Memorandum• UTAH DEPARTMENT OF TRANSPORTATION

DATE: April 12, 2001

TO: Frank Ashland- UGS

FROM: Jim Higbee, P.E.- Geotechnical Engineer

SUBJECT: Legacy Parkway Seismic Shear Wave Velocity Data

It was good to talk with you again. Here are two sets of the seismic shear wave velocity data we had taken on the Legacy Parkway project. The first three soundings were performed to an approximate depth of 37 meters, while the fourth (located at the north interchange in Farmington), was unfortunately only run to 16 meters. I've also provided location maps showing their four locations.

Hope this is useful for your future use.

Jim

CONETEC

Seismic Wave Velocity Calculations

Job No.: 00-300
Client: Kleinfelder
Location Legacy Parkway
CPT Date: 5/1/00
CPT No.: SC-14-312

Geophone Offset (m): 0.20
Source Offset (m): 0.74

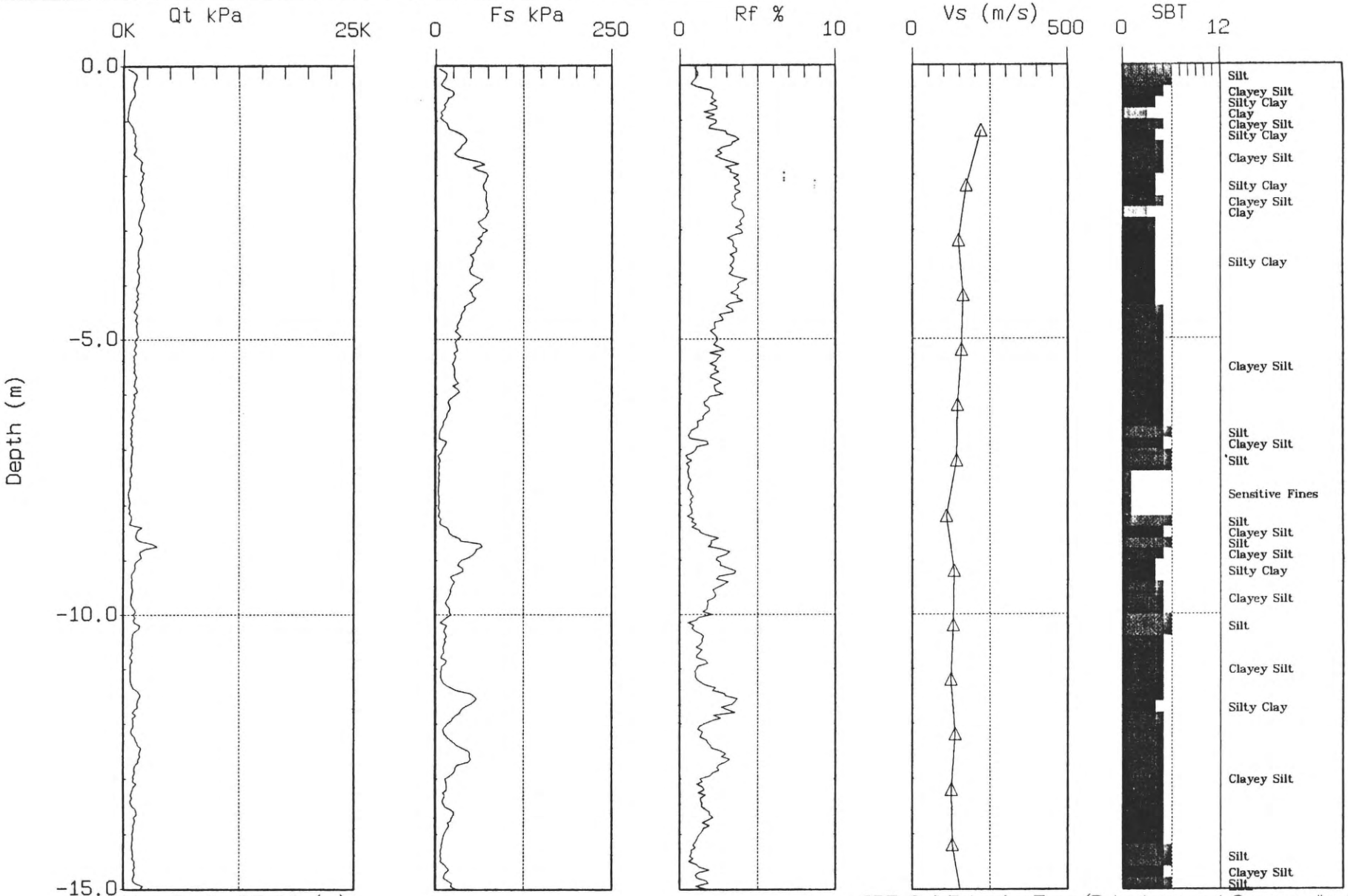
Test Depth (m)	Ray Path (m)	Incremental Distance (m)	Interval Depth (m)	Vs Interval Time (ms)	Vs Interval Velocity (m/s)
0.90	1.02				
1.90	1.85	0.84	1.20	3.81	219.3
2.90	2.80	0.95	2.20	5.50	171.9
3.90	3.77	0.97	3.20	6.62	147.1
4.90	4.76	0.98	4.20	6.06	162.5
5.90	5.75	0.99	5.20	6.35	155.9
6.90	6.74	0.99	6.20	6.91	143.7
7.90	7.74	0.99	7.20	7.04	141.3
8.90	8.73	1.00	8.20	9.17	108.6
9.90	9.73	1.00	9.20	7.47	133.4
10.90	10.73	1.00	10.20	7.66	130.2
11.90	11.72	1.00	11.20	8.15	122.4
12.90	12.72	1.00	12.20	7.35	135.8
13.90	13.72	1.00	13.20	7.99	125.0
14.90	14.72	1.00	14.20	7.83	127.5
15.90	15.72	1.00	15.20	6.39	156.3
16.90	16.72	1.00	16.20	6.87	145.4
17.90	17.72	1.00	17.20	4.15	240.7
18.90	18.71	1.00	18.20	4.63	215.8
19.90	19.71	1.00	19.20	4.00	249.8
20.90	20.71	1.00	20.20	4.05	246.7
21.90	21.71	1.00	21.20	4.64	215.4
22.90	22.71	1.00	22.20	5.50	181.7
23.90	23.71	1.00	23.20	5.01	199.5
24.90	24.71	1.00	24.20	5.01	199.5
25.90	25.71	1.00	25.20	4.03	248.0
26.90	26.71	1.00	26.20	3.91	255.7
27.90	27.71	1.00	27.20	3.79	263.8
28.90	28.71	1.00	28.20	4.03	248.1
29.90	29.71	1.00	29.20	3.79	263.8
30.90	30.71	1.00	30.20	4.29	233.0
31.90	31.71	1.00	31.20	4.06	246.2
32.90	32.71	1.00	32.20	4.29	233.0
33.90	33.71	1.00	33.20	4.17	239.7
34.90	34.71	1.00	34.20	3.05	327.8
35.90	35.71	1.00	35.20	3.49	286.5
36.90	36.71	1.00	36.20	3.50	285.7

CONETEC

Legacy Parkway

Site: SC-14-312
Location: STRUCTURE 14

Cone: 20 TON A 070
Date: 05:01:00 21:43



Max. Depth: 37.20 (m)
Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

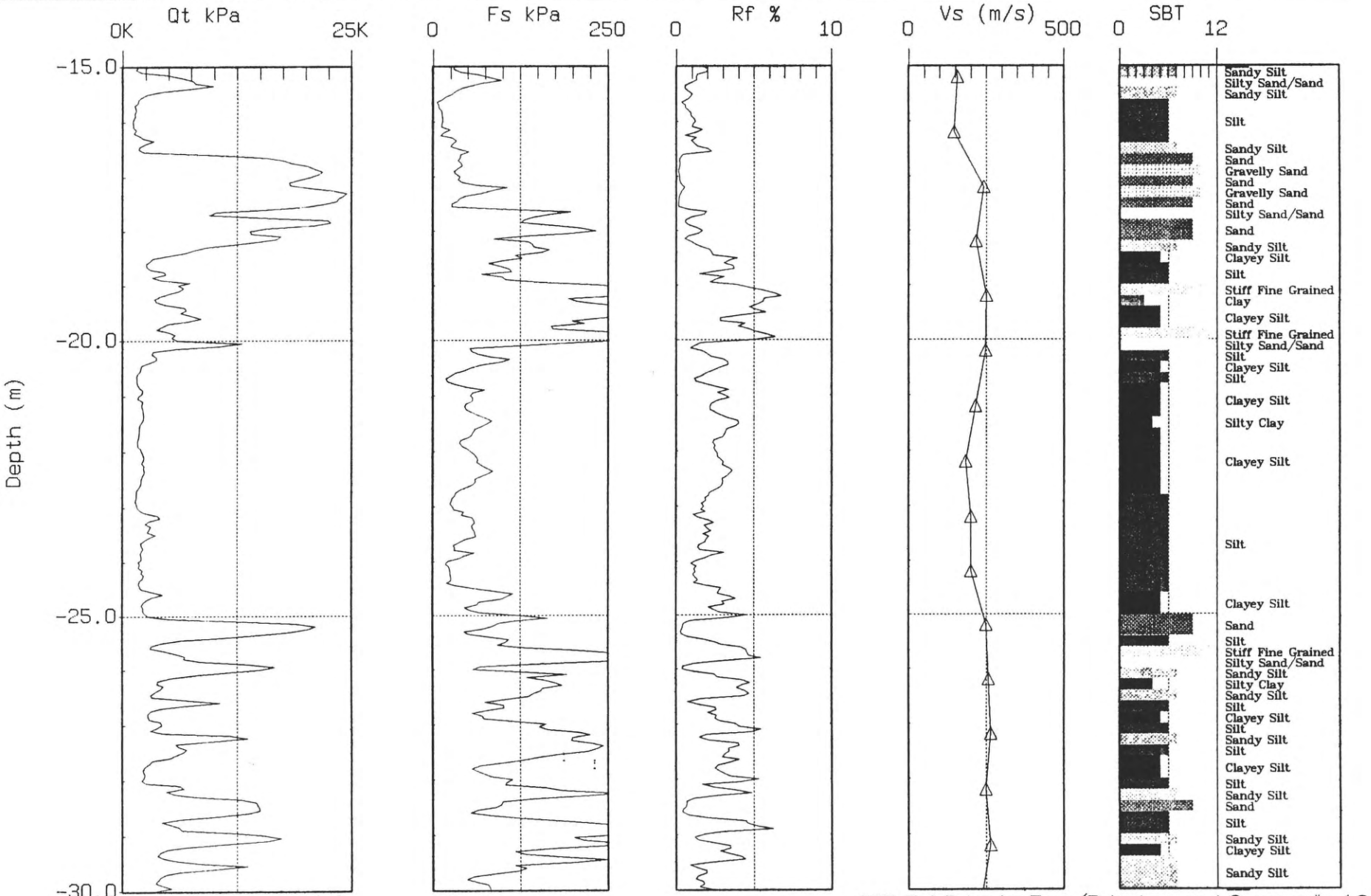
PLATE H-2

CONE TEC

Legacy Parkway

Site: SC-14-312
Location: STRUCTURE 14

Cone: 20 TON A 070
Date: 05:01:00 21:43



Max. Depth: 37.20 (m)

Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

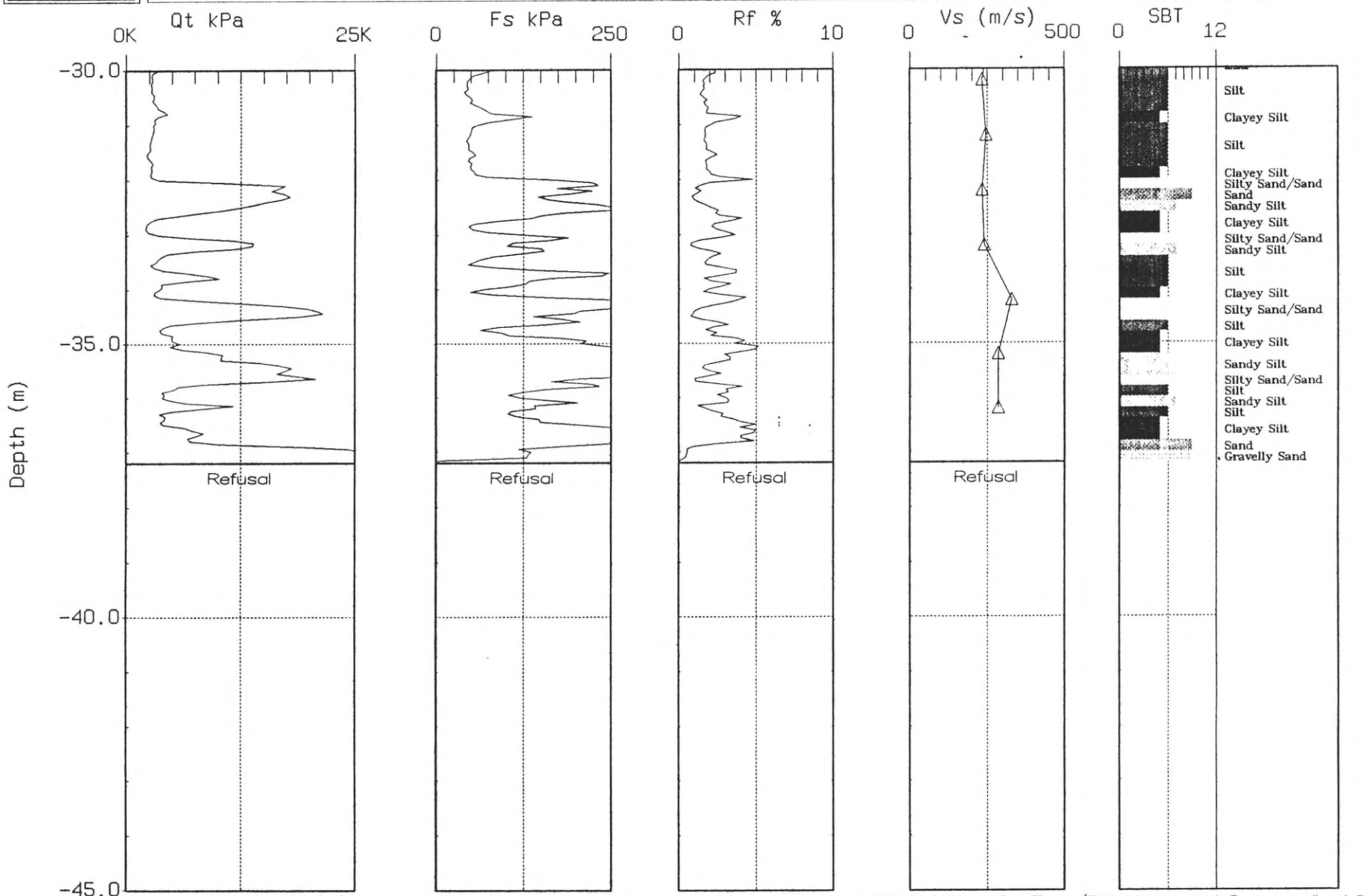
PLATE H-3

CONETEC

Legacy Parkway

Site: SC-14-312
Location: STRUCTURE 14

Cone: 20 TON A 070
Date: 05:01:00 21:43



Max. Depth: 37.20 (m)
Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

PLATE H-4

CONETEC

Seismic Wave Velocity Calculations

Job No.: 00-300
Client: Kleinfelder
Location Legacy Parkway
CPT Date: 5/10/00
CPT No.: SC-15-361

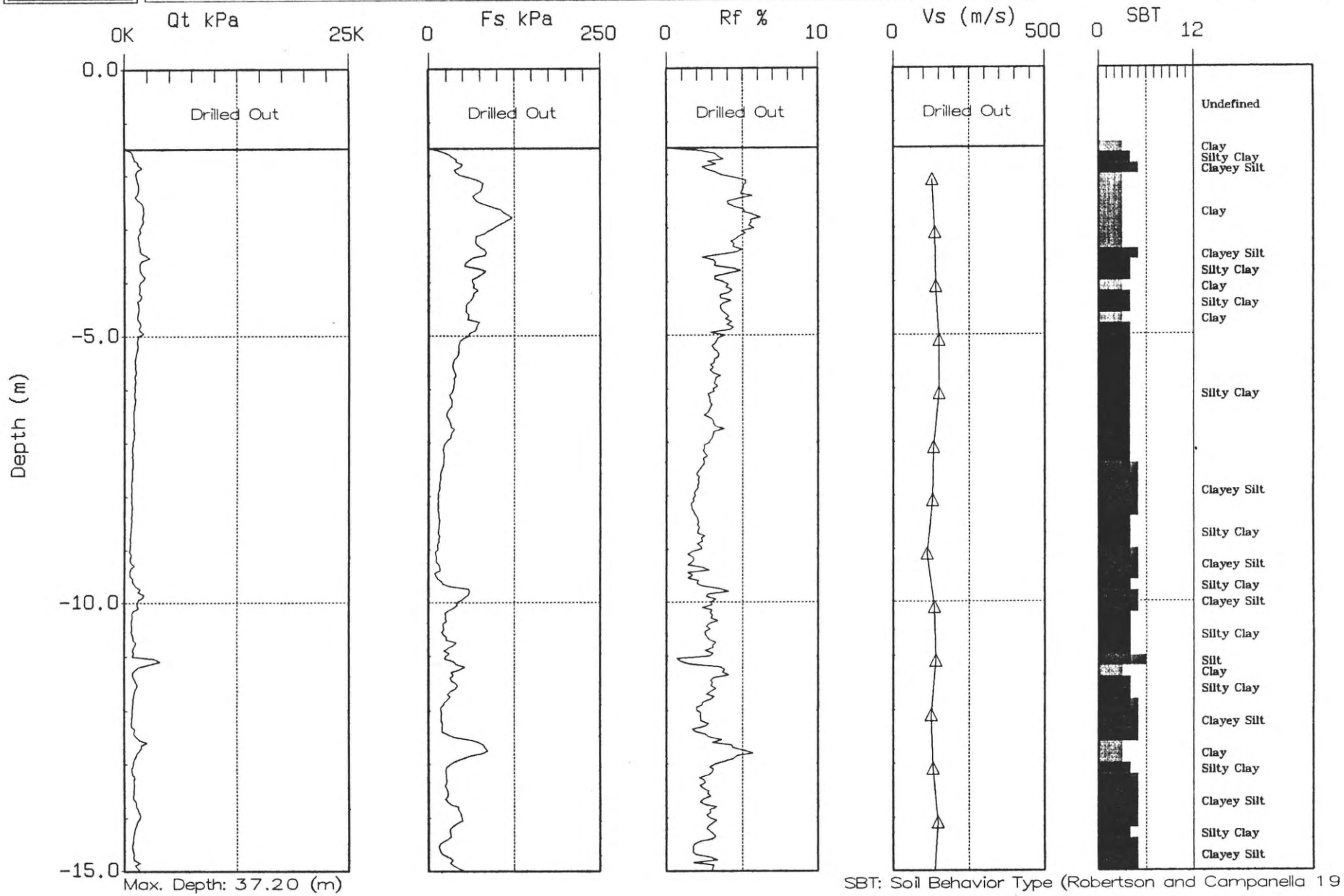
Geophone Offset (m): 0.20
Source Offset (m): 0.61

Test Depth (m)	Ray Path (m)	Incremental Distance (m)	Interval Depth (m)	Vs Interval Time (ms)	Vs Interval Velocity (m/s)
1.80	1.71				
2.80	2.67	0.96	2.10	7.52	127.4
3.80	3.65	0.98	3.10	7.14	137.4
4.80	4.64	0.99	4.10	7.14	138.5
5.80	5.63	0.99	5.10	6.58	150.9
6.80	6.63	1.00	6.10	6.58	151.2
7.80	7.62	1.00	7.10	7.52	132.5
8.80	8.62	1.00	8.10	7.71	129.3
9.80	9.62	1.00	9.10	9.02	110.6
10.80	10.62	1.00	10.10	7.42	134.5
11.80	11.62	1.00	11.10	7.19	138.9
12.80	12.61	1.00	12.10	8.04	124.2
13.80	13.61	1.00	13.10	7.61	131.3
14.80	14.61	1.00	14.10	6.77	147.6
15.80	15.61	1.00	15.10	7.33	136.3
16.80	16.61	1.00	16.10	7.19	139.0
17.80	17.61	1.00	17.10	6.63	150.7
18.80	18.61	1.00	18.10	6.90	144.8
19.80	19.61	1.00	19.10	4.80	208.2
20.80	20.61	1.00	20.10	4.73	211.3
21.80	21.61	1.00	21.10	4.16	240.3
22.80	22.61	1.00	22.10	3.91	255.7
23.80	23.61	1.00	23.10	4.40	227.2
24.80	24.61	1.00	24.10	5.62	177.9
25.80	25.61	1.00	25.10	5.98	167.2
26.80	26.61	1.00	26.10	4.89	204.4
27.80	27.61	1.00	27.10	4.64	215.5
28.80	28.61	1.00	28.10	4.04	247.5
29.80	29.61	1.00	29.10	3.42	292.3
30.80	30.61	1.00	30.10	3.73	268.0
31.80	31.61	1.00	31.10	4.13	242.1
32.80	32.61	1.00	32.10	3.76	265.9
33.80	33.61	1.00	33.10	3.76	265.9
34.80	34.61	1.00	34.10	4.21	237.5
35.80	35.61	1.00	35.10	4.14	241.5
36.80	36.61	1.00	36.10	3.31	302.1

Legacy Parkway

Site: SC-15-361
Location: STRUCTURE 15

Cone: 20 TON A 070
Date: 05:10:00 10:07



Max. Depth: 37.20 (m)
Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

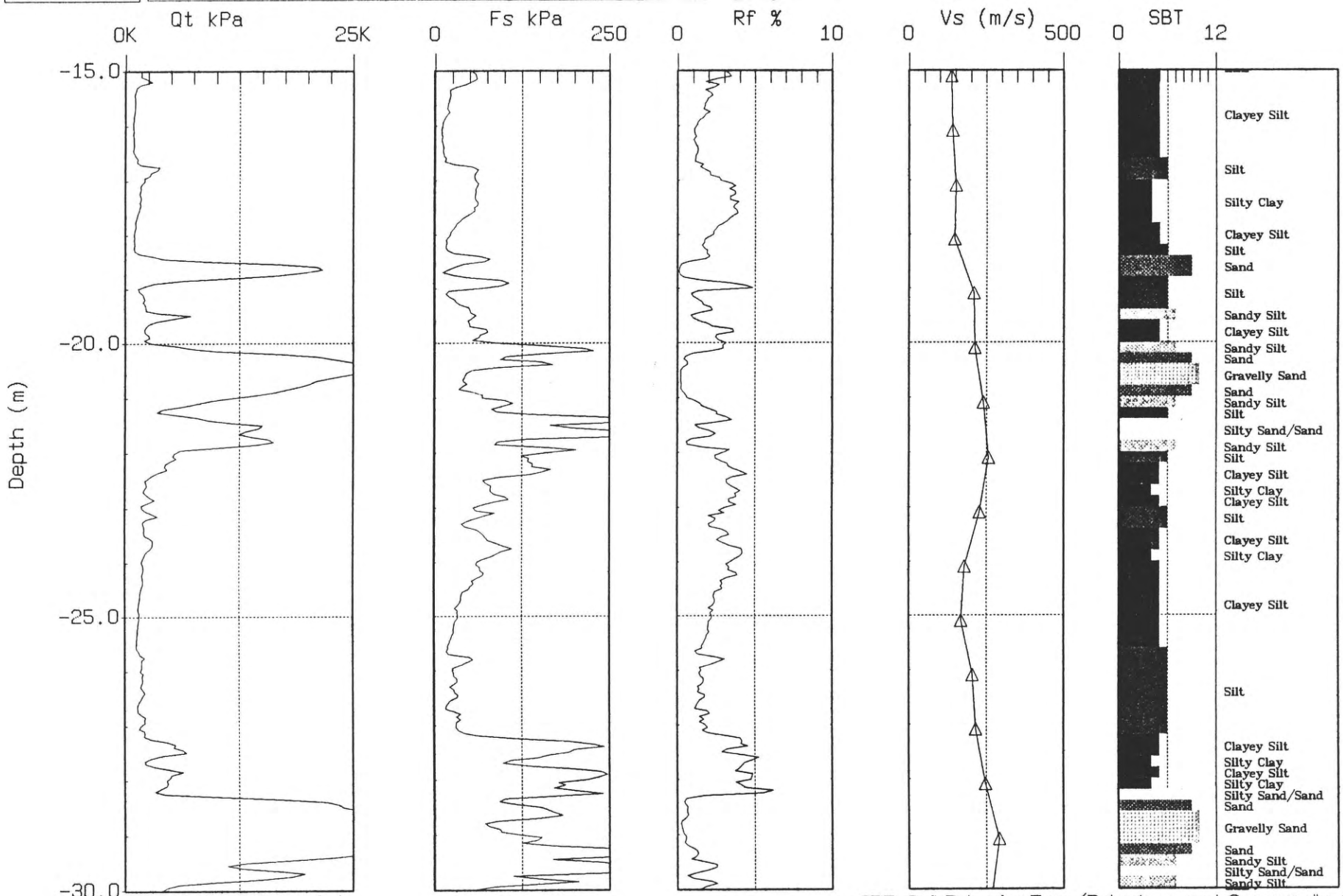
PLATE H-6

CONETEC

Legacy Parkway

Site: SC-15-361
Location: STRUCTURE 15

Cone: 20 TON A 070
Date: 05:10:00 10:07



Max. Depth: 37.20 (m)

Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

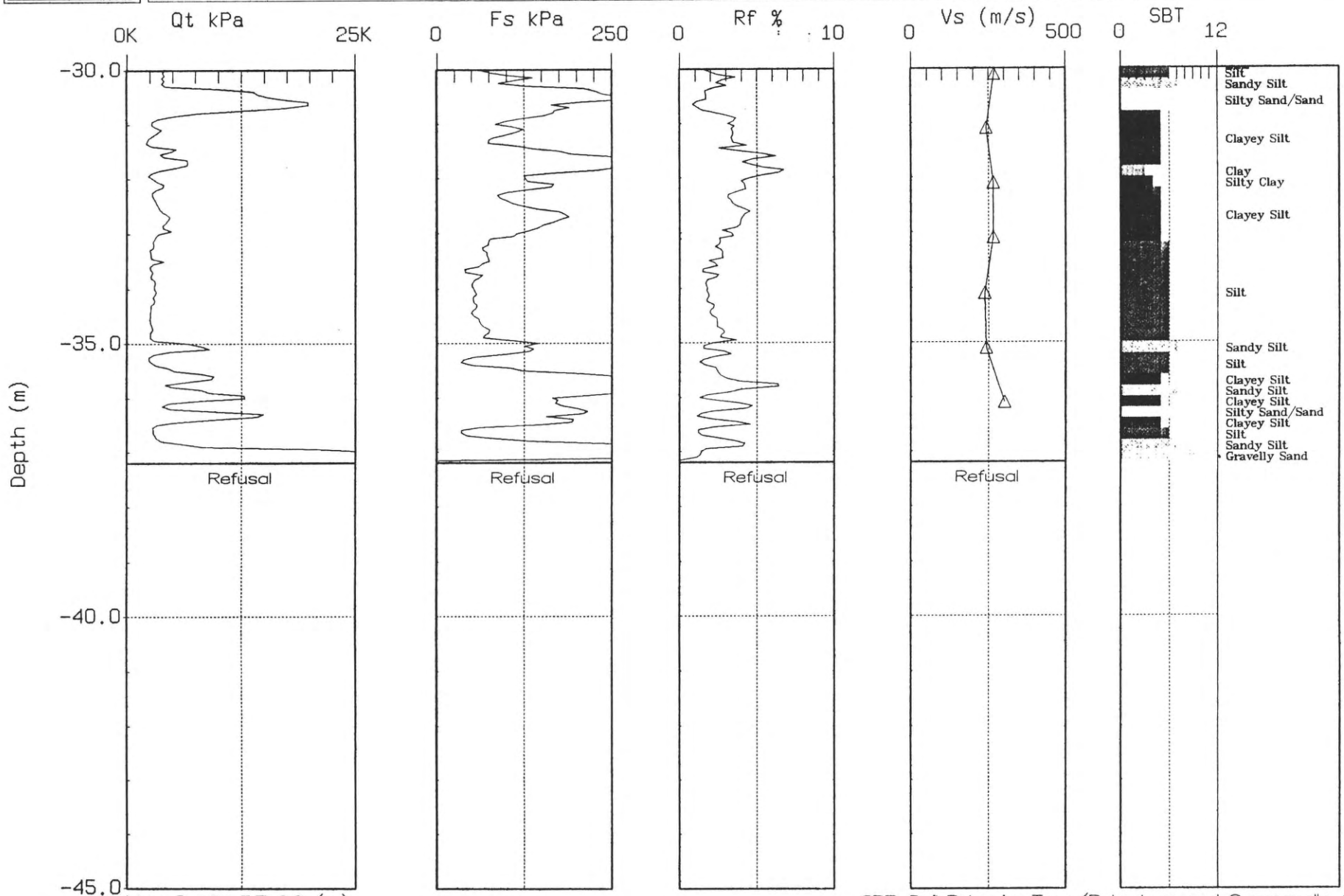
PLATE H-7

CONETEC

Legacy Parkway

Site: SC-15-361
Location: STRUCTURE 15

Cone: 20 TON A 070
Date: 05:10:00 10:07



Max. Depth: 37.20 (m)
Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

PLATE H-8

CONETEC

Seismic Wave Velocity Calculations

Job No.: 00-300
Client: Kleinfelder
Location Legacy Parkway
CPT Date: 5/1/00
CPT No.: SC-33-358

