APPENDIX C

GEOPHYSICAL SURVEYS

PARDEE DAM PROJECT

The Pardee Dam Project involved the video investigations of three boreholes, designated as MW-7, MW-8, and I-1. These investigations were conducted using a high amplification downhole video camera with a 4.8 mm. wide angle lens in conjunction with a Gyro that can be oriented to "point" to a specified direction for use as a point of reference. In this study, that point of reference is true north, and is represented by a white dot on the video monitor displaying the video images. As the camera is lowered (or raised) in the borehole, any rotation of the camera will cause a rotation of the video image, but the Gyro will continue to orient itself to true north and serve as a reference from which measurements of the attitudes of any features appearing in the borehole can be made. The video images with the "Gyro dot" are then recorded on VHS video cassette tapes for review and examination under more suitable conditions.

When reviewing the video, it can be seen that the borehole has intersected sedimentary and structural features in the lithologic units that it passes through. In this study, the predominant features seen are fractures. The attitudes of these fractures are measurable by noting the first and last appearances of these features (which will be seen as elliptical traces) and using geometric/trigonometric calculations to determine dip angles. The dip direction can be measured directly from the video image by noting the topmost or bottommost portion of the feature and measuring from the "Gyro dot" (true north) using a clear protractor type acrylic overlay, known as a compass rose.

The orientation and measurement of the fractures in the three boreholes was difficult at best. Intersecting fractures, "dying out" of fractures and dislodged pieces of the sidewalls made delineating the actual outline of the fractures a challenge. Where traceable, the fractures were noted by depth, and their dip direction and angle were measured. These measurements are contained in the following tables and are organized with respect to each particular borehole. It should be noted that all measurements were done manually and the accuracy of the measurements must be viewed within the guidelines of human error.

The three boreholes are located along the south side of Pardee Reservoir. Elevations of each site were unavailable at the time the study took place. Direct relationships are, therefore, difficult to determine and only generalities can be made.

Fractures are found from surface to the bottom in each borehole. Many of these fractures have been infilled by precipitated minerals giving the fractures a "healed" appearance. This is especially true at depths approaching static water level, where there is more fluid migration through the strata. Some fractures have been enlarged by corrasion or some other erosional process. In most cases, the original morphology of the fractures has been altered, but not to such a degree as to preclude measurement of the attitudes of the fractures.

Borehole MW-7 is the least intensely fractured and seemingly most stable of the boreholes. This hole deviates increasingly from vertical with increased depth, from 15 degrees off vertical at 50 feet to 20 degrees off vertical at 147 feet. The borehole also shifts direction toward the west with increasing depth, from north 27 degrees west at 50 feet to north 46 degrees west at 147 feet. These changes in the orientation of the borehole create the need to make adjustments in the fracture measurements accordingly. This is easily done with minor geometric manipulations. These corrections have been made and the values given in the tables reflect these adjustments. Similar corrections have been made for Borehole MW-7, though this hole has been bridged over by dislodged pieces of the sidewall at 36 feet, making the calculations less complex. Borehole I-1 is essentially vertical, so these corrections are not necessary.

Most of the fractures in Borehole MD-8 have been altered to such a degree that their attitudes are not distinguishable. The large numbers of intersecting fractures, as well as apparent fluid movement throughout, have dislodged pieces of the strata at the borehole interface causing numerous "washed out" areas. The measurable fractures are predominantly dipping to the south and southwest, but this may be representative of only the top of the borehole and not the entire borehole.

The fractures in Boreholes MD-7 and I-1 are more easily delineated and measured. As in MD-8, many fractures have been enlarged so as to change their apparent morphology, although this

BARBOUR

Well Surveying Corporation

is not nearly as prevalent in MD-7 and I-1. The general direction of dip of the fractures in Borehole MD-7 is to the east and northeast, while in Borehole I-1, the general orientation is to the east and southeast. In both boreholes, fractures were not traceable below static water level due to the cloudiness of the water.

There is much that could be inferred from the fracture measurements, but that is beyond the scope of this particular research. This was a data gathering and documenting study, and interpretations and conclusions should be left to those with a better understanding of the intent of this project.

438 Calle San Pablo, Suite I / Camarillo, California 93010 / (805) 482-4988

PARDEE DAM PROJECT
BOREHOLE MD-7

DEPTH	BEARING	STRIKE	DIP ANGLE
8.9 FEET	N. 78 E.	N. 12 W.	NA
9.6 FEET	N. 82 E.	N. 08 W.	NA
11.0 FEET	N. 87 E.	N. 03 W.	18
11.6 FEET	S. 67 E.	N. 23 W.	81
12.7 FEET	N. 20 E.	N. 70 W.	46
14.8 FEET	N. 29 E.	N. 61 W.	45
14.9 FEET	N. 28 E.	N. 62 W.	45
16.2 FEET	N. 38 W.	N. 52 E.	63
17.4 FEET	nearly horizontal		
16.2 FEET	N. 54 E.	N. 36 W.	85
18.5 FEET	S. 15 E.	N. 75 E.	20
18.8 FEET	N. 19 E.	N. 71 W.	46
19.3 FEET	N. 70 W.	N. 20 E.	58
20.0 FEET	N. 07 W.	N. 83 E.	48
21.0 FEET	N. 23 E.	N. 67 W.	46
21.5 FEET	S. 29 W.	N. 61 E.	54
25.1 FEET	S. 35 E.	N. 55 E.	21
25.9 FEET	S. 04 W.	N. 86 W.	12
26.9 FEET	N. 64 E.	N. 26 W.	22
28.2 FEET	N. 60 E.	N. 30 W.	38
30.4 FEET	S. 71 E.	N. 19 E.	32
34.4 FEET	S. 79 E.	N. 11 E.	44
37.0 FEET	S. 19 E.	N. 71 E.	25
38.4 FEET	S. 45 W.	N. 45 W.	60
39.9 FEET	S. 76 E.	N. 14 E.	33
42.4 FEET	S. 81 E.	N. 09 E.	44
43.0 FEET	S. 56 E.	N. 34 E.	40
45.5 FEET	N. 80 E.	N. 10 W.	37
45.6 FEET	N. 78 E.	N. 12 W.	56
54.1 FEET	horizontal		
54.5 FEET	S. 49 W.	N. 41 W.	55
55.0 FEET	horizontal		
56.4 FEET	horizontal		
57.0 FEET	S. 77 W.	N. 13 W.	24
57.2 FEET	S. 71 E.	N. 19 E.	15
56.8 FEET	N. 44 W.	N. 46 E.	85
57.8 FEET	N. 43 W.	N. 47 E.	10
61.1 FEET	S. 83 E.	N. 07 E.	16
61.3 FEET	S. 83 E.	N. 07 E.	16
62.6 FEET	S. 85 E.	N. 05 E.	17
63.2 FEET	S. 60 E.	N. 30 E.	13
65.4 FEET	S. 64 E.	N. 26 E.	13
68.5 FEET	S. 45 W.	N. 45 W.	55
74.9 FEET	S. 84 E.	N. 06 E.	33
76.8 FEET	horizontal		
84.4 FEET	N. 69 E.	N. 21 W.	37
88.0 FEET	N. 40 E.	N. 50 W.	42
88.2 FEET	N. 42 E.	N. 48 W.	25
88.5 FEET	N. 47 E.	N. 43 W.	41
93.6 FEET	S. 08 W.	N. 82 W.	32
94.0 FEET	S. 11 W.	N. 79 W.	15
95.4 FEET	N. 81 E.	N. 09 W.	45
96.5 FEET	horizontal		

PARDEE DAM PROJECT
BOREHOLE MD-7
PAGE TWO

DEPTH	BEARING	STRIKE	DIP ANGLE
98.1 FEET	N. 75 E.	N. 15 W.	35
98.5 FEET	S. 05 W.	N. 85 W.	12
98.7 FEET	S. 08 W.	N. 82 W.	49
101.8 FEET	S. 02 E.	N. 88 E.	11
102.1 FEET	S. 02 E.	N. 88 E.	11
103.1 FEET	N. 08 E.	N. 82 W.	48
104.9 FEET	N. 07 E.	N. 83 W.	59
105.6 FEET	N. 03 E.	N. 87 W.	32
106.5 FEET	N. 75 E.	N. 15 W.	47
109.1 FEET	N. 48 E.	N. 42 W.	52
111.7 FEET	N. 46 E.	N. 44 W.	52
114.8 FEET	N. 76 W.	N. 14 E.	48
117.4 FEET	N. 57 E.	N. 33 W.	22
117.4 FEET	N. 42 E.	N. 48 W.	60
119.6 FEET	S. 38 E.	N. 52 E.	21
126.1 FEET	N. 13 E.	N. 77 W.	47
126.2 FEET	N. 39 E.	N. 51 W.	61
127.1 FEET	N. 18 W.	N. 72 E.	53
127.6 FEET	S. 60 E.	N. 30 E.	37
129.6 FEET	N. 62 W.	N. 28 E.	63
129.9 FEET	S. 18 E.	N. 72 E.	25
130.0 FEET	S. 70 W.	N. 20 W.	26
132.1 FEET	N. 50 E.	N. 40 W.	50
132.2 FEET	N. 25 E.	N. 65 W.	44
132.5 FEET	N. 52 E.	N. 48 W.	39
132.7 FEET	N. 45 W.	N. 45 E.	38
132.8 FEET	N. 56 E.	N. 34 W.	49
133.4 FEET	N. 56 E.	N. 34 W.	21
133.4 FEET	N. 25 E.	N. 65 W.	68
133.7 FEET	N. 50 E.	N. 40 W.	22
133.9 FEET	N. 54 E.	N. 36 W.	49
134.2 FEET	N. 53 E.	N. 37 W.	49
135.2 FEET	N. 55 E.	N. 35 W.	38
135.3 FEET	N. 49 E.	N. 41 W.	50
137.3 FEET	S. 78 E.	N. 12 E.	39
137.7 FEET	N. 54 E.	N. 36 W.	38
138.3 FEET	N. 51 E.	N. 39 W.	58
138.7 FEET	N. 69 E.	N. 21 W.	46
139.0 FEET	N. 54 E.	N. 36 W.	38
141.1 FEET	S. 78 E.	N. 12 E.	28
141.8 FEET	N. 56 E.	N. 34 W.	38
142.1 FEET	N. 55 E.	N. 35 W.	49
142.5 FEET	N. 53 E.	N. 37 W.	21
143.3 FEET	static water level		
148.4 FEET	bottom		

PARDEE DAM PROJECT
BOREHOLE MD-8

DEPTH	BEARING	STRIKE	DIP ANGLE
10.3 FEET	S. 10 E.	N. 80 E.	NA
11.3 FEET	S. 7 W.	N. 83 W.	NA
14.2 FEET	N. 25 E.	N. 65 W.	42
15.0 FEET	N. 34 W.	N. 56 E.	39
21.1 FEET	S.	N. 90 E.	25
21.2 FEET	S. 14 W.	N. 76 W.	22
24.5 FEET	S. 14 W.	N. 76 W.	39
25.2 FEET	S. 15 W.	N. 75 W.	38
25.4 FEET	S. 16 W.	N. 74 W.	49
25.8 FEET	S. 9 W.	N. 81 W.	52
26.1 FEET	S. 10 E.	N. 80 E.	45
26.3 FEET	S. 6 W.	N. 84 W.	41
26.5 FEET	S. 11 E.	N. 79 E.	45
26.8 FEET	S. 4 W.	N. 86 W.	65
27.1 FEET	S. 5 W.	N. 85 W.	24
27.6 FEET	S. 11 W.	N. 79 W.	22
27.9 FEET	S. 7 W.	N. 83 W.	40
28.6 FEET	S. 15 W.	N. 75 W.	50
29.7 FEET	S. 10 W.	N. 80 W.	23
29.9 FEET	S. 2 E.	N. 88 E.	26
30.9 FEET	S. 6 W.	N. 84 W.	24
30.9 FEET	S. 89 W.	N. 1 W.	3
32.1 FEET	S. 3 E.	N. 87 E.	43
34.6 FEET	S. 1 E.	N. 89 E.	42
35.1 FEET	S. 32 W.	N. 58 W.	34
35.7 FEET	S. 8 W.	N. 82 W.	51
36.4 FEET	dislodged rocks in borehole		

