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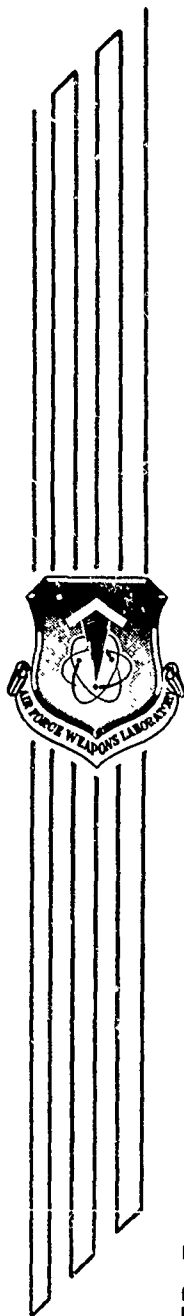
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SCHOONER OBSERVATIONS AND EARLY RESULTS

(Interim Report)

Robert W. Henny

The Eric H. Wang Civil Engineering Research Facility
The University of New Mexico
Albuquerque, New Mexico
Contract F29601-68-C-0009

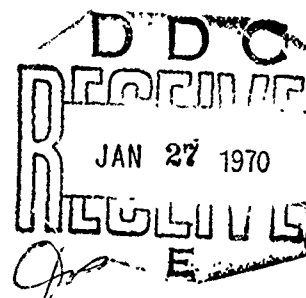


TECHNICAL REPORT NO. AFWL-TR-69-133

October 1969

AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
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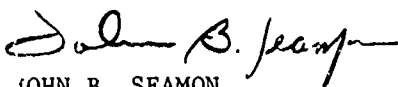
FOREWORD

This report was prepared by the Eric H. Wang Civil Engineering Research Facility, University of New Mexico, Albuquerque, New Mexico, under Contract F29601-68-C-0009. The research was performed under Program Element 61102H, Project 5710, Subtask SA102, and was funded by the Defense Atomic Support Agency (DASA).

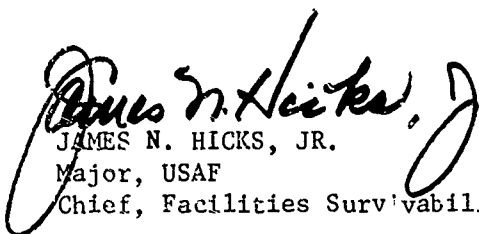
Inclusive dates of research were September 1968 through February 1969. The report was submitted 22 September 1969 by the Air Force Weapons Laboratory Project Officer, Captain John B. Seamon (WLCP).

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This report has been reviewed and is approved.



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ABSTRACT

Project SCHOONER was a 35-KT nuclear cratering Plowshare experiment detonated in a layered tuffaceous medium. This paper briefly summarizes the Air Force Weapons Laboratory (AFWL) technical effort on Project SCHOONER as conducted by the Eric H. Wang Civil Engineering Research Facility (CERF). Early observations, data, and analysis on site, crater, ejecta, missiles, and cloud are presented. The apparent crater was 426 feet in radius and 208 feet in depth. The continuous ejecta limit was asymmetrical, varying between 1,700 and 2,700 feet. Maximum missile range exceeded 6,000 feet.

(Distribution Limitation Statement No. 2)

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SECTION I

INTRODUCTION

The purpose of this report is to briefly summarize the Air Force Weapons Laboratory (AFWL) technical effort on Project SCHOONER as conducted by the Eric H. Wang Civil Engineering Research Facility (CERF) and to provide some early observations, data, and analysis.

All data is preliminary, and analysis of it and subsequent conclusions drawn from it should be treated as tentative and subject to revision.

The data compilation and analysis presented in this report were completed in February 1969. The following is an excerpt from an official Lawrence Radiation Laboratory (LRL) description of Project SCHOONER, dated April 25, 1969.

Project SCHOONER was a nuclear experiment in a layered tuffaceous medium executed as a part of the Plowshare program for development of nuclear excavation. SCHOONER was detonated on December 8, 1968, at approximately 0800:00.149.6 (PST), 1600:00.149.6 (GMT), in area 20, Nevada Test Site (NTS). The resultant yield was 35 ± 5 KT. The emplacement hole was U20u at geodetic coordinates:

Longitude: W 116° 33' 57.1419"

Latitude: N 37° 20' 36.3187"

Surface Ground Zero (GZ) was 5,562.4 feet mean sea level (MSL); emplacement depth (to the working point) was 108.1 meters (355 feet).

Reference 1 should be consulted for pre-shot information including geology, material properties, device design, radiation, and predictions.

SECTION II

SCHOONER OBJECTIVES

The primary objective of Project SCHOONER was to investigate the physical parameters which affect cratering at low and low-intermediate yields (ref. 2). The SCHOONER technical program was divided into six general areas of investigation.

- (1) Radiological Effects Measurements
- (2) Cloud and Surface Motion Measurements
- (3) Surface Effects Instrumentation
- (4) Airblast Measurements
- (5) Crater Measurements
- (6) Other Programs

Individual experimental plans in each of these general areas are documented in reference 3.

AFWL-CERF participation in SCHOONER was approved by Hq. USAF, AEC/DPNE, and LRL/K-Division as a noninterference add-on technical program. The AFWL technical program was submitted during September 1968 and subsequently revised in October 1968.

The primary objective of the AFWL-CERF technical program was the study of the Project SCHOONER site and crater and the resulting ejecta and missile population (ref. 4). Specific objectives were

- (1) Site: To investigate, through pre-shot and post-shot studies, the SCHOONER Test Site and to perform pertinent pre-shot and post-shot material properties tests.
- (2) Crater: To perform apparent, true, and volumetric crater measurements as a function of azimuthal bearing.
- (3) Ejecta: To determine the mass distribution, size distribution, thickness, areal density, material properties, and other pertinent characteristics of ejecta as a function of radial distance and azimuthal bearing.
- (4) Missiles: To determine the location and weight of all natural and artificial missiles and to study the areal density, specific area, size distribution, maximum range, and the specific characteristics including material properties of the missiles as a function of radial distance and azimuthal bearing.

- (5) Cloud: To determine cloud properties as a function of time and to study discrete missiles and ejecta streams falling out of the cloud.

It became apparent that previously used field techniques were not adequate to sufficiently measure and analyze the crater area and the ejecta and missile population resulting from large cratering events like SCHOONER. Therefore, early in the program, a second objective was instituted--to develop photographic techniques for the measurement and analysis of the crater area and the ejecta and missile population.

SECTION III

LOCATION AND TOPOGRAPHY

The SCHOONER Test Site is located at area 20 in the far northwest corner of the Nevada Test Site. Figures 1 and 2 give the location. The emplacement hole U20u was established at Nevada State Coordinates (N944,009; E529,300) with an approximate elevation of 5,562 feet above MSL. The site is located in the center of a relatively flat portion of Pahute Mesa, having a relief of less than 40 feet within 1,500 feet of Ground Zero. Figure 3 provides two views of the SCHOONER site.

