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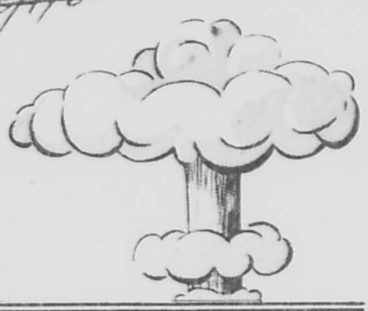
OCTOBER-NOVEMBER 1951

Project 4.2

PHYSICAL CHARACTERISTICS OF CRATER AND LIP



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OPERATION JANGLE

PROJECT 4.2

PHYSICAL CHARACTERISTICS OF CRATER AND LIP

by

J. A. BISHOP & F. E. LOWANCE

May 1952

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RESEARCH AND EVALUATION LABORATORY
Port Hueneme, California

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ABSTRACT

A study was made to determine the physical dimensions of the craters and lips resulting from the subsurface and surface explosions. Soil samples were taken to establish the characteristics and properties of the soil within the anticipated underground shot crater area. Topographic surveys were made before and after the blast of the areas surrounding the zero points and quantities of earth moved were estimated. An attempt was made to establish the "true" crater depth resulting from the underground shot by measuring the amount of radioactive contamination which obtained from the surface to a depth of two feet.

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SECTION 1

INTRODUCTION

1.1 GENERAL

Estimates have been made of the crater effects that can be expected from detonation of atomic explosives below the surface of the earth by extrapolating from the results of other high energy explosives. These estimates have necessarily been very approximate due to the lack of sufficient data at various energy levels to provide for normal extrapolation techniques. Theoretical studies at present have not resulted in sufficient correlation with high explosive tests to allow for an accurate estimate of the results of atomic explosions.

The effects from an atomic explosion are those due to nuclear and thermal radiation, energy transmitted through atmospheric waves, and energy transmitted through ground waves. Actual distribution of energy in atmospheric and ground waves will be affected by the amount which is lost in rupture and cratering. As this fraction is increased there will be some proportional decrease of the energy transmitted in ground and atmospheric waves. Therefore, a knowledge of the dimensions of the crater and lip can be employed in calculating the energy distributed in the atmospheric and ground waves.

The craters' dimensions are determined by making accurate topographical surveys of the anticipated crater areas, and similar surveys following the explosion employing usual surveying techniques. Because of the radiation hazards existing for some time following the explosions, probing to establish the craters' true depths was not possible.

1.2 THE SITE

The area from which the samples of soil for this project were taken is a broad basin rimmed with mountains ranging from 2000 to 4000 feet above the lowest points of the valley. The soil of the basin consists of an alluvial deposit which is poorly sorted and has more or less consolidated. Fairly strong winds in the area have covered portions of the basin with layers of fine sand and silt size particles. Vegetation in the area is sparse and is principally sagebrush.

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The soil, to the depths examined in this project (185)feet), is dry and granular. There is no apparent stratification but rather the mass is heterogeneous containing pockets or lenses of caleche, coarse grained, and extremely fine sand. It developed that the soil could be excavated with vertical walls to a considerable depth indicating that the particles are cemented together, or that the grains interlock, because of their shape, to produce a stable mass. Since the soil was dry it is believed that the latter is the primary reason for its stability.

1.3 OBJECTIVE

The objective of this project was the determination of the physical characteristics of the craters and lips formed by the deterioration of surface and subsurface atomic weapons. From measurements establishing these dimensions and soil data obtained from the sampling and testing of the soils in the anticipated crater areas, calculations were to be made in the amount of material ejected and deposited on the lips and in the immediate vicinity.

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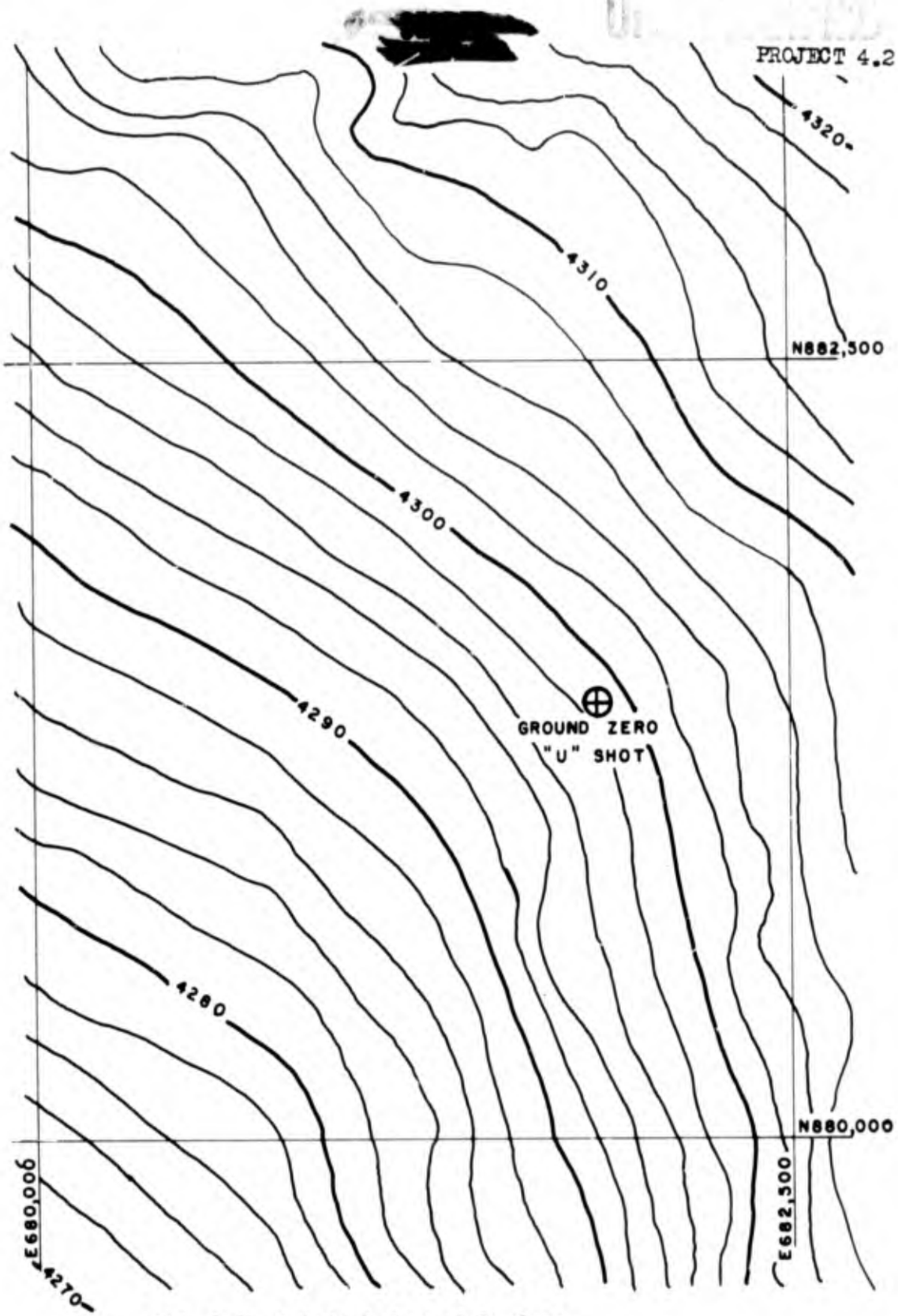