Geophone Offset (m): 0.20
Source Offset (m): 0.56

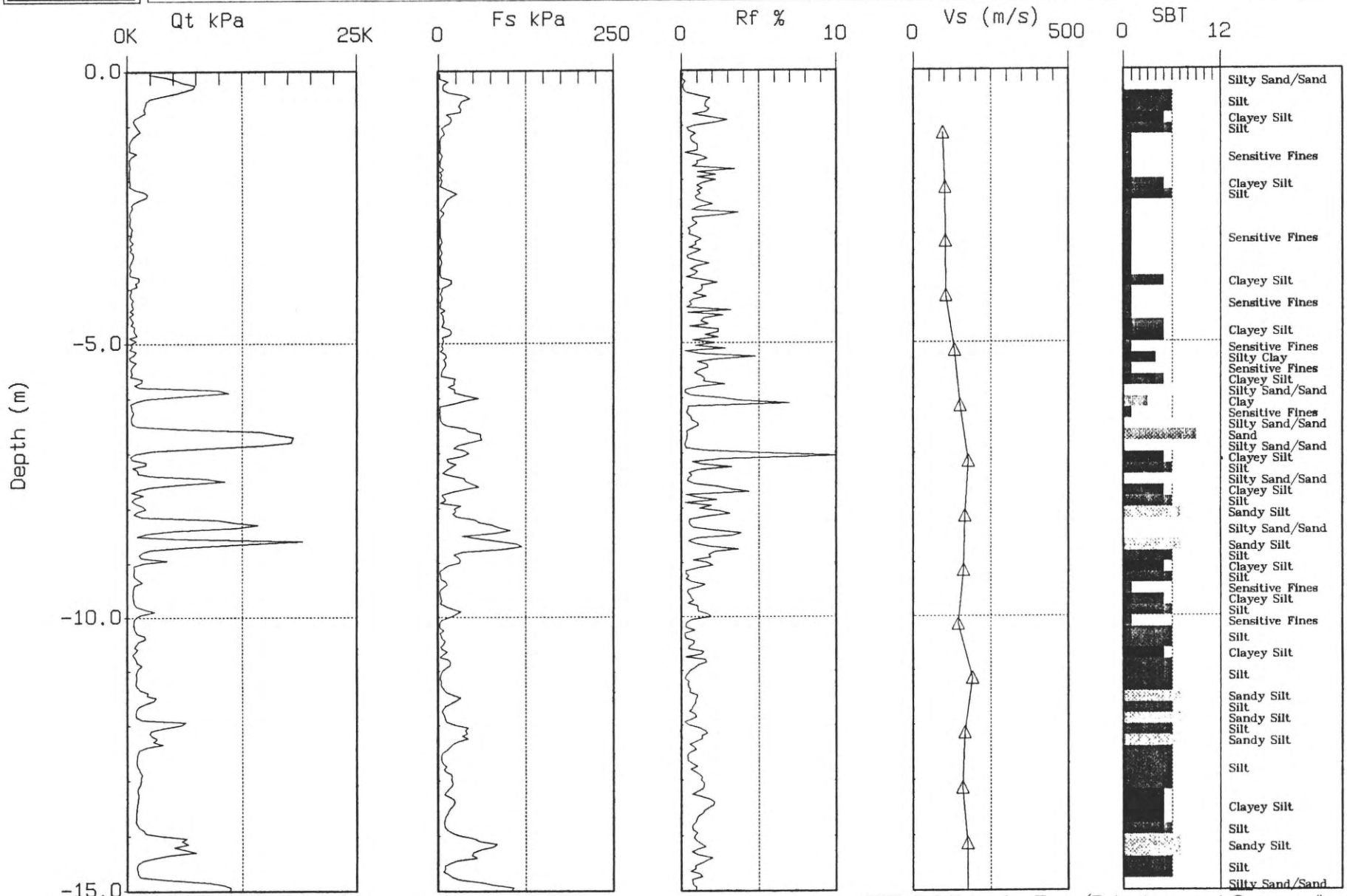
Test Depth (m)	Ray Path (m)	Incremental Distance (m)	Interval Depth (m)	Vs Interval Time (ms)	Vs Interval Velocity (m/s)
0.85	0.86				
1.85	1.74	0.88	1.15	9.40	94.1
2.85	2.71	0.97	2.15	9.59	100.7
3.85	3.69	0.98	3.15	9.58	102.7
4.85	4.68	0.99	4.15	9.40	105.4
5.85	5.68	0.99	5.15	7.52	132.2
6.85	6.67	1.00	6.15	6.58	151.3
7.85	7.67	1.00	7.15	5.64	176.8
8.85	8.67	1.00	8.15	6.01	166.0
9.85	9.67	1.00	9.15	6.21	160.7
10.85	10.66	1.00	10.15	6.91	144.5
11.85	11.66	1.00	11.15	5.27	189.5
12.85	12.66	1.00	12.15	6.01	166.2
13.85	13.66	1.00	13.15	6.32	158.1
14.85	14.66	1.00	14.15	5.71	175.0
15.85	15.66	1.00	15.15	5.72	174.7
16.85	16.66	1.00	16.15	6.16	162.2
17.85	17.66	1.00	17.15	5.57	179.4
18.85	18.66	1.00	18.15	5.86	170.6
19.85	19.66	1.00	19.15	6.62	151.0
20.85	20.66	1.00	20.15	5.03	198.7
21.85	21.66	1.00	21.15	4.37	228.8
22.85	22.66	1.00	22.15	5.07	197.2
23.85	23.66	1.00	23.15	4.37	228.8
24.85	24.66	1.00	24.15	4.65	215.0
25.85	25.66	1.00	25.15	4.94	202.4
26.85	26.66	1.00	26.15	4.93	202.8
27.85	27.66	1.00	27.15	3.67	272.4
28.85	28.66	1.00	28.15	3.66	273.2
29.85	29.66	1.00	29.15	4.09	244.5
30.85	30.66	1.00	30.15	3.71	269.5
31.85	31.65	1.00	31.15	3.67	272.4
32.85	32.65	1.00	32.15	4.04	247.5
33.85	33.65	1.00	33.15	3.85	259.7
34.85	34.65	1.00	34.15	4.14	241.5
35.85	35.65	1.00	35.15	3.38	295.8
36.55	36.35	0.70	36.00	2.35	297.8

CONETEC

Legacy Parkway

Site: SC-33-358
Location: STRUCTURE 33

Cone: 20 TON A 070
Date: 05:04:00 18:34



Max. Depth: 36.55 (m)
Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

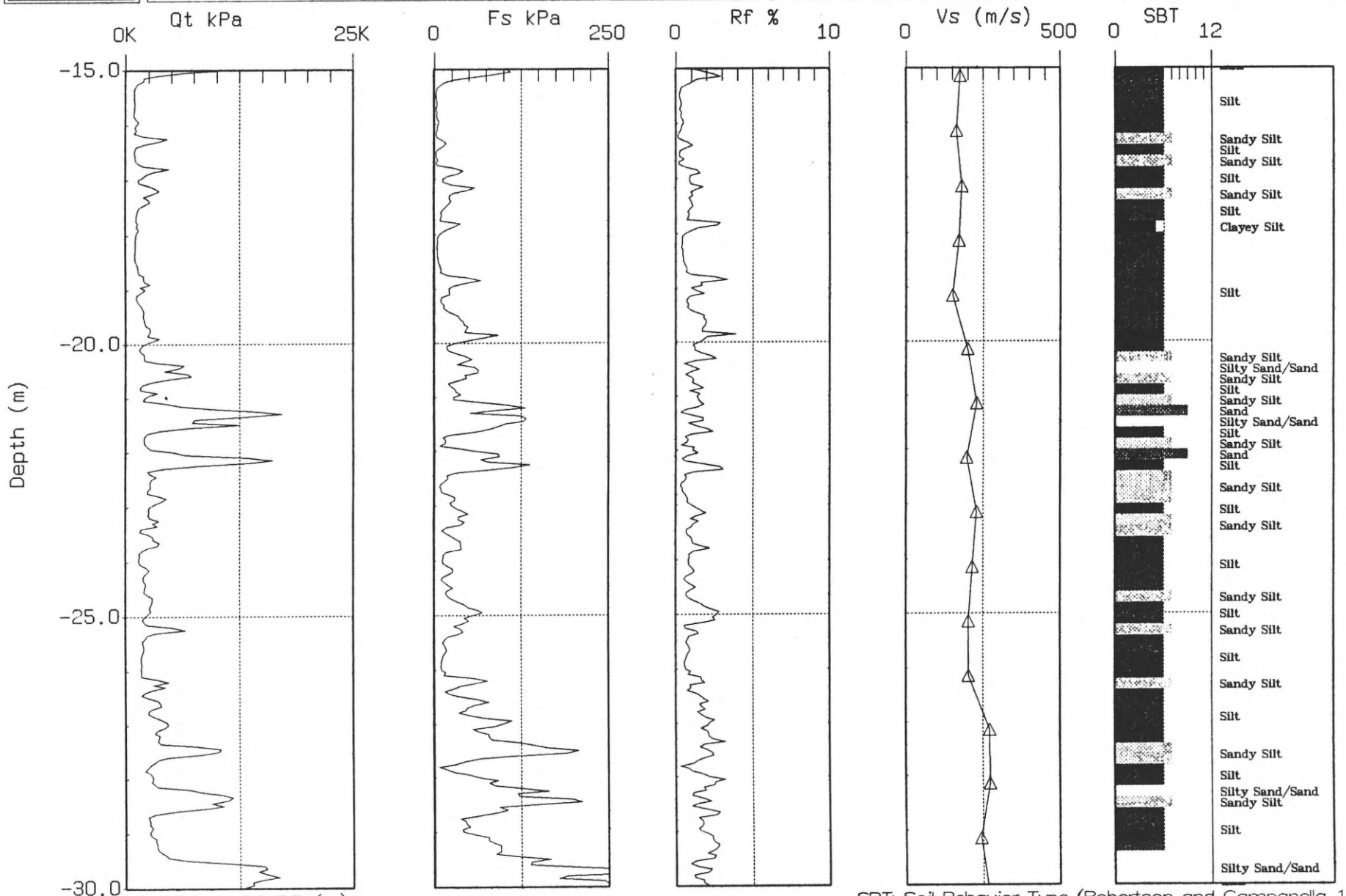
PLATE H-10

CONETEC

Legacy Parkway

Site: SC-33-358
Location: STRUCTURE 33

Cone: 20 TON A 070
Date: 05:04:00 18:34



Max. Depth: 36.55 (m)

Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

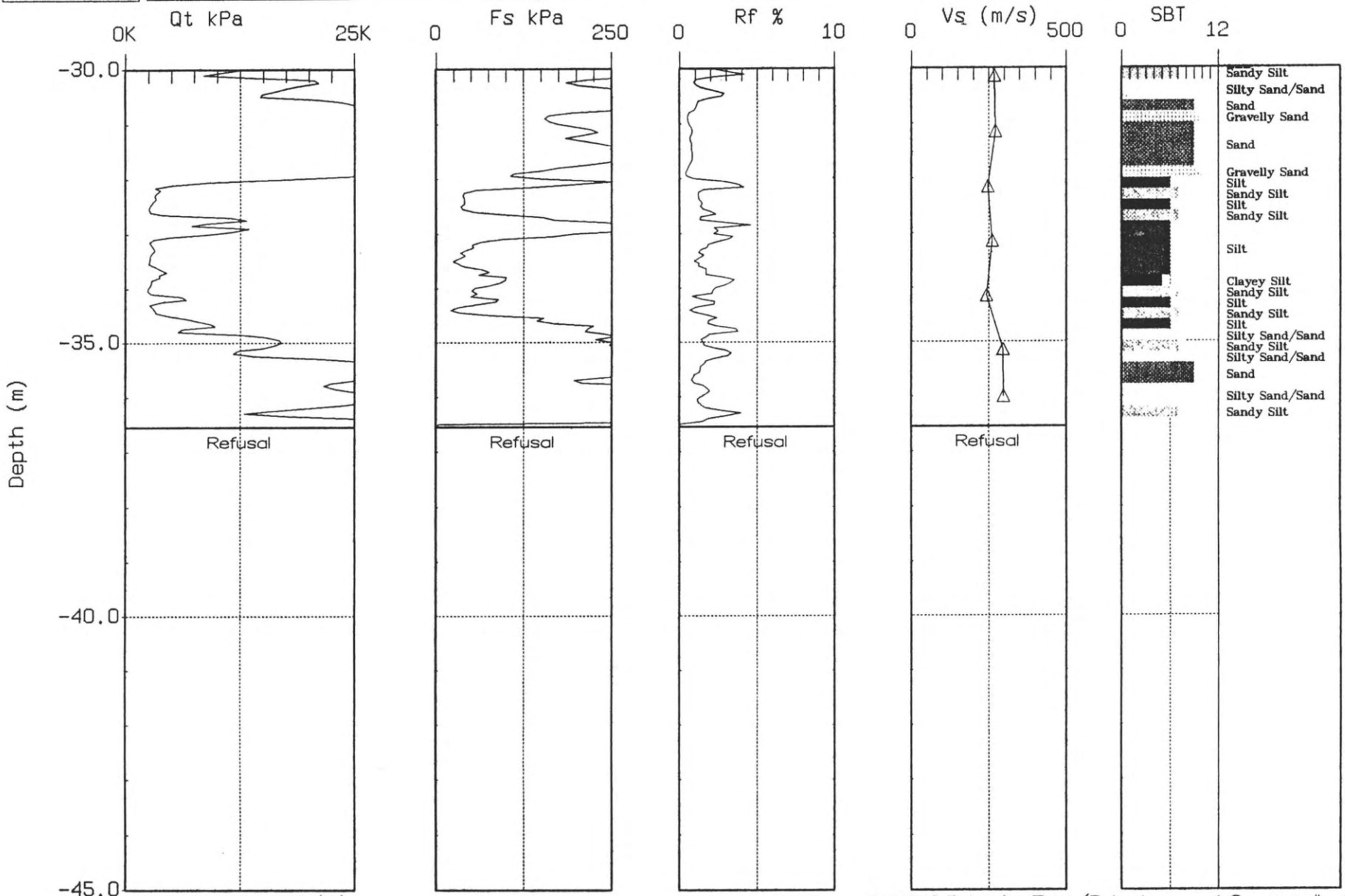
PLATE H-11

CONETEC

Legacy Parkway

Site: SC-33-358
Location: STRUCTURE 33

Cone: 20 TON A 070
Date: 05:04:00 18:34



Max. Depth: 36.55 (m)
Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

PLATE H-12

CONETEC

Seismic Wave Velocity Calculations

Job No.: 00-300
Client: Kleinfelder
Location Legacy Parkway
CPT Date: 5/9/00
CPT No.: RC-373

Geophone Offset (m): 0.20
Source Offset (m): 0.61

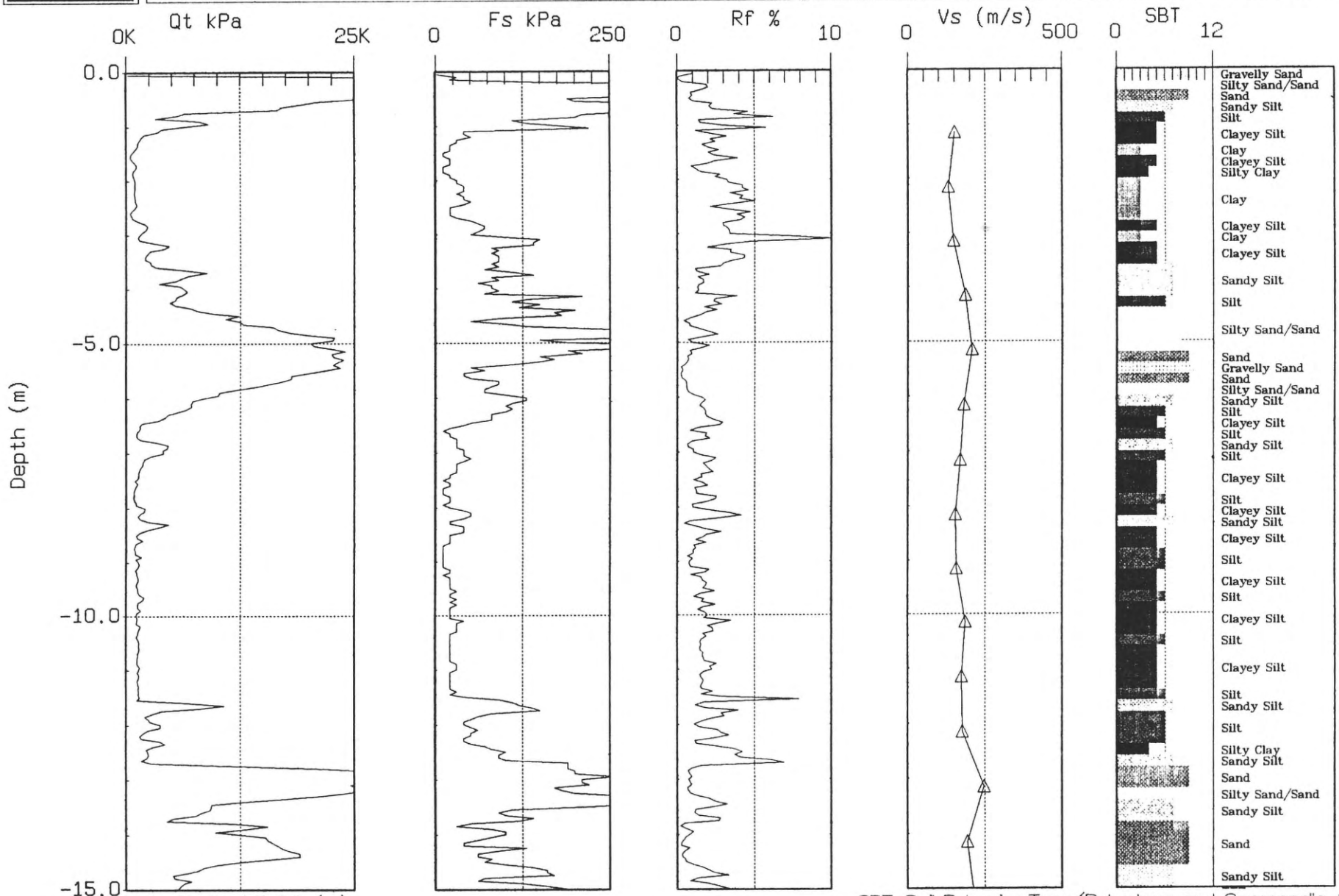
Test Depth (m)	Ray Path (m)	Incremental Distance (m)	Interval Depth (m)	Vs Interval Time (ms)	Vs Interval Velocity (m/s)
0.85	0.89				
1.85	1.76	0.87	1.15	5.78	150.1
2.85	2.72	0.96	2.15	7.33	131.0
3.85	3.70	0.98	3.15	6.63	148.0
4.85	4.69	0.99	4.15	5.36	184.6
5.85	5.68	0.99	5.15	4.79	207.3
6.85	6.68	1.00	6.15	5.50	180.9
7.85	7.67	1.00	7.15	5.92	168.3
8.85	8.67	1.00	8.15	6.48	153.9
9.85	9.67	1.00	9.15	6.35	157.1
10.85	10.67	1.00	10.15	5.36	186.2
11.85	11.67	1.00	11.15	5.73	174.3
12.85	12.66	1.00	12.15	5.64	177.1
13.85	13.66	1.00	13.15	4.04	247.3
14.85	14.66	1.00	14.15	5.17	193.2
15.85	15.66	1.00	15.15	4.70	212.6

CONETEC

Legacy Parkway

Site: RC-373
Location: ROAD BORING-373

Cone: 20 TON A 070
Date: 05:09:00 09:14



Max. Depth: 15.90 (m)

Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

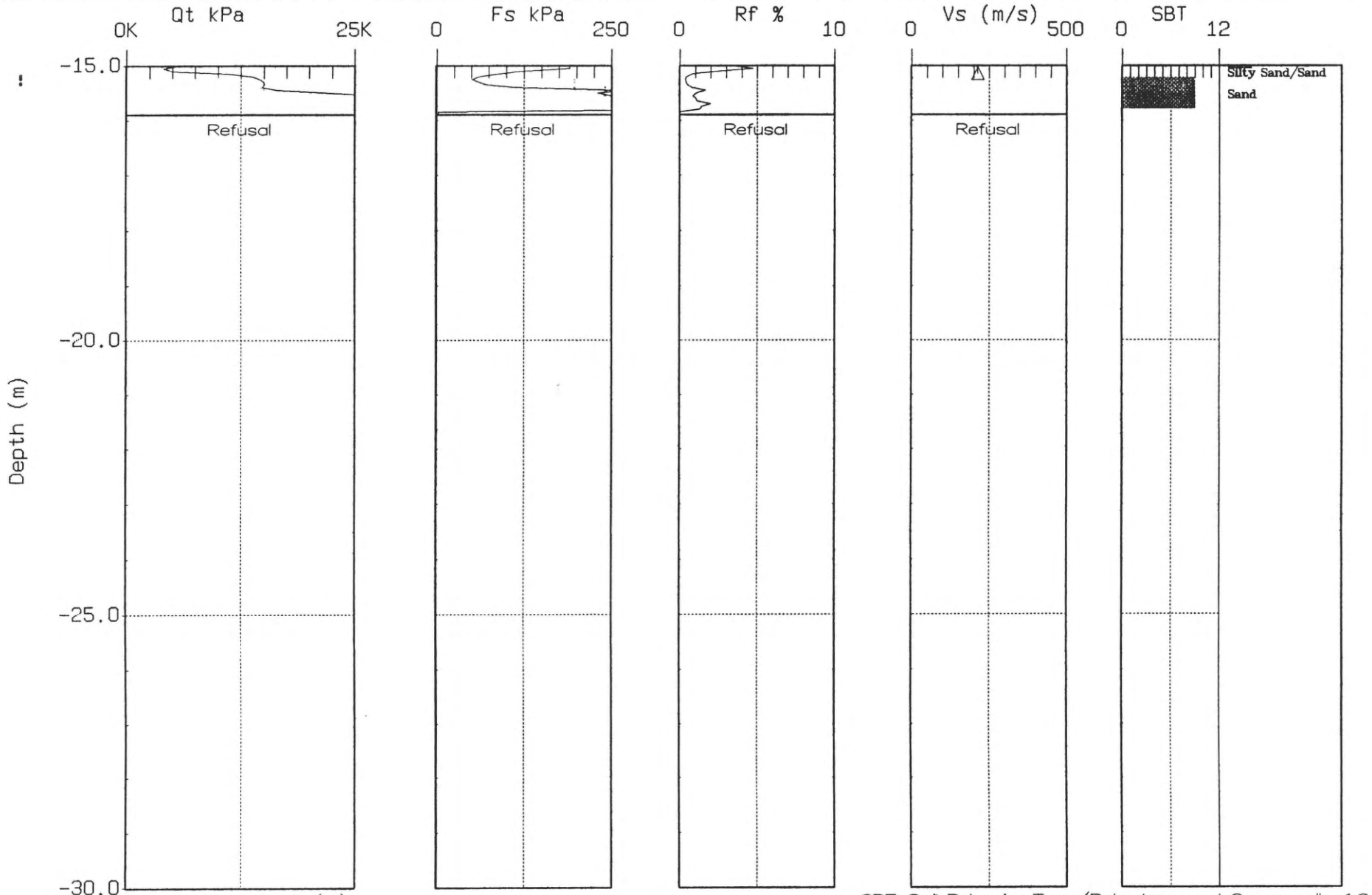
PLATE H-14

CONETEC

Legacy Parkway

Site: RC-373
Location: ROAD BORING-373

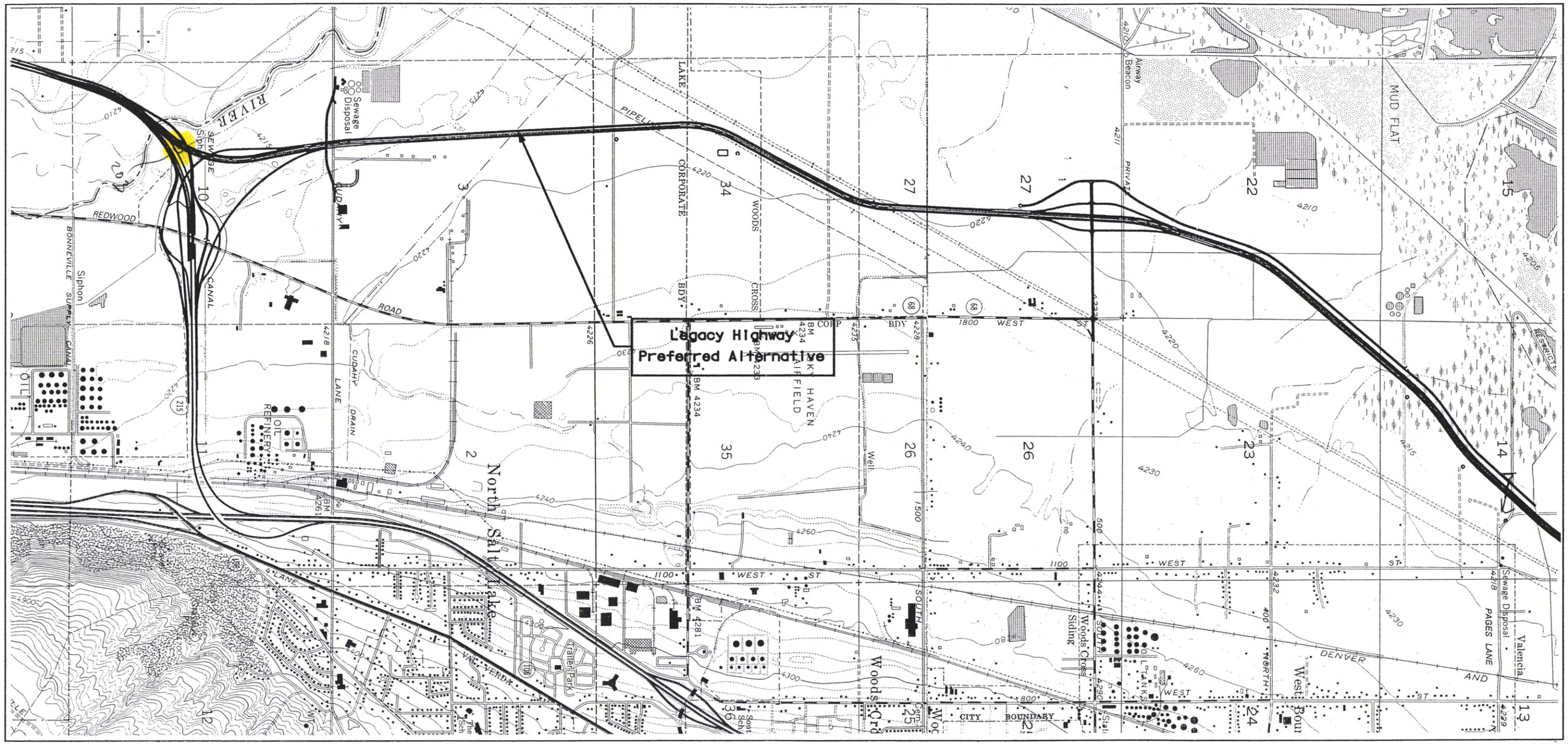
Cone: 20 TON A 070
Date: 05:09:00 09:14



Max. Depth: 15.90 (m)
Depth Inc.: 0.05 (m)

SBT: Soil Behavior Type (Robertson and Campanella 19

PLATE H-15



BASE MAPS:
SALT LAKE CITY NORTH AND FARMINGTION, UTAH
U.S.G.S. 7.5 MINUTE QUADRANGLE
1963 AND 1952
Photorevised 1969 and 1975

Project Number - 35-8163-05

SCALE 1:24,000

0 1000 2000 FEET

1" = 2000'

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

UTAH

QUADRANGLE LOCATION

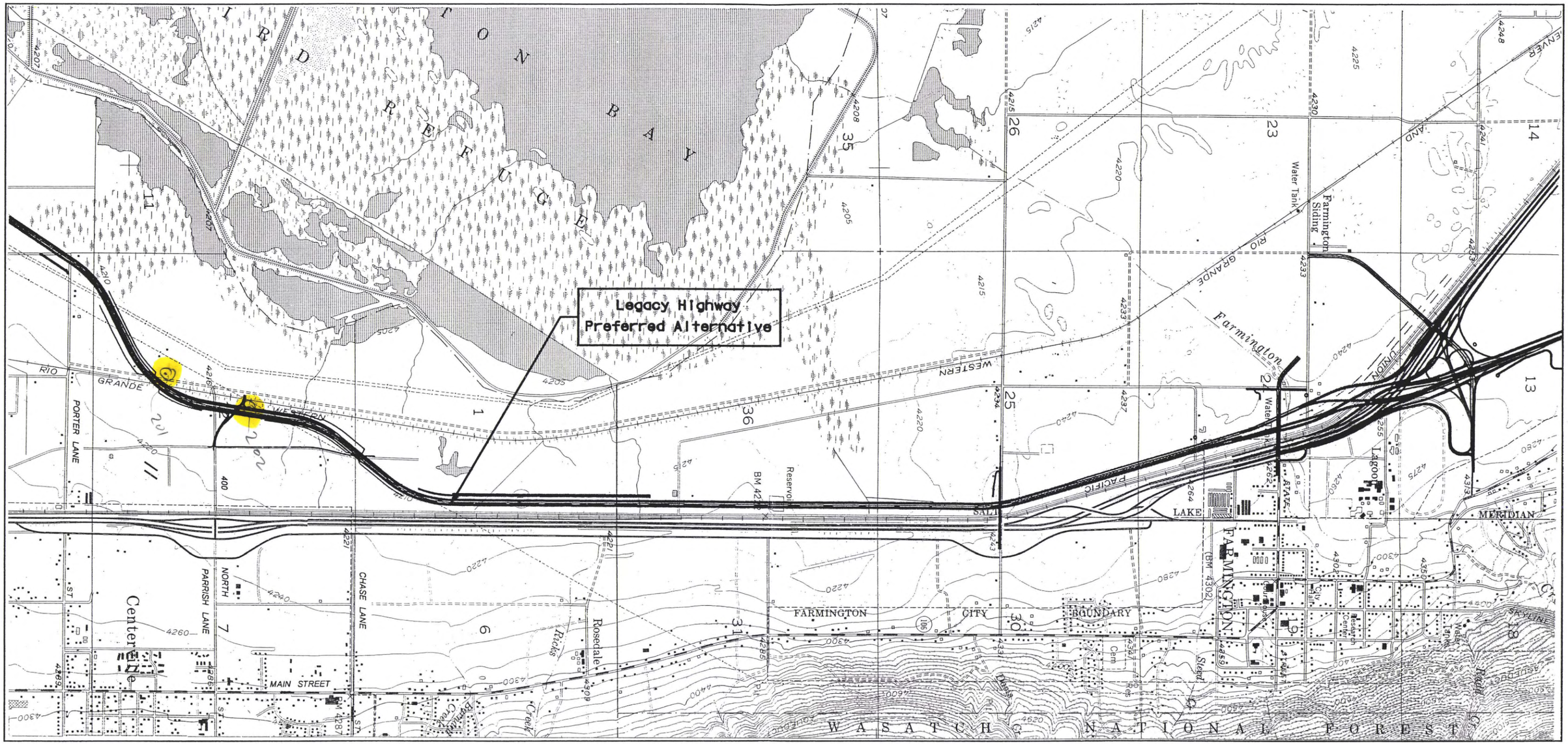
6-00

KLEINFELDER, INC.