SCHOONER Site Location, Fig. 2

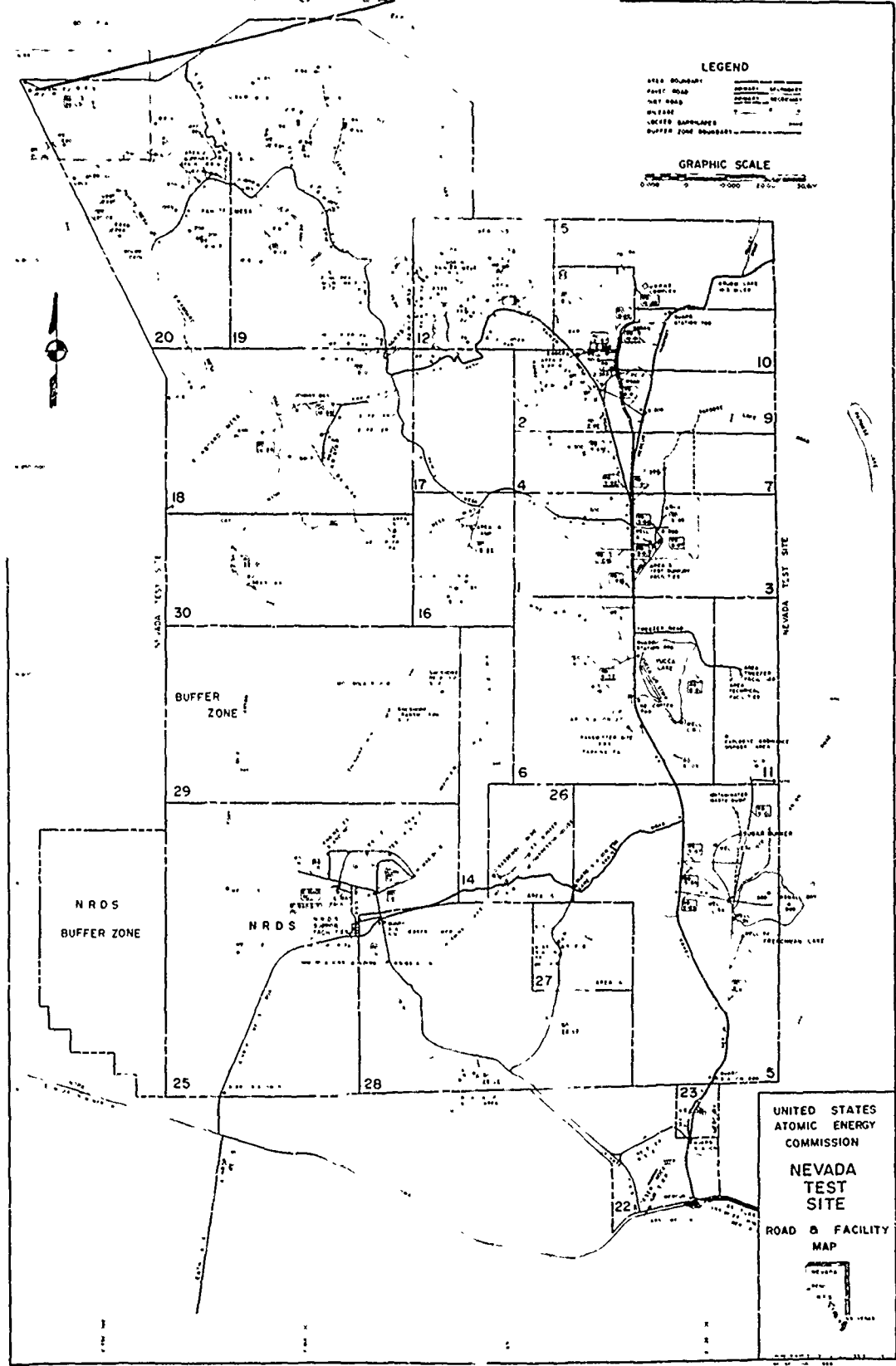


Figure 1. Index Map of Nevada Test Site Showing Area Boundaries

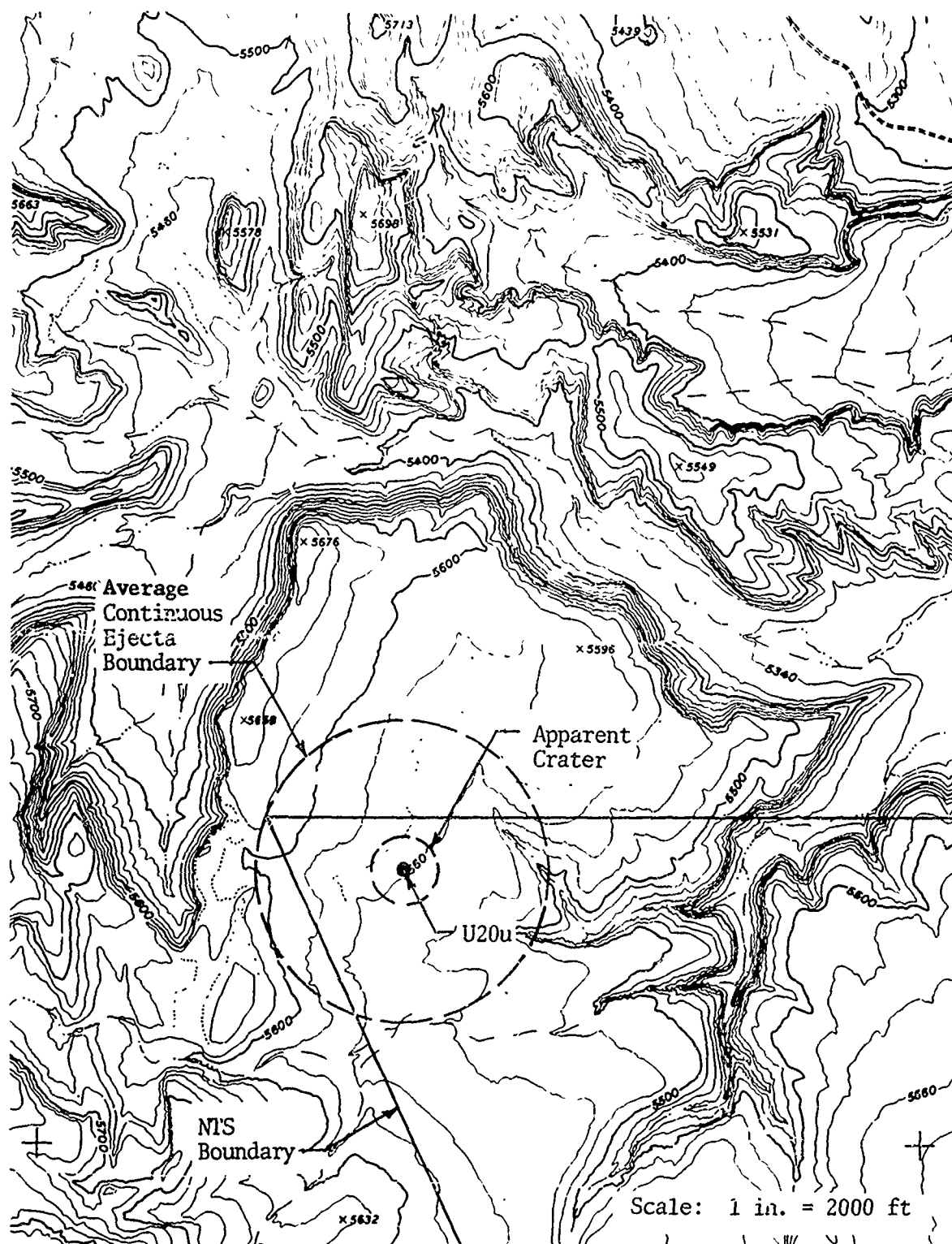


Figure 2. Topographic Map of SCHOONER Test Site



Several Miles South of GZ



Along N35°W Radial at 1000 Feet

Figure 3. SCHOONER Test Site, View of Ground Zero Area

SECTION IV

GEOLOGY

The stratigraphy consists of a layered sequence of welded and bedded tuffs and ash flows in nearly horizontal position overlaid by 1 to 4 feet of soil cover. Figure 4 presents the stratigraphic correlation between AFWL satellite holes and other nearby holes, as determined by the U.S. Geologic Survey (ref. 5). Table I presents the lithology of the core obtained from AFWL satellite hole 2.

The water table at the SCHOONER Test Site was located between 800 and 1,000 feet below the ground surface. Two predominant, nearly vertical dipping joint sets were observed: N5°E and S85°E.

