 5	30 55	44
5- 6	30 85	42	5- 6	30 85	55
6- 7	30 115	58	6- 7	30 115	64
7- 8	30 145	70	7- 8	30 145	77
8- 9	30 175	86	8- 9	30 175	80
9-10	30 205	103	9-10	30 205	85
10-11	30 235	116	10-11	30 235	89
11-12	30 265	125	11-12	30 265	99
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	30 30	19	SP- 1	60 60	42
1- 2	30 60	42	1- 2	30 90	58
2- 3	30 90	52	2- 3	30 120	72
3- 4	30 120	60	3- 4	30 150	78
4- 5	30 150	71	4- 5	30 180	85
5- 6	30 180	92	5- 6	30 210	90
6- 7	30 210	110	6- 7	30 240	95
7- 8	30 240	114	7- 8	30 270	97
8- 9	30 270	118	8- 9	30 300	102
9-10	30 300	122	9-10	30 330	110
10-11	30 330	132	10-11	30 360	115
11-12	30 360	142	11-12	30 390	120
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	30 30	20	SP-12	60 60	37
12-11	30 60	34	12-11	30 90	48
11-10	30 90	47	11-10	30 120	62
10- 9	30 120	60	10- 9	30 150	71
9- 8	30 150	73	9- 8	30 180	80
8- 7	30 180	83	8- 7	30 210	85
7- 6	30 210	96	7- 6	30 240	89
6- 5	30 240	103	6- 5	30 270	98
5- 4	30 270	114	5- 4	30 300	102
4- 3	30 300	127	4- 3	30 330	110
3- 2	30 330	130	3- 2	30 360	113
2- 1	30 360	135	2- 1	30 390	123

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 8-A			Test Site 8-B		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	5	SP- 1	10 10	6
1- 2	5 15	8	1- 2	5 15	10
2- 3	5 20	11	2- 3	5 20	13
3- 4	5 25	14	3- 4	5 25	17
4- 5	30 55	29	4- 5	30 55	31
5- 6	30 85	38	5- 6	30 85	41
6- 7	30 115	47	6- 7	30 115	50
7- 8	30 145	59	7- 8	30 145	59
8- 9	30 175	69	8- 9	30 175	69
9-10	30 205	89	9-10	30 205	82
10-11	30 235	92	10-11	30 235	92
11-12	30 265	99	11-12	30 265	97
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	20	SP- 1	60 60	25
1- 2	30 90	28	1- 2	30 90	37
2- 3	30 120	40	2- 3	30 120	47
3- 4	30 150	52	3- 4	30 150	55
4- 5	30 180	61	4- 5	30 180	65
5- 6	30 210	71	5- 6	30 210	75
6- 7	30 240	80	6- 7	30 240	90
7- 8	30 270	90	7- 8	30 270	100
8- 9	30 300	100	8- 9	30 300	106
9-10	30 330	105	9-10	30 330	112
10-11	30 360	115	10-11	30 360	116
11-12	30 390	125	11-12	30 390	124
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	28	SP-12	60 60	30
12-11	30 90	38	12-11	30 90	41
11-10	30 120	48	11-10	30 120	50
10- 9	30 150	58	10- 9	30 150	66
9- 8	30 180	68	9- 8	30 180	72
8- 7	30 210	83	8- 7	30 210	81
7- 6	30 240	91	7- 6	30 240	90
6- 5	30 270	98	6- 5	30 270	100
5- 4	30 300	108	5- 4	30 300	108
4- 3	30 330	116	4- 3	30 330	115
3- 2	30 360	119	3- 2	30 360	120
2- 1	30 390	128	2- 1	30 390	128

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 8-C			Test Site 8-D		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	8	SP- 1	10 10	4
1- 2	5 15	12	1- 2	5 15	9
2- 3	5 20	16	2- 3	5 20	11
3- 4	5 25	20	3- 4	5 25	13
4- 5	30 55	30	4- 5	30 55	26
5- 6	30 85	42	5- 6	30 85	35
6- 7	30 115	52	6- 7	30 115	48
7- 8	30 145	60	7- 8	30 145	57
8- 9	30 175	72	8- 9	30 175	67
9-10	30 205	80	9-10	30 205	71
10-11	30 235	92	10-11	30 235	79
11-12	30 265	100	11-12	30 265	83
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	31	SP- 1	60 60	26
1- 2	30 90	40	1- 2	30 90	36
2- 3	30 120	51	2- 3	30 120	44
3- 4	30 150	65	3- 4	30 150	54
4- 5	30 180	76	4- 5	30 180	68
5- 6	30 210	86	5- 6	30 210	78
6- 7	30 240	93	6- 7	30 240	88
7- 8	30 270	105	7- 8	30 270	98
8- 9	30 300	112	8- 9	30 300	108
9-10	30 330	122	9-10	30 330	118
10-11	30 360	130	10-11	30 360	128
11-12	30 390	142	11-12	30 390	133
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
A spread was not run at this site.			SP-12	60 60	31
			12-11	30 90	41
			11-10	30 120	51
			10- 9	30 150	61
			9- 8	30 180	71
			8- 7	30 210	86
			7- 6	30 240	96
			6- 5	30 270	101
			5- 4	30 300	113
			4- 3	30 330	123
			3- 2	30 360	131
			2- 1	30 390	141



Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 8-E			Test Site 8-F		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	1	SP- 1	10 10	4
1- 2	5 15	4	1- 2	5 15	7
2- 3	5 20	8	2- 3	5 20	10
3- 4	5 25	9	3- 4	5 25	11
4- 5	30 55	28	4- 5	30 55	20
5- 6	30 85	37	5- 6	30 85	26
6- 7	30 115	41	6- 7	30 115	35
7- 8	30 145	50	7- 8	30 145	43
8- 9	30 175	62	8- 9	30 175	53
9-10	30 205	70	9-10	30 205	83
10-11	30 235	79	10-11	30 235	93
11-12	30 265	88	11-12	30 265	98
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	30	SP- 1	60 60	23
1- 2	30 90	42	1- 2	30 90	30
2- 3	30 120	48	2- 3	30 120	38
3- 4	30 150	57	3- 4	30 150	50
4- 5	30 180	69	4- 5	30 180	60
5- 6	30 210	80	5- 6	30 210	65
6- 7	30 240	83	6- 7	30 240	90
7- 8	30 270	92	7- 8	30 270	98
8- 9	30 300	108	8- 9	30 300	104
9-10	30 330	118	9-10	30 330	112
10-11	30 360	125	10-11	30 360	120
11-12	30 390	135	11-12	30 390	129
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	25	SP-12	60 60	25
12-11	30 90	33	12-11	30 90	33
11-10	30 120	52	11-10	30 120	38
10- 9	30 150	57	10- 9	30 150	50
9- 8	30 180	65	9- 8	30 180	58
8- 7	30 210	75	8- 7	30 210	66
7- 6	30 240	87	7- 6	30 240	76
6- 5	30 270	97	6- 5	30 270	102
5- 4	30 300	117	5- 4	30 300	114
4- 3	30 330	123	4- 3	30 330	118
3- 2	30 360	135	3- 2	30 360	124
2- 1	30 390	154	2- 1	30 390	126

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 9-A				Test Site 9-B			
Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)
<u>Short Spread</u>				<u>Short Spread</u>			
SP- 1	10	10	8	SP- 1	10	10	7
1- 2	5	15	11	1- 2	5	15	11
2- 3	5	20	12	2- 3	5	20	12
3- 4	5	25	13	3- 4	5	25	13
4- 5	30	55	21	4- 5	30	55	23
5- 6	30	85	28	5- 6	30	85	31
6- 7	30	115	37	6- 7	30	115	36
7- 8	30	145	45	7- 8	30	145	57
8- 9	30	175	56	8- 9	30	175	67
9-10	30	205	62	9-10	30	205	73
10-11	30	235	71	10-11	30	235	77
11-12	30	265	80	11-12	30	265	87
<u>Long Spread</u>				<u>Long Spread</u>			
SP- 1	60	60	28	SP- 1	60	60	19
1- 2	30	90	35	1- 2	30	90	29
2- 3	30	120	42	2- 3	30	120	36
3- 4	30	150	55	3- 4	30	150	42
4- 5	30	180	64	4- 5	30	180	50
5- 6	30	210	74	5- 6	30	210	61
6- 7	30	240	81	6- 7	30	240	71
7- 8	30	270	96	7- 8	30	270	87
8- 9	30	300	106	8- 9	30	300	106
9-10	30	330	116	9-10	30	330	111
10-11	30	360	126	10-11	30	360	121
11-12	30	390	136	11-12	30	390	131
<u>Reverse Spread</u>				<u>Reverse Spread</u>			
SP-12	60	60	22	SP-12	60	60	21
12-11	30	90	29	12-11	30	90	29
11-10	30	120	37	11-10	30	120	36
10- 9	30	150	43	10- 9	30	150	51
9- 8	30	180	51	9- 8	30	180	69
8- 7	30	210	60	8- 7	30	210	70
7- 6	30	240	63	7- 6	30	240	80
6- 5	30	270	75	6- 5	30	270	85
5- 4	30	300	86	5- 4	30	300	93
4- 3	30	330	117	4- 3	30	330	99
3- 2	30	360	130	3- 2	30	360	108
2- 1	30	390	135	2- 1	30	390	113