PARDEE DAM PROJECT
BOREHOLE I-1

DEPTH	BEARING	STRIKE	DIP ANGLE
6.4 FEET	N. 69 E.	N. 21 W.	NA
7.0 FEET	S. 27 E.	N. 63 E.	NA
7.9 FEET	S. 1 E.	N. 89 E.	58
8.8 FEET	N. 72 E.	N. 18 W.	39
8.8 FEET	N. 67 E.	N. 23 W.	58
9.3 FEET	N. 85 E.	N. 5 W.	63
9.8 FEET	N. 30 E.	N. 60 W.	50
10.5 FEET	N. 83 E.	N. 7 W.	39
10.8 FEET	N. 77 W.	N. 13 E.	39
10.8 FEET	N. 77 E.	N. 13 W.	63
11.1 FEET	N. 69 E.	N. 21 W.	58
11.8 FEET	S. 15 W.	N. 75 W.	58
12.5 FEET	S. 72 E.	N. 18 E.	39
12.7 FEET	S. 87 E.	N. 3 E.	58
13.0 FEET	S. 5 E.	N. 85 E.	67
13.5 FEET	S. 20 W.	N. 70 W.	58
14.4 FEET	N. 71 E.	N. 19 W.	39
15.1 FEET	N. 75 E.	N. 15 W.	50
15.9 FEET	N. 47 W.	N. 43 E.	39
16.2 FEET	N. 79 E.	N. 11 W.	22
16.2 FEET	N. 86 E.	N. 4 W.	50
17.3 FEET	N. 83 E.	N. 7 W.	58
17.9 FEET	S. 52 E.	N. 38 E.	58
18.0 FEET	S. 73 E.	N. 17 E.	58
18.5 FEET	S. 66 E.	N. 24 E.	63
18.7 FEET	S. 86 E.	N. 4 E	58
19.4 FEET	S. 32 W.	N. 58 W.	39
19.7 FEET	N. 83 E.	N. 7 W.	50
19.8 FEET	N. 90 E.	N.	58
20.2 FEET	S. 89 E.	N. 1 E.	58
20.5 FEET	S. 85 E.	N. 5 E.	58
21.2 FEET	S. 52 E.	N. 38 E.	39
22.0 FEET	S. 66 E.	N. 24 E.	50
22.0 FEET	S. 34 E.	N. 56 E.	50
23.2 FEET	S. 63 E.	N. 27 E.	63
23.6 FEET	N. 3 W.	N. 87 E.	39
23.8 FEET	S.	N. 90 E.	67
24.5 FEET	S. 51 W.	N. 39 W.	50
25.6 FEET	S. 48 W.	N. 42 W.	22
26.2 FEET	N. 76 W.	N. 14 E.	39
26.2 FEET	N. 69 W.	N. 21 E.	39
26.4 FEET	N. 58 W.	N. 32 E.	22
26.4 FEET	N. 41 W.	N. 49 E.	39
27.2 FEET	S. 57 E.	N. 33 E.	58
27.2 FEET	N. 2 E.	N. 88 W.	58
27.5 FEET	N. 9 E.	N. 81 W.	50
28.3 FEET	N. 6 E.	N. 84 W.	50
29.0 FEET	S. 81 W.	N. 9 W.	58
29.6 FEET	S. 65 E.	N. 25 E.	58
30.4 FEET	S. 67 E.	N. 23 E.	22
30.6 FEET	S. 65 E.	N. 26 E.	63
31.3 FEET	S. 87 E.	N. 3 E.	67
32.0 FEET	S. 57 E.	N. 33 E.	39

PARDEE DAM PROJECT
BOREHOLE I-1

DEPTH	BEARING	STRIKE	DIP ANGLE
32.2 FEET	S. 82 E.	N. 8 E.	39
33.1 FEET	S. 80 E.	N. 10 E.	22
33.7 FEET	N. 12 E.	N. 78 W.	50
34.0 FEET	N. 6 E.	N. 84 W.	22
34.6 FEET	N. 80 E.	N. 10 W.	63
35.9 FEET	S. 87 E.	N. 3 E.	63
36.5 FEET	S. 86 E.	N. 4 E.	63
37.5 FEET	S. 30 W.	N. 60 W.	50
38.1 FEET	S. 53 W.	N. 37 W.	50
38.5 FEET	N. 85 E.	N. 5 W.	50
38.7 FEET	S. 54 W.	N. 36 W.	22
40.0 FEET	horizontal		
40.4 FEET	N. 52 W.	N. 38 E.	74
41.6 FEET	S. 58 E.	N. 32 E.	58
41.6 FEET	S. 72 E.	N. 18 E.	63
42.3 FEET	S. 1 E.	N. 89 E.	70
43.4 FEET	S. 6 W.	N. 84 W.	50
44.9 FEET	S. 14 W.	N. 76 W.	39
45.3 FEET	N. 90 E.	N.	50
45.6 FEET	N. 88 E.	N. 2 W.	63
46.7 FEET	N. 81 E.	N. 9 W.	67
47.2 FEET	N. 44 W.	N. 46 E.	22
47.6 FEET	N. 84 E.	N. 6 W.	39
48.2 FEET	S. 76 E.	N. 14 E.	39
49.7 FEET	N. 64 E.	N. 26 W.	22
49.7 FEET	S. 77 E.	N. 13 E.	39
50.0 FEET	S. 11 W.	N. 79 W.	22
50.1 FEET	S. 14 W.	N. 76 W.	50
50.7 FEET	N. 88 W.	N. 2 E.	39
51.5 FEET	N. 75 E.	N. 15 W.	50
53.5 FEET	N. 48 W.	N. 42 E.	39
54.3 FEET	N. 69 E.	N. 21 W.	50
54.3 FEET	S. 26 W.	N. 64 W.	50
54.9 FEET	S. 33 W.	N. 57 W.	22
54.9 FEET	S. 46 W.	N. 44 W.	50
56.3 FEET	S. 84 E.	N. 6 E.	50
57.4 FEET	N. 82 E.	N. 8 W.	58
57.8 FEET	S. 87 E.	N. 3 E.	39
59.4 FEET	S. 4 W.	N. 86 W.	67
60.4 FEET	S. 88 E.	N. 2 E.	22
60.5 FEET	S. 88 E.	N. 2 E.	39
61.1 FEET	S. 54 W.	N. 36 W.	67
62.1 FEET	S. 67 W.	N. 23 W.	58
62.6 FEET	S. 39 W.	N. 51 W.	39
62.6 FEET	S. 45 W.	N. 45 W.	39
63.0 FEET	S. 86 E.	N. 4 E.	58
64.0 FEET	N. 88 E.	N. 2 W.	63
64.4 FEET	S. 20 W.	N. 70 W.	76
65.1 FEET	N. 55 E.	N. 35 W.	39
65.4 FEET	N. 55 E.	N. 35 W.	50
65.6 FEET	S. 73 E.	N. 17 E.	58
67.0 FEET	S. 39 W.	N. 51 W.	39
69.3 FEET	N. 80 E.	N. 10 W.	39

DEPTH	BEARING	STRIKE	DIP ANGLE
70.5 FEET	S. 29 W.	N. 61 W.	22
71.1 FEET	N. 81 E.	N. 9 W.	22
71.8 FEET	S. 22 E.	N. 68 E.	39
72.1 FEET	N. 61 W.	N. 29 E.	58
72.5 FEET	S. 38 W.	N. 52 W.	22
74.6 FEET	static water level		
177.5 FEET	bottom		

GEOPHYSICAL INVESTIGATION
PARDEE DAM RAISE
Amador County, California

for
Earth Sciences Associates
701 Welch Road
Palo Alto, California 94304

by
Portola Geophysics
900 Wayside Road
Portola Valley, California 94028

March 1991

Portola Geophysics
900 Wayside Road, Portola Valley, CA 94028 (415) 851-5342

March 28, 1991
1170

Mr. Phillip A. Frame
Earth Sciences Associates, Inc.
701 Welch Road
Palo Alto, California 94304

Subject: **Geophysical Investigation Pardee Dam Raise**
RE: East Bay Municipal Utilities District
Amador County, California

Dear Mr. Frame:

The following report describes the findings and conclusions regarding our seismic refraction and downhole seismic geophysical investigation of the East Bay Municipal Utilities District proposed Pardee Dam raise in Amador County, California. This geophysical investigation was conducted in accordance with our mutually agreed upon survay parameters and standing arrangement for geophysical services.

We appreciate the opportunity to have been of service to you on this project. If you have any questions regarding this report, any aspect of our investigation, or if you need additional services, please contact our office.

Very truly yours,

PORTOLA GEOPHYSICS

Patrick O. Shires
Principal Geophysicist
RGP 879

GEOPHYSICAL INVESTIGATION
PARDEE DAM RAISE
Amador County, California

Table of Contents

FIGURES

Table of Contents (cont.)

1.0 INTRODUCTION

This report describes the methods and equipment used and interpreted results of a geophysical investigation of the East Bay Municipal Utilities District proposed Pardee Dam raise in Amador County, California. This investigation was conducted in accordance with our mutually agreed upon survey parameters and standing arrangement for geophysical services.

1.1 Project Description

The proposed project consists of the raising of the existing dam and spillway area and the construction of a dike in the northern portion of the reservoir in Amador County, California.

1.2 Purpose and Scope of Investigation

The purposes of our investigation were to: 1) investigate the site using various seismic (geophysical) methods, 2) evaluate the depth to and rippability of bedrock and 3) evaluate engineering properties of the subsurface materials.

The scope of work included field seismic refraction and downhole seismic surveys followed by geophysical analysis of the acquired data and preparation of this report.

2.0 SEISMIC REFRACTION SURVEY

A total of thirteen (13) individual seismic refraction lines with a combined spread length of 3560 feet were recorded in the vicinity of the proposed dam raise and northern dike. These seismic refraction lines were recorded in the locations shown on figures 1 and 7. The interpreted results are presented on figures 2 through 6 and figures 8 through 9. The method and equipment used and the interpreted results are discussed in the following sections of this report.

2.1 Method and Equipment Used

The seismic refraction survey procedure used for all lines consisted of placing twelve (12) geophones in as straight a line as practical (in plan) spaced at 10- or 25-foot intervals along as constant a slope as practical (in profile). A large sledge hammer was impacted at 10 or 12.5 feet (typically) off both ends and at the center of each line. The hammer impact generated seismic compression waves which were refracted through subsurface materials and received by the deployed geophones. Signals from the energy source initiation (time break) and from the geophones were monitored (amplified and filtered) simultaneously by a seismograph and displayed graphically in analog form by an oscillograph. Permanent records produced by the oscillograph were field checked, catalogued, printed, and returned to the office for data reduction and interpretation.

Seismic refraction lines were surveyed for location and elevation using Brunton compass and measuring tape methods. Locations and elevations should be considered approximate.

The data reduction and interpretation procedure consisted of the following sequence of tasks:

- visually picking first breaks of compression waves (P-waves) from the analog records of the oscillograph / seismic system,

- plotting of time-distance graphs utilizing raw data,

- preliminary determination of apparent velocities,

- plotting of elevation data along the profiles,

- measurement of differences between actual geophone elevations and a constant slope profile,

- computer analysis of preliminary apparent velocities and elevation differences to determine travel-time corrections,

- adjustment of the time-distance graphs and refinement of apparent velocity determinations satisfying reciprocity,

- comparison of time-distance and velocity data with a catalog of subsurface structures to interpret an appropriate seismic refraction model,

- computer analysis (using computer program developed by Shires, 1983, involving principles published by Mooney, 1977, Handbook of Engineering Geophysics, satisfying the condition of reciprocity, travel-time = distance/velocity, and Snell's Law of Refraction) of apparent velocity and intercept time data to determine depths of refractors, true velocities, dips of refractors, and angles of wave incidence (seismic raypaths),

- measurement of time deviations from "best fit" apparent velocity slopes on the time-distance graphs,

- computer analysis of apparent velocities and time deviations to determine refractor profile corrections,

- adjustment of refractor depths to reflect time deviations,

- correlation of results with known geologic factors (from mapping and/or borehole logs), with adjacent or overlapping seismic refraction data and with adjacent gravity and seismic reflection data, and

- final preparation of interpreted subsurface velocity profiles.

