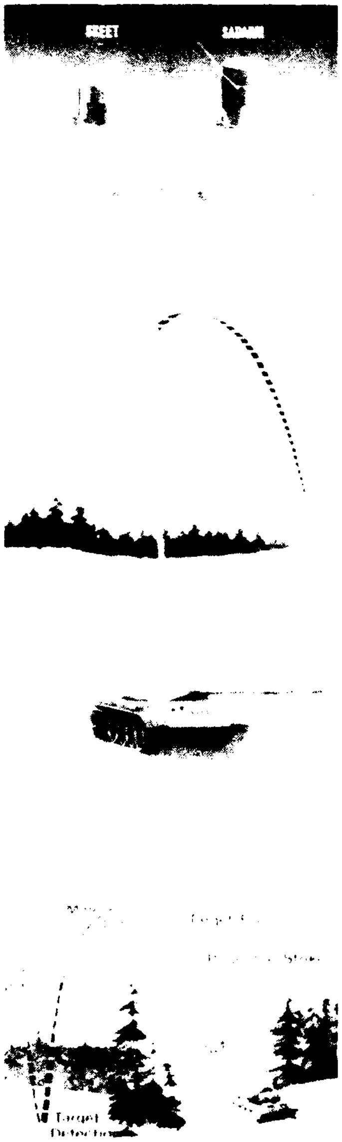
MISCELLANEOUS PAPER EL-91-14

(2)

US Army Corps of Engineers



ENVIRONMENTAL SITE CHARACTERIZATION FOR THE WIDE AREA MINE SENSOR DEMONSTRATION, ABERDEEN PROVING GROUND, OCTOBER 1988

by

Bruce M. Sabol, Thomas E. Berry, Ben L. Carnes

Environmental Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

May 1991

Final Report

Prepared for US Army Armament Research, Development, and Engineering Center
Picatinny Arsenal, New Jersey 07806-5000

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
May 1991

3. REPORT TYPE AND DATES COVERED
Final report

4. TITLE AND SUBTITLE
Environmental Site Characterization for the Wide Area Mine Sensor Demonstration, Aberdeen Proving Ground, October 1988

5. FUNDING NUMBERS

6. AUTHOR(S)
Bruce M. Sabol, Thomas E. Berry, Ben L. Carnes

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USAE Waterways Experiment Station, Environmental Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199

8. PERFORMING ORGANIZATION REPORT NUMBER
Miscellaneous Paper EL-91-14

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US Army Armament Research, Development, and Engineering Center, Picatinny Arsenal, New Jersey 07806-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Under the Proof-of-Principle program for the development of a wide area mine (WAM), the US Army Engineer Waterways Experiment Station (WES) was responsible for characterization of the temperature environment in which WAM developmental tests would be conducted. The principal temperate area for WAM testing was designated to be the US Army Aberdeen Proving Ground (APG), Maryland.

This report presents data that characterize terrain and environmental factors expected to affect WAM sensor performance. Field measurements were made before and during the conduct of WAM captive flight tests and ground sensor data acquisition exercises. Measurements included soil and seismic tests, a quantitative vegetation survey, thermal terrain characterization measurements, and the collection of onsite meteorological data.

14. SUBJECT TERMS
Mine use
Operational environment
Temperature environment
Testing
Wide area mine

15. NUMBER OF PAGES
42

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
UNCLASSIFIED

18. SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

PREFACE

The study reported herein was conducted by the US Army Engineer Waterways Experiment Station (WES) with funding provided by the US Army Armament Research, Development, and Engineering Center (ARDEC), Picatinny Arsenal, New Jersey, in support of the Wide Area Mine Proof-of-Principle program. Mr. George Lutz was the ARDEC Technical Monitor.

The study was conducted under the general supervision of Dr. John Harrison, Chief of the Environmental Laboratory; Dr. Victor E. LaGarde III, Chief of the Environmental Systems Division (ESD); and Mr. Harold W. West, Chief of the Environmental Analysis Group (EAG). Direct supervision was provided by Mr. Bruce M. Sabol, WES project coordinator. The report was prepared by Mr. Sabol, Mr. Thomas E. Berry, and Dr. Ben L. Carnes of the ESD. Data acquisition support was provided by Messrs. David L. Leese, Clay B. Blount, and Thomas B. Kean.

Commander and Director of WES was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

This report should be cited as follows:

Sabol, Bruce M., Berry, Thomas E., and Carnes, Ben L. 1991. "Environmental Site Characterization for the Wide Area Mine Sensor Demonstration, Aberdeen Proving Ground, October 1988," Miscellaneous Paper EL-91-14, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
inches	2.54	centimeters
miles (US statute)	1.609347	kilometers
square inches	6.4516	square centimeters

ENVIRONMENTAL SITE CHARACTERIZATION FOR THE WIDE AREA MINE SENSOR DEMONSTRATION, ABERDEEN PROVING GROUND OCTOBER 1988

PART I: INTRODUCTION

1. As part of support to the Wide Area Mine (WAM) Proof-of-Principle program, the US Army Engineer Waterways Experiment Station (WES) documented environmental and terrain conditions prior to and during each sensor demonstration test. The second in a series of WAM sensor demonstration tests was conducted at Aberdeen Proving Ground (APG) during the period 17-28 October 1988. Captive flight testing (CFT) of the airborne sensor was performed at Perryman Test Track on 17-23 October 1988; ground sensor testing was performed at the Old Bombing Site on 24-28 October 1988 (see location map, Figure 1). The APG site was selected as an analog for Central Europe because of its temperature climate and vegetated (grassland) terrain surfaces.

Purpose and Scope

2. Quantitative characterization was performed at these sites using a variety of automated instrumentation and manual survey techniques. An automated weather station was installed at the Old Bombing Site to collect (record) meteorological conditions continuously during the 2-week period. Staring radiometers were installed at the Perryman Test Area to record radiometric temperatures of selected terrain features during the captive flight testing. At the ground sensor test site, seismic data were collected using seismic refraction survey techniques. Additionally, soil and vegetation surveys were conducted, and the topography was surveyed and mapped.

3. This report briefly describes procedures, data collected, and results from each of these efforts and provides a cursory comparison of site conditions at APG relative to the Yuma Proving Ground (YPG) WAM test site. A more comprehensive description of background and procedures for these measurements can be found in the YPG site characterization report.*

---

* Bruce Sabol et al. 1989. "Environmental Site Characterization for the Wide Area Mine Sensor Demonstration, Yuma Proving Ground, August 1988," Miscellaneous Paper EL-89-7, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

General Description of Sites

4. The Perryman Test Area (Figure 2), used for CFT, is a mobility testing facility containing a straight and flat 2.5-mile-long* asphalt road with several nonpaved hummocky trails parallel to it. Captive flight tests were conducted with the target vehicles moving on the asphalt road. The adjacent terrain is flat and level; it contains grasses and small shrubs in the immediate vicinity of the road. Just prior to the CFT, the grass adjoining the road was mowed.

5. The area used for ground sensor testing, the Old Bombing Site, consists of the 0.6 mile-long section of straight asphalt road between "F" tower on the north end and "C" tower on the south end (see Figure 3 and Photos 1 and 2). Adjoining this section of road is an area of open terrain with dense grassy vegetation that slopes gently downhill to the south. The wide Bush River is located about 1,000 ft to the west of the road. North of F tower, the road is surrounded by a mature hardwood forest. South of C tower, the road turns to the east. The ground sensor testbeds were positioned on a concrete pad 500 ft west of the asphalt road at the north end of the site; ground sensor lines were placed nearby (Figure 3). For most testing the vehicles were moving along the asphalt road; a limited amount of testing was performed with vehicles traveling cross country (i.e., off-road).

---

* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

PART II: TEST MEASUREMENTS

Meteorological Conditions

6. Weather conditions during the test were normal fall conditions for the APG area. Most days were sunny to partly cloudy with a few days of light rain. Average air temperature was 10.5° C, and the daytime average was 12.6° C. Daily average conditions over the test period are presented in Figure 4; average diurnal condit .s for the captive flight test period are presented in Figure 5. Wind conditions during the ground sensor testing are depicted in Figure 6. During the CFT period, the number of tests conducted under overcast conditions is noteworthy because this tended to create low levels of thermal background clutter. During the ground sensor test period, the occurrence of relatively strong wind conditions is significant because this caused acoustic signatures to be refracted and resulted in acoustic and seismic background noise caused by vegetation movements; additionally, the acoustic source was downwind of the sensor for most of the testing. (The complete weather data set is available from WES.)

Radiometric Temperature Conditions

7. During the CFT period, radiometric recording instrumentation was installed along the east edge of the asphalt road at the Perryman Test Area, approximately 1.5 mile north of the southern end of the asphalt road. Eight radiometers were emplaced to record radiometric temperatures of the following surfaces.

Surface Type	Number of Radiometers
Asphalt road	2
Grass in full sun	2
Unpaved road (dirt)	2
Grass in full shade	1
Grass in partial shade	1

The average radiometric temperature (averaged over all surfaces) versus time is shown in Figure 7. The average diurnal thermal response for the four surface types is shown in Figure 8. Thermal contrast between background surface types is expressed as the standard deviation of the four types (Figures 8 and 9). (The complete radiometer data set is available from WES.)

Topographic Survey

8. A topographic survey of the ground sensor test site, on the west side of the road, was conducted by surveying 250 points between F and C towers. The topographic data were then used to prepare the elevation contour map (Figure 10).

9. The ground surface rises from a marshy, wet lowland at the 4-ft mean sea level (MSL) contour to the concrete pad (testbed location) at the 19-ft MSL contour. Most vehicle movement along the paved road occurred between the 17-ft contour to the north and the 8-ft contour to the south. The vehicle movement off-road occurred between the 18-ft contour to the north and the 9-ft contour to the south. Slopes in this area range from 0 to 8 percent in the north-south direction, and from 0 to 2 percent in the east-west direction. One effect of this is that vehicles traveling in a northerly direction required higher engine speeds (creating more engine noise) to maintain the required test speed. This might result in different ground sensor performance for vehicles traveling in opposite directions.

Subsurface Survey

10. Prior to the ground sensor test, a seismic refraction survey was conducted at the Old Bombing Site. Procedures used were similar to those described in the YPG site characterization report and consisted of running seismic refraction lines perpendicular and parallel to the road at five locations 25 to 100 ft west of the road (Figure 11).

11. The survey revealed a reasonably uniform subsurface coastal type geology. Surface topography varied as described above; consequently, the water table (bottom layer) varied from 4 to 18 ft below the surface. The surface soil is a sand/silt/clay mixture. Seismic refraction survey results are shown in Figures 12-21. The seismic properties are summarized below.

Layer	P-wave ft/sec	S-wave* ft/sec	Layer Thickness, ft Range	Layer Thickness, ft Average**
1	1,220	427	1.5-5.0	3.6
2	1,980	950	4.1-13.0	8.5
3	5,050	1,050	--†	--

* Estimated from a limited amount of data.
** Thickness will vary, especially with varying surface elevations.
† No data.

12. The geological material in layer 2 is approximately the same as that in layer 3, except for the presence of the water table. This causes the shear wave velocity to be approximately the same in each layer since saturated soil will not carry a shear load. The site transfer function is presented in Figure 22.

Vegetation Conditions

13. Vegetation present at the ground sensor test site consists of a grassy plain surrounded by deciduous trees along the north and south borders (Figure 3). Plants identified in this area are typical of those common to the Atlantic Coastal Plain. These are listed in Table 1.

14. The forest on the northern boundary consists of mature trees, 40 to 60 ft tall, averaging 15 in. in diameter at breast height (dbh). These species were predominantly black locust, black cherry, sycamore, and native walnut. Trees immediately bordering the test area to the south consisted of smaller sweetgums (20 to 33 ft tall, 3 to 5 in. dbh) that occurred along a drainage ditch running perpendicular to the asphalt road.

15. The grassy area, consisting of grasses, ferns, and small shrubs, was sampled at four locations (Figure 3). Vegetation within a 1-meter square area was measured for height, then cut for weighing (fresh weight) and classification. Vegetation height and density data are shown below.

Sample Location	Height, in.	Density, g/sq m
1	46	790
2	25	1,000
3	40	1,000
4	30	1,000

16. Of particular significance to the WAM ground sensor was the dense grassy vegetation in the vicinity of the sensor lines. For many tests the sensors were installed with minimum disturbance to the grasses (Photo 3). Additionally, several inches of thick spongy plant detritus and stems, rhizomes, and roots from live plants blanketed the ground, making it difficult to achieve good seismic coupling with the substrate.

Surface Soil Conditions

17. A soil survey was performed at the Old Bombing Site prior to conducting the ground sensor test. Soil samples and cone penetrometer measurements (using a 0.2-sq in. cone) were made at each of the five sampling locations (Figure 3); cone penetrometer measurements were taken along a line between the C and F towers several hundred feet west of the road. Samples were obtained by removing vegetation and collecting soil to a depth of 5 in. Samples were returned to WES for laboratory analysis and classification. Three replicate cone index (CI) measurements were taken at each location. Soil classification data are presented in Figure 23; the CI data are summarized in Table 2.

18. Soil analysis revealed a sand/silt/clay mixture at all locations with decreasing bearing strength as the ground elevation decreased and became saturated. It was determined that the southern half of the site would not be trafficable by heavy-tracked vehicles; therefore, the off-road vehicle tests were performed in the northern half of the site proceeding from the north to the south (Figure 3).

PART III: SUMMARY

19. The WAM sensor testing at Aberdeen Proving Ground provided a significantly different sensor environment from the earlier test at YPG. Captive flight testing was performed in an area with relatively few terrain types and under generally low solar loading and moderate temperatures. This would make for low levels of thermal background clutter. Ground sensor testing was performed in a dense grassy area under generally windy conditions. This provided an excellent test of the effects of wind and vegetation background noise. Additionally, the dense vegetation ground cover provided a good test of geophone coupling (for Textron WAM only, since the Honeywell WAM geophone was not operationally deployed). The computed seismic site transfer function indicates that relatively good low-frequency propagation occurs but the site has a low cutoff frequency (frequency above which seismic waves are attenuated), tending to damp high-frequency signals over short distances. This should provide a good test of ground sensor system classifiers that use high- and low-frequency components in making classification decisions.