Legacy Parkway - Preferred Alternative
I-215 Interchange to I-15/U.S. 89 Interchange

PROJECT VICINITY MAP

PLATE
A-2



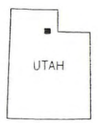
BASE MAP:
FARMINGTION, UTAH
U.S.G.S. 7.5 MINUTE QUADRANGLE
1952
Photorevised 1969 and 1975
Project Number - 35-8163-05

SCALE 1:24,000

0 1000 2000 FEET

1" = 2000'

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929



QUADRANGLE LOCATION

6-00

KLEINFELDER, INC.

Legacy Parkway - Preferred Alternative
I-215 Interchange to I-15/U.S. 89 Interchange

PROJECT VICINITY MAP

PLATE
A-3

KLEINFELDER

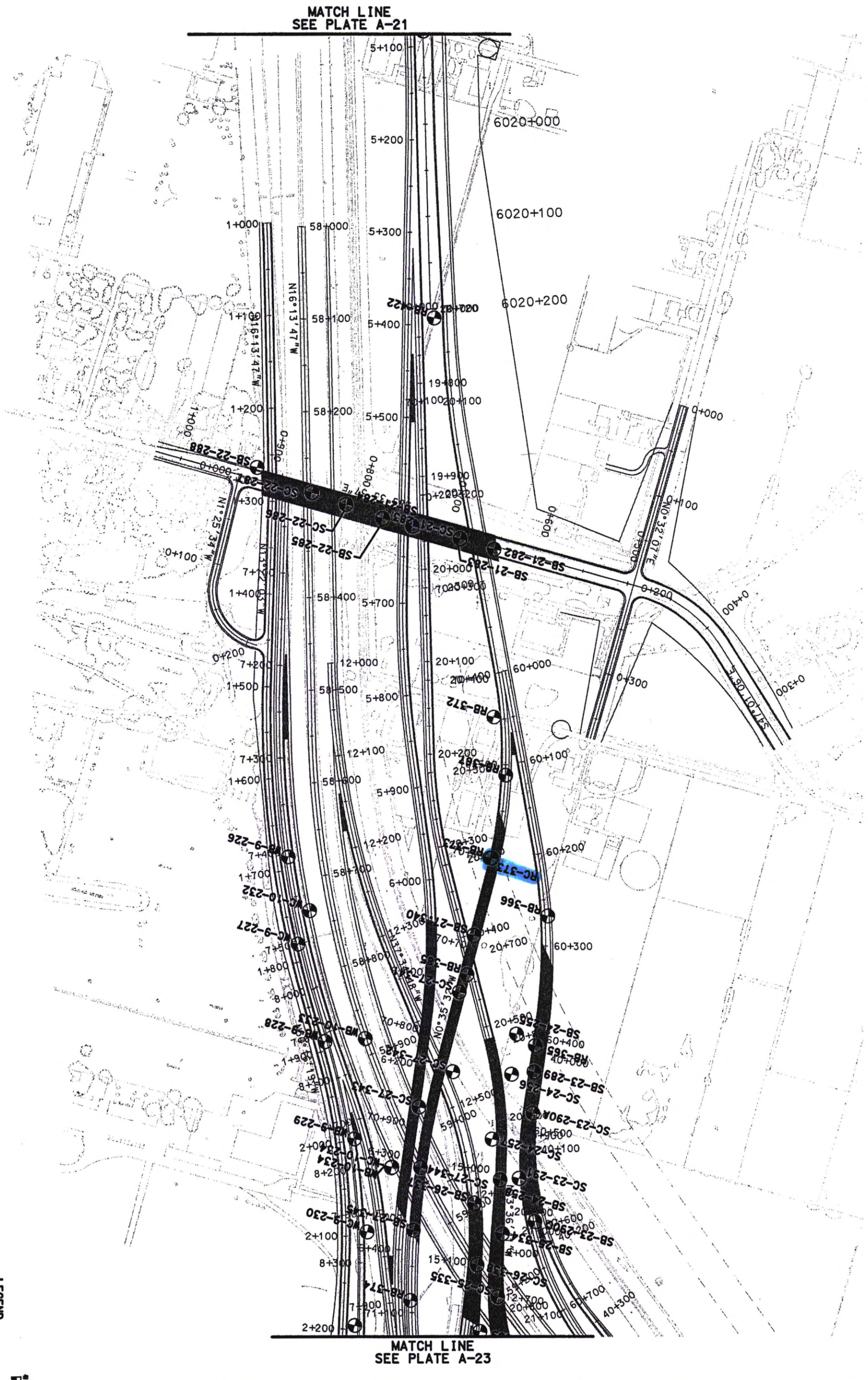
Project No. 35-8163-05

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange

EXPLORATION LOCATION DRAWING

PLATE

A-17



KLEINFELDER

Project No. 35-8163-05

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange

EXPLORATION LOCATION DRAWING

PLATE

A-22

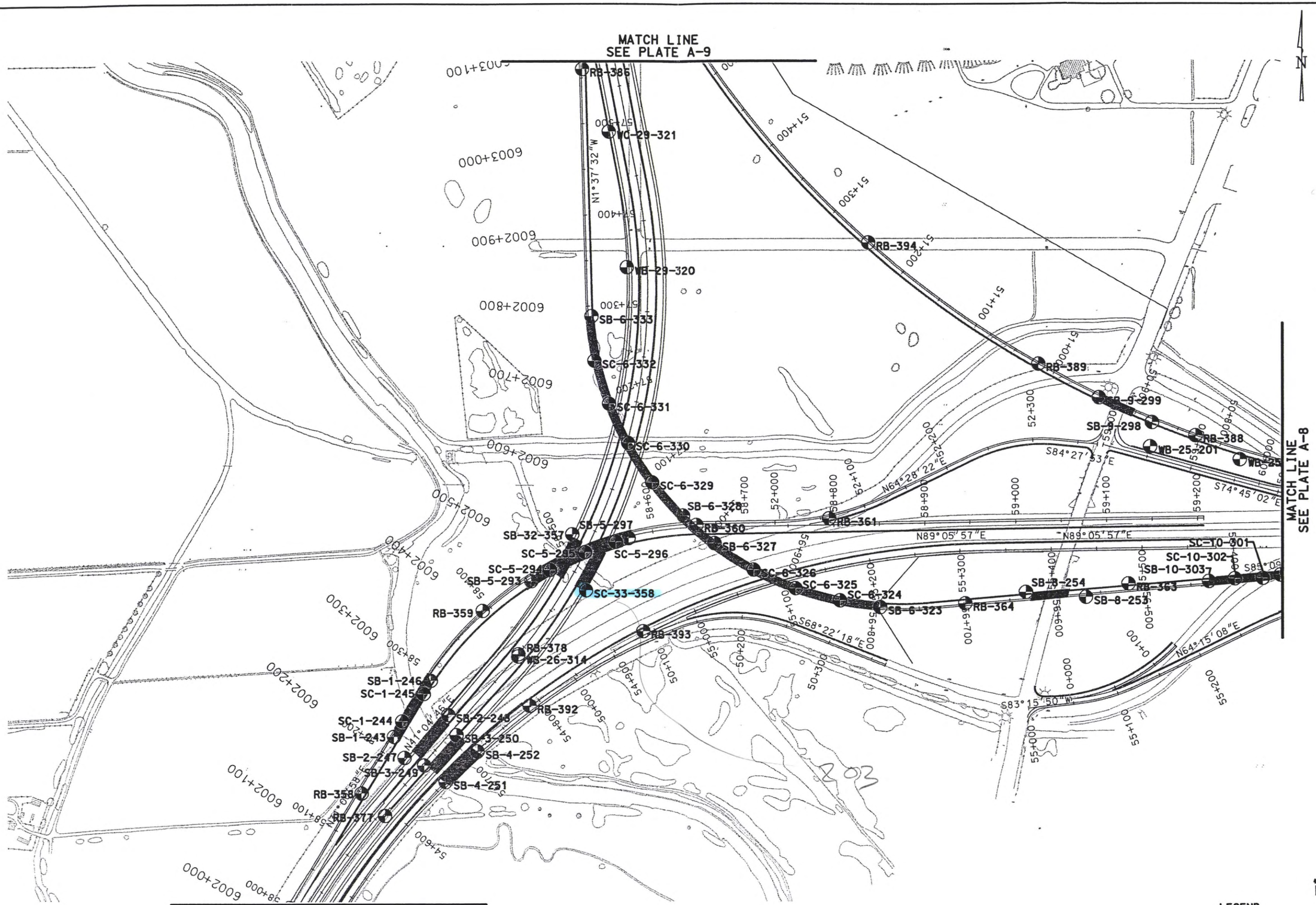


PLATE A-7

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange

EXPLORATION LOCATION DRAWING

KLEINFELDER

Project No. 35-8163-05

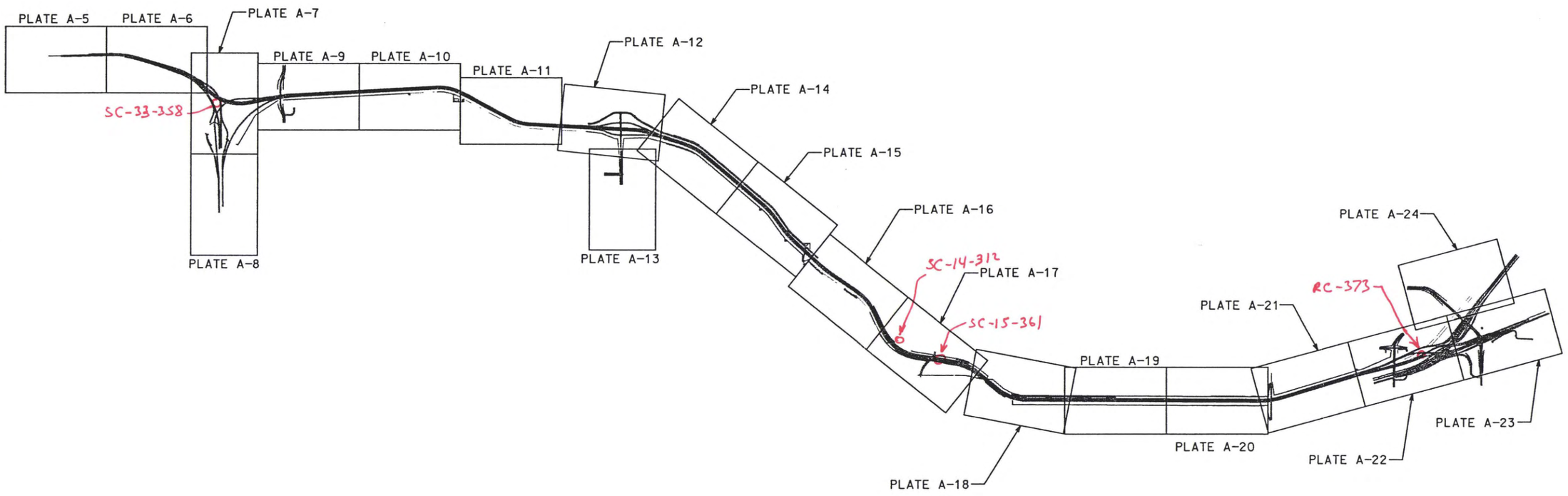


PLATE A-4

Legacy Parkway - Preferred Alternative
I-215 to I-15/US 89 Interchange
KEY TO
EXPLORATION LOCATION DRAWING

KLEINFELDER
Project No. 35-8163-05

#204

GEOSEISMIC AND GEOTECHNICAL EVALUATION EXISTING OGDEN CITY MUNICIPAL BUILDING REMODEL / SEISMIC STUDY OGDEN, UTAH

Submitted To:

Ogden City Public Works
2484 Washington Boulevard, Suite 211
Ogden, Utah 84401

Submitted By:

AGRA Earth & Environmental, Inc.
Salt Lake City, Utah

May 15, 1997

Job No. 7-817-000786

AGRA
Earth & Environmental

RESULTS OF DOWNHOLE SEISMIC SHEAR WAVE SURVEY AT THE OGDEN MUNICIPAL BUILDING, 26th STREET & WASHINGTON BOULEVARD, OGDEN, UTAH

Prepared For: AGRA INC.
Salt Lake City, Utah

Prepared By: LGS Geophysics Inc.
Salt Lake City, Utah

April, 1997

LGS GEOPHYSICS INC.
engineering, environmental, mining geophysics

Introduction

Presented in this report are the results of a downhole, seismic shear wave survey conducted within Boring B-2, located at the east central area of the Ogden Municipal Building, 26th Street and Washington Boulevard, Ogden, Utah. The purpose of the survey was to determine the seismic shear wave velocities of the subsoils at successive, five foot depth intervals within the boring. The seismic velocities thus measured form the basis for determining the elastic moduli of the subsoils under dynamic, low strain (X 10-E5 to -E4 in./in.) and high loading rate conditions. These moduli, as determined by this survey, are a function of the gross strength characteristics of the earth materials being investigated, under these low strain and high loading rate conditions.

Field Investigations

Field investigations were conducted in April, 1997. The test hole had been cased with 2 in. ID, PVC casing and backfilled with sand in preparation for conducting the survey. The downhole measurements were conducted using two orthogonal geophone units, spaced five feet apart, with each unit containing a vertical, a transverse and a radially oriented geophone. The field procedure consisted of placing the two units into the cased boring and recording the arrival of the various components of surface generated seismic waves as they arrived, successively, at the upper and lower units. This seismic energy was generated in such a way that it contained a relatively large, horizontally polarized, shear wave component. The ground motions caused by this surface signal, on its successive arrival at the two geophone units in the boring, were then transmitted to the seismograph where it was subsequently amplified and recorded. The direction of the energy impact was then reversed to confirm the onset of the shear wave arrival, thereby making use of its polarization characteristic and facilitating its identification. The geophones were then lowered five ft. and the process repeated for each successive five foot depth increment to the bottom of the test hole.

Equipment:

A signal enhancement seismograph was used in the data collection.

avoid possible signal distortion. A signal voltage sampling rate of 50,000 measurements per second was used in the analog to digital converter step to allow a high degree of accuracy (+ 0.1 milliseconds) in determining the arrival times of the seismic signals of interest. The frequency response of the vertical and the radial and transversely mounted, horizontal geophones within each of the geophone packages was 8 Hz.

Data Reduction, Comments

The use of two geophone packages, separated by a five ft. interval, enabled the measurement of interval times as well as the total travel time to the geophones from the source. Use of the interval times in the calculations avoids the possibility of potential measurement error due to any delay inherent in the timing system and essentially eliminates the affect of different travel time paths, of the seismic energy, as a source of error. Corrections were made in the depth increments in determining the seismic velocities to compensate for the 3 foot offset of the seismic source from the hole collar.

The shear modulus (G) was computed by the relationship given below, using the shear wave velocity (Vs) measured for each depth increment and the in situ density (d) of the material.

$$G = d(Vs)^2$$

{d=soil moist unit weight/gravity constant(32.2 ft./sec.^{2})}

Youngs' modulus was then determined for each depth increment, using the shear modulus and Poissons' ratio for the same increment, by the following relationship:

$$E = 2G(1+p)$$

Poissons' ratio can be determined from the ratio of the compressional and the shear wave seismic velocities. However, the compressional seismic velocities, unlike the shear wave velocities, are affected by water saturation and are thus not representative of the unsaturated condition required for the Poissons' ratio

determination. For this reason an assumed Poissons' ratio of .35 and .40 was used for in determining the Youngs modulus values presented in Tables I. We believe that an assumed value is appropriate under these circumstances since Poissons' ratio has a relatively minor affect on the results of the shear and Youngs moduli calculations.

Results

The results of the calculations together with the seismic velocities measured are presented on Table I.

We have appreciated providing this service to you. Please contact us if there are any questions on the above or if we may be of further service to you.

LGS GEOPHYSICS INC.

LaMonte Sorenson
Principal

TABLE I

204

RESULTS OF DOWNHOLE SHEAR WAVE
SURVEY, BORING B-2, OGDEN
MUNICIPAL BUILDING, OGDEN, UTAH

DEPTH (ft.)	Vs (ft./sec.)	G (lb./ft.^{2})	E (lb./ft.^{2})
0- 5	861 262.4	2.77 x 10E6	7.76 x 10E6
5-10	666 203.0	1.65 "	4.62 "
10-15	1053 321.0	4.66 "	12.58 "
15-20	1053 "	4.66 "	12.58 "
20-25	870 265.2	2.82 "	7.90 "
25-30	800 243.8	2.39 "	6.70 "
30-35	714 217.6	1.90 "	5.32 "
35-40	833 253.9	2.56 "	7.17 "
40-45	870 265.2	2.82 "	7.90 "
45-50	714 217.6	1.92 "	5.34 "
50-55	909 277.1	3.08 "	8.62 "
55-60	952 290.2	3.38 "	9.46 "
60-65	833 253.9	2.56 "	7.17 "
65-70	869 264.9	2.82 "	7.90 "
70-75	833 253.9	2.56 "	7.17 "
75-80	869 264.9	2.82 "	7.90 "
80-85	833 253.9	2.56 "	7.17 "
85-90	741 225.9	2.05 "	5.74 "
90-95	770 234.7	2.21 "	6.19 "
93-98	817 249.0	2.49 "	6.97 "

Vp = compressional wave velocity
Vs = shear wave velocity

p = Poissons' ratio
G = shear modulus
E = Young's modulus

soil unit weights used:

0 - 10'	120 pcf
10- 20'	135 pcf
15-100'	120 pcf

Poissons' ratio assumed:

0 - 10'	.40
10- 20'	.35
20-100'	.40

V_{s30} = 255.6

832 ft/s

254 m/s

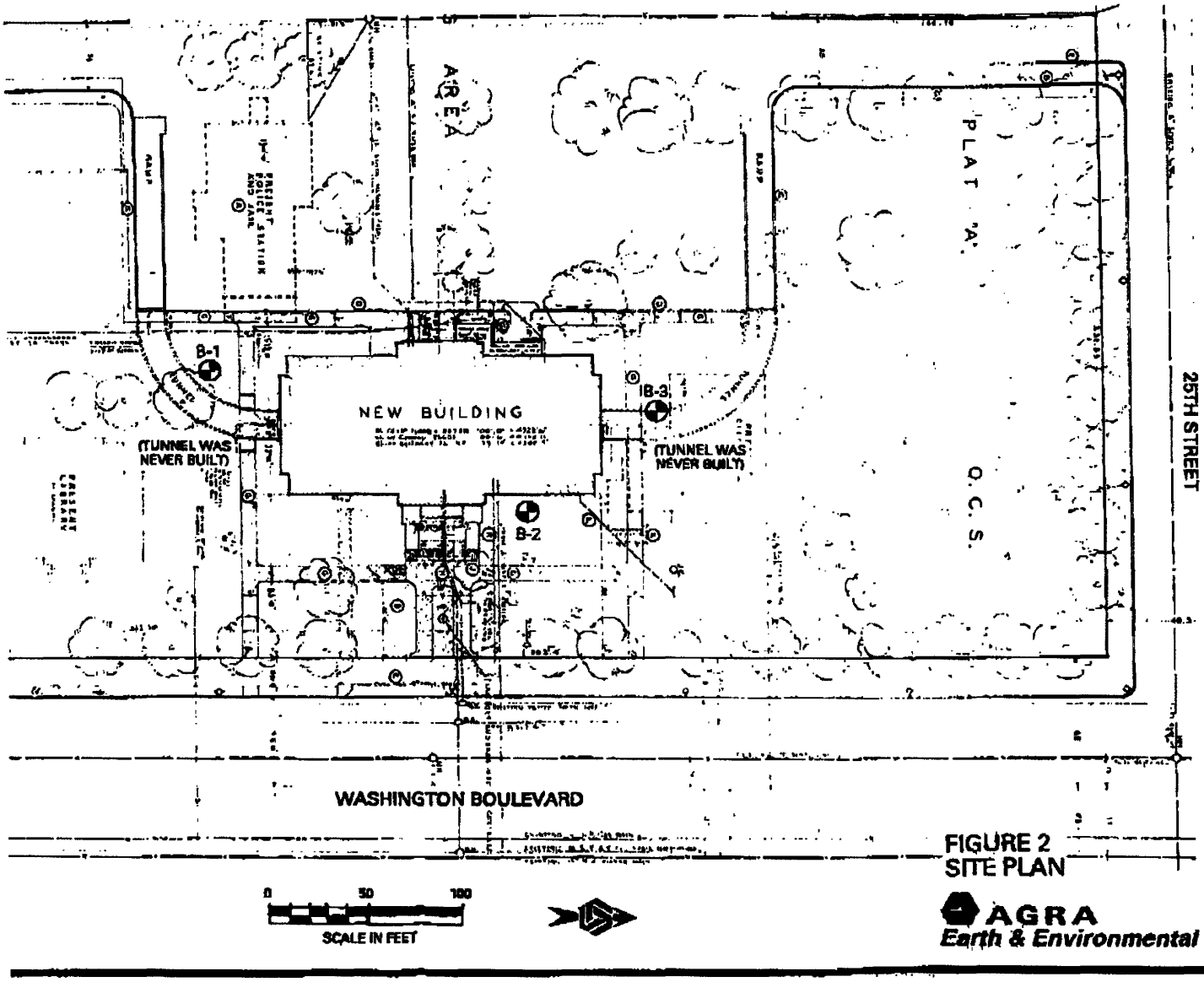


FIGURE 2
SITE PLAN

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PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								CL FILL	very moist soft	**SANDY CLAY** with major roots (topsoil) to 4"; fine to coarse sand; dark brown, FILL
								GM FILL	moist medium dense	**SANDY GRAVEL** with silt; fine to coarse sand; fine and coarse gravel; dark brown, FILL
5				D	12	82	34.9	CL	moist stiff	**SANDY CLAY**; fine sand; dark brown to black grades to brown
10				D	60			GP/ GM	slightly moist medium dense to dense	**SANDY GRAVEL** with trace silt; fine to coarse sand; fine and subrounded to rounded coarse gravel and small cobbles; brown
15				D	60				saturated dense	grades with some silt
20				D	37				saturated medium dense	
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
▼	13.6	12:00	04-17-97

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

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FIGURE 4B

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density Lbs. per cubic foot	Moisture Content of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
25				D	11					
								CL	saturated medium stiff to stiff	**SILTY CLAY TO CLAY** with occasional thin seams of silt and fine sand; seams to 1/8"; brown
30				D	11	94	29.5			
35				D	10	85	35.5			
40				D	10	86	32.4			occasional silt and fine silty sand seams
45				D	13	105	22.2		stiff	grades with more silt and fine sand seams
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
▼	13.6	12:00	04-17-97

SAMPLE TYPE

A - Auger cuttings
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T - 3" O.D. thin-walled Shelby tube.
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C - California Split Spoon Sample

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FIGURE 4B (con't)

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30 inch free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50				D	17	106	22.0	CL	saturated stiff	CLAY with occasional fine sandy silt seams; seams to 1/4"; brown with some gray
										possible gravel in drilling at 53.5'
55										
60				D	14	101	24.7			
65										
70				D	14					
75										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
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SAMPLE TYPE

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D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

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FIGURE 4B (con't)

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content % of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
75										
80				D	19					thin silt/sand seams exhibit inclined bedding
85										
90				D	17	103	23.6			grades with less silt layers
95										possible gravel layer 93.5' to 94.5'
100									very stiff	

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
▼	13.6	12:00	04-17-97

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
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AGRA Earth & Environmental

FIGURE 4B (con't)

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
100				D	41					
										Stopped drilling at 100.0'.
										Stopped sampling at 101.5'.
										Installed 2" blank flush coupled PVC pipe to 101.5'.
105										Backfilled angular space with 3/4" minus sand, sloughing during drilling at 56.0' to 60.0', and 15.0' to 25.0'.
										Backfilled from 3.0' to 7.5' consisted of 3/8" minus bentonite clay chips.
110										
115										
120										
										The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.
125										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
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FIGURE 4B (con't)

GEOSEISMIC AND GEOTECHNICAL EVALUATION
EXISTING OGDEN CITY MUNICIPAL BUILDING
REMODEL / SEISMIC STUDY
OGDEN, UTAH

Submitted To:

Ogden City Public Works
2484 Washington Boulevard, Suite 211
Ogden, Utah 84401

Submitted By:

AGRA Earth & Environmental, Inc.
Salt Lake City, Utah

May 15, 1997

Job No. 7-817-000786

AGRA
Earth & Environmental

RESULTS OF DOWNHOLE SEISMIC SHEAR WAVE SURVEY AT THE OGDEN MUNICIPAL BUILDING, 26th STREET & WASHINGTON BOULEVARD, OGDEN, UTAH

Prepared For: AGRA INC.
Salt Lake City, Utah

Prepared By: LGS Geophysics Inc.
Salt Lake City, Utah

April, 1997

Introduction

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Field Investigations

Field investigations were conducted in April, 1997. The test hole had been cased with 2 in. ID, PVC casing and backfilled with sand in preparation for conducting the survey. The downhole measurements were conducted using two orthogonal geophone units, spaced five feet apart, with each unit containing a vertical, a transverse and a radially oriented geophone. The field procedure consisted of placing the two units into the cased boring and recording the arrival of the various components of surface generated seismic waves as they arrived, successively, at the upper and lower units. This seismic energy was generated in such a way that it contained a relatively large, horizontally polarized, shear wave component. The ground motions caused by this surface signal, on its successive arrival at the two geophone units in the boring, were then transmitted to the seismograph where it was subsequently amplified and recorded. The direction of the energy impact was then reversed to confirm the onset of the shear wave arrival, thereby making use of its polarization characteristic and facilitating its identification. The geophones were then lowered five ft. and the process repeated for each successive five foot depth increment to the bottom of the test hole.

Equipment:

A signal enhancement seismograph was used in the data collection.

avoid possible signal distortion. A signal voltage sampling rate of 50,000 measurements per second was used in the analog to digital converter step to allow a high degree of accuracy (+ 0.1 milliseconds) in determining the arrival times of the seismic signals of interest. The frequency response of the vertical and the radial and transversely mounted, horizontal geophones within each of the geophone packages was 8 Hz.