Fig. 1.1 Original Ground Surface
Vicinity Ground Zero - U-Shot
Scale 1" - 500'

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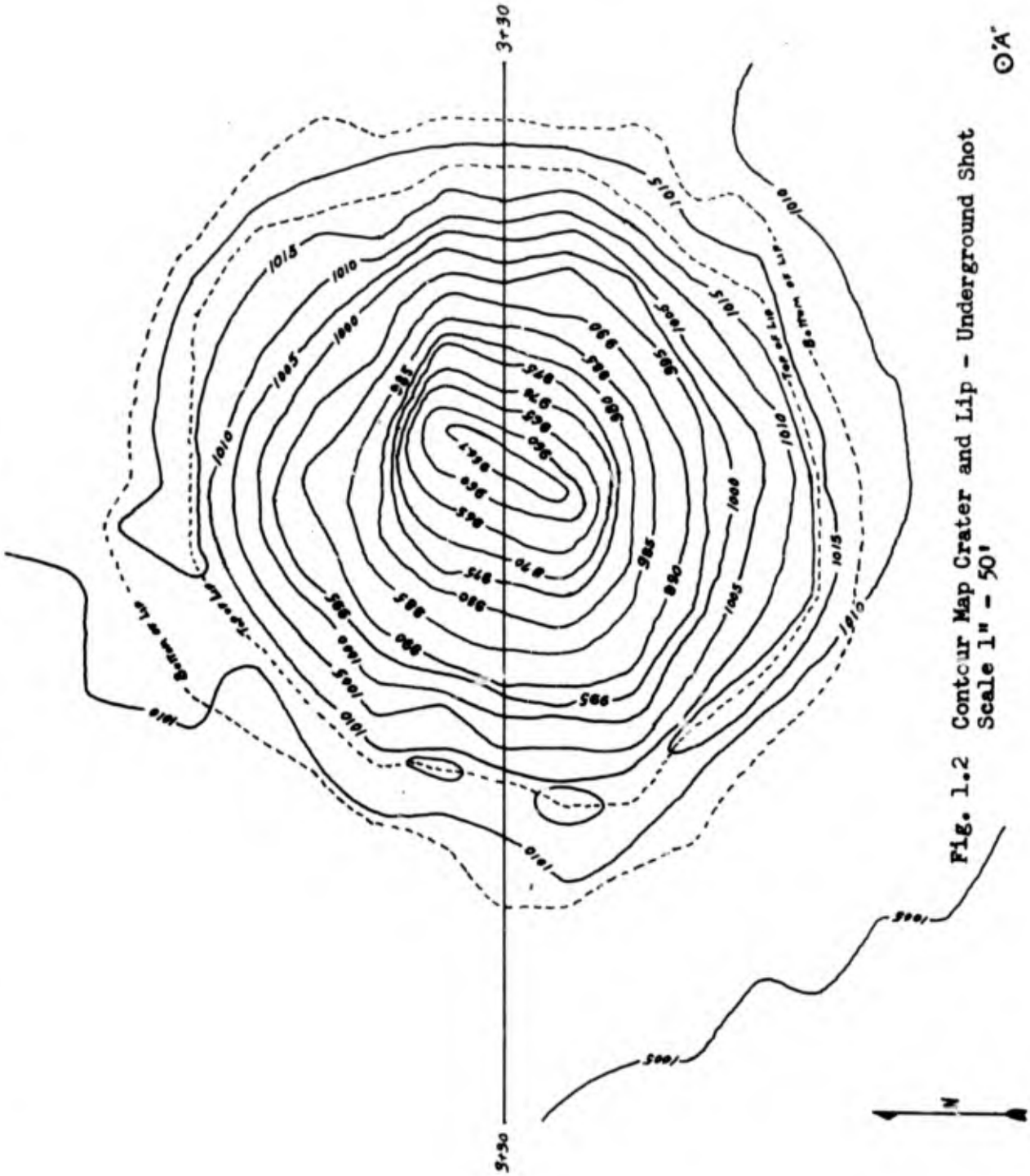

Fig. 1.2 Contour Map Crater and Lip - Underground Shot
Scale 1" = 50'

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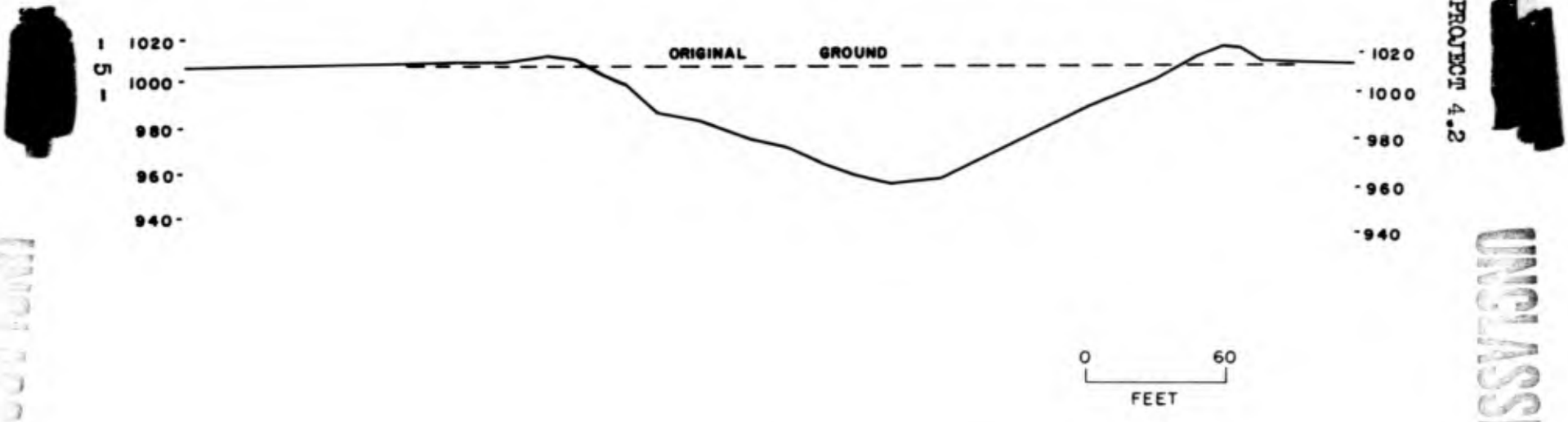