Table 1

Plants Encountered at Ground Sensor Test Site

Family	Genus/Species	Common Name
Graminae	*Erianthus* sp.	Plume grass
	Panicum sp.	Panic grass
	Panicum virgatum	Switch grass
	Andropogon sp.	Broom sedge
	Sorghastrum nataxs	Indian grass
	Elymus sp.	Wild rye
	Manisuris sp.	
	Paspalum sp.	Paspulum
Compositae	*Euputorium hyssopifolium*	Dog fennel
	Euputorium rotundifolium	Dog fennel
Fabacaea	*Lespedeza* sp.	Lespedeza
Labiatae	*Monarda* sp.	Mint
Polypodiaceae	*Dryoptepis* sp.	Fern
	Polypodiure sp.	Fern
Myricaceae	*Myrica* sp.	Myrtle
Rosaceae	*Rubus* sp.	Blackberry
Leguminoseae	*Robinia pseudoacacia*	Black locust
Rosaceae	*Prunus nigra*	Black cherry
Platanaceae	*Platanus occidentalis*	Sycamore
Inglandaceae	*Juglans nigra*	Native walnut
Hamamelidaceae	*Liquidamber sytraciflua*	Sweet gum

Table 2

Cone Index Measurements Using a 0.2-Square Inch Cone

Location	Depth, in.											Measured Moisture, %
	0	1	2	3	4	5	6	9	12	15	18	
1	70	160	190	260	480	550	610	670	350	390+	750+	17
2	50	380	670+	750+	750+	750+	750+	--	--	--	--	15
3	50	190	320	490	590	670	680	590	540	680	670+	18
4	60	210	290	400	470	540	550+	480+	510+	550+	620+	17
5	60	210	340	450	530	600	590	510	740+	750+	750+	15
F Tower	40	90	130	140	180	260	410	480+	630	--	--	--
	20	50	90	180	270	360	430	550	580+	--	--	--
	50	180	410	560	750+	--	--	--	--	--	--	--
	40	90	250	440	750+	--	--	--	--	--	--	--
	40	90	90	80	90	110	350	420+	550+	--	--	--
	20	60	70	310+	330+	350+	390+	360+	620+	--	--	--
	30	80	130	150	170	180	180	190	210	--	--	--
C Tower	40	110	160	200	220	240	250	410	450	--	--	--