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 9-C			Test Site 9-D		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	11	SP- 1	10 10	4
1- 2	5 15	16	1- 2	5 15	7
2- 3	5 20	20	2- 3	5 20	10
3- 4	5 25	24	3- 4	5 25	14
4- 5	30 55	36	4- 5	30 55	29
5- 6	30 85	43	5- 6	30 85	37
6- 7	30 115	50	6- 7	30 115	44
7- 8	30 145	60	7- 8	30 145	52
8- 9	30 175	70	8- 9	30 175	63
9-10	30 205	78	9-10	30 205	79
10-11	30 235	86	10-11	30 235	84
11-12	30 265	96	11-12	30 265	87
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	33	SP- 1	60 60	29
1- 2	30 90	42	1- 2	30 90	37
2- 3	30 120	52	2- 3	30 120	45
3- 4	30 150	62	3- 4	30 150	59
4- 5	30 180	82	4- 5	30 180	64
5- 6	30 210	89	5- 6	30 210	76
6- 7	30 240	95	6- 7	30 240	84
7- 8	30 270	103	7- 8	30 270	88
8- 9	30 300	113	8- 9	30 300	96
9-10	30 330	120	9-10	30 330	99
10-11	30 360	125	10-11	30 360	104
11-12	30 390	140	11-12	30 390	106
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	26	SP-12	60 60	29
12-11	30 90	35	12-11	30 90	39
11-10	30 120	42	11-10	30 120	47
10- 9	30 150	67	10- 9	30 150	59
9- 8	30 180	77	9- 8	30 180	69
8- 7	30 210	87	8- 7	30 210	79
7- 6	30 240	92	7- 6	30 240	82
6- 5	30 270	102	6- 5	30 270	89
5- 4	30 300	109	5- 4	30 300	95
4- 3	30 330	117	4- 3	30 330	98
3- 2	30 360	122	3- 2	30 360	99
2- 1	30 390	127	2- 1	30 390	107

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 9-E				Test Site 9-F			
Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)
<u>Short Spread</u>				<u>Short Spread</u>			
SP- 1	10	10	1	SP- 1	10	10	4
1- 2	5	15	3	1- 2	5	15	7
2- 3	5	20	5	2- 3	5	20	9
3- 4	5	25	8	3- 4	5	25	12
4- 5	30	55	21	4- 5	30	55	29
5- 6	30	85	31	5- 6	30	85	43
6- 7	30	115	39	6- 7	30	115	51
7- 8	30	145	52	7- 8	30	145	60
8- 9	30	175	71	8- 9	30	175	72
9-10	30	205	74	9-10	30	205	79
10-11	30	235	82	10-11	30	235	86
11-12	30	265	92	11-12	30	265	91
<u>Long Spread</u>				<u>Long Spread</u>			
SP- 1	60	60	28	SP- 1	60	60	23
1- 2	30	90	38	1- 2	30	90	46
2- 3	30	120	50	2- 3	30	120	51
3- 4	30	150	60	3- 4	30	150	61
4- 5	30	180	75	4- 5	30	180	70
5- 6	30	210	77	5- 6	30	210	75
6- 7	30	240	85	6- 7	30	240	83
7- 8	30	270	87	7- 8	30	370	91
8- 9	30	300	93	8- 9	30	300	101
9-10	30	330	97	9-10	30	330	109
10-11	30	360	101	10-11	30	360	112
11-12	30	390	106	11-12	30	390	120
<u>Reverse Spread</u>				<u>Reverse Spread</u>			
SP-12	60	60	21	SP-12	60	60	31
12-11	30	90	29	12-11	30	90	42
11-10	30	120	39	11-10	30	120	54
10- 9	30	150	48	10- 9	30	150	65
9- 8	30	180	64	9- 8	30	180	71
8- 7	30	210	66	8- 7	30	210	82
7- 6	30	240	71	7- 6	30	240	91
6- 5	30	270	78	6- 5	30	270	93
5- 4	30	300	81	5- 4	30	300	102
4- 3	30	330	91	4- 3	30	330	113
3- 2	30	360	96	3- 2	30	360	118
2- 1	30	390	101	2- 1	30	390	123

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 9-G			Test Site 10-A		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	6
1- 2	5 15	6	1- 2	5 15	11
2- 3	5 20	8	2- 3	5 20	15
3- 4	5 25	9	3- 4	5 25	19
4- 5	30 55	17	4- 5	30 55	29
5- 6	30 85	28	5- 6	30 85	39
6- 7	30 115	40	6- 7	30 115	49
7- 8	30 145	50	7- 8	30 145	56
8- 9	30 175	59	8- 9	30 175	59
9-10	30 205	67	9-10	30 205	67
10-11	30 235	76	10-11	30 235	73
11-12	30 265	80	11-12	30 265	83
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	25	SP- 1	60 60	33
1- 2	30 90	32	1- 2	30 90	37
2- 3	30 120	41	2- 3	30 120	39
3- 4	30 150	49	3- 4	30 150	53
4- 5	30 180	58	4- 5	30 180	60
5- 6	30 210	68	5- 6	30 210	69
6- 7	30 240	79	6- 7	30 240	74
7- 8	30 270	91	7- 8	30 270	90
8- 9	30 300	98	8- 9	30 300	95
9-10	30 330	107	9-10	30 330	103
10-11	30 360	115	10-11	30 360	105
11-12	30 390	119	11-12	30 390	118
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	29	SP-12	60 60	34
12-11	30 90	37	12-11	30 90	44
11-10	30 120	46	11-10	30 120	51
10- 9	30 150	53	10- 9	30 150	58
9- 8	30 180	63	9- 8	30 180	66
8- 7	30 210	71	8- 7	30 210	76
7- 6	30 240	81	7- 6	30 240	88
6- 5	30 270	88	6- 5	30 270	96
5- 4	30 300	97	5- 4	30 300	103
4- 3	30 330	103	4- 3	30 330	108
3- 2	30 360	111	3- 2	30 360	120
2- 1	30 390	116	2- 1	30 390	129

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 10-B			Test Site 10-C		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	6
1- 2	5 15	9	1- 2	5 15	10
2- 3	5 20	11	2- 3	5 20	15
3- 4	5 25	12	3- 4	5 25	18
4- 5	30 55	21	4- 5	30 55	35
5- 6	30 85	35	5- 6	30 85	44
6- 7	30 115	47	6- 7	30 115	52
7- 8	30 145	57	7- 8	30 145	59
8- 9	30 175	67	8- 9	30 175	72
9-10	30 205	73	9-10	30 205	77
10-11	30 235	81	10-11	30 235	87
11-12	30 265	90	11-12	30 265	97
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	22	SP- 1	60 60	34
1- 2	30 90	30	1- 2	30 90	42
2- 3	30 120	42	2- 3	30 120	49
3- 4	30 150	50	3- 4	30 150	58
4- 5	30 180	60	4- 5	30 180	67
5- 6	30 210	74	5- 6	30 210	75
6- 7	30 240	80	6- 7	30 240	84
7- 8	30 270	92	7- 8	30 270	99
8- 9	30 300	98	8- 9	30 300	109
9-10	30 330	105	9-10	30 330	116
10-11	30 360	110	10-11	30 360	121
11-12	30 390	120	11-12	30 390	129
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	38	SP-12	60 60	33
12-11	30 90	49	12-11	30 90	44
11-10	30 120	58	11-10	30 120	52
10- 9	30 150	64	10- 9	30 150	64
9- 8	30 180	74	9- 8	30 180	72
8- 7	30 210	76	8- 7	30 210	78
7- 6	30 240	83	7- 6	30 240	89
6- 5	30 270	99	6- 5	30 270	93
5- 4	30 300	102	5- 4	30 300	99
4- 3	30 330	107	4- 3	30 330	107
3- 2	30 360	112	3- 2	30 360	112
2- 1	30 390	117	2- 1	30 390	122

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 10-D			Test Site 10-E		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	7	SP- 1	10 10	7
1- 2	5 15	12	1- 2	5 15	13
2- 3	5 20	17	2- 3	5 20	17
3- 4	5 25	19	3- 4	5 25	20
4- 5	30 55	31	4- 5	30 55	28
5- 6	30 85	39	5- 6	30 85	35
6- 7	30 115	50	6- 7	30 115	44
7- 8	30 145	58	7- 8	30 145	53
8- 9	30 175	67	8- 9	30 175	60
9-10	30 205	74	9-10	30 205	70
10-11	30 235	85	10-11	30 235	85
11-12	30 265	89	11-12	30 265	92
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	37	SP- 1	60 60	30
1- 2	30 90	44	1- 2	30 90	40
2- 3	30 120	54	2- 3	30 120	52
3- 4	30 150	61	3- 4	30 150	60
4- 5	30 180	69	4- 5	30 180	70
5- 6	30 210	76	5- 6	30 210	78
6- 7	30 240	86	6- 7	30 240	90
7- 8	30 270	95	7- 8	30 270	100
8- 9	30 300	104	8- 9	30 300	105
9-10	30 330	108	9-10	30 330	112
10-11	30 360	116	10-11	30 360	120
11-12	30 390	123	11-12	30 390	125
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	34	SP-12	60 60	25
12-11	30 90	44	12-11	30 90	32
11-10	30 120	52	11-10	30 120	44
10- 9	30 150	61	10- 9	30 150	54
9- 8	30 180	70	9- 8	30 180	58
8- 7	30 210	76	8- 7	30 210	65
7- 6	30 240	82	7- 6	30 240	76
6- 5	30 270	90	6- 5	30 270	86
5- 4	30 300	94	5- 4	30 300	102
4- 3	30 330	102	4- 3	30 330	106
3- 2	30 360	112	3- 2	30 360	116
2- 1	30 390	122	2- 1	30 390	128