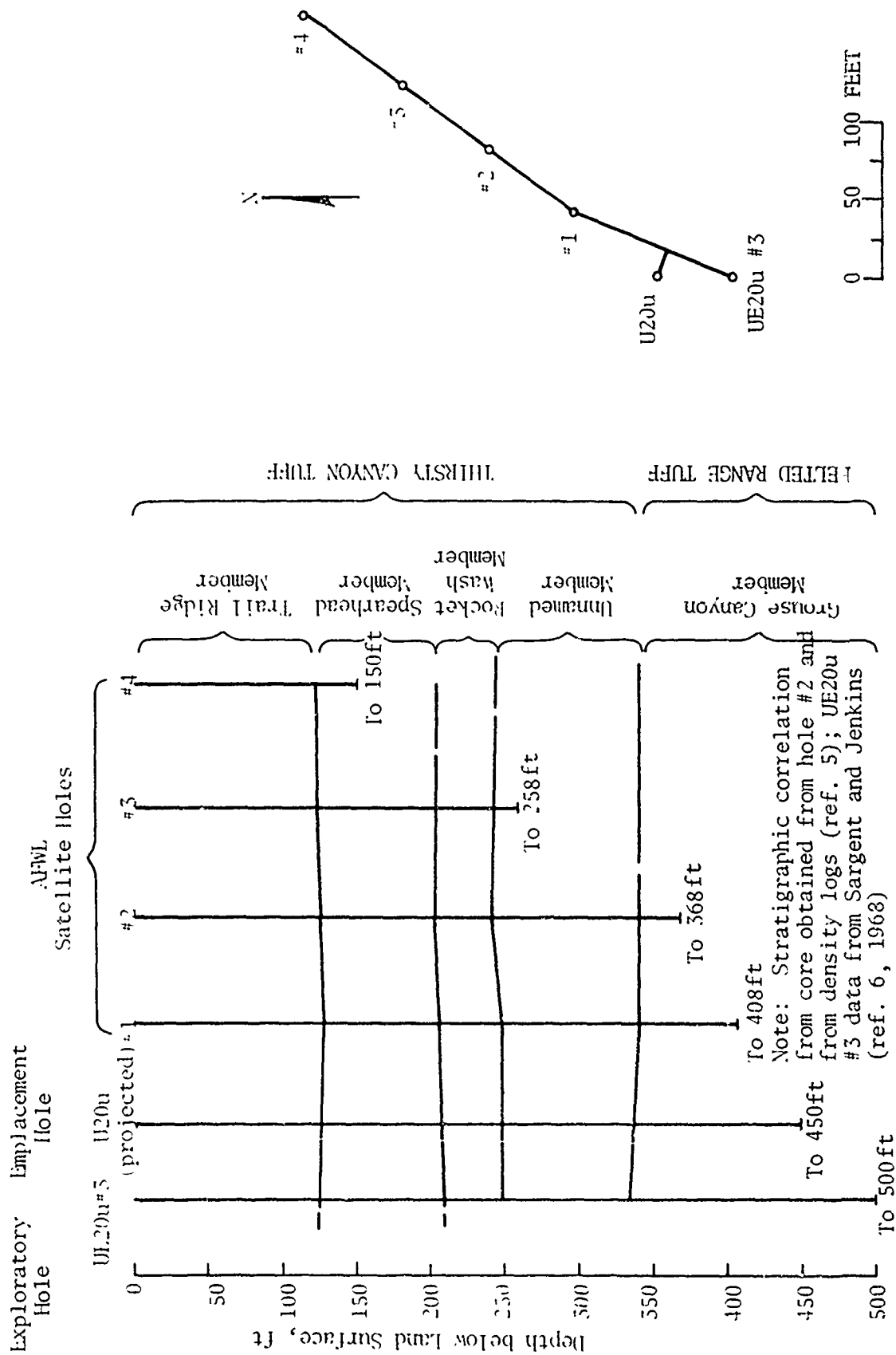


Figure 4. Stratigraphic Section at SGOONER Ground Zero Area

Table I
LITHOLOGY OF CORE FROM AFWL SATELLITE HOLE 2

Material	Thickness, ft	Depth, ft
THIRSTY CANYON TUFF		
Trail Ridge Member:		
Ash-flow tuff, light to dark gray, welded, dense, phenocryst of feldspar, and a few fragments of rhyolite	98	98
Ash-flow tuff, medium purplish-gray, welded, dense, phenocrysts of feldspar, and a few fragments of rhyolite and dark gray pumice, horizontal vugs of devitrified pumice as much as 3 inches in length, partings 1 to 3 inches apart along vugs	12	110
Ash-flow tuff, black, welded, dense, lithic-rich (mostly rhyolite), a few horizontal vugs less than 0.5 inch long	5	115
Ash-flow tuff, light greenish-gray, moderately welded, phenocrysts of feldspar, lithic-rich	9	124
Spearhead Member:		
Sediment, tuffaceous, light yellow to light reddish-brown, lithic-rich (mostly pumice), friable to consolidated (moderately welded)	11	135
Ash-flow tuff, dark gray, moderately welded, phenocrysts of feldspar, a few rock fragments of rhyolite and pumice, upper 5 feet of unit very fine-grained	13	148
Same as above, except nonwelded and with horizontally oriented vugs up to 1 inch in length	36	184
Ash-flow tuff, light to dark gray, moderately to densely welded, lower 2 feet argillized	18	202
Rocket Wash Member:		
Ash-flow tuff, very light gray, nonwelded to moderately welded, very fine-grained, few fragments of pumice, light reddish-brown from 237 to 242 feet, argillized	40	242

Table I (Concl'd)

Material	Thickness, ft	Depth, ft
THIRSTY CANYON TUFF		
Unnamed Member:		
Sediment, tuffaceous, light gray to light grayish-brown, friable, extremely friable from 261 to 272 feet, mostly pumice fragments, argillized	30	272
Sediment, tuffaceous, buff, friable to semi-consolidated, some fragments of pumice	25	297
Sediments, pumiceous, very light gray to buff, friable, lower 7 feet argillized	17	314
Ash-flow tuff, medium brown, welded, a few phenocrysts of feldspar and rock fragments	12	326
Sediment, pumiceous, light-gray, friable, lower 4 feet argillized	13	339
BELTED RANGE TUFF		
Grouse Canyon Member:		
Ash-flow tuff, light greenish-gray to dark gray, welded, dense, horizontally oriented collapsed pumice fragments, black, 0.25 to 3 inches in length, pumice partly devitrified with vugs containing feldspar and quartz phenocrysts	29	368

Note: From reference 5.

SECTION V

SUMMARY OF PERFORMED TASKS AND STATUS OF RECOVERY AND ANALYSIS

AFWL-CERF tasks were accomplished in accordance with the technical program (ref. 4) without major exception. Figure 5 shows the SCHOONER Test Site during October; tar-oil strips, drill holes, grout trench, device tower, etc. can be seen. Following is a synopsis of the principal tasks performed in areas of objectives.

1. Site.

The pre-shot geological investigation of the SCHOONER Test Site included a review of the limited previous work followed by a general reconnaissance of the area including investigation of the exposures along the mesa walls and in several stream cuts in the proximity of Ground Zero. Joint studies were performed at three locations.

Four 6-3/4-inch-diameter holes were drilled along the N35E radial at 70, 140, 210, and 290 feet. Drilling, coring, and geophysical logging operations were supervised by a three-man U.S. Geological Survey team under contract to AFWL and directed by CERF. Reference 5 is the report documenting their findings.

Drill cuttings were obtained from hole 1; hole 2 was continually cored. Table II presents pertinent drill hole data together with geophysical logs obtained. Cuttings and core were logged and examined in the field; table I presents a generalized stratigraphic section obtained from the four AFWL satellite holes. Selected portions of the core were wrapped for future material properties tests. The core is presently stored at CERF awaiting analysis.

A seismic refraction survey was conducted in the northeast quadrant along five radials from Ground Zero to 300 feet; results are being analyzed.

Figure 6 presents selected photographs of the pre-shot ground surface.

2. Crater.

Pre-shot, post-shot, and resulting isopach maps were prepared from aerial stereophotographs by American Aerial Surveys for the U.S. Army Nuclear Cratering Group. The quantity and extent of ejecta necessitated using a larger scale than originally planned (1 in. = 40 ft). The new scale is 1 inch equals 100 feet with a contour interval of 5 feet.



Scale:
1 in. = 400 ft

Figure 5. SCHCONER Pre-shot Aerial View

Table II

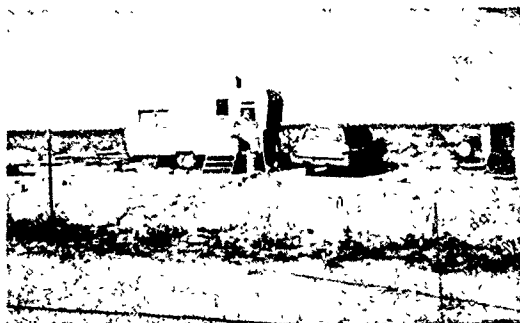
DRILL HOLE AND GEOPHYSICAL LOG DATA

Hole No.	Coordinate	Distance from GZ, ft	Hole Diameter, in.	Tot. Depth, ft	Drill Fluid	Core	Logs						Comments
							Directional	Caliper	3D*	CVL*	Density, γ - γ	Gamma Neutron, γ - γ	
1	N944, 067 E529, 340	70	6-3/4	408	Davis Mix	--	✓	--	--	✓	--	--	Drill cuttings obtained
2	N944, 124 E529, 380	140	6-3/4	368	Davis Mix	✓	✓	✓	✓	✓	✓	✓	Hole slumped; required re-drilling from 150 ft
3	N944, 181 E529, 420	210	6-3/4	258	Air	--	✓	--	--	✓	--	--	No drill cuttings
4	N944, 247 E529, 467	290	6-3/4	150	Air	--	✓	✓	✓	✓	✓	--	No drill cuttings

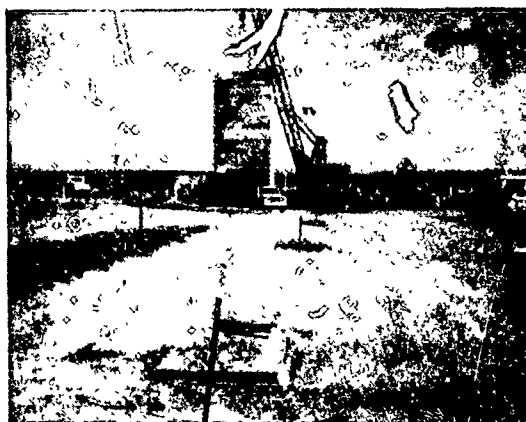
* Logs run at 100-foot intervals during drilling; all logs (3D and CVL repeated) run on completed hole. 3D and CVL logs were attempted without success because of inability to retain sufficient drilling fluid.

--No data.

✓ Data.



