TECHNICAL MEMORANDUM

MAPS SHOWING LOCATIONS OF AGGREGATE DEPOSITS IN THE COASTAL PLAINS OF TEXAS

TEXAS TRANSPORTATION INSTITUTE
THE TEXAS A&M UNIVERSITY SYSTEM
COLLEGE STATION, TEXAS

TECHNICAL MEMORANDUM

TEXAS TRANSPORTATION INSTITUTE

Cooperative Research Program
with
Texas Highway Department

HPR_____

TO: Billy Neeley, Materials and Test Division, D-9

STUDY NO._____

FROM: Robert L. Lytton, Texas Transportation Institute

AREA NO._____

SUBJECT: Maps Showing Locations of Aggregate Deposits in the Coastal Plains of Texas

DATE: May 4, 1984

This technical memorandum transmits and identifies maps that were developed in the course of Study 2-9-79-267, "Location of Marginal Flexible Base Sources." The maps are regional maps which indicate the sources with high potential for producing base course aggregates. Also included in this memorandum are the results of sieve analyses that were made of gravels that were sampled for several sites that were located in the course of the study. Each map or figure will be identified and described separately and in sequence. The maps and figures are arranged by subject matter to present the location of Cemented Sandstones, River Gravels, and "High" Gravels.

CEMENTED SANDSTONES

Figure 1 shows the location of the Catahoula formation where the cemented sandstones occur along the Texas Gulf Coast.

Figure 2 shows the location of the most likely areas for finding hard, cemented sandstones that can be crushed and used for base course. The high potential areas are shown cross-hatched on the figure.

Figure 3 is an enlargement of a portion of the map shown in Figure 2, stretching from the Grimes County eastward to the Louisiana border.

Figure 4 is an aerial photograph of several active pits and several more prospects for pits near Carlisle, Texas. The lake shown in the photograph is Lake Livingston.

Figure 5 is a topographic map of the same site near Carlisle, Texas showing locations of drill holes, seismic survey stations, and estimated depths to the sandstone. Data from the numbered drill holes is summarized in Appendix A.

Table 1 gives the results of the seismic surveys and the interpretation of the velocity data that was obtained.

RIVER GRAVELS

Figure 6 shows a State map of the sources of river gravels that are found in the Brazos and Colorado river valleys.

Figure 7 shows the location of several gravel-producing deposits in the San Jacinto, Trinity, Neches, and Sabine River Valleys. Data from the numbered drill holes shown in this map were used to outline the areas of high potential. The drill hole data are summarized in Appendix B.

Figure 8 shows a topographic map of a gravel-producing point bar deposit along the Neches River.

Figure 9 is an aerial photograph of the same area, known as Deserter Island, near Silsbee, Texas.

Figure 10 shows an electrical resistivity sounding curve taken on Deserter Island, showing interpretations of the resistivity readings.

Figure 11 is a contour map of resistivity that was measured at Deserter Island showing the location of drill holes that were made to verify the results of the soundings. A description of the cuttings from the numbered drill holes is given in Appendix C.

cc: Research Engineer, File D-8

Figure 12 is a map of the bedrock surface underlying the Brazos River. Gravels are found in the deepest portions of the riverbed.

Figure 13 is a map showing floodplain cross-sections of the lower Brazos River from Falls County to Fort Bend County, illustrating where gravels are found.

Figure 14 is a map of the lower Brazos River from Milam County to Brazoria County showing where samples were taken to determine the typical bedding patterns and gradation of the aggregates found at each of the locations: Sample locations 1 through 8 (SL-1 through SL-8). The gradation curves and bedding at each sample location are described in Appendix D.

Figure 15 is a profile view of the Brazos River showing cross-hatched areas of high gradient and high degrees of curvature (sinuosity) which were found in this Study to be good indicators of gravel deposits.

Figure 16 is another profile view of the Brazos River showing the sample locations which were first shown in Figure 14, and the floodplain cross-section locations that were first shown in Figure 13.

Figure 17 is an isometric map of the Brazos River and of gravel deposits in Fort Bend County, showing the depth and thickness of a thick gravel deposit that was located by the gradient-sinuosity method developed in this Study and confirmed by drill hole data.

Figure 18 is a profile view of the Colorado River showing gradient, sinuosity, and location of major gravel pits.

Figure 19 is a graph of aggregate size versus miles down the river starting at the Milam-Falls County line. Aggregate sizes get smaller with distance down the river.

"HIGH" GRAVELS

Figure 20 is a map of Texas showing the location of the Willis formation which is one of several closely associated formations, such as the Oakville, within which "high" gravels are found. These gravels are found on hilltops and have a distinctive red or yellow color. The color comes from iron which acts as a cement. Iron nodules are also found with these gravels which are sometimes called "iron ore gravel."

Figure 21 shows the location of the Willis outcrop in east Texas. Data from numbered drill holes are tabulated in Appendix B.

Figure 22 is a reproduction of a color-infrared photograph of the Willis formation in east Texas showing lighter-toned areas where gravels are found.

Figure 23 is a black-and-white photograph of the Willis formation in South Texas showing how trees grow on the gravelly sites while the finer-grained soils are cultivated.

Figure 24 is a black-and-white photograph of the Willis formation showing a potential gravel deposit about one mile northeast of Willis, Texas.

Figure 25 is a map of the same area as in the photograph in Figure 24. This figure shows the hole no., percent gravel, depth to the gravel deposit, and thickness of the deposit. A description of the cuttings from each of the numbered drill holes is given in Appendix E.

Table 2 gives the results of sieve analyses that were made on gravels from each of the numbered drill holes shown in Figure 25. The average gradation from all drill holes is given at the bottom of the table.

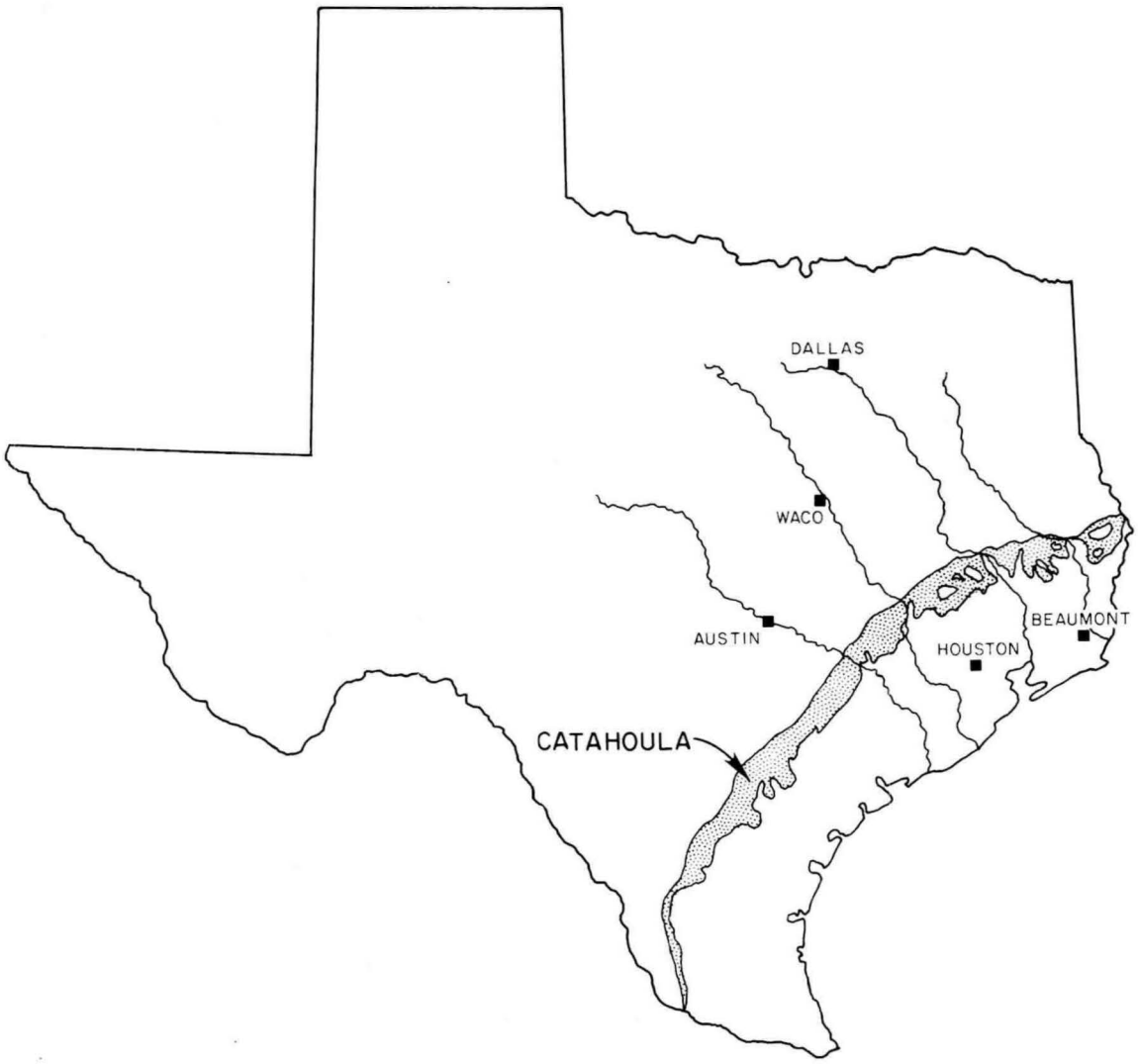

Figure 1. Outcrop belt of the Catahoula Formation.

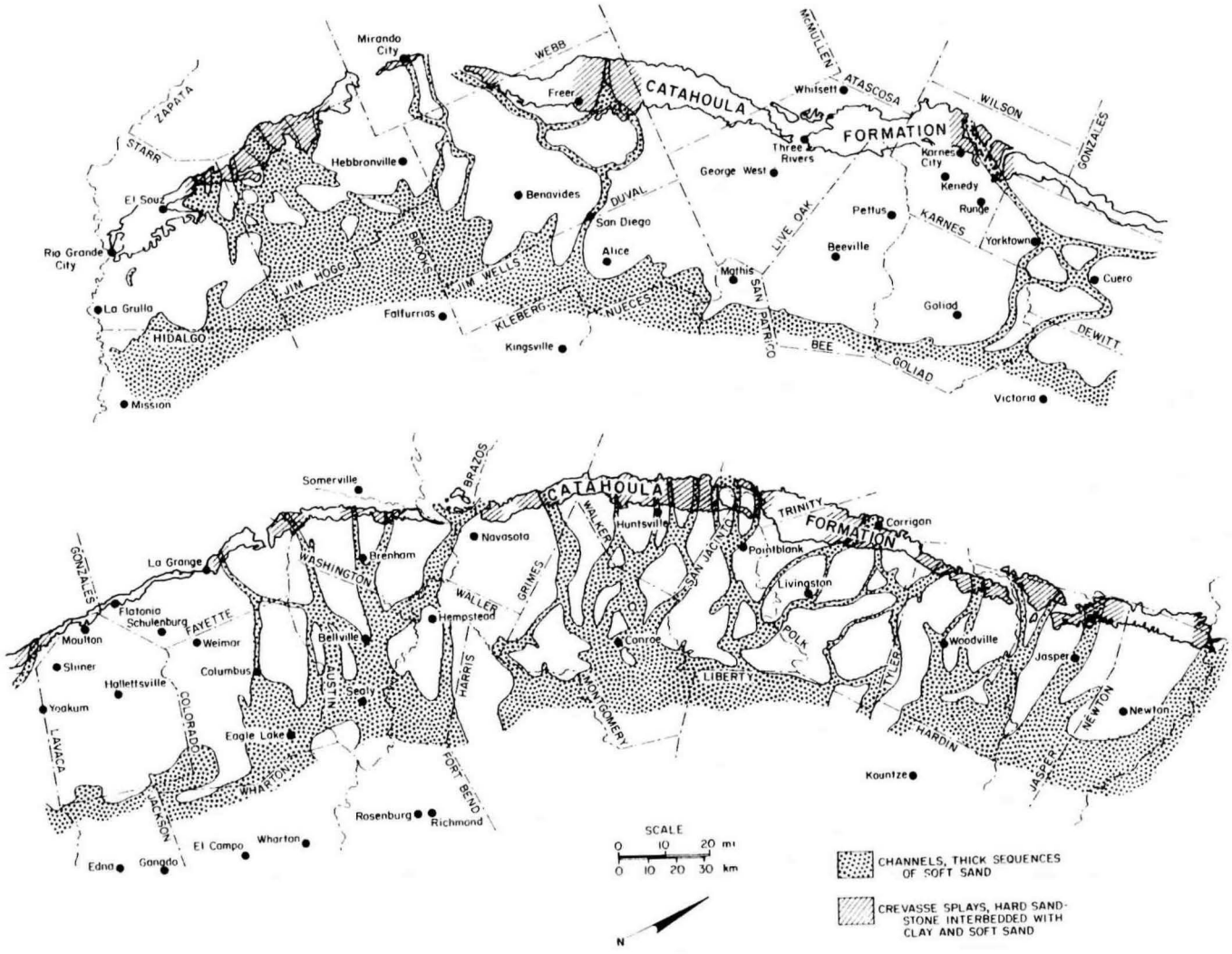

Figure 2. Map of the Distribution of Sand in the Catahoula Formation and Drill Hole Locations (whjch are tabulated in Appendix B).

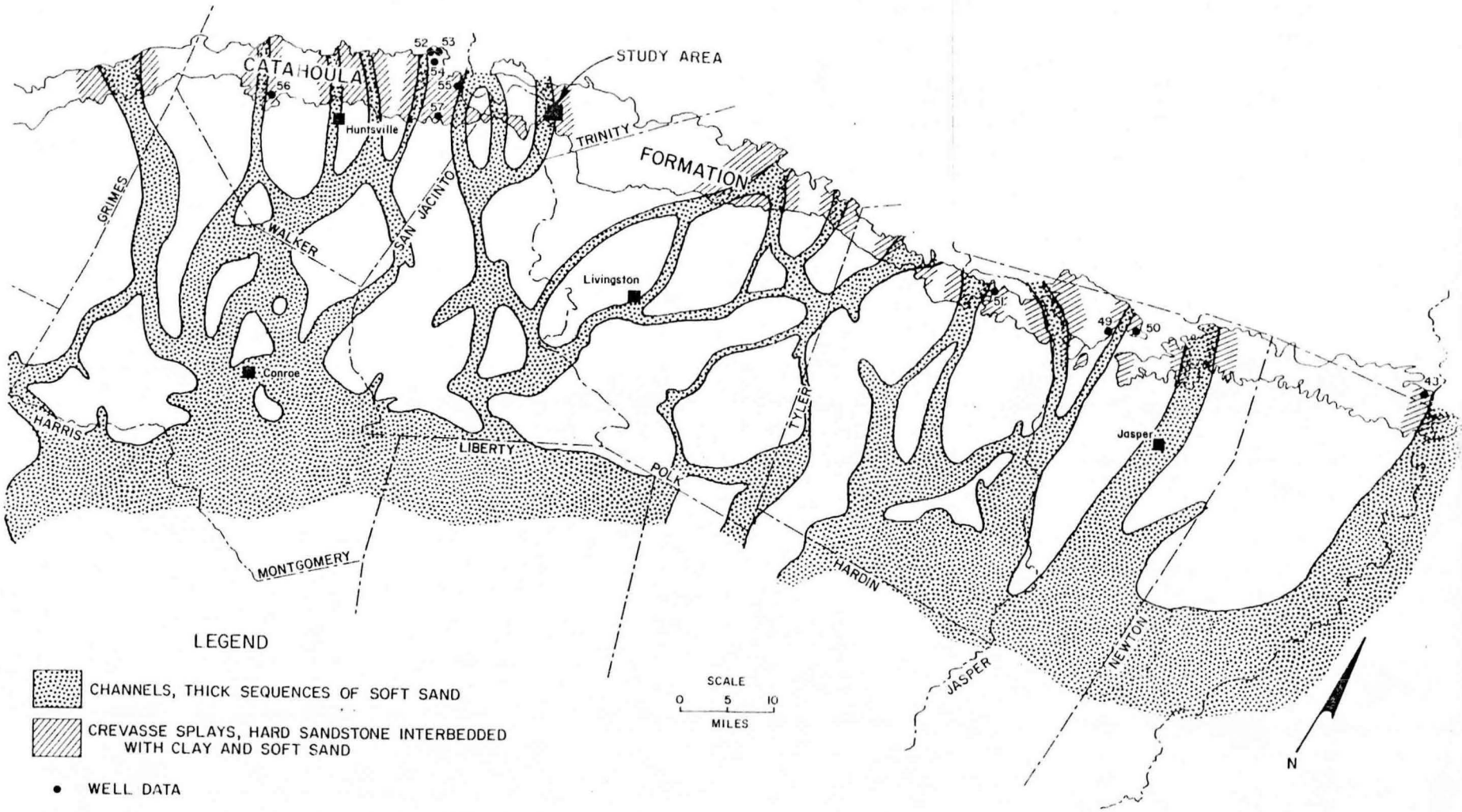

Figure 3. Map of Distribution of Sand in the Catahoula Formation in East Texas and Drill Hole Locations (which are tabulated in Appendix B).

Figure 4. C-IR air photograph of sandstone prospect near Carlisle, Texas. Thin arrows point to light toned patches that represent near surface or outcropping sandstones. The thick arrows point to rock pits.
(C-lR stands for Color-Infrared.)

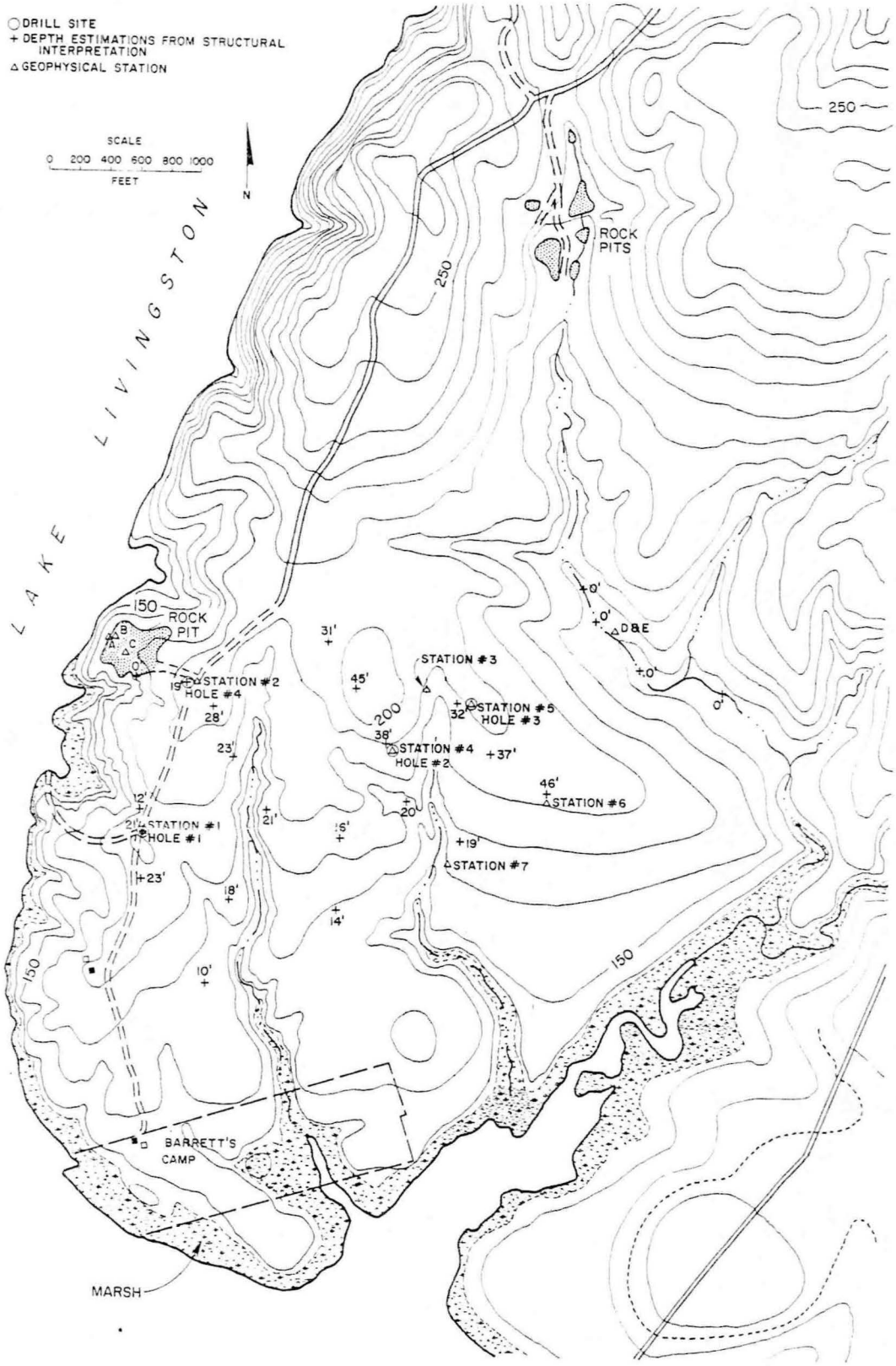

Figure 5. Topographic map of sandstone prospect near Carlisle, Texas that shows locations of drill holes, seismic surveys and structural determinations. (Contour interval = 10 feet.)