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 10-F			Test Site 10-G		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	7	SP- 1	10 10	6
1- 2	5 15	12	1- 2	5 15	9
2- 3	5 20	15	2- 3	5 20	12
3- 4	5 25	16	3- 4	5 25	13
4- 5	30 55	24	4- 5	30 55	19
5- 6	30 85	32	5- 6	30 85	26
6- 7	30 115	42	6- 7	30 115	35
7- 8	30 145	58	7- 8	30 145	41
8- 9	30 175	68	8- 9	30 175	51
9-10	30 205	74	9-10	30 205	61
10-11	30 235	82	10-11	30 235	69
11-12	30 265	91	11-12	30 265	76
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	30	SP- 1	60 60	19
1- 2	30 90	39	1- 2	30 90	27
2- 3	30 120	49	2- 3	30 120	35
3- 4	30 150	55	3- 4	30 150	43
4- 5	30 180	64	4- 5	30 180	51
5- 6	30 210	71	5- 6	30 210	60
6- 7	30 240	81	6- 7	30 240	70
7- 8	30 270	90	7- 8	30 270	85
8- 9	30 300	100	8- 9	30 300	88
9-10	30 330	104	9-10	30 330	93
10-11	30 360	111	10-11	30 360	98
11-12	30 390	119	11-12	30 390	100
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	30	SP-12	60 60	19
12-11	30 90	40	12-11	30 90	28
11-10	30 120	52	11-10	30 120	35
10- 9	30 150	60	10- 9	30 150	42
9- 8	30 180	68	9- 8	30 180	49
8- 7	30 210	75	8- 7	30 210	60
7- 6	30 240	83	7- 6	30 240	78
6- 5	30 270	89	6- 5	30 270	80
5- 4	30 300	96	5- 4	30 300	85
4- 3	30 330	103	4- 3	30 330	90
3- 2	30 360	110	3- 2	30 360	98
2- 1	30 390	118	2- 1	30 390	102



Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 10-H			Test Site 10-I				
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)		
<u>Short Spread</u>			<u>Short Spread</u>				
SP- 1	10	10	5	SP- 1	10	10	5
1- 2	5	15	8	1- 2	5	15	10
2- 3	5	20	10	2- 3	5	20	12
3- 4	5	25	11	3- 4	5	25	17
4- 5	30	55	15	4- 5	30	55	30
5- 6	30	85	22	5- 6	30	85	37
6- 7	30	115	29	6- 7	30	115	47
7- 8	30	145	37	7- 8	30	145	52
8- 9	30	175	45	8- 9	30	175	60
9-10	30	205	52	9-10	30	205	70
10-11	30	235	61	10-11	30	235	80
11-12	30	265	70	11-12	30	265	88
<u>Long Spread</u>			<u>Long Spread</u>				
SP- 1	60	60	16	SP- 1	60	60	18
1- 2	30	90	26	1- 2	30	90	35
2- 3	30	120	27	2- 3	30	120	41
3- 4	30	150	42	3- 4	30	150	50
4- 5	30	180	47	4- 5	30	180	57
5- 6	30	210	54	5- 6	30	210	64
6- 7	30	240	64	6- 7	30	240	72
7- 8	30	270	74	7- 8	30	270	82
8- 9	30	300	81	8- 9	30	300	89
9-10	30	330	94	9-10	30	330	96
10-11	30	360	99	10-11	30	360	101
11-12	30	390	104	11-12	30	390	110
<u>Reverse Spread</u>			<u>Reverse Spread</u>				
SP-12	60	60	20	SP-12	60	60	30
12-11	30	90	26	12-11	30	90	41
11-10	30	120	36	11-10	30	120	47
10- 9	30	150	46	10- 9	30	150	55
9- 8	30	180	51	9- 8	30	180	58
8- 7	30	210	56	8- 7	30	210	67
7- 6	30	240	66	7- 6	30	240	76
6- 5	30	270	76	6- 5	30	270	84
5- 4	30	300	86	5- 4	30	300	95
4- 3	30	330	96	4- 3	30	330	98
3- 2	30	360	106	3- 2	30	360	105
2- 1	30	390	111	2- 1	30	390	111

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 11-A			Test Site 11-B		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	3	SP- 1	10 10	8
1- 2	5 15	5	1- 2	5 15	9
2- 3	5 20	8	2- 3	5 20	11
3- 4	5 25	10	3- 4	5 25	12
4- 5	30 55	18	4- 5	30 55	25
5- 6	30 85	26	5- 6	30 85	39
6- 7	30 115	34	6- 7	30 115	51
7- 8	30 145	44	7- 8	30 145	62
8- 9	30 175	52	8- 9	30 175	67
9-10	30 205	60	9-10	30 205	76
10-11	30 235	65	10-11	30 235	77
11-12	30 265	75	11-12	30 265	81
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	19	SP- 1	60 60	31
1- 2	30 90	30	1- 2	30 90	45
2- 3	30 120	35	2- 3	30 120	51
3- 4	30 150	42	3- 4	30 150	59
4- 5	30 180	50	4- 5	30 180	63
5- 6	30 210	56	5- 6	30 210	70
6- 7	30 240	62	6- 7	30 240	76
7- 8	30 270	77	7- 8	30 270	81
8- 9	30 300	82	8- 9	30 300	85
9-10	30 330	90	9-10	30 330	91
10-11	30 360	92	10-11	30 360	93
11-12	30 390	102	11-12	30 390	96
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	29	SP-12	60 60	31
12-11	30 90	34	12-11	30 90	40
11-10	30 120	42	11-10	30 120	52
10- 9	30 150	47	10- 9	30 150	56
9- 8	30 180	57	9- 8	30 180	61
8- 7	30 210	60	8- 7	30 210	67
7- 6	30 240	68	7- 6	30 240	75
6- 5	30 270	75	6- 5	30 270	79
5- 4	30 300	84	5- 4	30 300	86
4- 3	30 330	92	4- 3	30 330	91
3- 2	30 360	102	3- 2	30 360	96
2- 1	30 390	105	2- 1	30 390	100

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 11-C			Test Site 11-D		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	2
1- 2	5 15	4	1- 2	5 15	4
2- 3	5 20	5	2- 3	5 20	8
3- 4	5 25	6	3- 4	5 25	10
4- 5	30 55	11	4- 5	30 55	23
5- 6	30 85	19	5- 6	30 85	30
6- 7	30 115	29	6- 7	30 115	40
7- 8	30 145	36	7- 8	30 145	46
8- 9	30 175	46	8- 9	30 175	56
9-10	30 205	55	9-10	30 205	60
10-11	30 235	61	10-11	30 235	70
11-12	30 265	65	11-12	30 265	80
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	9	SP- 1	60 60	25
1- 2	30 90	14	1- 2	30 90	31
2- 3	30 120	22	2- 3	30 120	41
3- 4	30 150	26	3- 4	30 150	48
4- 5	30 180	37	4- 5	30 180	56
5- 6	30 210	47	5- 6	30 210	62
6- 7	30 240	52	6- 7	30 240	73
7- 8	30 270	57	7- 8	30 270	80
8- 9	30 300	63	8- 9	30 300	93
9-10	30 330	69	9-10	30 330	98
10-11	30 360	76	10-11	30 360	106
11-12	30 390	79	11-12	30 390	108
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	22	SP-12	60 60	25
12-11	30 90	27	12-11	30 90	34
11-10	30 120	37	11-10	30 120	42
10- 9	30 150	47	10- 9	30 150	49
9- 8	30 180	54	9- 8	30 180	56
8- 7	30 210	62	8- 7	30 210	62
7- 6	30 240	67	7- 6	30 240	74
6- 5	30 270	69	6- 5	30 270	82
5- 4	30 300	75	5- 4	30 300	98
4- 3	30 330	81	4- 3	30 330	102
3- 2	30 360	84	3- 2	30 360	106
2- 1	30 390	92	2- 1	30 390	114