Fig. 1.3 Crater Centerline Profile - Underground Shot East-West

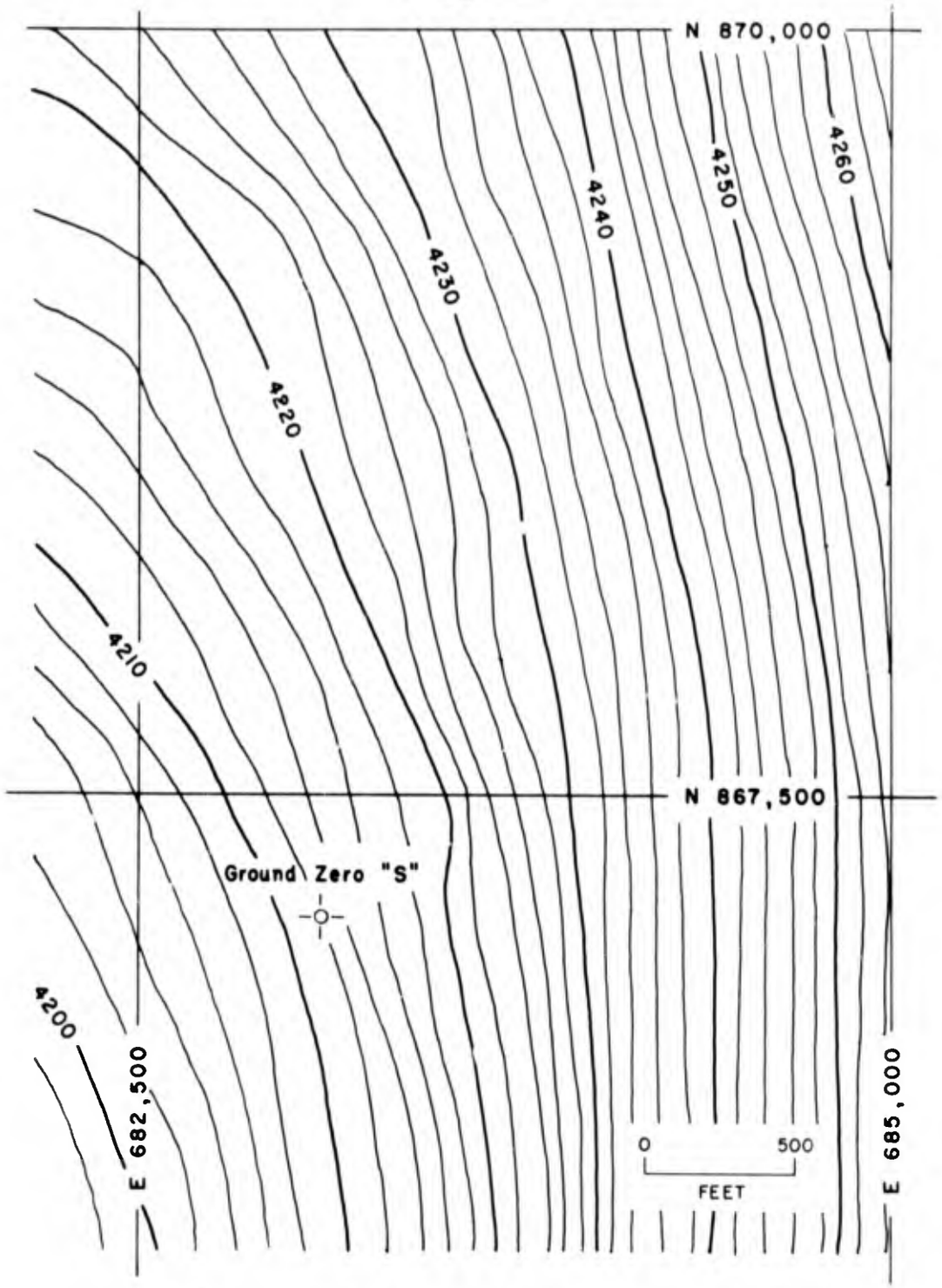

Fig. 1.4 Original Ground Surface
Vicinity Ground Zero - Surface Shot

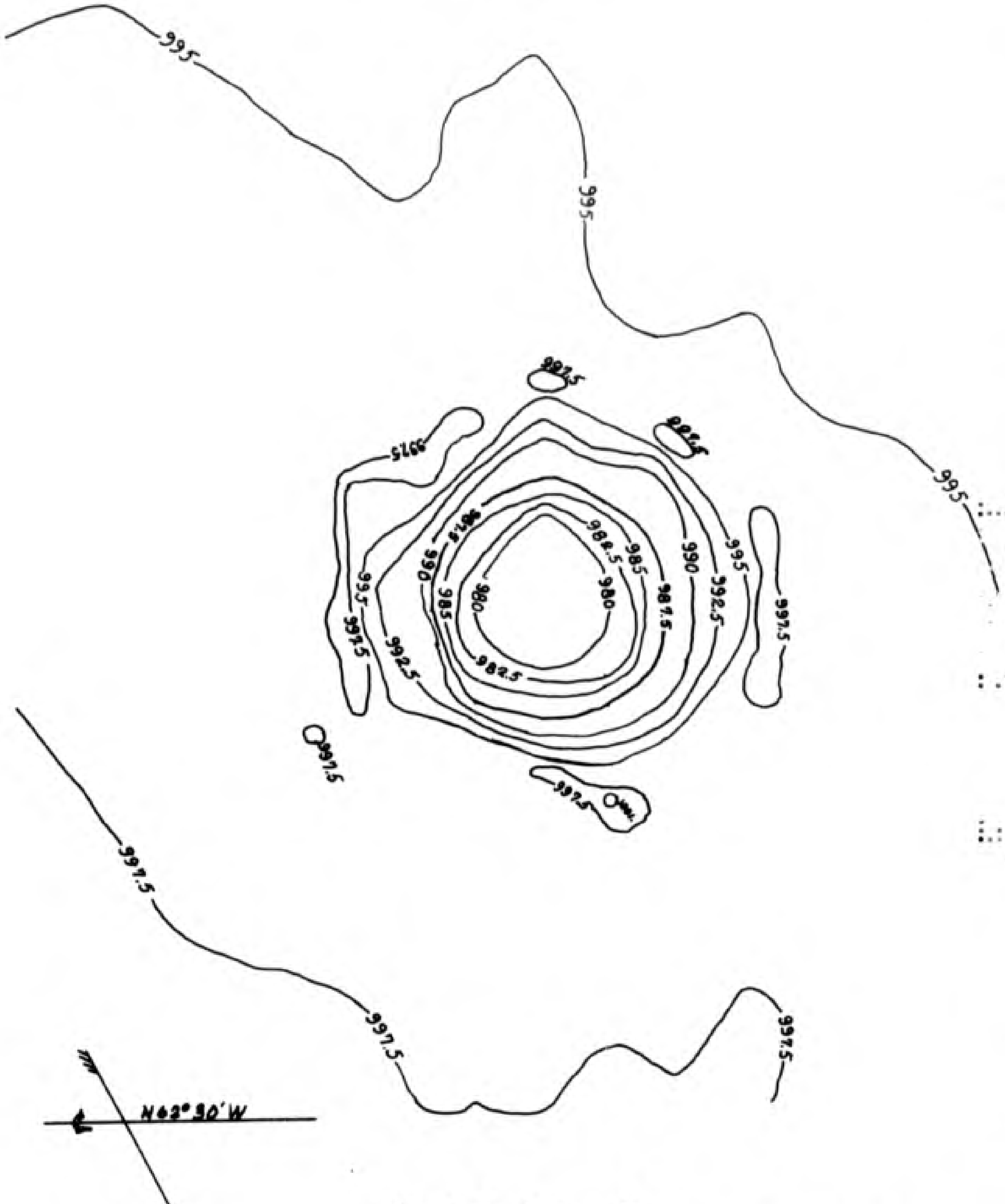

Fig. 1.5 Contour Map
Crater and Lip - Surface Shot
Scale 1" - 40'