Data Reduction. Comments

The use of two geophone packages, separated by a five ft. interval, enabled the measurement of interval times as well as the total travel time to the geophones from the source. Use of the interval times in the calculations avoids the possibility of potential measurement error due to any delay inherent in the timing system and essentially eliminates the affect of different travel time paths, of the seismic energy, as a source of error. Corrections were made in the depth increments in determining the seismic velocities to compensate for the 3 foot offset of the seismic source from the hole collar.

The shear modulus (G) was computed by the relationship given below, using the shear wave velocity (Vs) measured for each depth increment and the in situ density (d) of the material.

$$G = d(Vs)^2$$

{d=soil moist unit weight/gravity constant(32.2 ft./sec.^{2})}

Youngs' modulus was then determined for each depth increment, using the shear modulus and Poissons' ratio for the same increment, by the following relationship:

$$E = 2G(1+p)$$

Poissons' ratio can be determined from the ratio of the compressional and the shear wave seismic velocities. However, the compressional seismic velocities, unlike the shear wave velocities, are affected by water saturation and are thus not representative of the unsaturated condition required for the Poissons' ratio

determination. For this reason an assumed Poissons' ratio of .35 and .40 was used for in determining the Youngs modulus values presented in Tables I. We believe that an assumed value is appropriate under these circumstances since Poissons' ratio has a relatively minor affect on the results of the shear and Youngs moduli calculations.

Results

The results of the calculations together with the seismic velocities measured are presented on Table I.

We have appreciated providing this service to you. Please contact us if there are any questions on the above or if we may be of further service to you.

LGS GEOPHYSICS INC.

LaMonte Sorenson
Principal

TABLE I

RESULTS OF DOWNHOLE SHEAR WAVE SURVEY, BORING B-2, OGDEN MUNICIPAL BUILDING, OGDEN, UTAH

DEPTH (ft.)	Vs (ft./sec.)	G (lb./ft.^{2})	E (lb./ft.^{2})
0- 5	861	2.77 x 10E6	7.76 x 10E6
5-10	666	1.65 "	4.62 "
10-15	1053	4.66 "	12.58 "
15-20	1053	4.66 "	12.58 "
20-25	870	2.82 "	7.90 "
25-30	800	2.39 "	6.70 "
30-35	714	1.90 "	5.32 "
35-40	833	2.56 "	7.17 "
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45-50	714	1.92 "	5.34 "
50-55	909	3.08 "	8.62 "
55-60	952	3.38 "	9.46 "
60-65	833	2.56 "	7.17 "
65-70	869	2.82 "	7.90 "
70-75	833	2.56 "	7.17 "
75-80	869	2.82 "	7.90 "
80-85	833	2.56 "	7.17 "
85-90	741	2.05 "	5.74 "
90-95	770	2.21 "	6.19 "
93-98	817	2.49 "	6.97 "

Vp = compressional wave velocity
Vs = shear wave velocity

p = Poissons' ratio
G = shear modulus
E = Young's modulus

soil unit weights used:

0 - 10'	120 pcf
10- 20'	135 pcf
15-100'	120 pcf

Poissons' ratio assumed:

0 - 10'	.40
10- 20'	.35
20-100'	.40

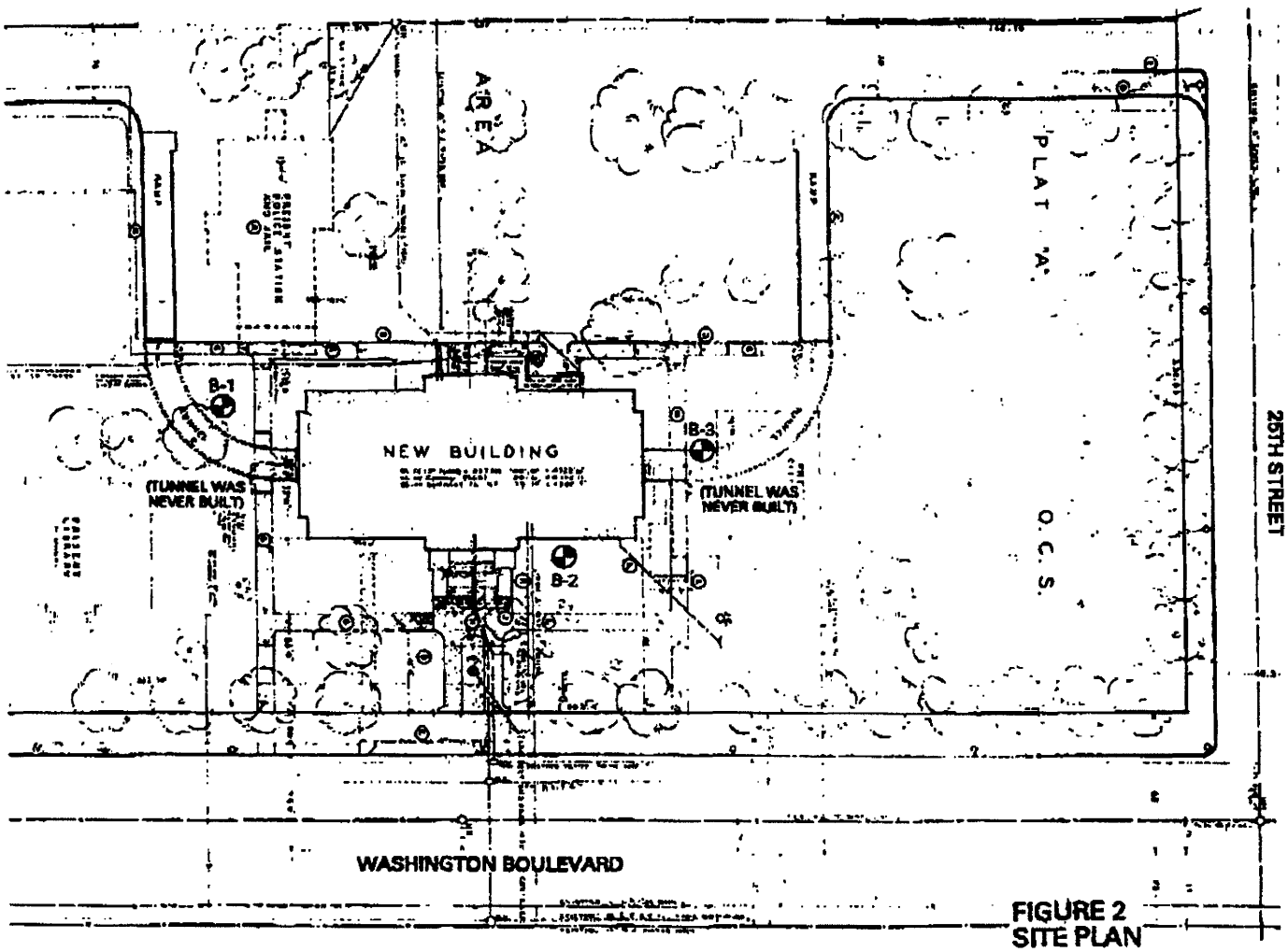

FIGURE 2
SITE PLAN

AGRA
Earth & Environmental

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs per cubic foot	Moisture Content Percent of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
0								CL FILL	very moist soft	SANDY CLAY with major roots (topsoil) to 4"; fine to coarse sand; dark brown, FILL
								GM FILL	moist medium dense	SANDY GRAVEL with silt; fine to coarse sand; fine and coarse gravel; dark brown, FILL
5				D	12	82	34.9	CL	moist stiff	SANDY CLAY; fine sand; dark brown to black grades to brown
								GP/ GM	slightly moist medium dense to dense	SANDY GRAVEL with trace silt; fine to coarse sand; fine and subrounded to rounded coarse gravel and small cobbles; brown
10				D	60					
15				D	60				saturated dense	grades with some silt
20				D	37				saturated medium dense	
25										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
▼	13.6	12:00	04-17-97

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

AGRA
Earth & Environmental

FIGURE 4B

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30-inch-fall drop hammer	Dry Density Lbs. per cubic foot	Moisture Content % of Dry Weight	Unified Classification	REMARKS	VISUAL CLASSIFICATION
25				D	11					
								CL	saturated medium stiff to stiff	SILTY CLAY TO CLAY with occasional thin seams of silt and fine sand; seams to 1/8"; brown
30				D	11	94	29.5			
35				D	10	85	35.5			
40				D	10	86	32.4			occasional silt and fine silty sand seams
45				D	13	105	22.2		stiff	grades with more silt and fine sand seams
50										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
▼	13.6	12:00	04-17-97

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
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T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split spoon Sample

AGRA Earth & Environmental

FIGURE 4B (con't)

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot - 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content % of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
50			X	D	17	106	22.0	CL	saturated stiff	CLAY with occasional fine sandy silt seams; seams to 1/4"; brown with some gray
										possible gravel in drilling at 53.5'
55										
60			X	D	14	101	24.7			
65										
70			X	D	14					
75										

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
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SAMPLE TYPE

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T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

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FIGURE 4B
(con't)

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-317-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth in Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content % of Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
75										
80				D	19					thin silt/sand seams exhibit inclined bedding
85										
90				D	17	103	23.6			grades with less silt layers
95										possible gravel layer 93.5' to 94.5'
100									very stiff	

GROUNDWATER

	DEPTH	HOUR	DATE
▽	13.6	14:47	03-10-97
▼	13.6	12:00	04-17-97

SAMPLE TYPE

A - Auger cuttings
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D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

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FIGURE 4B (con't)

PROJECT Ogden Municipal Building
2500 Washington Boulevard, Ogden, Utah

LOG OF TEST BORING NO. B-2

JOB NO. 7-817-000786 DATE 03-11-97

RIG TYPE CME 550
BORING TYPE 3-3/4" ID Hollow-Stem Auger
SURFACE ELEV.
DATUM

Depth In Feet	Continuous Penetration Resistance	Graphical Log	Sample	Sample Type	Blows/foot - 140 lb. 30" free-fall drop hammer	Dry Density lbs. per cubic foot	Moisture Content Percent Dry Weight	Unified Soil Classification	REMARKS	VISUAL CLASSIFICATION
100				D	41					
105										
110										
115										
120										
125										

Stopped drilling at 100.0'.

Stopped sampling at 101.5'.

Installed 2" blank flush coupled PVC pipe to 101.5'.

Backfilled angular space with 3/4" minus sand, sloughing during drilling at 56.0' to 60.0', and 15.0' to 25.0'.

Backfilled from 3.0' to 7.5' consisted of 3/8" minus bentonite clay chips.

The discussion in the text under the section titled, SUBSURFACE CONDITIONS, is necessary to a proper understanding of the nature of the subsurface materials.

GROUNDWATER

DEPTH	HOUR	DATE
13.6	14:47	03-10-97
13.6	12:00	04-17-97

SAMPLE TYPE

A - Auger cuttings
S - 2" O.D. 1.38" I.D. tube sample.
U - 3" O.D. 2.42" I.D. tube sample.
T - 3" O.D. thin-walled Shelby tube.
D - 3 1/4" O.D. 2.42" I.D. tube sample.
C - California Split Spoon Sample

AGRA Earth & Environmental

FIGURE 4B (con't)

UGS

APR 29 2003

205 #206

Earthtec Testing & Engineering P.C. 133 North 1330 West Orem, Utah 84057
Phone: (801) 225-5711 Fax: (801) 225-3363

To: Francis Ashland, P.G.

Company: Utah Geological Survey
1594 West North Temple
SLC, Utah 84114-6100

From: Curtis Tanner

Date: April 25, 2003

Subject: CPT Logs and Shear Wave Velocity Data

Enclosed: One copy of the CPT Data including Shear Wave Velocity Data for:
Nestle Tank Site, 815 Raymond Klauk Way, Springville, UT
Morinda (Tahitian Noni) Site, 1150 South Auto Mall Dr. American Fork, UT

Comments:

Curtis Tanner, P.E.
133 North 1330 West
Orem, Utah 84057
801-225-5711 Office
801-225-3363 Fax

CONETEC

ConeTec, Inc.
Geotechnical and Environmental Site Investigation Contractors

3589 West 500 South, Suite 3, Salt Lake City, UT 84104 • Tel:(801) 973-3801 • Fax:(801) 973-3802
Web: www.conetec.com • Email: ctecslc@attglobal.net

205

December 24, 2001 Job No.: 01-352

Mr. Dave Nelson
Earthtec Testing & Engineering, Inc.
133 North 1330 West
Orem, UT 84057

Tel: (801) 225-5711
Fax: (801) 225-3363

Re: CPT Results
Morinda Site
American Fork, Utah

Dear Dave,

Per your request, we have completed the CPT investigation for the above referenced project. Enclosed is one set of standard CPT plots, seismic CPT plots, pore pressure dissipation plots, CPT interpretations and a data diskette. The diskette contains data files for the CPT plots (*.cor files), the files for the PPD plots (*.ppd files) and the interpretation files (*.if* files). The interpretation files with the "ifp" extension are printable text files, while the interpretation files with the "ifi" extension are comma and delimited files that can be imported into any spreadsheet. The following table summarizes the work performed at the site.

CPT Location	CPT Filename	Maximum Depth (ft)	PPD Depth (ft)	PPD Duration (sec)	Ueq (ft)	Comments
CPT-1	352CP01	100.88	37.89	200	36.0	Seismic

Many correlations have been developed for design parameters based on CPT data. The interpretations are presented only as a guide for geotechnical use and should be carefully scrutinized for consideration in any geotechnical design.

Assumptions have been made regarding soil unit weights, groundwater level and interpretational methods, which may or may not apply to this site. The undrained shear strength calculations have been determined based on an assumed N_{kt} value of 12.5 and the estimated depth to groundwater is based on the results of the pore pressure dissipation test. Additionally, the following table summarizes the values assigned to the specific soil behavior type zones.

Zone	SPT Qt/N	Unit Wt. (kN/m^3)	Unit Wt. (pcf)	K (cm/s)	Description
0	1.0	19.5	124.1	$1x10^{-15}$	Undefined
1	2.0	17.5	111.4	$1x10^{-15}$	Sensitive Fines
2	1.0	12.5	79.6	$1x10^{-7}$	Organic Soil
3	1.0	17.5	111.4	$5x10^{-8}$	Clay
4	1.5	18.0	114.6	$5x10^{-7}$	Silty Clay
5	2.0	18.0	114.6	$5x10^{-6}$	Clayey Silt
6	2.5	18.0	114.6	$5x10^{-5}$	Silt
7	3.0	18.5	117.8	$5x10^{-4}$	Sandy Silt
8	4.0	19.0	120.9	$5x10^{-3}$	Silty Sand/Sand
9	5.0	19.5	124.1	$5x10^{-2}$	Sand
10	6.0	20.0	127.3	5	Gravelly Sand
11	1.0	20.5	130.5	$1x10^{-15}$	Stiff Fine Grained
12	2.0	19.0	120.9	$1x10^{-5}$	Cemented Sand

We appreciate the opportunity of providing these services to you. If you have any questions regarding the enclosed material or if, we can be of additional assistance, please contact us.

Sincerely,

ConeTec, Inc.

Shawn D. Steiner, P.E.
Manager

CONETEC

Shear Wave Velocity Calculations

205

Job No.: 01-352
Client: Earthtec
CPT No.: CPT-1
Location Morinda AF
Date: 12/18/01

Geophone Offset (m): 0.20
Source Offset (2') (m): 0.61

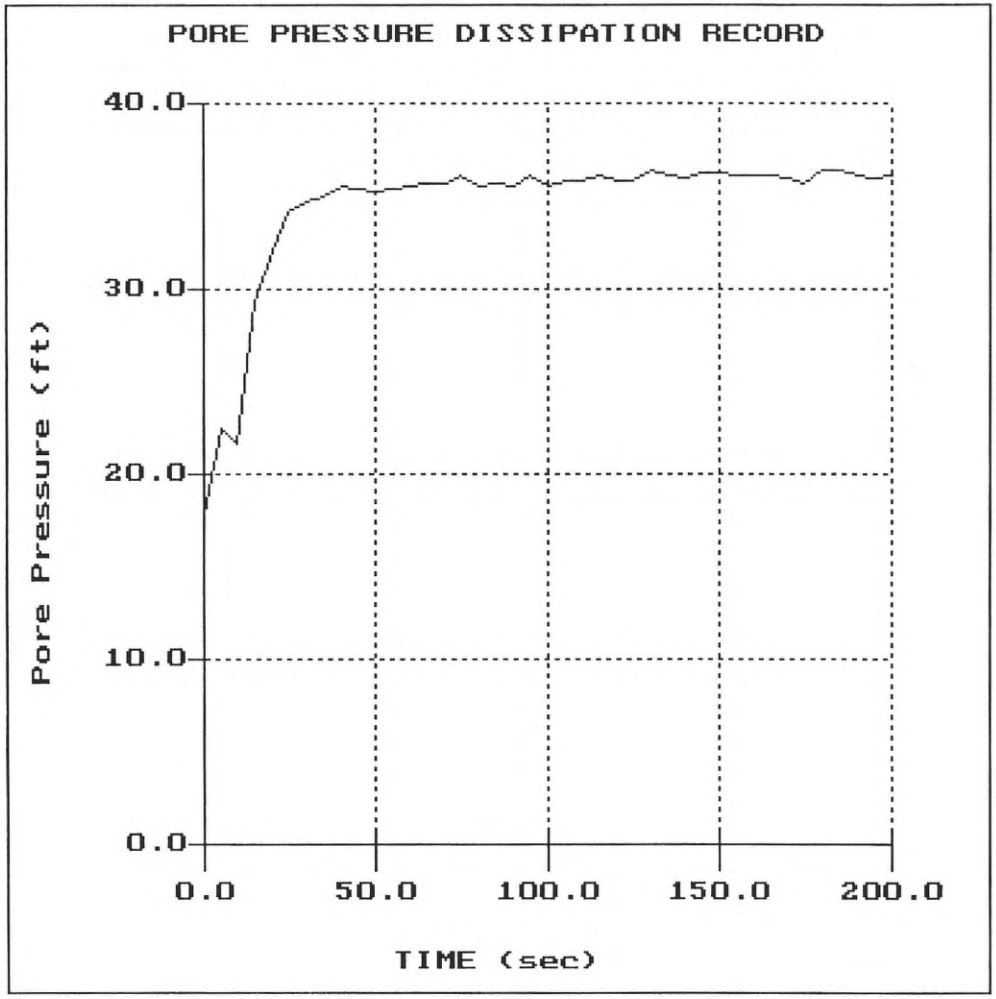
Test Depth (m)	Geophone Depth (m)	Ray Path (m)	Incremental Distance (m)	Time Interval (ms)	Interval Velocity (m/s)	Interval Depth (m)	Interval Velocity (ft/s)	Interval Depth (ft)
0.75	0.55	0.82						
1.75	1.55	1.67	0.84	8.46	99.8	1.05	327.4	3.4
2.75	2.55	2.62	0.96	7.19	133.0	2.05	436.2	6.7
3.75	3.55	3.60	0.98	8.32	117.8	3.05	386.4	10.0
4.75	4.55	4.59	0.99	6.63	149.1	4.05	489.1	13.3
5.75	5.55	5.58	0.99	7.19	138.1	5.05	452.9	16.6
6.75	6.55	6.58	0.99	8.45	117.7	6.05	386.2	19.8
7.75	7.55	7.57	1.00	7.05	141.3	7.05	463.5	23.1
8.75	8.55	8.57	1.00	5.92	168.4	8.05	552.5	26.4
9.75	9.55	9.57	1.00	5.36	186.1	9.05	610.6	29.7
10.75	10.55	10.57	1.00	5.02	198.8	10.05	652.2	33.0
11.75	11.55	11.57	1.00	4.93	202.5	11.05	664.3	36.2
12.75	12.55	12.56	1.00	5.64	177.1	12.05	580.8	39.5
13.75	13.55	13.56	1.00	5.08	196.6	13.05	645.0	42.8
14.75	14.55	14.56	1.00	5.07	197.1	14.05	646.3	46.1
15.75	15.55	15.56	1.00	5.08	196.7	15.05	645.1	49.4
16.75	16.55	16.56	1.00	4.23	236.2	16.05	774.9	52.6
17.75	17.55	17.56	1.00	4.23	236.3	17.05	774.9	55.9
18.75	18.55	18.56	1.00	4.93	202.7	18.05	664.9	59.2
19.75	19.55	19.56	1.00	4.94	202.3	19.05	663.6	62.5
20.75	20.55	20.56	1.00	4.60	217.3	20.05	712.7	65.8
21.75	21.55	21.56	1.00	4.79	208.7	21.05	684.5	69.0
22.75	22.55	22.56	1.00	5.08	196.8	22.05	645.4	72.3
23.75	23.55	23.56	1.00	5.50	181.8	23.05	596.2	75.6
24.75	24.55	24.56	1.00	5.35	186.9	24.05	612.9	78.9
25.75	25.55	25.56	1.00	4.52	221.2	25.05	725.4	82.2
26.75	26.55	26.56	1.00	4.23	236.3	26.05	775.2	85.4
27.75	27.55	27.56	1.00	4.65	215.0	27.05	705.2	88.7
28.75	28.55	28.56	1.00	3.66	273.2	28.05	896.0	92.0
29.75	29.55	29.56	1.00	4.09	244.4	29.05	801.8	95.3
30.75	30.55	30.56	1.00	3.81	262.4	30.05	860.7	98.6

V_{S30} 174 m/s

Earthtec

Hole No.:CPT-1
Location:MORINDA AF

Cone: 20 TON A 098
Date:12:18:01 09:51



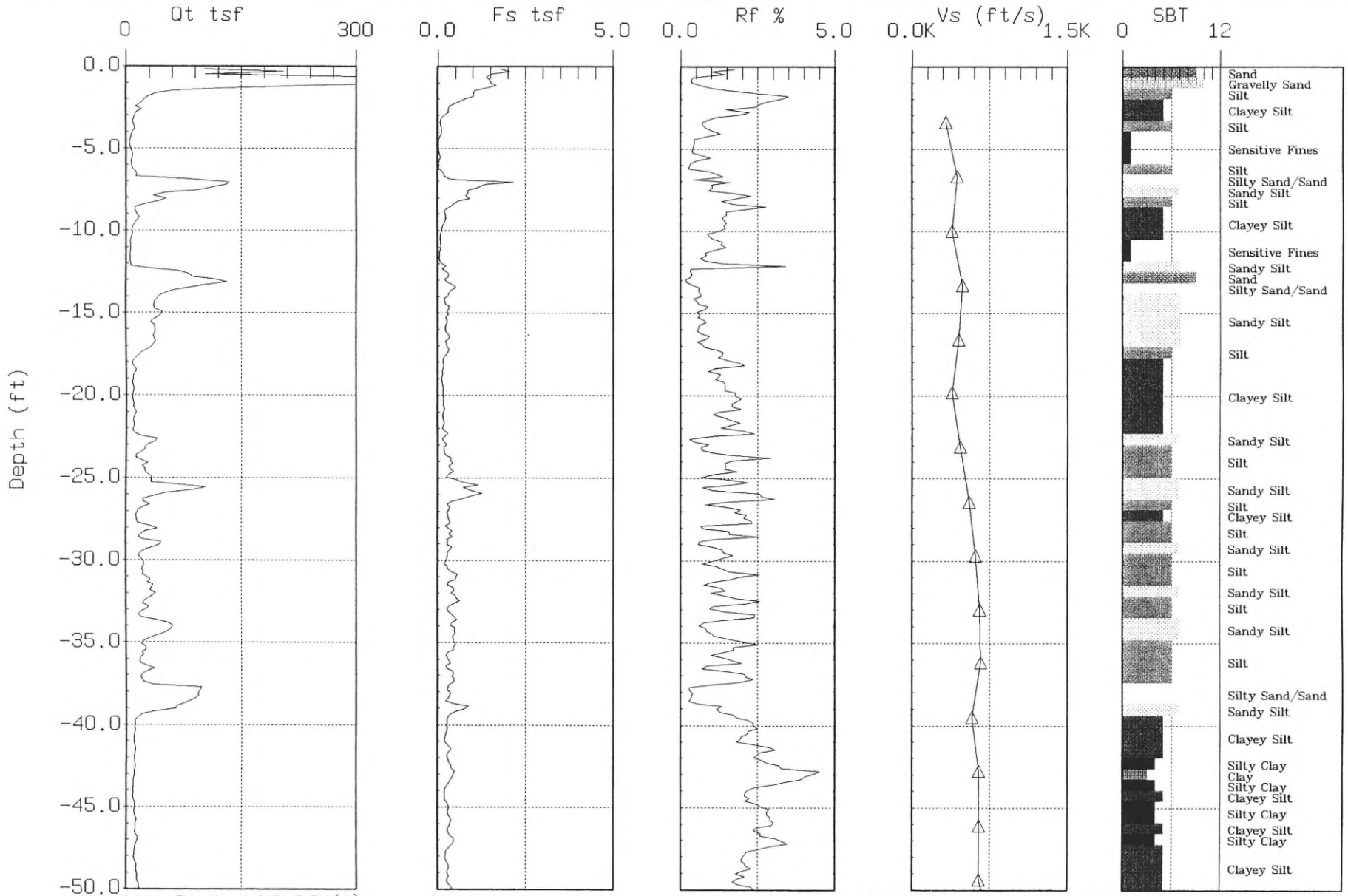
File: 352CP01.PPD
Depth (m): 11.55
(ft): 37.89
Duration : 200.0s
U-min: 17.79 0.0s
U-max: 36.37 185.0s

CONETEC

Earthtec

Hole No.: CPT-1
Location: MORINDA AF

Cone: 20 TON A 098
Date: 12:18:01 09:51



Max. Depth: 100.88 (ft)
Depth Inc.: 0.164 (ft)

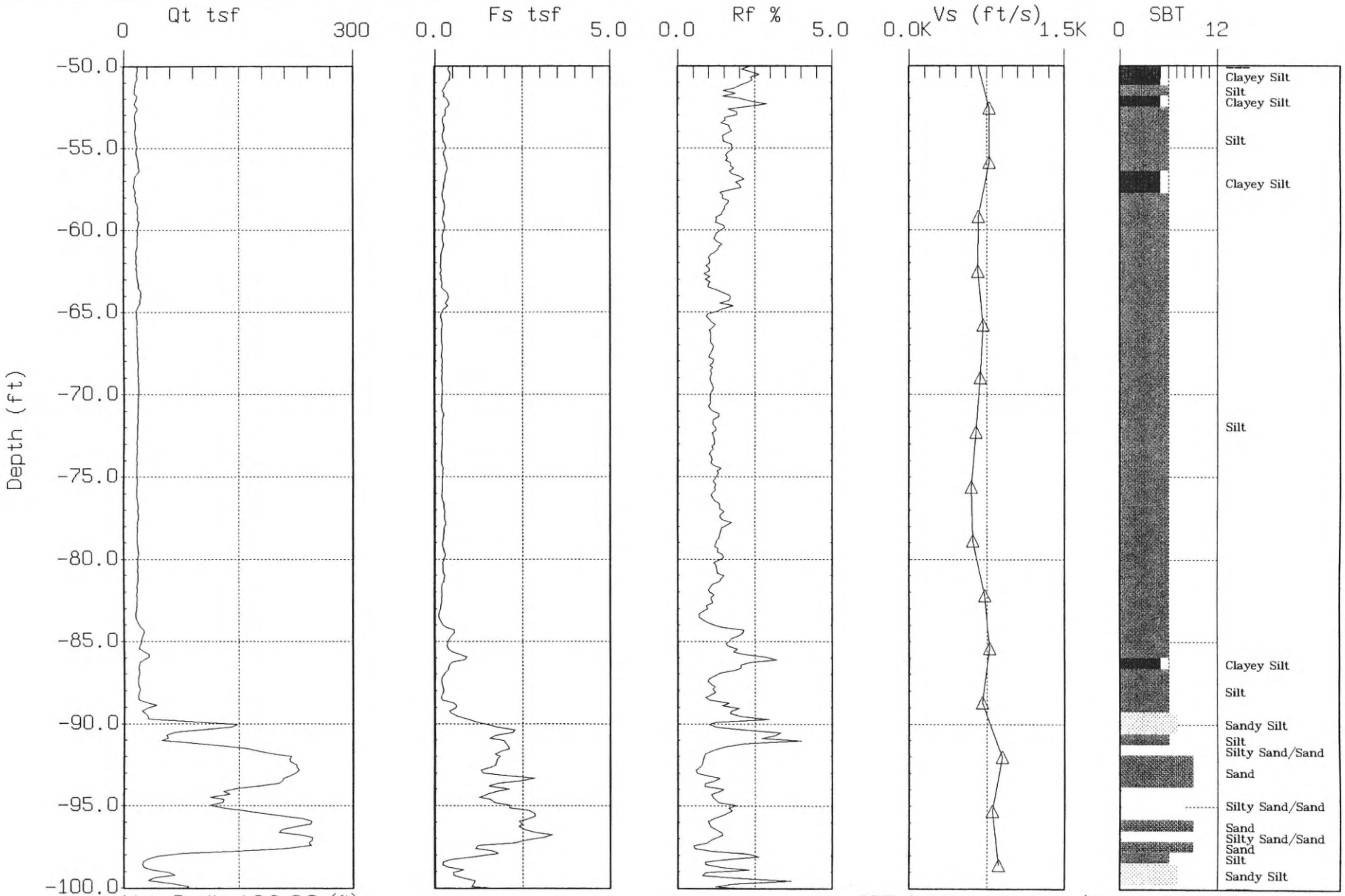
SBT: Soil Behavior Type (Robertson and Campanella 19

CONETEC

Earthtec

Hole No.: CPT-1
Location: MORINDA AF

Cone: 20 TON A 098
Date: 12:18:01 09:51



Max. Depth: 100.88 (ft)
Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson and Campanella 19

CONETEC

ConeTec, Inc.