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 11-E			Test Site 11-F		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	1
1- 2	5 15	4	1- 2	5 15	3
2- 3	5 20	9	2- 3	5 20	5
3- 4	5 25	9	3- 4	5 25	7
4- 5	30 55	21	4- 5	30 55	18
5- 6	30 85	29	5- 6	30 85	30
6- 7	30 115	39	6- 7	30 115	40
7- 8	30 145	50	7- 8	30 145	49
8- 9	30 175	54	8- 9	30 175	57
9-10	30 205	67	9-10	30 205	64
10-11	30 235	74	10-11	30 235	73
11-12	30 265	84	11-12	30 265	82
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	21	SP- 1	60 60	24
1- 2	30 90	32	1- 2	30 90	33
2- 3	30 120	38	2- 3	30 120	41
3- 4	30 150	50	3- 4	30 150	50
4- 5	30 180	58	4- 5	30 180	59
5- 6	30 210	68	5- 6	30 210	67
6- 7	30 240	78	6- 7	30 240	77
7- 8	30 270	85	7- 8	30 270	88
8- 9	30 300	90	8- 9	30 300	92
9-10	30 330	96	9-10	30 330	103
10-11	30 360	105	10-11	30 360	107
11-12	30 390	110	11-12	30 390	112
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	29	SP-12	60 60	17
12-11	30 90	39	12-11	30 90	27
11-10	30 120	46	11-10	30 120	38
10- 9	30 150	51	10- 9	30 150	43
9- 8	30 180	58	9- 8	30 180	51
8- 7	30 210	67	8- 7	30 210	61
7- 6	30 240	80	7- 6	30 240	70
6- 5	30 270	87	6- 5	30 270	79
5- 4	30 300	88	5- 4	30 300	85
4- 3	30 330	101	4- 3	30 330	91
3- 2	30 360	112	3- 2	30 360	98
2- 1	30 390	115	2- 1	30 390	108

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 11-G			Test Site 12-A		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	4	SP- 1	10 10	2
1- 2	5 15	7	1- 2	5 15	5
2- 3	5 20	9	2- 3	5 20	7
3- 4	5 25	12	3- 4	5 25	8
4- 5	30 55	20	4- 5	30 55	16
5- 6	30 85	28	5- 6	30 85	23
6- 7	30 115	39	6- 7	30 115	32
7- 8	30 145	46	7- 8	30 145	39
8- 9	30 175	52	8- 9	30 175	46
9-10	30 205	62	9-10	30 205	54
10-11	30 235	68	10-11	30 235	56
11-12	30 265	73	11-12	30 265	62
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	24	SP- 1	60 60	24
1- 2	30 90	34	1- 2	30 90	30
2- 3	30 120	39	2- 3	30 120	36
3- 4	30 150	48	3- 4	30 150	41
4- 5	30 180	54	4- 5	30 180	46
5- 6	30 210	61	5- 6	30 210	54
6- 7	30 240	70	6- 7	30 240	62
7- 8	30 270	78	7- 8	30 270	68
8- 9	30 300	84	8- 9	30 300	78
9-10	30 330	91	9-10	30 330	85
10-11	30 360	99	10-11	30 360	91
11-12	30 390	106	11-12	30 390	96
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	24	SP-12	60 60	20
12-11	30 90	34	12-11	30 90	29
11-10	30 120	42	11-10	30 120	35
10- 9	30 150	47	10- 9	30 150	43
9- 8	30 180	56	9- 8	30 180	48
8- 7	30 210	61	8- 7	30 210	56
7- 6	30 240	71	7- 6	30 240	62
6- 5	30 270	75	6- 5	30 270	69
5- 4	30 300	80	5- 4	30 300	77
4- 3	30 330	85	4- 3	30 330	83
3- 2	30 360	92	3- 2	30 360	90
2-11	30 390	103	2- 1	30 390	94

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 12-B			Test Site 12-C		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	1
1- 2	5 15	5	1- 2	5 15	5
2- 3	5 20	8	2- 3	5 20	10
3- 4	5 25	11	3- 4	5 25	11
4- 5	30 55	20	4- 5	30 55	27
5- 6	30 85	28	5- 6	30 85	35
6- 7	30 115	39	6- 7	30 115	45
7- 8	30 145	46	7- 8	30 145	51
8- 9	30 175	53	8- 9	30 175	56
9-10	30 205	61	9-10	30 205	61
10-11	30 235	64	10-11	30 235	71
11-12	30 265	75	11-12	30 265	75
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	20	SP- 1	60 60	31
1- 2	30 90	28	1- 2	30 90	38
2- 3	30 120	35	2- 3	30 120	44
3- 4	30 150	41	3- 4	30 150	50
4- 5	30 180	50	4- 5	30 180	56
5- 6	30 210	57	5- 6	30 210	65
6- 7	30 240	65	6- 7	30 240	75
7- 8	30 270	71	7- 8	30 270	83
8- 9	30 300	78	8- 9	30 300	87
9-10	30 330	83	9-10	30 330	93
10-11	30 360	94	10-11	30 360	102
11-12	30 390	111	11-12	30 390	110
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	24	SP-12	60 60	22
12-11	30 90	31	12-11	30 90	30
11-10	30 120	38	11-10	30 120	39
10- 9	30 150	45	10- 9	30 150	48
9- 8	30 180	54	9- 8	30 180	57
8- 7	30 210	61	8- 7	30 210	67
7- 6	30 240	66	7- 6	30 240	74
6- 5	30 270	77	6- 5	30 270	82
5- 4	30 300	86	5- 4	30 300	86
4- 3	30 330	89	4- 3	30 330	94
3- 2	30 360	95	3- 2	30 360	101
2- 1	30 390	102	2- 1	30 390	104

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 12-D			Test Site 12-E		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	2
1- 2	5 15	6	1- 2	5 15	6
2- 3	5 20	10	2- 3	5 20	11
3- 4	5 25	11	3- 4	5 25	13
4- 5	30 55	19	4- 5	30 55	27
5- 6	30 85	26	5- 6	30 85	38
6- 7	30 115	36	6- 7	30 115	44
7- 8	30 145	44	7- 8	30 145	52
8- 9	30 175	54	8- 9	30 175	59
9-10	30 205	58	9-10	30 205	69
10-11	30 235	68	10-11	30 235	72
11-12	30 265	78	11-12	30 265	75
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	20	SP- 1	60 60	27
1- 2	30 90	33	1- 2	30 90	37
2- 3	30 120	39	2- 3	30 120	50
3- 4	30 150	46	3- 4	30 150	56
4- 5	30 180	54	4- 5	30 180	63
5- 6	30 210	60	5- 6	30 210	71
6- 7	30 240	67	6- 7	30 240	77
7- 8	30 270	76	7- 8	30 270	79
8- 9	30 300	81	8- 9	30 300	96
9-10	30 330	88	9-10	30 330	101
10-11	30 360	91	10-11	30 360	106
11-12	30 390	97	11-12	30 390	112
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	20	SP-12	60 60	29
12-11	30 90	29	12-11	30 90	40
11-10	30 120	35	11-10	30 120	48
10- 9	30 150	42	10- 9	30 150	55
9- 8	30 180	48	9- 8	30 180	63
8- 7	30 210	56	8- 7	30 210	71
7- 6	30 240	71	7- 6	30 240	80
6- 5	30 270	75	6- 5	30 270	91
5- 4	30 300	83	5- 4	30 300	99
4- 3	30 330	88	4- 3	30 330	100
3- 2	30 360	93	3- 2	30 360	108
2- 1	30 390	95	2- 1	30 390	117

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 12-F			Test Site 12-G		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	3	SP- 1	10 10	2
1- 2	5 15	5	1- 2	5 15	5
2- 3	5 20	7	2- 3	5 20	8
3- 4	5 25	9	3- 4	5 25	10
4- 5	30 55	20	4- 5	30 55	21
5- 6	30 85	28	5- 6	30 85	30
6- 7	30 115	37	6- 7	30 115	39
7- 8	30 145	42	7- 8	30 145	47
8- 9	30 175	49	8- 9	30 175	51
9-10	30 205	60	9-10	30 205	60
10-11	30 235	69	10-11	30 235	70
11-12	30 265	75	11-12	30 265	78
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	27	SP- 1	60 60	21
1- 2	30 90	34	1- 2	30 90	33
2- 3	30 120	42	2- 3	30 120	42
3- 4	30 150	47	3- 4	30 150	50
4- 5	30 180	57	4- 5	30 180	53
5- 6	30 210	66	5- 6	30 210	58
6- 7	30 240	76	6- 7	30 240	66
7- 8	30 270	84	7- 8	30 270	71
8- 9	30 300	98	8- 9	30 300	80
9-10	30 330	102	9-10	30 330	93
10-11	30 360	108	10-11	30 360	102
11-12	30 390	113	11-12	30 390	106
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	21	SP-12	60 60	25
12-11	30 90	30	12-11	30 90	35
11-10	30 120	38	11-10	30 120	41
10- 9	30 150	45	10- 9	30 150	46
9- 8	30 180	54	9- 8	30 180	50
8- 7	30 210	59	8- 7	30 210	55
7- 6	30 240	69	7- 6	30 240	64
6- 5	30 270	75	6- 5	30 270	75
5- 4	30 300	81	5- 4	30 300	85
4- 3	30 330	88	4- 3	30 330	95
3- 2	30 360	94	3- 2	30 360	104
2- 1	30 390	108	2- 1	30 390	106



Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 13-A			Test Site 13-B		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	6	SP- 1	10 10	4
1- 2	5 15	10	1- 2	5 15	5
2- 3	5 20	15	2- 3	5 20	7
3- 4	5 25	17	3- 4	5 25	9
4- 5	30 55	30	4- 5	30 55	16
5- 6	30 85	45	5- 6	30 85	24
6- 7	30 115	49	6- 7	30 115	27
7- 8	30 145	67	7- 8	30 145	33
8- 9	30 175	74	8- 9	30 175	46
9-10	30 205	80	9-10	30 205	53
10-11	30 235	83	10-11	30 235	61
11-12	30 265	92	11-12	30 265	68
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	29	SP- 1	60 60	20
1- 2	30 90	42	1- 2	30 90	26
2- 3	30 120	50	2- 3	30 120	34
3- 4	30 150	56	3- 4	30 150	39
4- 5	30 180	67	4- 5	30 180	54
5- 6	30 210	74	5- 6	30 210	64
6- 7	30 240	80	6- 7	30 240	70
7- 8	30 270	87	7- 8	30 270	76
8- 9	30 300	92	8- 9	30 300	80
9-10	30 330	97	9-10	30 330	83
10-11	30 360	102	10-11	30 360	87
11-12	30 390	106	11-12	30 390	90
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	34	SP-12	60 60	19
12-11	30 90	38	12-11	30 90	29
11-10	30 120	46	11-10	30 120	38
10- 9	30 150	54	10- 9	30 150	43
9- 8	30 180	72	9- 8	30 180	49
8- 7	30 210	75	8- 7	30 210	55
7- 6	30 240	86	7- 6	30 240	64
6- 5	30 270	88	6- 5	30 270	70
5- 4	30 300	93	5- 4	30 300	78
4- 3	30 330	102	4- 3	30 330	87
3- 2	30 360	104	3- 2	30 360	97
2- 1	30 390	112	2- 1	30 390	108

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 14-A			Test Site 14-B		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	9	SP- 1	10 10	5
1- 2	5 15	10	1- 2	5 15	6
2- 3	5 20	12	2- 3	5 20	9
3- 4	5 25	14	3- 4	5 25	11
4- 5	30 55	20	4- 5	30 55	18
5- 6	30 85	24	5- 6	30 85	25
6- 7	30 115	31	6- 7	30 115	30
7- 8	30 145	34	7- 8	30 145	33
8- 9	30 175	36	8- 9	30 175	36
9-10	30 205	37	9-10	30 205	38
10-11	30 235	41	10-11	30 235	41
11-12	30 265	46	11-12	30 265	46
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	20	SP- 1	60 60	19
1- 2	30 90	25	1- 2	30 90	23
2- 3	30 120	30	2- 3	30 120	27
3- 4	30 150	36	3- 4	30 150	29
4- 5	30 180	42	4- 5	30 180	32
5- 6	30 210	45	5- 6	30 210	38
6- 7	30 240	50	6- 7	30 240	41
7- 8	30 270	53	7- 8	30 270	47
8- 9	30 300	57	8- 9	30 300	50
9-10	30 330	58	9-10	30 330	53
10-11	30 360	62	10-11	30 360	57
11-12	30 390	67	11-12	30 390	--
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	25	SP-12	60 60	16
12-11	30 90	28	12-11	30 90	21
11-10	30 120	31	11-10	30 120	23
10- 9	30 150	36	10- 9	30 150	30
9- 8	30 180	38	9- 8	30 180	32
8- 7	30 210	46	8- 7	30 210	38
7- 6	30 240	47	7- 6	30 240	42
6- 5	30 270	50	6- 5	30 270	45
5- 4	30 300	55	5- 4	30 300	48
4- 3	30 330	61	4- 3	30 330	53
3- 2	30 360	64	3- 2	30 360	58
2- 1	30 390	70	2- 1	30 390	63

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 14-C			Test Site 14-D		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	6	SP- 1	10 10	6
1- 2	5 15	10	1- 2	5 15	11
2- 3	5 20	14	2- 3	5 20	14
3- 4	5 25	18	3- 4	5 25	16
4- 5	30 55	24	4- 5	30 55	22
5- 6	30 85	28	5- 6	30 85	28
6- 7	30 115	33	6- 7	30 115	36
7- 8	30 145	42	7- 8	30 145	44
8- 9	30 175	45	8- 9	30 175	50
9-10	30 205	52	9-10	30 205	53
10-11	30 235	56	10-11	30 235	58
11-12	30 265	61	11-12	30 265	63
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	21	SP- 1	60 60	16
1- 2	30 90	28	1- 2	30 90	25
2- 3	30 120	33	2- 3	30 120	31
3- 4	30 150	--	3- 4	30 150	--
4- 5	30 180	43	4- 5	30 180	44
5- 6	30 210	48	5- 6	30 210	53
6- 7	30 240	52	6- 7	30 240	57
7- 8	30 270	57	7- 8	30 270	62
8- 9	30 300	62	8- 9	30 300	67
9-10	30 330	69	9-10	30 330	69
10-11	30 360	75	10-11	30 360	71
11-12	30 390	80	11-12	30 390	76
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	26	SP-12	60 60	20
12-11	30 90	31	12-11	30 90	26
11-10	30 120	35	11-10	30 120	29
10- 9	30 150	40	10- 9	30 150	33
9- 8	30 180	48	9- 8	30 180	39
8- 7	30 210	51	8- 7	30 210	47
7- 6	30 240	58	7- 6	30 240	51
6- 5	30 270	62	6- 5	30 270	55
5- 4	30 300	67	5- 4	30 300	64
4- 3	30 330	73	4- 3	30 330	70
3- 2	30 360	76	3- 2	30 360	73
2- 1	30 390	84	2- 1	30 390	78

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 15-A			Test Site 15-B		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	2
1- 2	5 15	3	1- 2	5 15	8
2- 3	5 20	4	2- 3	5 20	10
3- 4	5 25	5	3- 4	5 25	11
4- 5	30 55	11	4- 5	30 55	16
5- 6	30 85	17	5- 6	30 85	20
6- 7	30 115	23	6- 7	30 115	26
7- 8	30 145	31	7- 8	30 145	32
8- 9	30 175	35	8- 9	30 175	37
9-10	30 205	41	9-10	30 205	41
10-11	30 235	46	10-11	30 235	45
11-12	30 265	52	11-12	30 265	50
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	18	SP- 1	60 60	18
1- 2	30 90	25	1- 2	30 90	24
2- 3	30 120	29	2- 3	30 120	29
3- 4	30 150	34	3- 4	30 150	33
4- 5	30 180	39	4- 5	30 180	39
5- 6	30 210	45	5- 6	30 210	44
6- 7	30 240	49	6- 7	30 240	48
7- 8	30 270	57	7- 8	30 270	54
8- 9	30 300	60	8- 9	30 300	58
9-10	30 330	61	9-10	30 330	63
10-11	30 360	65	10-11	30 360	68
11-12	30 390	70	11-12	30 390	72
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	12	SP-12	60 60	16
12-11	30 90	19	12-11	30 90	22
11-10	30 120	24	11-10	30 120	28
10- 9	30 150	29	10- 9	30 150	33
9- 8	30 180	34	9- 8	30 180	37
8- 7	30 210	39	8- 7	30 210	42
7- 6	30 240	50	7- 6	30 240	48
6- 5	30 270	54	6- 5	30 270	52
5- 4	30 300	63	5- 4	30 300	56
4- 3	30 330	65	4- 3	30 330	64
3- 2	30 360	71	3- 2	30 360	68
2- 1	30 390	74	2- 1	30 390	72

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 15-C			Test Site 16-A		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	4
1- 2	5 15	5	1- 2	5 15	7
2- 3	5 20	6	2- 3	5 20	8
3- 4	5 25	7	3- 4	5 25	9
4- 5	30 55	13	4- 5	30 55	17
5- 6	30 85	19	5- 6	30 85	23
6- 7	30 115	25	6- 7	30 115	29
7- 8	30 145	31	7- 8	30 145	39
8- 9	30 175	35	8- 9	30 175	46
9-10	30 205	41	9-10	30 205	50
10-11	30 235	45	10-11	30 235	59
11-12	30 265	51	11-12	30 265	61
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	16	SP- 1	60 60	21
1- 2	30 90	21	1- 2	30 90	30
2- 3	30 120	27	2- 3	30 120	35
3- 4	30 150	31	3- 4	30 150	40
4- 5	30 180	37	4- 5	30 180	47
5- 6	30 210	41	5- 6	30 210	51
6- 7	30 240	48	6- 7	30 240	60
7- 8	30 270	54	7- 8	30 270	62
8- 9	30 300	59	8- 9	30 300	66
9-10	30 330	65	9-10	30 330	71
10-11	30 360	71	10-11	30 360	80
11-12	30 390	76	11-12	30 390	87
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	12	SP-12	60 60	24
12-11	30 90	19	12-11	30 90	32
11-10	30 120	24	11-10	30 120	38
10- 9	30 150	29	10- 9	30 150	45
9- 8	30 180	35	9- 8	30 180	49
8- 7	30 210	40	8- 7	30 210	51
7- 6	30 240	44	7- 6	30 240	59
6- 5	30 270	53	6- 5	30 270	68
5- 4	30 300	57	5- 4	30 300	71
4- 3	30 330	67	4- 3	30 330	73
3- 2	30 360	69	3- 2	30 360	76
2- 1	30 390	80	2- 1	30 390	79