AFWL/CERF Trailer



Device Tower



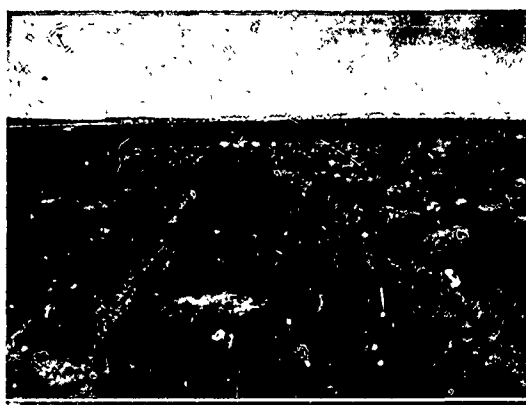
Ground Zero and Flare Strip



Typical Ground Surface



View toward GZ
(N80E, 2100 ft)



View toward GZ along Tar-Oil Strip
(N80E, 1200 ft)

Figure 6. Selected Photographs of Pre-shot Ground Surface

AFWL-CERF supplemented this effort by establishing a high-resolution aerial photo test area 300 feet by 1,200 feet centered on N35E radial. Within this area each missile greater than 0.5 foot would be located, and its size and weight determined by stereographic methods. A detailed field survey was planned to determine the effectiveness of this technique. The control panels were completely buried by ejecta and will require reestablishment before the photography.

3. Ejecta.

Three radial and three concentric tar-oil strips 10 feet wide by 1/2 inch thick were emplaced before the shot for the purpose of defining original ground surface and for providing an ejecta collection and trenching surface. For collection of ejecta fines, eighty-five 3-foot by 3-foot canvas tarps and two hundred forty-seven 1-foot by 1-foot tupperware trays were set out in a geometric pattern before the shot. Figures 7 and 8 give the locations.

To date fifty trays and tarps (locations beyond 1,500 feet) have been located and covered; twenty of them have been photographed, recovered, and stored. Figure 9 presents selected pre-shot photographs of ejecta trays and tarps.

4. Missiles.

While the resolution of the acquired aerial stereophotographs is sufficient for crater and ejecta analysis, it is not sufficient for identifying small discrete missiles (~1/2 pound). A new set of aerial photographs is required.

The four AFWL drill holes were backfilled with a color-coded grout; a cross-sectional view is provided in figure 10. The grout backfill for each one-half hole consisted of a single identifying color matrix within which a different bead-rock combination was placed in 10-foot sections. A surface strip of color-coded grout 2 feet by 6 inches by 347 feet was located along the drill hole radial; and the color code was changed every 10 feet. There has been no attempt to locate any of the grout to date. The planned color photography of the high-resolution test-photo area for the purpose of identifying ejected color-coded grout was canceled because of the extensive ejecta depths.

Figure 11 presents selected photographs of the grouting.

5. Cloud.

The detonation was photographed from a number of aircraft and land-based camera stations. The purpose of this photography was to document the mound growth and the cloud, and it was directed by LRL. Immediately before the event, AFWL