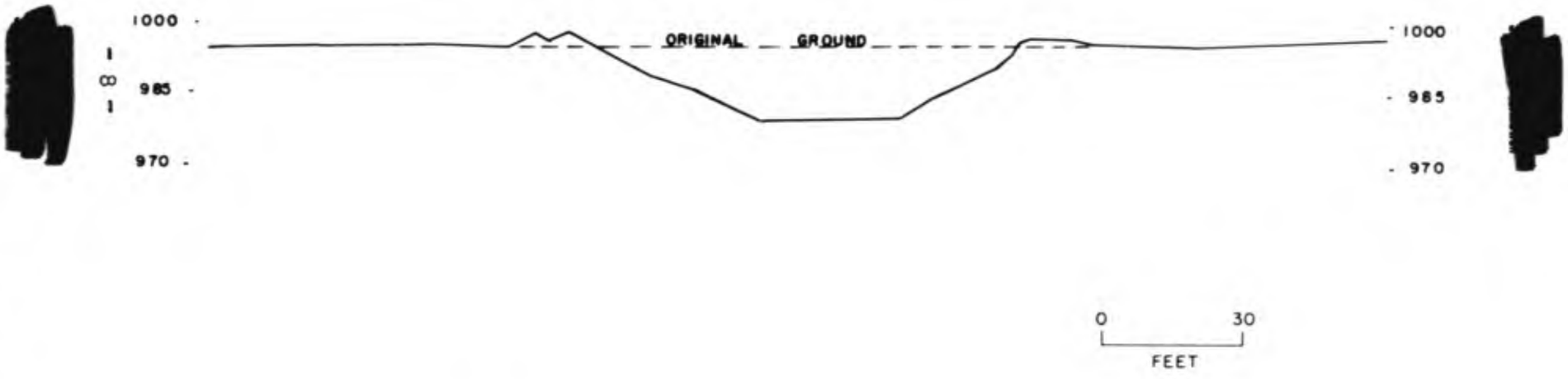

Fig. 1.6 Crater Centerline Profile - Surface Shot
Bearing N62° 30'W

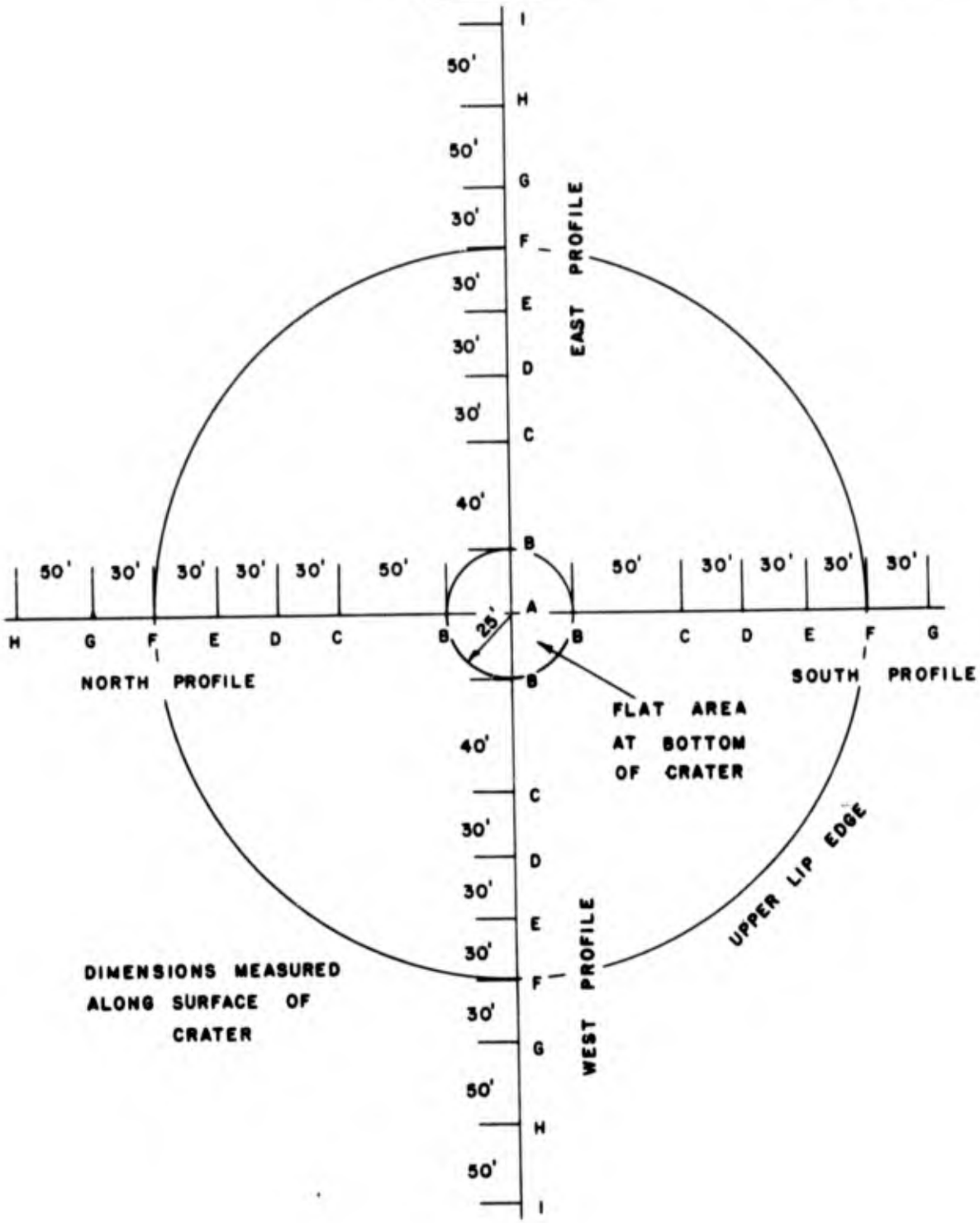

Fig. 1.7 Pattern of Radiation Level Measurements
Underground Shot
Not to Scale

[redacted]

SECTION 2

EXPERIMENTAL PROCEDURE

2.1 THEORETICAL CONSIDERATIONS

Experimental work conducted on a model scale has indicated that the size of the crater produced by buried charges has been relatively insensitive to the type of soil. Fundamentally, however, it is believed that the amount of cratering which can be expected is directly related to the shearing strength of the soil in which the explosion occurs. The sudden release of energy upon detonation causes forces, the effects of which are not completely understood but which are undoubtedly related to the dynamic stress-strain properties of the soil. When a buried charge is exploded there are shearing components of the resulting forces along some curved surface which are greater than the shearing resistance of the soil. At some distance from the detonation these are still of such a magnitude that they cause rupturing and displacement of a mass of soil. The location of this surface was sought in this project but it was not to be expected that this surface would be clearly defined because the random nature of the soil would cause a variation in the velocity of travel of compression waves.

The problem of theoretically predicting the extent of the expected crater does not lend itself to ready analysis because all the factors governing its formation are not clearly understood. Estimates of the size of the anticipated crater have been made based on empirical formulae developed in the study of high explosive detonations. Whether or not these formulae are valid for use in analyzing nuclear explosion effects is still open to question.

2.2 PROCEDURE

To obtain soil samples for examination and laboratory analysis 14 holes were bored within the anticipated underground shot crater area. The logs or records of these borings were examined for similarity and samples from eight holes were selected as representative of the entire number and retained for examination. The holes were bored on radii approximately 45° apart and spaced at 50 feet, 100 feet, 200 feet and 300 feet from ground zero. Samples were taken at every 10 feet of depth and the depths of the holes varied from 100 feet at the 300 foot distance to 185 feet at the 50 foot circle.

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It was hoped before the program was begun that undisturbed samples could be obtained for test purposes, but the dry granular nature of the soil obviated this possibility. A method was employed, therefore, whereby the hole was advanced to the desired depths by augering and washing and the samples were recovered by driving split tube samplers into the soil under the action of a falling weight. Thus the samples so obtained were classed as disturbed and were remolded for use in the direct shear tests for shearing strength determinations. After direct shear testing, the samples were used for specific gravity determinations and mechanical analysis.