Table 1. Results of Seismic Surveys.

Station	Layer	Velocity (ft/msec)	Depth to Layer (ft)	Material
A	A	4.55	Surface	Sandstone
B	B	4.69	Surface	Sandstone
C	C	3.75	Surface	Fractured, silty claystone
D	D	3.45	Surface	Silty sandstone
E	E	2.27	Surface	Fractured, silty sandstone
1	V_1	1.12	Surface	Weathered Zone
	V_2	4.1	12.5	Weathered Zone
	V_3	7.65	45	Weathered Zone
2	V_1	1.02	Surface	Weathered Zone
	V_2	1.99	4	Weathered Zone
	V_3	3.22	16	Weathered Zone
3	V_1	1.06	Surface	Weathered Zone
	V_2	2.76	7	Weathered Zone
	V_3	5.7	19	Weathered Zone
4	V_1	0.8	Surface	Weathered Zone
	V_2	3.53	9	Weathered Zone
	V_3	5.26	15	Weathered Zone
5	V_1	0.76	Surface	Weathered Zone
	V_2	6.64	13	Weathered Zone
	V_3	22.2	55	Weathered Zone
6	V_1	0.64	Surface	Weathered Zone
	V_2	1.28	5	Weathered Zone
	V_3	2.34	11	Weathered Zone
7	V_1	0.81	Surface	Weathered Zone
	V_2	6.64	14.4	Weathered Zone

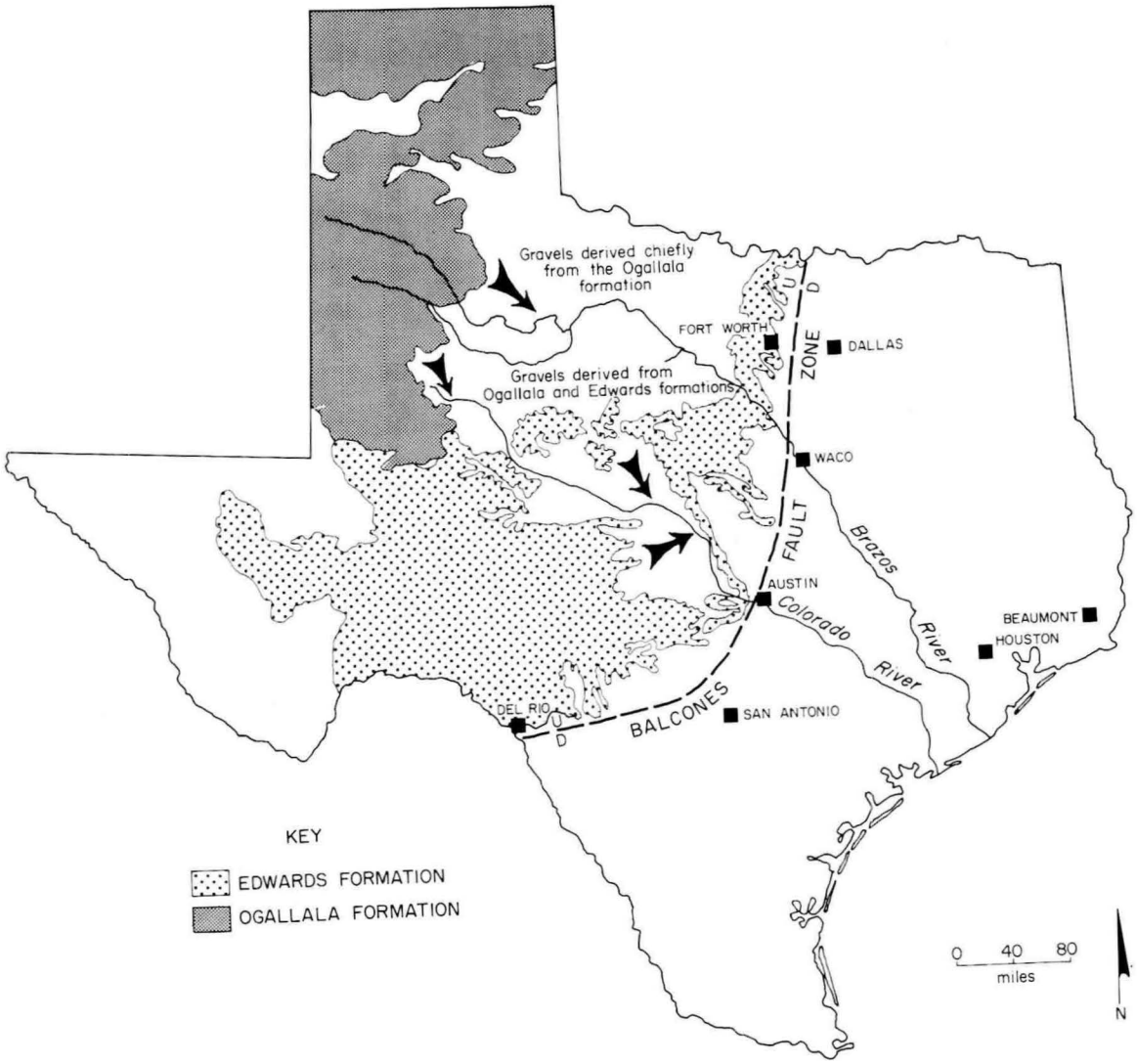

Figure 6. Sources of gravel for Gulf Coast rivers.

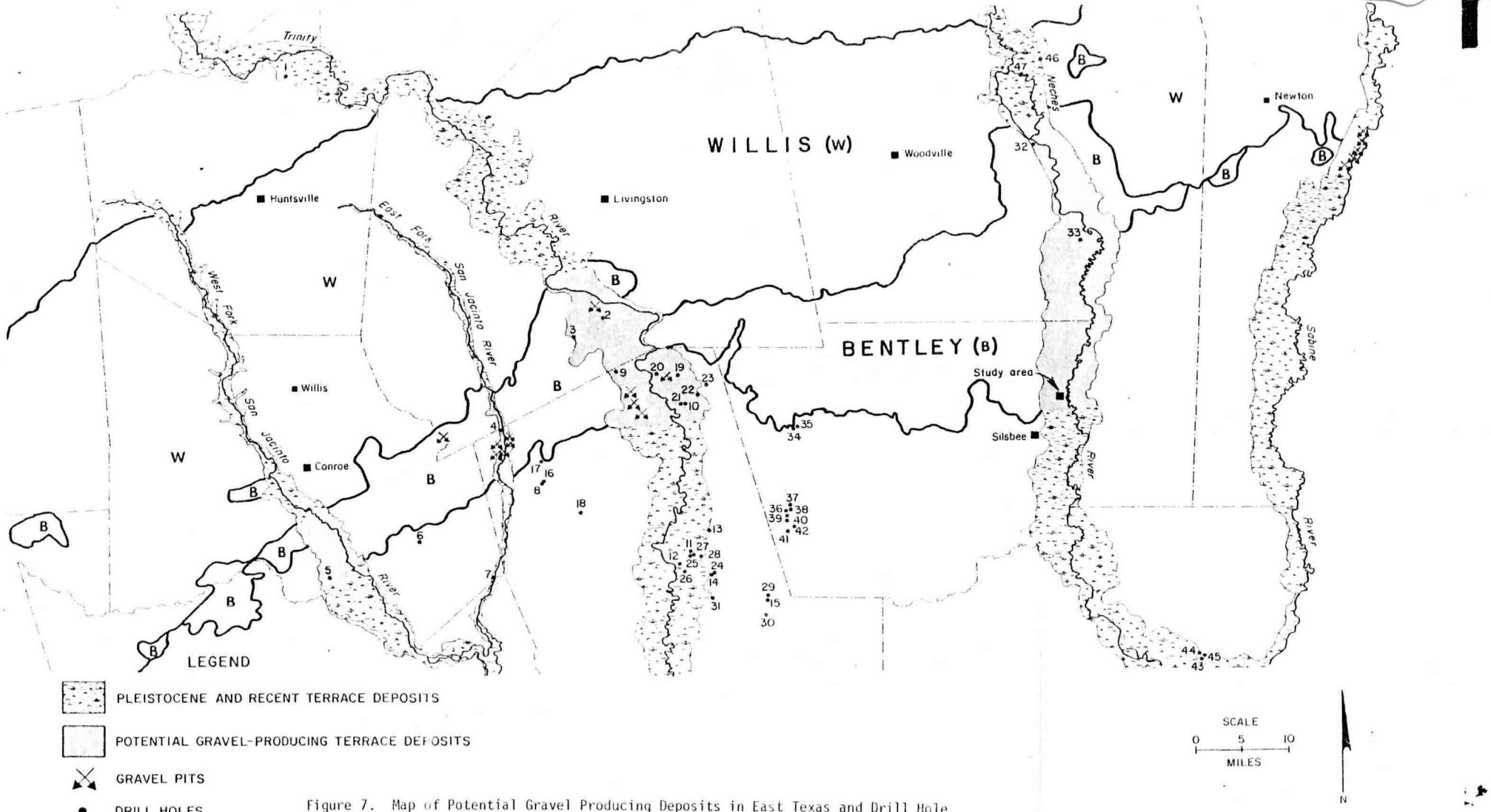

Figure 7. Map of Potential Gravel Producing Deposits in East Texas and Drill Hole Locations (which are tabulated in Appendix B).

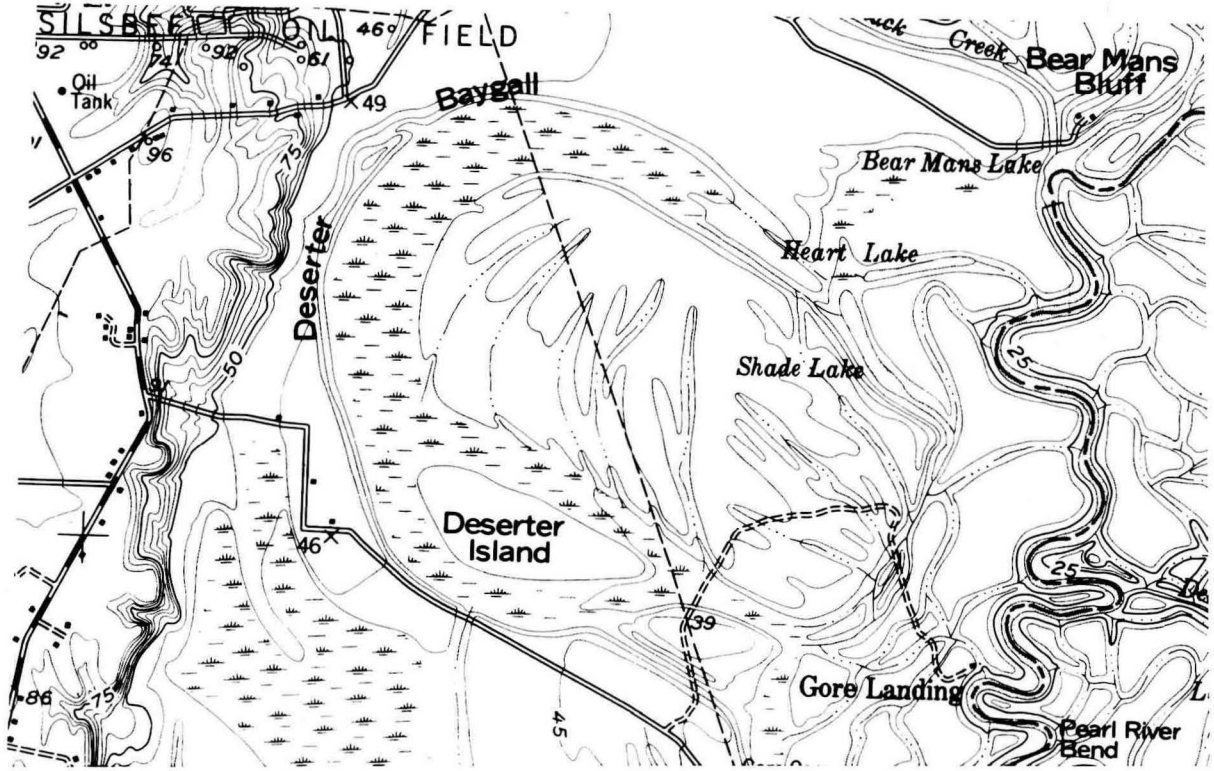

Figure 8. Topographic map of an ancient point-bar deposit along the Neches River. (Contour interval = 5 feet.)

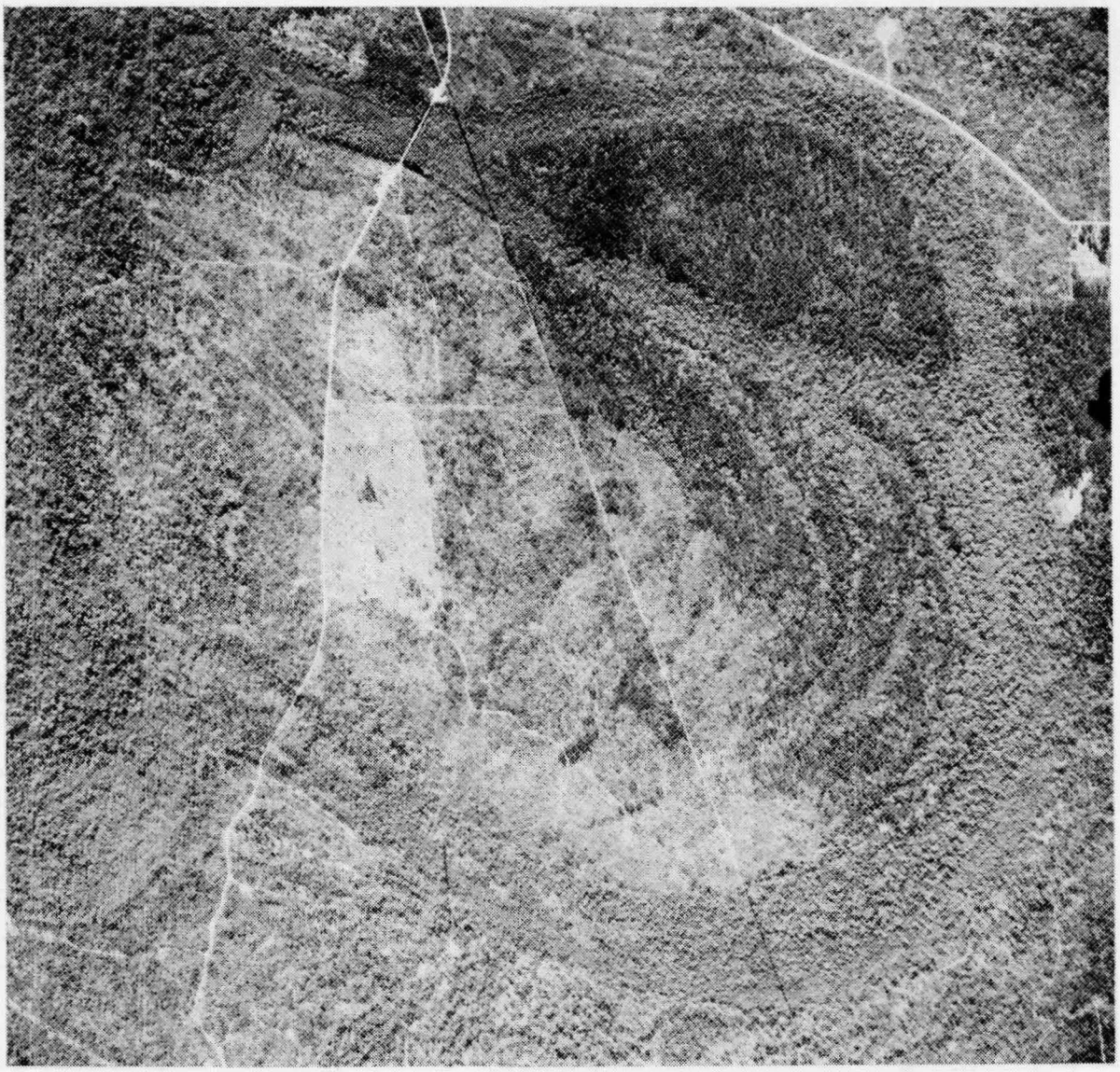

Figure 9. Black and white air photograph of the same point-bar shown in Figure 8.

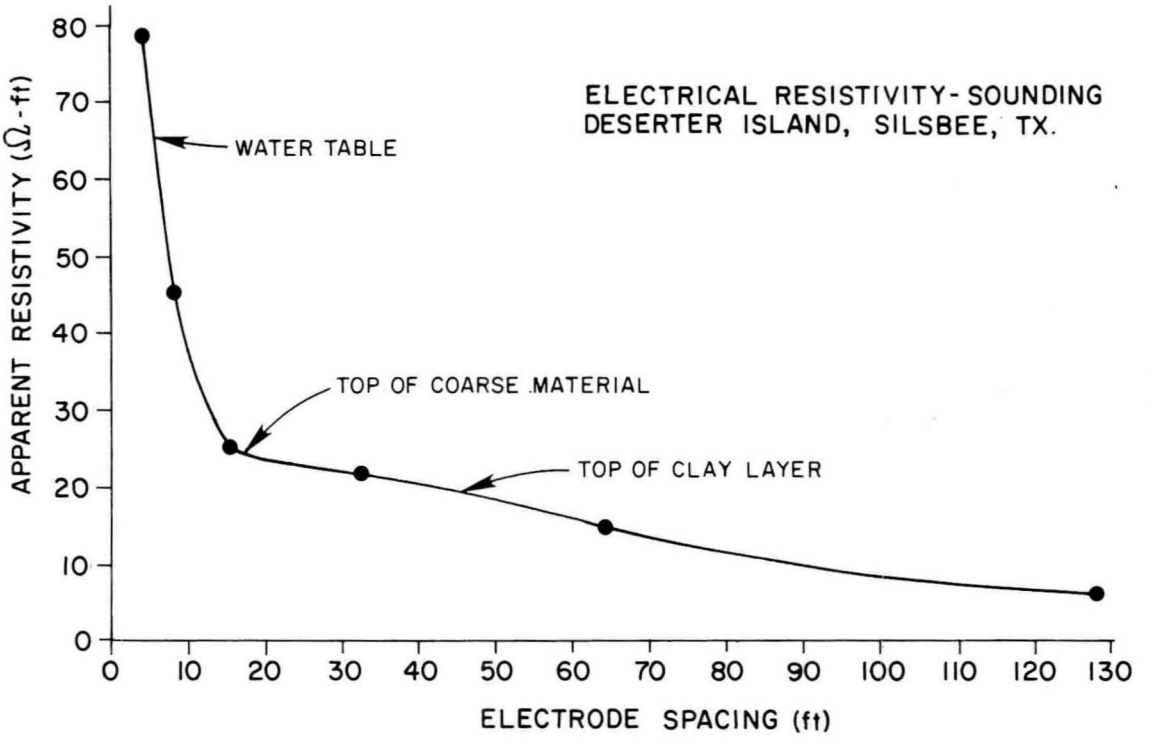

Figure 10. Electrical resistivity-sounding curve, taken at Deserter Island, Silsbee, Texas.

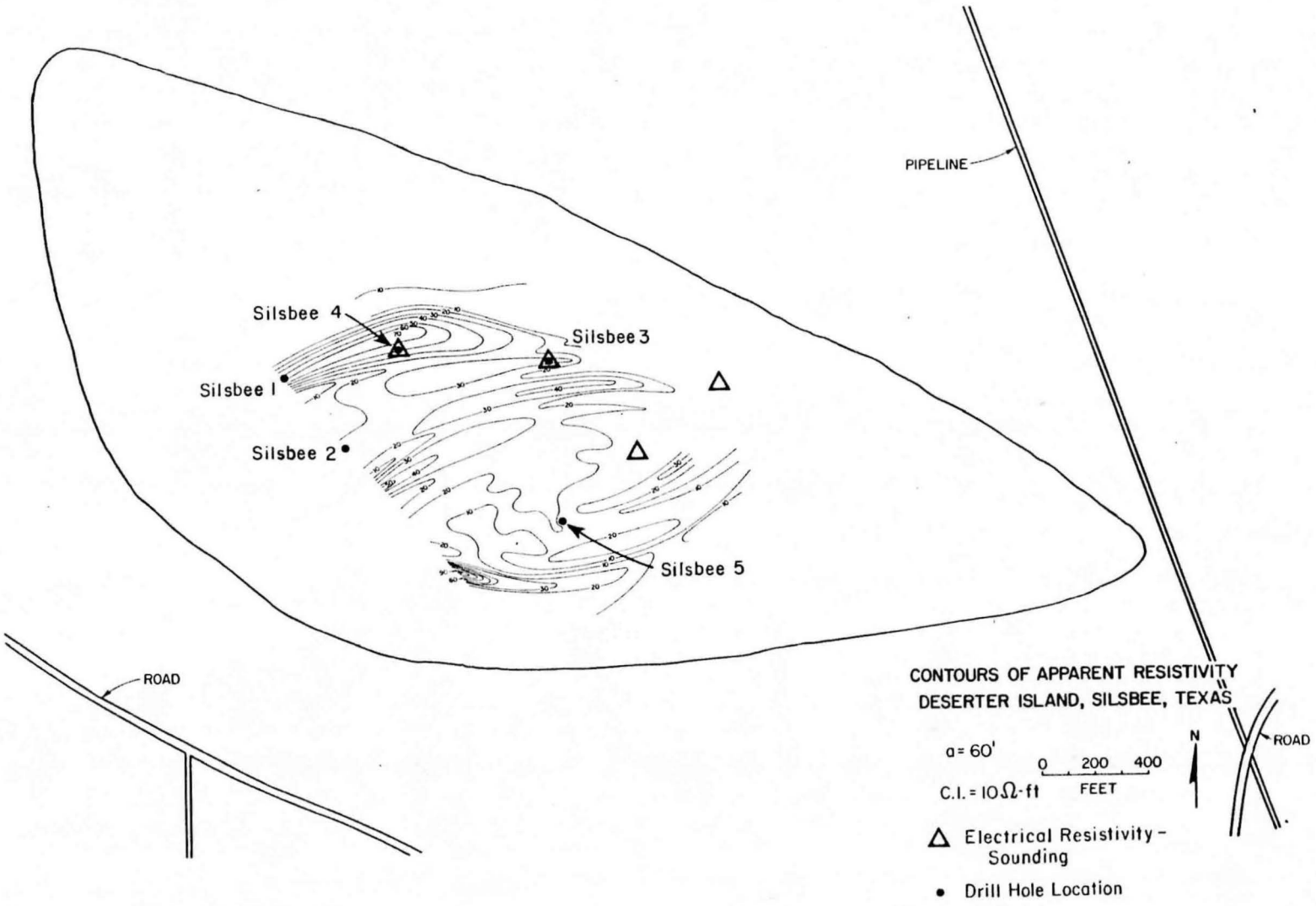

Figure 11. Contour map of apparent resistivity for Deserter Island, Silsbee, Texas. (Appendix C describes the cuttings from the numbered drill holes.)