The equipment used for the seismic refraction survey consisted of twelve (12) geophones at one time of 10 Hz natural frequency. The geophones were connected to 10- or 25-foot take-out spacing cables using Mueller clips. The combination seismograph/oscillograph used was a 24-channel ABEM™ Terraloc Seismic System mounted on a pack frame for portability.

The energy source used was a 16-pound sledge hammer equipped with seismograph/oscillograph trigger mechanism.

2.2 Interpreted Results

2.2.1 Knoll to North of Existing Dam

Seismic refraction line S-1 was recorded in the vicinity of the topographic knoll to the north of the existing dam in the location shown on Figure 1. Results are presented in Figure 2. This line was 300 feet long and was recorded to interpret the depth to and characteristics (i.e. rippability) of the subsurface materials in the vicinity of the knoll to the north of the existing dam. Twelve geophones were spaced at intervals of 25 feet with hammer impacts 12.5 feet off both ends and at the center of the line.

The northern knoll area is interpreted to be underlain by three (3) velocity zones (refractors) to the depth surveyed. The zone closest to the ground surface is characterized by low velocity (1080 ft/sec) materials to depths (measured perpendicular to the ground surface) of 2.7 to 5.3 feet. This upper zone corresponds to residual soils, colluvium and/or deeply weathered bedrock materials that are relatively dry. The next zone down is characterized by medium to high velocity (6100 to 7010 ft/sec) materials from 2.7 to 5.3 feet extending down to 30.7 to 70.5 feet beneath the ground surface. This zone corresponds to denser materials such as weathered bedrock. The underlying zone consists of high velocity (13,820 ft/sec) materials from 30.7 to 70.5 feet to the depth limit of information obtained (about 96 feet). This zone corresponds to relatively fresh bedrock materials.

2.2.2 Existing Dam Area

Seismic refraction lines S-2 through S-4 were recorded in the vicinity of the existing dam site in the locations shown on Figure 1. Results are presented in Figures 2 and 3. These lines were 300 feet long each, and were recorded to interpret the depth to and characteristics (i.e., rippability) of the subsurface materials in the vicinity of the existing dam site. Twelve geophones were spaced at intervals of 25 feet with hammer impacts 12.5 feet off both ends and at the center of each line.

The existing dam area is interpreted to be underlain by three (3) velocity zones (refractors) to the depth surveyed. The zone closest to the ground surface is characterized by low velocity (860 to 1600 ft/sec) materials to depths (measured perpendicular to the slope surface) of 3.9 to 17.8 feet. This upper zone corresponds to residual soils, colluvium, fill and/or deeply weathered bedrock materials that are relatively dry. The next zone down is characterized by medium velocity (4930 to 5320 ft/sec) materials from 3.9 to 17.8 feet extending down to 17.7 to 51.4 feet beneath the ground surface. This zone corresponds to denser materials such as weathered bedrock. The underlying zone consists of high velocity (10,930 to 14,700 ft/sec) materials from 17.7 to 51.4 feet to the depth limit of information obtained (about 96 feet). This zone corresponds to relatively fresh bedrock materials.

2.2.3 Knoll to South of Existing Dam

Seismic refraction lines S-5 and S-6 were recorded over the knoll to the south of the existing dam in the locations shown on Figure 1. Results are presented in Figure 4. These lines were 300 feet long each, and were recorded to interpret the depth to and characteristics (i.e., rippability) of the subsurface materials in the vicinity of the topographic knoll to the south of the existing dam. Twelve geophones were spaced at intervals of 25 feet with hammer impacts 12.5 feet off both ends and at the center of each line.

The southern knoll area is interpreted to be underlain by three (3) velocity zones (refractors) to the depth surveyed. The zone closest to the ground surface is characterized by low velocity (1230 to 1820 ft/sec) materials to depths of 2.2 to 7.3 feet. This upper zone corresponds to residual or colluvial soils or deeply weathered bedrock materials that are relatively dry. The next zone down is characterized by medium velocity (6260 to 7650 ft/sec) materials from 2.2 to 7.3 feet extending down to

30.2 to 74.1 feet beneath the ground surface. This zone corresponds to denser materials such as weathered bedrock. The underlying zone consists of high velocity (13,210 to 15,620 ft/sec) materials from 30.2 to 74.1 feet to the depth limit of information obtained (about 96 feet). This zone corresponds to relatively fresh bedrock materials.

2.2.4 Existing Spillway Area

Seismic refraction lines S-7 through S-9 were recorded east of, and perpendicular to, the existing spillway in the locations shown on Figure 1. Results are presented in figurss 5 and 6. These lines were 300 feet long and were recorded to interpret the depth to and characteristics of the subsurface materials in the vicinity of the existing spillway. Twelve geophones were spaced at intervals of 25 feet with hammer impacts 12.5 feet off both ends and at the center of each line.

The existing spillway area is interpreted to be underlain by two (2) velocity zones (refractors) to the depth surveyed. The zone closest to the ground surface is characterized by low velocity (860 to 1560 ft/sec) materials to depths of 3.7 to 17.1 feet. This upper zone corresponds to residual or alluvial soils or deeply weathered bedrock materials that are relatively dry. The underlying zone consists of high velocity (7710 to 13,080 ft/sec) materials from 3.7 to 17.1 feet to the depth limit of information obtained (about 96 feet). This zone corresponds to relatively fresh bedrock materials.

2.2.5 Proposed Northern Dike Area

Seismic refraction lines S-10 through S-13 were recorded on the abutments for a proposed dike to the far north of the existing dam in the locations shown on Figure 7. Results are presented in figures 8 through 9. These lines were 300 or 130 feet long each, and were recorded to interpret the depth to and characteristics (i.e., rippability) of the subsurface materials in the vicinity of the proposed dike to the north of the existing dam. Twelve geophones were spaced at intervals of 25 or 10 feet with hammer impacts 12.5 or 10 feet off both ends and at the center of each 25-foot spacing line.

The northern dike area is interpreted to be underlain by three (3) velocity zones (refractors) to the depth surveyed. The zone closest to the ground surface is characterized by low velocity (890 to 1360 ft/sec) materials to depths of 1.8 to 7.1 feet. This upper zone corresponds to residual or alluvial soils or deeply weathered bedrock materials that are relatively dry. The next zone down is characterized by low to medium velocity (2500 to 5210 ft/sec) materials from 1.8 to 7.1 feet extending down to 20.4 to 49.5 feet beneath the ground surface. This zone corresponds to denser materials such as weathered bedrock. The underlying zone consists of high velocity (9730 to 12,490 ft/sec) materials from 20.4 to 49.5 feet to the depth limit of information obtained (about 40 to 96 feet). This zone corresponds to relatively fresh bedrock materials.

2.3 Rippability

Rippability is strongly influenced by the physical condition of the rock masses to be ripped. Structural features in rock such as bedding planes, cleavage planes, joints, fractures and shear zones influence rippability. Rock masses tend to be rippable if they have closely-spaced fractures, joints, or other planes of weakness. Massive rock materials lacking discontinuities, even where partially weathered, may exhibit marginal rippability, requiring blasting for removal.

Seismic compression wave velocities can be related to both rock hardness and fracture density. Seismic refraction velocities have been related to rippability by the Caterpillar Tractor Company (1990) as displayed on numerous graphs relating seismic velocity for various rock types to rippability with various types of equipment (combinations of dozers and rippers). In general, metamorphic rocks are similar to granitic rocks in their rippability characteristics, being slightly more rippable at higher velocities. These rocks tend to become marginally rippable above 7300 to 8000 feet/second using a D9 Dozer with a Multi or Single Shank No. 9 Ripper.

3.0 DOWNHOLE SEISMIC SURVEY

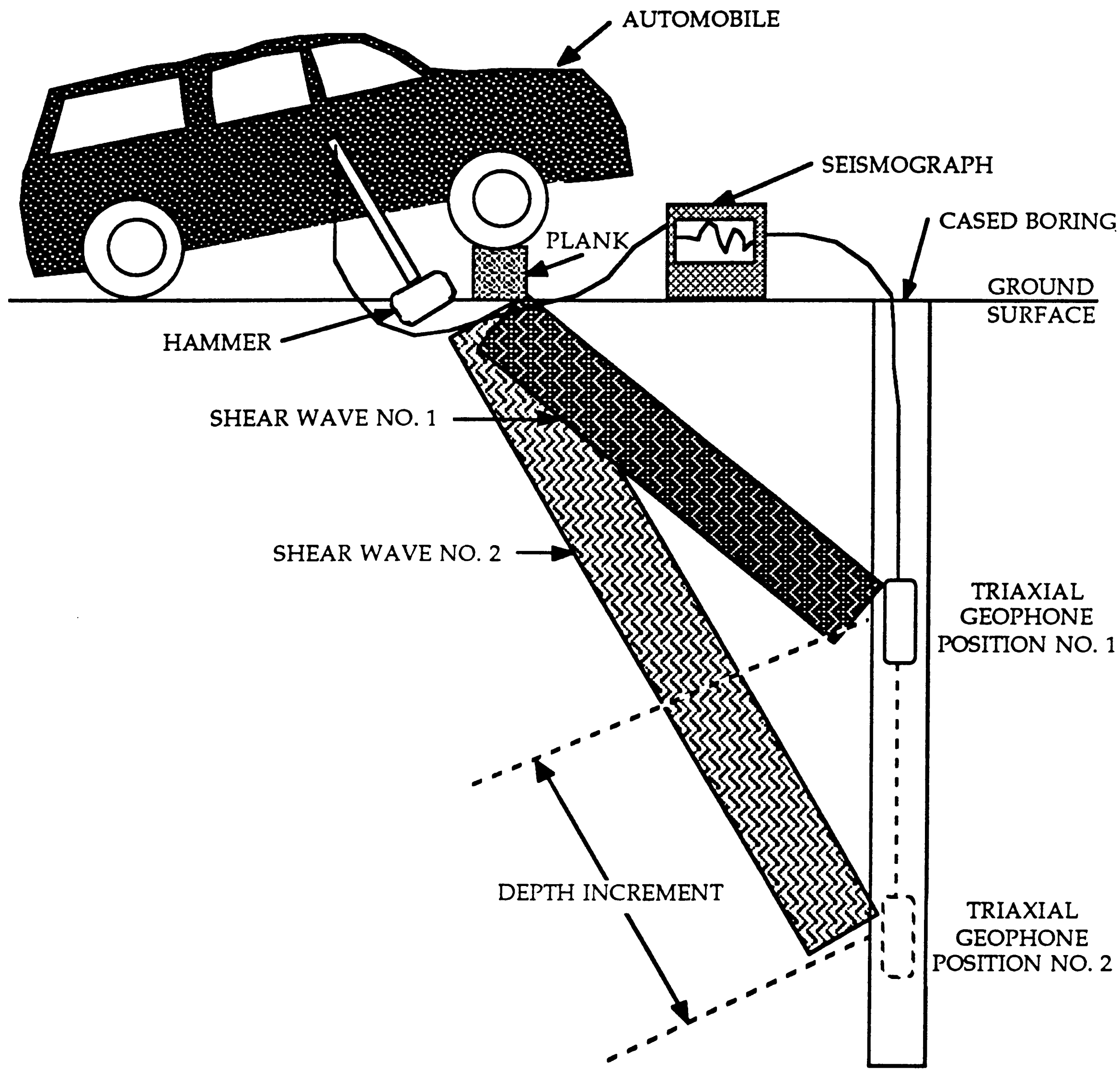
Downhole seismic surveys were conducted in two, uncased borings (MD-7 and MD-8) in the locations shown on Figure 1.