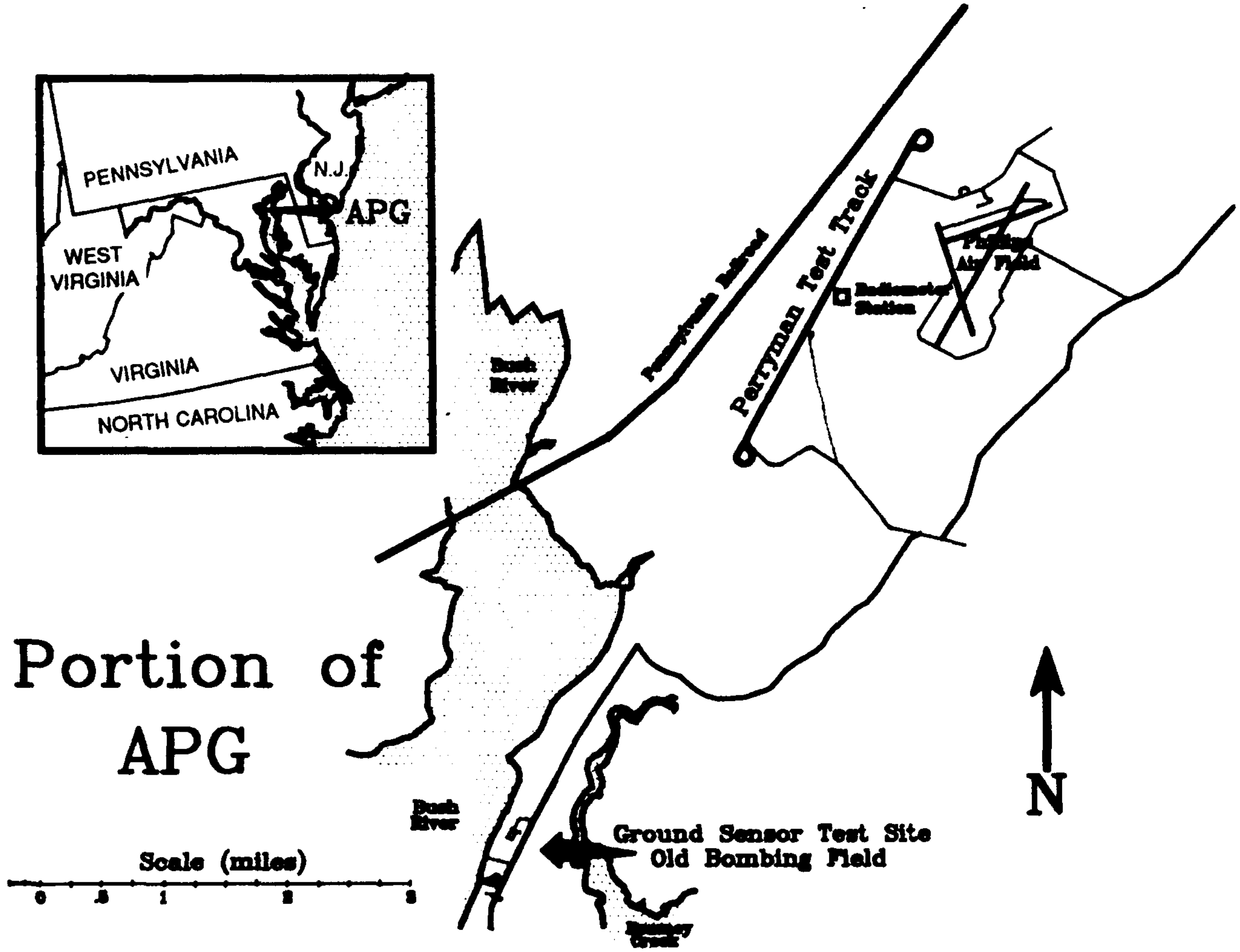


Figure 1. Location map

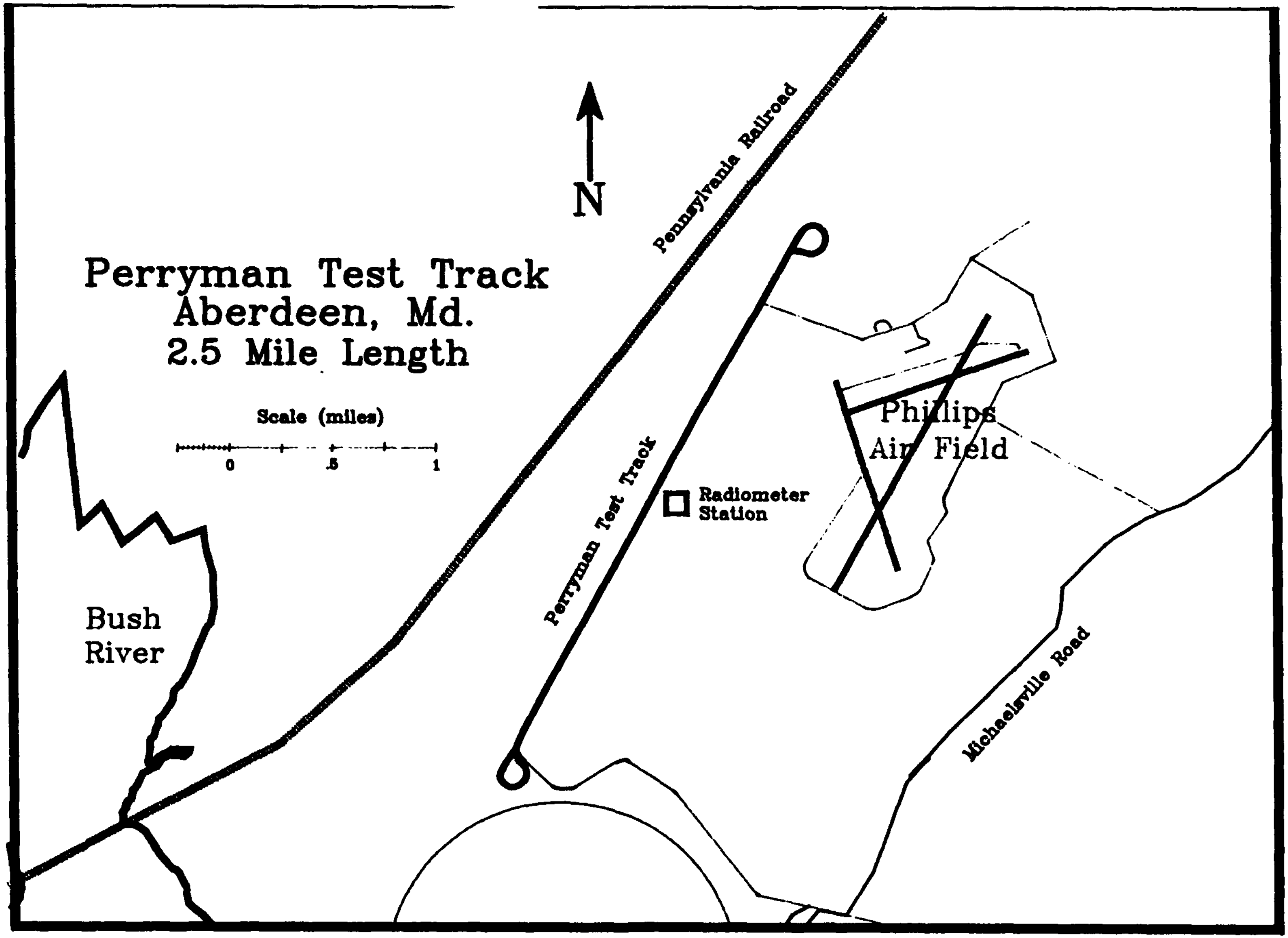


Figure 2. Perryman Test Area used for captive flight testing

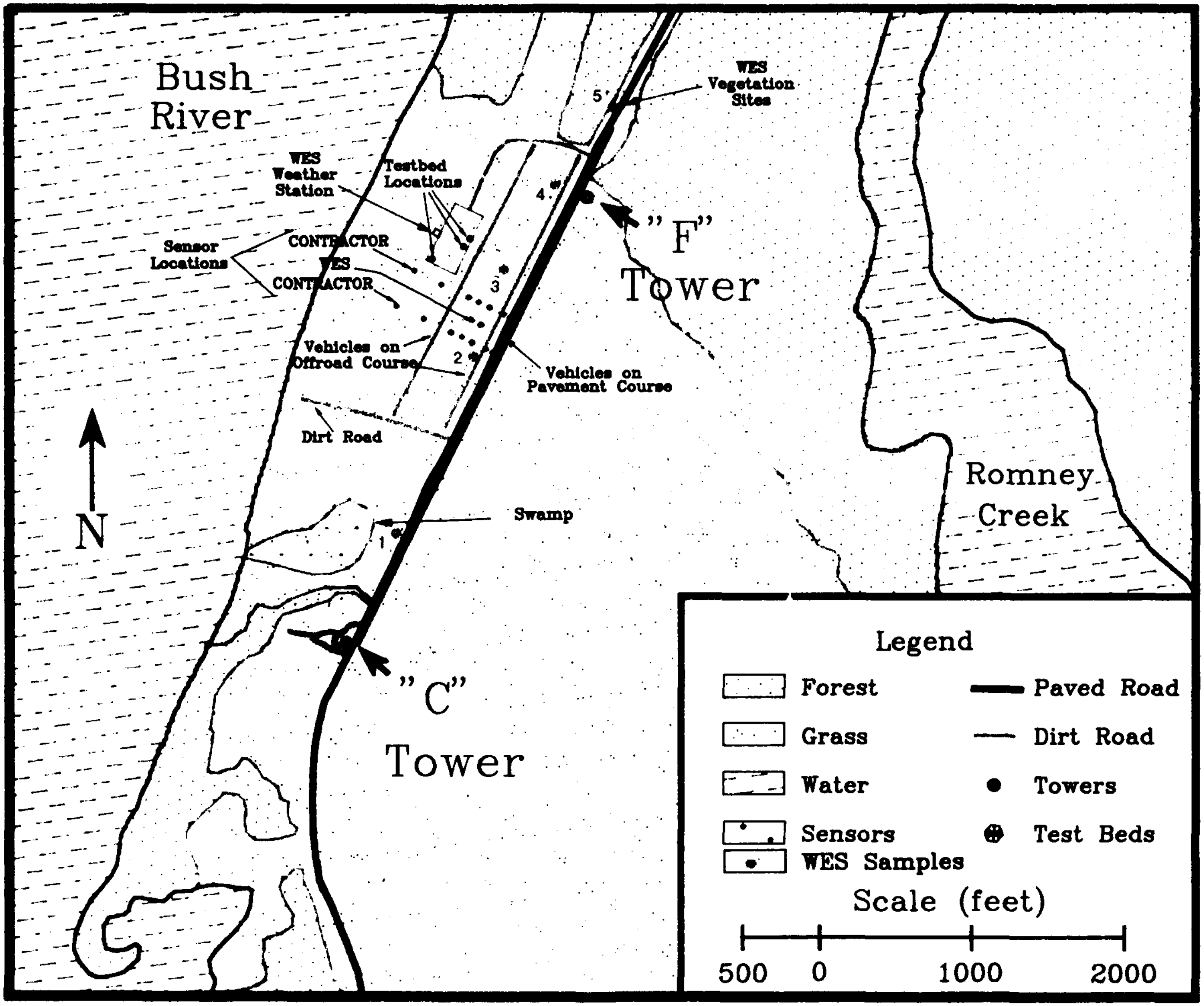


Figure 3. Old Bombing Site used for ground sensor testing

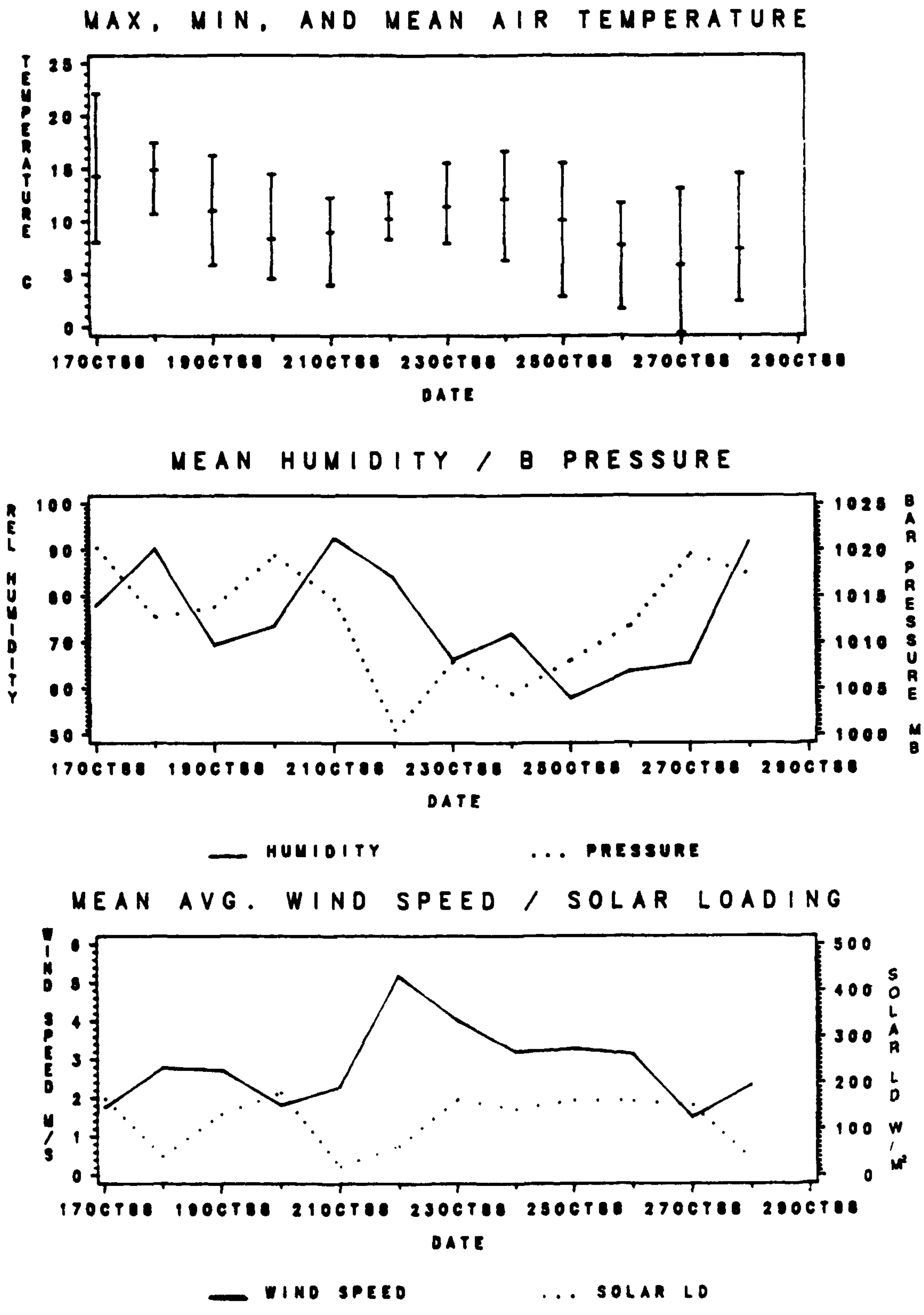


Figure 4. Daily average weather conditions

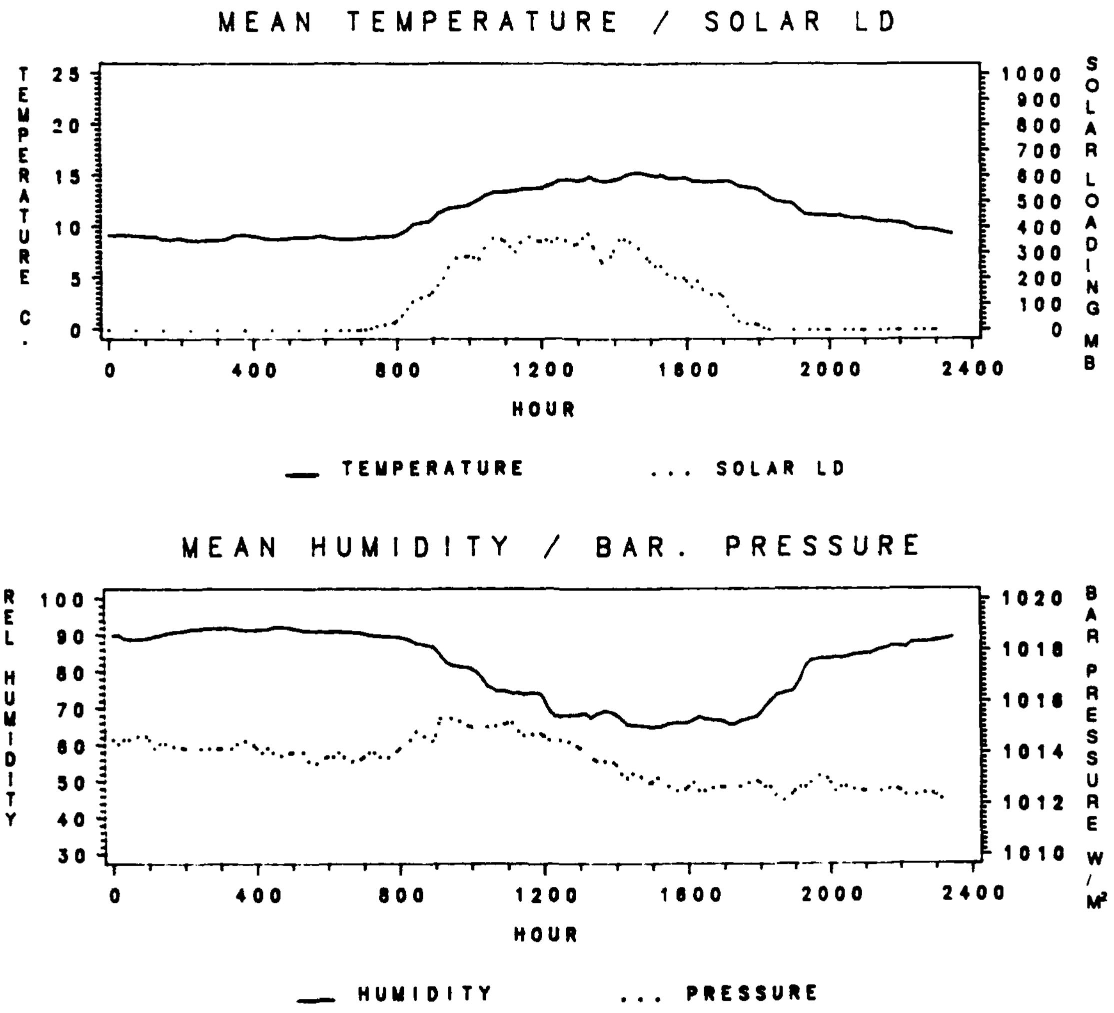


Figure 5. Mean diurnal conditions during CFT

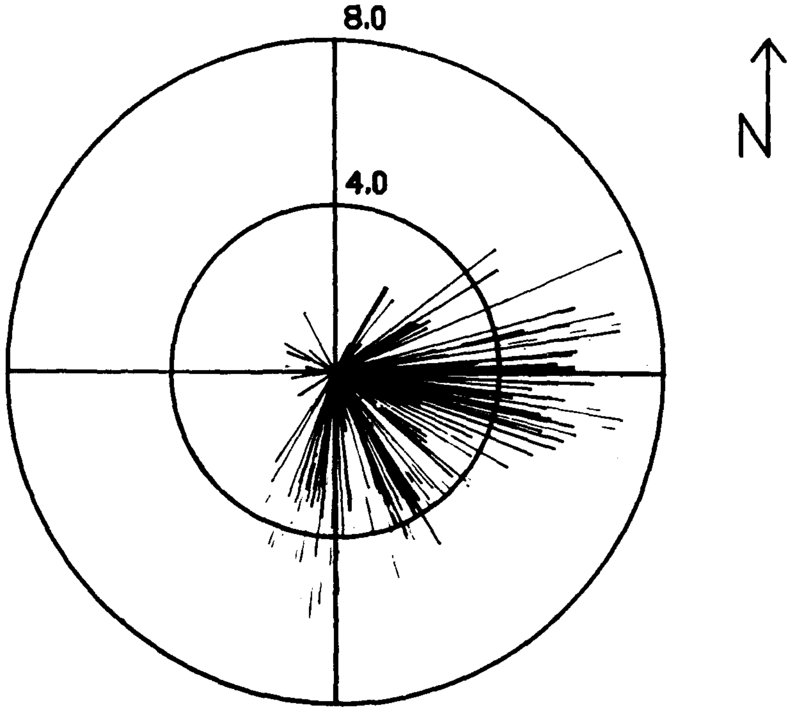


Figure 6. Daytime wind speed (m/sec) and direction during ground sensor testing, 24-28 October 1988

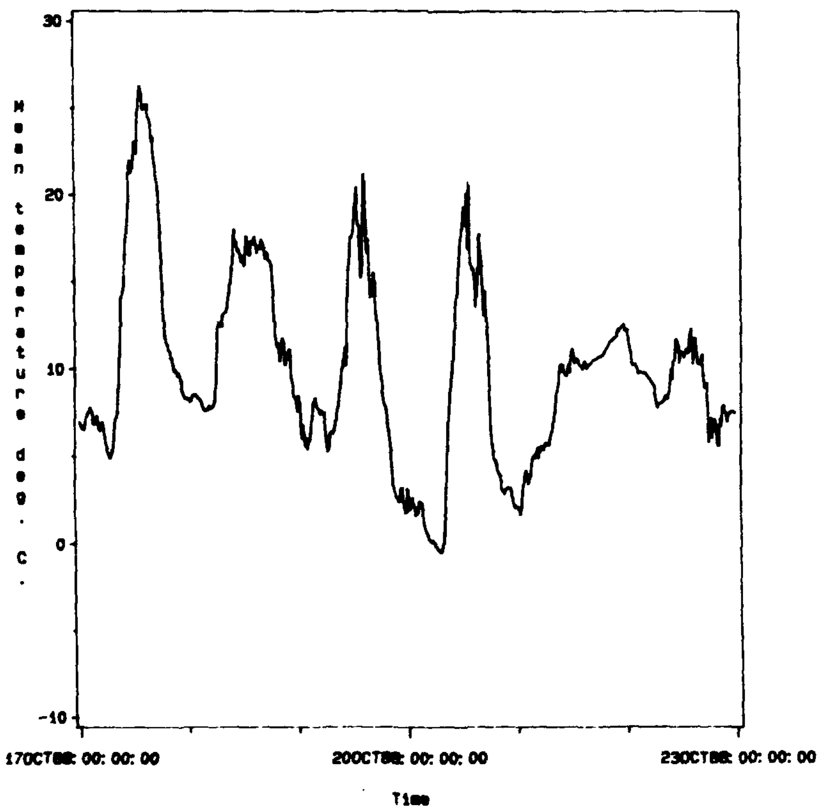


Figure 7. Mean radiometric temperature of background during CFT, 17-22 October 1988

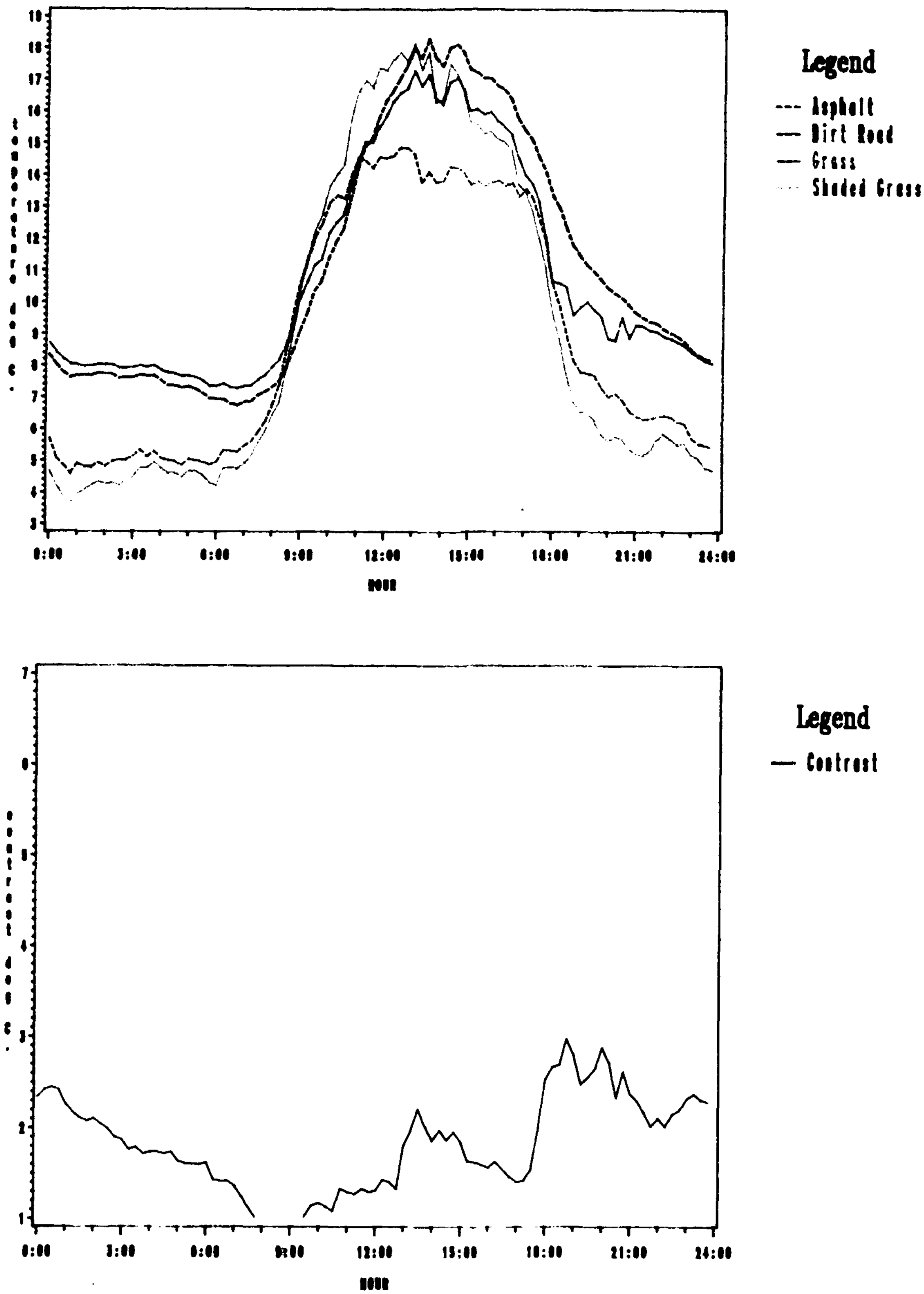


Figure 8. Temperature data during CFT, 17-22 October 1988, showing average diurnal surface temperatures (top) and thermal contrast (bottom)