Geotechnical and Environmental Site Investigation Contractors

PO Box 22082, Salt Lake City, UT 84122 • 3589 West 500 South, Suite 3, Salt Lake City, UT 84104
Tel: (801) 973-3801 • Fax: (801) 973-3802 • Web: www.conetec.com • Email: conetecslc@attglobal.net

206

September 23, 2002

Job No.: 02-360

Mr. Curtis Tanner
Earthtec Testing & Engineering, Inc.
133 North 1330 West
Orem, UT 84057

Tel: (801) 225-5711
Fax: (801) 225-3363

Re: CPT Results
Tank Center
Springville, Utah

Dear Curtis,

Per your request, we have completed the CPT investigation for the above referenced project. Enclosed is one set of standard CPT plots, seismic CPT plots, pore pressure dissipation plots and a data diskette. The diskette contains data files for the CPT plots (*.cor files), the files for the PPD plots (*.ppd files). The following table summarizes the work performed at the site.

CPT Location	CPT Filename	Maximum Depth (ft)	PPD Depth (ft)	PPD Duration (sec)	Ueq (ft)	Comments
CPT-1	360CP01	150.10	16.24	400	12.1	Seismic to 100 ft.

Many correlations have been developed for design parameters based on CPT data. The interpretations are presented only as a guide for geotechnical use and should be carefully scrutinized for consideration in any geotechnical design.

Assumptions have been made regarding soil unit weights, groundwater level and interpretational methods, which may or may not apply to this site. The following table summarizes the values assigned to the specific soil behavior type zones.

Zone	SPT Qt/N	Unit Wt. (kN/m^3)	Unit Wt. (pcf)	K (cm/s)	Description
0	1.0	19.5	124.1	$1x10^{-15}$	Undefined
1	2.0	12.5	79.6	$1x10^{-7}$	Sensitive Fines
2	1.0	17.5	111.4	$1x10^{-15}$	Organic Soil
3	1.0	17.5	111.4	$5x10^{-8}$	Clay
4	1.5	18.0	114.6	$5x10^{-7}$	Silty Clay
5	2.0	18.0	114.6	$5x10^{-6}$	Clayey Silt
6	2.5	18.0	114.6	$5x10^{-5}$	Silt
7	3.0	18.5	117.8	$5x10^{-4}$	Sandy Silt
8	4.0	19.0	120.9	$5x10^{-3}$	Silty Sand/Sand
9	5.0	19.5	124.1	$5x10^{-2}$	Sand
10	6.0	20.0	127.3	5	Gravelly Sand
11	1.0	20.5	130.5	$1x10^{-15}$	Stiff Fine Grained
12	2.0	19.0	120.9	$1x10^{-5}$	Cemented Sand

We appreciate the opportunity of providing these services to you. If you have any questions regarding the enclosed material or if, we can be of additional assistance, please contact us.

Sincerely,

ConeTec, Inc.

Shawn D. Steiner, P.E.
Manager

Enclosures

206

CONETEC

Shear Wave Velocity Calculations

Job No.: 02-360
Client: Earthtec Testing & Engineering
CPT No.: CPT-1
Location Tank Center
Date: 9/7/02

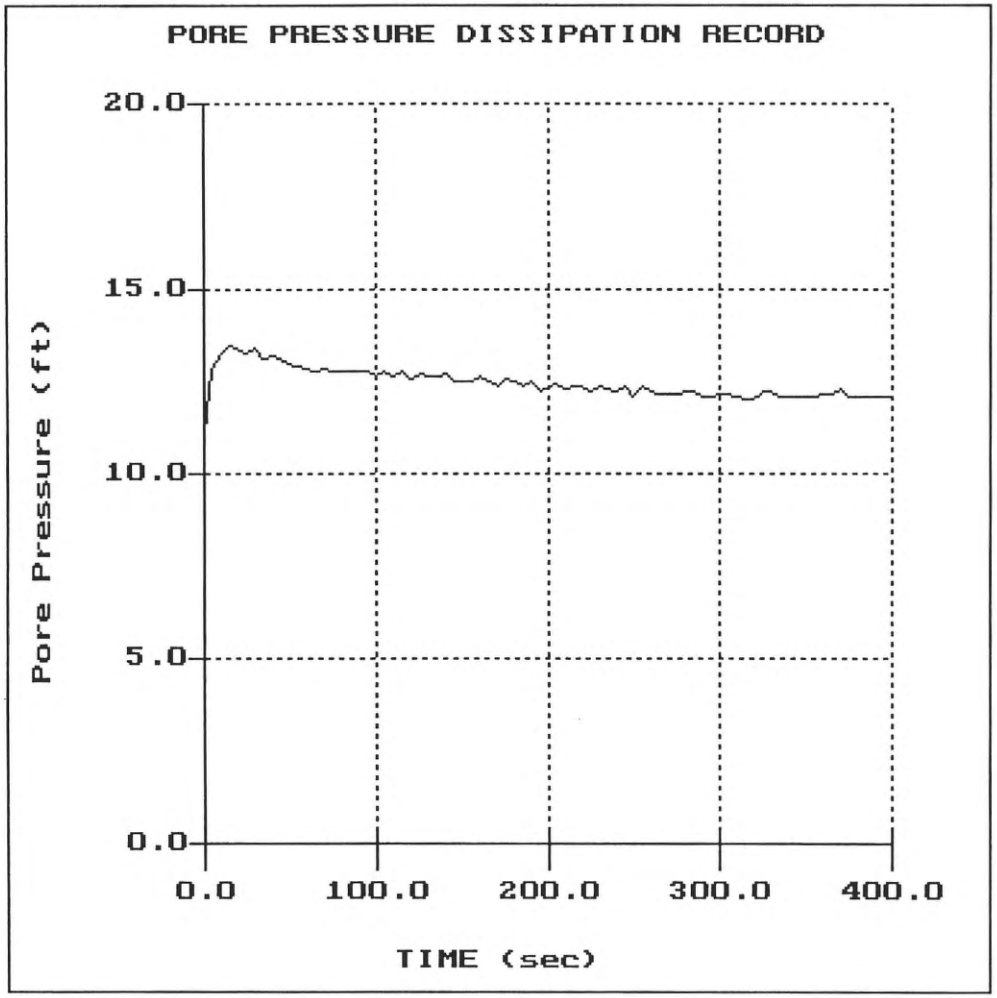
Geophone Offset (m): 0.20
Source Offset (2') (m): 0.61

Test Depth (m)	Geophone Depth (m)	Ray Path (m)	Incremental Distance (m)	Time Interval (ms)	Interval Velocity (m/s)	Interval Depth (m)	Interval Velocity (ft/s)	Interval Depth (ft)
0.80	0.60	0.86						
1.80	1.60	1.71	0.86	8.60	99.6	1.10	326.7	3.6
2.80	2.60	2.67	0.96	6.63	144.5	2.10	474.1	6.9
3.80	3.60	3.65	0.98	6.62	148.1	3.10	485.9	10.2
4.80	4.60	4.64	0.99	6.49	152.4	4.10	499.8	13.4
5.80	5.60	5.63	0.99	6.20	160.1	5.10	525.3	16.7
6.80	6.60	6.63	1.00	6.35	156.7	6.10	514.0	20.0
7.80	7.60	7.62	1.00	6.48	153.8	7.10	504.3	23.3
8.80	8.60	8.62	1.00	7.33	136.0	8.10	446.2	26.6
9.80	9.60	9.62	1.00	7.19	138.8	9.10	455.2	29.8
10.80	10.60	10.62	1.00	6.89	144.9	10.10	475.2	33.1
11.80	11.60	11.62	1.00	7.07	141.2	11.10	463.2	36.4
12.80	12.60	12.61	1.00	6.92	144.3	12.10	473.4	39.7
13.80	13.60	13.61	1.00	6.31	158.3	13.10	519.2	43.0
14.80	14.60	14.61	1.00	5.57	179.4	14.10	588.3	46.2
15.80	15.60	15.61	1.00	4.96	201.4	15.10	660.8	49.5
16.80	16.60	16.61	1.00	4.96	201.5	16.10	660.8	52.8
17.80	17.60	17.61	1.00	4.81	207.8	17.10	681.5	56.1
18.80	18.60	18.61	1.00	5.27	189.6	18.10	622.0	59.4
19.80	19.60	19.61	1.00	5.26	190.0	19.10	623.3	62.6
20.80	20.60	20.61	1.00	5.71	175.1	20.10	574.2	65.9
21.80	21.60	21.61	1.00	5.42	184.4	21.10	604.9	69.2
22.80	22.60	22.61	1.00	5.71	175.1	22.10	574.2	72.5
23.80	23.60	23.61	1.00	6.32	158.2	23.10	518.8	75.8
24.80	24.60	24.61	1.00	6.16	162.3	24.10	532.3	79.0
25.80	25.60	25.61	1.00	6.02	166.1	25.10	544.7	82.3
26.80	26.60	26.61	1.00	6.16	162.3	26.10	532.3	85.6
27.80	27.60	27.61	1.00	5.72	174.8	27.10	573.3	88.9
28.80	28.60	28.61	1.00	5.71	175.1	28.10	574.3	92.2
29.80	29.60	29.61	1.00	5.57	179.5	29.10	588.7	95.4
30.80	30.60	30.61	1.00	4.51	221.7	30.10	727.1	98.7

Earthtec

Hole No.:CPT-1
Location:TANK CENTER

Cone: 20 TON A 122
Date:09:07:02 09:39



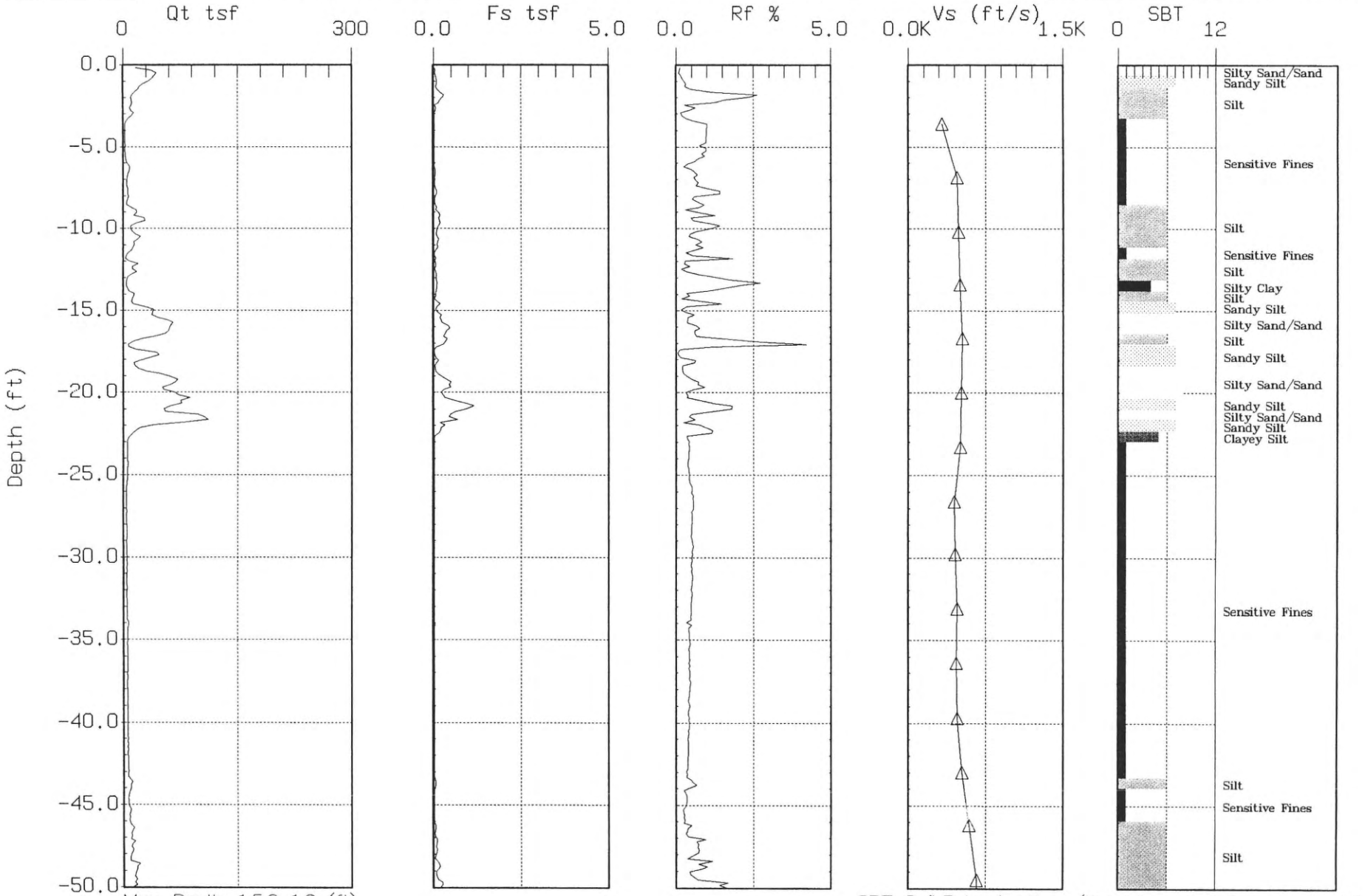
File: 360CP01.PPD
Depth (m): 4.95
(ft): 16.24
Duration : 400.0s
U-min: 11.03 0.0s
U-max: 13.47 15.0s

CONETEC

Earthtec

Hole No.: CPT-1
Location: TANK CENTER

Cone: 20 TON A 122
Date: 09:07:02 09:39



Max. Depth: 150.10 (ft)
Depth Inc.: 0.164 (ft)

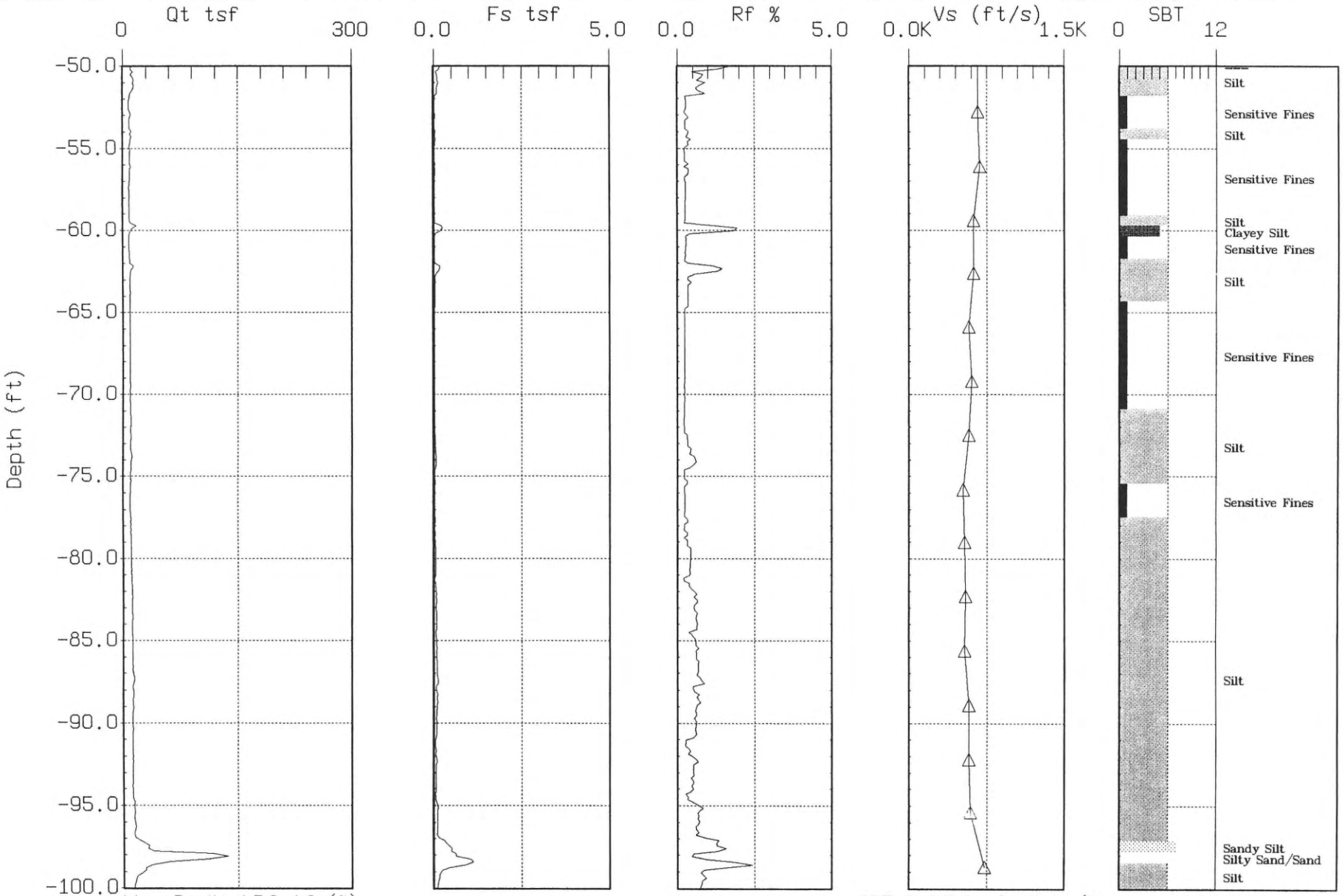
SBT: Soil Behavior Type (Robertson and Campanella 19

CONETEC

Earthtec

Hole No.: CPT-1
Location: TANK CENTER

Cone: 20 TON A 122
Date: 09:07:02 09:39



Max. Depth: 150.10 (ft)
Depth Inc.: 0.164 (ft)

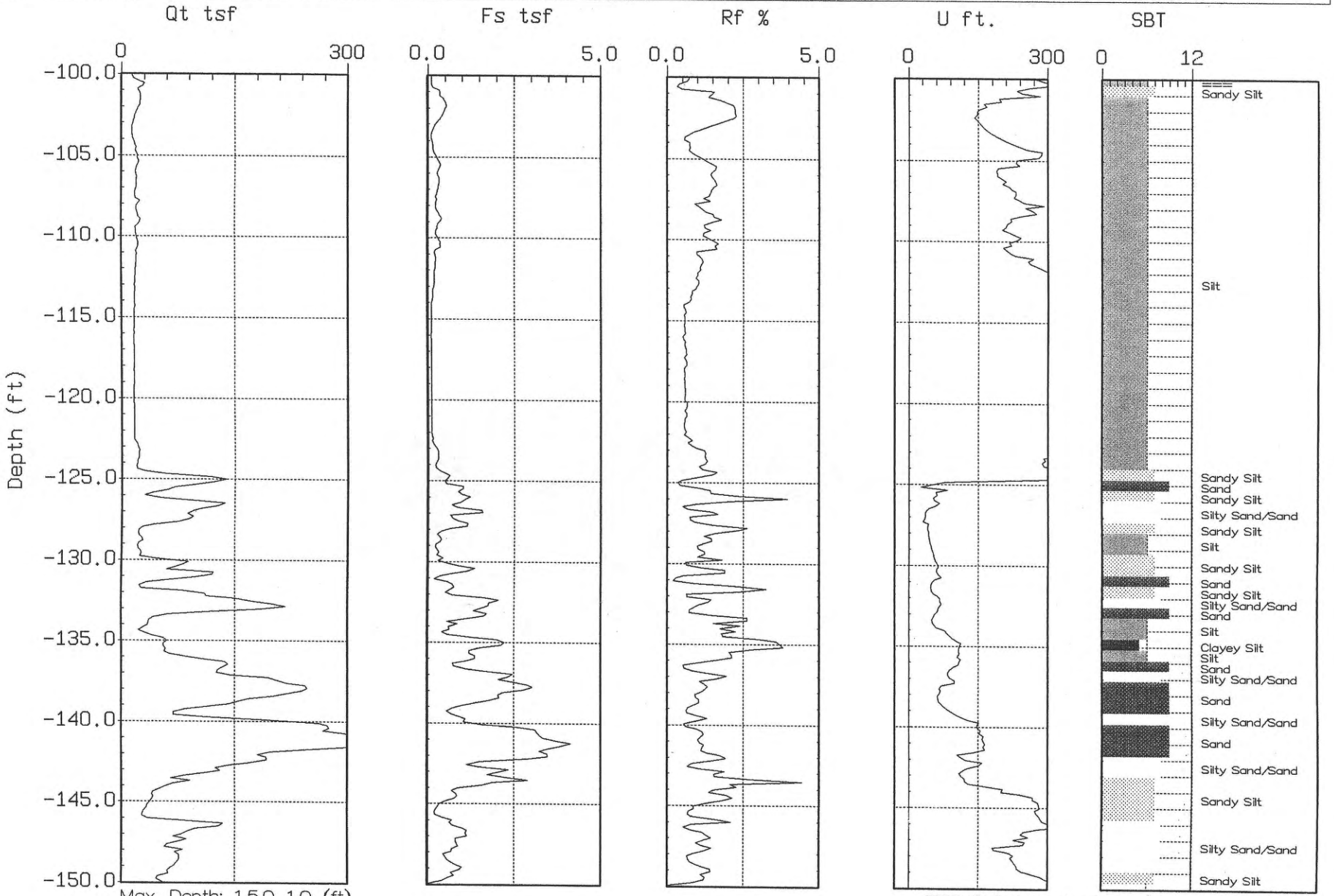
SBT: Soil Behavior Type (Robertson and Campanella 19

CONETEC

Earthtec

Hole No.: CPT-1
Location: TANK CENTER

Cone: 20 TON A 122
Date: 09:07:02 09:39



Max. Depth: 150.10 (ft)
Depth Inc.: 0.164 (ft)

SBT: Soil Behavior Type (Robertson 1990)

● Equilibrium Pore Pressure from Dissipation

207

ave of all sites

SASW Testing at the Metropolitan Water District, Little Cottonwood Canyon Water Treatment Plant Salt Lake City, Utah

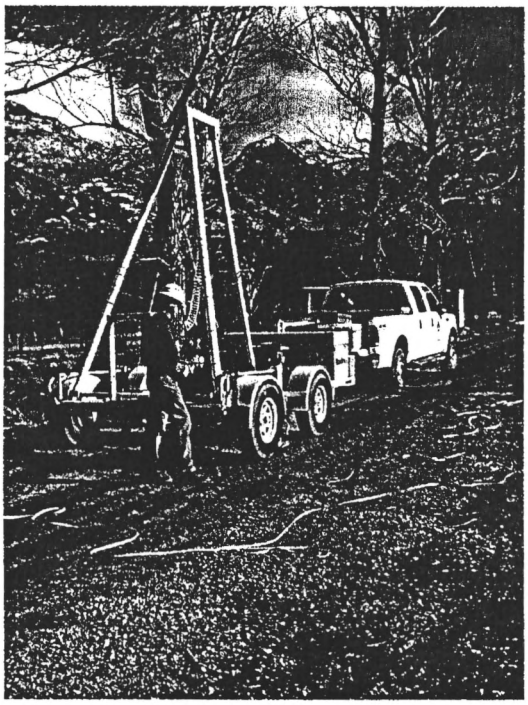
Dr. James A. Bay,
Jeffrey Gilbert, and
Intuorn Sasanakul

Department of Civil and Environmental Engineering
Utah State University
Logan, Utah 84322-4110

Prepared for

URS Corporation
500 12th Street
Suite 200
Oakland, CA 94607-4014

April 18, 2003



Introduction

On 17 February 2003, Spectral-Analysis-of-Surface-Wave (SASW) tests were performed at nine locations at the Metropolitan Water District, Water Treatment Plant at the mouth of Little Cottonwood Canyon, in Salt Lake City, Utah. The test were conducted by Dr. James A. Bay, Inthuorn, Sasanakul, Jeffery Gilbert, and Kenneth D. Jewkes from Utah State University. The purpose of the testing was to determine the shear wave velocity profiles across the facility.

The SASW Method

General Theory The SASW method is a nonintrusive seismic technique used to determine the shear wave velocity profile of a site using wave sources and receivers on the ground surface (1-4). Unlike other surface seismic methods, such as refraction, the SASW method can be used to detect and measure the properties of softer layers located beneath stiffer layers.

The SASW method is used to measure the propagation velocity of Rayleigh-type surface waves. These surface waves propagate along the ground surface, and exhibit wave motion that attenuates with depth into the earth. Practically all wave motion occurs at depths within one wavelength of ground surface. The velocity of Rayleigh-type surface waves is largely controlled by the shear modulus of the material through which the waves are propagating, with the Rayleigh wave velocity about 10% less than the shear wave velocity of that material.

When surface waves propagate through a uniform material with a constant shear modulus, waves with various wavelengths will all propagate with the same velocity. This condition is shown in Fig. 1. If the velocity varies with depth, different wavelengths will propagate at different velocities. This is known as dispersion and plots that show the variation in wave velocity with either wavelength or frequency are called dispersion curves. For example, a dispersion curve for a system with two layers (a soft layer over a stiffer layer) is shown in Fig. 2. Wavelengths that are less than the thickness of the surface layer only disturb the surface layer and propagate with a velocity that is only influenced by the softer, surface layer. As the wavelengths become longer than the thickness of the surface layer, the waves disturb the stiffer layer and exhibit velocities that are influenced by the stiffer layer. As the wavelengths become longer, the stiffer layer exerts more influence until the wavelengths become long relative to thickness of the surface layer, and the wave velocity is only influenced by the stiffer layer. More complicated layered systems result in more complicated dispersion curves.

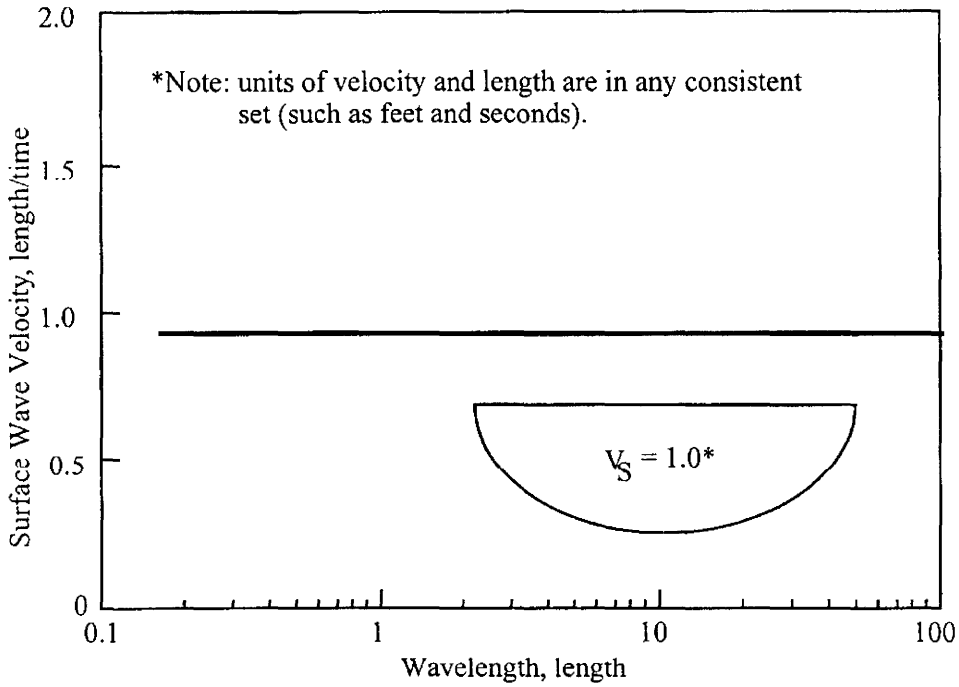


Fig. 1 Surface Wave Dispersion for a Single, Uniform Layer

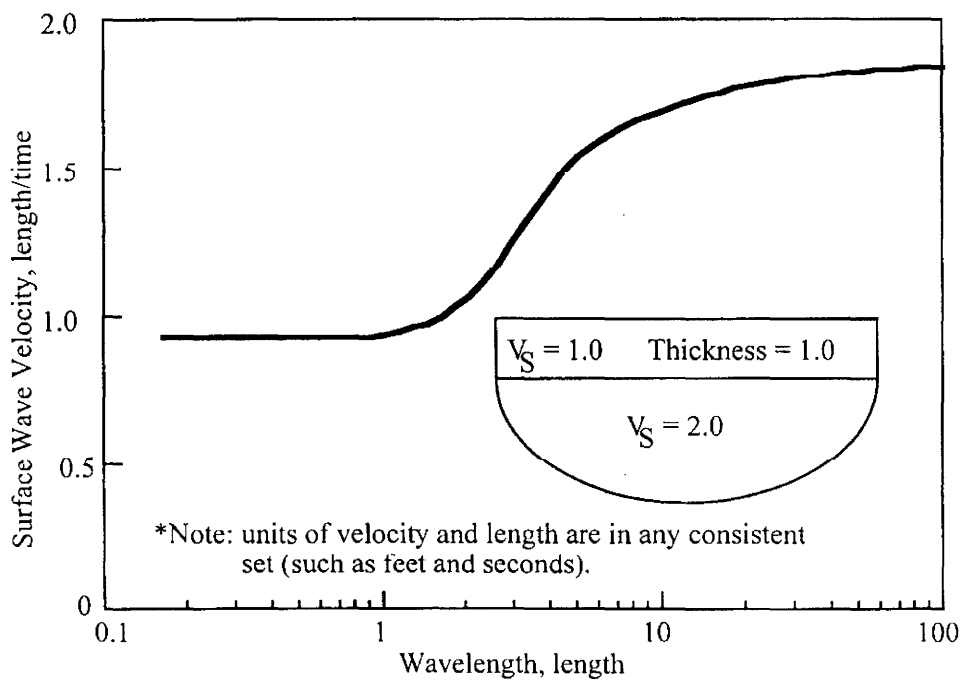


Fig. 2 Surface Wave Dispersion for a Two-Layer System

Testing Procedure The SASW method requires two or more receivers, capable of measuring the vertical motion of the ground surface, a source or sources capable of generating a wide range of frequencies, and a recording instrument capable of separating the waveforms from the receivers into their various frequency components. The general testing configuration used for the testing at the water treatment plant is shown in Fig. 3. The receivers and the source are positioned along a line with the distance between the source and the first receiver the same as the distance between the first receiver and the second receiver. The distance between the second and third receiver is equal to the distance from the source to the second receiver. Measurements are made simultaneously between receivers 1 and 2, and receivers 2 and 3. For a given spacing, wavelengths from 0.5 time the spacing between receivers, to 2 times the spacing between receivers can usually be measured. Testing typically begins with a short spacing and then the spacing is increased in subsequent tests to measure longer wavelengths. An 8-lb instrumented hammer was used as a wave sources to generate high frequencies (short wavelengths) at receiver spacings of 6 and 12 ft. At longer receiver spacings, a 4500-lb drop weight was employed to generate lower frequencies (longer wavelengths). Site geometry limited the longest receiver spacing at each site, with maximum spacings ranging from 170 to 300 ft. Tests at each receiver spacing are usually repeated by reversing the direction of wave propagation to average out any receiver-coupling effects and any effects of lateral variability at the site. The waveforms are recorded and spectral analyses performed on a Fast-Fourier-Transform (FFT) dynamic signal analyzer.