3.1 Method and Equipment Used

The downhole seismic survey procedure used for all recordings consisted of placeing a triaxial geophone bundle at 5-foot depth intervals within uncased borings.

The geophone bundle was clamped against the inside of the borings at successive depth intervals by inflation of a pneumatic bladder. For Boring MD-7, a wooden plank (4-inch by 6-inch by 8 feet long) was placed perpendicular to the boring at a distance of 10 feet from the top of the boring (see sketch on following page). A 16-pound sledge hammer was impacted alternately at both ends of the plank to produce successive shear waves of reversed polarity, and then was impacted vertically on a metal plate at the ground surface to produce compression waves. For Boring MD-8, a heavy steel pry bar, with flattened tip, was driven two feet into the ground about 5 feet out from the boring, in line with the dip of the boring. A 16-pound sledge hammer equipped with seismograph/oscillograph triggering switch was impacted on a metal plate leaned against both sides of the pry bar to produce successive shear waves with reversed polarity. The hammer was also impacted vertically on a steel plate placed at the ground surface (also 5 feet from the top of the boring) to produce compression waves. The hammer impacts generated shear and compression waves which traveled through the subsurface materials and were received by the deployed geophone bundle at successive depths. The geophones were monitored and displayed graphically in analog form on an ABEM™ Terraloc Seismic System, portable 24-channel seismograph system. Paper records were produced, catalogued and returned to the office for data reduction and interpretation.

Typical Downhole Seismic Set-Up (Boring MD-7)



Compression and shear wave results and bulk density estimates were used to calculate engineering parameters by spreadsheet.

The equipment used for the downhole seismic survey consisted of one triaxial geophone bundle of 4.5 Hz natural frequency with 300 feet of cabling and a pneumatic bladder (with 300 feet of supply tube). The geophones were connected to a 24-channel ABEM™ Terraloc Seismic System. The sweep traces for each horizontal (transverse and longitudinal) geophone were juxtaposed such that successive shear waves of reversed polarity stood out to facilitate picking of first arrivals of shear waves.

3.2 Interpreted Results

3.2.1 Boring MD-7

Downhole seismic recording MD-7 was conducted in Boring MD-7 near the central portion of the right abutment of the existing dam in the location shown on Figure 1. Boring MD-7 was drilled at an inclination of 70° down from the horizontal toward the northeast. Although the boring was drilled to a depth of approximately 150 feet, the hole was surveyed to a depth (inclined) of 135 feet. Figure 10 presents survey results in terms of time-distance plots of shear and compression wave velocities. The plots reflect actual distance from the offset energy source to the geophone. In order to correlate this information with boring logs, the assumption is made that velocities for the longer angular distance are representative of the velocities within the vertical depth intervals surveyed. Table 1 lists shear and compression wave velocities as a function of depth interval.

TABLE 1

(Velocities, MD-7)

Depth Interval (ft.)	Shear Velocity (ft./sec.)	Compression Velocity (ft./sec.)
0.0 - 4.7	1410	1770
4.7 - 14.1	2380	6320
14.1 - 56.6	3850	14,750
56.6 - 127.3	9510	14,750

Various calculations can be made involving shear wave velocities, compression wave velocities, and bulk density. Table 2 presents calculations of Poisson's ratio, compression modulus, and shear modulus derived from downhole-measured compression wave and shear wave velocities and assumed bulk densities.

TABLE 2
(Velocity/Density Calculations, MD-7)

Depth Interval (Feet)	Compression Velocity (ft./sec.)	Shear Velocity (ft./sec.)	Bulk Density (pcf)	Poisson's Ratio (μ)	Compression Modulus (psf)	Shear Modulus (psf)
0.0-4.7	1770	1410	130	0.42	2.29E+07	8.08E+06
4.7-14.1	6320	2380	150	0.42	7.53E+07	2.66E+07
14.1-56.6	14,750	3850	150	0.46	2.03E+08	6.95E+07
56.6-127.3	14,750	9510	150	0.14	9.70E+08	4.24E+08

The following formulae were used to calculate Poisson's ratio (μ), compression (Young's) modulus (E) and shear modulus (G), where $\surd$=bulk density, Vp=compression wave velocity and Vs=shear wave velocity:

$\mu=[(Vp/Vs)^2-2]/[2(Vp/Vs)^2-2]$, $E=2Vs^2(\surd/32)(1+\mu)$, and $G=Vs^2(\surd/32)$.

3.2.2 Boring MD-8

Downhole seismic recording MD-8 was performed in Boring MD-8 near the midslope portion of the left abutment of the existing dam in the location shown on Figure 1. Boring MD-8 was drilled at an inclination of 67° dipping from the horizontal toward the southeast. Although the boring was drilled to a depth of approximately 150 feet, the hole was blocked at a depth (inclined) of 35 feet at the time of the downhole survey. Figure 11 presents survey results in terms of time-distance plots of shear and compression wave velocities. The plots reflect actual distance from the offset energy source to the geophone. In order to correlate this information with boring logs, the assumption is made that velocities for the longer angular distance are representative of the velocities within the vertical depth intervals surveyed. Table 3 lists shear and compression wave velocities as a function of depth interval.

TABLE 3

(Velocities, MD-8)

Depth Interval (ft.)	Shear Velocity (ft./sec.)	Compression Velocity (ft./sec.)
0.0 - 9.4	1220	1870
9.4 - 32.1	2610	5880

Table 4 presents calculations of Poisson's ratio, compression modulus, and shear modulus derived from downhole-measured compression wave and shear wave velocities and assumed bulk densities.

TABLE 4

(Velocity/Density Calculations, MD-8)

Depth Interval (Feet)	Compression Velocity (ft./sec.)	Shear Velocity (ft./sec.)	Bulk Density (pcf)	Poisson's Ratio (μ)	Compression Modulus (psf)	Shear Modulus (psf)
0.0-9.4	1870	1220	130	0.13	1.37E+07	6.05E+06
9.4-32.1	5880	2610	150	0.26	8.80E+07	3.19E+07

3.3 Downhole Summary

In general, compression and shear wave velocities in the materials underlying the left and right abutments of the existing dam increase with depth and appear reasonable for the type of materials encountered.

4.0 INVESTIGATION LIMITATIONS

The subsurface profiles presented in this report represent the most reasonable interpretation of geophysical survey data based on our limited knowledge of the existing geologic conditions at the site. The results are presented for design feasibility information only and are not intended to serve as information for determining construction procedures. Interpretations were made in accordance with generally accepted geophysical methods and practices. This warranty is in lieu of all other warranties, express or implied.

The quality of seismic refraction data for this survey was good, but in some cases affected by background noise from passing aircraft, irregular terrain, wind, and lateral inhomogeneity. These factors produced noise signals and/or scatter in the recorded data, limiting the accuracy of first break compression wave picks and interpretation. The seismic refraction method used has some inherent limitations such as the possibility for undetectable hidden layers, blind zones, and velocity inversions. The maximum depth of reliable seismic information obtained during this survey can be assumed to be approximately one-third of the length of the individual lines, with information at a maximum depth underlying the middle one-third of the lines. For example, a seismic refraction line 300 feet in length will typically yield reliable data on subsurface materials to a depth of about 100 feet beneath the middle 100 feet of the line.

The absence of exploratory borings and other subsurface geologic information in some of the areas surveyed limits the reliability of geophysical interpretation, since more than one interpretation is often possible for a given set of data, and correlation with borings or other subsurface information is important in establishing accuracy.

5.0 REFERENCES

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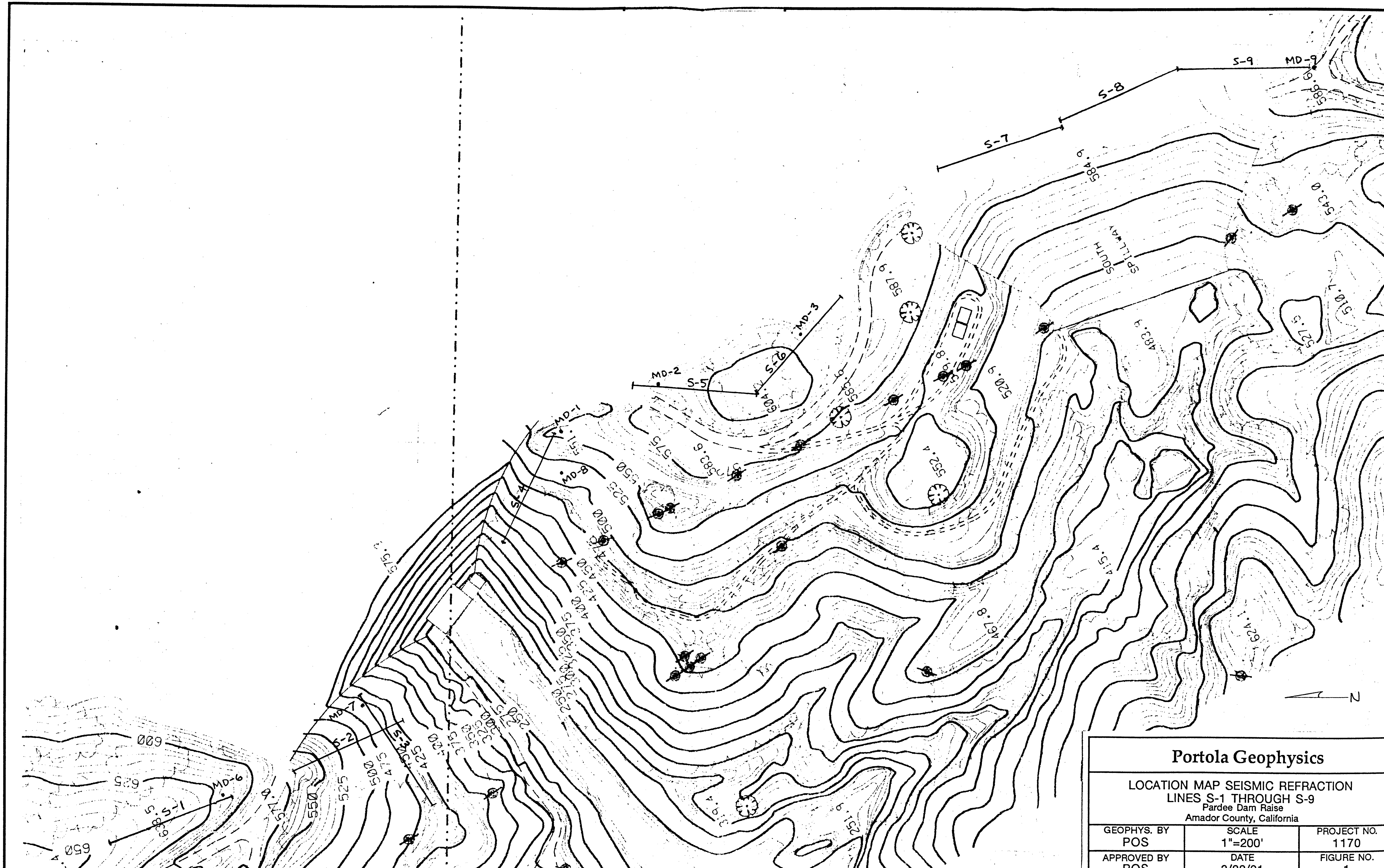
Dobrin, M. B., (1960), "Introduction to Geophysical Prospecting", McGraw-Hill Book Company.

Mooney, (1977), "Handbook of Engineering Geophysics", Bison Instruments™, Inc.

Shires, P. O., (1983), "A Seismic Refraction Interpretation Program for Multi-Dipping Layers".

Shires, P. O., (1989), "A Downhole Seismic Interpretation Program".