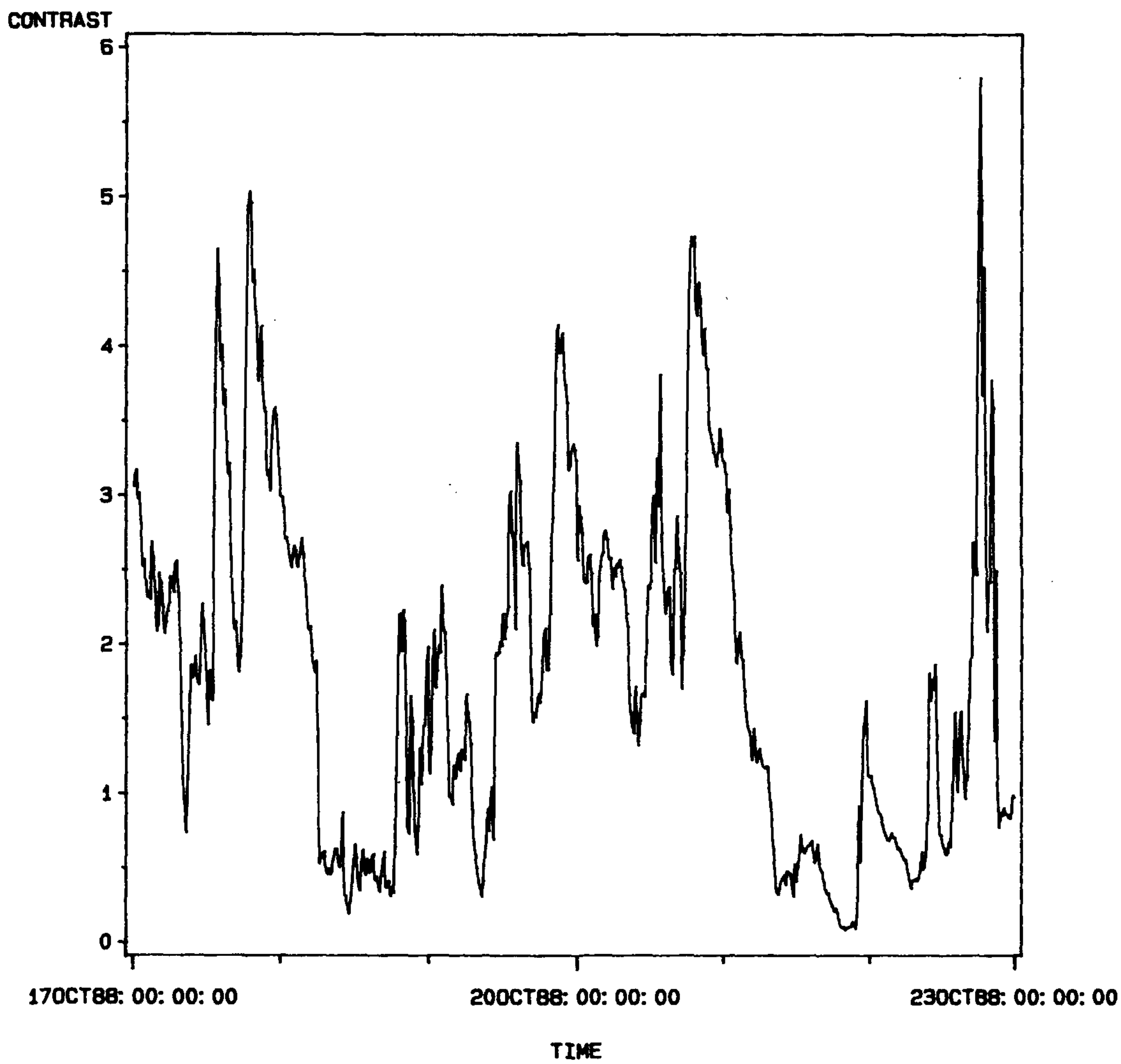


Figure 9. Thermal contrast indicator during CFT

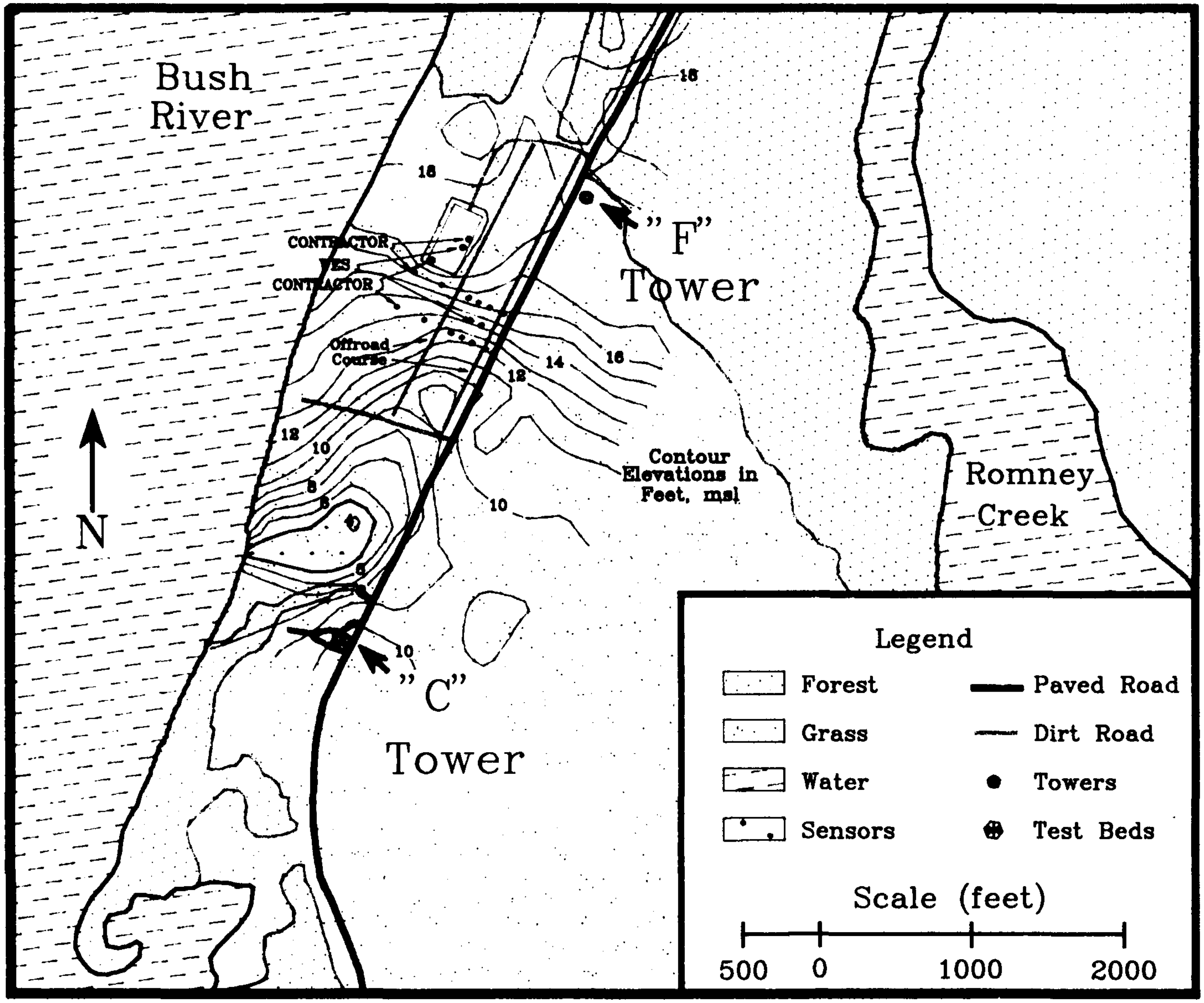


Figure 10. Topography of ground sensor test site

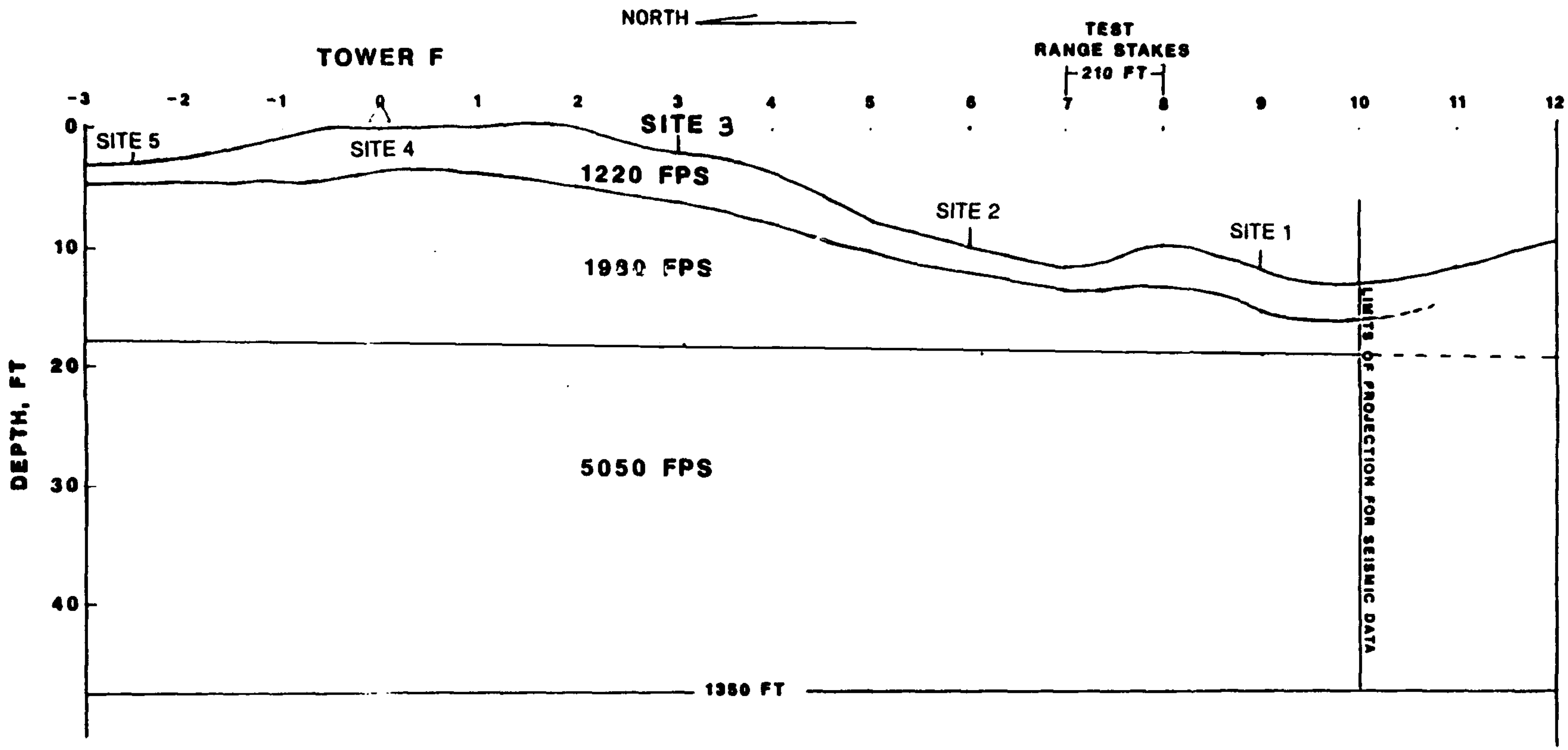
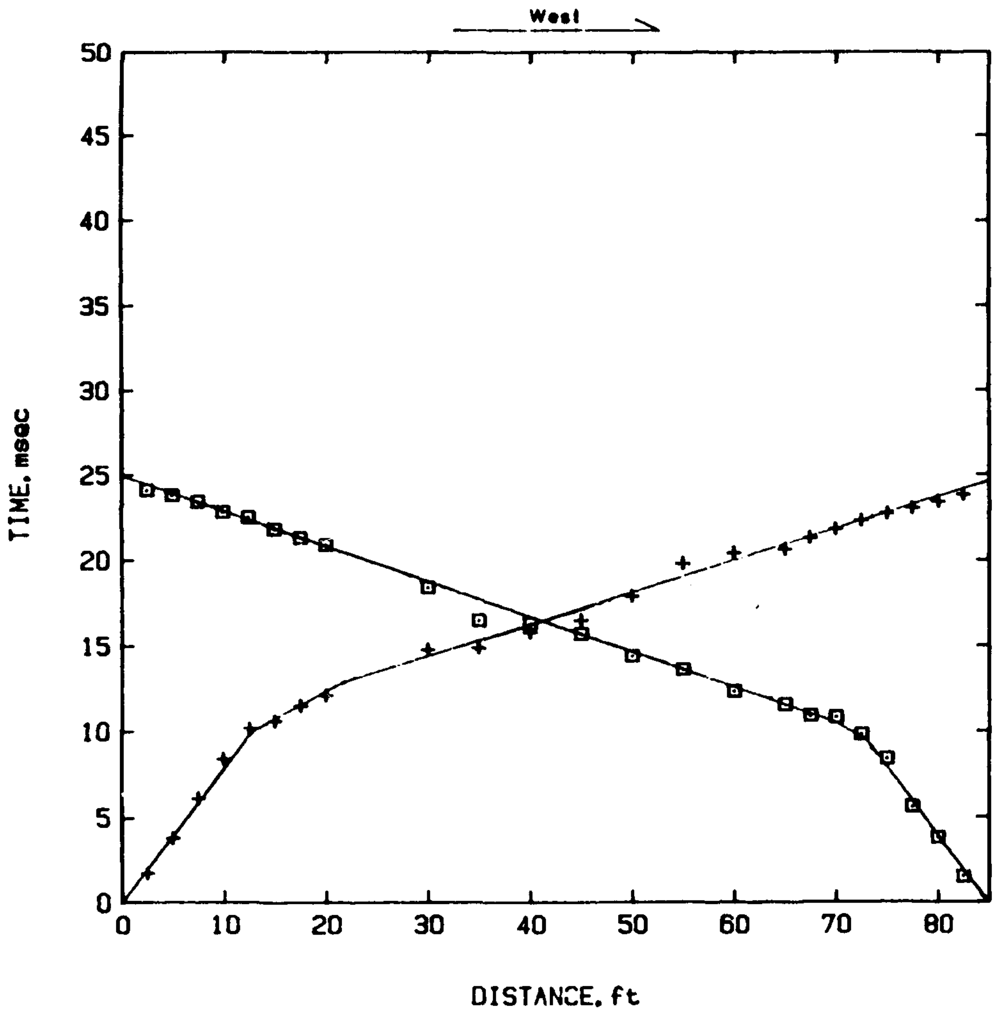


Figure 11. Representative profile of APG ground sensor test site



SITE 1, LINE A, STAKE 9

APGWAMS

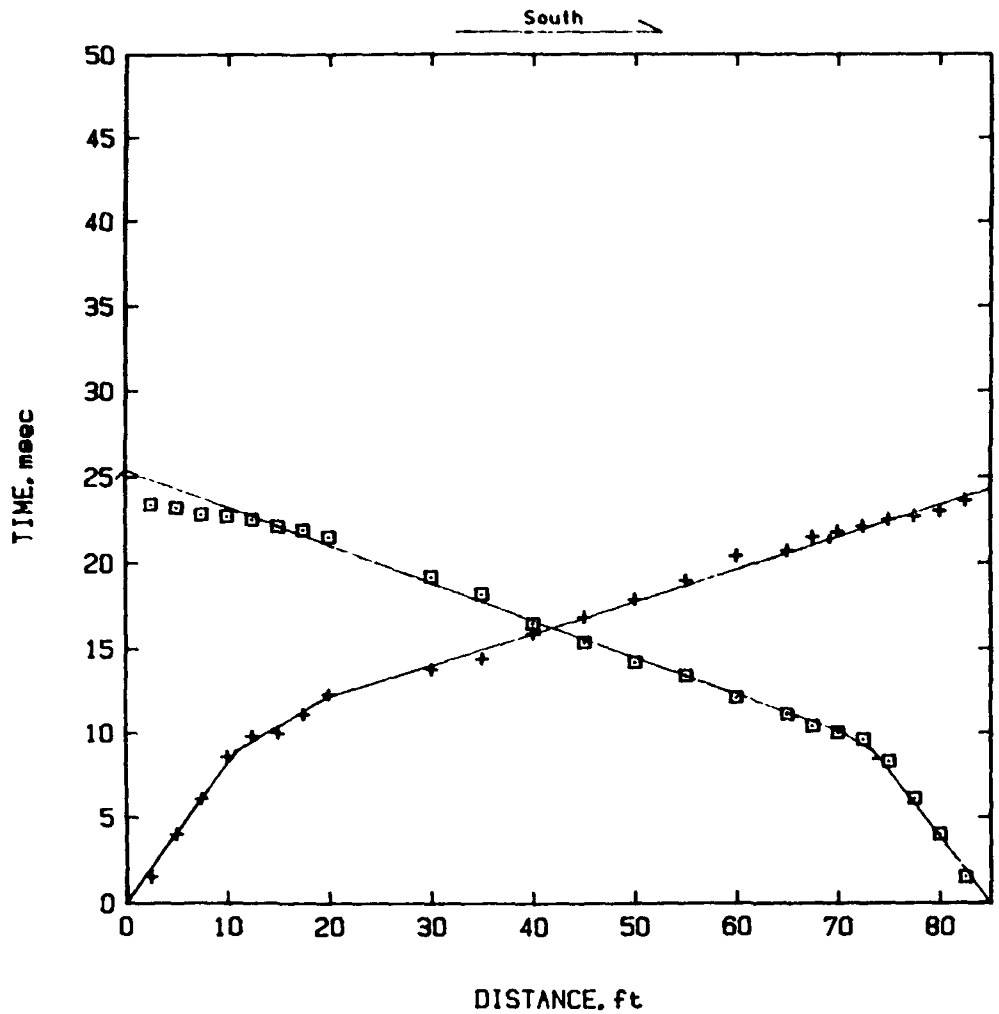
*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1285	0.0	1270	.0
2	9118	5.9	3200	5.7
3	5398	8.9	4828	7.4