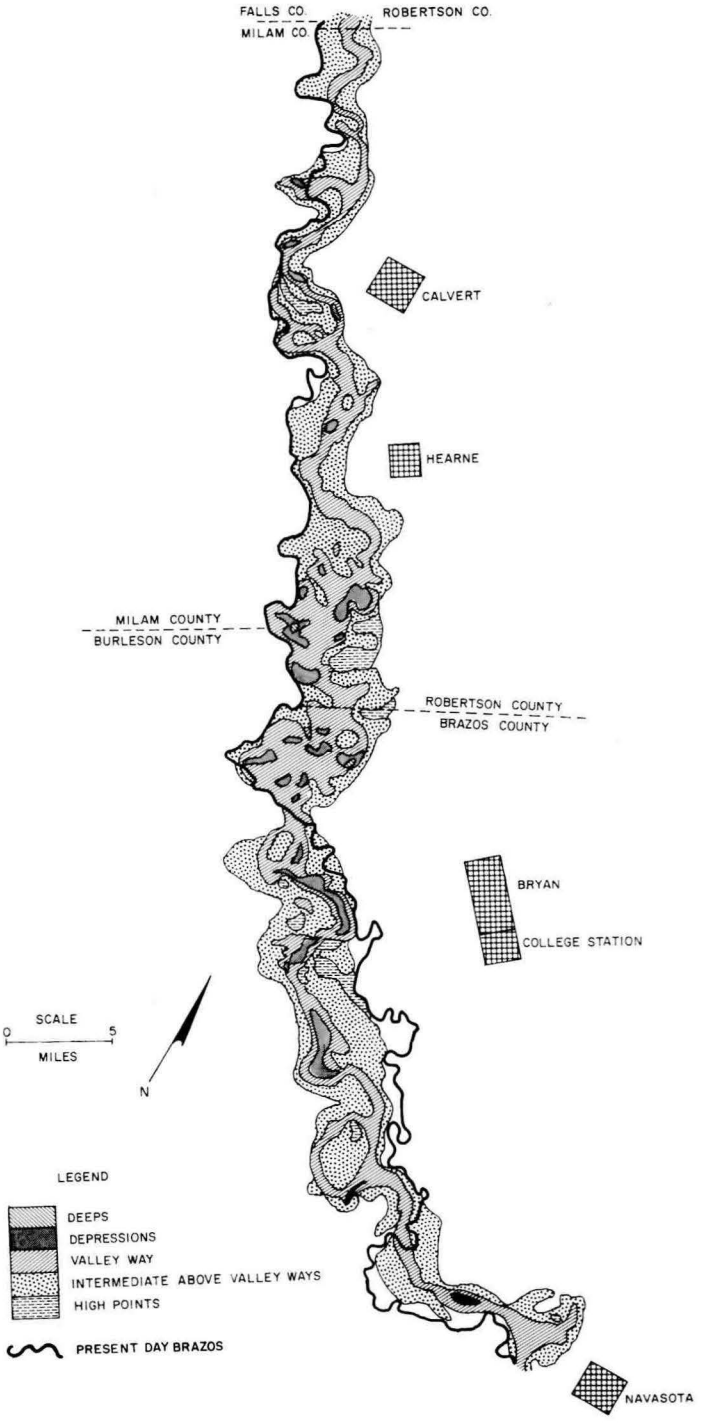

Figure 12. Plan view of the bedrock surface underlying the Brazos floodplain in the upper study area .

Figures 13 and 14 are folded in the pocket which is labeled Appendix F.

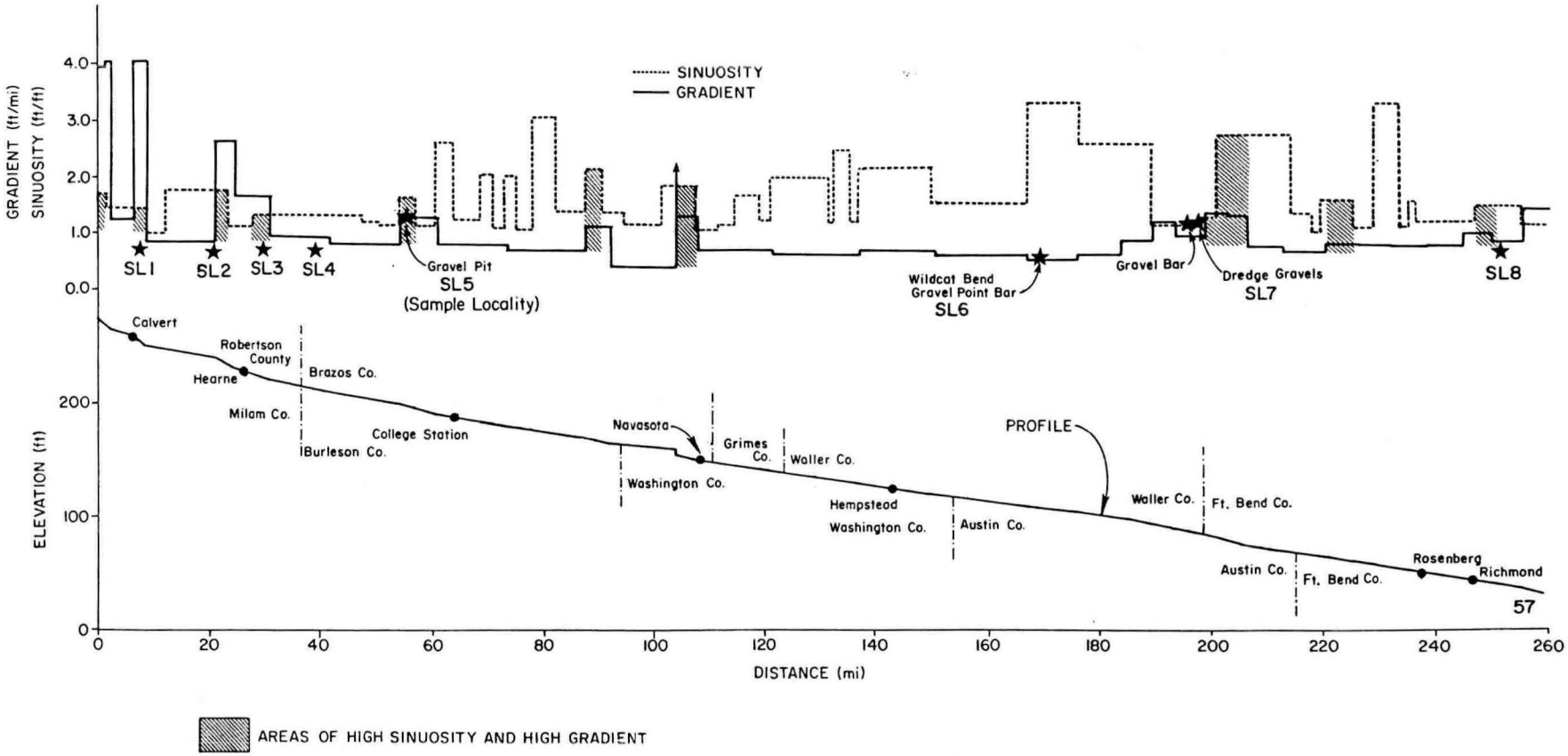

Figure 15. Graphical plot of river gradient vs. river distance, river sinuosity vs. river distance and the longitudinal profile for the Brazos River.

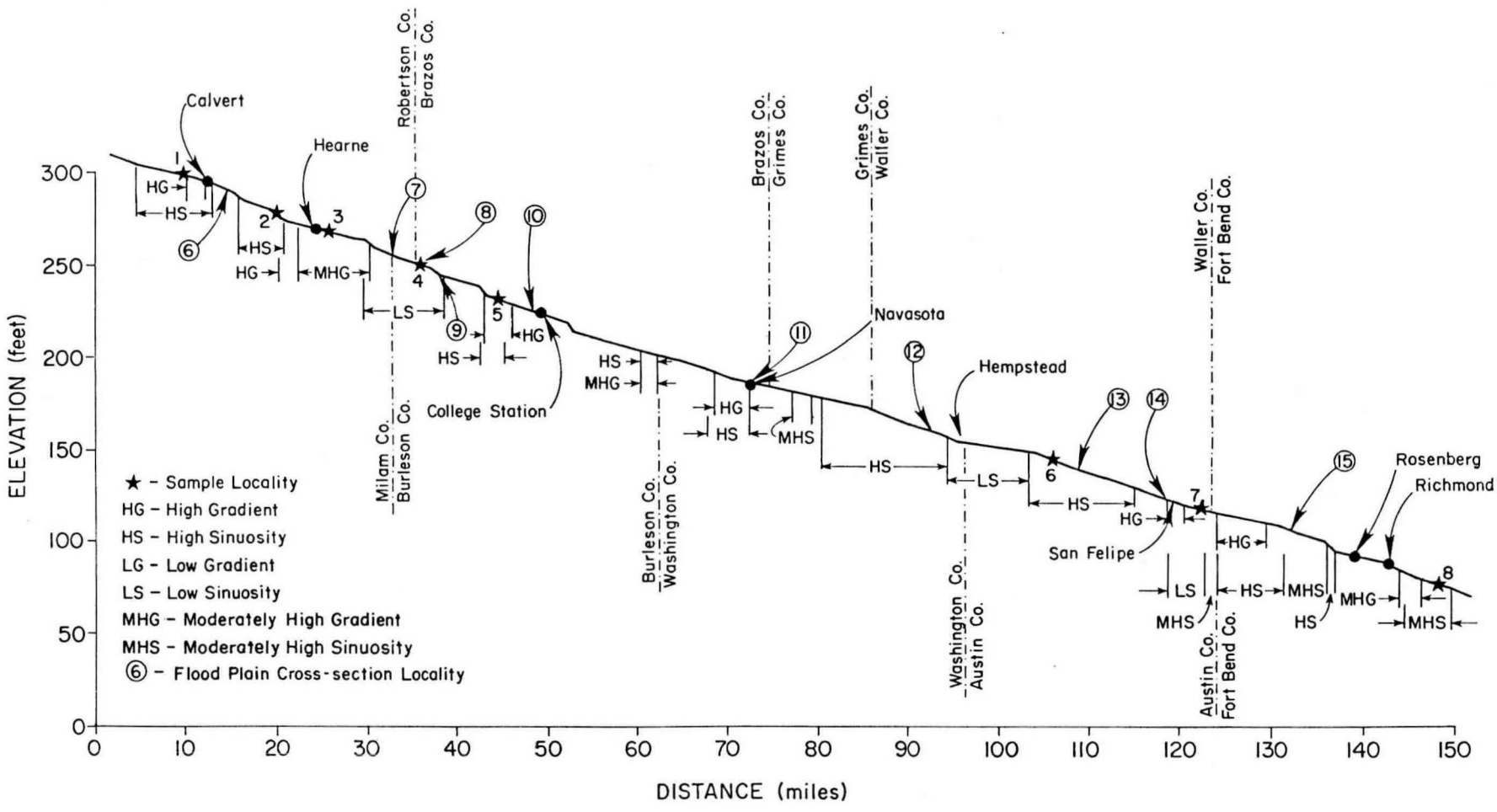

Figure 16. Longitudinal profile of the Brazos River floodplain showing location of the floodplain cross sections, and areas of high river gradient (HG), low river gradient (LG), high river sinuosity (HS), and low river sinuosity (LS).

Figure 17 is folded in the pocket which is labeled Appendix F.

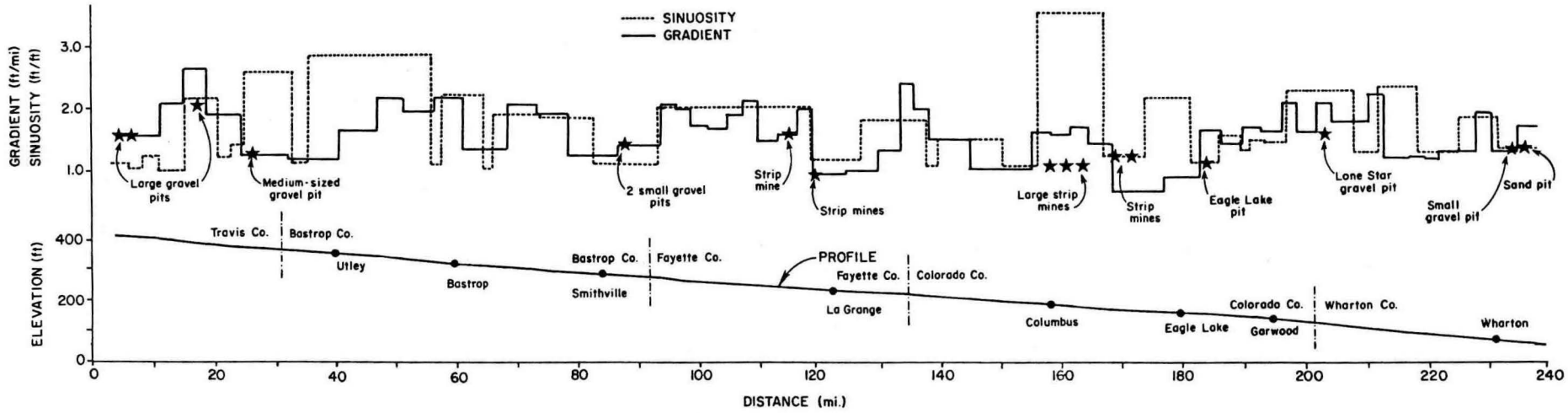

Figure 18. Graphical plot of river gradient vs. river distance, river sinuosity vs. river distance and the longitudinal profile for the Colorado River.

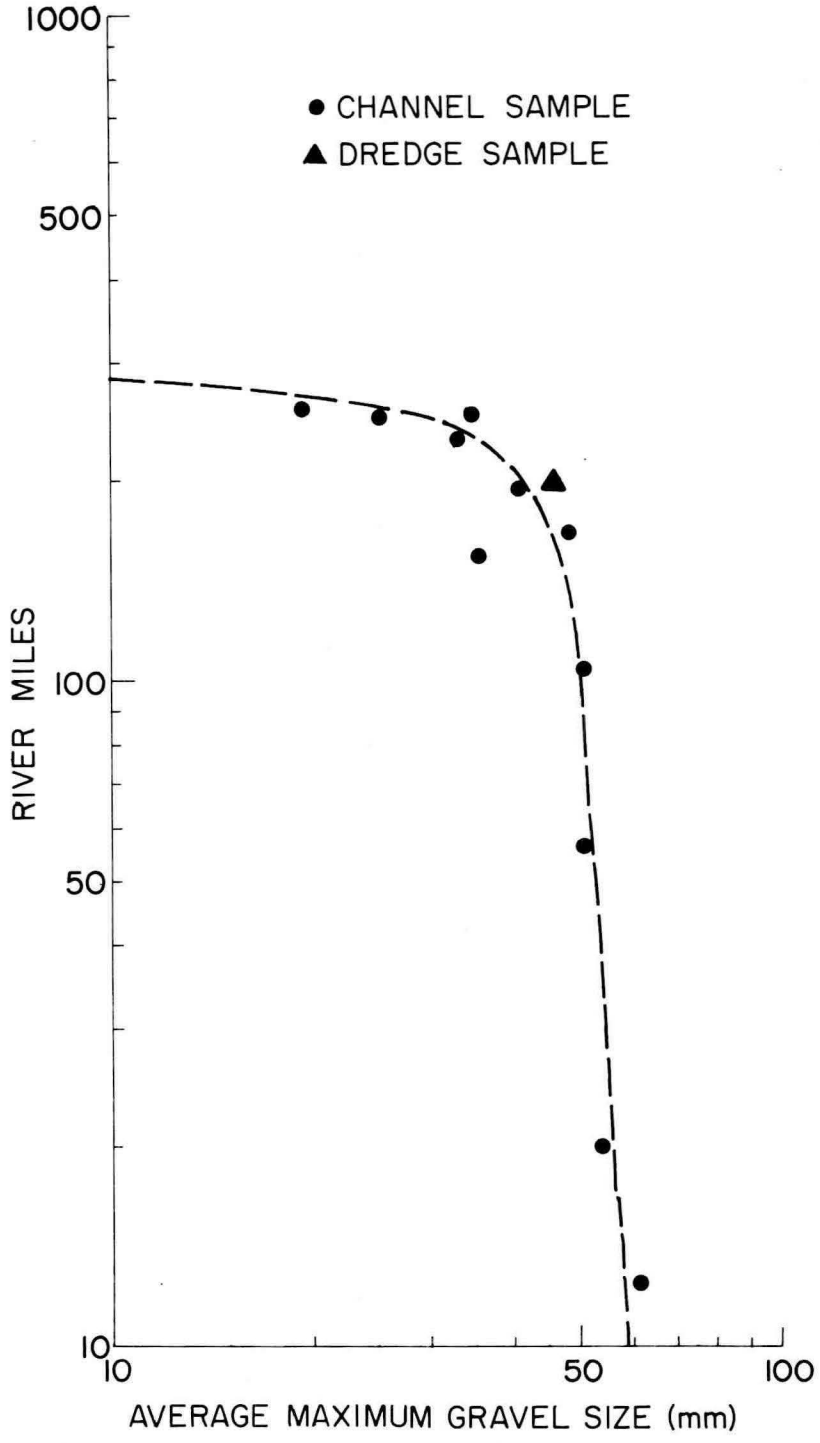

Figure 19. Variation of gravel grain size with river distance for the lower Brazos River.

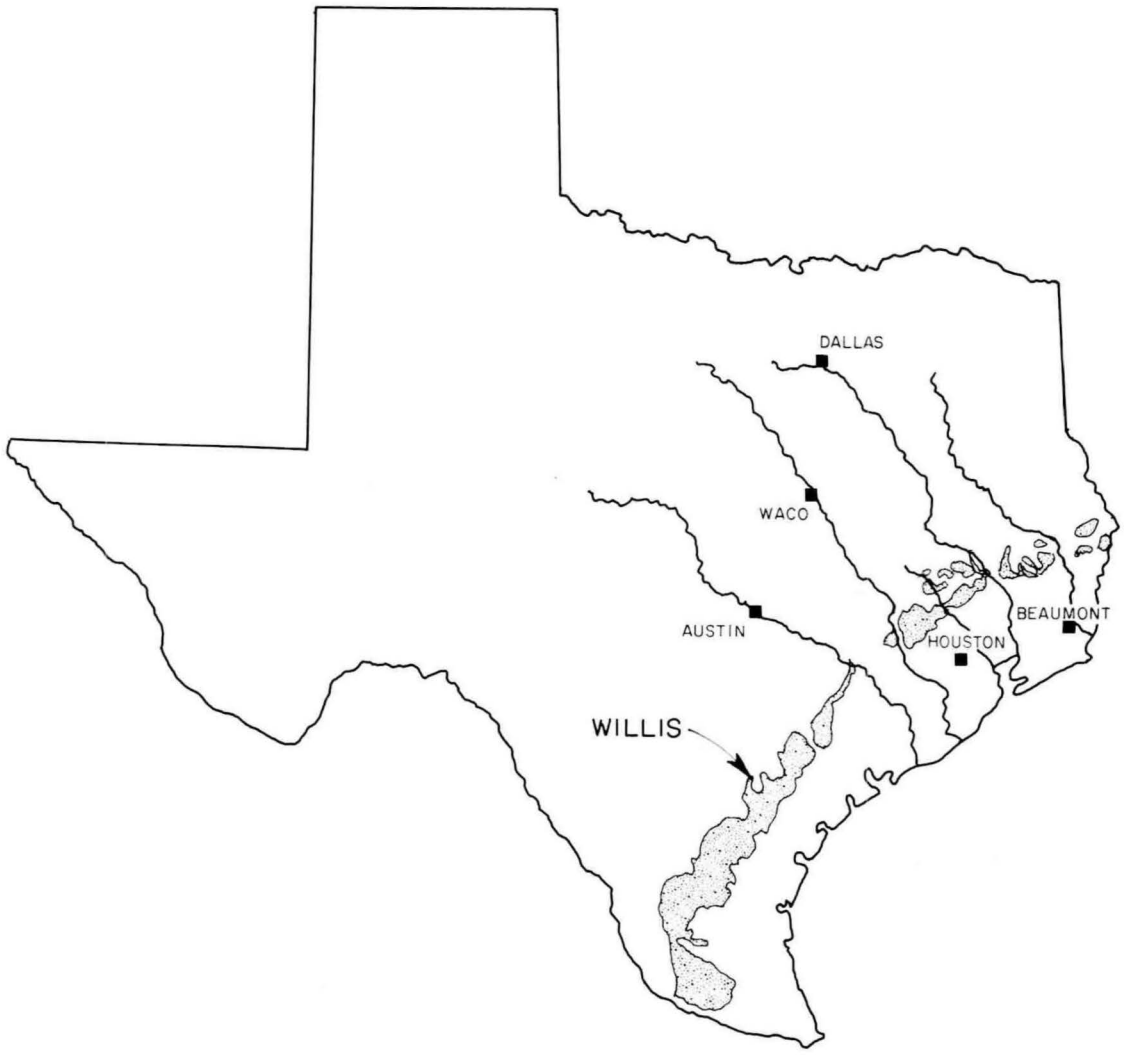

Figure 20. Outcrop belt of the Willis Formation.