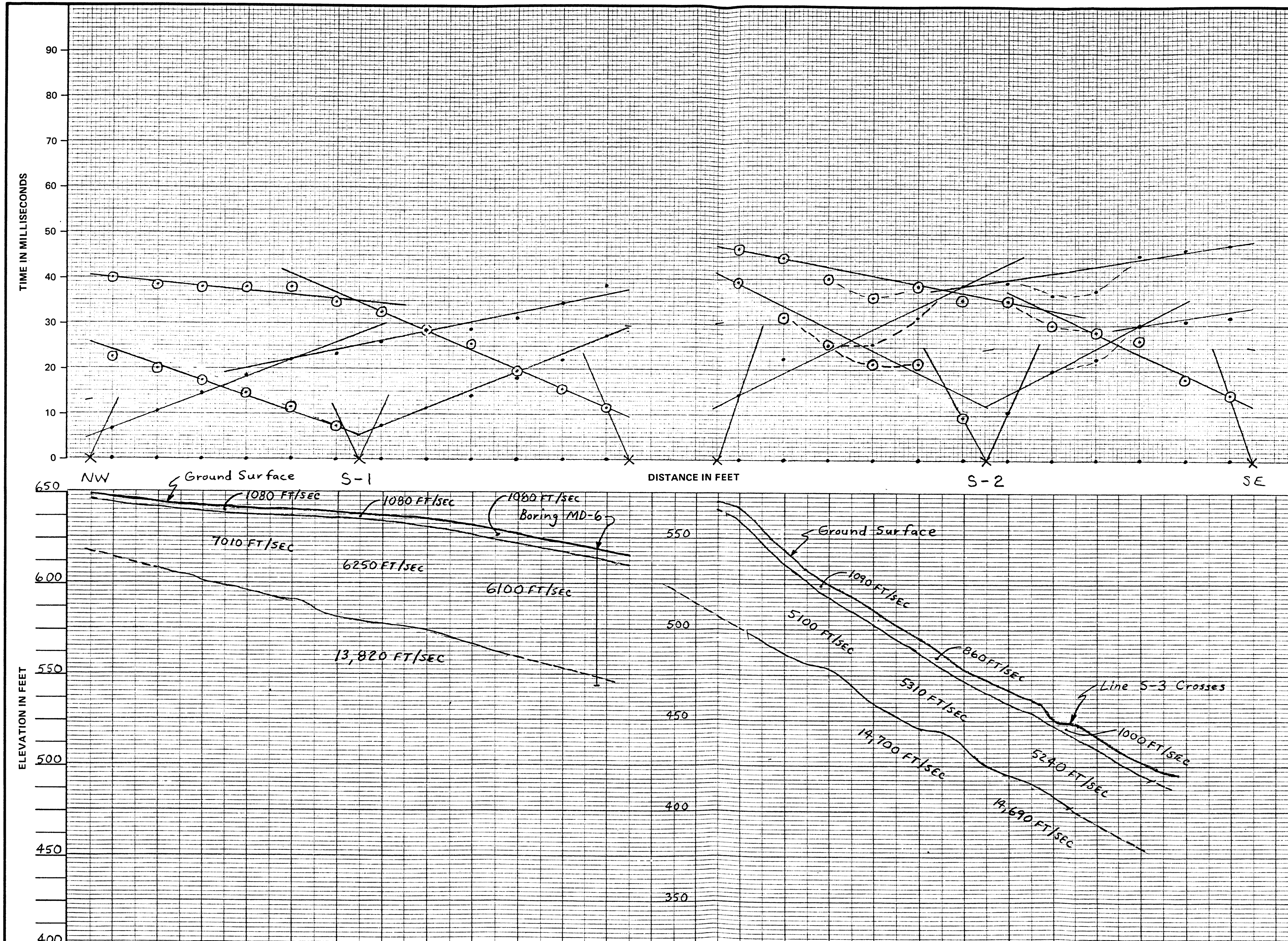
FIGURES



Portola Geophysics

LOCATION MAP SEISMIC REFRACTION
LINES S-1 THROUGH S-9
Pardee Dam Raise
Amador County, California

GEOPHYS. BY	SCALE	PROJECT NO.
POS	1"=200'	1170
APPROVED BY	DATE	FIGURE NO.
POS	3/28/91	1



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900 Wayside Road Portola Valley, CA 94028

SEISMIC REFRACTION SURVEY
DATA AND INTERPRETED SUBSURFACE VELOCITY PROFILES

PARDEE DAM RAISE
AMADOR COUNTY, CALIFORNIA

REGISTERED GEOPHYSICIST ★ PATRICK O. SHIRES No. 879 ★ STATE OF CALIFORNIA

EXPLANATION

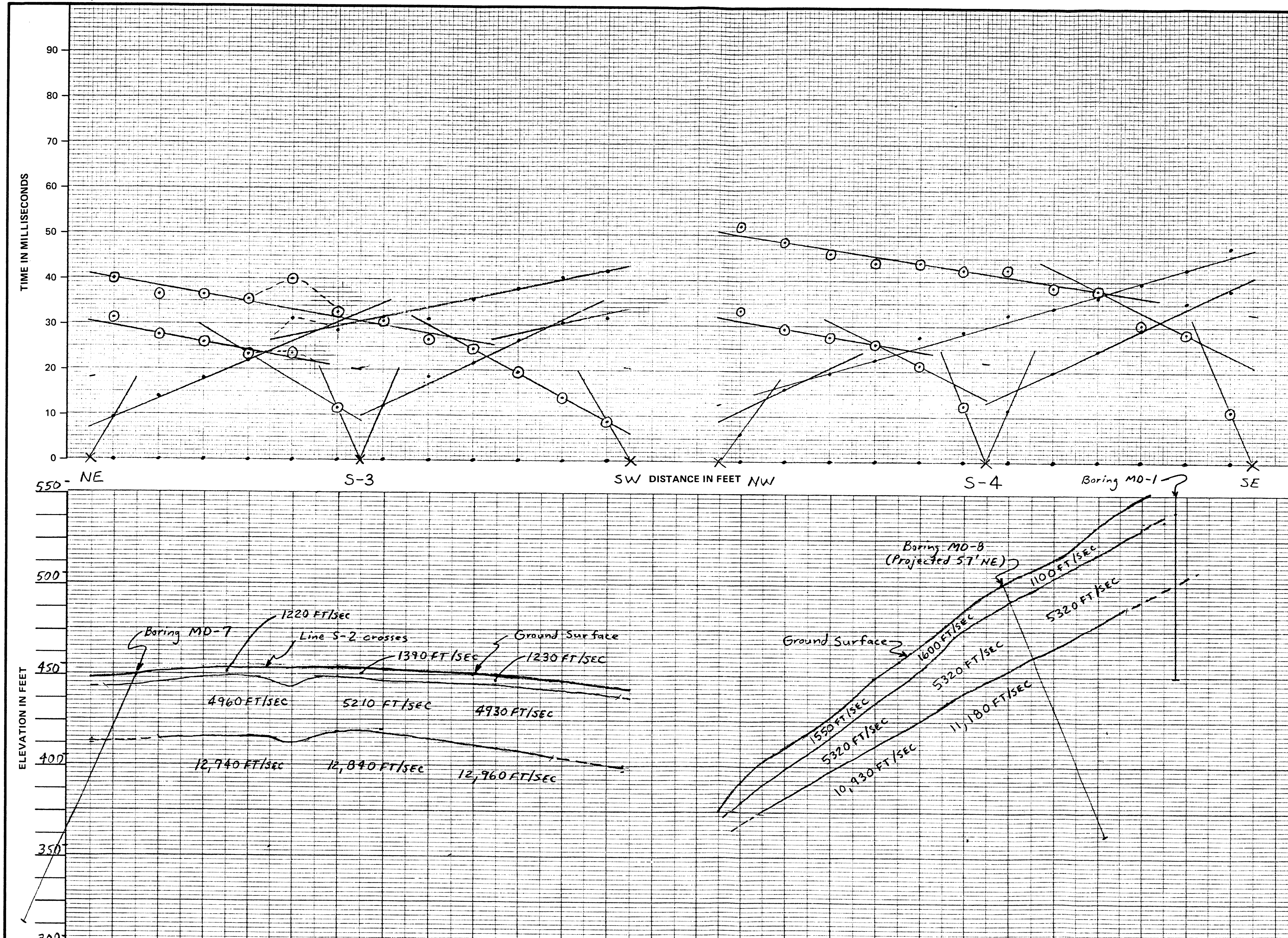
1. TIME–DISTANCE GRAPHS AT TOP OF FIGURE REPRESENT SEISMIC REFRACTION SURVEY DATA; DOTS ON BOTTOM LINE OF GRAPHS REPRESENT GEOPHONE LOCATIONS, X'S REPRESENT SHOT POINT LOCATIONS.
   VERTICAL SCALE: 1" = 20 MILLISECONDS
   HORIZONTAL SCALE: 1" = 50 FEET
2. SUBSURFACE VELOCITY PROFILES AT BOTTOM OF FIGURE REPRESENT INTERPRETATIONS OF SEISMIC REFRACTION DATA AND ARE INTENDED FOR DESIGN PURPOSES ONLY.
   VERTICAL AND HORIZONTAL SCALE: 1" = 50 FEET
3. LOCATION OF SEISMIC LINES SHOWN ON FIGURE NO.(S) 1

SEISMIC LINE NO.(S): S-1 & S-2

DATE: 3/27/91

PROJECT NO.: 3438F

FIGURE NO.: 2



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SEISMIC REFRACTION SURVEY
DATA AND INTERPRETED SUBSURFACE VELOCITY PROFILES