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1280		
2	9150	4.0	4.0
3	5080	8.5	6.5

Figure 12. Results of p-wave refraction survey for site 1, parallel to road



SITE 1, LINE B, STAKE 9

APGWAM8

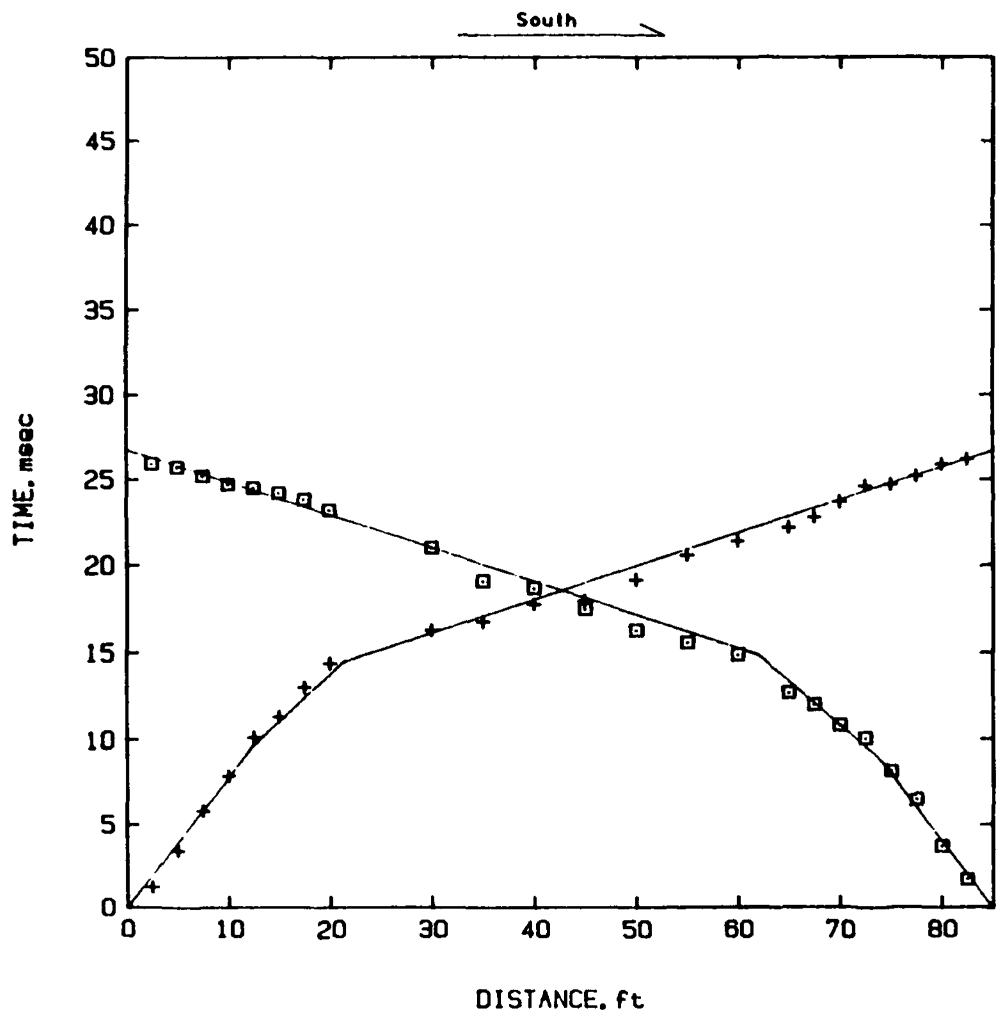
*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1228	.0	1297	.0
2	2772	5.0	2900	5.0
3	5354	8.4	4583	6.8

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1260		
2	2830	3.5	3.5
3	4920	9.0	8.0

Figure 13. Results of p-wave refraction survey for site 1, perpendicular to road



SITE 2, LINE A, STAKE 5

APGWAM1

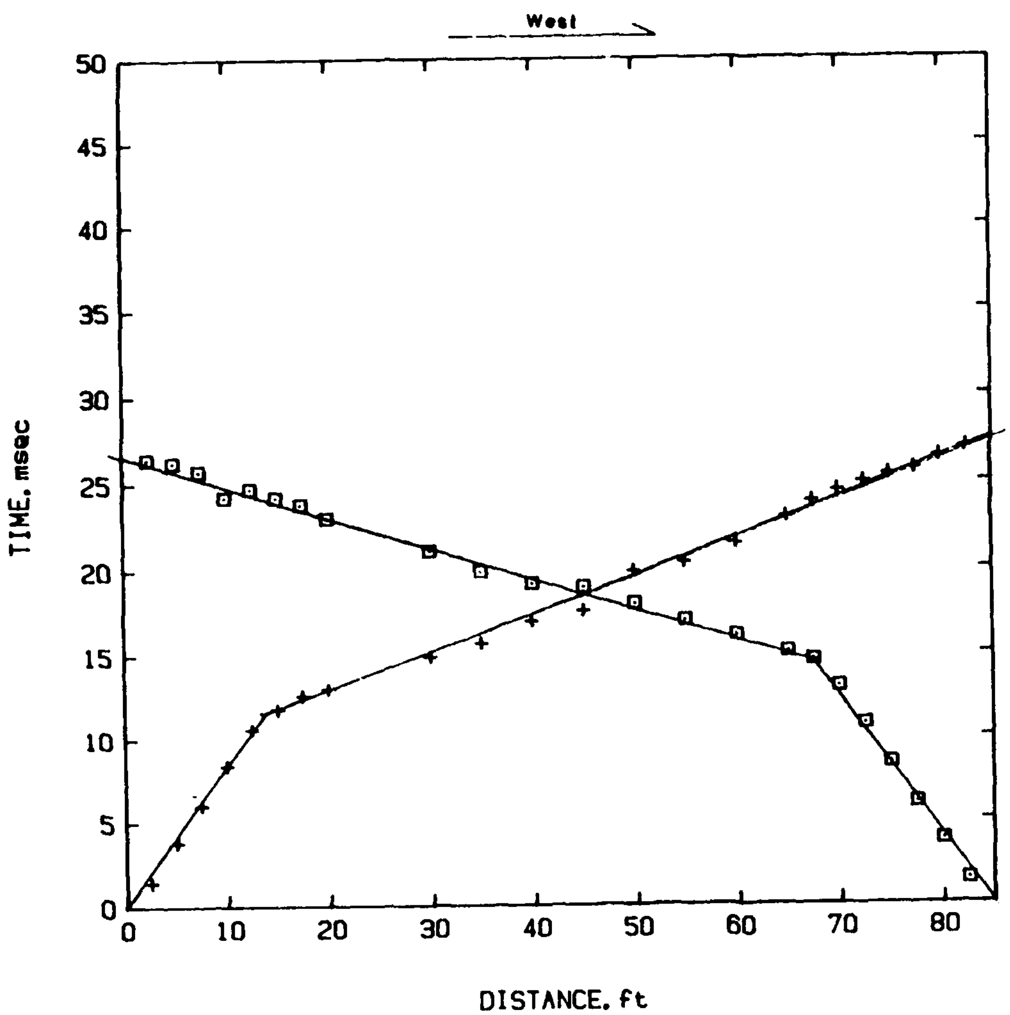
*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1291	.0	1248	.0
2	1825	2.8	1952	3.1
3	5219	10.4	5229	10.5

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1270		
2	1880	2.5	2.5
3	5220	9.0	9.0

Figure 14. Results of p-wave refr[illegible]ion survey for site 2, parallel to road



SITE 2, LINE B, STAKE 6

APGWAM2

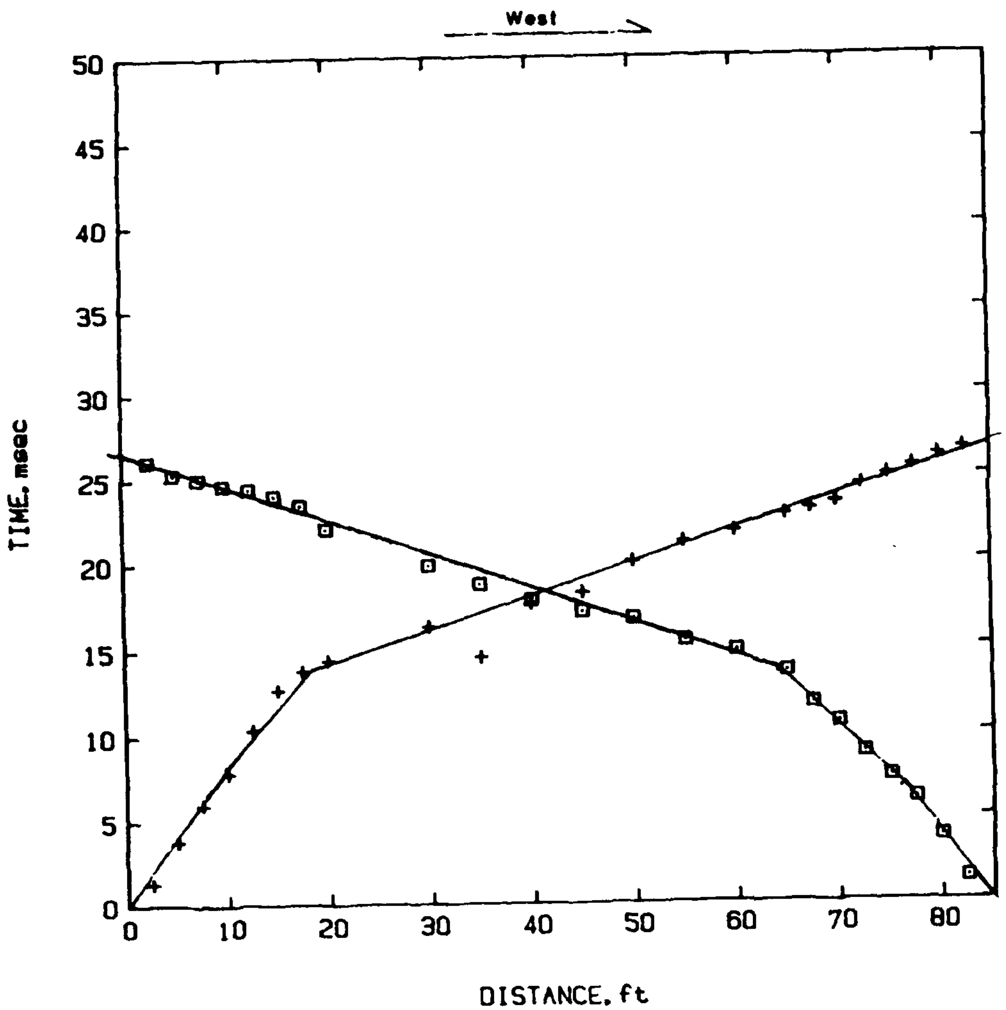
*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1199	0.0	1212	0.0
2	4471	8.5	5591	11.4

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1210		
2	4980	5.5	7.0

Figure 15. Results of p-wave refraction survey for site 2, perpendicular to road (replicate 1)



SITE 2, LINE C, STAKE 6

APGWAM58

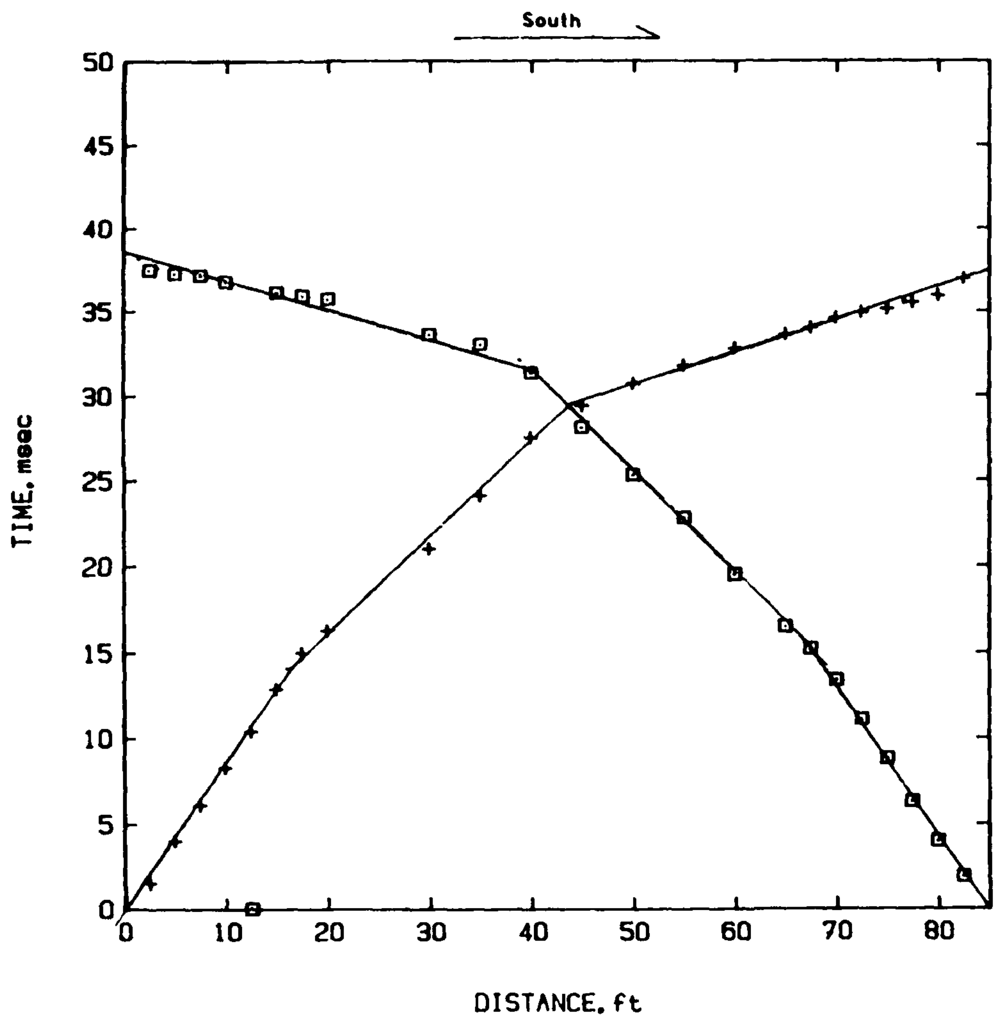
*** INPUT DATA ***

LAYER #	FORWARD VEL. FT/S	FORWARD TI. MSEC	REVERSE VEL. FT/S	REVERSE TI. MSEC
1	1218	0.0	1288	.0
2	1500	1.8	1770	1.9
3	5207	10.4	4973	9.5