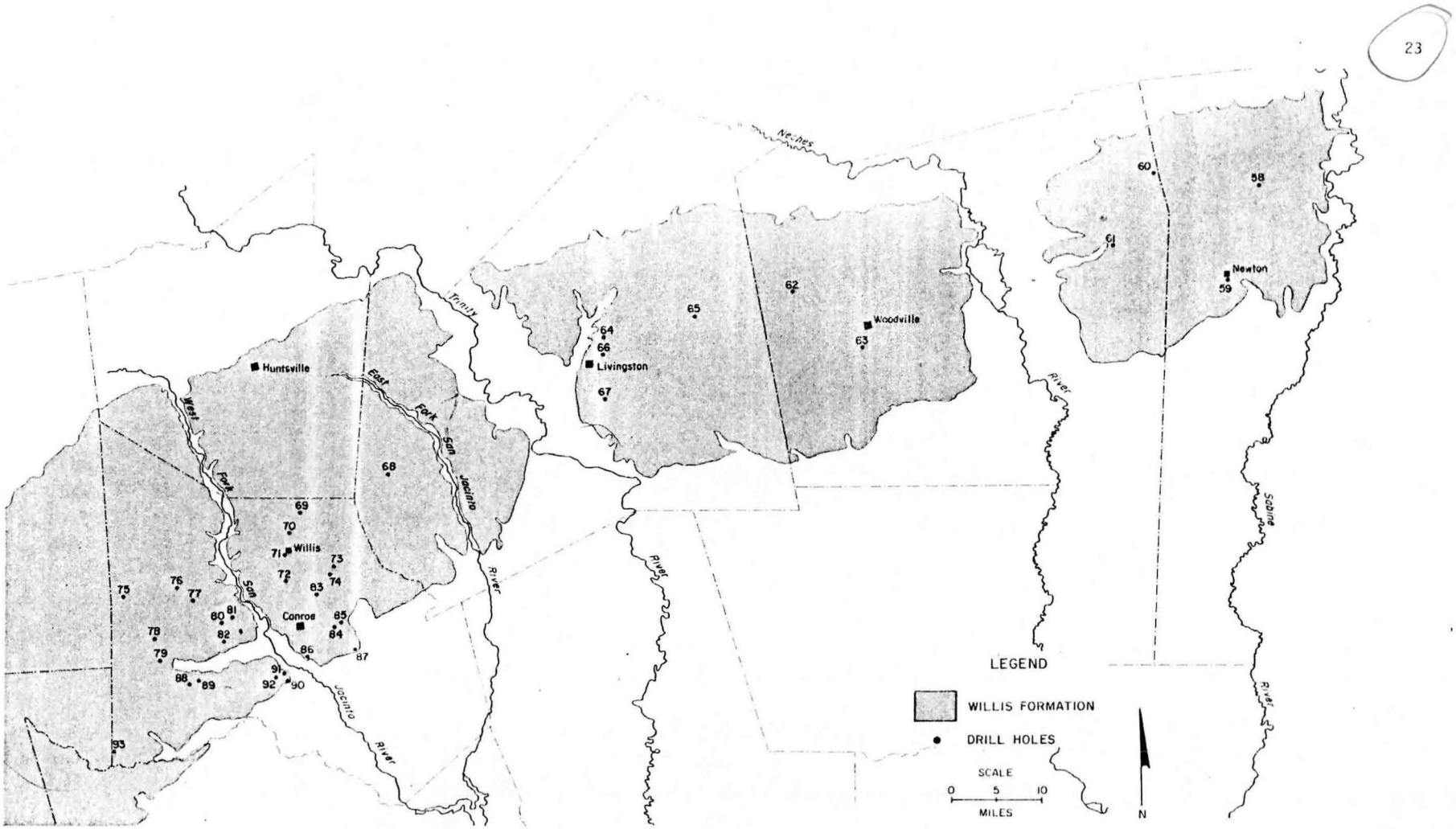

Figure 21. Outcrop pattern of the Willis Formation in east Texas. The Willis outcrop band is mapped together with the Fleming Formation because the Fleming is commonly covered by the Willis Formation on the high ridges and exposed in the eroded valleys. Data from numbered drill holes is tabulated in Appendix B.

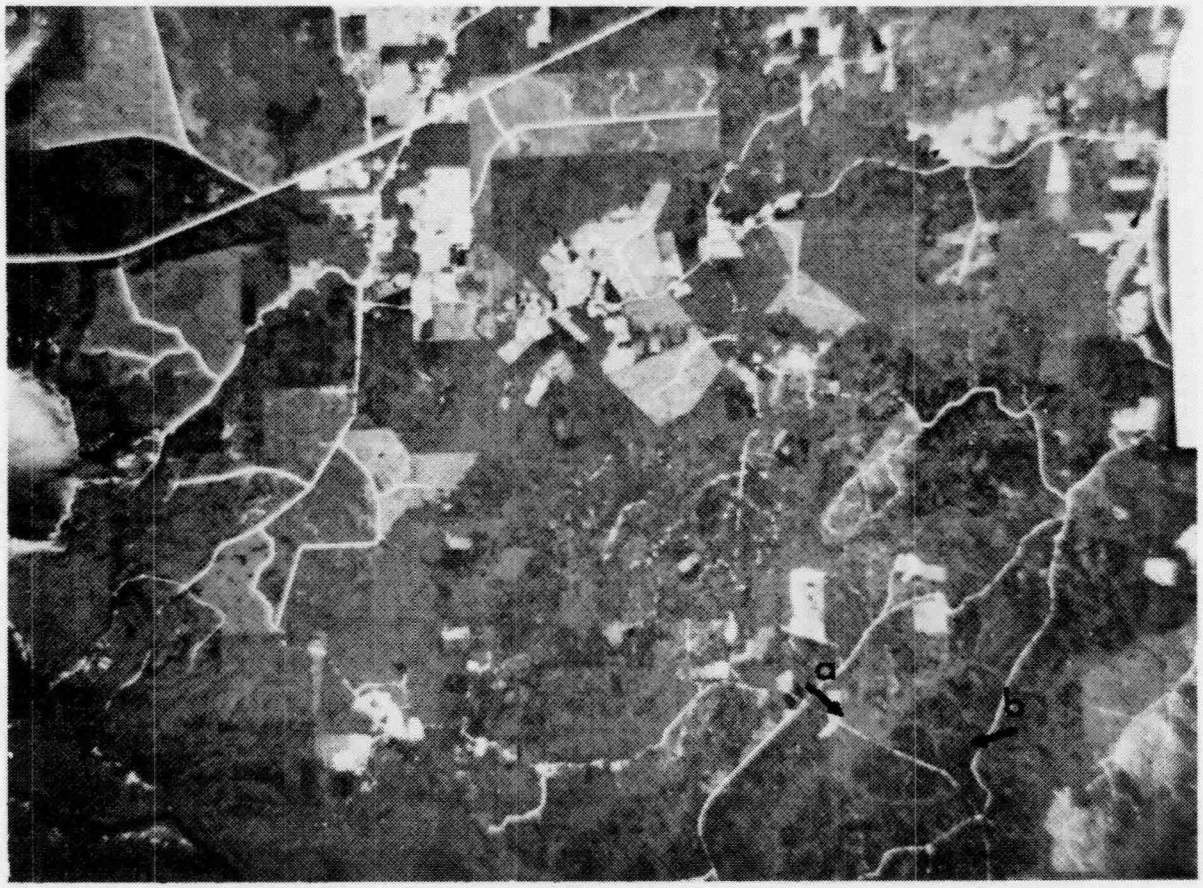

Figure 22. C-IR reproduction of Willis Formation in east Texas. Symbol (a) represents lighter-toned vegetation growing in poorly drained soils (b) dark-toned pine forests on well drained soil. (C-1R means Color Infrared.)

Figure 23. Black and white photograph of Willis Formation in south Texas. Arrow is pointing to forested area on gravel bearing soils. Cultivated land is on finer grained soil.

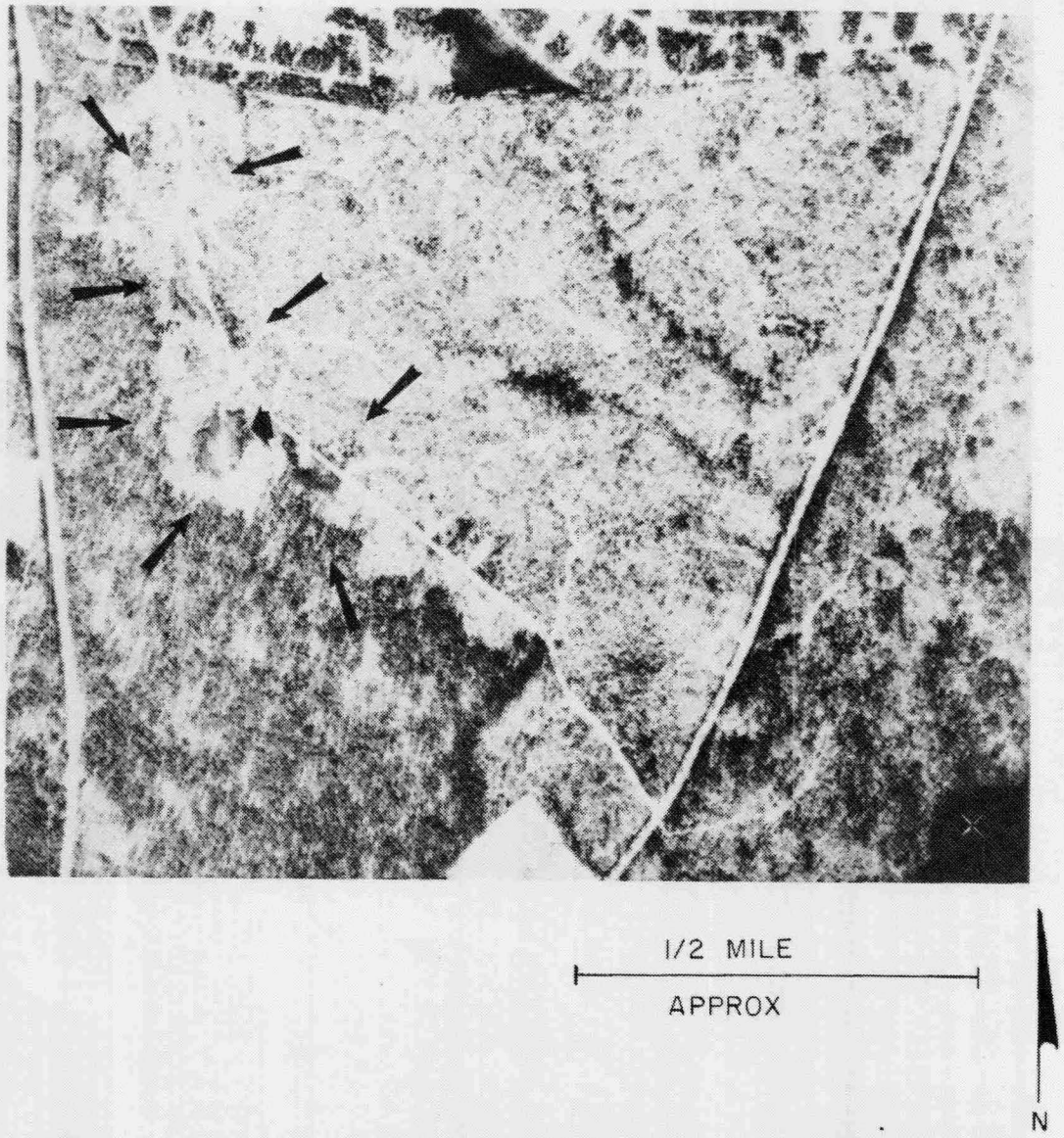

Figure 24. Black and white photograph of the gravel prospect in the Willis Formation. Site is located approximately 1 mile northeast of Willis, Texas. The thin arrows points to a small region that was previously stripped. (Photograph courtesy of Champion Realty Corporation.)

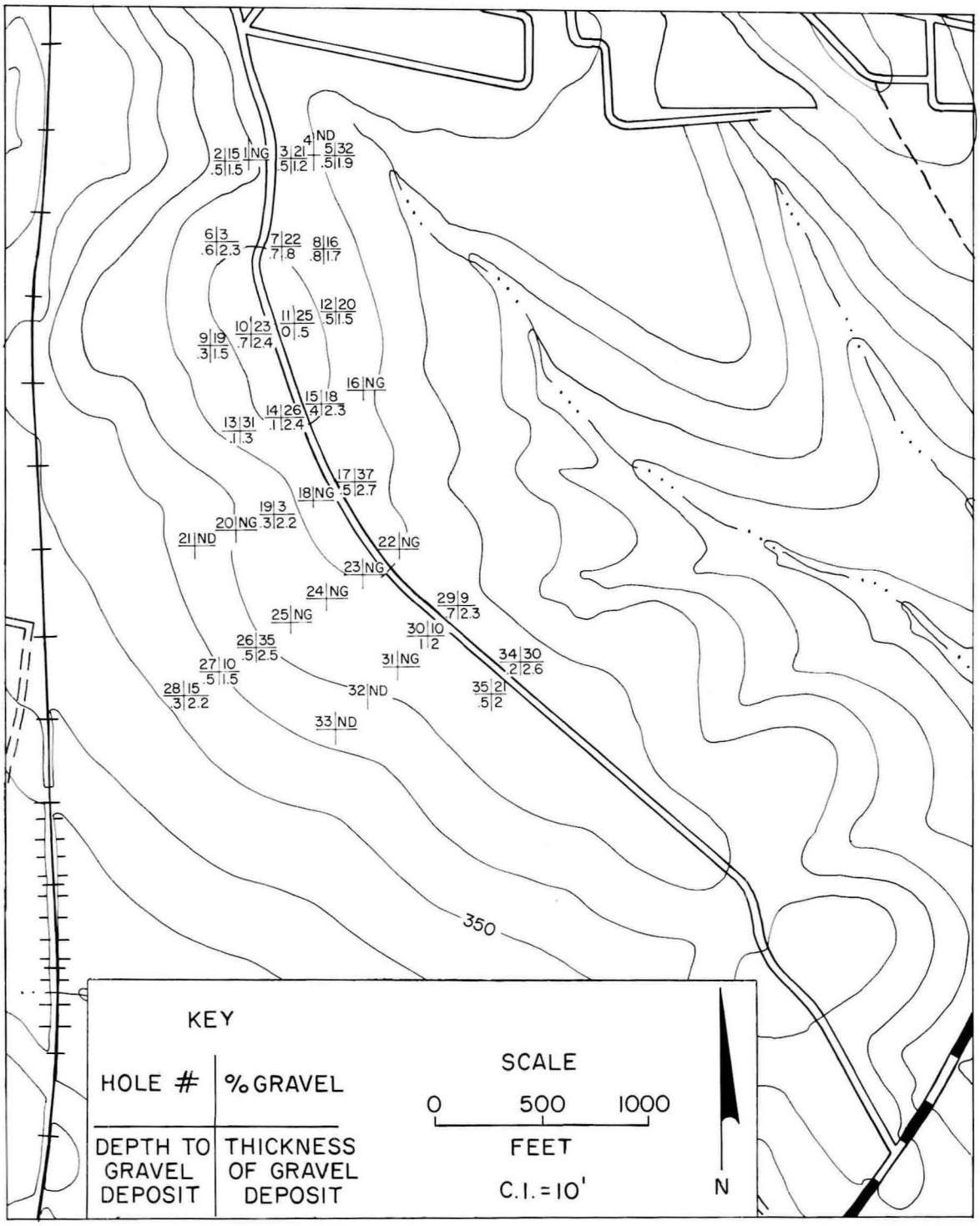

Figure 25. Map of gravel prospect in the Willis Formation showing drill hole locations and results.

Table 2. Results of Sieve Analysis of Samples from Willis Formation.

	Percent of Total Sample Retained on Each Sieve Size							
	Medium Gravel			Fine Gravel		Sand		Silt
Hole #	1.05 in.	.624 in.	.263 in.	.187 in.	.0787 in.	.0165 in.	.0029 in.	<.0029
2	0	1.22	5.75	2.63	5.87	22.17	54.77	7.59
3	0	1.57	11.12	3.61	4.97	23.64	46.84	8.25
5	0	4.09	15.53	5.18	7.37	20.6	40.99	6.24
6	0	0	1.03	.91	1.55	28.88	56.2	11.43
7	0	2.71	9.99	3.18	5.67	29.92	40.42	8.11
8	0	2.5	5.44	2.79	5.39	37.23	40.61	6.04
9	0	1.43	10.04	2.77	4.61	34.98	38.57	7.6
10	0	3.19	13.61	5.11	1.56	23.56	43.52	9.45
11	0	2.59	4.36	6.25	12.18	29.3	35.54	9.78
12	0	1.76	15.01	3.41	4.87	23.72	41.74	9.49
13	0	2.08	13.31	9.05	12.39	34.45	25.21	3.51
14a	0	.68	16.39	17.28	23.61	28.36	12.37	1.31

(Continued)

Table 2. (Continued).