PARDEE DAM RAISE
AMADOR COUNTY, CALIFORNIA

REGISTERED GEOPHYSICIST PATRICK O. SHIRES No. 879 STATE OF CALIFORNIA

EXPLANATION

1. TIME–DISTANCE GRAPHS AT TOP OF FIGURE REPRESENT SEISMIC REFRACTION SURVEY DATA; DOTS ON BOTTOM LINE OF GRAPHS REPRESENT GEOPHONE LOCATIONS, X'S REPRESENT SHOT POINT LOCATIONS.
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   HORIZONTAL SCALE: 1" = 50 FEET
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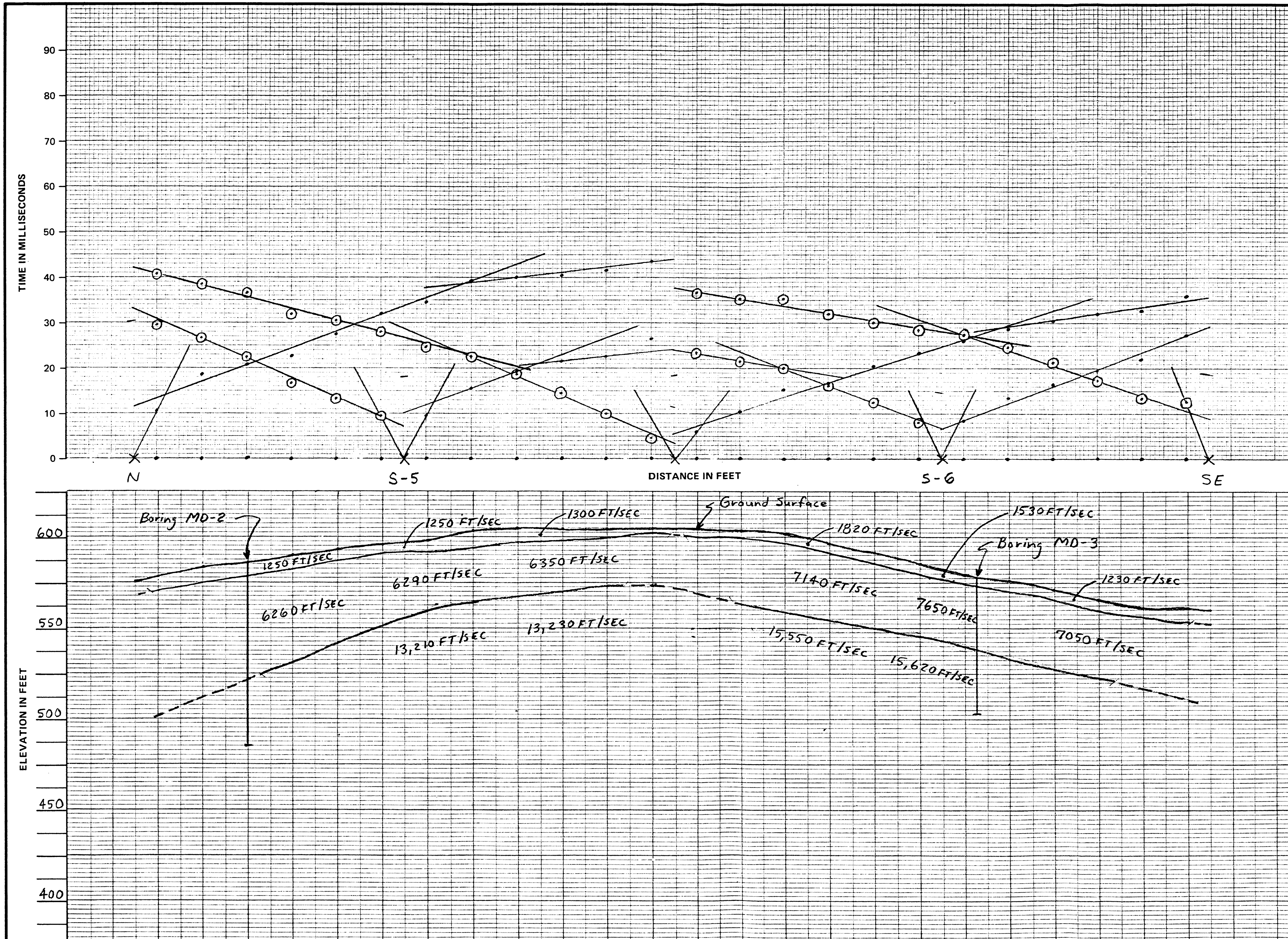
   VERTICAL AND HORIZONTAL SCALE: 1" = 50 FEET
3. LOCATION OF SEISMIC LINES SHOWN ON FIGURE NO.(S) 1

SEISMIC LINE NO.(S): S-3 & S-4

DATE: 3/27/91

PROJECT NO.: 3438F

FIGURE NO.: 3



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SEISMIC REFRACTION SURVEY
DATA AND INTERPRETED SUBSURFACE VELOCITY PROFILES

PARDEE DAM RAISE
AMADOR COUNTY, CALIFORNIA

REGISTERED GEOPHYSICIST ★ PATRICK O. SHIRES No. 879 STATE OF CALIFORNIA ★

EXPLANATION

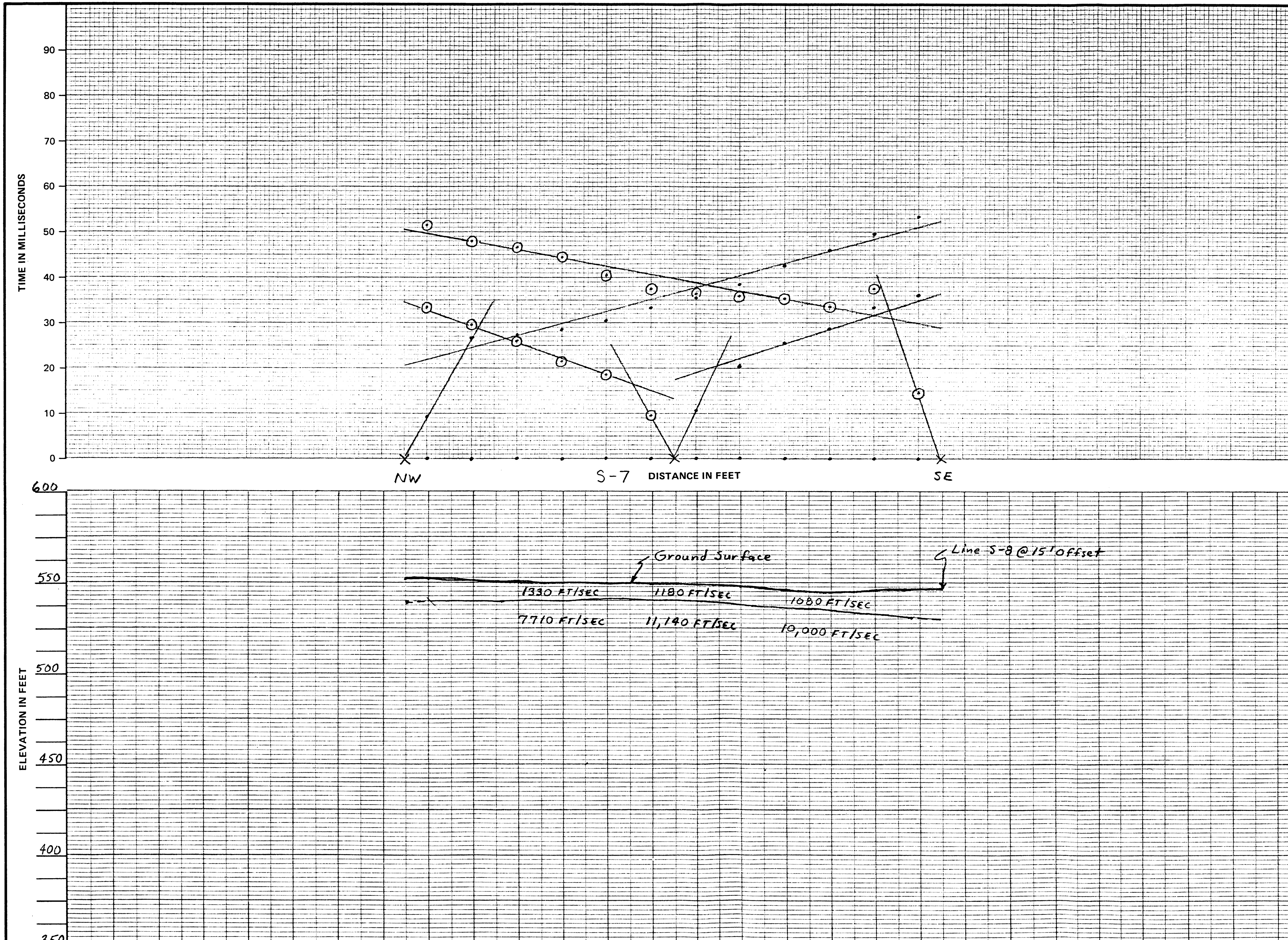
1. TIME–DISTANCE GRAPHS AT TOP OF FIGURE REPRESENT SEISMIC REFRACTION SURVEY DATA; DOTS ON BOTTOM LINE OF GRAPHS REPRESENT GEOPHONE LOCATIONS, X'S REPRESENT SHOT POINT LOCATIONS.
   VERTICAL SCALE: 1" = 20 MILLISECONDS
   HORIZONTAL SCALE: 1" = 50 FEET
2. SUBSURFACE VELOCITY PROFILES AT BOTTOM OF FIGURE REPRESENT INTERPRETATIONS OF SEISMIC REFRACTION DATA AND ARE INTENDED FOR DESIGN PURPOSES ONLY.
   VERTICAL AND HORIZONTAL SCALE: 1" = 50 FEET
3. LOCATION OF SEISMIC LINES SHOWN ON FIGURE NO.(S) 1

SEISMIC LINE NO.(S): S-5 & S-6

DATE: 3/27/91

PROJECT NO.: 3438F

FIGURE NO.: 4



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SEISMIC REFRACTION SURVEY
DATA AND INTERPRETED SUBSURFACE VELOCITY PROFILES

PARDEE DAM RAISE
AMADOR COUNTY, CALIFORNIA

REGISTERED GEOPHYSICIST PATRICK O. SHIRES No. 879 STATE OF CALIFORNIA

EXPLANATION

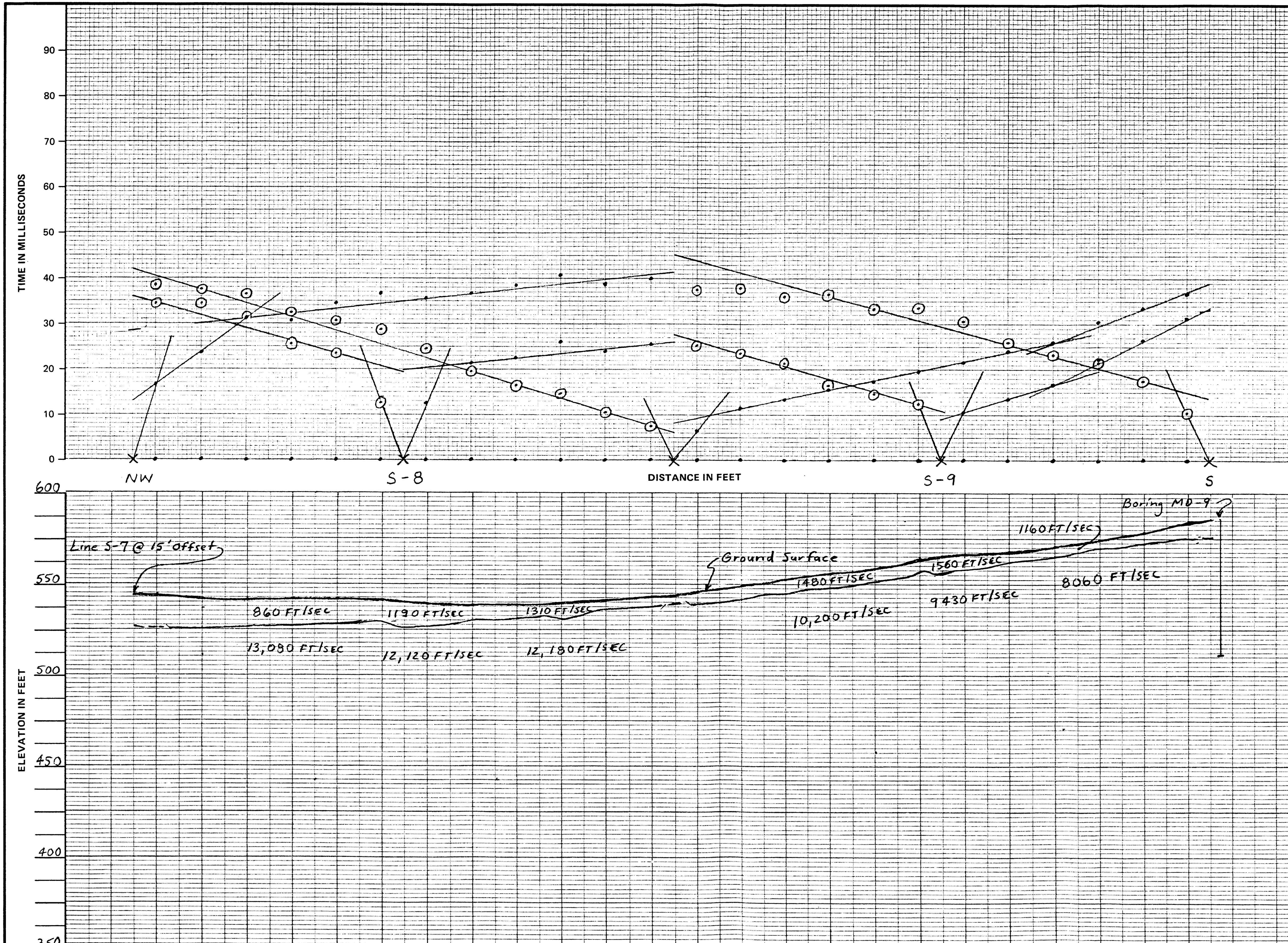
1. TIME–DISTANCE GRAPHS AT TOP OF FIGURE REPRESENT SEISMIC REFRACTION SURVEY DATA; DOTS ON BOTTOM LINE OF GRAPHS REPRESENT GEOPHONE LOCATIONS, X'S REPRESENT SHOT POINT LOCATIONS.
   VERTICAL SCALE: 1" = 20 MILLISECONDS
   HORIZONTAL SCALE: 1" = 50 FEET
2. SUBSURFACE VELOCITY PROFILES AT BOTTOM OF FIGURE REPRESENT INTERPRETATIONS OF SEISMIC REFRACTION DATA AND ARE INTENDED FOR DESIGN PURPOSES ONLY.
   VERTICAL AND HORIZONTAL SCALE: 1" = 50 FEET
3. LOCATION OF SEISMIC LINES SHOWN ON FIGURE NO.(S) 1