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1240		
2	1810	1.5	2.0
3	5080	8.5	7.5

Figure 16. Results of p-wave refraction survey for site 2, perpendicular to road (replicate 2)



SITE 3, LINE A, STAKE 3

APGWAM3

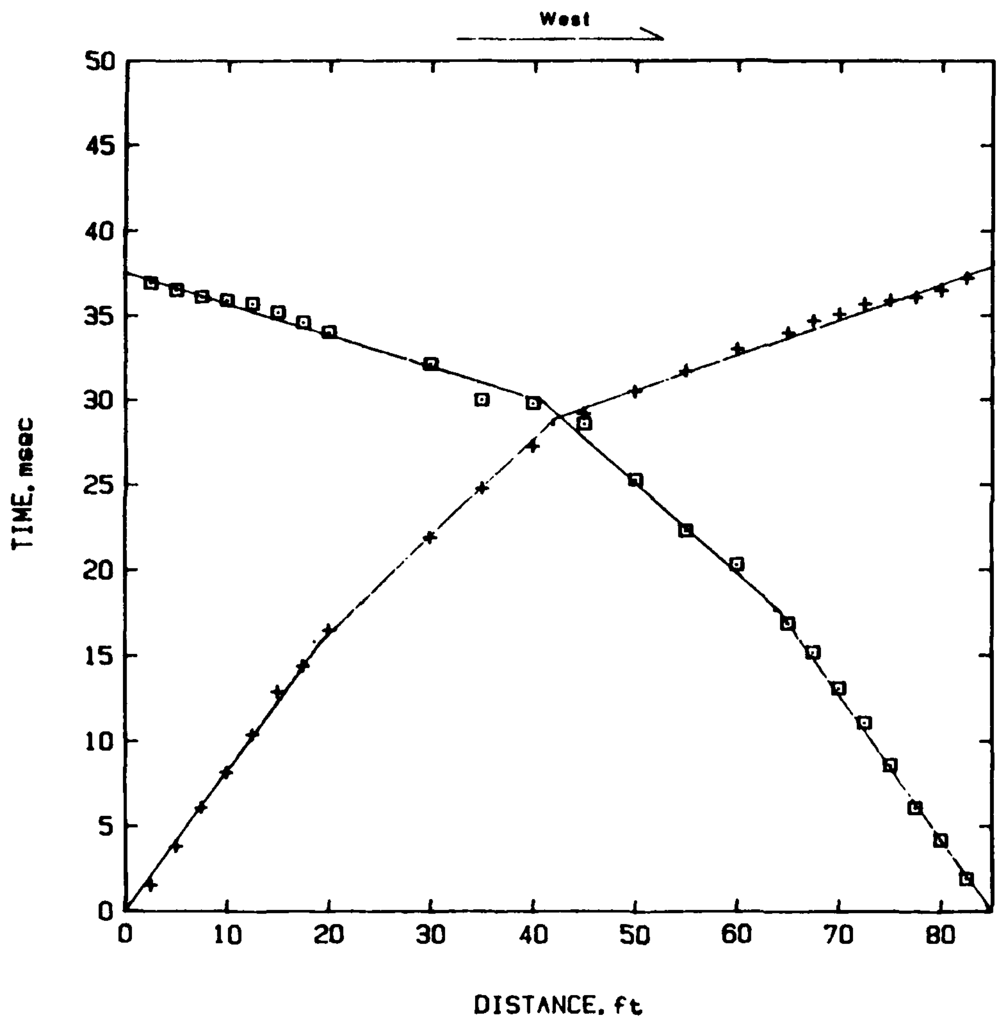
*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1169	0.0	1148	0.0
2	1787	4.9	1695	5.0
3	5194	21.0	5653	23.5

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1160		
2	1730	4.0	4.0
3	5400	17.0	19.5

Figure 17. Results of p-wave refraction survey for site 3, parallel to road



SITE 3, LINE B, STAKE 3

APGWAM4

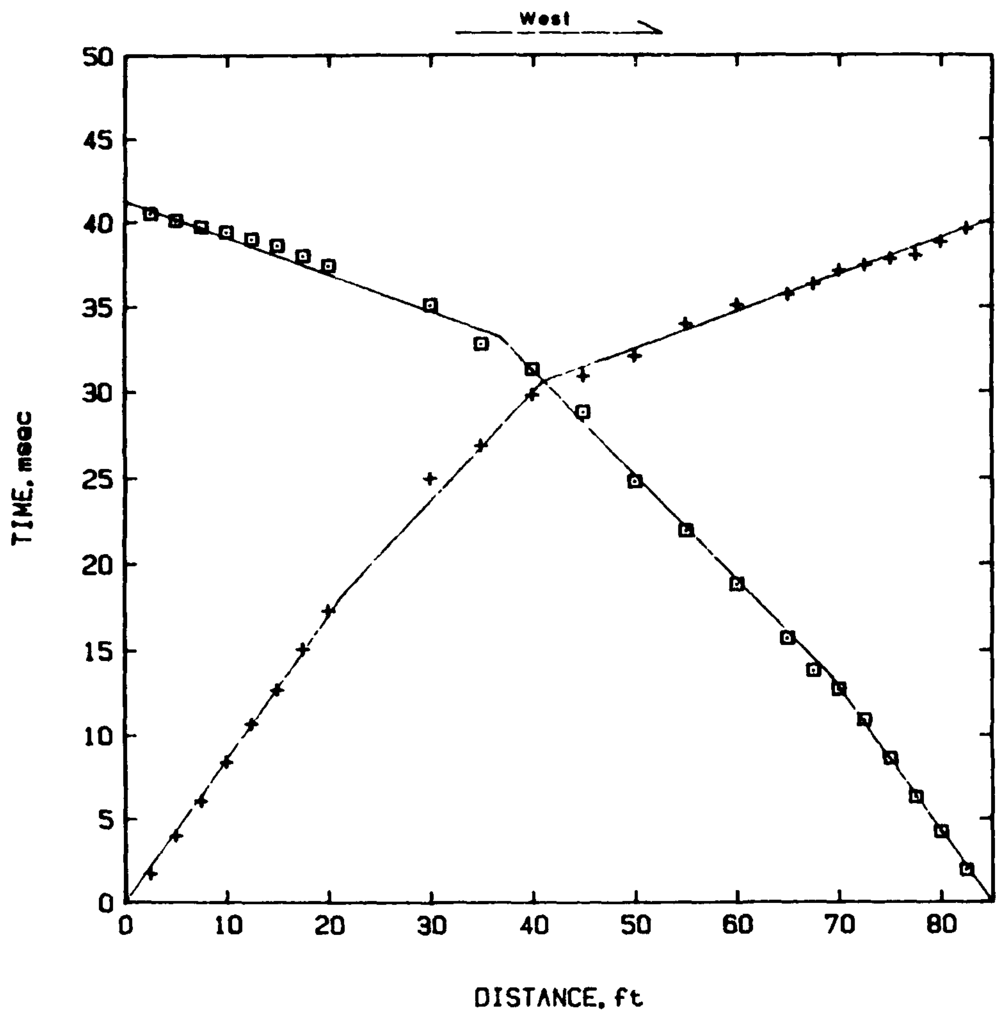
*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1220	0.0	1182	0.0
2	1748	4.8	1897	6.7
3	4766	20.0	5388	21.7

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1200		
2	1810	4.0	5.5
3	5050	17.5	18.0

Figure 18. Results of p-wave refraction survey for site 3, perpendicular to road



SITE 4, LINE A, STAKE 0

APGWAM7A

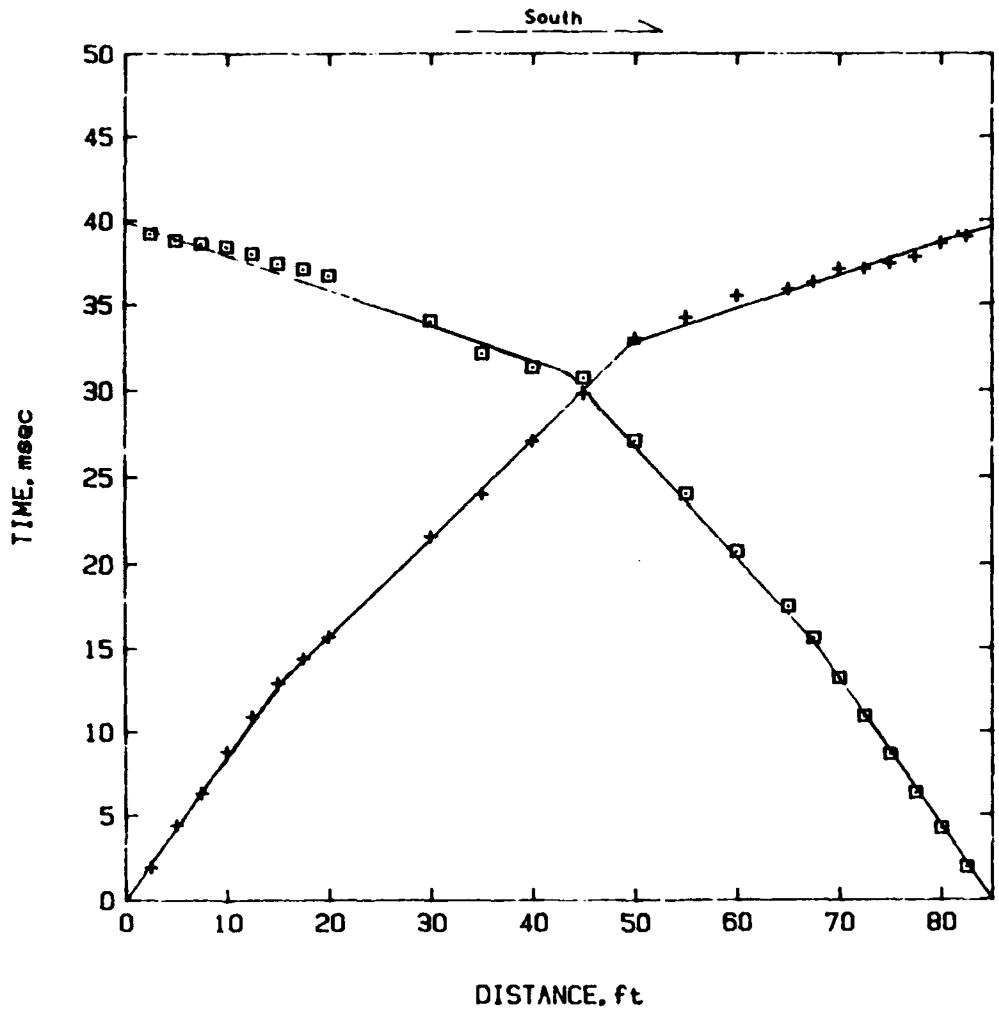
*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1174	.0	1170	0.0
2	1591	4.8	1644	3.9
3	4590	21.7	4591	22.7

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1170		
2	1610	4.0	3.5
3	4590	17.0	16.0

Figure 19. Results of p-wave refraction survey for site 4, parallel to road



SITE 4, LINE B, STAKE 0

APGWAM78

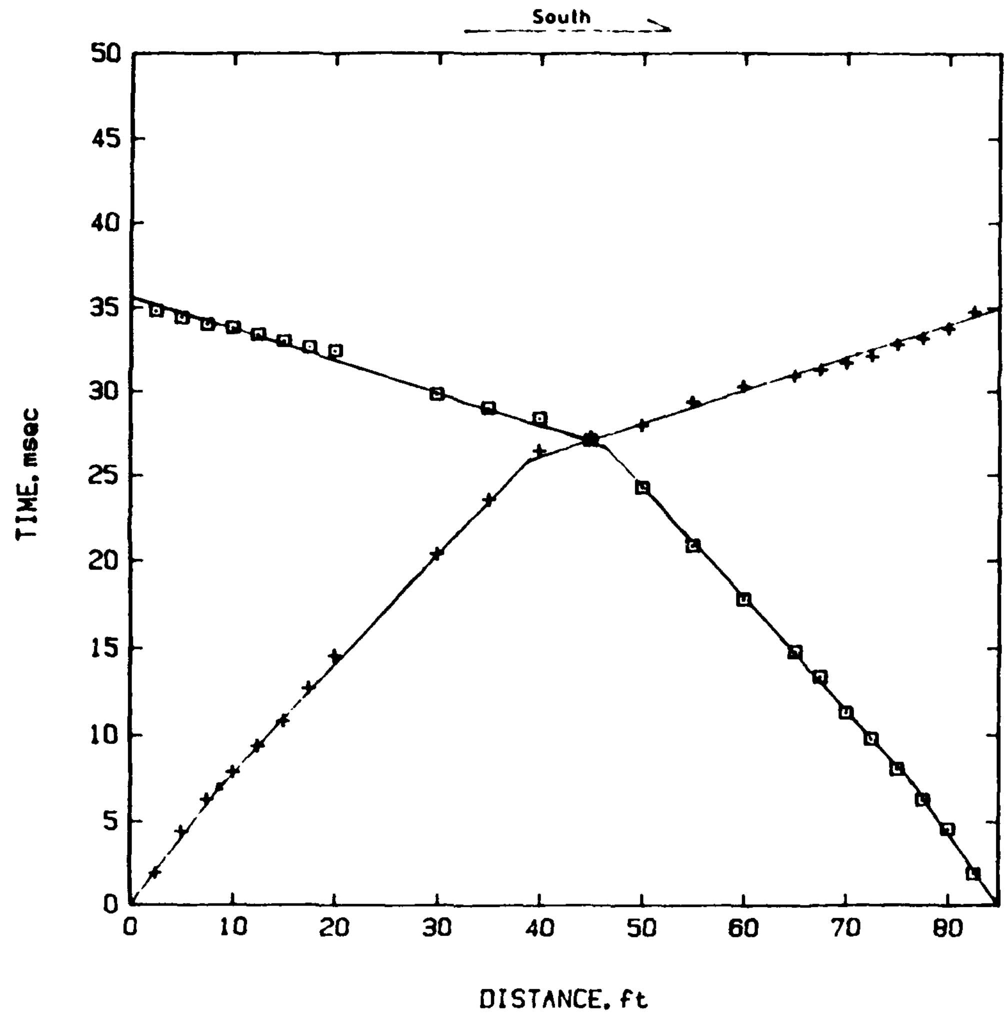
*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1187	0.0	1141	0.0
2	1745	4.2	1535	4.0
3	5097	23.0	4850	22.4