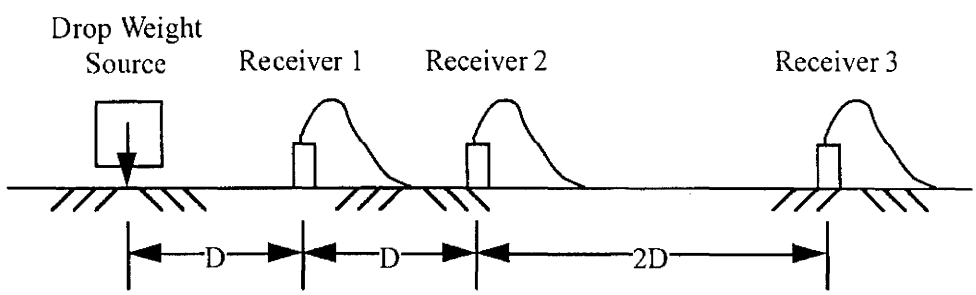


Fig. 3 SASW Testing Configuration

Forward Modeling Procedure The dispersion curve for a site is measured using the procedures described above. An iterative forward modeling process is then used to determine the shear wave velocity profile of the site from the measured dispersion curve. This involves making an initial estimate of the shear wave velocity profile and assuming values of mass density and either Poisson's ratio or confined compression wave (P-wave) velocity. Forward modeling is then performed with a computer to determine the theoretical dispersion curve for the estimated profile. The theoretical dispersion curve is then compared to the measured dispersion curve and the estimated profile is modified accordingly. This procedure is repeated until the measured and theoretical dispersion curves match each other very closely, at which point the estimated profile will closely represent the actual velocity profile at the site A program developed by Professor Jose M. Roesset of the University of Texas is used to perform the forward modeling (5).

Testing at Little Cottonwood Canyon Water Treatment Plant

Locations of nine SASW test locations are shown on the aerial photograph in Fig. 4. The lines indicate the alignment of receiver arrays with the approximate centerline of the array marked with a circular target.

Outer Access Gate The experimental dispersion curve measured at the outer access gate is shown in Fig. 5. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 6. A plot of the shear wave velocity profile is shown in Fig. 7. Tabulated values of the parameters used in forward modeling are presented in Table 1.

Southwest of Aeration Basin The experimental dispersion curve measured southwest of the aeration basin is shown in Fig. 8. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 9. A plot of the shear wave velocity profile is shown in Fig. 10. Tabulated values of the parameters used in forward modeling are presented in Table 2.

South of Old Chemical Building The experimental dispersion curve measured south of the old chemical building is shown in Fig. 11. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 12. A plot of the shear wave velocity profile is shown in Fig. 13. Tabulated values of the parameters used in forward modeling are presented in Table 3.

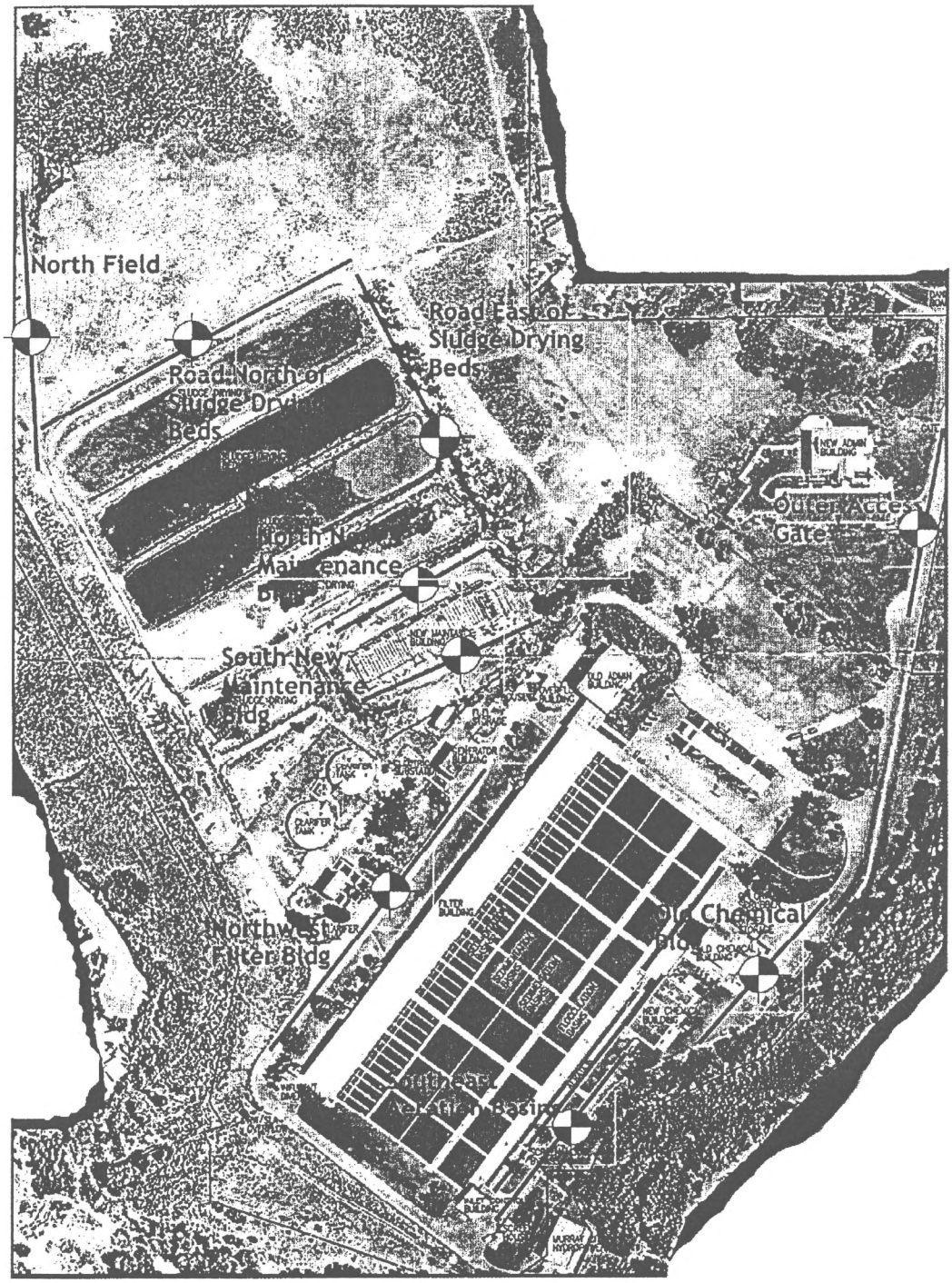


Fig. 4 Aerial Photograph Showing the SASW Test Locations at the Little Cottonwood Canyon Water Treatment Plant.

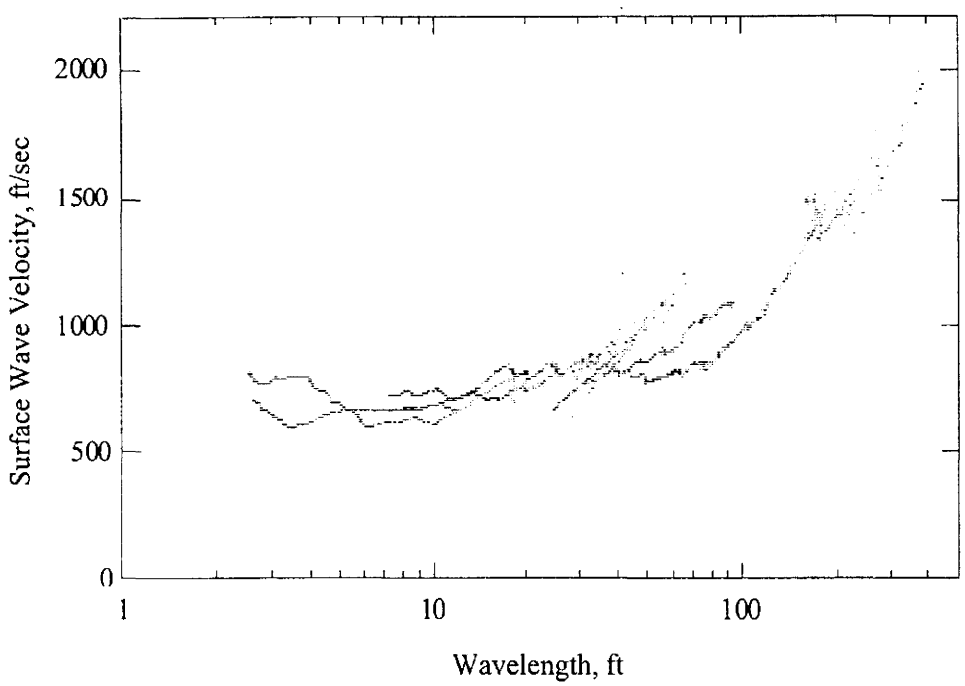


Fig. 5 Experimental Dispersion Curve Measured at the Outer Access Gate, Little Cottonwood Canyon Water Treatment Plant.

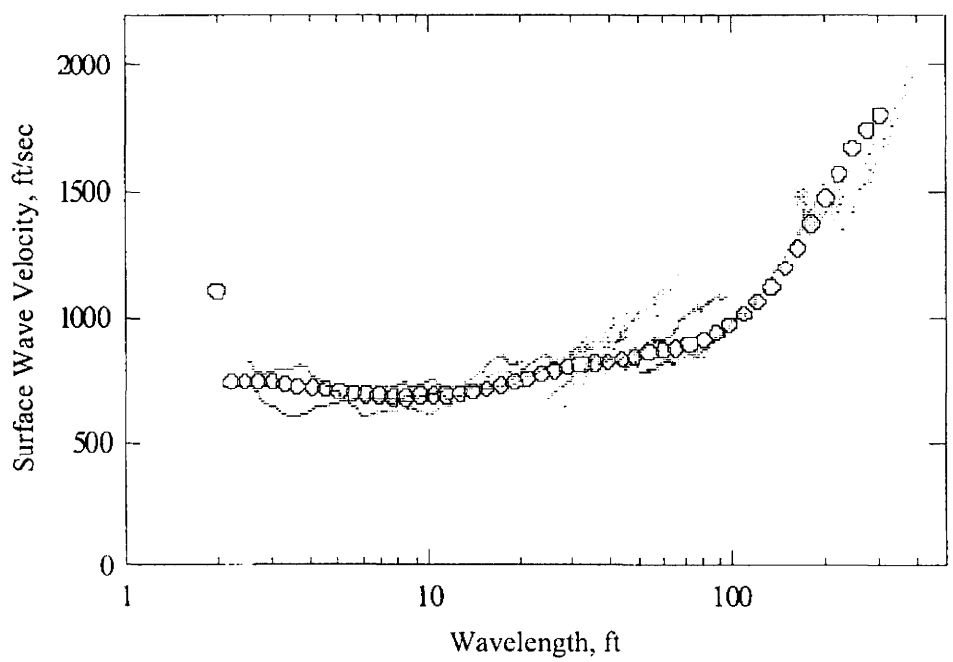


Fig. 6 Comparison between Experimental and Theoretical Dispersion Curves from Outer Access Gate, Little Cottonwood Canyon Water Treatment Plant.

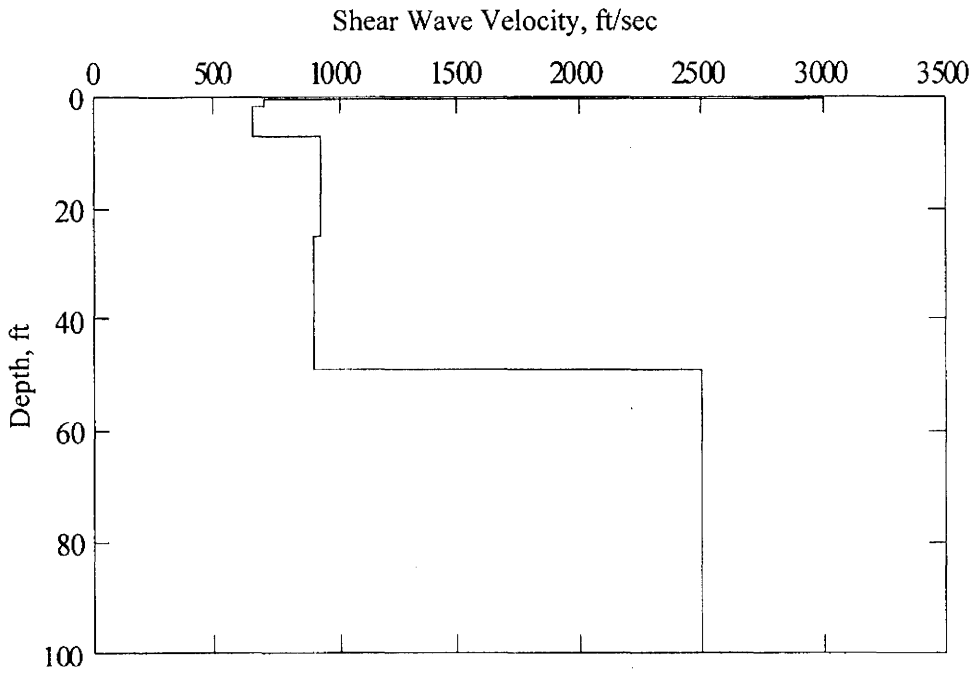


Fig. 7 Shear Wave Velocity Profile Determined from SASW Test at Outer Access Gate, Little Cottonwood Canyon Water Treatment Plant.

Table1 Soil Profile from SASW Test at Outer Access Gate, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	0.25	3000	5610	120
2	1.75	700	1350	120
3	5.0	650	1220	120
4	18.0	935	1750	120
5	24.0	900	1680	120
6	51.0*	2500	4680	135

* Half-space in model

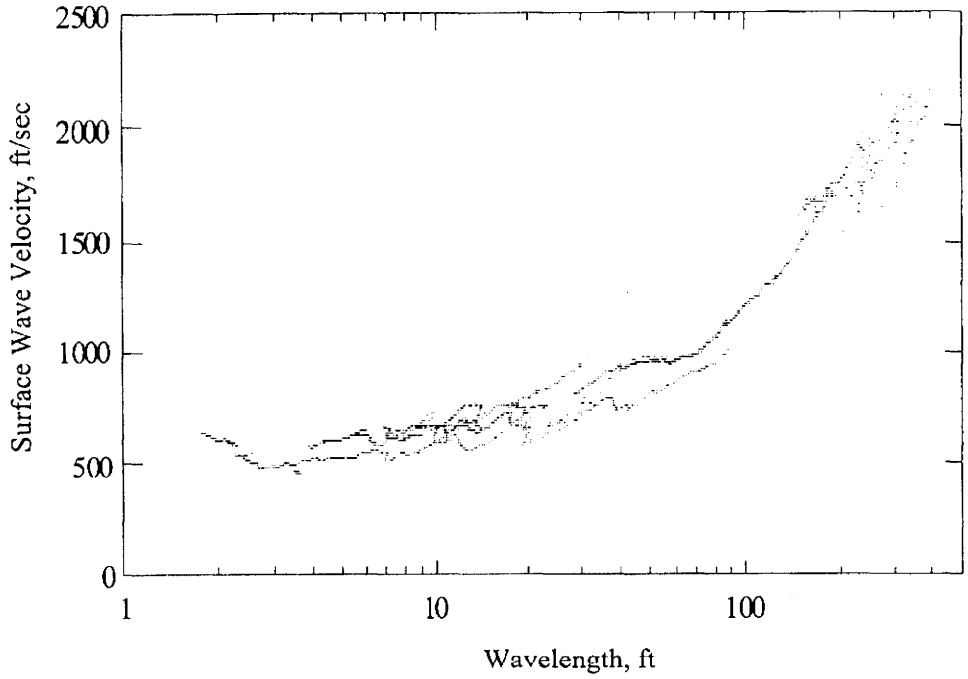


Fig. 8 Experimental Dispersion Curve Measured Southwest of the Aeration Basin, Little Cottonwood Canyon Water Treatment Plant.

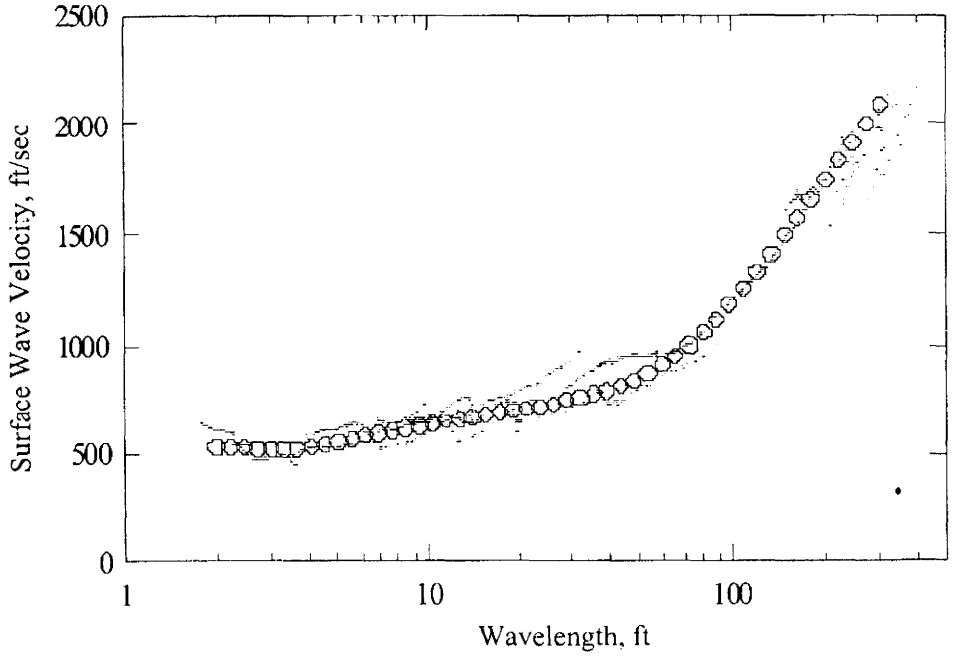


Fig. 9 Comparison between Experimental and Theoretical Dispersion Curves from Southwest of Aeration Basin, Little Cottonwood Canyon Water Treatment Plant.

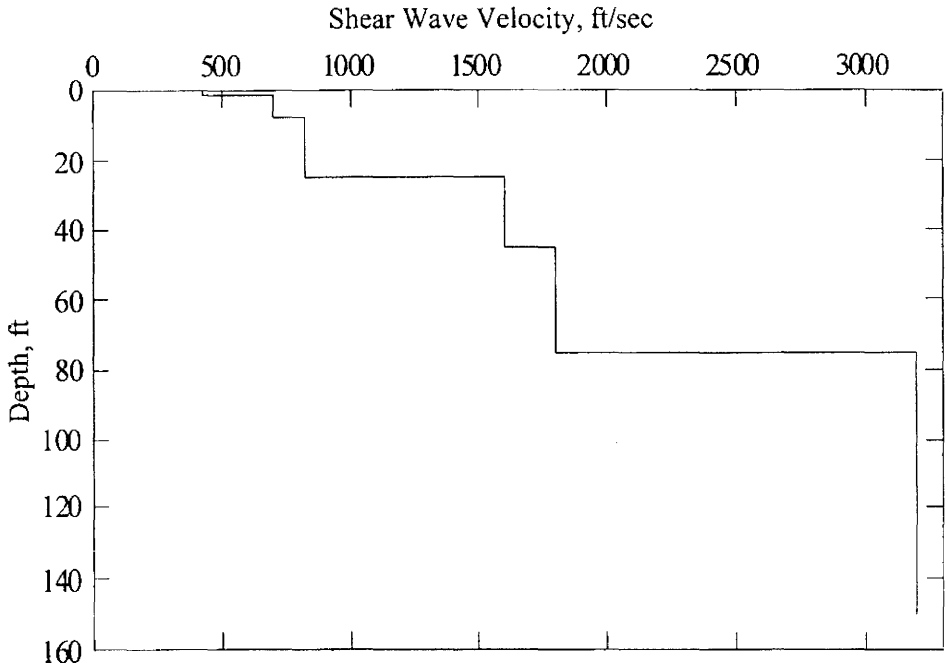


Fig. 10 Shear Wave Velocity Profile Determined from SASW Test Southwest of Aeration Basin, Little Cottonwood Canyon Water Treatment Plant.

Table 2 Soil Profile from SASW Test Southwest of Aeration Basin, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	0.2	2500	4680	145
2	1.3	425	795	120
3	6.5	700	1310	120
4	17.0	825	1540	120
5	20.0	1600	2990	120
6	30.0	1800	3370	135
7	75*	3200	5990	135

* Half-space in model

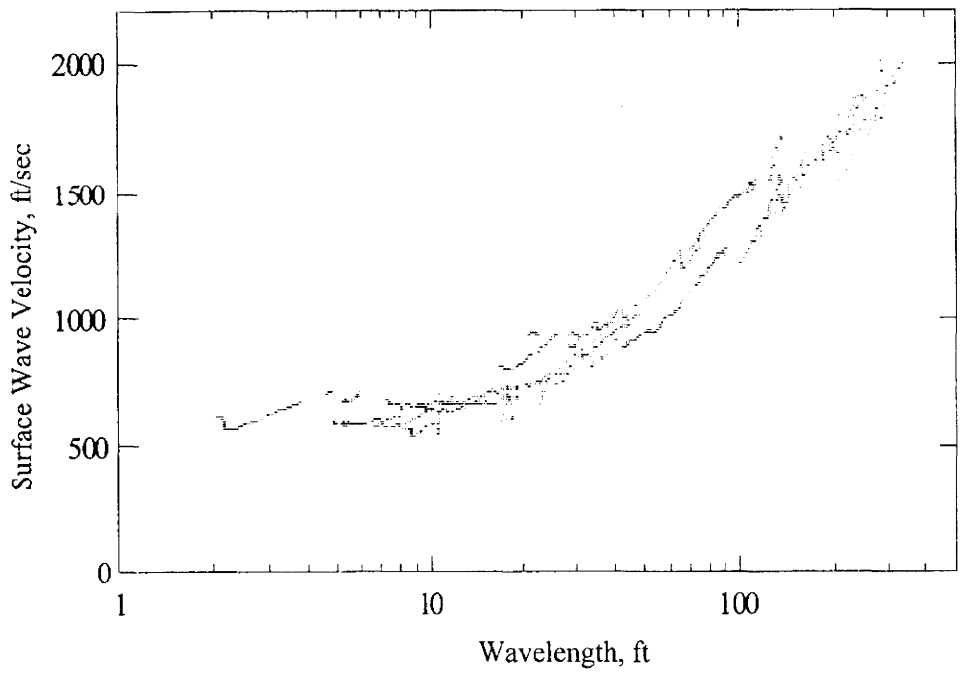


Fig. 11 Experimental Dispersion Curve Measured South of Old Chemical Building, Little Cottonwood Canyon Water Treatment Plant.

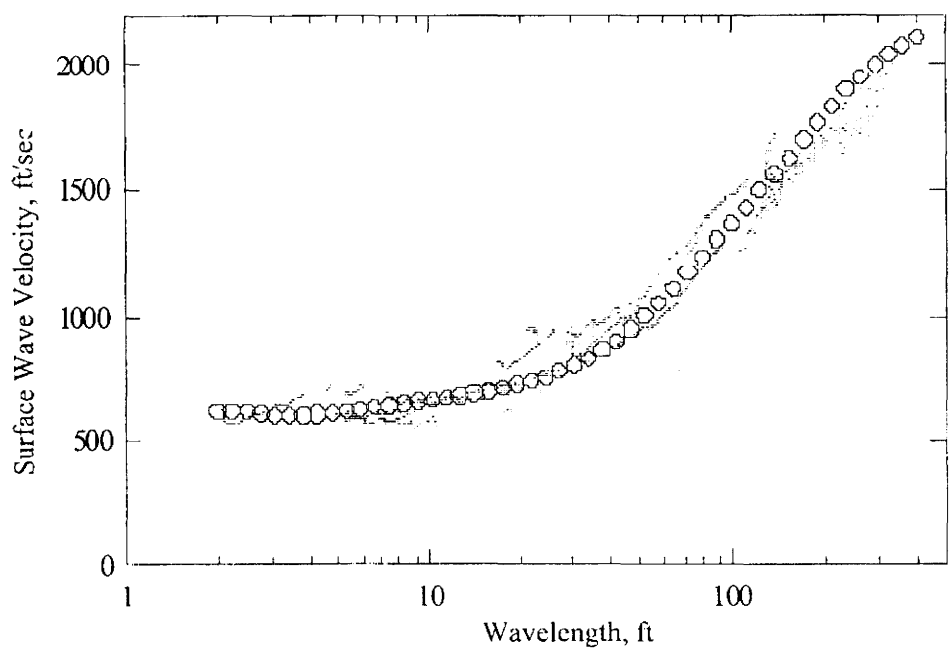


Fig. 12 Comparison between Experimental and Theoretical Dispersion Curves from South of the Old Chemical Building, Little Cottonwood Canyon Water Treatment Plant.

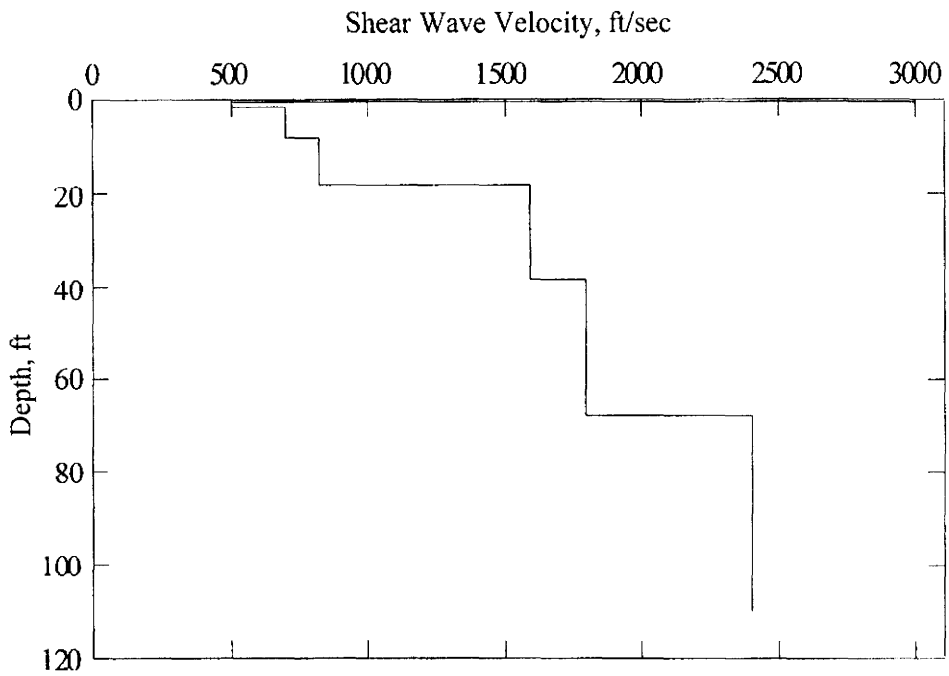


Fig. 13 Shear Wave Velocity Profile Determined from SASW Test South of the Old Chemical Building, Little Cottonwood Canyon Water Treatment Plant.