	Percent of Total Sample Retained on Each Sieve Size							
	Medium Gravel			Fine Gravel		Sand		Silt
Hole #	1.05 in.	.624 in.	.263 in.	.187 in.	.0787 in.	.0165 in.	.0029 in.	<.0029
14b	0	.32	4.99	4.3	8.89	36.06	37.62	7.82
15	0	.31	6.29	3.07	8.41	33.76	37.93	10.23
17	0	0	10.35	8.24	18.57	44.3	15.22	3.32
19	0	0	1.48	0.3	.88	36.54	49.0	11.8
26	0	2.30	13.33	9.68	10.04	42.07	18.51	4.07
27	0	0	3.89	1.66	4.39	38.87	41.55	9.64
28	0	0	7.65	3.26	3.85	45.68	32.54	7.02
29	0	.58	3.4	1.52	3.48	38.07	38.25	14.7
30	0	1.26	3.16	1.35	3.73	38.36	40.19	11.95
34	5.77	1.27	14.24	3.8	5.24	20.96	38.27	10.45
35	0	1.72	11.32	3.17	4.69	28.92	30.03	10.15
Average	0.25	1.37	8.77	4.46	7.31	32.19	37.65	8.26

APPENDIX A

Description of Cuttings from Drill Holes in the Catahoula Formation near Carlisle, Texas

DRILL HOLE DATA FROM HOLE #1

Depth to top (ft)	Thickness (ft)	Description	Environment of Deposition
0	1 1/2	Sand brown, surface sand	Oxidized zone
1 1/2	2 1/2	Clay, mottled gray and red, plastic, sandy	Oxidized zone
4	2	Clay, mottled gray and red, plastic, sandy	Oxidized zone
6	1/2	Went into light gray sandy clay, plastic	Oxidized zone
6 1/2	7 1/2	Sand-silty, fine, mottled, red and gray, some clay, minor gravel-rare	Oxidized zone
14	1	Clay-plastic, gray, found worn fragment of oyster shell, slightly silty	Fluvial
15	3 1/2	Sand, very fine, with clay, light yellowish-gray, decreasing clay downward	Fluvial
18 1/2	1 1/2	Ash and sandy-ashy material is silty, white and very hard	Fluvial
20	2	Sand, gray, very fine silty	Fluvial

DRILL HOLE DATA FROM HOLE #2

Depth to top (ft)	Thickness (ft)	Description	Environment of Deposition
0	4 1/2	Brown sand, medium, silty	Oxidized zone
4 1/2	1	Sand, brown, much clay and silt, mottled, streaks of red, mostly gray, occasional gravel	Oxidized zone
5 1/2	4 1/2	Ash, stiff, light gray to white, seems to be silty- become yellow stained near 6' and becoming more clay-like -increasing amount of clay Downwards, appears as individual clods or balls	Fluvial
10	8	Clay, very stiff, gray with reddish yellow streaks, brown root tubes	Fluvial
18	1	Same with increasing amounts of silt, brown root tubes	Fluvial
19	5	Same with silt and minor amounts of very fine sand	Fluvial
24	3	Clay, sandy, gray, sand is greater than 10%, very fine, clay is plastic, sand content increasing downward at 24' hit a water bearing layer	Fluvial

DRILL HOLE DATA FROM HOLE #3

Depth to top (ft)	Thickness (ft)	Description	Environment of Deposition
0	4	Brown, sand, medium, much silt	Oxidized zone
4	1	Clay mottled, rust red and gray, sandy, fine sand	Oxidized zone
5	2	Sand, mottled, red and gray, medium grained	Oxidized zone
7	1	Sand, mottled, lighter red and gray, medium grained	Oxidized zone
8	6	Sand, fine grained, light gray, with red lenses	Fluvial
14	2	Clay, bluish gray, bluish gray sand above it, clay is plastic	Fluvial
		Sand falling in hole - unable to drill through	

DRILL HOLE DATA FROM HOLE #4

Depth to top (ft)	Thickness (ft)	Description	Environment of Deposition
0	4	Brown, sandy, silty clay, abundant organic material	Oxidized zone
4	3 1/2	Sand, fine grained, alternating layers of red and gray, red layers are mostly clay	Oxidized zone
7 1/2	4	Sand, fine grained, mottled, red and gray, some clay matrix	Oxidized zone
11 1/2	1/2	Clay, gray, plastic, blocky with some gravel	Fluvial
12	5	Clay, stiff, ashy, light to yellowish gray, same material seen in hole #2 (12-24' zone) some fine organic filled roots tubes	Fluvial
17	3	Clay, stiff, sandy, same as above except dryer, crumblyer with very fine sand	Fluvial

Table 1. Results of Seismic Surveys

Station	Layer	Velocity (ft/msec)	Depth to Layer (ft)	Material
A	A	4.55	Surface	Sandstone
B	B	4.69	Surface	Sandstone
C	C	3.75	Surface	Fractured, silty claystone
D	D	3.45	Surface	Silty sandstone
E	E	2.27	Surface	Fractured, silty sandstone
1	V_1	1.12	Surface	Weathered Zone
	V_2	4.1	12.5	" "
	V_3	7.55	45	" "
2	V_1	1.02	Surface	Weathered Zone
	V_2	1.99	4	" "
	V_3	3.22	16	" "
3	V_1	1.06	Surface	Weathered Zone
	V_2	2.76	7	" "
	V_3	5.7	19	" "
4	V_1	0.8	Surface	Weathered Zone
	V_2	3.53	9	" "
	V_3	5.26	15	" "
5	V_1	0.78	Surface	Weathered Zone
	V_2	6.64	13	" "
	V_3	22.2	55	" "
6	V_1	0.64	Surface	Weathered Zone
	V_2	1.28	5	" "
	V_3	2.34	11	" "
7	V_1	0.81	Surface	Weathered Zone
	V_2	6.64	14.4	" "

APPENDIX B

Water Well Data from the Texas Department of Water Resources

DRILL HOLE DATA USED FOR AGGREGATE RESOURCE MAPS

Hole #	Original No.	Report	Depth of top (ft)	Thickness (ft)	Description	Formation
1	C-6	WdB 5003	0	11	Surface clay and gravel	Terrace
2	Wu-61-25-801	WdR 80	23	5	Blue gravel	Terrace
3	Wu-61-25-101	WdR 80	12	23	Sand and gravel, large	Terrace
4	123	WdR San Jacinto Co	35	20	Gravel	Terrace
5	TS-60-53-805	WdR 136	25	46	Sand and gravel	Terrace
6	TS-60-54-604	WdR 136	18	11	Sand and gravel	Terrace
7	TS-60-48-802	WdR 136	20	17	Sand and gravel	Terrace
8	SB-60-48-802	WdR 72	67	21	Sand and gravel	Terrace
9	SB-61-33-605	WdR 72	18	6	Sand and gravel	Terrace
	"	"	52	19	Coarse sand and fine gravel	Terrace
10	SB-61-34-801	WdR 72	24	26	Sand and gravel	Terrace
11	SB-61-50-604	WdR 72	12	26	Sand and gravel	Terrace
12	SB-61-50-801	WdR 72	0	36	Sand and gravel	Terrace
13	SB-61-51-107	WdR 72	74	16	Sand and gravel	Terrace

DRILL HOLE DATA (cont.)

Hole #	Original No.	Report	Depth of top (ft)	Thickness (ft)	Description	Formation
14	SB-61-51-709	WdR 72	74	16	Sand and gravel	Terrace
15	SB-61-59-305	WdR 72	65	23	Sand and gravel	Terrace
16	9	WdR Liberty Co	67	21	Sand and gravel	Terrace
17	10	WdR Liberty Co	0	112	Sand and gravel	Terrace
18	28	WdR Liberty Co	85	34	Sand and gravel	Terrace
19	48	WdR Liberty Co	80	20	Clay and gravel	Terrace
20	50	WdR Liberty Co	46	39	Sandy clay and gravel	Terrace
21	52	WdR Liberty Co	24	26	Sand and gravel	Terrace
22	69	WdR Liberty Co	24	13	Sand and gravel	Terrace
23	70	WdR Liberty Co	67	11	Sand and gravel	Terrace
24	154	WdR Liberty Co	50	32	Sand and gravel	Terrace

DRILL HOLE DATA (cont.)

Hole #	Original No.	Report	Depth of top (ft)	Thickness (ft)	Description	Formation
17	10	WdR Liberty Co	0	112	Sand and gravel	Terrace
18	28	WdR Liberty Co	85	34	Sand and gravel	Terrace
19	48	WdR Liberty Co	80	20	Clay and gravel	Terrace
20	50	WdR Liberty Co	46	39	Sandy clay and gravel	Terrace
21	52	WdR Liberty Co	24	26	Sand and gravel	Terrace
22	69	WdR Liberty Co	24	13	Sand and gravel	Terrace
23	70	WdR Liberty Co	67	11	Sand and gravel	Terrace
24	154	WdR Liberty Co	50	32	Sand and gravel	Terrace
25	155	WdR Liberty Co	12	26	Sand and gravel	Terrace
26	158	WdR Liberty Co	0	36	Sand and gravel	Terrace

DRILL HOLE DATA (cont.)

Hole #	Original No.	Report	Depth of top (ft)	Thickness (ft)	Description	Formation
27	159	WdR Liberty Co	12	26	Sand and gravel	Terrace
28	160	WdR Liberty Co	50	18	Sand and gravel	Terrace
29	167	WdR Liberty Co	84	22	Sand and gravel	Terrace
30	173	WdR Liberty Co	121	6	Sand and gravel	Terrace
31	194	WdR Liberty Co	68	4	Gravel	Terrace
32	YJ-61-15-501	WdR 74	2	13	Clay and gravel	Terrace
33	YJ-61-24-707	WdR 74	15	43	Sand and gravel	Terrace
34	LH-61-44-101	WdB 6406	84	10	Sand and gravel	Terrace
35	LH-61-44-102	WdB 6406	43	52	Sand and gravel	Terrace
36	LH-61-52-110	WdB 6406	55	7	Sand and gravel	Terrace
37	LH-61-52-112	WdB 6406	82	3	Sand and gravel	Terrace
38	LH-61-52-115	WdB 6406	70	14	Sand and gravel	Terrace

DRILL HOLE DATA (cont.)

Hole #	Original No.	Report	Depth to top (ft)	Thickness (ft)	Description	Formation
39	LH-61-52-121	WdB 6406	91	17	Sand and gravel	Terrace
40	LH-61-52-123	WdB 6406	64	21	Sand and gravel	Terrace
41	LH-61-52=132	WdB 6406	79	18	Sand and gravel	Terrace
42	LH-61-52-133	WdB 6406	88	14	Sand and gravel	Terrace
43	UJ-62-57-903	WdB 6416	62	29	Sand and gravel	Terrace
44	UJ-62-57-904	WdB 6516	60	24	Sand and gravel	Terrace
45	UJ-62-57-905	WdB 6516	53	24	Sand and gravel	Terrace
46	PR-61-07-604	WdR 59	5	50	Sand and gravel	Terrace
47	PR-61-07-801	WdR 59	50	10	Yellow sand and gravel	Terrace
48	WS-36-52-403	WdB 37	16	27	Sand rock	Catahoula
49	PR-37-63-801	WdR 59	20	42	Limestone, soft, white	Catahoula
	"	"	65	21	Sandstone, limestone, mixed streaks	Catahoula
	"	"	88	4	Sandstone, hard	Catahoula
50	PR-37-64-402	WdR 59	38	106	Shale, blue, sandstone	Catahoula

DRILL HOLE DATA (cont.)

Hole #	Original No.	Report	Depth to top (ft)	Thickness (ft)	Description	Formation
52	C-8	WdB 5003	31	6	Sand rock	Catahoula
	"	"	50	1	Blue sandstone	Catahoula
	"	"	56	2	Blue sandstone	Catahoula
	"	"	70	3	Blue sandstone	Catahoula
53	C-9	WdB 5003	46	4	Blue sandstone	Catahoula
	"	"	53	8	Very hard sand rock	Catahoula
54	C-10	WdB 5003	46	4	Sandstone	Catahoula
	"	"	53	8	Hard sand rock	Catahoula
	"	"	110	4	Hard sand rock	Catahoula
55	D-2	WdB 5003	12	1	Sand rock	Catahoula
	"	"	45	9	Sand rock	Catahoula
	"	"	70	10	Hard sand rock	Catahoula
	"	"	80	4	Rock	Catahoula
56	F-24	WdB 5003	58	4	Hard sand rock	Catahoula
57	G-6	WdB 5003	36	4	Rock	Catahoula

DRILL HOLE DATA (cont.)

Hole #	Original	Report	Depth to top (ft)	Thickness (ft)	Description	Formation
58	TZ-36-59-803	WdR 59	15	15	Gravel	Willis
	"	"	182	39	Sand and gravel	Willis
59	TZ-62-10-310	WdR 59	152	37	Sand and gravel	Willis
60	PR-36-57-901	WdR 59	21	94	Sand, gravel, with clay	Willis
61	PR-62-01-701	WdR 59	42	79	Sand and gravel	Willis
62	YJ-61-12-201	WdR 74	95	20	Sand and gravel	Willis
63	YJ-61-21-212	WdR 74	89	3	Gravel, fine	Willis
64	UT-61-09-907	WdB 82	25	5	Sand and gravel	Willis
	"	"	60	10	Lime, white and lime rock	Willis
65	UT-61-11-701	WdB 82	0	22	Iron rock and red clay	Willis
66	UT-61-17-305	WdB 82	25	2	Gravel	Willis
67	UT-61-17-903	WdB 82	50	1	Gravel	Willis

DRILL HOLE DATA (cont.)

Hole #	Original No.	Report	Depth to top (ft)	Thickness (ft)	Description	Formation
68	WU-70-30-504	WdR 80	0	20	Clay and gravel	Willis
	"	"	46	10	Clay with hard gravel streaks	Willis
	"	"	56	8	Sand and gravel	Willis
69	TS-60-37-202	WdR 136	0	8	Clay and gravel	Willis
70	TS-60-37-401	WdR 136	0	25	Gravel	Willis
71	TS-60-37-405	WdR 136	0	30	Sand and gravel	Willis
72	TS-60-37-703	WdR 136	6	26	Sand and gravel	Willis
73	TS-60-37-902	WdR 136	21	24	Sand and gravel	Willis
74	TS-60-37-904	WdR 136	24	12	Sand and gravel	Willis
75	TS-60-42-307	WdR 136	12	10	Sand, shale and gravel	Willis
76	TS-60-43-201	WdR 136	0	35	Sand, gravel and clay	Willis
77	TS-60-43-302	WdR 136	0	65	Clay, gravel and ore	Willis
78	TS-60-43-702	WdR 136	7	40	Sand and gravel, red	Willis
79	TS-60-43-703	WdR 136	43	9	Sand and gravel, white	Willis

DRILL HOLE DATA (cont.)

Hole #	Original No.	Report	Depth to top (ft)	Thickness (ft)	Description	Formation
80	TS-70-44-401	WdR 136	0	18	Clay, sand and gravel	Willis
81	TS-60-44-503	WdR 136	23	37	Sand and gravel	Willis
82	TS-60-44-702	WdR 136	0	22	Sand and gravel	Willis
83	TS-60-45-201	WdR 136	87	17	Sand and gravel	Willis
84	TS-60-45-606	WdR 136	85	25	Sand and yellow gravel	Willis
85	TS-60-45-608	WdR 136	62	43	Sand and gravel	Willis
86	TS-60-45-805	WdR 136	3	20	Sand and gravel	Willis
87	TS-60-46-707	WdR 136	59	76	Sand and gravel	Willis
88	TS-60-51-301	WdR 136	3	9	Clay and gravel	Willis
89	TS-60-51-302	WdR 136	3	18	Sand, clay and gravel	Willis
90	TS-60-53-102	WdR 136	63	15	Sand and gravel	Willis
91	TS-60-53-103	WdR 136	22	20	Sand and gravel	Willis
92	TS-60-53-104	WdR 136	30	50	Sand and gravel	Willis
93	TS-60-58-205	WdR 136	58	28	Sand, gravel, iron ore	Willis

DRILL HOLE DATE (cont.)

The sources for these reports are: Alexander, 1945; Alexander and Breeding, 1945; Anders, 1967; Anders, et al., 1968; Baker, 1964; Popkin 1971; Sandeen, 1968; Terver, 1968a; Tarver, 1968b; Wesselman 1967; Wesselman, 1965; and Winslow, 1950.

APPENDIX C

Description of Cuttings from Drill Holes at Deserter Island

DRILL HOLE DATA FROM DESERTER ISLAND, SILSBEE, TEXAS

Hole #	Depth to top (ft)	Thickness (ft)	Description	Environment of Deposition
Silsbee 1	0	30	Sand, brown quartz rich, minor amounts of "Pea" gravel	Fluvial, point bar
	30	4	Clay, gray, plastic, silty	
Silsbee 2	0	27	Sand, brown, medium grained, quartz	Fluvial, point bar
	27	10	Sand, clean, quartz, minor amounts of dark minerals, coarse becoming very coarse toward base, some "Pea" gravel near base	
	37	4	Clay, gray, plastic, sandy at top becoming silty downward	
Silsbee 3	0	36	Sand, brown, quartz, fine grained	Fluvial, point bar
	36	4	Clay, light gray, plastic, sandy with lenses of reddish brown oxidezed clay throughout	

DRILL HOLE DATA FROM DESERTER ISLAND, SILSBEE, TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Environment of Deposition
Silsbee 4	0	50	Sand, brown, medium to coarse grained quartz	Fluvial, point bar
	50	10	Sand, brown, very coarse with some siliceous "Pea" gravel	
	60	1/2	Clay, brown, plastic	
	60	59 1/2	Sand, brown, coarse with "Pea" gravel interbedded with thin brown clay layers	
Silsbee 5	0	28	Sand, brown, quartz, fine to medium becoming coarser downward	Fluvial, point bar
			Clay, gray, plastic, slightly silty	

APPENDIX D

Sample Data

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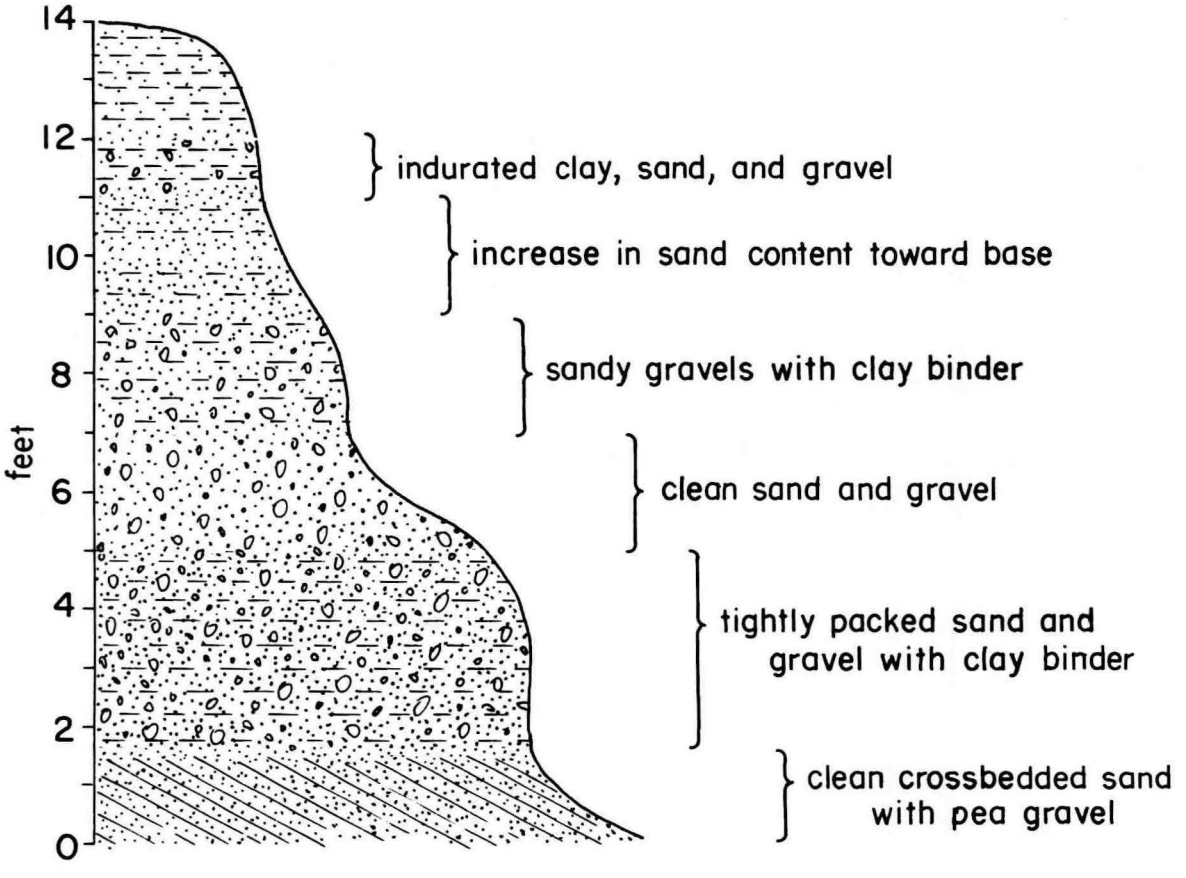

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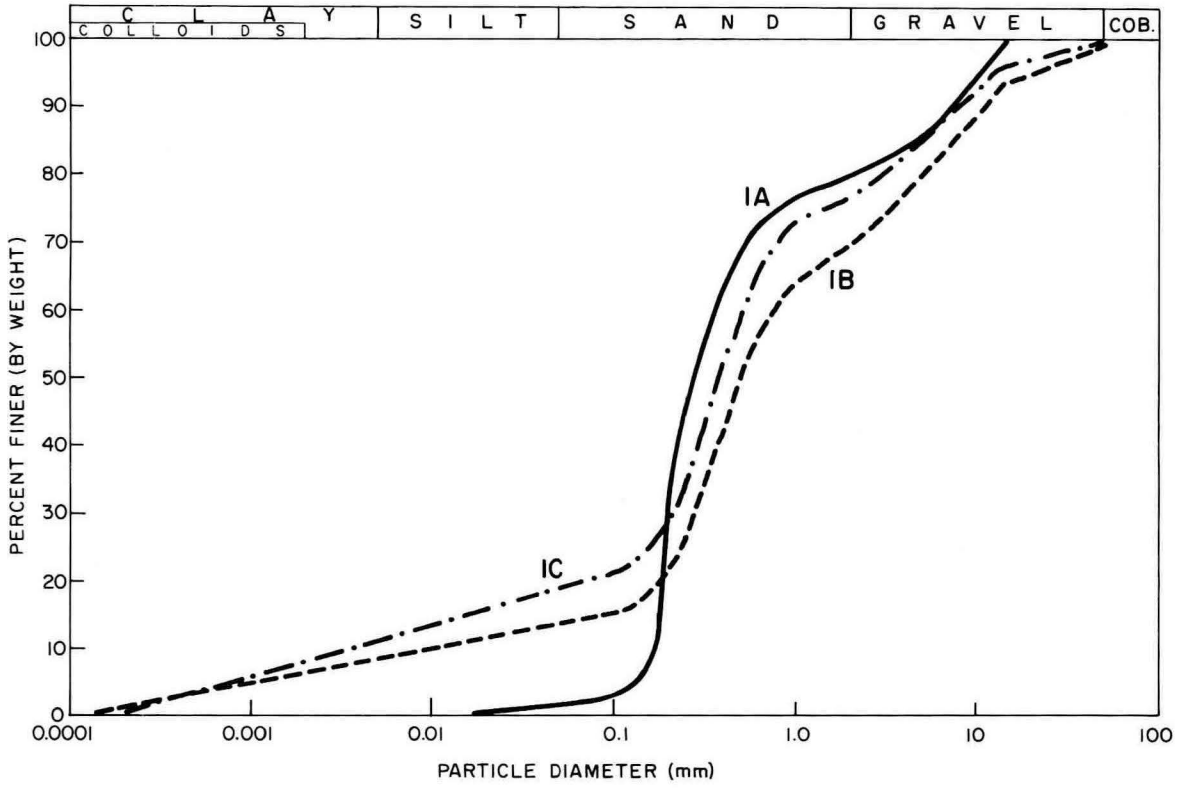