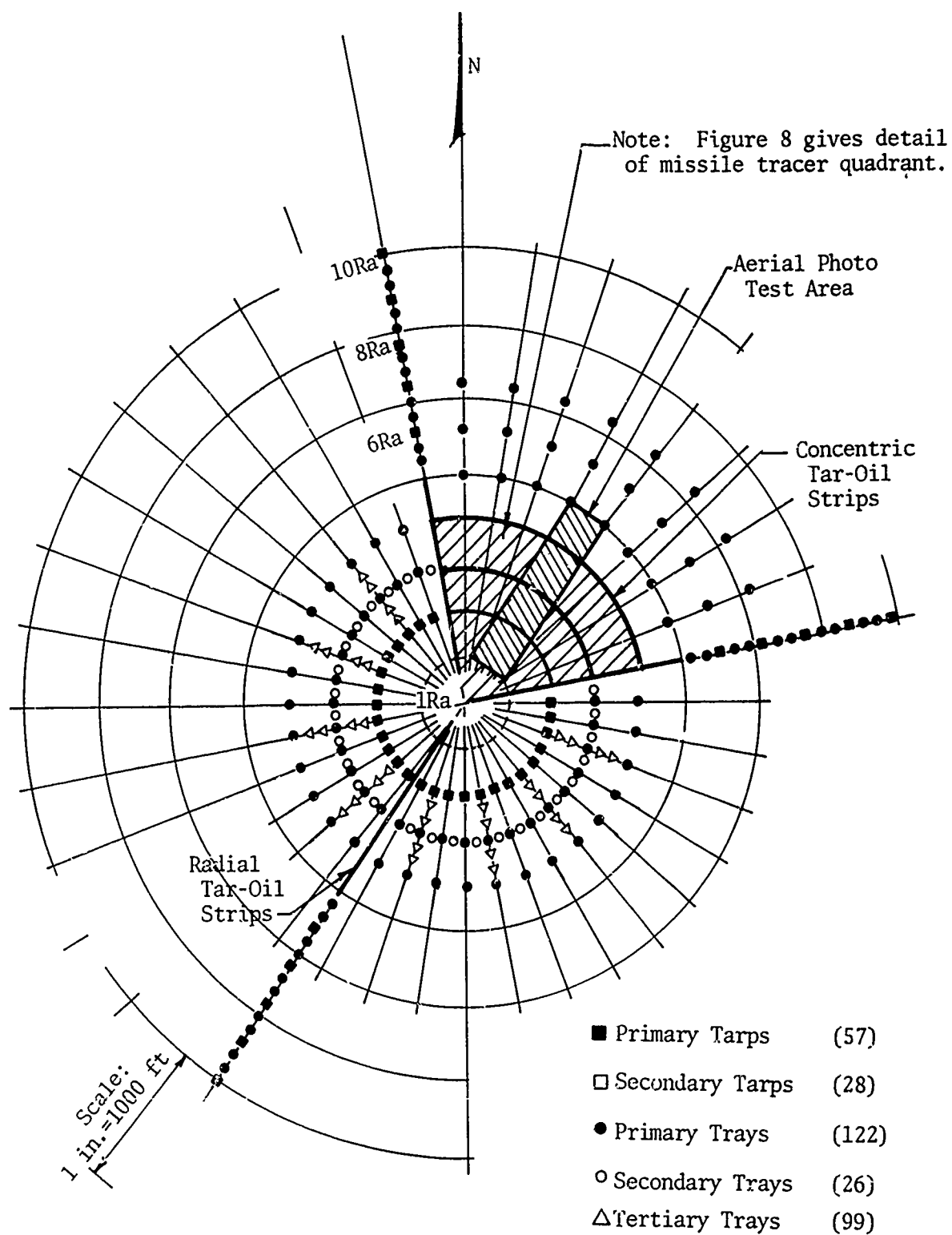


Figure 7. Ejecta Strip and Pad Layout

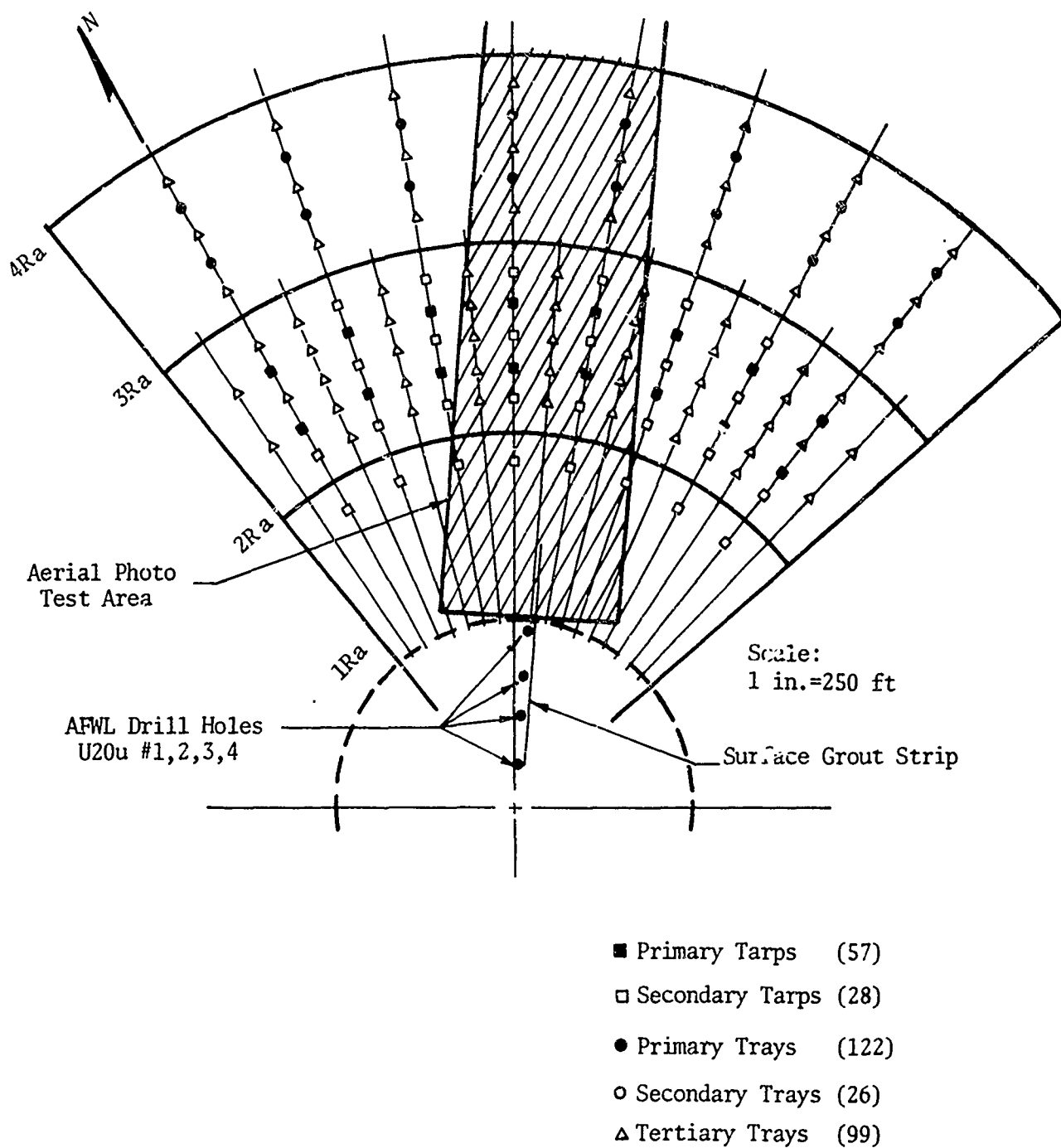


Figure 8. Detail of Missile Tracer Quadrant



Canvas Tarp



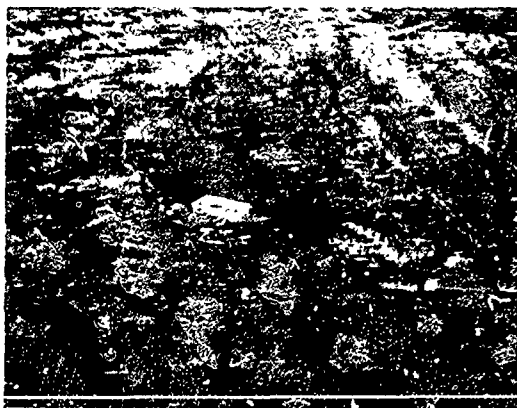
Canvas Tarp



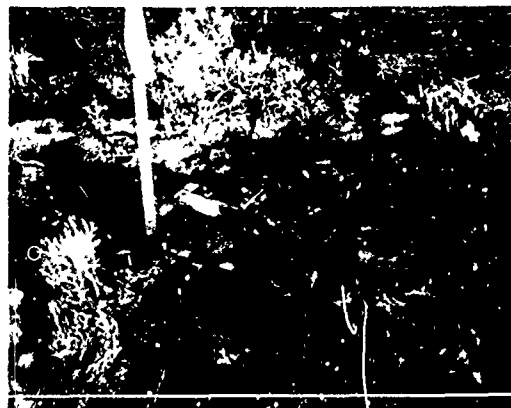
Primary Tupperware Tray



Ejecta Trays in Field



Tertiary Tupperware Tray



Aerial Photographic Marker

Figure 9. Selected Pre-shot Photographs of Ejecta Trays and Tarps

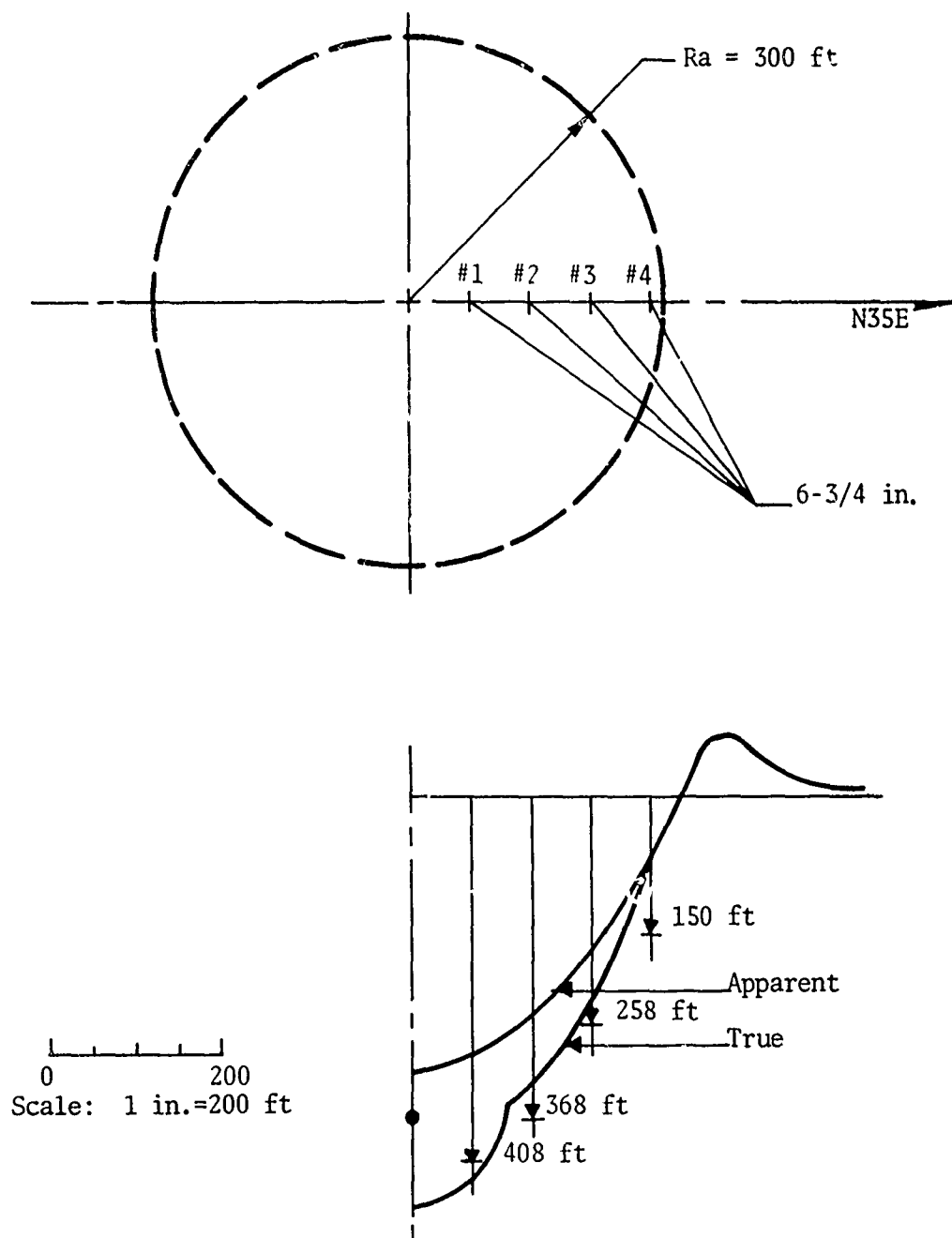
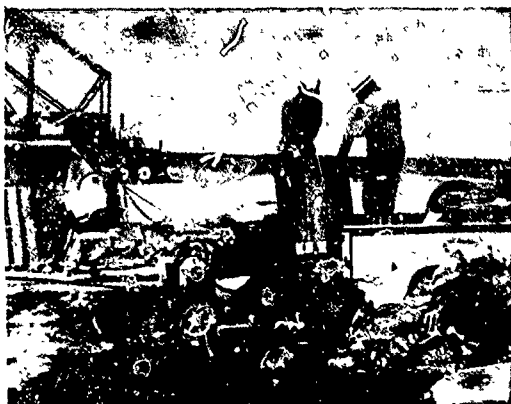


Figure 10. Drill Hole Layout



Mixing Grout



Pumping Grout



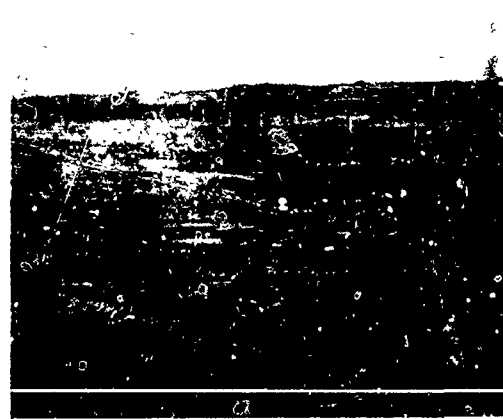
Plumbing Hole



Pouring Grout in Trench



Grouting Completed



Drill Hole Area

Figure 11. Selected Photographs of Grouting

supplemented the effort by contracting EG & G to photograph the transient ejecta at the best resolution possible with the equipment available.