Table 3 Soil Profile from SASW Test South of Old Chemical Building, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	0.2	3000	5610	145
2	1.3	500	935	120
3	6.5	700	1310	120
4	10.0	825	1540	120
5	20.0	1600	2990	120
6	30.0	1800	3370	135
7	42.0*	2400	4490	135

* Half-space in model

Northwest of Filter Building The experimental dispersion curve measured northwest of filter building is shown in Fig. 14. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 15. A plot of the shear wave velocity profile is shown in Fig. 16. Tabulated values of the parameters used in forward modeling are presented in Table 4.

South of new Maintenance Building The experimental dispersion curve measured south of the new maintenance building is shown in Fig. 17. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 18. A plot of the shear wave velocity profile is shown in Fig. 19. Tabulated values of the parameters used in forward modeling are presented in Table 5.

North of new Maintenance Building The experimental dispersion curve measured north of the new maintenance building is shown in Fig. 20. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 21. A plot of the shear wave velocity profile is shown in Fig. 22. Tabulated values of the parameters used in forward modeling are presented in Table 6.

East of Sludge Drying Beds The experimental dispersion curve measured east of the sludge drying beds is shown in Fig. 23. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 24. A plot of the shear wave velocity profile is shown in Fig. 25. Tabulated values of the parameters used in forward modeling are presented in Table 7.

North of Sludge Drying Beds The experimental dispersion curve measured north of the sludge drying beds is shown in Fig. 26. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 27. A plot of the shear wave velocity profile is shown in Fig. 28. Tabulated values of the parameters used in forward modeling are presented in Table 8.

Field North of Sludge Drying Beds The experimental dispersion curve measured in field north of the sludge drying beds is shown in Fig. 29. The comparison between the experimental and theoretical dispersion curves determined from forward modeling is shown in Fig. 30. A plot of the shear wave velocity profile is shown in Fig. 31. Tabulated values of the parameters used in forward modeling are presented in Table 9.

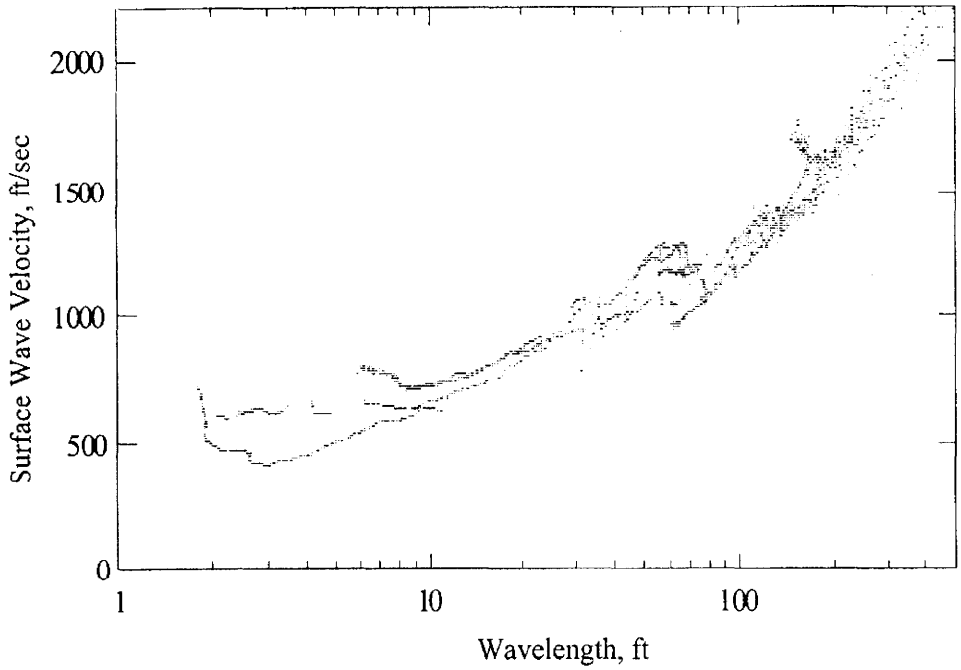


Fig. 14 Experimental Dispersion Curve Measured Northwest of Filter Building, Little Cottonwood Canyon Water Treatment Plant.

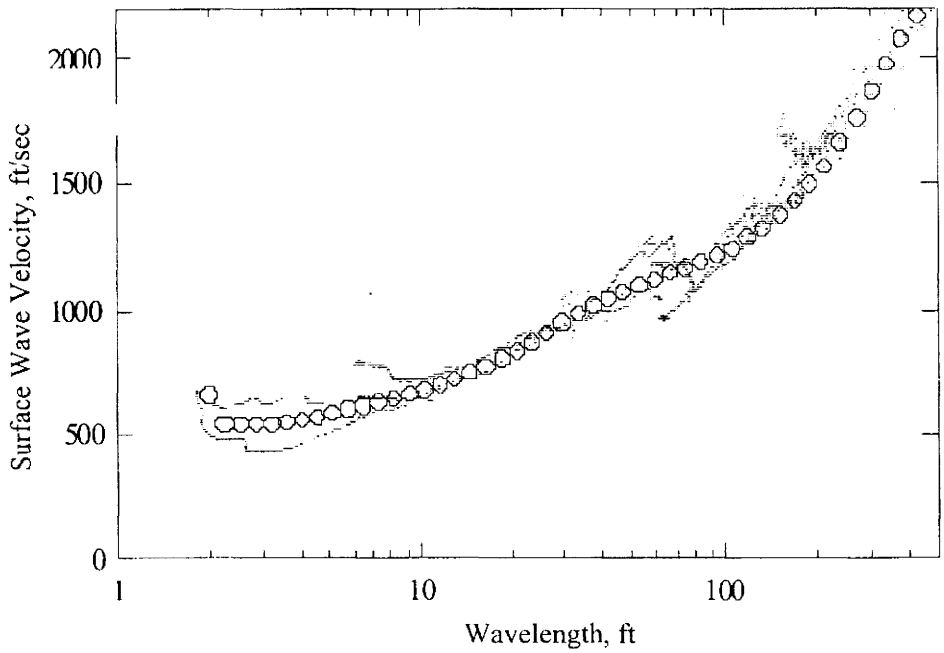


Fig. 15 Comparison between Experimental and Theoretical Dispersion Curves from Northwest of Filter Building, Little Cottonwood Canyon Water Treatment Plant.

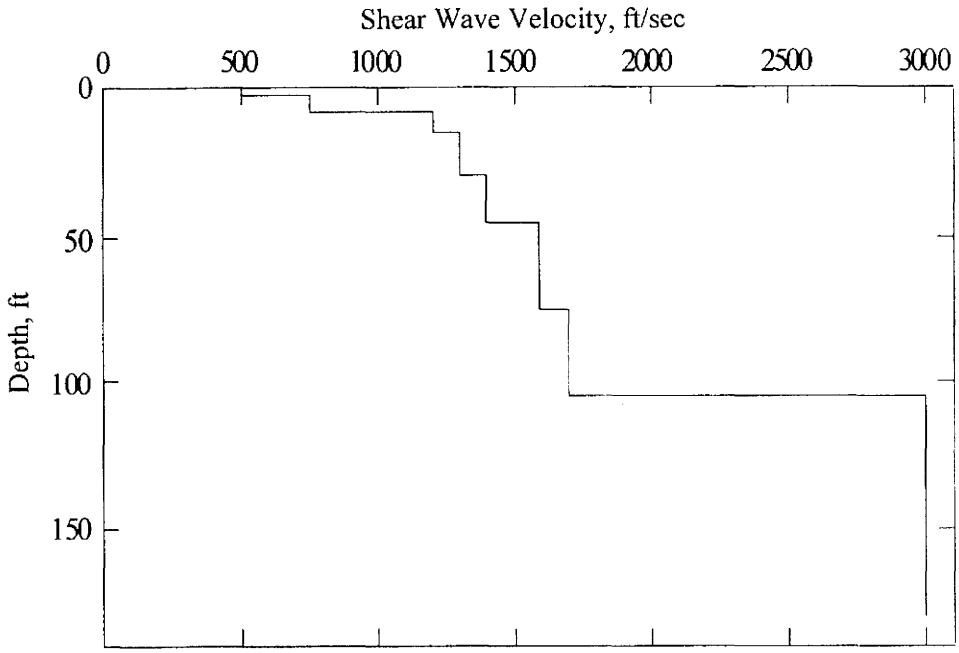


Fig. 16 Shear Wave Velocity Profile Determined from SASW Test Northwest of Filter Building, Little Cottonwood Canyon Water Treatment Plant.

Table 4 Soil Profile from SASW Test Northwest of Filter Building, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	0.15	2400	4990	145
2	1.85	500	935	120
3	6.0	750	1400	120
4	7.0	1200	2245	120
5	14.0	1300	2430	120
6	16.0	1400	2620	120
7	30.0	1600	2990	120
8	30.0	1700	3180	120
9	75*	3000	5610	135

* Half-space in model

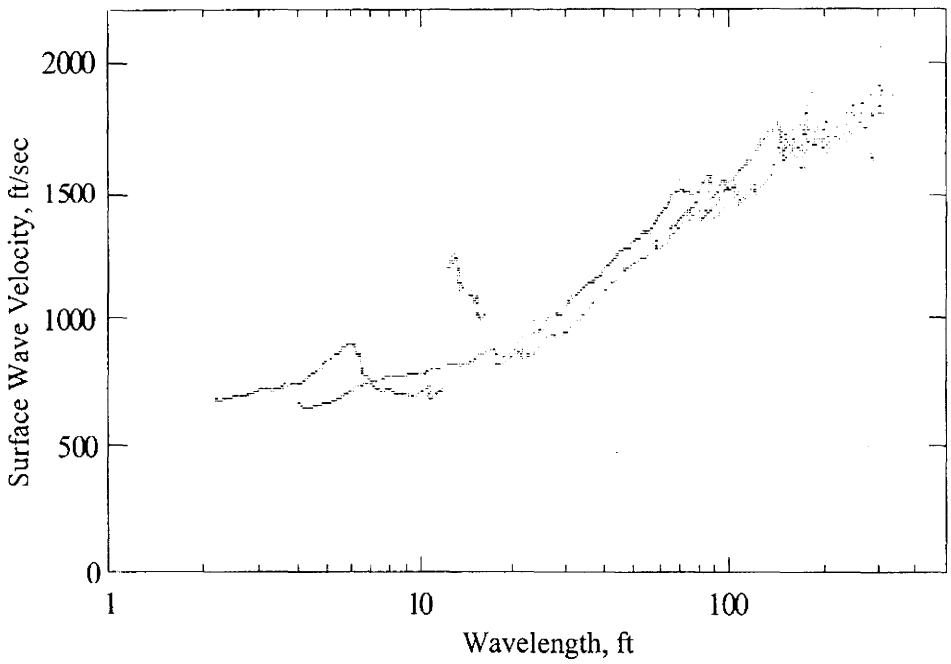


Fig. 17 Experimental Dispersion Curve Measured South of New Maintenance Building, Little Cottonwood Canyon Water Treatment Plant.

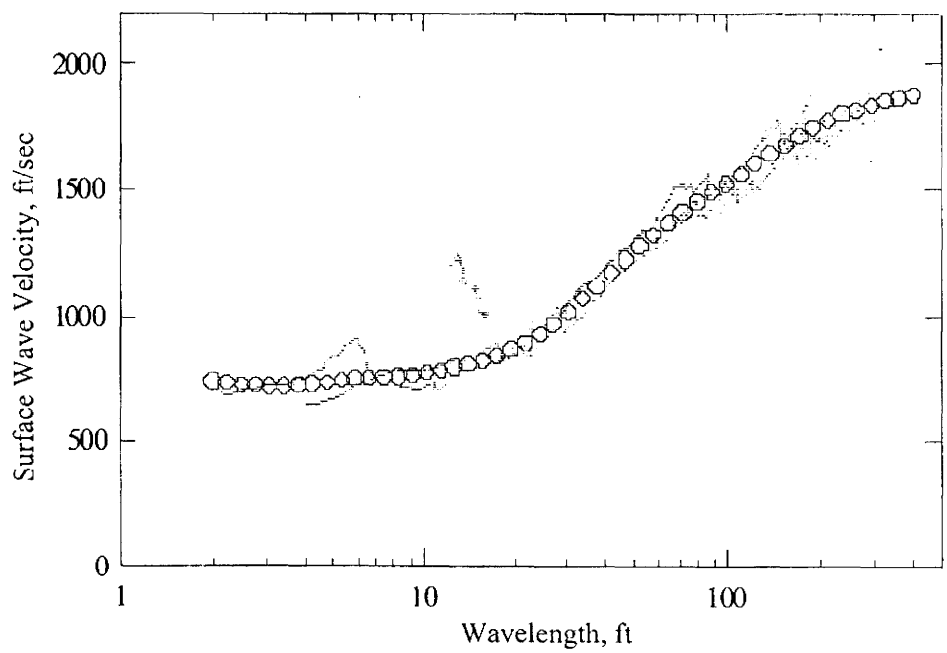


Fig. 18 Comparison between Experimental and Theoretical Dispersion Curves from South of New Maintenance Building, Little Cottonwood Canyon Water Treatment Plant.

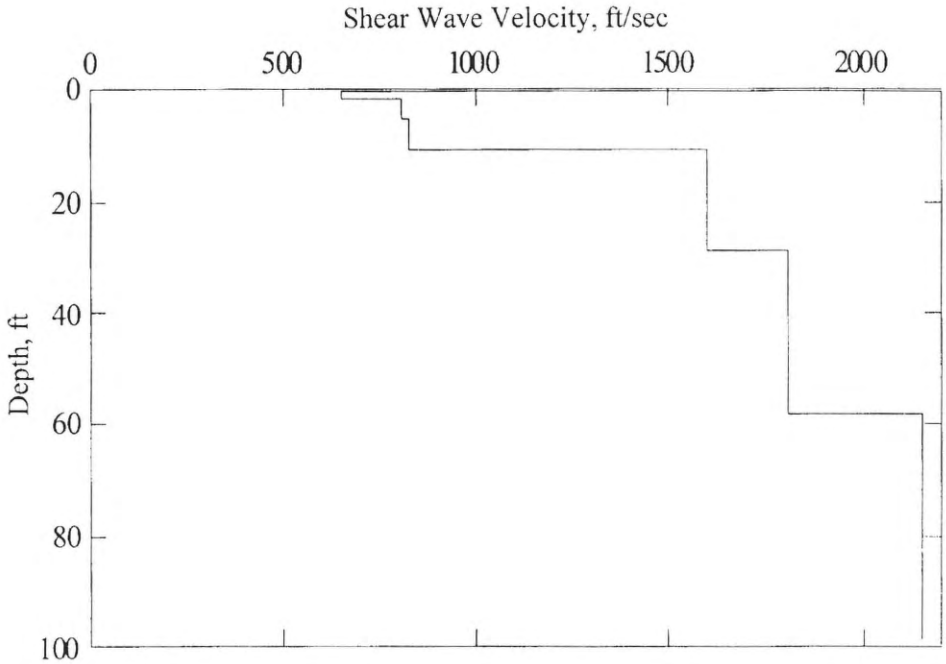


Fig. 19 Shear Wave Velocity Profile Determined from SASW Test South of New maintenance Building, Little Cottonwood Canyon Water Treatment Plant.

Table 5 Soil Profile from SASW Test South of New Maintenance Building, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	0.2	2500	4680	145
2	1.3	650	1220	120
3	4.0	800	1500	120
4	5.0	825	1540	120
5	18.0	1600	2990	120
6	30.0	1800	3370	135
7	40.0*	2150	4020	135

* Half-space in model

94.5 ft

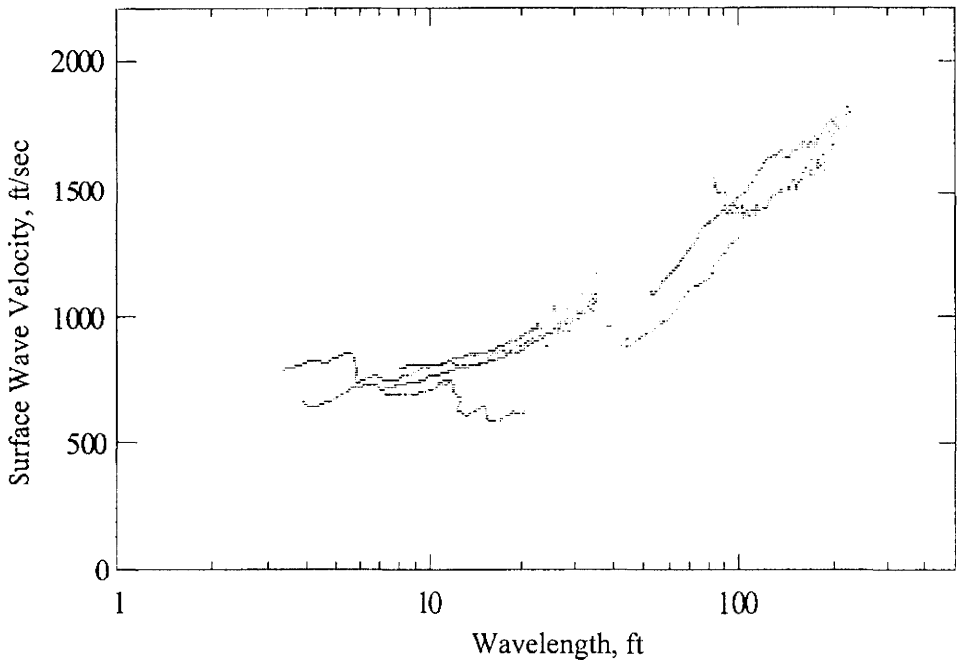


Fig. 20 Experimental Dispersion Curve Measured North of New Maintenance Building, Little Cottonwood Canyon Water Treatment Plant.

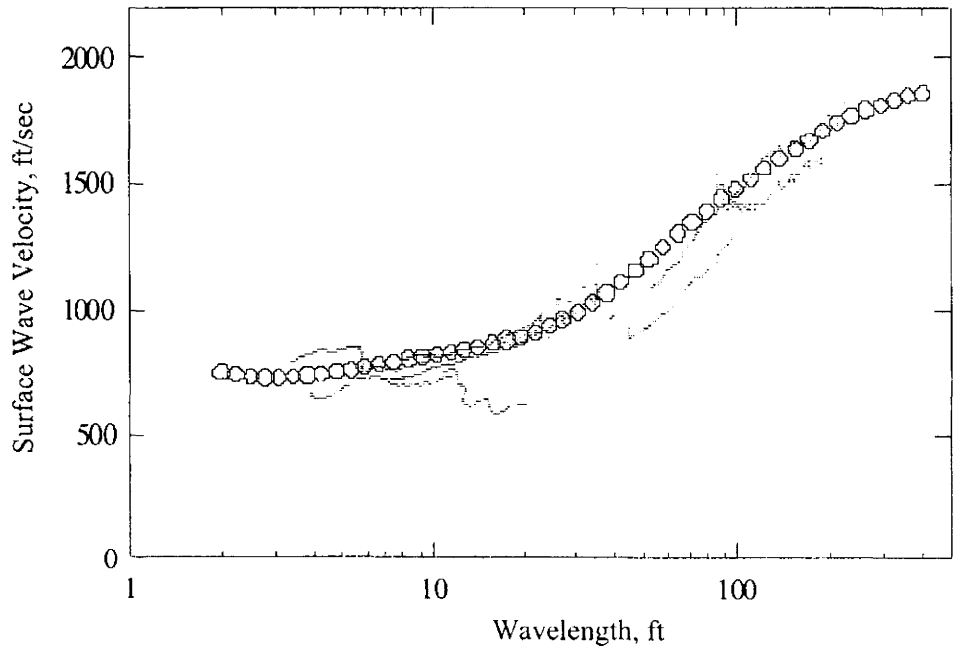


Fig. 21 Comparison between Experimental and Theoretical Dispersion Curves from North of New Maintenance Building, Little Cottonwood Canyon Water Treatment Plant.

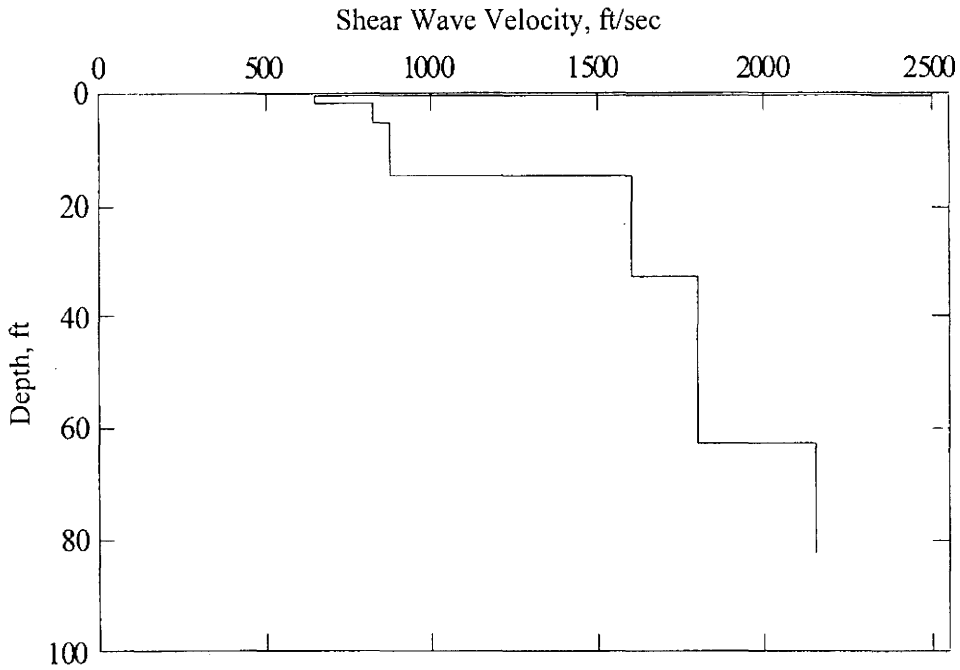


Fig. 22 Shear Wave Velocity Profile Determined from SASW Test North of New Maintenance Building, Little Cottonwood Canyon Water Treatment Plant.

Table 6 Soil Profile from SASW Test North of New Maintenance Building, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	0.2	2500	4680	145
2	1.3	650	1220	120
3	4.0	825	1540	120
4	9.0	875	1640	120
5	18.0	1600	2990	120
6	30.0	1800	3370	135
7	20.0*	2150	4020	135

* Half-space in model

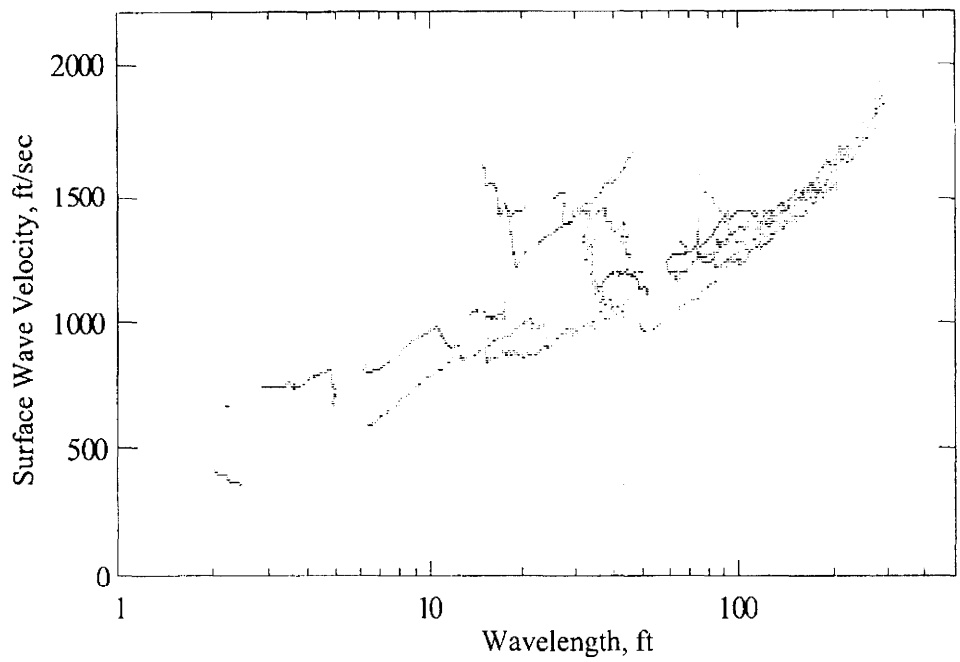


Fig. 23 Experimental Dispersion Curve Measured East of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

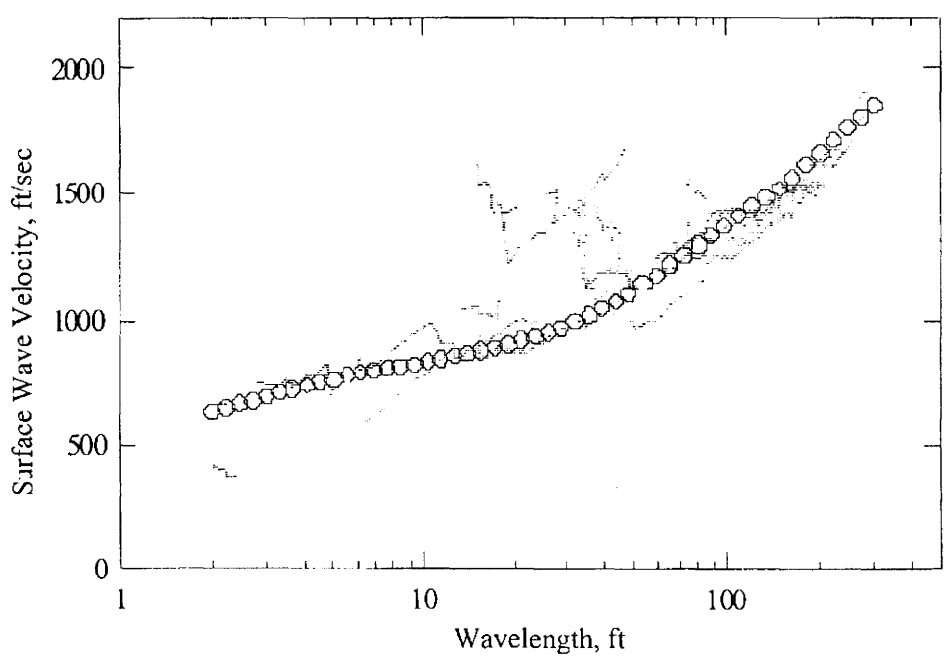


Fig. 24 Comparison between Experimental and Theoretical Dispersion Curves from East of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

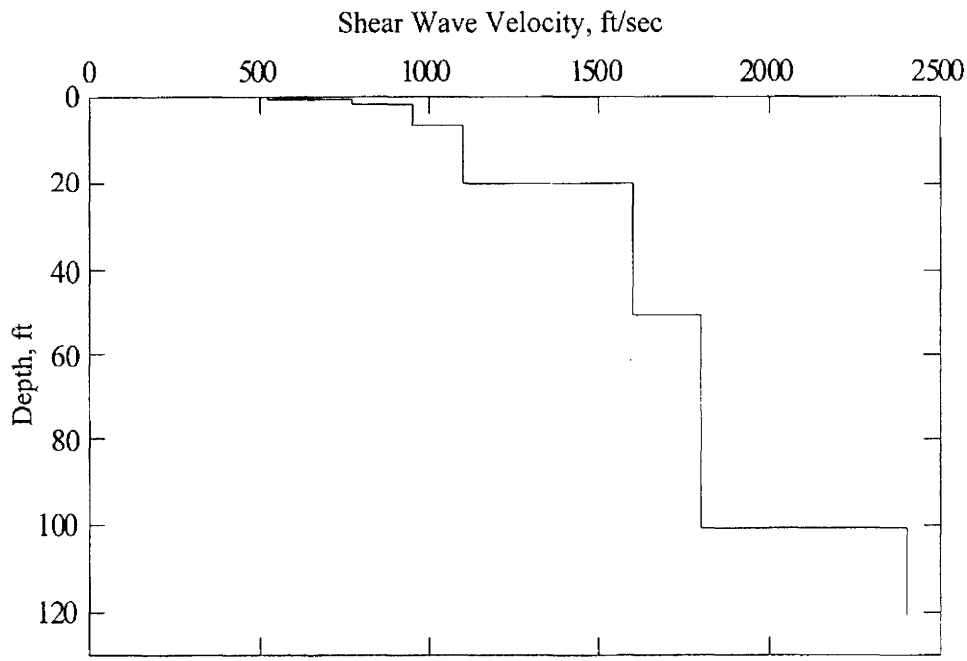


Fig. 25 Shear Wave Velocity Profile Determined from SASW Test East of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