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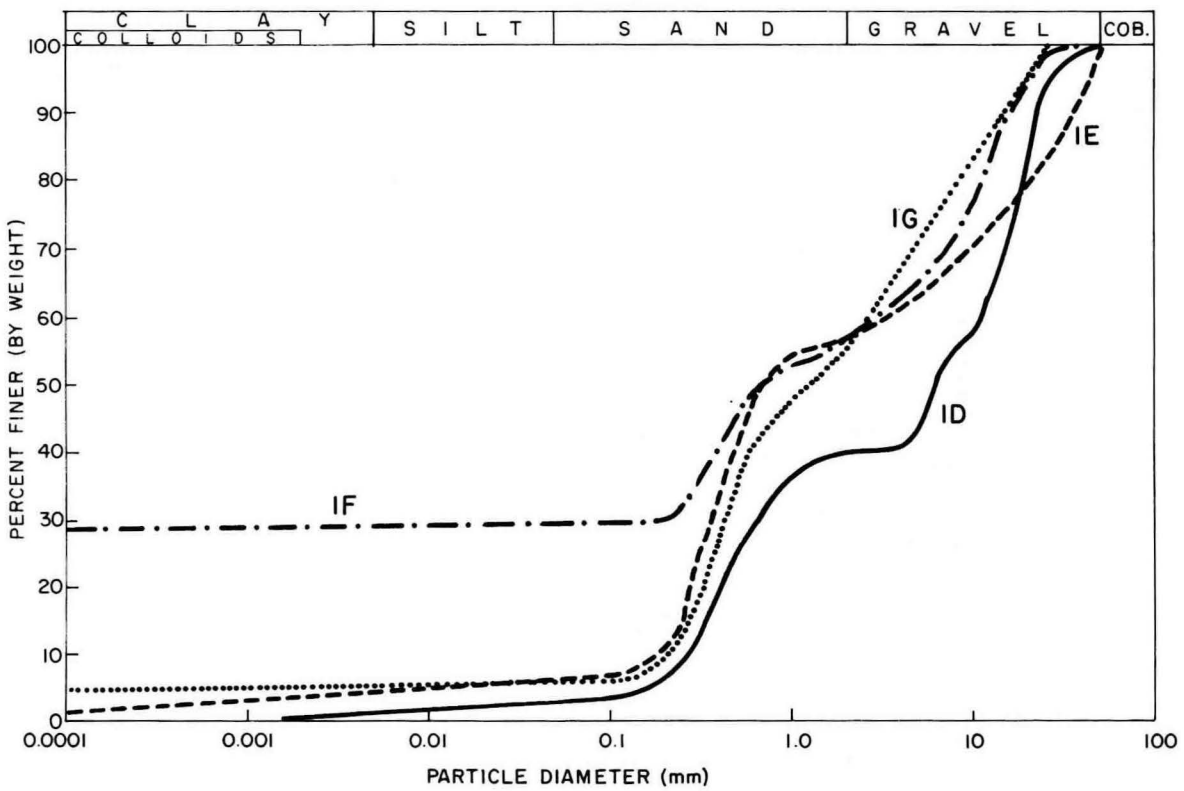

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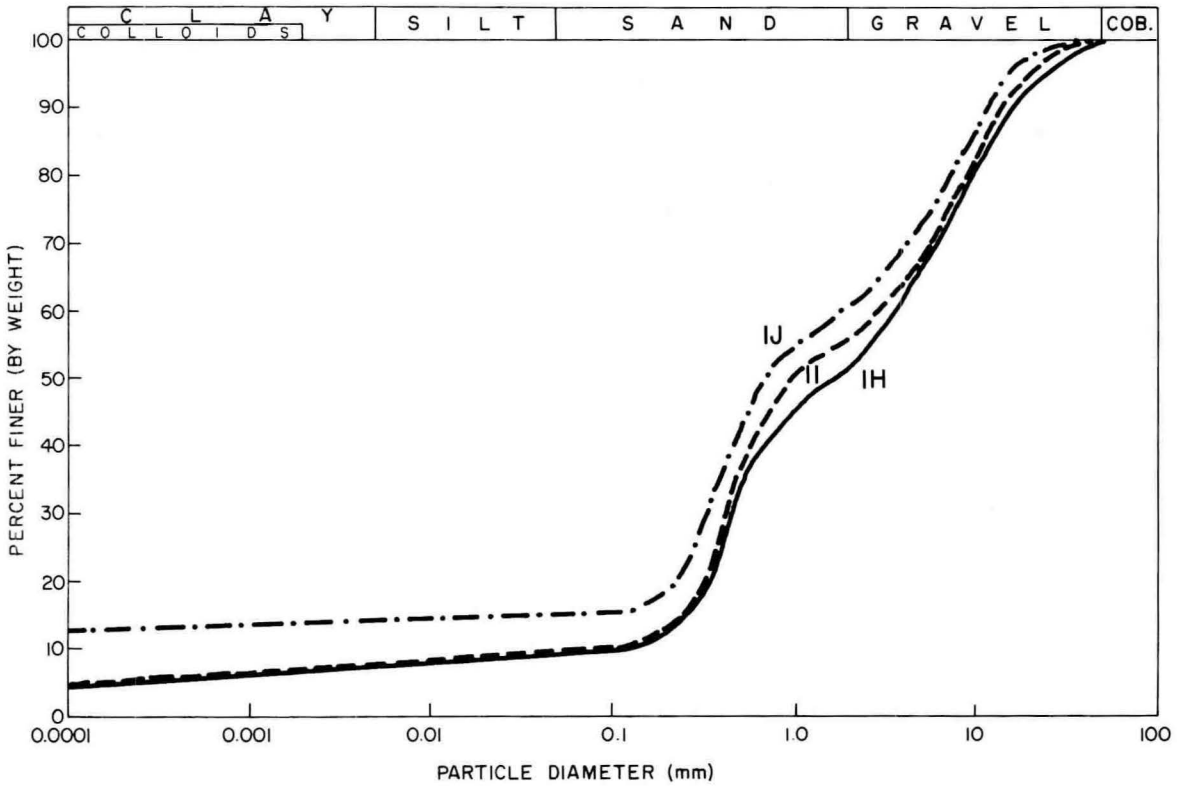

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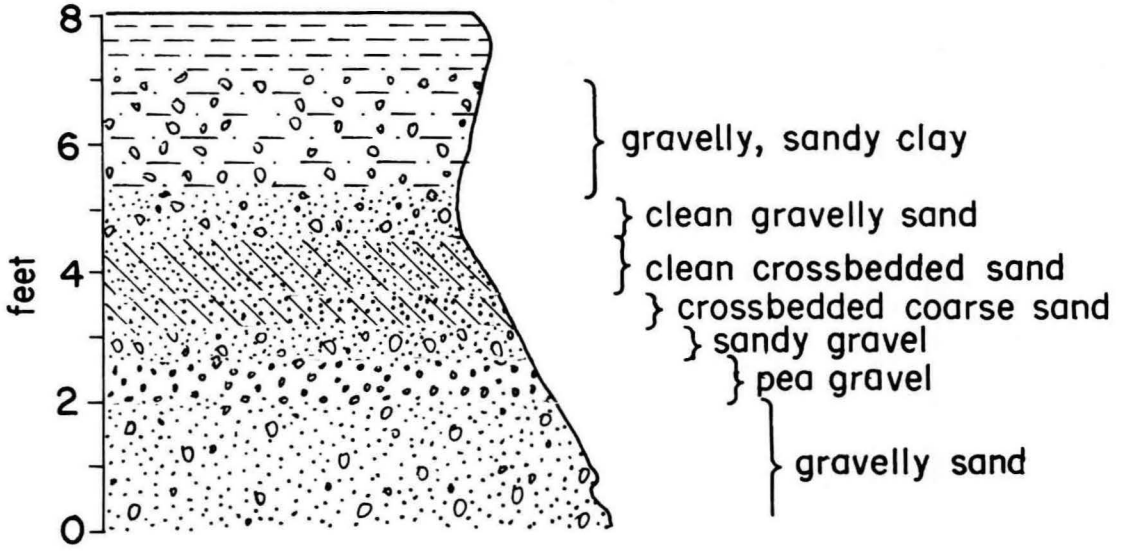

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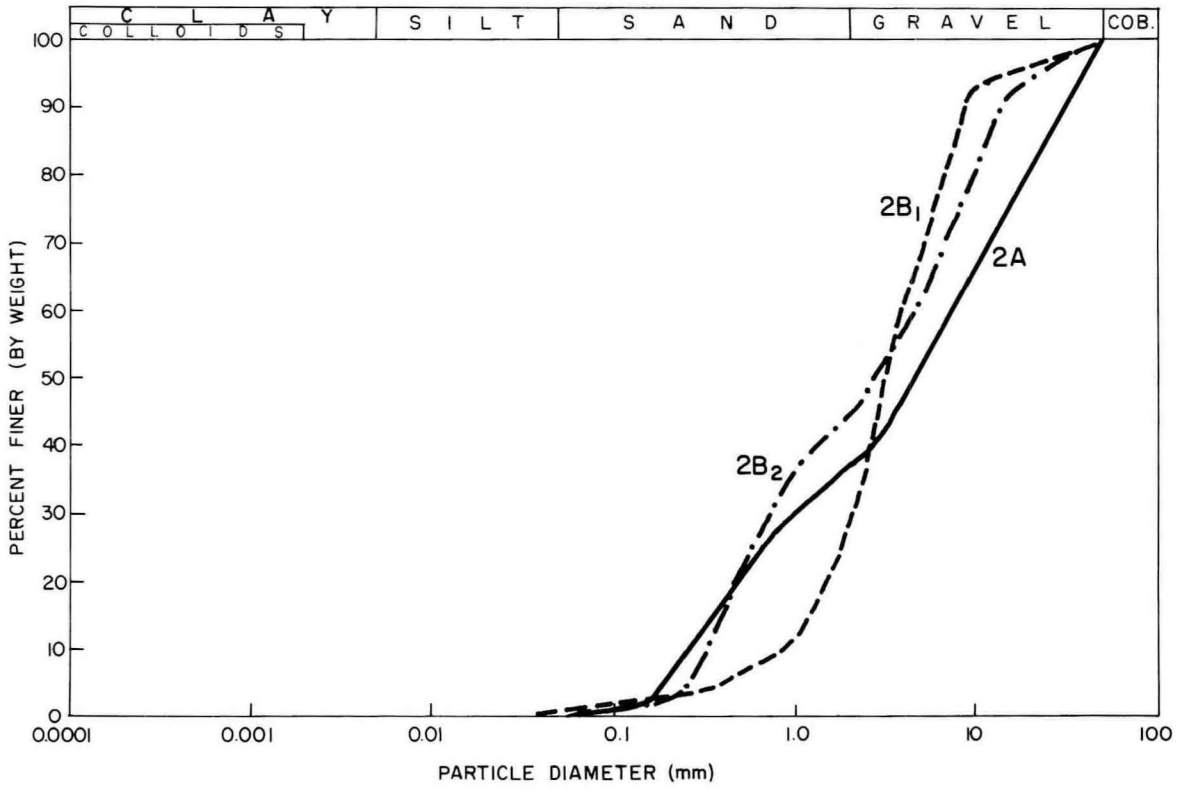

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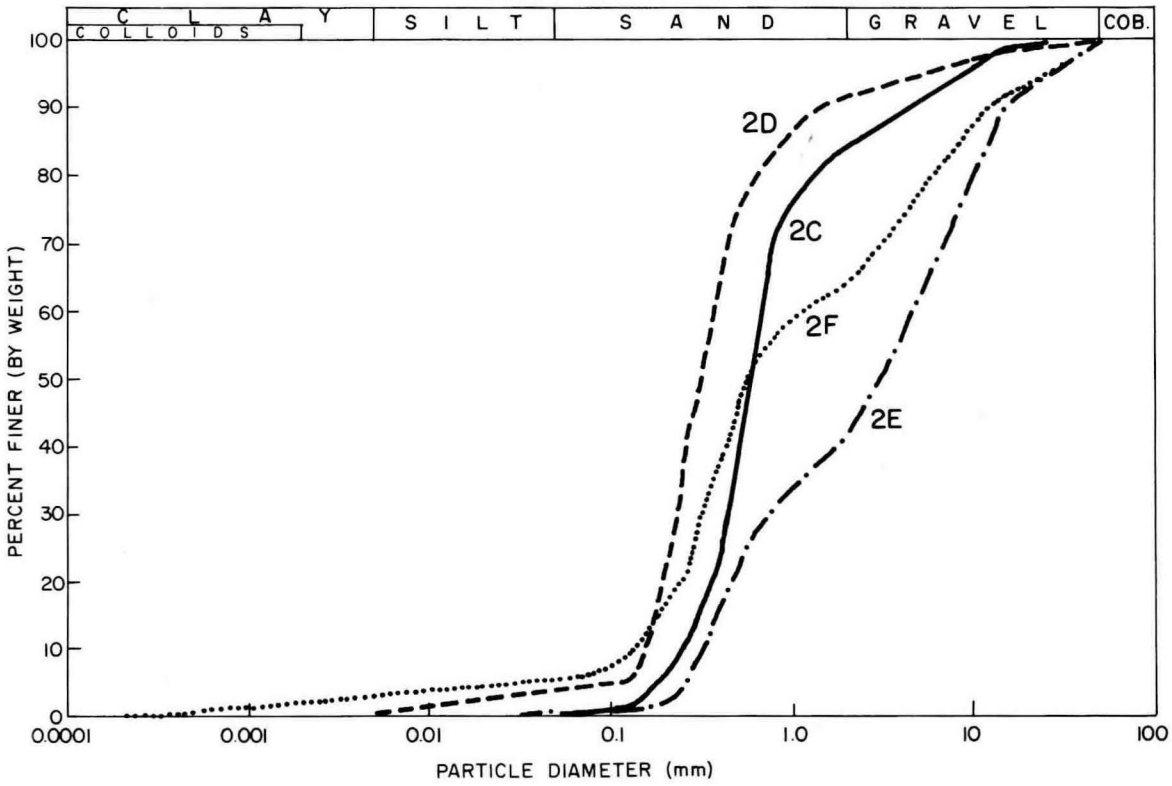

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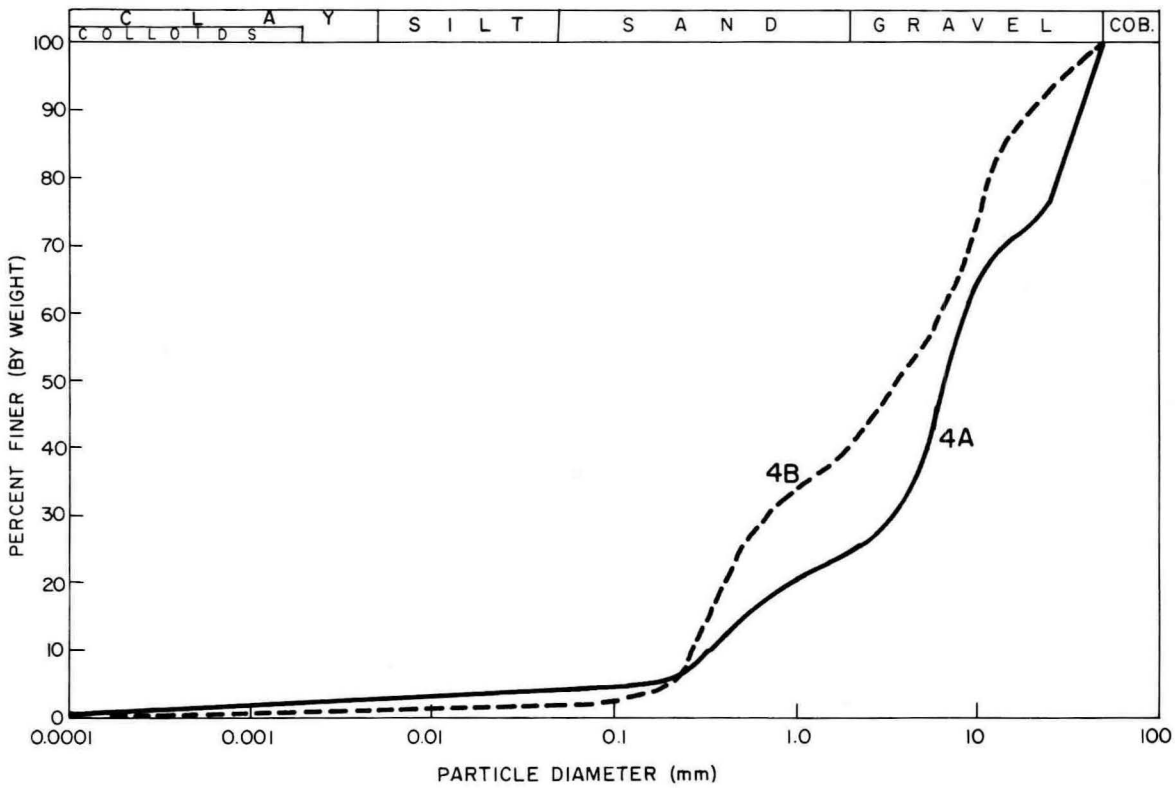

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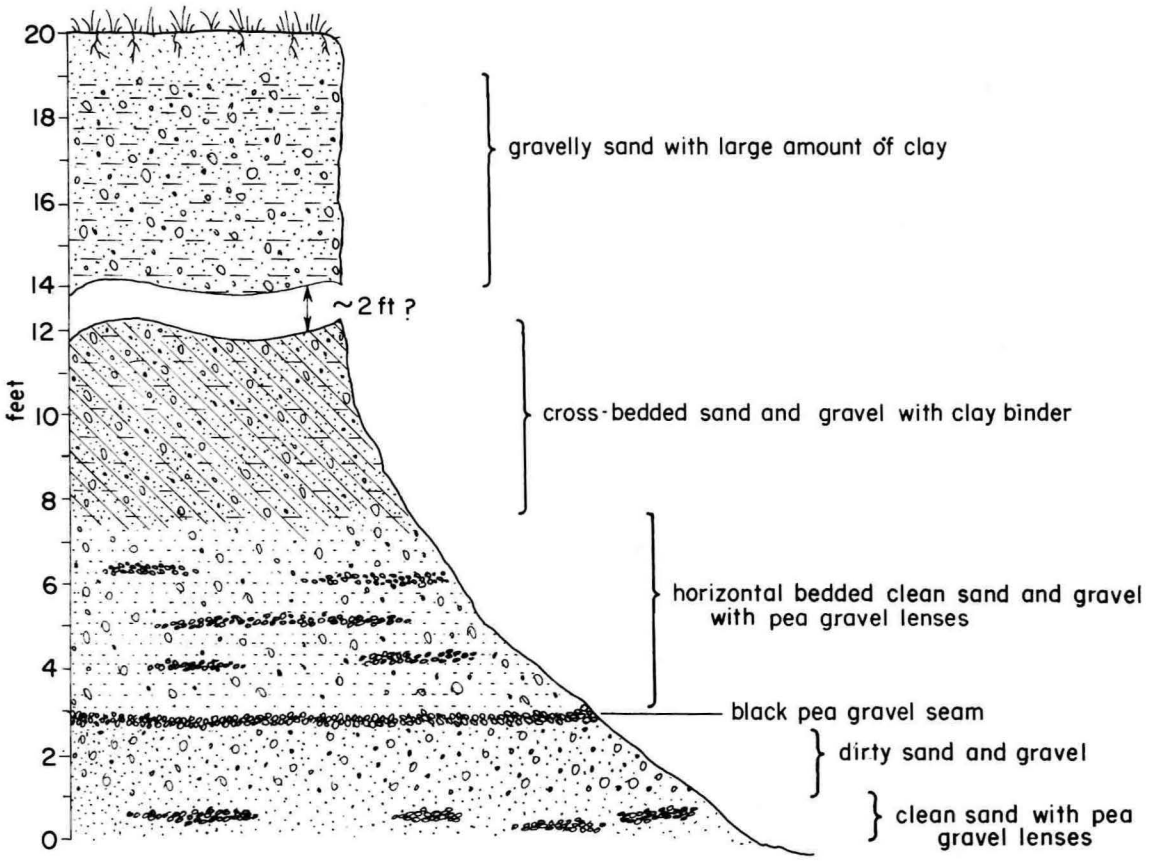