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1170		
2	1620	3.5	3.5
3	4960	18.5	18.0

Figure 20. Results of p-wave refraction survey for site 4, perpendicular to road



SITE 5, LINE A, STAKE (-3)

APGWAMB

*** INPUT DATA ***

	FORWARD		REVERSE	
LAYER #	VEL. FT/S	TI. MSEC	VEL. FT/S	TI. MSEC
1	1254	.0	1180	.0
2	1597	1.5	1552	1.8
3	5084	10.2	5171	10.2

*** COMPUTED SEISMIC PROFILE ***

LAYER #	TRUE VEL. FT/S	DEPTH FOR. FT	DEPTH REV. FT
1	1210		
2	1570	1.5	1.5
3	5120	14.5	15.5

Figure 21. Results of p-wave refraction survey for site 5, parallel to road

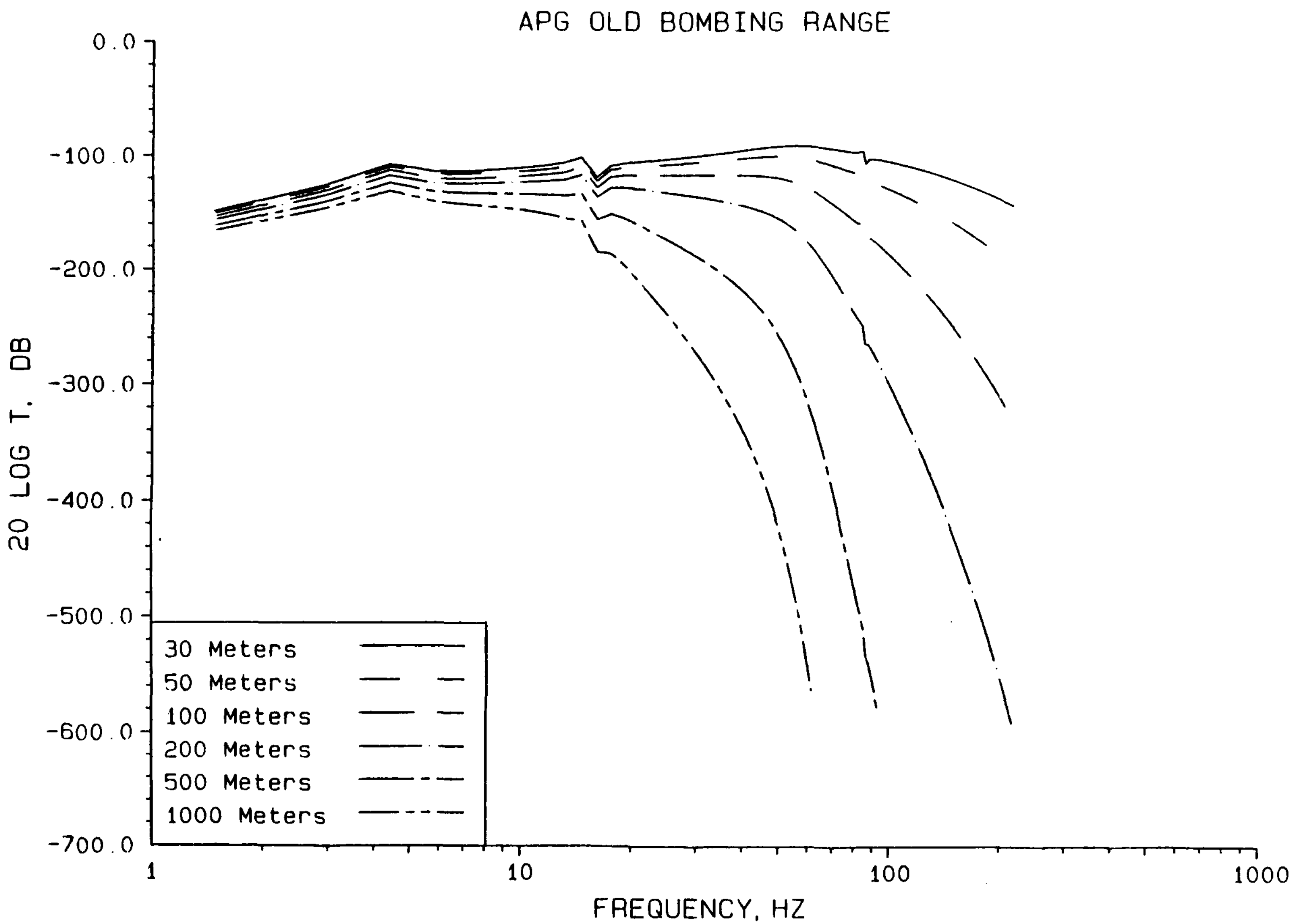
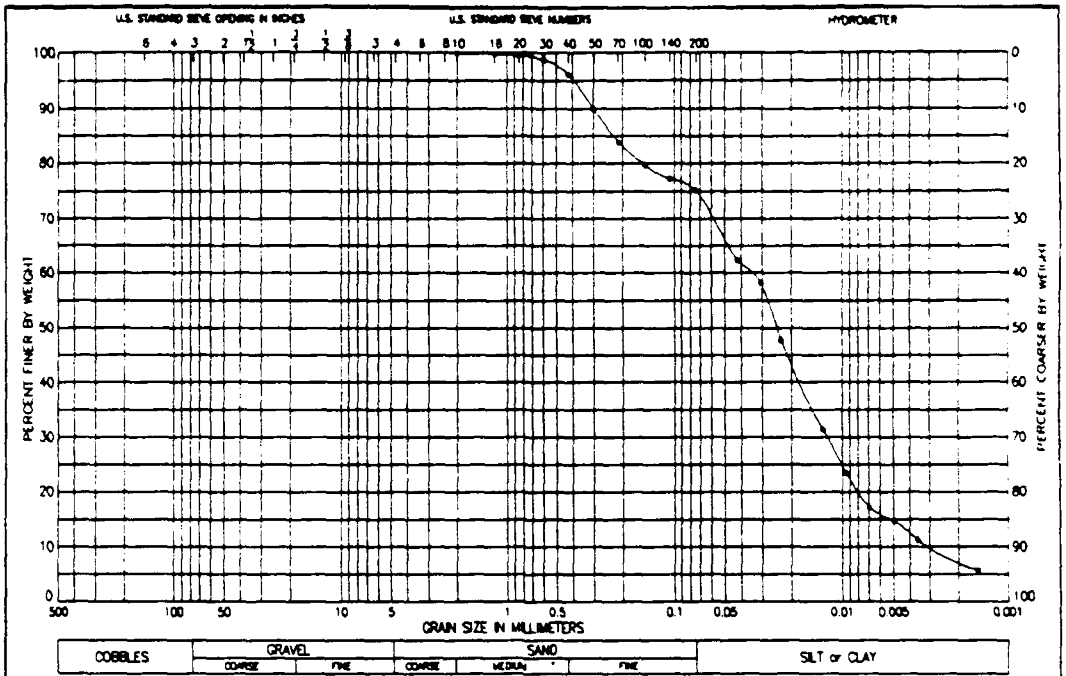


Figure 22. Seismic transfer function for APG ground sensor test site



LL 36	PL 28	PI 8	GS 2.63	NAT W %	

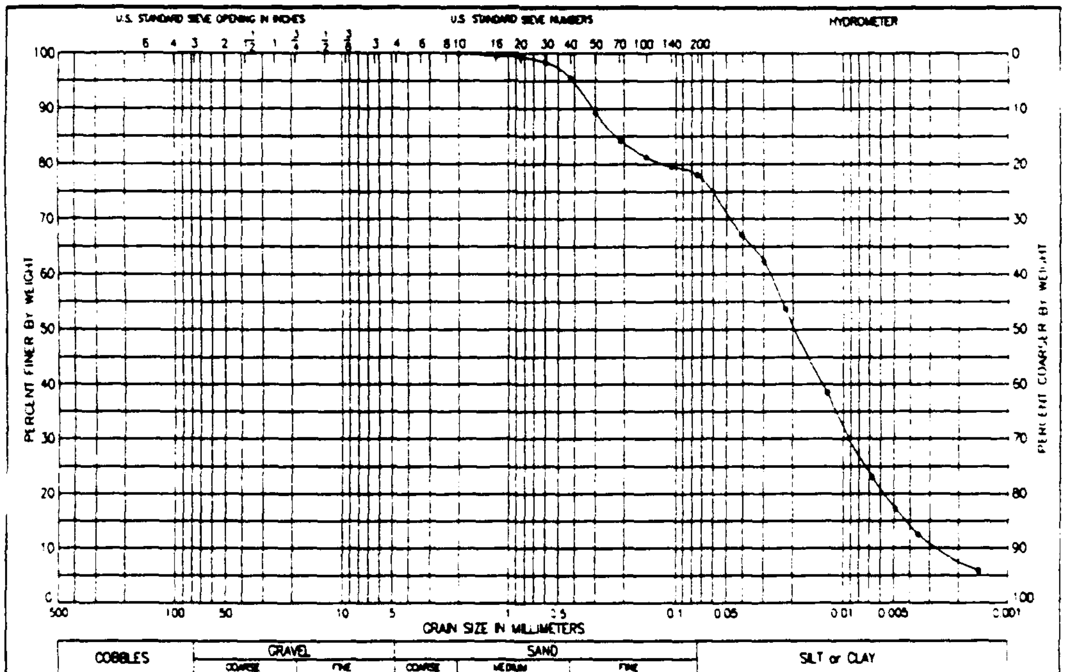
CLASSIFICATION
SANDY SILT (ML) GRAY

PROJECT WAM TEST ABERDEEN MD.

BORING NO. SAMPLE NO 1

DEPTH/ELEV 0–5" DATE 15NOV88

GRADATION CURVE



LL 38	PL 25	PI 13	GS 2.63	NAT W %	

CLASSIFICATION
SANDY SILTY CLAY (CL) GRAY

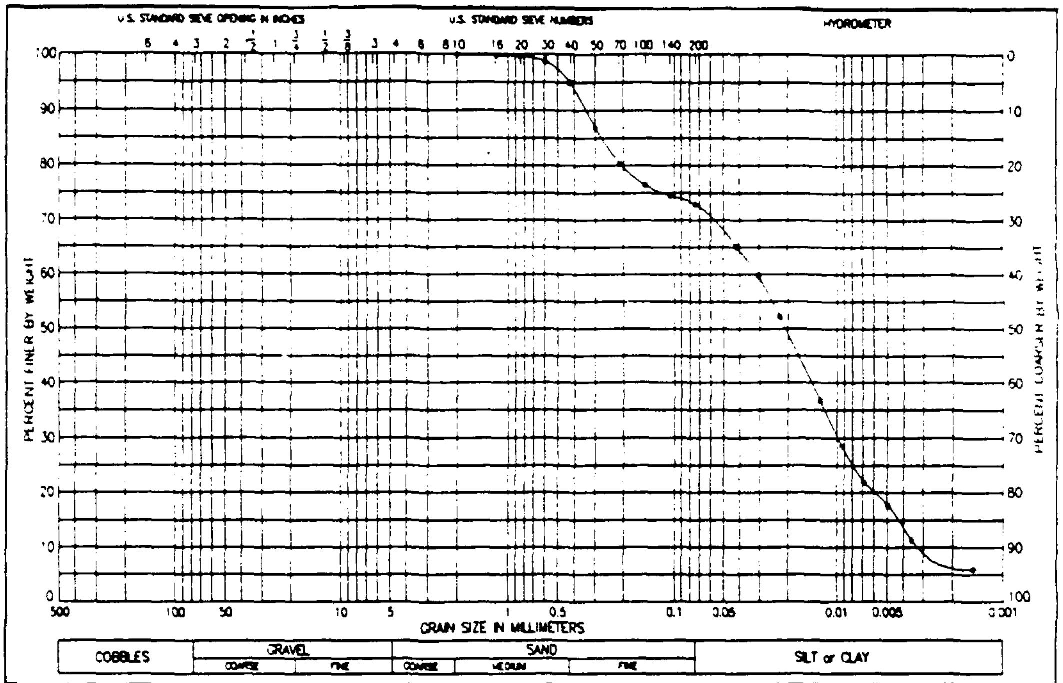
PROJECT WAM TEST ABERDEEN MD.

BORING NO SAMPLE NO. 2

DEPTH/ELEV 0–5" DATE 15NOV88

GRADATION CURVE

Figure 23. Soil test results, Samples 1-5 (Sheet 1 of 3)

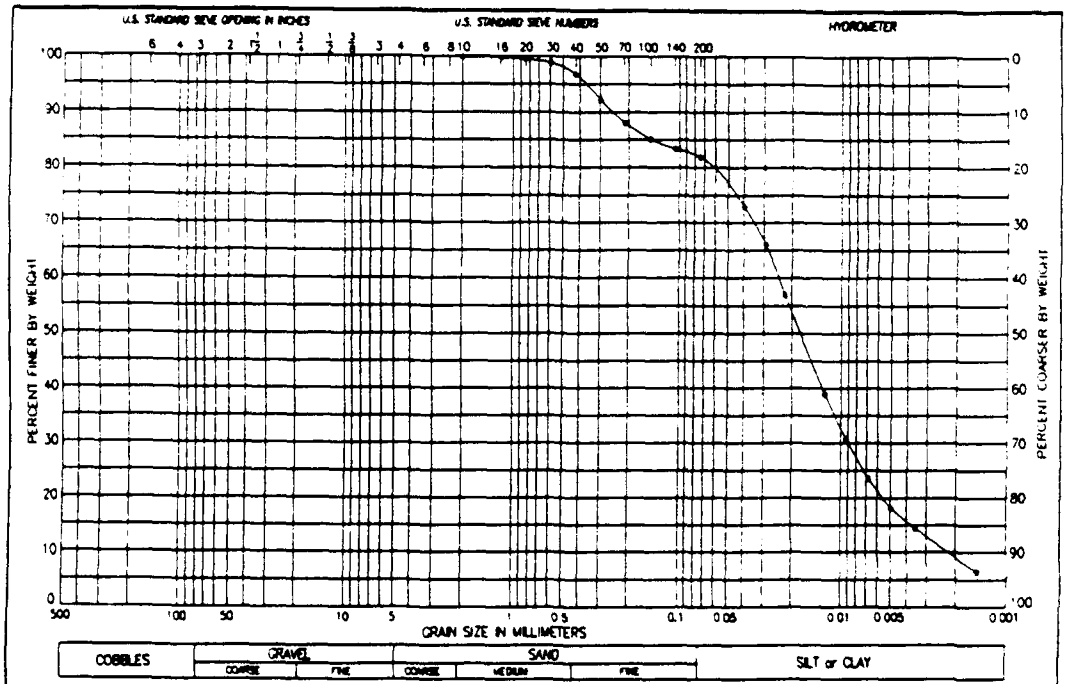


LL 38	PL 26	PI 12	GS 2.62	NAT W.%	

CLASSIFICATION
SANDY CLAYEY SILT (ML) GRAY

GRADATION CURVE

PROJECT WAM TEST ABERDEEN MD.
BORING NO.
SAMPLE NO. 3
DEPTH/ELEV 0-5"
DATE 15NOV88



LL 36	PL 25	PI 11	GS 2.62	NAT W.%	

CLASSIFICATION
SANDY CLAYEY SILT (ML) GRAY

GRADATION CURVE

PROJECT WAM TEST ABERDEEN MD.
BORING NO.
SAMPLE NO. 4
DEPTH/ELEV 0-5"
DATE 15NOV88

Figure 23. (Sheet 2 of 3)