Field or in-place densities at selected locations within the anticipated crater area were measured at depths of 2 feet, 3 feet, 4 feet, 10 feet and 15 feet.

It was planned that topographic surveys of the areas would be made following completion of the construction program. It was found, however, that the building activity within the areas did not appreciably change the terrain configuration. Accordingly, use was made of a topographic map already prepared by the Corps of Engineers, portions of which are included as Figures 1.1 and 1.4, to show the practically constant slope of the areas. Following the explosions accurate surveys of the resulting crater and lip areas were made for purposes of estimating the quantities of earth moved. Unfortunately, these surveys had to be delayed until the degree of radioactivity of the areas was such that personnel could work in the areas a reasonable length of time. The contamination also precluded the determination of the true crater depths by probing. During the time between the explosions and the surveys the area was exposed to the elements and the surface soil was blown about by wind and consolidated by rain and snow. While the extent of such disturbance is not known it was believed to be sufficient enough to make probings for true depth determinations unreliable. Accordingly, it was decided to attempt to ascertain the true depth of the crater (resulting from the underground shot) by measuring the degree of radioactivity of the soil at depths of 3 inches, 6 inches, 12 inches and 24 inches from the crater surface. This decision was based on the assumption that all soil ejected (the true volume) would be exposed to radiation and that falling back into the hole would remain contaminated. In effect the purpose was to establish the presence of a "radioactive gradient" from the surface to the true depth. The efforts were not particularly successful, however, as the amount of contamination of the soil at depths below 12 inches remaining at the time of the measurements was very minute. These measurements of contamination were made by NRDL personnel in connection with NRDL projects.

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SECTION 3

RESULTS

3.1 SUMMARY

Direct shear measurements of the angle of internal friction of the soils tested indicated a maximum ϕ value of 58° and a minimum of 37° with an average of 51°.

Typical field densities obtained by the calibrated sand method at the various levels were as follows: at a depth of 2 feet, 85 lbs/cu ft; at 3 feet, 102 lbs/cu ft; at 4 feet, 94 lbs/cu ft; at 10 feet, 97 lbs/cu ft; and at 15 feet, 88 lbs/cu ft.

The lowest absolute specific gravity of the soil tested was 2.40 and the maximum was 2.74. An average value for all soils tested was 2.56.

Maximum depth of the crater resulting from the underground shot determined by the topographic survey was approximately 53 feet as measured from the original ground surface. The maximum height of lip above orginal ground surface was 8 feet and the width of the crater was approximately 258 feet.

Maximum depth of the crater resulting from the surface shot was approximately 17 feet and the height of the lip was 5 feet above original ground surface. The width of the crater was approximately 90 feet.