Table 7 Soil Profile from SASW Test East of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	0.5	525	980	120
2	1.0	775	1450	120
3	5.5	950	1780	120
4	13.0	1100	2060	120
5	31.0	1600	2990	120
6	50.0	1800	3370	135
7	20.0*	2400	4490	135

* Half-space in model

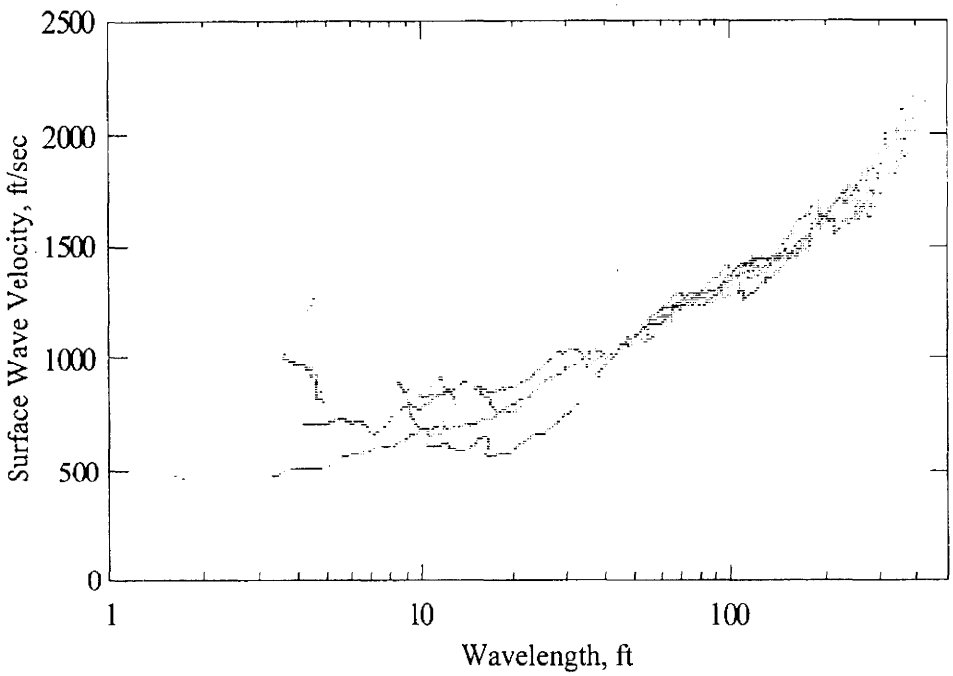


Fig. 26 Experimental Dispersion Curve Measured North of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

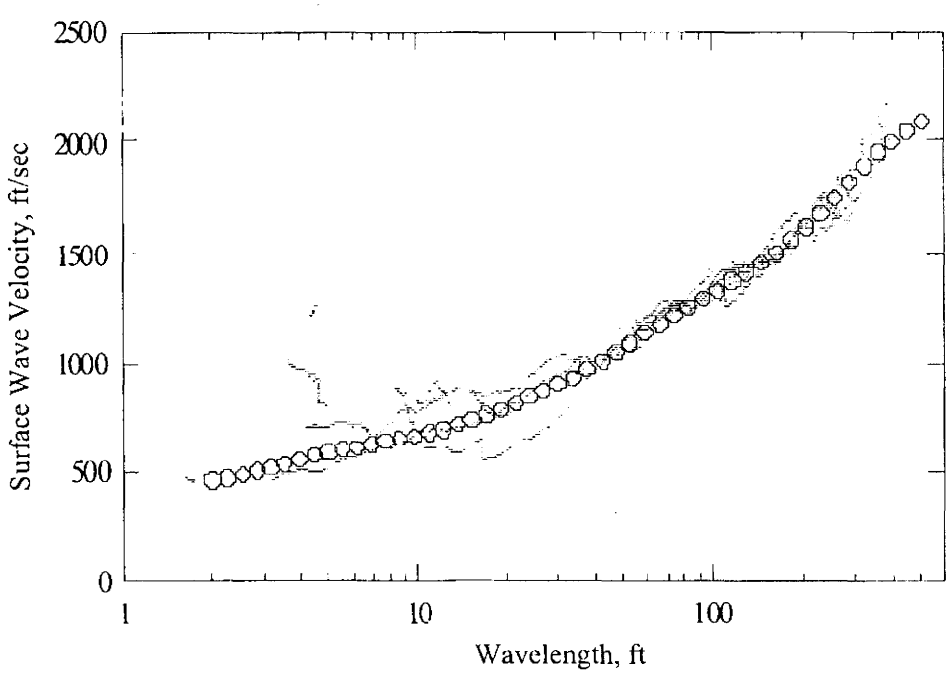


Fig. 27 Comparison between Experimental and Theoretical Dispersion Curves from North of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

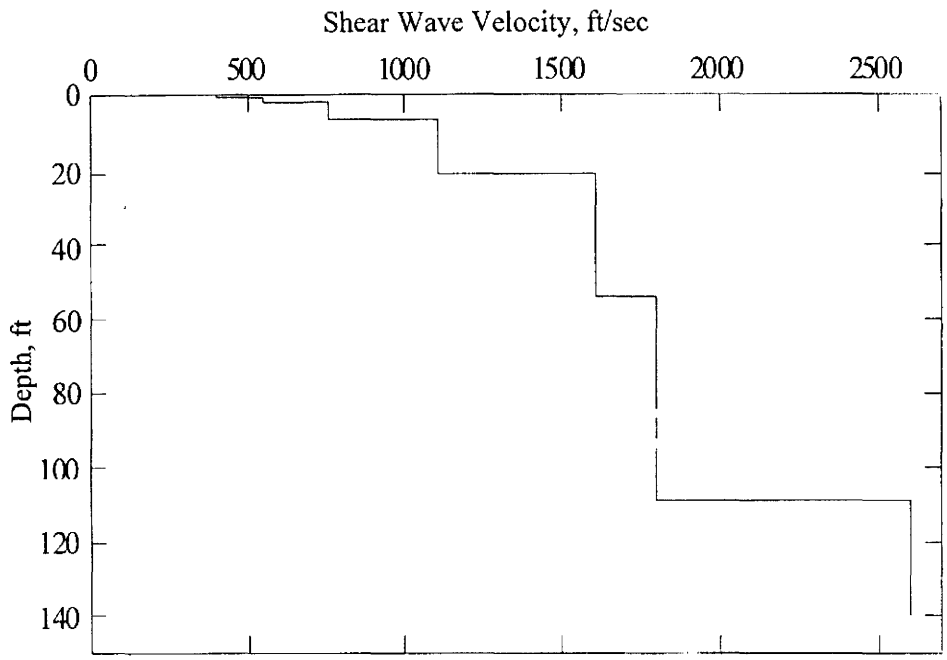


Fig. 28 Shear Wave Velocity Profile Determined from SASW Test North of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

Table 8 Soil Profile from SASW Test North of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	0.5	400	750	120
2	1.0	550	1030	120
3	5.5	775	1450	120
4	13.0	1100	2060	120
5	34.0	1600	2990	120
6	55.0	1800	3370	135
7	31.0*	2600	4860	135

* Half-space in model

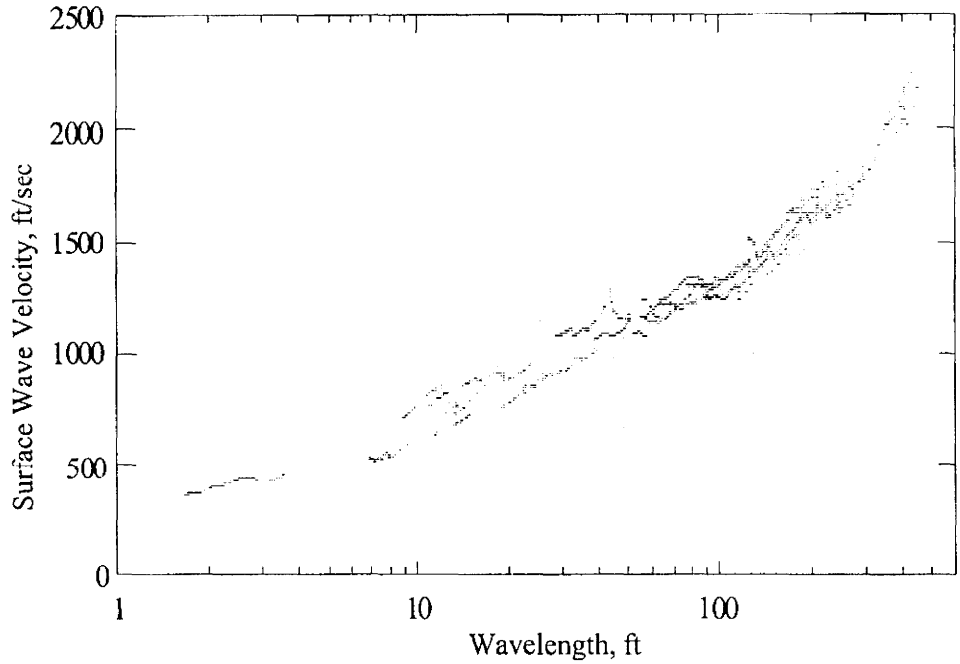


Fig. 29 Experimental Dispersion Curve Measured in Field North of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

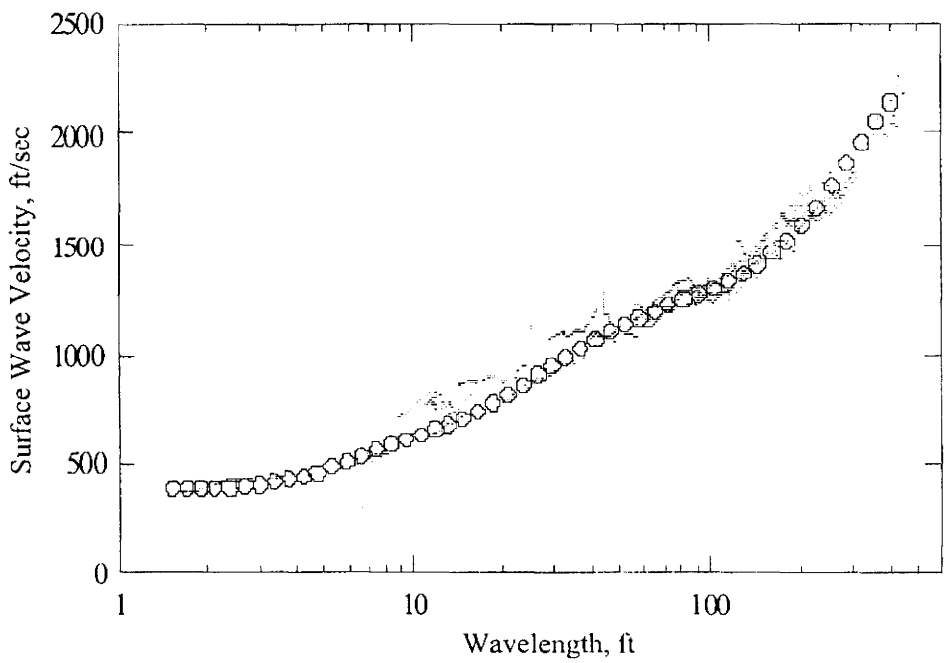


Fig. 30 Comparison between Experimental and Theoretical Dispersion Curves from Field North of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

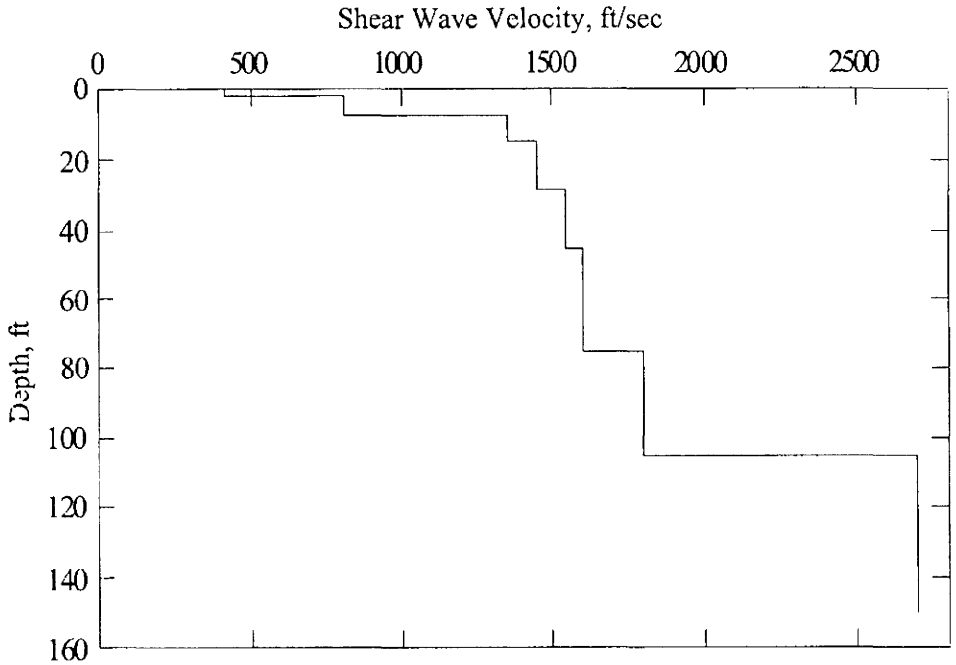


Fig. 31 Shear Wave Velocity Profile Determined from SASW Test in Field North of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

Table 9 Soil Profile from SASW Test in Field North of Sludge Drying Beds, Little Cottonwood Canyon Water Treatment Plant.

Layer No.	Layer Thickness (ft)	Shear Wave Velocity (ft/sec)	Assumed P-Wave Velocity (ft/sec)	Assumed Unit Weight (lb/ft^3)
1	2.0	420	790	120
2	6.0	800	1500	120
3	7.0	1350	2530	120
4	14.0	1450	2710	120
5	16.0	1550	2900	120
6	30.0	1600	2990	120
7	30.0	1800	3370	120
8	45.0*	2700	5050	135

* Half-space in model

Conclusions

High quality dispersion curves were obtained from field SASW measurements at all of the sited except the site East of the sludge drying beds. This site was on a constructed fill, and there was significant scatter in the dispersion data. The Forward modeling procedure resulted in good matches between experimental and theoretical dispersion. This indicates that shear wave velocity profiles presented should accurately represent the shear wave velocity profiles at each site.

References

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2. Nazarian, S., "In Situ Determination of Elastic Moduli of Soil Deposits and Pavement Systems by Spectral-Analysis-of-Surface-Waves Method," Ph.D. Dissertation, The University of Texas at Austin, December 1984.
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Respectfully Submitted

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Metro water plant data (Bay and others, 2003)

	layer	thickr	Vs (ft/s)	b/c				layer	thickr	Vs (ft/s)	b/c	
t1		0.25	3000	8.33333E-05		t1		0.25	3000	8.33E-05		432506
		1.75	700	0.0025				1.75	700	0.0025		4493176
		5	650	0.007692308				5	650	0.007692		
		18	935	0.019251337				18	935	0.019251		
		24	900	0.026666667				24	900	0.026667		207
		51	2500	0.0204				51	2500	0.0204		
		100		0.076593645				100		0.076594		
		30.5	**Vsmean**	**1305.6**	**397.9**				**Vs30**	**1305.6**		**397.9**
t2		0.2	2500	0.00008		t2		0.2	2500	0.00008		432315
		1.3	425	0.003058824				1.3	425	0.003059		4492839
		6.5	700	0.009285714				6.5	700	0.009286		
		17	825	0.020606061				17	825	0.020606		
		20	1600	0.0125				20	1600	0.0125		208
		30	1800	0.016666667				30	1800	0.016667		
		75	3200	0.0234375				25	3200	0.007813		
		150	45.7	0.085634765				100		0.07001		
			Vsmean	**1751.6**	**533.9**				**Vs30**	**1428.4**		**435.4**
t3		0.2	3000	6.66667E-05		t3		0.2	3000	6.67E-05		
		1.3	500	0.0026				1.3	500	0.0026		432417
		6.5	700	0.009285714				6.5	700	0.009286		
		10	825	0.012121212				10	825	0.012121		4492923
		20	1600	0.0125				20	1600	0.0125		
		30	1800	0.016666667				30	1800	0.016667		
		42	2400	0.0175				32	2400	0.013333		209
		110	33.5	0.07074026				100		0.066574		
			Vsmean	**1555.0**	**474.0**				**Vs30**	**1502.1**		**457.8**
t4		0.15	2400	0.0000625		t4		0.15	2400	6.25E-05		432218
		1.85	500	0.0037				1.85	500	0.0037		
		6	750	0.008				6	750	0.008		4492970
		7	1200	0.005833333				7	1200	0.005833		
		14	1300	0.010769231				14	1300	0.010769		
		16	1400	0.011428571				16	1400	0.011429		
		30	1600	0.01875				30	1600	0.01875		210
		30	1700	0.017647059				25	1700	0.014706		
		75	3000	0.025								
								100		0.07325		
		180	54.9	0.101190694								
			Vsmean	**1778.8**	**542.2**				**Vs30**	**1365.2**		**416.1**
t5		0.2	2500	0.00008		t5		0.2	2500	0.00008		432247
		1.3	650	0.002				1.3	650	0.002		
		4	800	0.005				4	800	0.005		4493112
		5	825	0.006060606				5	825	0.006061		
		18	1600	0.01125				18	1600	0.01125		
		30	1800	0.016666667				30	1800	0.016667		211
		40	2150	0.018604651				41.5	2150	0.019302		
		98.5	ok 30.0	0.059661924				100		0.06036		
								** actual total depth 98.5 = 30.				
			Vsmean	**1651.0**	**503.2**				**Vs30**	**1656.7**		**505.0**

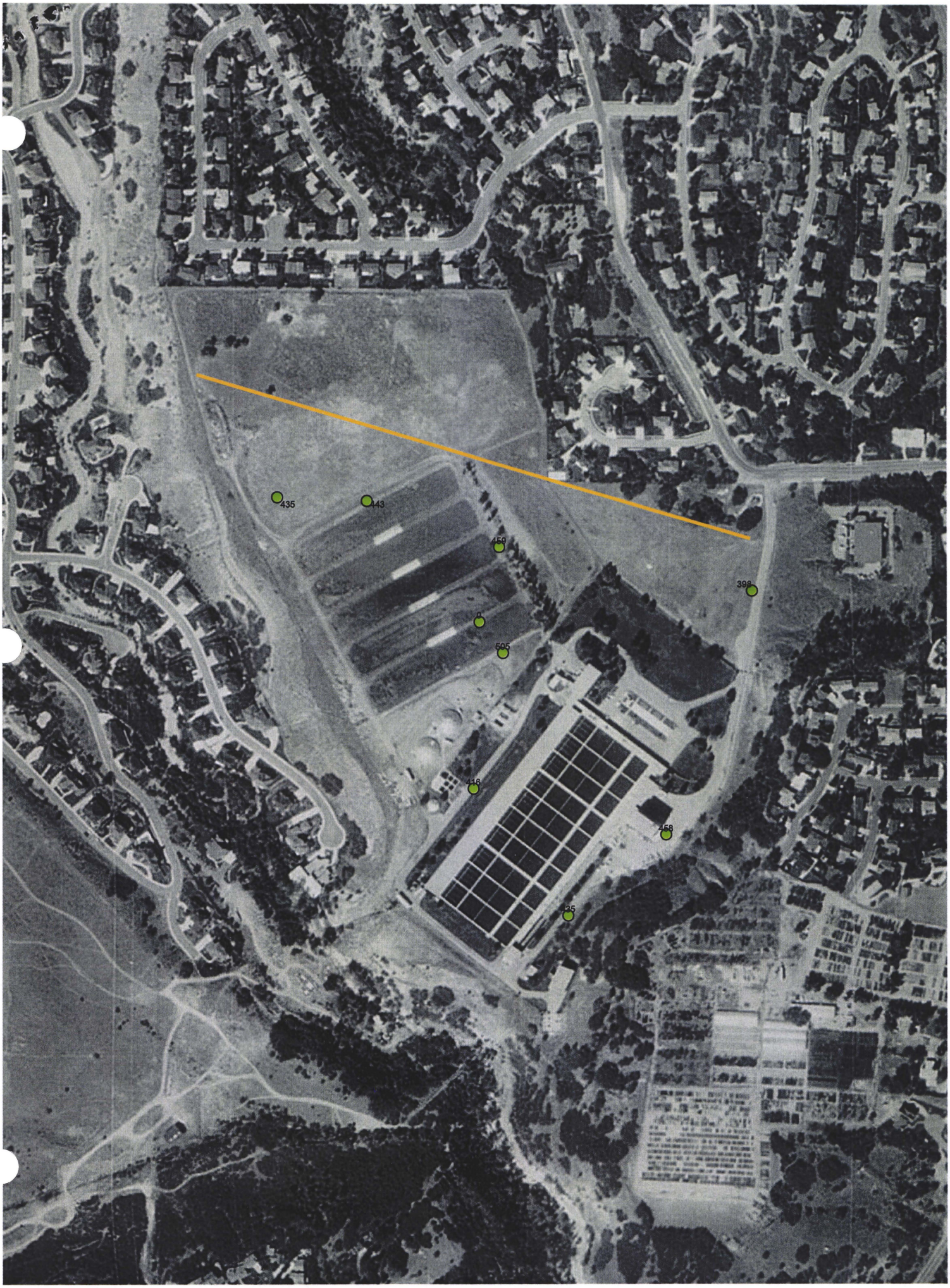
t6	0.2	2500	0.00008		t6	0.2	2500	0.00008		
	1.3	650	0.002			1.3	650	0.002		
	4	825	0.004848485			4	825	0.004848		
	9	875	0.010285714			9	875	0.010286		
	18	1600	0.01125			18	1600	0.01125		
	30	1800	0.016666667			30	1800	0.016667		
	20	2150	0.009302326			20	2150	0.009302		
	82.5	25.1	0.054433191			82.5		0.054433		
						** not vs30 (too shallow)				
		Vsmean	**1515.6**	**462.0**			**Vs30**	**1515.6**	**462.0**	
t7	0.5	525	0.000952381		t7	0.5	525	0.000952	432 244	
	1	775	0.001290323			1	775	0.00129	4493222	
	5.5	950	0.005789474			5.5	950	0.005789		
	13	1100	0.011818182			13	1100	0.011818		
	31	1600	0.019375			31	1600	0.019375		
	50	1800	0.027777778			49	1800	0.027222	212	
	20	2400	0.008333333							
	121	36.9	0.07533647			100		0.066448		
		Vsmean	**1606.1**	**489.5**			**Vs30**	**1504.9**	**458.7**	
t8	0.5	400	0.00125		t8	0.5	400	0.00125	432 012	
	1	550	0.001818182			1	550	0.001818		
	5.5	775	0.007096774			5.5	775	0.007097	4493274	
	13	1100	0.011818182			13	1100	0.011818		
	34	1600	0.02125			34	1600	0.02125		
	55	1800	0.030555556			46	1800	0.025556	213	
	31	2600	0.011923077							
	140	42.7	0.08571177			100		0.068789		
		Vsmean	**1633.4**	**497.9**			**Vs30**	**1453.7**	**443.1**	
t9	2	420	0.004761905		t9	2	420	0.004762		
	6	800	0.0075			6	800	0.0075		
	7	1350	0.005185185			7	1350	0.005185		
	14	1450	0.009655172			14	1450	0.009655		
	16	1550	0.010322581			16	1550	0.010323		
	30	1600	0.01875			30	1600	0.01875	214	
	30	1800	0.016666667			25	1800	0.013889		
	45	2700	0.016666667						432106	
	150	45.7	0.089508176			100		0.070064	4493270	
		Vsmean	**1675.8**	**510.8**			**Vs30**	**1427.3**	**435.0**	

Vs30 of mean plot

depth	thickness	Vs	
0	1	600	0.001666667
1	6	780	0.007692308
7	1	890	0.001123596
8	2	1010	0.001980198
10	5	1200	0.004166667
15	5	1210	0.004132231
20	5	1350	0.003703704
25	5	1500	0.003333333
30	15	1520	0.009868421
45	5	1780	0.002808989
50	5	1810	0.002762431
55	5	1860	0.002688172
60	15	1900	0.007894737
75	25	2130	0.011737089
100	5	2190	0.002283105
105	15	2610	0.005747126
120	20	2670	0.007490637
140	10	2960	0.003378378
150			
	150		0.084457788
Vs30		**1776.0**	**541.3**

Vs30 of mean plot

depth	thickness	Vs	
0	1	600	0.001667
1	6	780	0.007692
7	1	890	0.001124
8	2	1010	0.00198
10	5	1200	0.004167
15	5	1210	0.004132
20	5	1350	0.003704
25	5	1500	0.003333
30	15	1520	0.009868
45	5	1780	0.002809
50	5	1810	0.002762
55	5	1860	0.002688
60	15	1900	0.007895
75	25	2130	0.011737
100			
	100		0.065559
Vs30		**1525.4**	**464.9**


435
143
459
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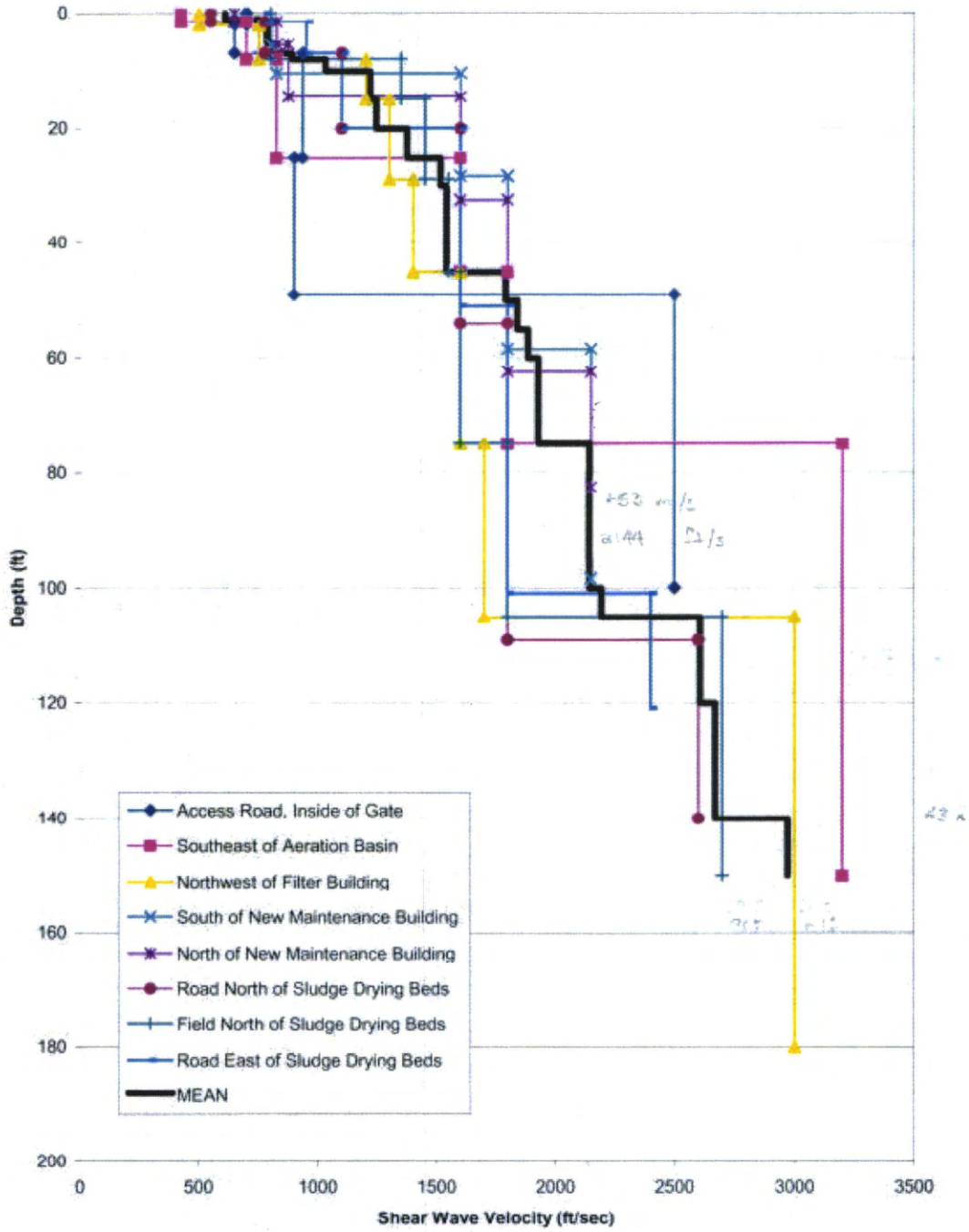
0
505
416
158
25

Preliminary Results of SASW Tests



V_{s30} mean = 1524 ft/sec

465 m/s