SEISMIC LINE NO.(S): S-7

DATE: 3/27/91

PROJECT NO.: 3438F

FIGURE NO.: 5



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SEISMIC REFRACTION SURVEY
DATA AND INTERPRETED SUBSURFACE VELOCITY PROFILES

PARDEE DAM RAISE
AMADOR COUNTY, CALIFORNIA

REGISTERED GEOPHYSICIST PATRICK O. SHIRES No. 879 STATE OF CALIFORNIA

EXPLANATION

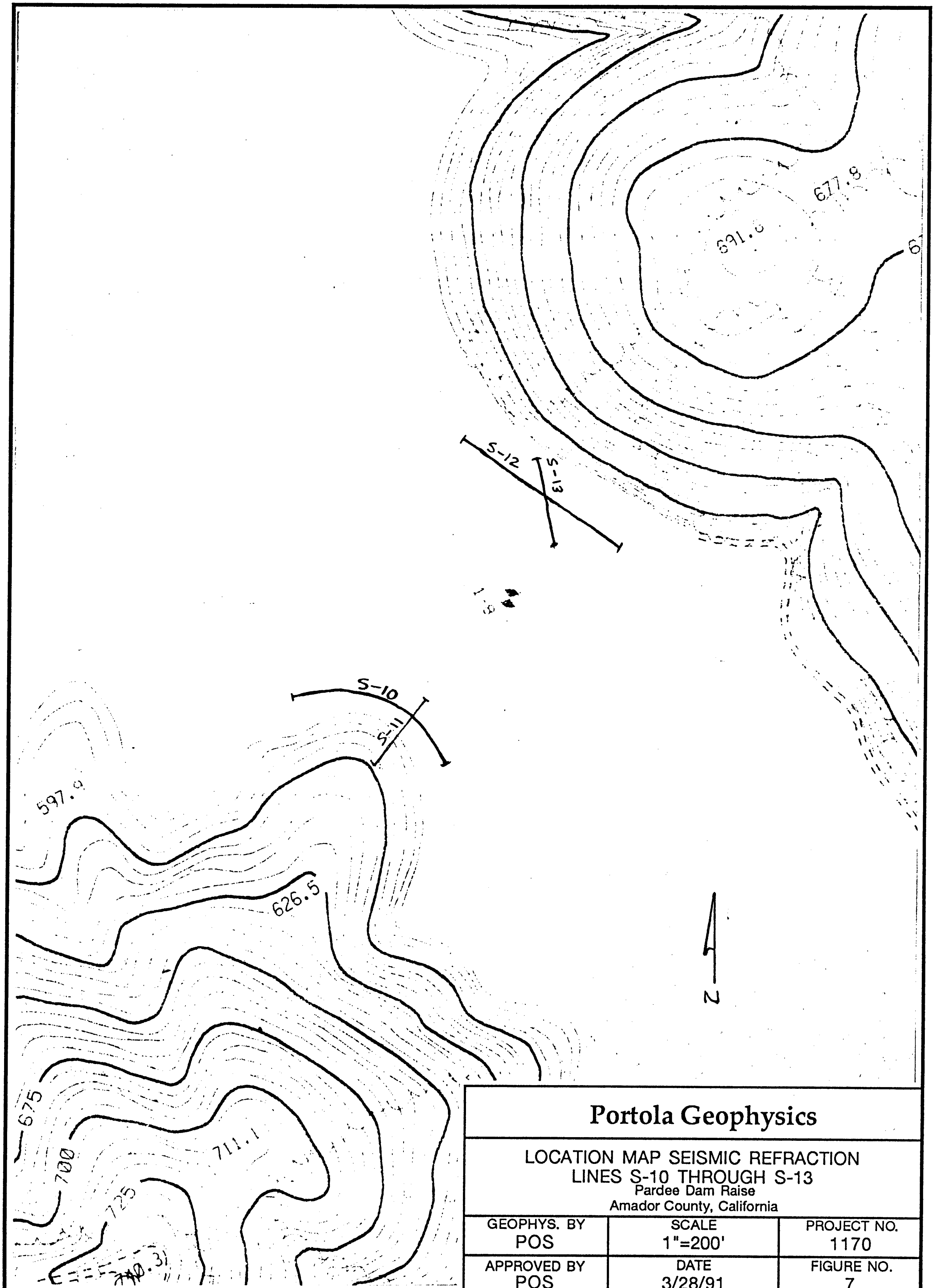
1. TIME–DISTANCE GRAPHS AT TOP OF FIGURE REPRESENT SEISMIC REFRACTION SURVEY DATA; DOTS ON BOTTOM LINE OF GRAPHS REPRESENT GEOPHONE LOCATIONS, X'S REPRESENT SHOT POINT LOCATIONS.
   VERTICAL SCALE: 1" = 20 MILLISECONDS
   HORIZONTAL SCALE: 1" = 50 FEET
2. SUBSURFACE VELOCITY PROFILES AT BOTTOM OF FIGURE REPRESENT INTERPRETATIONS OF SEISMIC REFRACTION DATA AND ARE INTENDED FOR DESIGN PURPOSES ONLY.
   VERTICAL AND HORIZONTAL SCALE: 1" = 50 FEET
3. LOCATION OF SEISMIC LINES SHOWN ON FIGURE NO.(S) 1

SEISMIC LINE NO.(S): S-8 & S-9

DATE: 3/27/91

PROJECT NO.: 3438F

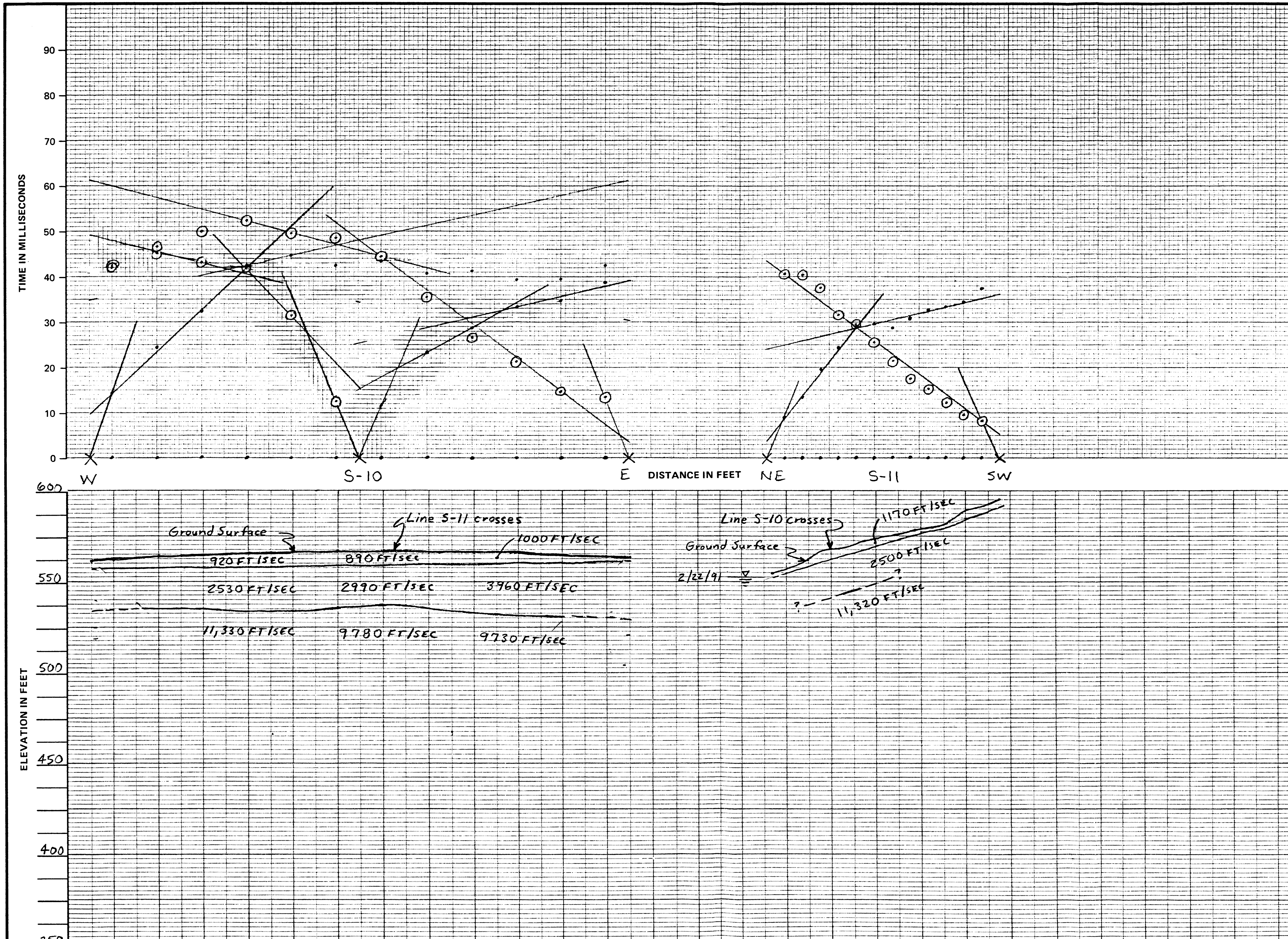
FIGURE NO.: 6



Portola Geophysics

LOCATION MAP SEISMIC REFRACTION
LINES S-10 THROUGH S-13
Pardee Dam Raise
Amador County, California

GEOPHYS. BY	SCALE	PROJECT NO.
POS	1"=200'	1170
APPROVED BY	DATE	FIGURE NO.
POS	3/28/91	7



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SEISMIC REFRACTION SURVEY
DATA AND INTERPRETED SUBSURFACE VELOCITY PROFILES