Two movie cameras (operating at 500 fps and 1,000 fps) were mounted in an NC-135 orbiting Ground Zero on a 10-mile radius. Resolution of missiles appears to be on the order of 5 to 10 feet. The field of view, however, was filled by the fireball and a cloud within a few seconds; thus usable data was acquired for only a few hundred frames and at early times. Some land-and aircraft-based movies have been taken from which good trajectory data can be obtained. A trajectory analysis study is currently under way.

SECTION VI

EVENT DATA AND OBSERVATIONS

SCHOONER was detonated on December 8, 1968, at approximately 0800:00 (PST), 1600:00 (GMT). Listed below are the best data available at this time.

(1) Depth of Burst	(DOB):	355 ft
(2) Yield	(W):	35 $\pm$ 5 KT
(3) Apparent Crater Radius	(R _a):	426 ft
(4) Apparent Crater Depth	(D _a):	208 ft
(5) Apparent Lip Height	(H _{al}):	44 ft
(6) Apparent Lip Crest Radius	(R _{al}):	483 ft
(7) Continuous Ejecta Limit	(R _{eb}):	1,700 to 2,700 ft
(8) Maximum Missile Range	(R _m):	6,000+ ft
(9) Maximum Missile Size	(M _m):	30 x 20 x 20 ft
(10) Apparent Crater Volume	(V _a):	2,282,870 yd ³
(11) Apparent Lip Volume	(V _{al}):	2,745,330 yd ³

At shot time the wind was from the southwest. A thin cloud cover existed at an altitude in excess of 5,000 feet above Ground Zero, resulting in adequate visibility but not optimum lighting for photography. Figure 12 provides a time sequence set of photographs of SCHOONER detonation.

A CERF official was aboard the official photography aircraft (CH-3 helicopter) observing at a slant range of 6 miles to the south and west of Ground Zero from -0015 to +0030. Two additional hours of flight time were logged over the crater and vicinity during shot day for the post-shot photography and observation.

The following pertinent observations were made:

- (1) Flare initiation and detonation appeared to be successful.
- (2) Mound buildup was symmetrical with venting occurring approximately at the top center.
- (3) Ejecta exhibited strong vertical movement indicating a significant gas-boost phase.
- (4) Extensive fireball or illuminated gas ball was observed.
- (5) Most discrete missiles exiting from the fireball were incandescent; some were seen to impact when still in an incandescent condition.
- (6) Ejecta and missiles could be followed throughout various phases of these trajectories. Many discrete missiles impacted in front of the developing base surge.

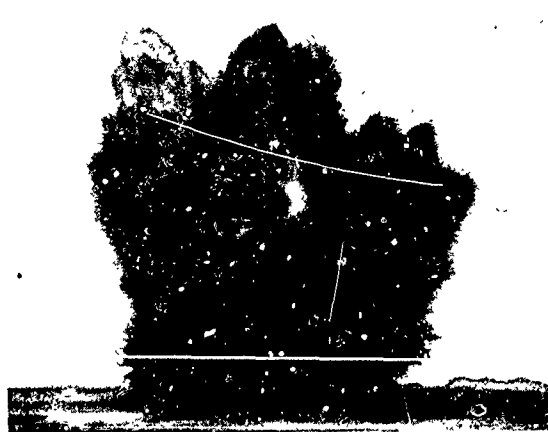
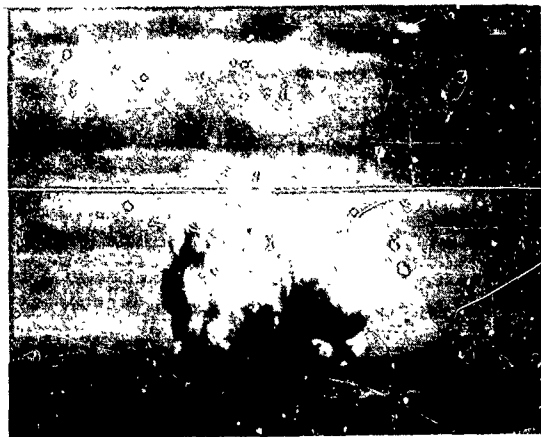


Figure 12. SCHOONER Time Sequence

- (7) Base surge developed and reached 2,000 to 4,000 feet south of Ground Zero and exceeded 1,500 feet in height.
- (8) Ejecta was deposited in an asymmetrical pattern with large areas of fine material evident.
- (9) Many missiles exceeding 1,000 cubic feet were observed.
- (10) Early post-shot slumping in the crater was observed.
- (11) Maximum missile range exceeded 6,000 feet.
- (12) Many secondary craters were formed.
- (13) The cloud over the crater area was largely dissipated by H + 1.

SECTION VII

RESULTS AND DISCUSSION

Figures 13, 14, and 15 are the pre-shot, post-shot, and resulting isopach maps prepared from aerial stereophotographs by American Aerial Surveys for the U.S. Army Nuclear Cratering Group. Figure 13 shows the AFWL tar-oil strips. Note that the zero contour line on the isopach map (fig. 15) should not necessarily be interpreted as the limit of continuous ejecta.

Figure 16 is an overhead photograph taken early after the shot. Base surge boundary on the upwind side can be delineated. The crater is relatively circular and the outer limit of ejecta appears to be relatively symmetrical. Figure 17 is an eastward-facing oblique view showing the slumped sides and flat bottom of the crater. Figure 18 is an overhead closeup of the crater area.

As of this date, two field reconnaissance trips to the SCHOONER site have been made by AFWL-CERF. The first trip in early January was for the purpose of correlating certain features delineated from aerial photographs and determining the logistics necessary for recovery of the ejecta trays and tarps. The second trip was made in February to collect the ejecta trays and tarps. The following early results are based upon the observation of the event, the aerial photographs, and the two field excursions.

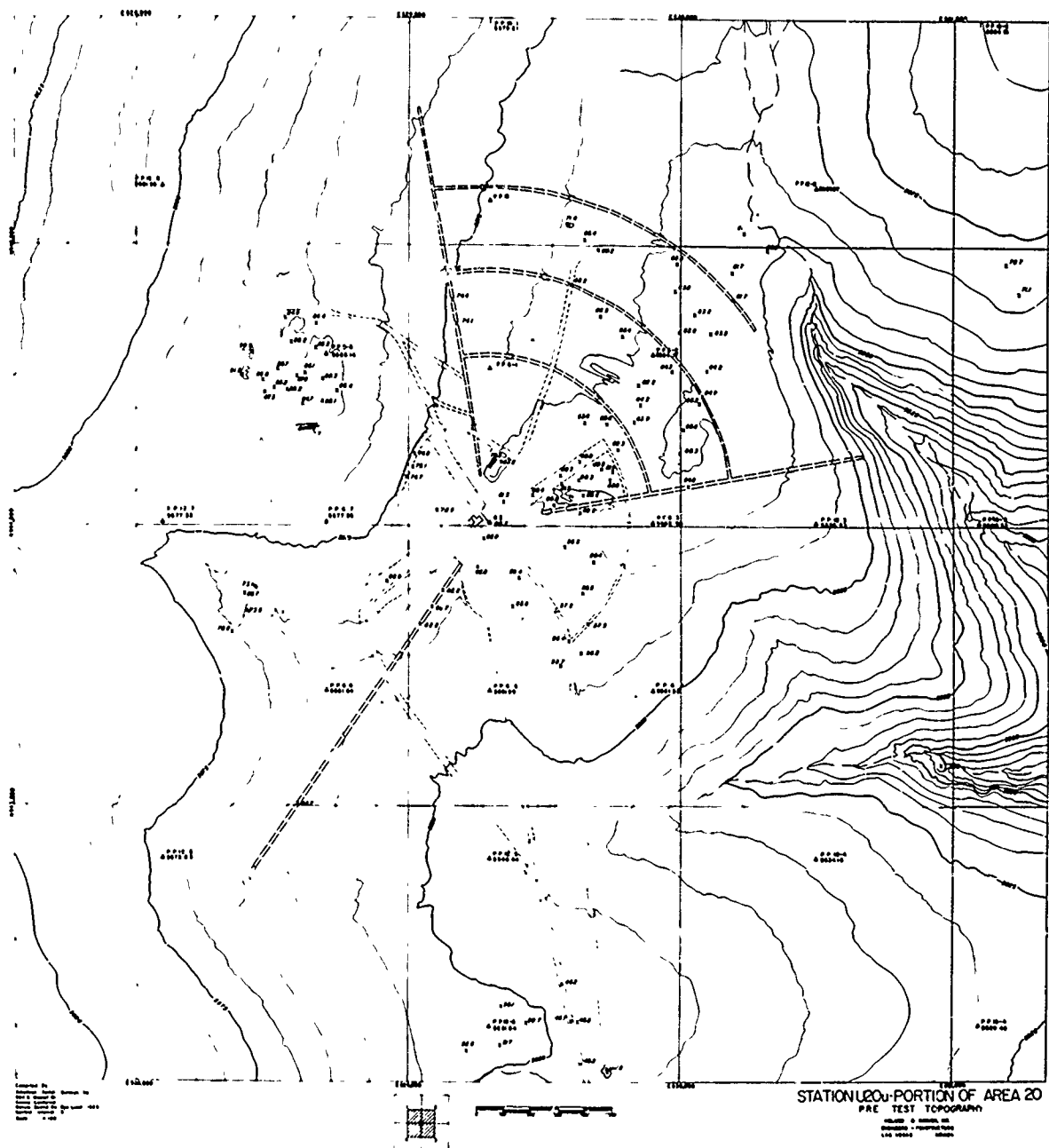
1. Crater.