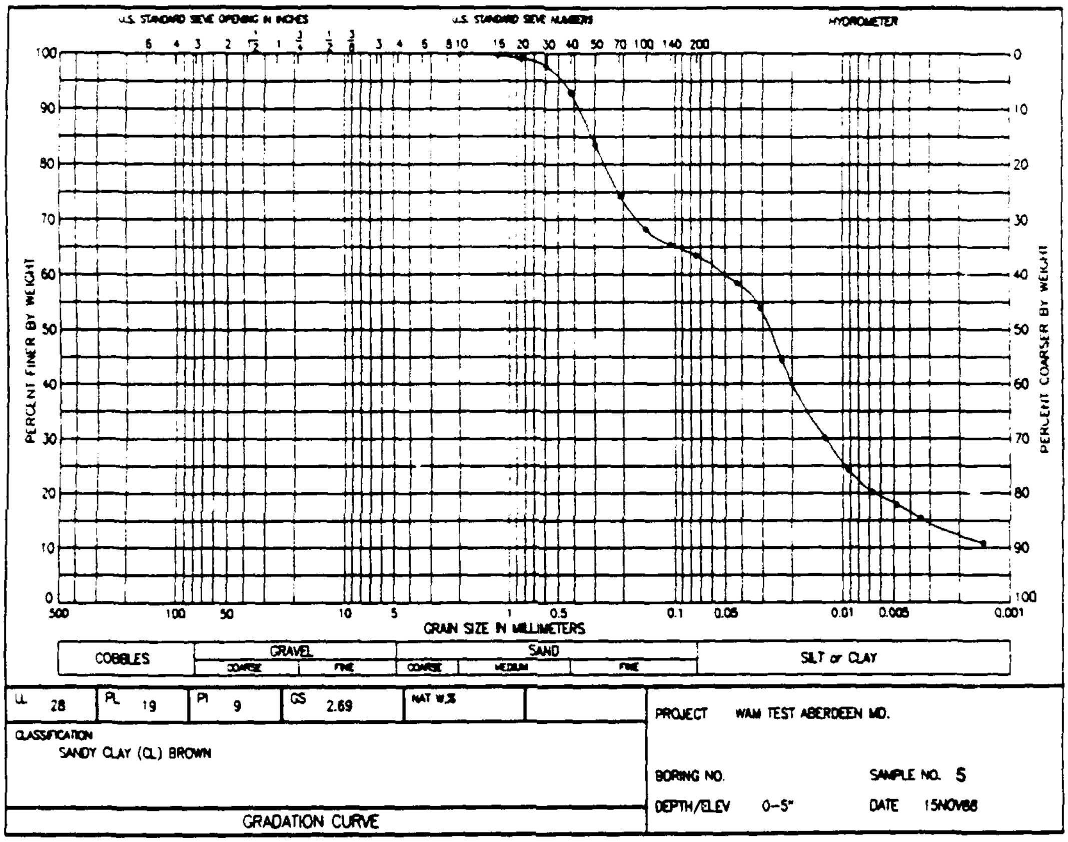


Figure 23. (Sheet 3 of 3)

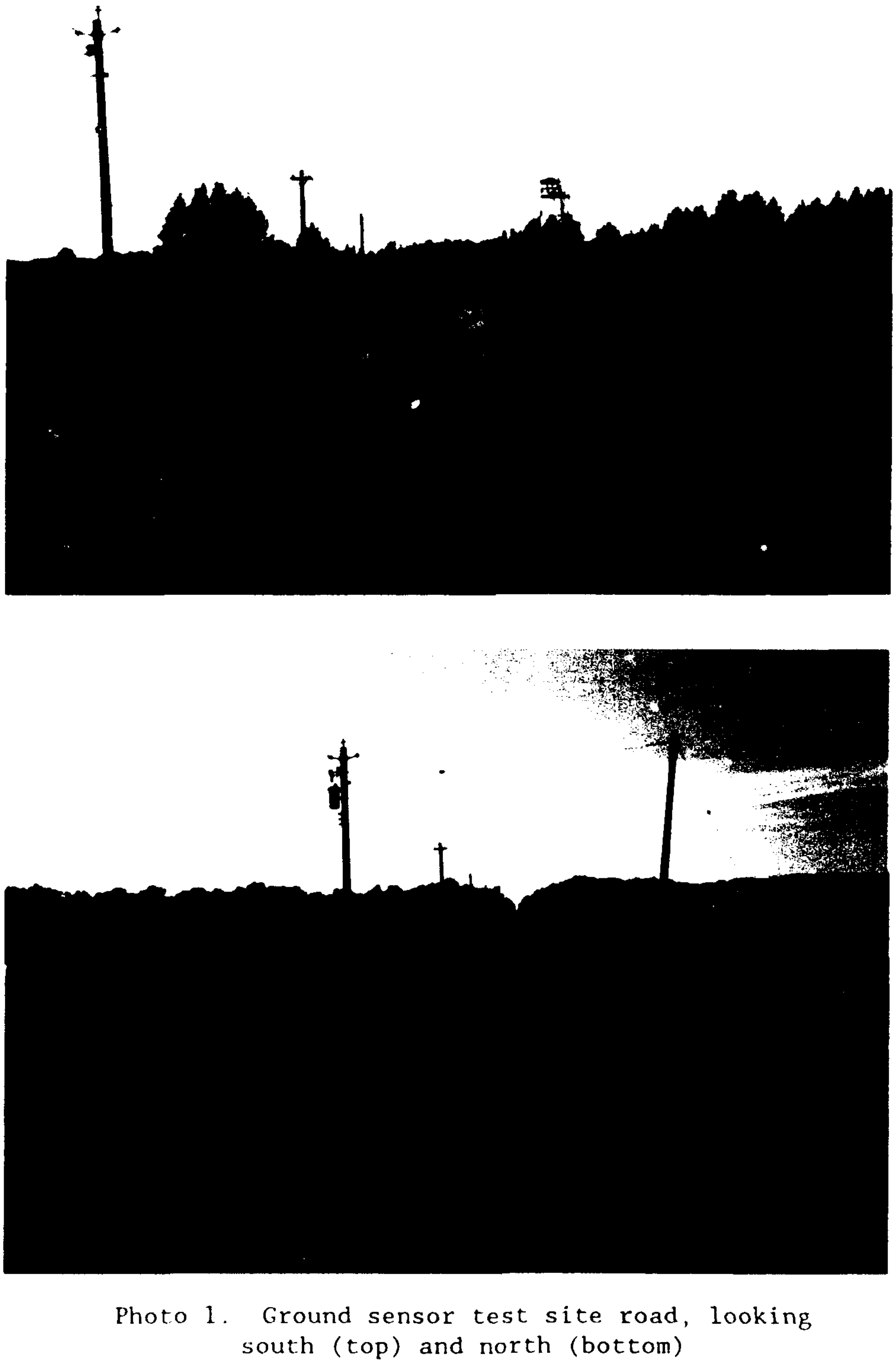


Photo 1. Ground sensor test site road, looking south (top) and north (bottom)

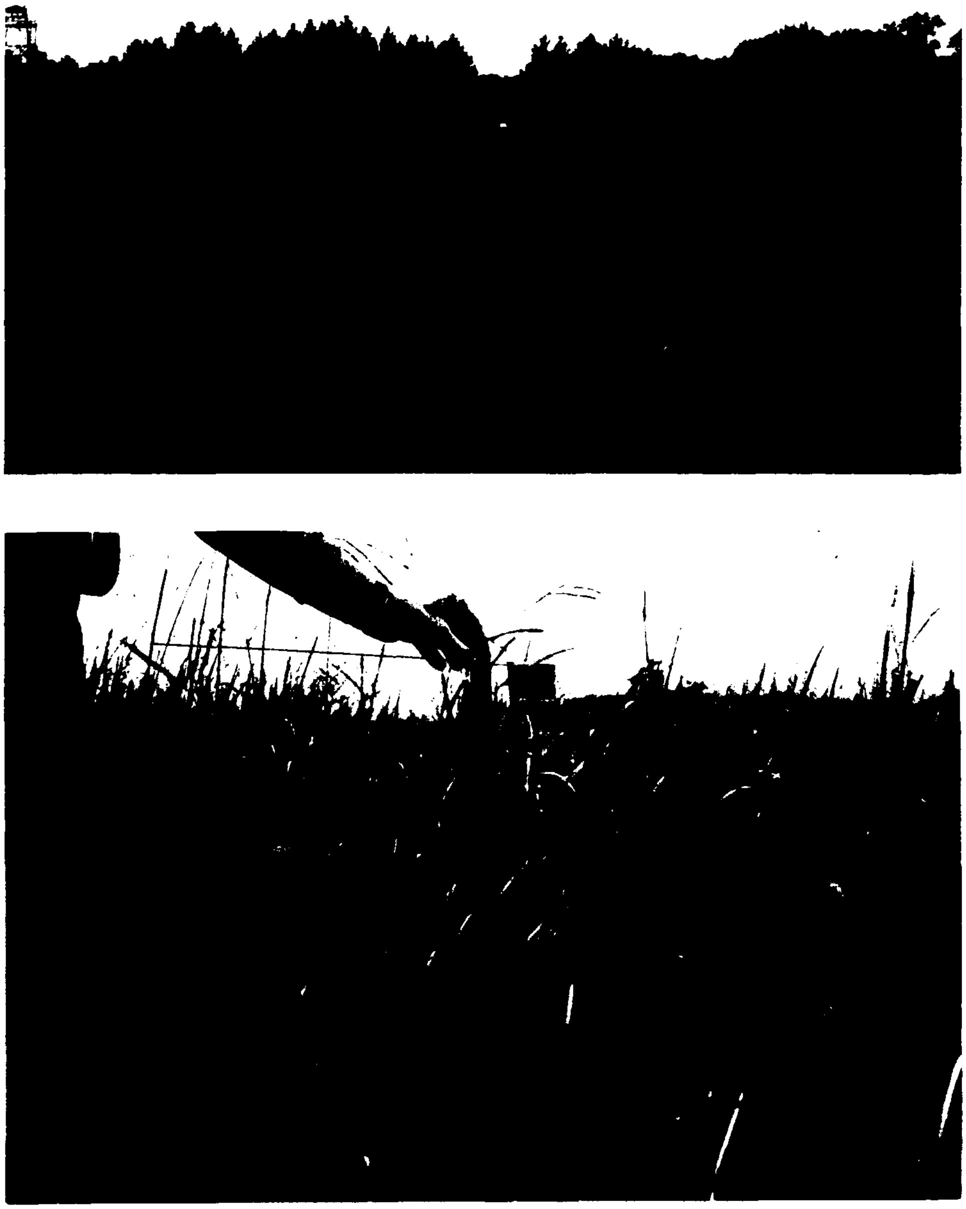


Photo 2. Grassy vegetation at ground sensor test site

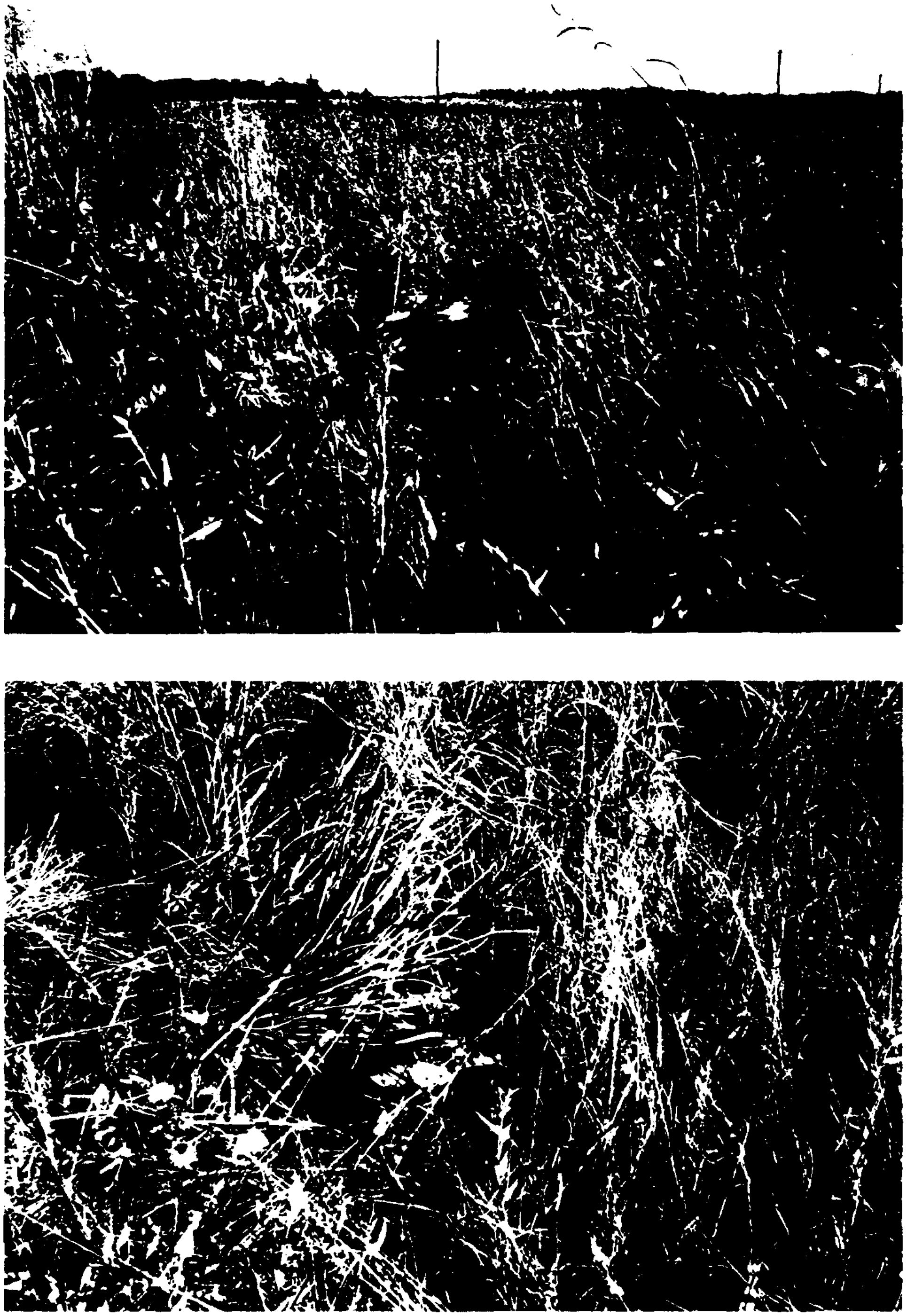


Photo 3. Ground sensors emplaced in grassy vegetation