PARDEE DAM RAISE
AMADOR COUNTY, CALIFORNIA

REGISTERED GEOPHYSICIST PATRICK O. SHIRES No. 879 STATE OF CALIFORNIA

EXPLANATION

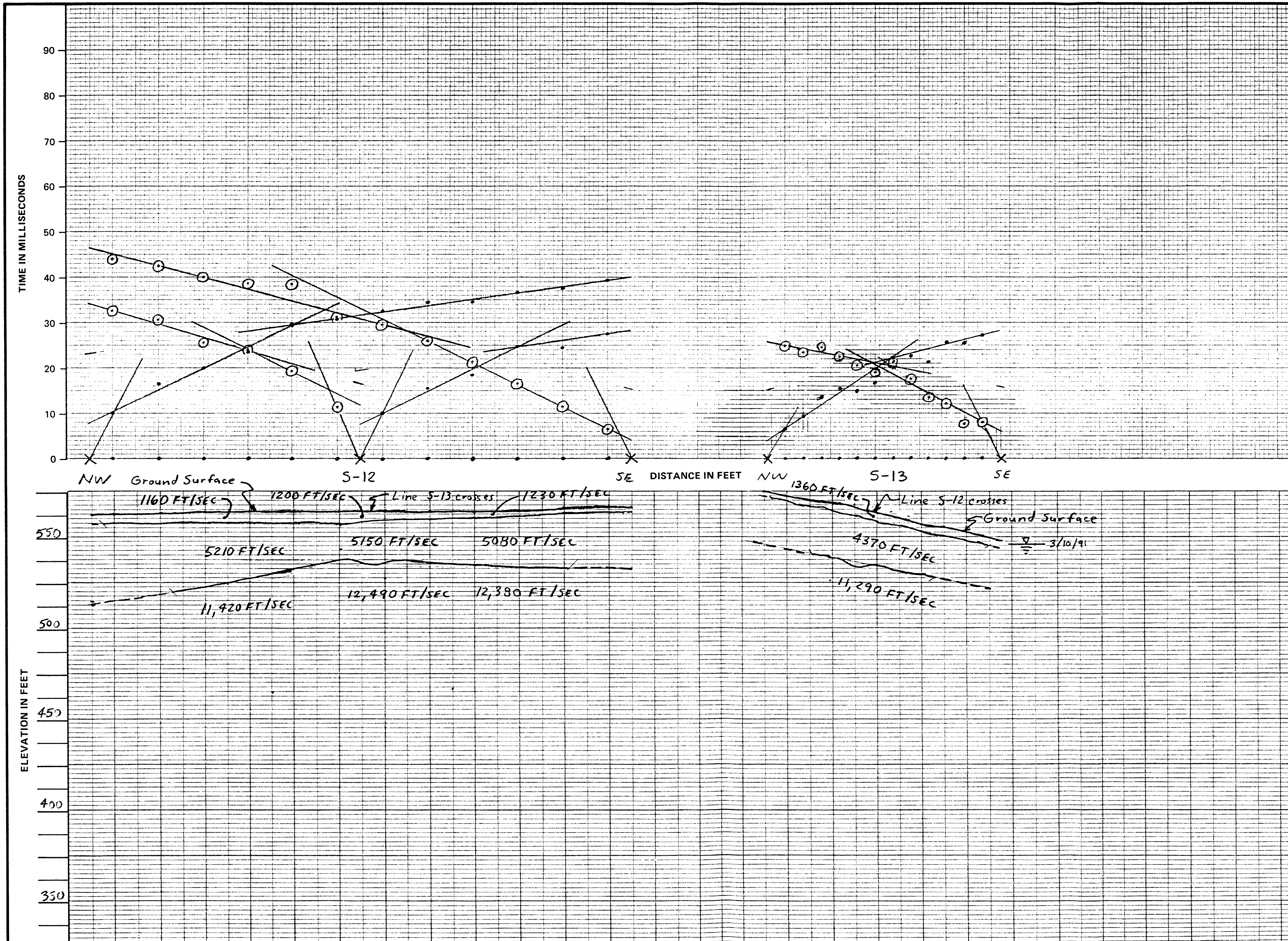
1. TIME–DISTANCE GRAPHS AT TOP OF FIGURE REPRESENT SEISMIC REFRACTION SURVEY DATA; DOTS ON BOTTOM LINE OF GRAPHS REPRESENT GEOPHONE LOCATIONS, X'S REPRESENT SHOT POINT LOCATIONS.
   VERTICAL SCALE: 1" = 20 MILLISECONDS
   HORIZONTAL SCALE: 1" = 50 FEET
2. SUBSURFACE VELOCITY PROFILES AT BOTTOM OF FIGURE REPRESENT INTERPRETATIONS OF SEISMIC REFRACTION DATA AND ARE INTENDED FOR DESIGN PURPOSES ONLY.
   VERTICAL AND HORIZONTAL SCALE: 1" = 50 FEET
3. LOCATION OF SEISMIC LINES SHOWN ON FIGURE NO.(S) 7

SEISMIC LINE NO.(S): S-10 & S-11

DATE: 3/27/91

PROJECT NO.: 3438F

FIGURE NO.: 8



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SEISMIC REFRACTION SURVEY
DATA AND INTERPRETED SUBSURFACE VELOCITY PROFILES

PARDEE DAM RAISE
AMADOR COUNTY, CALIFORNIA

REGISTERED GEOPHYSICIST PATRICK O. SHIRES No. 879 STATE OF CALIFORNIA

EXPLANATION

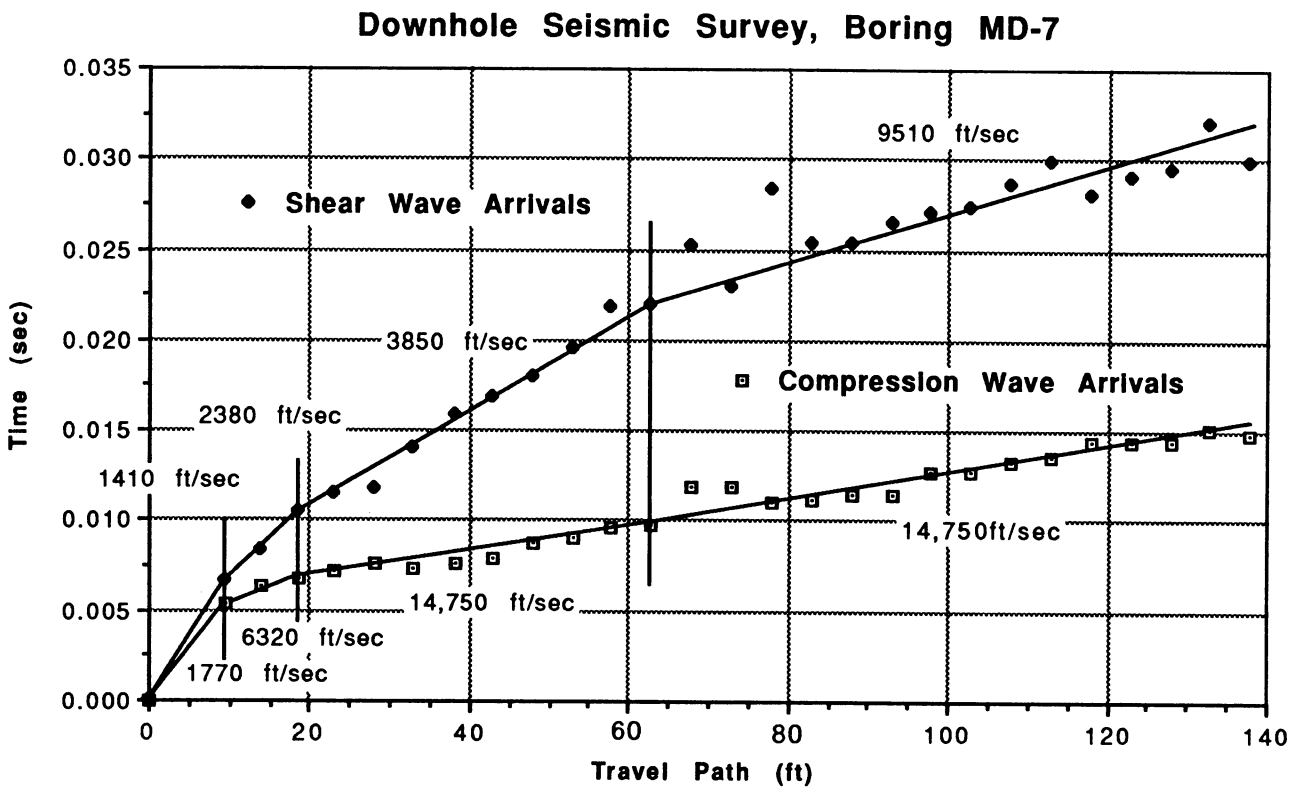
1. TIME–DISTANCE GRAPHS AT TOP OF FIGURE REPRESENT SEISMIC REFRACTION SURVEY DATA; DOTS ON BOTTOM LINE OF GRAPHS REPRESENT GEOPHONE LOCATIONS, X'S REPRESENT SHOT POINT LOCATIONS.
   VERTICAL SCALE: 1" = 20 MILLISECONDS
   HORIZONTAL SCALE: 1" = 50 FEET
2. SUBSURFACE VELOCITY PROFILES AT BOTTOM OF FIGURE REPRESENT INTERPRETATIONS OF SEISMIC REFRACTION DATA AND ARE INTENDED FOR DESIGN PURPOSES ONLY. VERTICAL AND HORIZONTAL SCALE: 1" = 50 FEET
3. LOCATION OF SEISMIC LINES SHOWN ON FIGURE NO.(S) 7

SEISMIC LINE NO.(S): S-12 & S-13

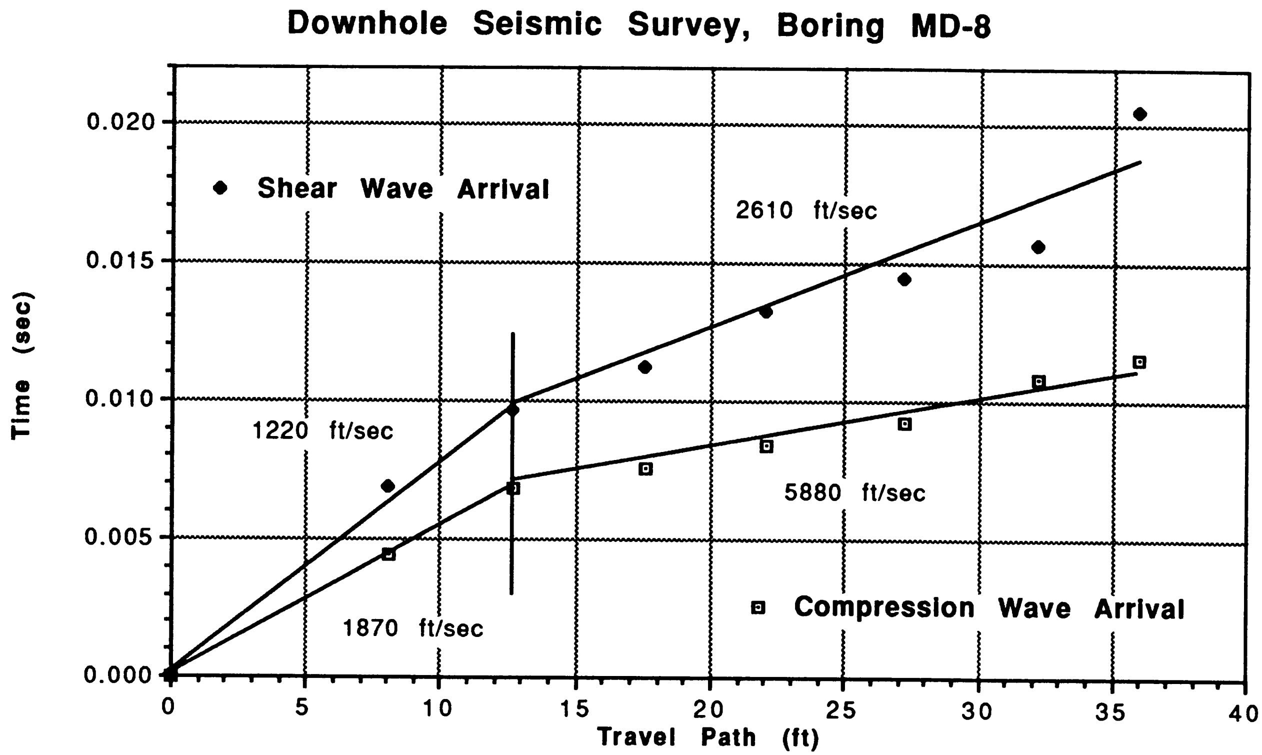
DATE: 3/27/91

PROJECT NO.: 3438 F.

FIGURE NO.: 9



Portola Geophysics		
Boring MD-7 Downhole Seismic Results Pardee Dam Raise Amador County, California		
GEOPHYS. BY POS	SCALE AS SHOWN	PROJECT NO. 1170
APPROVED BY POS	DATE 3/28/91	FIGURE NO. 10



Portola Geophysics

Boring MD-8 Downhole Seismic Results

Pardee Dam Raise
Amador County, California

GEOPHYS. BY	SCALE	PROJECT NO.
POS	AS SHOWN	1170
APPROVED BY	DATE	FIGURE NO.
POS	3/28/91	11