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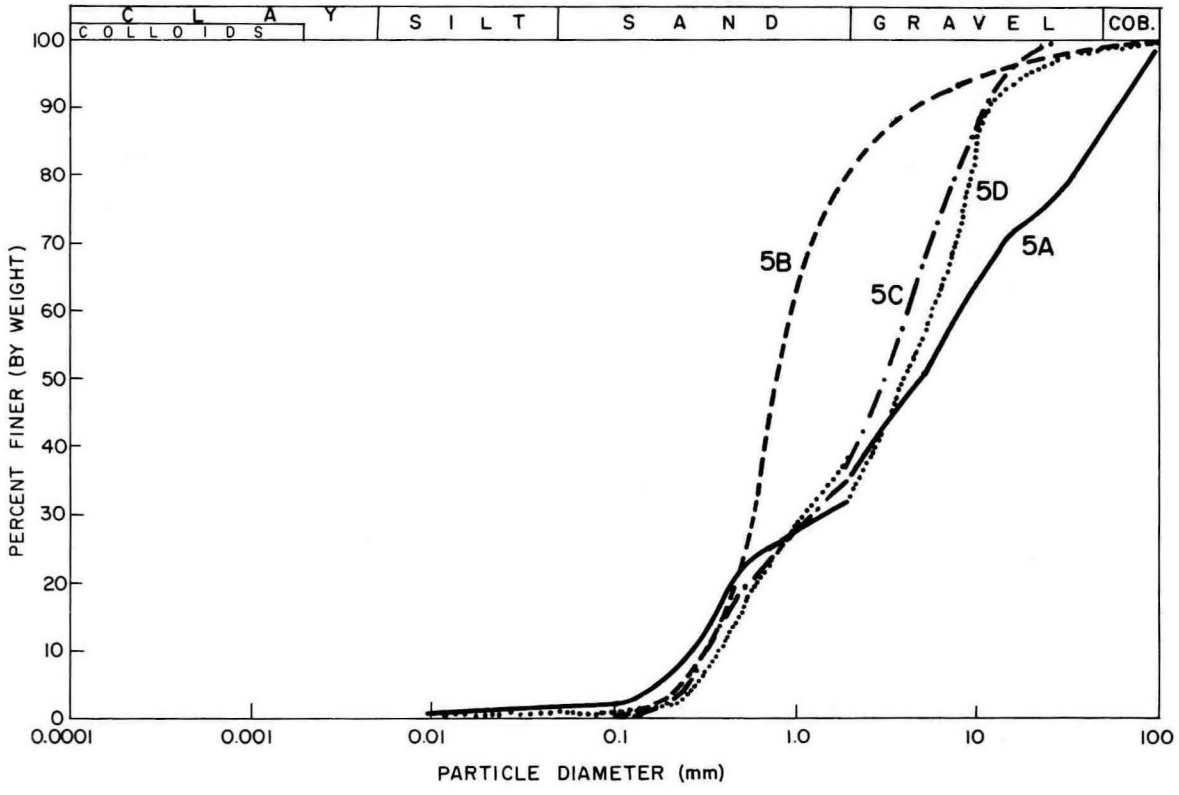

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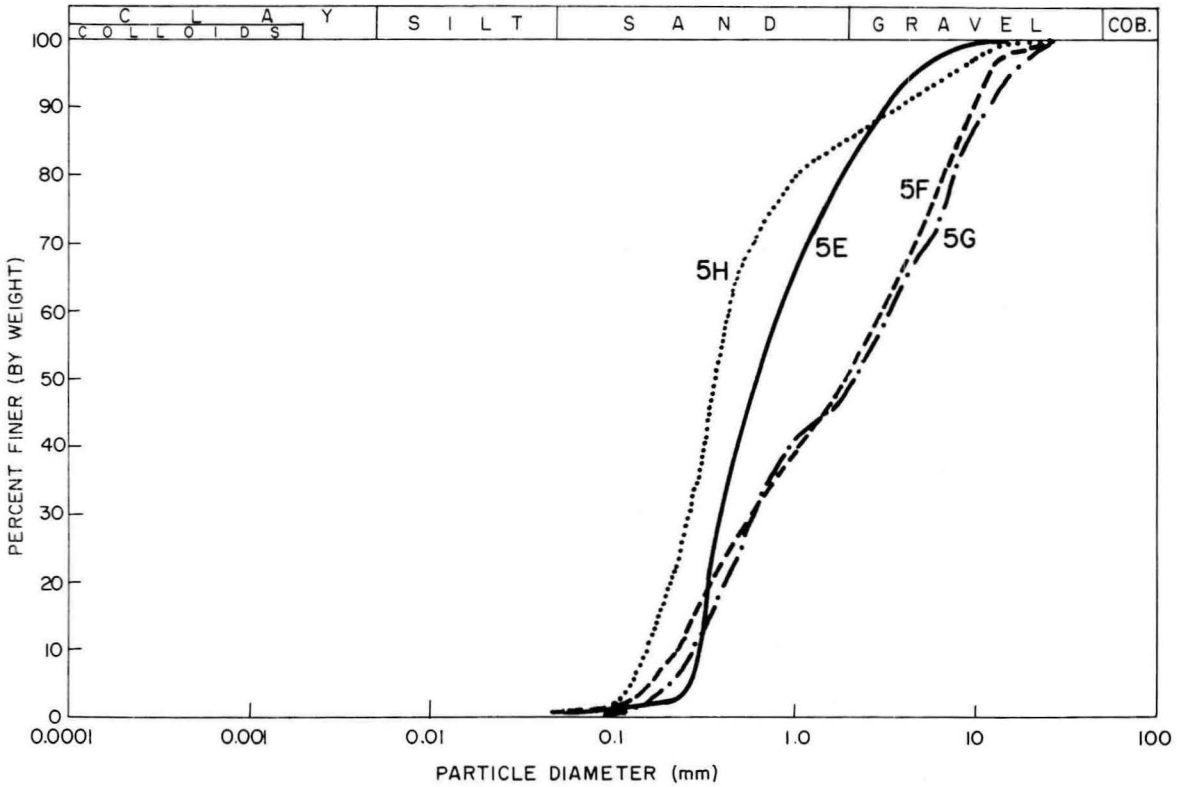

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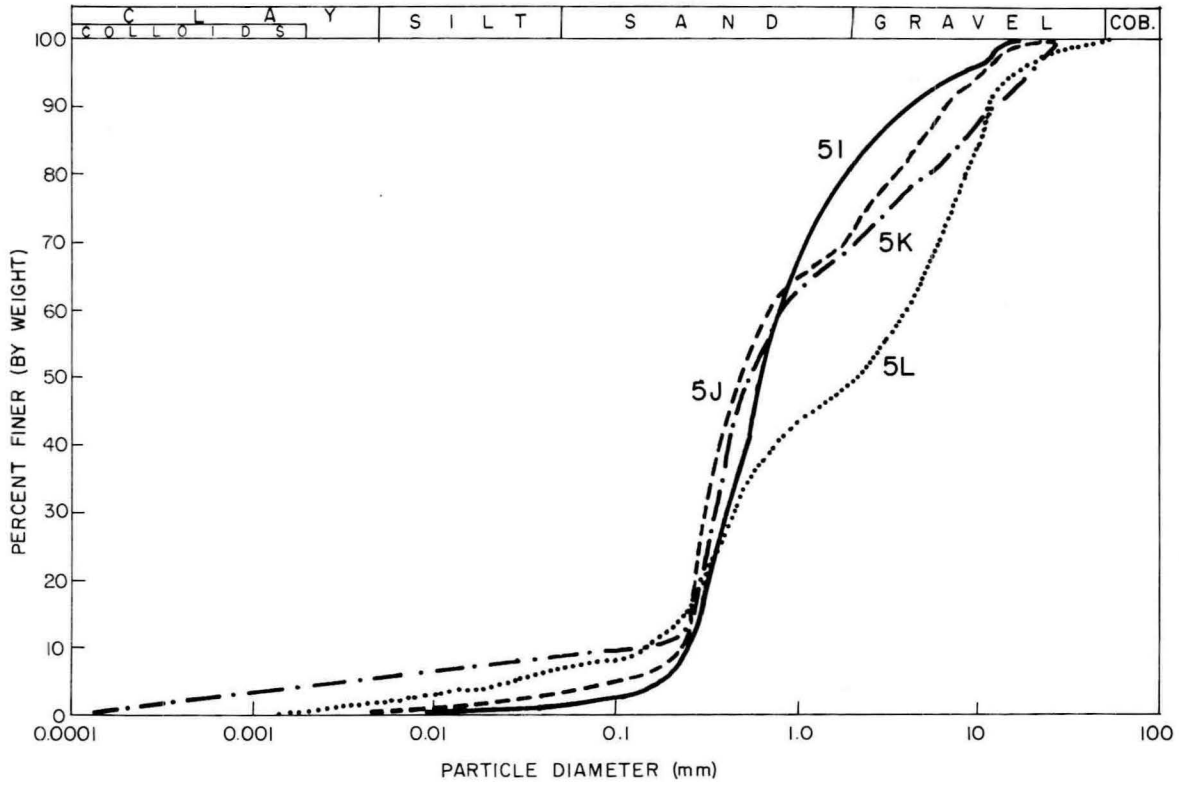

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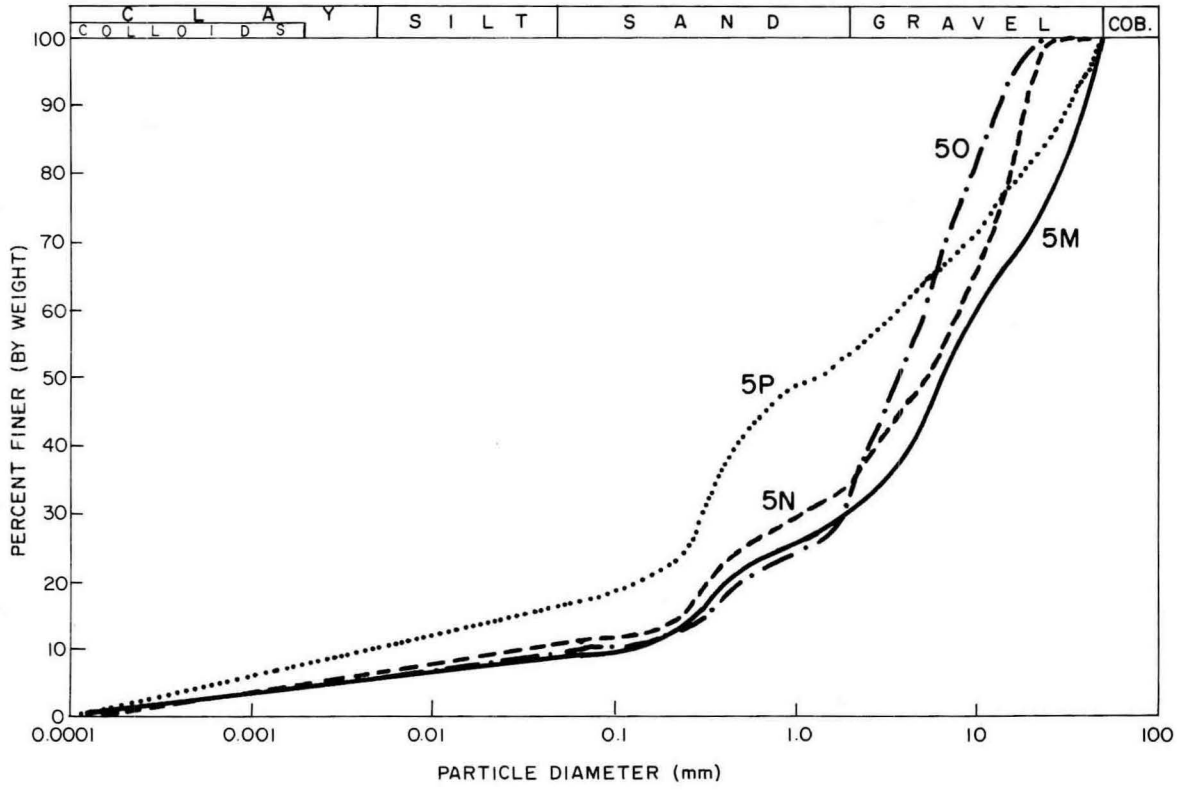

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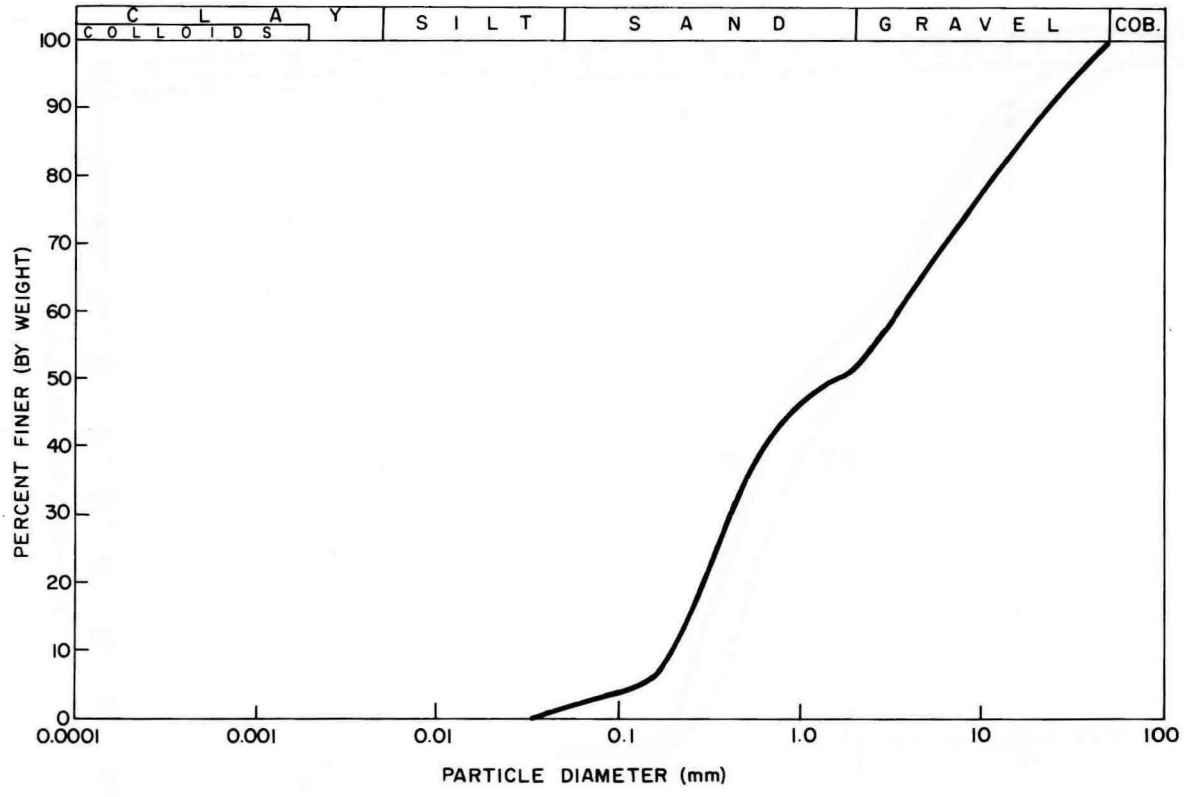

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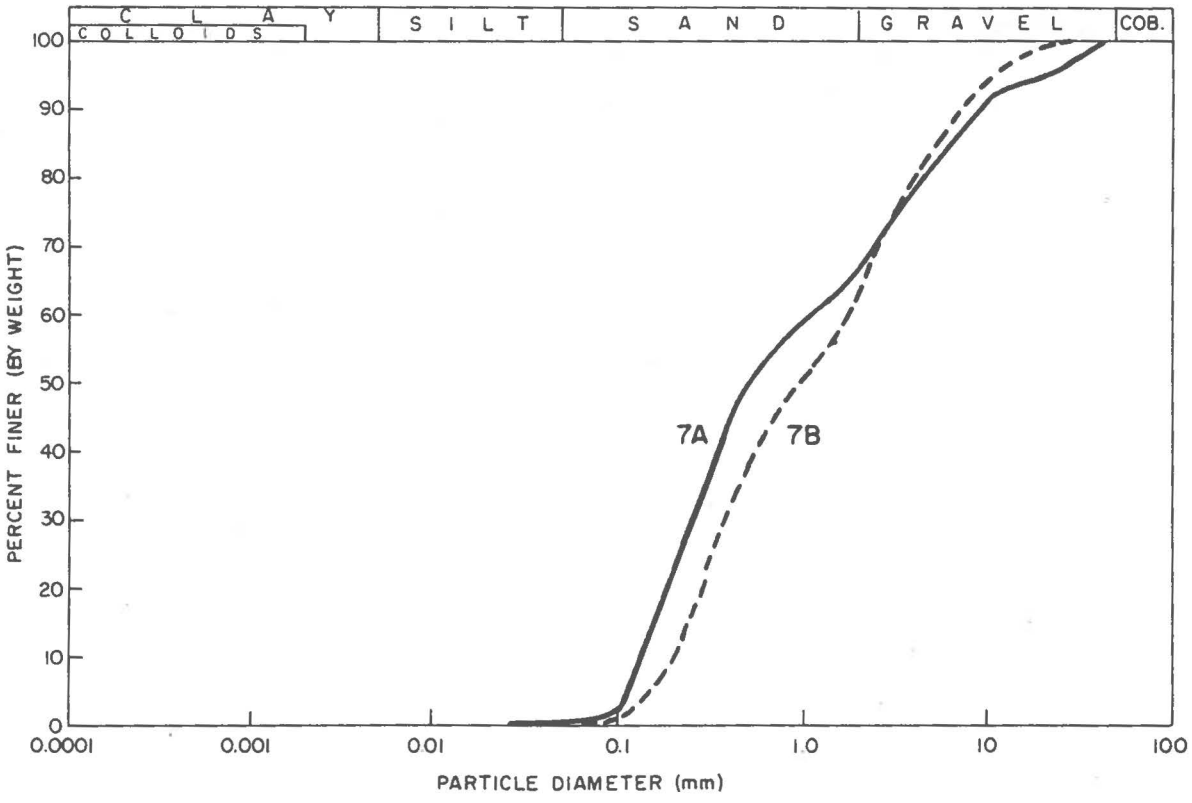
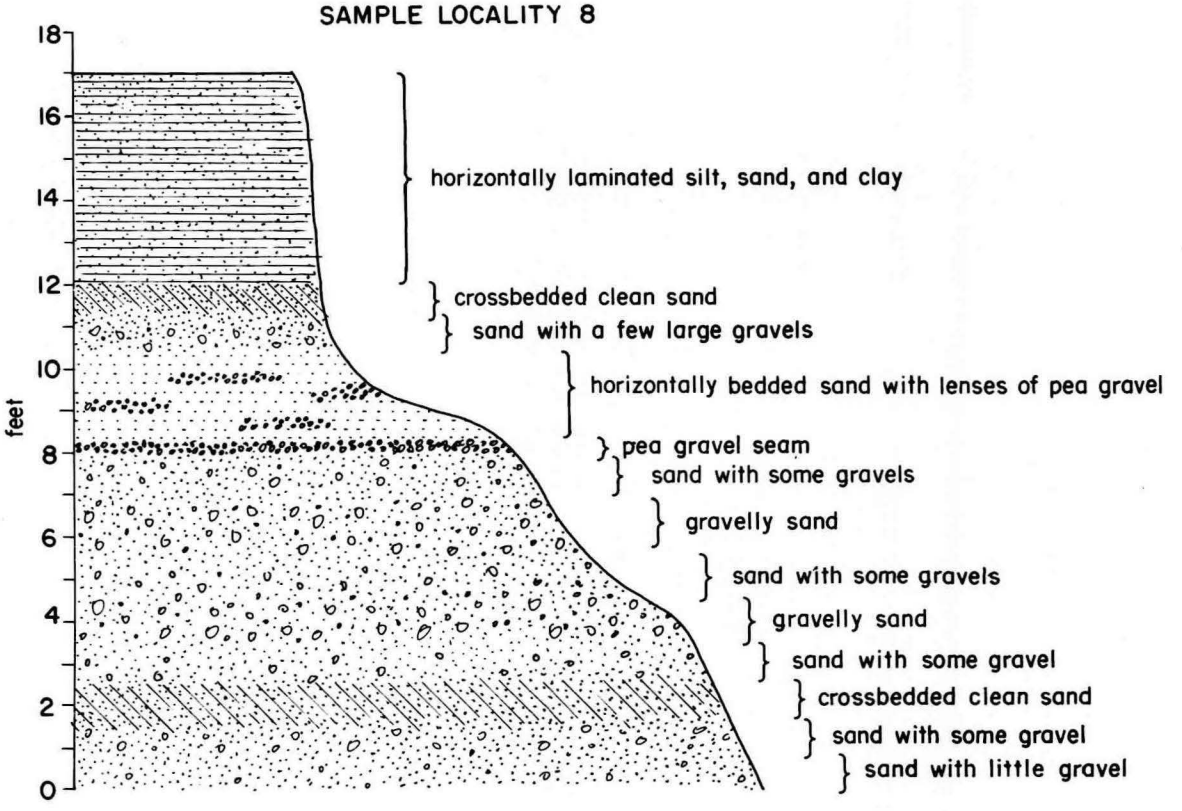
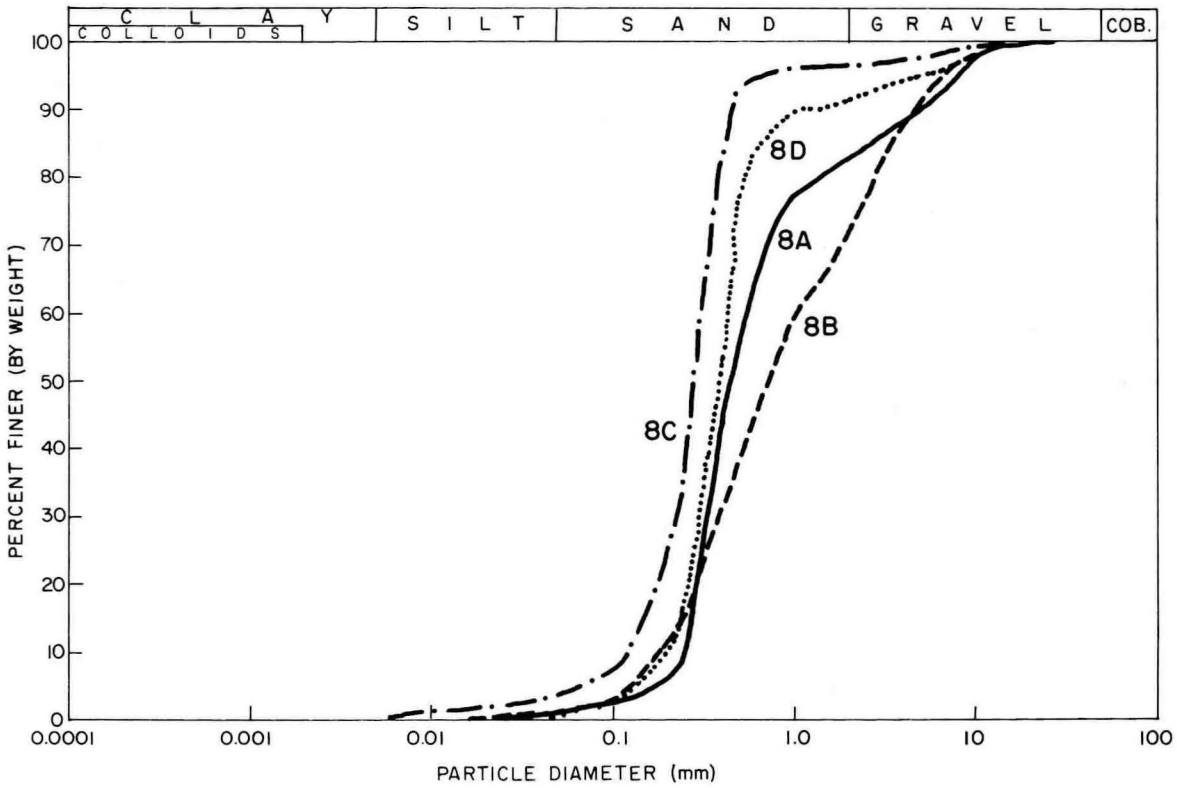