The volume of the crater resulting from the underground shot was 36,025 cubic yards and the lip volume was 5980 cubic yards. These volumes represent approximately 45,000 tons and 7500 tons of earth respectively, based on an average unit weight of soil of 93 lbs/cu ft.

The surface shot crater volume amounted to 1825 cubic yards and the volume of earth which comprised the lip was 450 cubic yards which represent approximately 2300 tons and 565 tons.

Figure 1.2 is a contour map of the crater and lip areas resulting from the underground shot and a profile or cross-section on an east-west line across the lip and crater taken at the crater's deepest point is shown in Figure 1.3. Figure 1.5 is a contour map of the crater and lip, resulting from the surface shot and Figure 1.6 is a profile taken across the crater's deepest point on a bearing of N62° 30'W.

The results of the measurements taken to determine the presence of a radioactive gradient in the soil on the sides and in the bottom of the crater resulting from the underground explosion are given in Table 3.1. The pattern of test locations in which these measurements were taken is shown in Figure 1.7.

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Table 3.1 - Radiation Level Measurements

Counts per Second (Bkg Standardized)

Station Depth (inches)	A	B	C	D	E	F	G	H	I	J
					North Profile					
0	1613.0	1322.0	188.0	959.0	369.0	806.0	515.0	1139.0	1435.0	1345.0
3	326.0	465.0	33.7	526.0	231.0	144.8	313.7	123.3	103.4	5.5
6	274.0	171.0	13.4	724.0	290.0	2.3	8.0	16.9	18.9	1.0
12	295.0	230.0	7.3	1403.0	685.0	9.7	2.9	8.8	6.5	3.6
24	241.0	220.0	4.5	319.0	96.5	5.2	4.6	15.2	4.1	7.4
					South Profile					
0	772.0	1970.0	1670.0	358.0	1160.0	306.0	1080.0	-	-	-
3	279.0	263.0	114.0	212.0	394.0	4.4	116.0	-	-	-
6	282.0	182.0	65.0	248.0	330.0	108.0	25.3	-	-	-
12	243.0	24.0	4.7	5.1	4.9	0.1	12.8	-	-	-
24	112.0	5.3	3.4	5.3	2.2	2.6	6.1	-	-	-
					East Profile					
0	785.0	496.0	1000.0	1275.0	833.0	580.0	1480.0	79.0	700.0	532.0
3	311.0	18.3	146.0	860.0	815.0	220.0	151.0	134.0	9.8	4.7
6	324.0	13.0	81.0	107.0	4.1	5.6	1.4	103.0	5.4	0.0
12	157.0	11.2	0.7	115.0	0.1	1.9	0.5	67.0	4.4	0.0
24	258.0	7.2	0.2	10.3	25.0	1.6	5.1	3.7	12.2	12.7
					West Profile					
0	1168.0	1283.0	1228.0	1202.0	81.0	830.0	1620.0	887.0	1134.0	524.0
3	214.0	335.0	366.0	453.0	71.0	85.0	1.6	9.6	22.0	31.0
6	114.0	287.0	4.0	88.0	5.0	1.6	1.5	0.0	0.3	1.5
12	248.0	123.0	0.3	6.4	1.8	2.8	2.2	1.4	0.0	0.0
24	209.0	136.0	1.7	3.4	4.7	2.3	40.0	32.0	8.2	1.7

Note: The counts/sec values have all been standardized with respect to each other. All samples weighed 50 gms and were counted with a GM Tube and Berkeley scaler under similar conditions.

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APPENDIX A

SOIL TEST DATA SHEETS

[redacted]

SOIL TEST DATA - NEVADA TEST SITE

HOLE NUMBER 4 D

Ground Elevation 4299.0 ft.	Sample Number	Sp.Gr.	Angle of Int.Fric. (Ø)	Sieve Analysis Cumulative Percent Retained							
				3/8	#4	#10	#20	#40	#60	#140	#200
0											
10	1	2.64	56	10.3	28.9	50.5	68.6	76.9	82.5	89.8	92.8
20	2	2.58	54	0.0	10.5	28.3	45.1	59.7	70.7	85.9	90.2
30	3	2.74	49	0.0	9.3	21.8	35.9	52.2	65.8	82.7	87.0
40	4	2.52	45	0.0	6.3	16.1	25.0	39.3	53.6	80.3	87.5
50	5	2.57	43	0.0	1.6	8.2	13.1	24.6	39.4	72.9	82.0
60	6	2.52	53	0.0	9.7	29.1	44.4	58.1	68.6	81.4	87.1
70	7	2.54	53	1.5	6.1	18.2	33.4	52.3	66.7	83.4	88.5
80	8	2.56	55	2.4	3.2	11.3	29.1	54.0	72.5	91.1	94.3
90	9	2.49	50	4.2	9.7	25.7	43.1	54.2	59.7	77.1	84.7
100	10	2.46	49	0.0	1.6	7.9	17.5	25.4	33.4	52.4	66.7
110	11	2.52	52	2.9	12.9	21.4	30.0	40.0	51.5	77.1	85.7
120	12	2.55	50	0.0	3.5	8.9	19.6	32.2	44.6	69.6	80.4
130	13	2.47	54	8.2	24.6	36.1	49.1	60.6	70.5	88.5	91.9
140	14	2.47	57	9.7	18.1	27.8	40.3	54.2	66.7	83.5	90.5
150	15	2.53	49	5.0	12.5	20.0	27.5	36.2	48.8	72.5	81.2
160	16	2.54	49	10.5	15.8	21.0	29.0	39.5	51.4	75.0	84.3
170	17	2.51	54	11.8	20.0	31.6	47.4	63.1	73.6	88.1	92.1
180	18	2.61	57	10.5	22.4	38.2	60.5	75.0	84.1	92.0	94.6
Bottom Elev. 4119.0 ft.											