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 16-B				Test Site 16-C			
Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)
<u>Short Spread</u>				<u>Short Spread</u>			
SP- 1	10	10	5	SP- 1	10	10	4
1- 2	5	15	9	1- 2	5	15	9
2- 3	5	20	13	2- 3	5	20	11
3- 4	5	25	16	3- 4	5	25	14
4- 5	30	55	31	4- 5	30	55	27
5- 6	30	85	38	5- 6	30	85	34
6- 7	30	115	45	6- 7	30	115	41
7- 8	30	145	48	7- 8	30	145	50
8- 9	30	175	50	8- 9	30	175	56
9-10	30	205	54	9-10	30	205	62
10-11	30	235	55	10-11	30	235	67
11-12	30	265	56	11-12	30	265	70
<u>Long Spread</u>				<u>Long Spread</u>			
SP- 1	60	60	29	SP- 1	60	60	28
1- 2	30	90	44	1- 2	30	90	37
2- 3	30	120	46	2- 3	30	120	43
3- 4	30	150	48	3- 4	30	150	49
4- 5	30	180	52	4- 5	30	180	54
5- 6	30	210	54	5- 6	30	210	61
6- 7	30	240	59	6- 7	30	240	65
7- 8	30	270	60	7- 8	30	270	71
8- 9	30	300	64	8- 9	30	300	75
9-10	30	330	70	9-10	30	330	76
10-11	30	360	71	10-11	30	360	81
11-12	30	390	74	11-12	30	390	83
<u>Reverse Spread</u>				<u>Reverse Spread</u>			
SP-12	60	60	28	SP-12	60	60	30
12-11	30	90	36	12-11	30	90	37
11-10	30	120	41	11-10	30	120	44
10- 9	30	150	47	10- 9	30	150	51
9- 8	30	180	50	9- 8	30	180	60
8- 7	30	210	54	8- 7	30	210	64
7- 6	30	240	56	7- 6	30	240	70
6- 5	30	270	60	6- 5	30	270	72
5- 4	30	300	62	5- 4	30	300	77
4- 3	30	330	65	4- 3	30	330	80
3- 2	30	360	67	3- 2	30	360	83
2- 1	30	390	71	2- 1	30	390	86

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 16-D			Test Site 17-A		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	4	SP- 1	10 10	6
1- 2	5 15	10	1- 2	5 15	9
2- 3	5 20	14	2- 3	5 20	12
3- 4	5 25	16	3- 4	5 25	13
4- 5	30 55	31	4- 5	30 55	26
5- 6	30 85	41	5- 6	30 85	31
6- 7	30 115	50	6- 7	30 115	39
7- 8	30 145	56	7- 8	30 145	44
8- 9	30 175	65	8- 9	30 175	48
9-10	30 205	68	9-10	30 205	52
10-11	30 235	71	10-11	30 235	54
11-12	30 265	78	11-12	30 265	61
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	32	SP- 1	60 60	22
1- 2	30 90	41	1- 2	30 90	31
2- 3	30 120	52	2- 3	30 120	41
3- 4	30 150	60	3- 4	30 150	47
4- 5	30 180	65	4- 5	30 180	49
5- 6	30 210	67	5- 6	30 210	53
6- 7	30 240	71	6- 7	30 240	57
7- 8	30 270	75	7- 8	30 270	63
8- 9	30 300	80	8- 9	30 300	65
9-10	30 330	81	9-10	30 330	70
10-11	30 360	85	10-11	30 360	73
11-12	30 390	86	11-12	30 390	79
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	25	SP-12	60 60	24
12-11	30 90	37	12-11	30 90	31
11-10	30 120	43	11-10	30 120	38
10- 9	30 150	52	10- 9	30 150	42
9- 8	30 180	56	9- 8	30 180	44
8- 7	30 210	62	8- 7	30 210	48
7- 6	30 240	69	7- 6	30 240	53
6- 5	30 270	70	6- 5	30 270	59
5- 4	30 300	78	5- 4	30 300	63
4- 3	30 330	80	4- 3	30 330	66
3- 2	30 360	82	3- 2	30 360	69
2- 1	30 390	84	2- 1	30 390	76

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 17-B				Test Site 17-C			
Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)		Compressional wave travel time (milliseconds)
<u>Short Spread</u>				<u>Short Spread</u>			
SP- 1	10	10	2	SP- 1	10	10	2
1- 2	5	15	3	1- 2	5	15	4
2- 3	5	20	5	2- 3	5	20	5
3- 4	5	25	6	3- 4	5	25	6
4- 5	30	55	10	4- 5	30	55	10
5- 6	30	85	16	5- 6	30	85	15
6- 7	30	115	21	6- 7	30	115	20
7- 8	30	145	28	7- 8	30	145	25
8- 9	30	175	32	8- 9	30	175	28
9-10	30	205	35	9-10	30	205	33
10-11	30	235	41	10-11	30	235	38
11-12	30	265	46	11-12	30	265	42
<u>Long Spread</u>				<u>Long Spread</u>			
SP- 1	60	60	12	SP- 1	60	60	10
1- 2	30	90	18	1- 2	30	90	15
2- 3	30	120	23	2- 3	30	120	20
3- 4	30	150	28	3- 4	30	150	23
4- 5	30	180	30	4- 5	30	180	27
5- 6	30	210	35	5- 6	30	210	31
6- 7	30	240	40	6- 7	30	240	36
7- 8	30	270	44	7- 8	30	270	40
8- 9	30	300	49	8- 9	30	300	44
9-10	30	330	52	9-10	30	330	48
10-11	30	360	59	10-11	30	360	53
11-12	30	390	63	11-12	30	390	57
<u>Reverse Spread</u>				<u>Reverse Spread</u>			
SP-12	40	40	10	SP-12	60	60	20
12-11	30	70	15	12-11	30	90	23
11-10	30	100	19	11-10	30	120	27
10- 9	30	130	23	10- 9	30	150	29
9- 8	30	160	30	9- 8	30	180	34
8- 7	30	190	33	8- 7	30	210	37
7- 6	30	220	39	7- 6	30	240	42
6- 5	30	250	43	6- 5	30	270	45
5- 4	30	280	48	5- 4	30	300	49
4- 3	30	310	53	4- 3	30	330	52
3- 2	30	340	57	3- 2	30	360	55
2- 1	30	370	59	2- 1	30	390	59



Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 18-A			Test Site 18-B		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	7	SP- 1	10 10	4
1- 2	5 15	10	1- 2	5 15	8
2- 3	5 20	12	2- 3	5 20	10
3- 4	5 25	14	3- 4	5 25	11
4- 5	30 55	28	4- 5	30 55	16
5- 6	30 85	35	5- 6	30 85	21
6- 7	30 115	43	6- 7	30 115	26
7- 8	30 145	49	7- 8	30 145	31
8- 9	30 175	55	8- 9	30 175	35
9-10	30 205	59	9-10	30 205	39
10-11	30 235	63	10-11	30 235	44
11-12	30 265	67	11-12	30 265	48
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	31	SP- 1	60 60	25
1- 2	30 90	37	1- 2	30 90	29
2- 3	30 120	43	2- 3	30 120	34
3- 4	30 150	48	3- 4	30 150	37
4- 5	30 180	56	4- 5	30 180	40
5- 6	30 210	61	5- 6	30 210	45
6- 7	30 240	68	6- 7	30 240	48
7- 8	30 270	71	7- 8	30 270	53
8- 9	30 300	77	8- 9	30 300	55
9-10	30 330	81	9-10	30 330	59
10-11	30 360	83	10-11	30 360	63
11-12	30 390	88	11-12	30 390	64
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	26	SP-12	60 60	22
12-11	30 90	35	12-11	30 90	26
11-10	30 120	42	11-10	30 120	30
10- 9	30 150	48	10- 9	30 150	33
9- 8	30 180	56	9- 8	30 180	38
8- 7	30 210	63	8- 7	30 210	42
7- 6	30 240	68	7- 6	30 240	47
6- 5	30 270	74	6- 5	30 270	53
5- 4	30 300	75	5- 4	30 300	56
4- 3	30 330	81	4- 3	30 330	61
3- 2	30 360	83	3- 2	30 360	65
2- 1	30 390	89	2- 1	30 390	68