SAMPLE LOCALITY 8
feet
18
16
14
12
10
8
6
4
2
0
horizontally laminated silt, sand, and clay
crossbedded clean sand
sand with a few large gravels
horizontally bedded sand with lenses of pea gravel
pea gravel seam
sand with some gravels
gravelly sand
sand with some gravels
gravelly sand
sand with some gravel
crossbedded clean sand
sand with some gravel
sand with little gravel

SAMPLE LOCALITY 8



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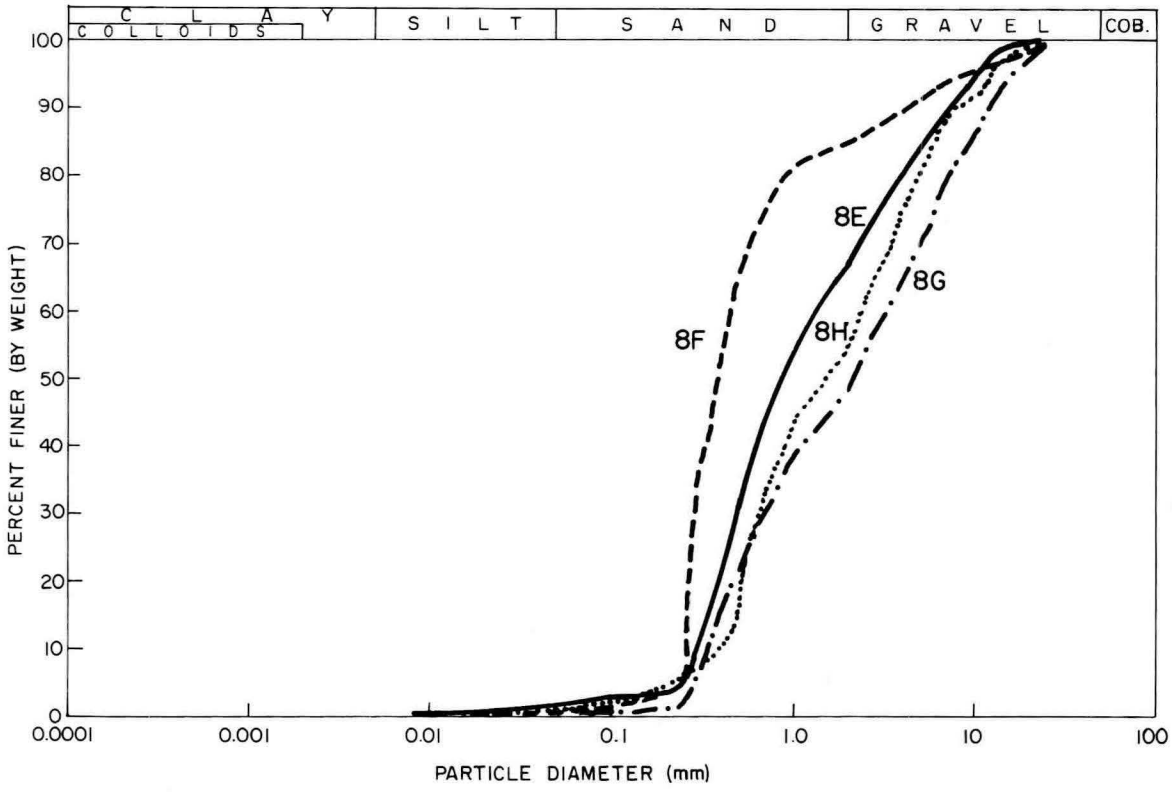

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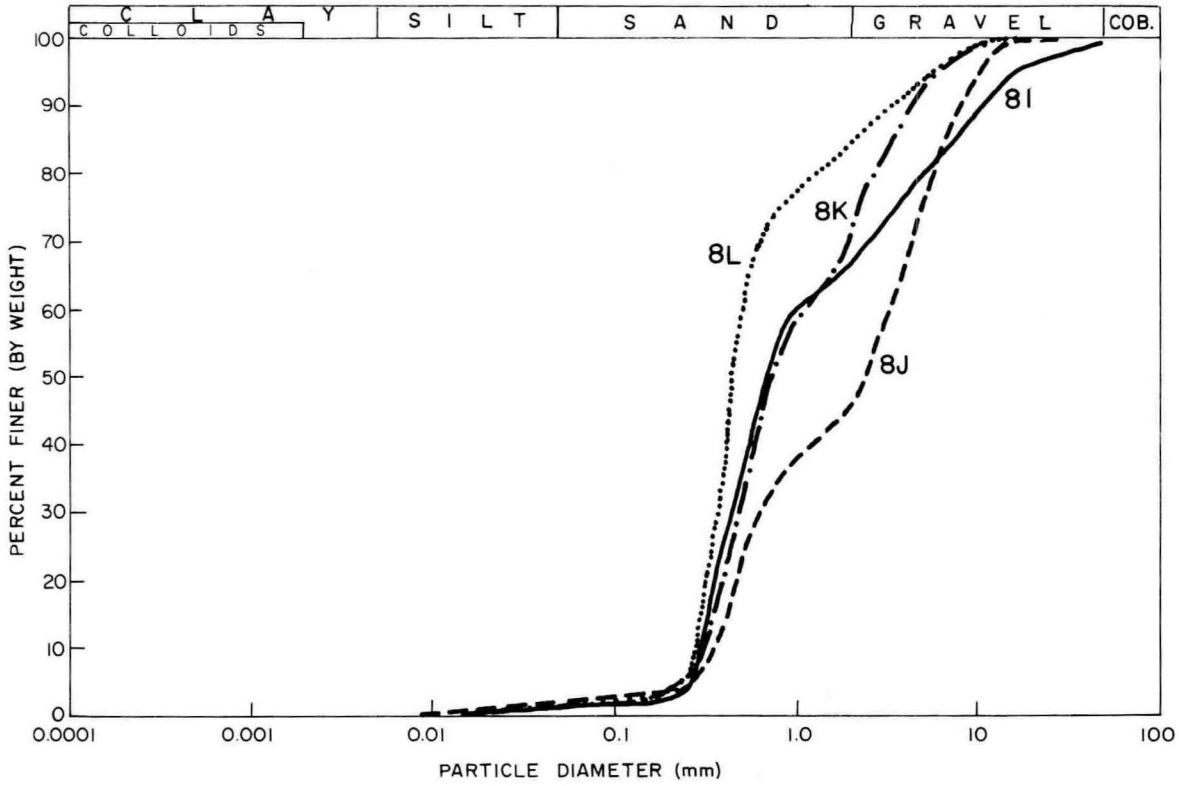

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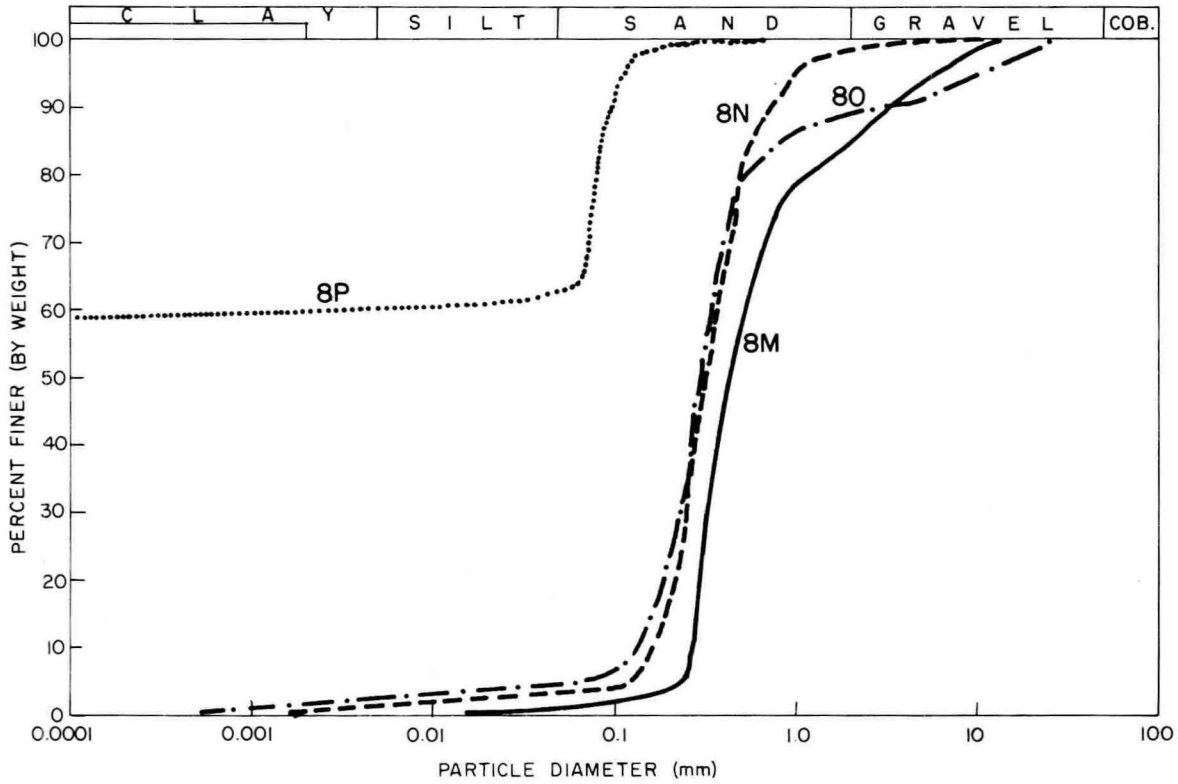

APPENDIX E

Description of Cuttings from Drill Holes in the Willis Formation, near the Town of Willis, Texas

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS, TEXAS

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
1	0	.5	Topsoil, dark grey, fine sand, silt and clay, abundant organic matter	No sample taken
	.5	1.5	Sand, brown, coarse to very coarse	
	1.5	-	Clay, sandy, mottled, red to brown	
2	0	.5	Topsoil, dark grey, fine sand, silt and clay, abundant organic matter, minor amounts of gravel	Interval sampled .5' - 1.5'
	.5	1.5	Sand, brown, very coarse, 15.45% gravel, gravel is 75% qtz and chert, and 25% ironstone nodules	
	1.5	-	Clay, sandy, mottled, red to brown, minor gravel present	
3	0	.5	Topsoil, dark grey, fine sand, silt and clay, abundant organic debris	Interval sampled .5' - 1.7'
	.5	1.2	Sand, dark grey to brown, coarse grained, 21.27% gravel, gravel is 75% qtz. and chert, and 25% ironstone	
	1.7	-	Clay, sandy, mottled, red to brown	
4				Hole not drilled
5	0	.5	Topsoil, dark grey, fine sand, silt and clay, abundant organic matter	Interval samples .5' - 1.9'

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
5 cont.	.5	1.9	Sand, coarse, brown, 32.17% gravel, gravel is 25% qtz and chert, 75% ironstone nodules	
-	1.9	-	Clay, sandy, mottled, red to brown, minor amounts of gravel	
6	0	.6	Topsoil, dark grey, fine sand, silt and clay abundant organic matter	Interval sampled .y' - 2.9'
	.6	2.3	Sand, brown, coarse grained, 3.49% gravel, gravel is 85% qtz and chert, 15% ironstone	
	2.9	-	Clay, sandy, mottled, red to brown	
7	0	.7	Topsoil, dark grey to brown, sandy silt, with abundant organic debris, minor amounts of gravel	Interval sampled .7' - 1.5'
	.7	.8	Sand, brown, coarse grained, 21.55% gravel; gravel is 50% chert and qtz., and 50% ironstone nodules	
	1.5	-	Clay, sandy, mottled, red to brown, minor gravel present	
8	0	.8	Topsoil, dark grey, fine sand, silt and clay, abundant organic matter	Interval sampled
	.8	1.7	Sand, brown, very coarse, 16.12% gravel; gravel is 80% qtz. and chert and 20% ironstone nodules	
	2.5	-	Clay, sandy, mottled, red to brown, minor gravel present	

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS, TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
9	0	.3	Topsoil, dark grey, sandy silt and clay, abundant gravel on surface, abundant organic matter	Interval sampled .3' - 1.8'
	.3	1.5	Sand brown, very coarse, 18.85% gravel; gravel is 10% chert anc qtz. and 90% ironstone	
	1.8	-	Clay, sandy, mottled, red to brown, minor gravel present	
10	0	.7	Topsoil, dark grey fine sand, silt and clay, minor amounts of gravel, abundant organic debris	Interval sampled .7' - 3.1'
	.7	2.4	Sand, brown, very coarse, 23.41% gravel, gravel is 98% ironstone and 2% qtz.	
	3.1	-	Clay, sandy, mottled, red to brown, minor gravel present	
	.4	2.3	Sand, brown, coarse, 18.08% gravel, gravel is 40% qtz. and chert, and 60% ironstone	
11	0	.5	Sand, brown, coarse, 25.38% gravel, gravel is 85% ironstone	No Topsoil Interval sampled 0' - .5'
	.5	-	Clay, sandy, mottled, red and brown	

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS, TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
12	0	.5	Topsoil, dark grey, fine sand, silt and clay, Abundant organic debris	Interval sampled .5' - 2.0'
	.5	1.5	Sand, brown, very coarse, 20.33% gravel, gravel is 75% qtz. and chert and 25% ironstone nodules	
	2.0	-	Clay, sandy, mottled, red and brown, minor amounts of gravel present	
13	0	.1	Topsoil, dark grey, coarse grained, with some silt, clay and abundant gravel	Interval sampled .1' - .4'
	.1	.3	Sand, brown, very coarse, 36.83% gravel, gravel is 90% qtz. and 10% ironstone	
	.4	-	Clay, sandy, mottled, red and brown	
14 (a,b)	0	.1	Topsoil, dark grey, fine sand, silt and clay, abundant organic matter	Interval sampled .1' - .5' (a) .5' - 2.5' (b)
	.1	.4	Gravel, with coarse sand, brown, 57.96% gravel, 90% qtz. and chert, 10% ironstone nodules	
	.5	2.0	Sand, brown, very coarse, 18.5% gravel, gravel is 85% qtz. and 25% ironstone	
	2.5	-	Clay, sandy, mottled, red to brown, with minor amounts of gravel	

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS, TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
15	0	.4	Topsoil, dark grey, fine sand, silt and clay, abundant organic matter	Interval sampled .4' - 2.7'
	.4	2.3	Sand, brown, coarse, 18.08% gravel, gravel is 40% qtz. and chert and 60% ironstone	
	2.7	-	Clay, sandy, mottled, red to brown	
16	0	.5	Topsoil, dark grey, fine sand, silt and clay, abundant organic matter	No sample taken
	.5	2.3	Sand, brown, coarse with minor amounts of gravel	
	2.8	-	Clay, sandy, mottled, red to brown	
17	0	.5	Topsoil, dark grey, fine sand, silt and clay, abundant organic matter, minor amounts of gravel	Interval sampled .5' - 3.2'
	.5	2.7	Sand, brown, coarse, 37.16% gravel, gravel is 100% qtz and chert	
	3.2	-	Clay, sandy, mottled, red to brown, minor amounts of gravel	
18	0	-	Clay, sandy, mottled, red to brown,scattered gravel on surface	No sample taken-- surface was apparently stripped

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS, TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
19	0	.3	Topsoil, dark grey, fine sand, silt and clay, abundant organic debris	Interval sampled .3 - 2.5'
	.3	2.2	Sand, brown, very coarse, 2.66% gravel, gravel 40% qtz. and chert and 60% ironstone	
	2.5	-	Clay, sandy, mottled, red to brown	
20	0	1	Topsoil, dark grey, fine sand, silt and clay with abundant organic debris	No sample taken
	1	-	Clay, sandy, mottled, red to brown	
21				Hole not drilled
22	0	.5	Topsoil, dark grey, fine sand, silt and clay, with abundant organic debris	No sample taken
	.5	2.5	Sand, brown, very coarse	
	3.0	-	Clay, sandy, mottled, red to brown	
23	0	.2	Topsoil, dark grey, fine grained sand, silt and clay, with abundant organic debris	No sample taken--surface stripped
	.2	-	Clay, sandy, red	
24	0	-	Clay, sandy, red, gravel scattered on surface and pushed in small piles	No sample taken--surface stripped

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS, TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
25			Same as Hole #24	
26	0	.5	Topsoil, dark grey, fine grained sand, silt and clay, with abundant organic debris	Interval sampled .5' - 2.5'
	.5	2.0	Sand, brown, very coarse, 35.35% gravel, gravel is 40% qtz. and chert and 60% ironstone	
	2.5	-	Clay, sandy, mottled, red to brown with minor amounts of gravel	
27	0	.5	Topsoil, fine sand, silt and clay, dark grey with abundant organic debris	Interval sampled .5' - 2.0' Hole terminated due to cave-in
	.5	-	Sand, light grey to brown, very coarse, 9.94% gravel, gravel is 95% qtz. and chert and 5% ironstone	
28	0	.3	Topsoil, dark grey, fine sand, silt and clay, with abundant organic debris, and minor amounts of gravel	Interval sampled .3' - 2.5'
	.3	2.2	Sand, brown, very coarse, 14.76% gravel, gravel is 50% qtz. and chert and 50% ironstone nodules	
	2.5	-	Clay, sandy, mottled, red to brown	

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS, TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
29	0	.7	Topsoil, dark grey, fine sand, silt and clay, with abundant organic debris	Interval sampled .7' - 3.0'
	.7	2.3	Sand, brown, very coarse, 8.98% gravel, gravel is 90% qtz. and chert and 10% ironstone nodules	
	3.0	-	Clay, sandy, mottled, red to brown	
30	0	1.0	Topsoil, dark grey, fine sand, silt and clay abundant organic debris	Interval sampled 1.0' - 3.0' Hole terminated by drill limit
	1.0	-	Sand, brown, very coarse grained, 9.5% gravel, gravelis 98% qtz. and chert and 2% ironstone	
31	0	2.5	Sand, brown, very coarse	No sample taken
	2.5	-	Clay, sandy, mottled, red to brown	
32				Hole not drilled
33				Hole not drilled
34	0	.2	Topsoil, dark grey, fine sand, silt and clay, abundant organic debris	Interval sampled .2' - 2.8'
	.2	2.6	Sand, brown, very coarse, 30.23% gravel, gravel is 40% chert and qutz. and 60% ironstone nodules	

DRILL HOLE DATA FROM THE WILLIS FORMATION, WILLIS, TEXAS
(cont.)

Hole #	Depth to top (ft)	Thickness (ft)	Description	Comments
34 cont.	2.8	-	Clay, sandy, mottled, red to brown	
35	0	.5	Topsoil, dark grey, fine sand, silt and clay, with abundant organic debris	Interval sampled .5' - 2.5'
	.5	2.0	Sand, brown, very coarse, 20.9% gravel, gravel is 20% qtz. and chert and 80% ironstone	
	2.5	-	Clay, sandy, mottled, red to brown	