SOIL TEST DATA - NEVADA TEST SITE

HOLE NUMBER 5 D

Ground Elevation 4300.0 ft.	Sample Number	Sp.Gr.	Angle of Int.Fric. (Ø)	Sieve Analysis Cumulative Percent Retained							
				3/8	#4	#10	#20	#40	#60	#140	#200
0											
10	1	2.59	43	0.0	2.6	5.3	7.9	13.2	21.7	48.7	65.8
20	2	2.59	37	45.7	49.8	54.8	62.0	69.0	76.2	86.3	90.3
30	3	2.60	43	10.9	21.1	29.7	43.8	56.3	68.8	82.9	87.6
40	4	2.48	46	5.1	9.0	15.7	23.6	34.2	46.0	73.4	78.6
50	5	2.54	48	0.0	0.4	4.2	20.3	40.6	68.8	78.3	83.2
60	6	2.56	48	1.5	8.9	17.1	31.9	47.5	57.8	74.0	80.9
70	7	2.54	54	0.0	3.2	17.8	41.1	57.3	68.6	82.3	86.4
80	8	2.54	46	8.3	15.2	22.1	31.0	42.7	56.6	82.7	89.6
90	9	2.46	46	9.2	20.4	25.5	34.7	41.8	51.1	79.6	87.8
100	10	2.50	47	0.0	2.1	7.8	17.0	27.7	39.7	69.5	81.6
110	11	2.52	49	3.1	10.8	20.0	33.9	47.8	60.0	78.5	84.6
120	12	2.55	48	6.7	13.4	20.9	31.4	43.3	55.2	75.4	83.6
130	13	2.56	55	11.5	16.5	25.2	39.6	54.0	66.2	76.3	89.3
140	14	2.51	58	11.0	22.0	32.4	50.0	66.9	77.9	89.7	92.6
150	15	2.53	49	4.5	11.9	18.7	28.4	38.8	50.0	75.4	84.3
Bottom Elev. 4150.0 ft.											

PROJECT 4.2

SOIL TEST DATA - NEVADA TEST SITE

HOLE NUMBER 7 D

Ground Elevation 4298 ft.	Sample Number	Sp.Gr.	Angle of Int.Fric. (Ø)	Sieve Analysis Cumulative Percent Retained							
				3/8	#4	#10	#20	#40	#60	#140	#200
0											
10	1	2.61	46	1.3	10.5	21.0	29.0	40.1	52.6	72.4	79.0
20	2	2.56	49	2.9	7.2	15.8	25.9	41.7	58.3	82.0	87.8
30	3	2.52	52	0.0	7.5	18.7	29.8	44.8	60.5	86.5	93.1
40	4	2.53	44	6.7	10.8	20.8	30.8	42.5	55.0	78.3	85.8
50	5	2.58	51	6.7	13.3	21.6	31.6	48.3	62.5	81.7	86.7
60	6	2.56	54	0.0	4.0	12.1	23.4	40.3	58.1	79.0	85.5
70	7	2.58	44	0.0	1.4	5.7	11.3	22.7	36.9	65.2	73.8
80	8	2.55	51	1.4	2.7	6.8	16.2	32.4	51.4	79.8	86.5
90	9	2.51	49	1.5	13.5	22.6	31.0	42.1	55.7	79.7	85.7
100	10	2.51	49	0.0	2.3	7.8	16.3	24.8	32.6	54.3	68.2
110	11	2.44	50	9.5	12.7	20.6	27.0	35.0	41.3	72.2	82.6
120	12	2.55	53	2.8	6.0	13.3	26.7	46.7	65.3	84.1	89.4
130	13	2.53	58	0.0	0.0	12.5	40.7	64.1	76.6	87.6	90.7
140	14	2.48	56	2.8	18.3	32.4	50.7	64.8	76.1	87.3	90.1
150	15	2.52	52	4.3	21.4	38.6	50.0	61.5	71.5	87.2	91.4
160	16	2.60	55	15.1	23.2	31.4	47.6	65.2	76.8	89.5	91.8
170	17	2.53	54	7.8	26.6	39.1	48.4	59.4	70.3	86.0	39.1
175	18	2.53	50	0.0	5.8	15.4	26.9	38.5	50.0	73.1	82.7
Bottom Elev. 4123.5 ft.											

SOIL TEST DATA - NEVADA TEST SITE

HOLE NUMBER 8 D

Ground Elevation 4298.0 ft.	Sample Number	Sp.Gr.	Angle of Int.Fric. (Ø)	Sieve Analysis Cumulative Percent Retained							
				3/8	#4	#10	#20	#40	#60	#140	#200
0											
10	1	2.58	42	11.9	17.8	25.0	32.1	36.9	44.0	65.4	75.0
20	2	2.52	55	7.3	14.5	23.6	36.4	54.5	69.1	87.4	91.0
30	3	2.53	55	5.3	10.6	20.0	33.3	49.3	65.3	84.0	88.0
40	4	2.57	47	0.0	4.5	10.7	18.2	28.8	42.4	69.6	81.8
50	5	2.57	51	1.1	2.2	8.9	20.0	33.4	46.8	70.1	76.8
60	6	2.54	53	3.7	7.4	18.5	29.6	43.2	58.0	79.0	85.1
70	7	2.53	54	0.0	3.0	10.4	20.9	34.4	47.8	74.6	82.0
80	8	2.52	52	3.3	11.5	19.7	31.2	42.6	54.1	77.0	87.0
90	9	2.47	49	4.0	9.5	16.2	25.6	36.5	47.3	73.0	81.0
100	10	2.40	53	5.9	8.8	11.8	20.6	30.9	42.6	72.0	82.4
110	11	2.42	47	0.0	3.1	7.7	13.8	20.0	29.2	67.7	80.0
120	12	2.48	56	1.3	5.5	15.1	31.5	50.6	67.1	86.3	90.5
130	13	2.50	57	0.0	6.1	16.9	35.4	52.4	64.6	83.1	87.7
140	14	2.51	55	0.0	15.4	34.6	51.4	65.4	76.9	89.7	92.4
150	15	2.39	53	2.9	10.0	21.4	38.6	58.5	71.4	87.1	91.4
Bottom Elev. 4148.0 ft.											

SOIL TEST DATA - NEVADA TEST SITE

HOLE NUMBER 9 D

Ground Elevation 4297.0 ft.	Sample Number	Sp.Gr.	Angle of Int.Fric. (Ø)	Sieve Analysis Cumulative Percent Retained							
				3/8	#4	#10	#20	#40	#60	#140	#200
0											
10	1	2.57	45	39.2	49.4	59.5	68.4	76.0	82.3	90.0	93.6
20	2	2.56	55	0.0	6.7	13.3	35.6	64.5	82.2	93.4	97.8
30	3	2.52	52	0.0	5.1	18.6	42.4	66.1	81.4	93.2	96.5
40	4	2.49	56	18.3	29.3	39.0	53.7	64.7	75.6	89.0	92.7
50	5	2.54	52	0.0	5.8	12.8	23.3	34.9	47.7	68.6	76.8
60	6	2.57	53	4.0	10.5	19.8	26.3	39.5	51.3	77.6	84.3
70	7	2.47	58	9.1	24.2	34.8	51.5	68.2	80.3	91.0	95.5
80	8		56	0.0	1.6	6.5	16.1	32.3	51.6	74.1	82.2
90	9	2.53	53	12.1	30.3	45.5	56.1	65.1	74.2	89.5	94.0
100	10	2.53	46	0.0	6.1	19.7	30.3	40.9	51.5	74.2	81.8
Bottom Elev. 4197.0 ft.											