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 18-C			Test Site 18-D				
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)		
<u>Short Spread</u>			<u>Short Spread</u>				
SP- 1	10	10	4	SP- 1	10	10	6
1- 2	5	15	7	1- 2	5	15	9
2- 3	5	20	12	2- 3	5	20	11
3- 4	5	25	15	3- 4	5	25	12
4- 5	30	55	23	4- 5	30	55	25
5- 6	30	85	30	5- 6	30	85	32
6- 7	30	115	37	6- 7	30	115	39
7- 8	30	145	43	7- 8	30	145	48
8- 9	30	175	49	8- 9	30	175	54
9-10	30	205	55	9-10	30	205	62
10-11	30	235	58	10-11	30	235	67
11-12	30	265	65	11-12	30	265	72
<u>Long Spread</u>			<u>Long Spread</u>				
SP- 1	60	60	22	SP- 1	60	60	26
1- 2	30	90	29	1- 2	30	90	35
2- 3	30	120	37	2- 3	30	120	41
3- 4	30	150	42	3- 4	30	150	48
4- 5	30	180	49	4- 5	30	180	54
5- 6	30	210	54	5- 6	30	210	57
6- 7	30	240	62	6- 7	30	240	65
7- 8	30	270	67	7- 8	30	270	69
8- 9	30	300	72	8- 9	30	300	75
9-10	30	330	79	9-10	30	330	78
10-11	30	360	83	10-11	30	360	87
11-12	30	390	88	11-12	30	390	90
<u>Reverse Spread</u>			<u>Reverse Spread</u>				
SP-12	60	60	21	SP-12	60	60	31
12-11	30	90	27	12-11	30	90	40
11-10	30	120	32	11-10	30	120	45
10- 9	30	150	38	10- 9	30	150	50
9- 8	30	180	45	9- 8	30	180	56
8- 7	30	210	52	8- 7	30	210	61
7- 6	30	240	56	7- 6	30	240	66
6- 5	30	270	66	6- 5	30	270	70
5- 4	30	300	71	5- 4	30	300	78
4- 3	30	330	77	4- 3	30	330	84
3- 2	30	360	--	3- 2	30	360	87
2- 1	30	390	82	2- 1	30	390	91

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 18-E			Test Site 19-A		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	5 5	4
1- 2	5 15	5	1- 2	5 10	7
2- 3	5 20	7	2- 3	5 15	14
3- 4	5 25	9	3- 4	5 20	18
4- 5	30 55	17	4- 5	10 30	20
5- 6	30 85	23	5- 6	10 40	24
6- 7	30 115	28	6- 7	10 50	25
7- 8	30 145	32	7- 8	10 60	29
8- 9	30 175	39	8- 9	10 70	34
9-10	30 205	43	9-10	10 80	38
10-11	30 235	48	10-11	10 90	40
11-12	30 265	53	11-12	10 100	42
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	20	SP- 1	10 10	7
1- 2	30 90	27	1- 2	30 40	22
2- 3	30 120	34	2- 3	30 70	30
3- 4	30 150	37	3- 4	30 100	39
4- 5	30 180	44	4- 5	30 130	47
5- 6	30 210	49	5- 6	30 160	53
6- 7	30 240	53	6- 7	30 190	64
7- 8	30 270	59	7- 8	30 220	67
8- 9	30 300	63	8- 9	30 250	72
9-10	30 330	66	9-10	30 280	81
10-11	30 360	71	10-11	30 310	86
11-12	30 390	75	11-12	30 340	92
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	23	A spread was not run at this site.		
12-11	30 90	28			
11-10	30 120	32			
10- 9	30 150	37			
9- 8	30 180	43			
8- 7	30 210	47			
7- 6	30 240	53			
6- 5	30 270	60			
5- 4	30 300	64			
4- 3	30 330	67			
3- 2	30 360	71			
2- 1	30 390	74			

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 19-B			Test Site 19-C		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone numbers	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	5
1- 2	5 15	3	1- 2	5 15	8
2- 3	5 20	5	2- 3	5 20	11
3- 4	5 25	6	3- 4	5 25	12
4- 5	30 55	12	4- 5	30 55	18
5- 6	30 85	15	5- 6	30 85	23
6- 7	30 115	22	6- 7	30 115	32
7- 8	30 145	28	7- 8	30 145	35
8- 9	30 175	33	8- 9	30 175	39
9-10	30 205	39	9-10	30 205	41
10-11	30 235	44	10-11	30 235	46
11-12	30 265	48	11-12	30 265	48
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	11	SP- 1	60 60	19
1- 2	30 90	19	1- 2	30 90	25
2- 3	30 120	24	2- 3	30 120	31
3- 4	30 150	29	3- 4	30 150	37
4- 5	30 180	36	4- 5	30 180	43
5- 6	30 210	37	5- 6	30 210	46
6- 7	30 240	45	6- 7	30 240	48
7- 8	30 270	49	7- 8	30 270	52
8- 9	30 300	55	8- 9	30 300	55
9-10	30 330	59	9-10	30 330	61
10-11	30 360	64	10-11	30 360	63
11-12	30 390	68	11-12	30 390	66
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	15	SP-12	60 60	19
12-11	30 90	22	12-11	30 90	24
11-10	30 120	25	11-10	30 120	--
10- 9	30 150	29	10- 9	30 150	31
9- 8	30 180	34	9- 8	30 180	36
8- 7	30 210	39	8- 7	30 210	39
7- 6	30 240	45	7- 6	30 240	45
6- 5	30 270	50	6- 5	30 270	51
5- 4	30 300	53	5- 4	30 300	55
4- 3	30 330	56	4- 3	30 330	59
3- 2	30 360	61	3- 2	30 360	64
2- 1	30 390	63	2- 1	30 390	66

Table 1.--Geophone Intervals and Compressional Wave Travel Times--Continued

Test Site 19-D			Test Site 19-E		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	2	SP- 1	10 10	6
1- 2	5 15	6	1- 2	5 15	9
2- 3	5 20	9	2- 3	5 20	10
3- 4	5 25	14	3- 4	5 25	11
4- 5	30 55	21	4- 5	30 55	17
5- 6	30 85	25	5- 6	30 85	23
6- 7	30 115	32	6- 7	30 115	30
7- 8	30 145	37	7- 8	30 145	35
8- 9	30 175	42	8- 9	30 175	40
9-10	30 205	44	9-10	30 205	46
10-11	30 235	50	10-11	30 235	50
11-12	30 265	52	11-12	30 265	56
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	22	SP- 1	60 60	24
1- 2	30 90	28	1- 2	30 90	30
2- 3	30 120	34	2- 3	30 120	35
3- 4	30 150	40	3- 4	30 150	39
4- 5	30 180	42	4- 5	30 180	45
5- 6	30 210	46	5- 6	30 210	51
6- 7	30 240	52	6- 7	30 240	57
7- 8	30 270	58	7- 8	30 270	62
8- 9	30 300	60	8- 9	30 300	67
9-10	30 330	64	9-10	30 330	72
10-11	30 360	65	10-11	30 360	75
11-12	30 390	68	11-12	30 390	81
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	17	SP-12	60 60	19
12-11	30 90	24	12-11	30 90	26
11-10	30 120	31	11-10	30 120	32
10- 9	30 150	35	10- 9	30 150	38
9- 8	30 180	39	9- 8	30 180	43
8- 7	30 210	45	8- 7	30 210	48
7- 6	30 240	51	7- 6	30 240	54
6- 5	30 270	55	6- 5	30 270	59
5- 4	30 300	58	5- 4	30 300	64
4- 3	30 330	60	4- 3	30 330	69
3- 2	30 360	63	3- 2	30 360	75
2- 1	30 390	68	2- 1	30 390	78

Table 1.--Geophones Intervals and Compressional Wave Travel Times--Continued

Test Site 20-A			Test Site 20-B		
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)
<u>Short Spread</u>			<u>Short Spread</u>		
SP- 1	10 10	4	SP- 1	10 10	3
1- 2	5 15	7	1- 2	5 15	5
2- 3	5 20	9	2- 3	5 20	8
3- 4	5 25	10	3- 4	5 25	9
4- 5	30 55	16	4- 5	30 55	24
5- 6	30 85	23	5- 6	30 85	38
6- 7	30 115	27	6- 7	30 115	42
7- 8	30 145	33	7- 8	30 145	45
8- 9	30 175	34	8- 9	30 175	49
9-10	30 205	39	9-10	30 205	50
10-11	30 235	43	10-11	30 235	54
11-12	30 265	46	11-12	30 265	58
<u>Long Spread</u>			<u>Long Spread</u>		
SP- 1	60 60	24	SP- 1	60 60	19
1- 2	30 90	26	1- 2	30 90	28
2- 3	30 120	30	2- 3	30 120	37
3- 4	30 150	34	3- 4	30 150	45
4- 5	30 180	36	4- 5	30 180	50
5- 6	30 210	43	5- 6	30 210	52
6- 7	30 240	46	6- 7	30 240	54
7- 8	30 270	52	7- 8	30 270	60
8- 9	30 300	54	8- 9	30 300	63
9-10	30 330	59	9-10	30 330	65
10-11	30 360	62	10-11	30 360	69
11-12	30 390	65	11-12	30 390	70
<u>Reverse Spread</u>			<u>Reverse Spread</u>		
SP-12	60 60	19	SP-12	60 60	26
12-11	30 90	27	12-11	30 90	31
11-10	30 120	30	11-10	30 120	36
10- 9	30 150	32	10- 9	30 150	40
9- 8	30 180	37	9- 8	30 180	45
8- 7	30 210	39	8- 7	30 210	49
7- 6	30 240	44	7- 6	30 240	55
6- 5	30 270	46	6- 5	30 270	61
5- 4	30 300	49	5- 4	30 300	62
4- 3	30 330	54	4- 3	30 330	65
3- 2	30 360	56	3- 2	30 360	68
2- 1	30 390	64	2- 1	30 390	71