Figure 19 shows three profiles through the apparent crater measured from the isopach map (fig. 15).

2. Ejecta.

In general, the ejecta population can only be termed as immense; the volume and extent appear to be twice that predicted. Walking within 2,000 feet of Ground Zero is difficult; missiles on the order of 10 cubic feet are plentiful out to 3,000 feet. The base surge deposit southwest of Ground Zero was found to be a few inches deep at 3,000 feet. This base surge deposit had been significantly washed and/or blown away between the first and second field excursions.

Figure 20 shows the apparent crater and the continuous ejecta boundary as traced from aerial photographs. The tar-oil strips and the outermost ejecta pads are superimposed. When they were checked in the field, it was found that the continuous ejecta boundary usually extended from 500 to 1,000 feet beyond the point



Scale:
1 in. = 600 ft

Figure 13. SCHOONER Pre-shot Topographic Map

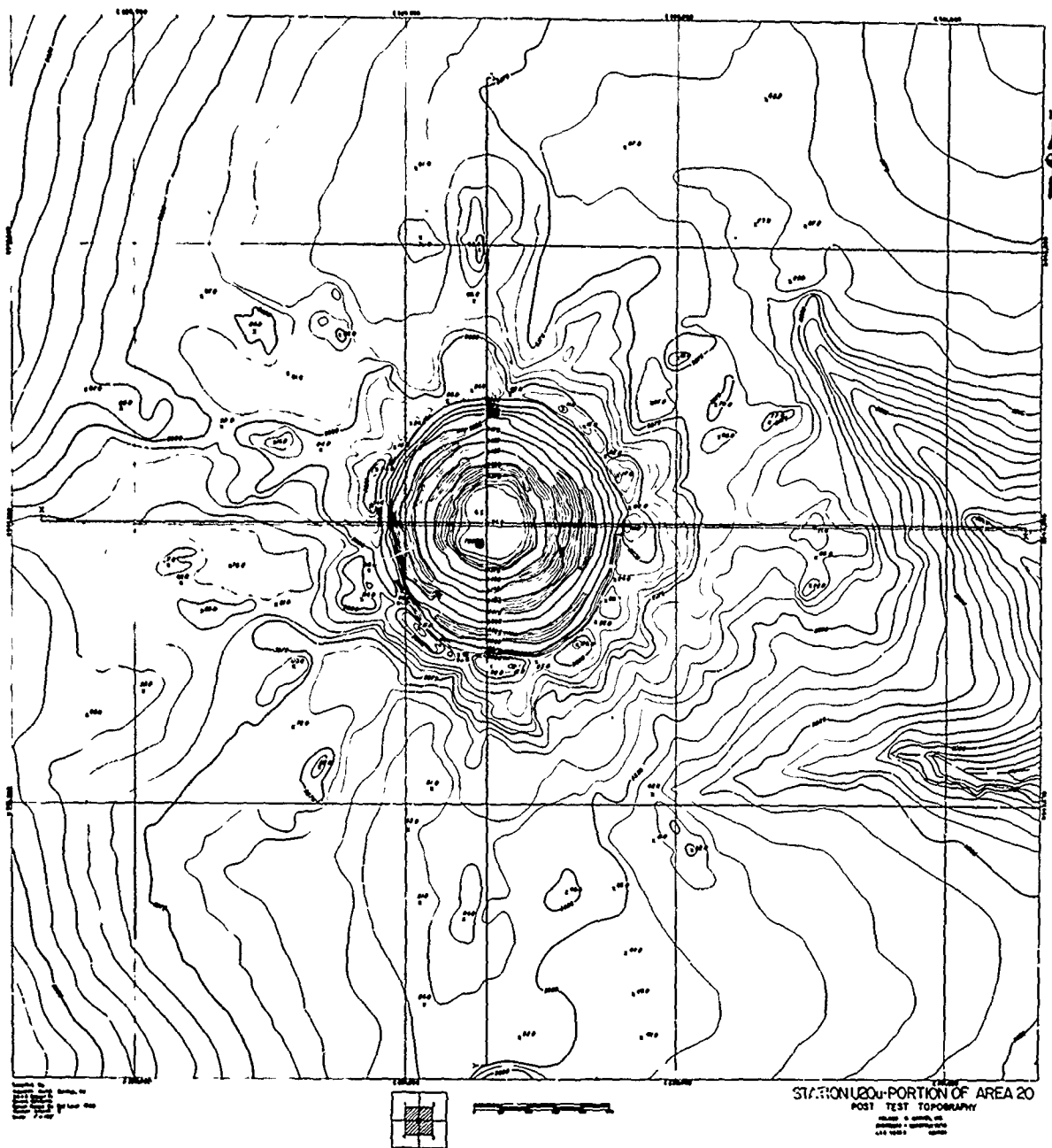
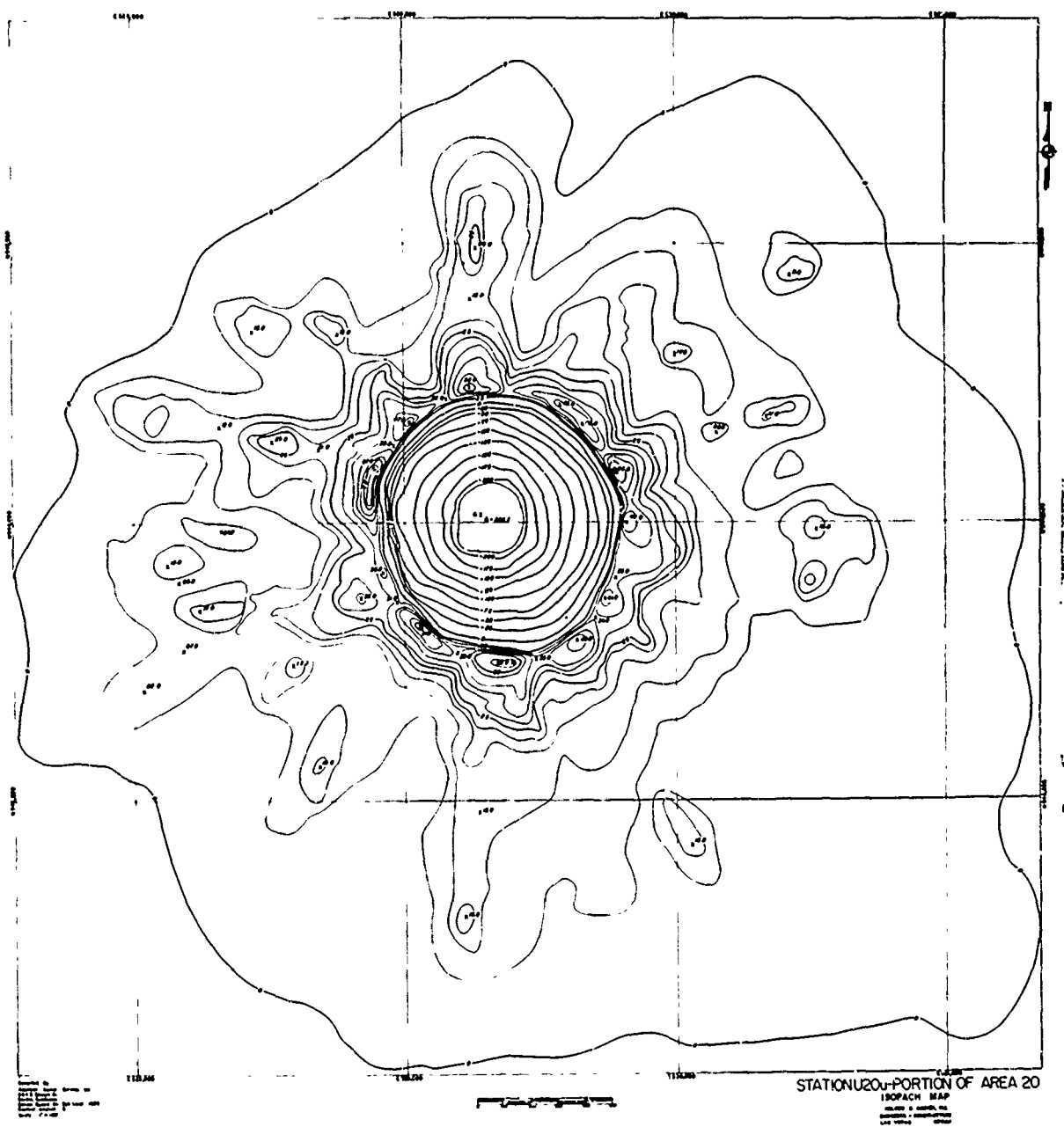
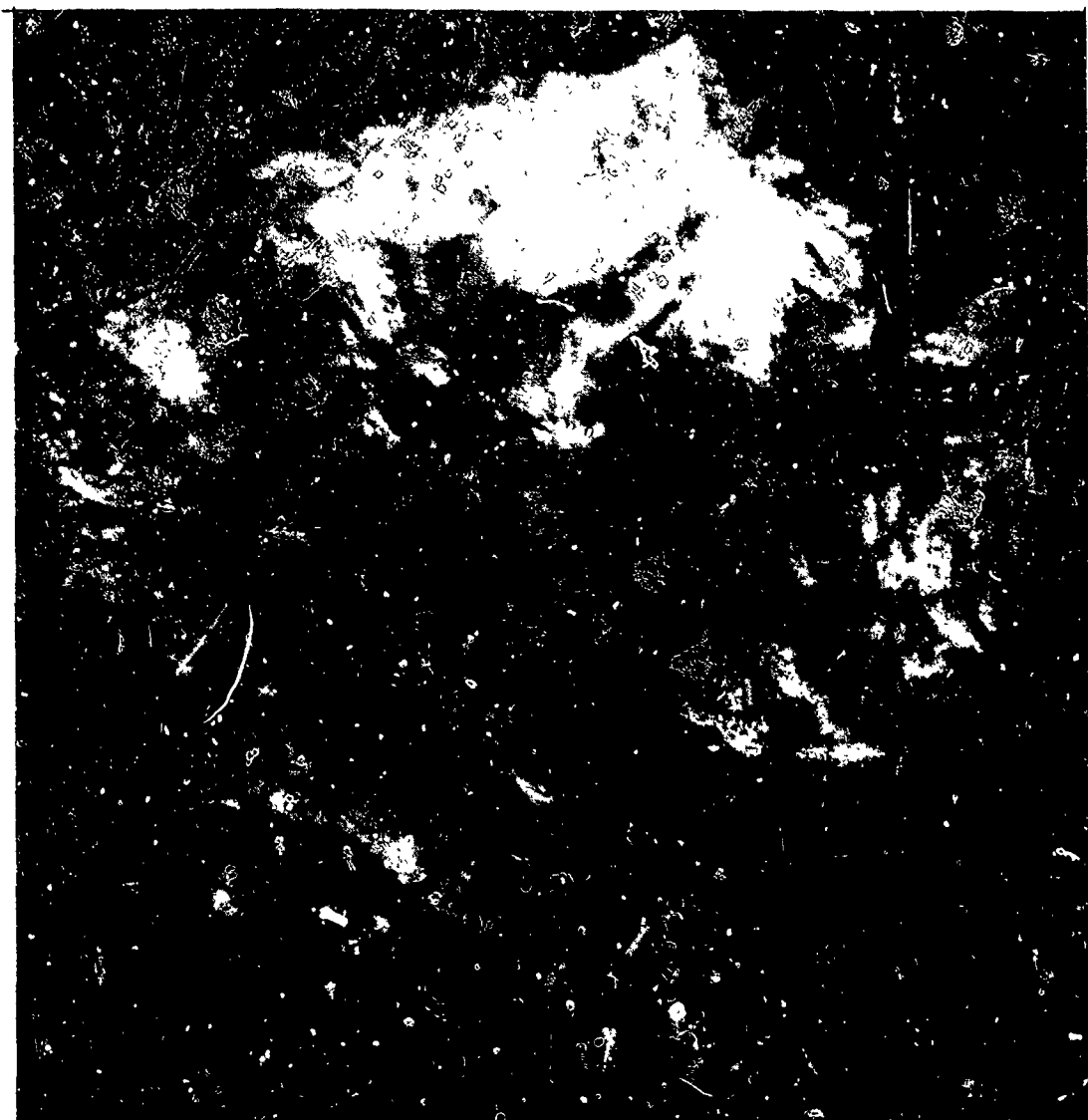