SOIL TEST DATA - NEVADA TEST SITE

HOLE NUMBER 10 D

Ground Elevation 4297.0 ft.	Sample Number	Sp.Gr.	Angle of Int.Fric. (ø)	Sieve Analysis Cumulative Percent Retained							
				3/8	#4	#10	#20	#40	#60	#140	#200
0											
10	1	2.58	40	44.0	54.6	60.0	66.6	73.3	80.0	89.2	92.0
20	2	2.58	51	38.1	50.0	47.6	65.2	71.8	77.2	88.2	92.4
30	3		49	0.0	4.2	10.6	23.4	36.2	51.1	74.5	83.0
40	4	2.51	55	0.0	10.9	21.9	37.6	50.0	62.5	78.1	84.4
50	5	2.55	48	0.0	4.7	12.5	26.6	42.2	56.3	74.9	79.6
60	6		57	5.0	21.6	33.4	46.7	60.0	73.3	88.4	91.6
70	7	2.55	47	0.0	4.2	8.5	19.7	32.4	46.5	71.9	78.8
80	8	2.51	52	0.0	1.9	8.9	23.2	35.8	50.0	78.6	85.9
90	9	2.53		0.0	6.7	21.7	40.0	56.7	68.4	83.3	88.4
100	10	2.46	53	3.0	9.0	20.9	34.3	46.3	58.2	79.1	86.6
110	11	2.46		2.9	10.3	22.0	35.2	47.1	57.3	79.4	88.2
120	12	252	47	1.3	5.2	14.3	25.9	37.7	49.4	72.7	80.5
130	13		56	5.8	18.8	33.4	49.3	65.2	76.7	88.5	92.7
140	14	2.61		0.0	9.5	28.4	48.7	65.0	77.0	87.8	92.0
150	15	2.45	57	0.0	6.1	19.5	34.2	47.5	59.7	79.2	85.3
160	16		56	0.0	4.2	16.9	33.8	47.8	60.6	80.3	85.9
170	17	2.49	57	0.0	9.7	32.0	48.7	63.8	73.6	87.5	91.6
175	18		56	3.5	9.2	20.7	41.3	57.4	71.2	87.4	90.7
Bottom Elev. 4122.0 ft.											

SOIL TEST DATA - NEVADA TEST SITE

HOLE NUMBER 11 D

Ground Elevation 4297.0 ft.	Sample Number	Sp.Gr.	Angle of Int.Fric. (Ø)	Sieve Analysis Cumulative Percent Retained							
				3/8	#4	#10	#20	#40	#60	#140	#200
0											
10	1		55	6.2	18.7	34.4	47.9	62.5	72.8	86.5	89.6
20	2		51	0.0	5.1	10.1	17.4	29.7	44.9	72.5	81.1
30	3		50	17.7	23.4	35.5	45.2	58.1	69.4	83.8	88.7
40	4		50	20.7	24.4	34.7	50.6	62.2	72.0	84.1	86.5
50	5	2.55	50	0.0	1.7	6.8	17.0	32.2	44.1	69.6	76.3
60	6	2.55	52	0.0	7.6	15.1	23.6	35.9	50.0	77.4	85.0
70	7		56	4.9	11.0	19.5	31.7	47.6	66.5	87.8	90.3
80	8	2.63	51	0.0	0.0	0.0	1.3	6.7	30.6	65.3	74.7
90	9										
100	10	2.50	46	0.0	1.7	5.2	9.5	19.0	27.6	57.0	67.2
110	11	2.52	54	6.6	13.2	28.3	46.2	64.2	75.5	86.9	90.5
120	12	2.49	52	7.3	12.2	21.1	29.2	41.5	50.5	74.8	82.8
130	13		50	8.8	11.7	23.5	36.8	50.0	64.7	85.2	89.6
140	14	2.54	54	3.2	9.5	23.8	38.2	57.1	71.5	85.7	89.0
150	15	2.52	44	2.9	8.8	17.7	28.0	39.7	51.5	76.5	85.4
Bottom Elev. 4147.0 ft.											

SOIL TEST DATA - NEVADA TEST SITE

HOLE NUMBER 16 D

Ground Elevation 4299.0 ft.	Sample Number	Sp.Gr.	Angle of Int.Fric. (Ø)	Sieve Analysis Cumulative Percent Retained							
				3/8	#4	#10	#20	#40	#60	#140	#200
0											
10	1	2.63	53	0.0	9.2	18.5	29.2	38.5	49.3	69.3	78.4
20	2	2.58	55	1.2	7.9	18.0	33.7	50.6	66.3	84.2	88.7
30	3	2.53		8.0	20.0	38.0	56.0	68.0	77.0	89.0	93.0
40	4	2.53	55	2.1	11.3	25.8	43.3	58.8	71.2	86.6	89.6
50	5	2.54	52	0.0	3.0	10.4	26.9	41.8	53.7	74.6	83.5
60	6	2.56	53	0.0	3.9	10.4	26.0	41.5	55.8	77.8	83.0
70	7		49	0.0	2.7	6.9	21.9	37.0	52.0	74.0	80.8
80	8		50	2.8	6.9	15.3	25.0	36.1	50.0	74.9	83.2
90	9	2.51	49	21.4	30.0	40.0	51.5	62.8	71.4	87.1	92.8
100	10	2.52	50	8.1	16.2	24.3	36.2	46.0	58.1	79.7	85.0
110	11	2.50	43	7.0	12.3	15.8	21.0	29.9	38.6	66.7	79.0
120	12	2.58	53	1.1	5.5	16.5	37.4	55.0	65.9	81.3	85.6
130	13	2.54	51	24.3	32.0	40.8	49.5	59.3	69.0	85.5	90.4
140	14	2.59		5.7	9.1	25.0	51.2	67.0	76.1	86.4	89.8
150	15	2.53	49	1.4	11.4	25.7	42.8	58.6	71.4	85.7	90.0
160	16	2.53	56	11.3	19.4	30.7	45.2	59.7	72.7	88.7	92.0
170	17	2.58	55	0.0	4.7	17.2	40.6	61.0	75.0	89.0	90.7
185	18	2.49	52	8.6	17.2	30.0	47.1	64.3	75.7	87.2	91.4
Bottom Elev. 4114.0 ft.											

[redacted]

PROJECT 4.2

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