Table 1.--Geophones Intervals and Compressional Wave Travel Times--Continued

Test Site 20-C			Test Site 20-D				
Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)	Shot point (SP) and geophone number	Interval and cumulative distances (feet)	Compressional wave travel time (milliseconds)		
<u>Short Spread</u>			<u>Short Spread</u>				
SP- 1	10	10	5	SP- 1	10	10	4
1- 2	5	15	8	1- 2	5	15	6
2- 3	5	20	10	2- 3	5	20	8
3- 4	5	25	11	3- 4	5	25	8
4- 5	30	55	21	4- 5	30	55	14
5- 6	30	85	29	5- 6	30	85	24
6- 7	30	115	36	6- 7	30	115	36
7- 8	30	145	41	7- 8	30	145	42
8- 9	30	175	46	8- 9	30	175	46
9-10	30	205	48	9-10	30	205	50
10-11	30	235	51	10-11	30	235	55
11-12	30	265	56	11-12	30	265	59
<u>Long Spread</u>			<u>Long Spread</u>				
SP- 1	60	60	24	SP- 1	60	60	17
1- 2	30	90	32	1- 2	30	90	26
2- 3	30	120	36	2- 3	30	120	31
3- 4	30	150	40	3- 4	30	150	35
4- 5	30	180	44	4- 5	30	180	40
5- 6	30	210	48	5- 6	30	210	44
6- 7	30	240	51	6- 7	30	240	51
7- 8	30	270	57	7- 8	30	270	53
8- 9	30	300	60	8- 9	30	300	57
9-10	30	330	64	9-10	30	330	60
10-11	30	360	67	10-11	30	360	65
11-12	30	390	71	11-12	30	390	67
<u>Reverse Spread</u>			<u>Reverse Spread</u>				
SP-12	60	60	26	SP-12	60	60	26
12-11	30	90	32	12-11	30	90	32
11-10	30	120	39	11-10	30	120	36
10- 9	30	150	44	10- 9	30	150	41
9- 8	30	180	46	9- 8	30	180	45
8- 7	30	210	50	8- 7	30	210	48
7- 6	30	240	55	7- 6	30	240	54
6- 5	30	270	59	6- 5	30	270	57
5- 4	30	300	59	5- 4	30	300	58
4- 3	30	330	63	4- 3	30	330	62
3- 2	30	360	68	3- 2	30	360	65
2- 1	30	390	71	2- 1	30	390	66

Table 2.--Compressional Wave Velocities, Average Total Porosities, and Average Specific Yields

Profile	Test site	Compressional wave velocities (rounded to nearest hundred)			Average total porosities from V <sub>2</sub> (percent by volume)	Average specific yields from V <sub>2</sub> (percent by volume)
		V <sub>1</sub> * (ft/s)	V <sub>2</sub> ** (ft/s)	V <sub>3</sub> ** (ft/s)		
1	A	1,000	3,000	--	36	30
2	A	1,000	2,600	--	39	31
3	A	1,200	--	--	38	31
3	B	1,100	2,700	--		
4	A	1,200	3,400	--	34	28
4	B	1,200	4,000	--		
4	C	1,400	3,400	--		
4	D	1,300	2,600	--		
4	E	1,300	4,000	--		
4	F	1,200	3,000	--		
5	A	1,100	3,000	7,100	38	31
5	B	1,000	3,600	--		
5	C	1,400	2,000	--		
5	D	1,700	2,400	5,300		
5	E	1,600	--	--		
6	A	1,400	2,300	6,000	41	32
6	B	1,700	2,300	--	40	32
7	A	1,500	2,400	5,700		
8	A	1,900	3,000	--		
8	B	1,500	3,100	--	35	29
8	C	1,300	--	--		
8	D	1,800	2,900	--		
8	E	2,600	3,100	--		
8	F	2,000	3,800	--		

See footnotes at end of table.



Table 2.--Compressional Wave Velocities, Average Total Porosities, and Average Specific Yields--Continued

Profile	Test site	Compressional wave velocities (rounded to nearest hundred)			Average total porosities from V <sub>2</sub> (percent by volume)	Average specific yields from V <sub>2</sub> (percent by volume)
		V <sub>1</sub> * (ft/s)	V <sub>2</sub> ** (ft/s)	V <sub>3</sub> ** (ft/s)		
9	A	1,300	3,400	--		
9	B	1,400	3,900	--		
9	C	1,000	3,800	--		
9	D	1,800	3,300	7,700	34	28
9	E	--	3,000	6,100		
9	F	2,200	3,900	--		
9	G	2,400	3,400	--		
10	A	1,300	3,700	--		
10	B	2,100	3,300	--		
10	C	1,400	3,600	--		
10	D	1,400	3,800	--		
10	E	1,300	3,100	--	33	28
10	F	1,400	3,900	--		
10	G	1,700	3,200	6,800		
10	H	2,000	3,800	--		
10	I	1,500	4,100	--		
11	A	2,500	4,000	--		
11	B	1,300	3,000	6,000		
11	C	3,900	--	--		
11	D	2,800	3,800	--	33	28
11	E	2,300	3,400	--		
11	F	2,700	3,500	--		
11	G	2,100	4,200	--		

See footnotes at end of table.

Table 2.--Compressional Wave Velocities, Average Total Porosities, and Average Specific Yields--Continued

Profile	Test site	Compressional wave velocities (rounded to nearest hundred)			Average total porosities from V <sub>2</sub> (percent by volume)	Average specific yields from V <sub>2</sub> (percent by volume)
		V <sub>1</sub> * (ft/s)	V <sub>2</sub> ** (ft/s)	V <sub>3</sub> ** (ft/s)		
12	A	2,900	4,600	--		
12	B	1,700	4,200	--		
12	C	1,100	3,700	--		
12	D	1,300	4,200	--	31	26
12	E	1,100	4,000	5,600		
12	F	2,800	3,700	--		
12	G	1,900	3,900	--		
13	A	1,500	3,600	5,900	33	28
13	B	1,400	3,800	--		
14	A	1,100	6,800	--		
14	B	2,300	7,200	--	23	19
14	C	1,500	5,800	--		
14	D	1,500	6,100	--		
15	A	4,900	5,800	--		
15	B	1,700	6,000	--	25	21
15	C	2,400	5,400	--		
16	A	2,000	5,300	--		
16	B	1,700	--	--	29	24
16	C	1,600	4,800	--		
16	D	1,500	3,900	--		
17	A	2,300	7,000	--		
17	B	5,200	6,400	--	22	18
17	C	3,200	7,600	--		

See footnotes at end of table.

Table 2.--Compressional Wave Velocities, Average Total Porosities, and Average Specific Yields--Continued

Profile	Test site	Compressional wave velocities (rounded to nearest hundred)			Average total porosities from V <sub>2</sub> (percent by volume)	Average specific yields from V <sub>2</sub> (percent by volume)
		V <sub>1</sub> * (ft/s)	V <sub>2</sub> ** (ft/s)	V <sub>3</sub> ** (ft/s)		
18	A	1,700	4,600	7,900		
18	B	1,800	7,300	--		
18	C	1,900	4,700	--	26	22
18	D	1,800	5,100	--		
18	E	2,600	5,500	--		
19	A	1,200	3,700	5,100		
19	B	4,000	6,300	--		
19	C	1,900	5,800	--	26	22
19	D	2,200	5,300	--		
19	E	1,800	5,600	--		
20	A	2,300	8,500	--		
20	B	2,500	7,800	--		
20	C	2,100	7,400	--	20	16
20	D	2,500	6,800	--		

\* Apparent velocity of short forward spread.

\*\* Best approximation of true velocities derived from harmonic mean formula.

Table 3.--Results of Laboratory Tests of Core Samples

(Laboratory tests conducted at the Texas Department of Water Resources' Materials Testing Laboratory)

<u>Sample site</u>	<u>Depth interval (ft)</u>	<u>Moisture content (percent by weight)</u>	<u>Total porosity (percent by volume)</u>	<u>Sample description</u>
2A	15.25 - 15.90	10.5	38.7	Sand, medium grain, tan
4B	11.80 - 12.45	8.0	31.7	Sand, clayey, fine grain, red
5D	12.00 - 12.60	11.6	31.5	Sand, clayey, fine to medium grain, red
6A	4.25 - 4.85	12.2	29.7	Sand, clayey, fine grain, red
9C	8.43 - 9.07	6.5	35.5	Sand, medium to coarse grain, tan
11A	8.74 - 9.39	6.0	36.0	Sand, medium to coarse grain, red
11D	11.93 - 12.57	5.1	39.4	Sand, medium grain, tan