Figure 14. SCHOONER Post-shot Topographic Map



Scale:
1 in. = 600 ft

Figure 15. SCHOONER Isopach Map



Scale:
1 in. = 2000 ft

Figure 16. Overhead View of SCHOONER

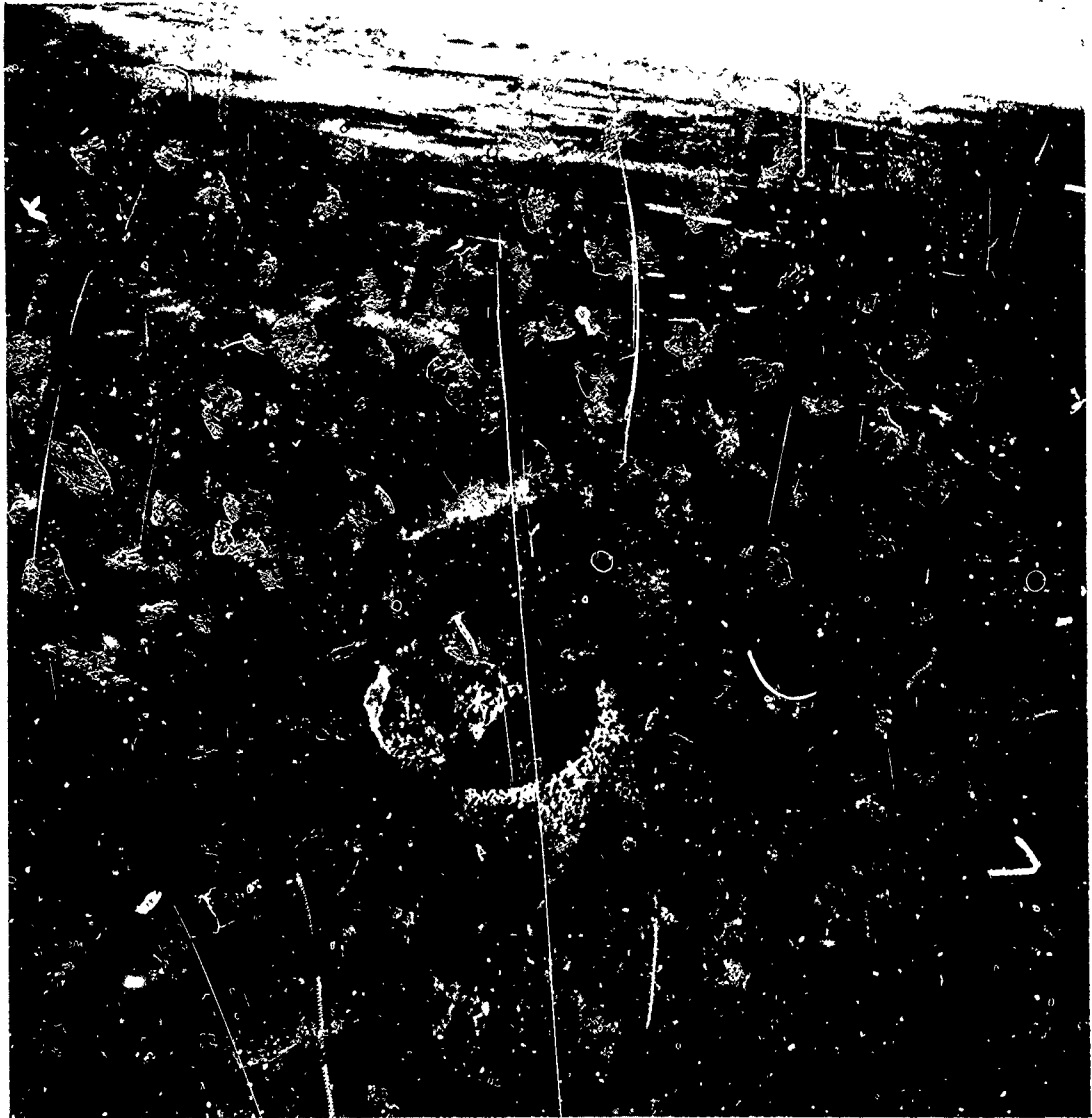


Figure 17. Oblique View of SCHOONER toward East



Scale:
1 in. = 1000 ft

Figure 18. Overhead Closeup of SCHOONER

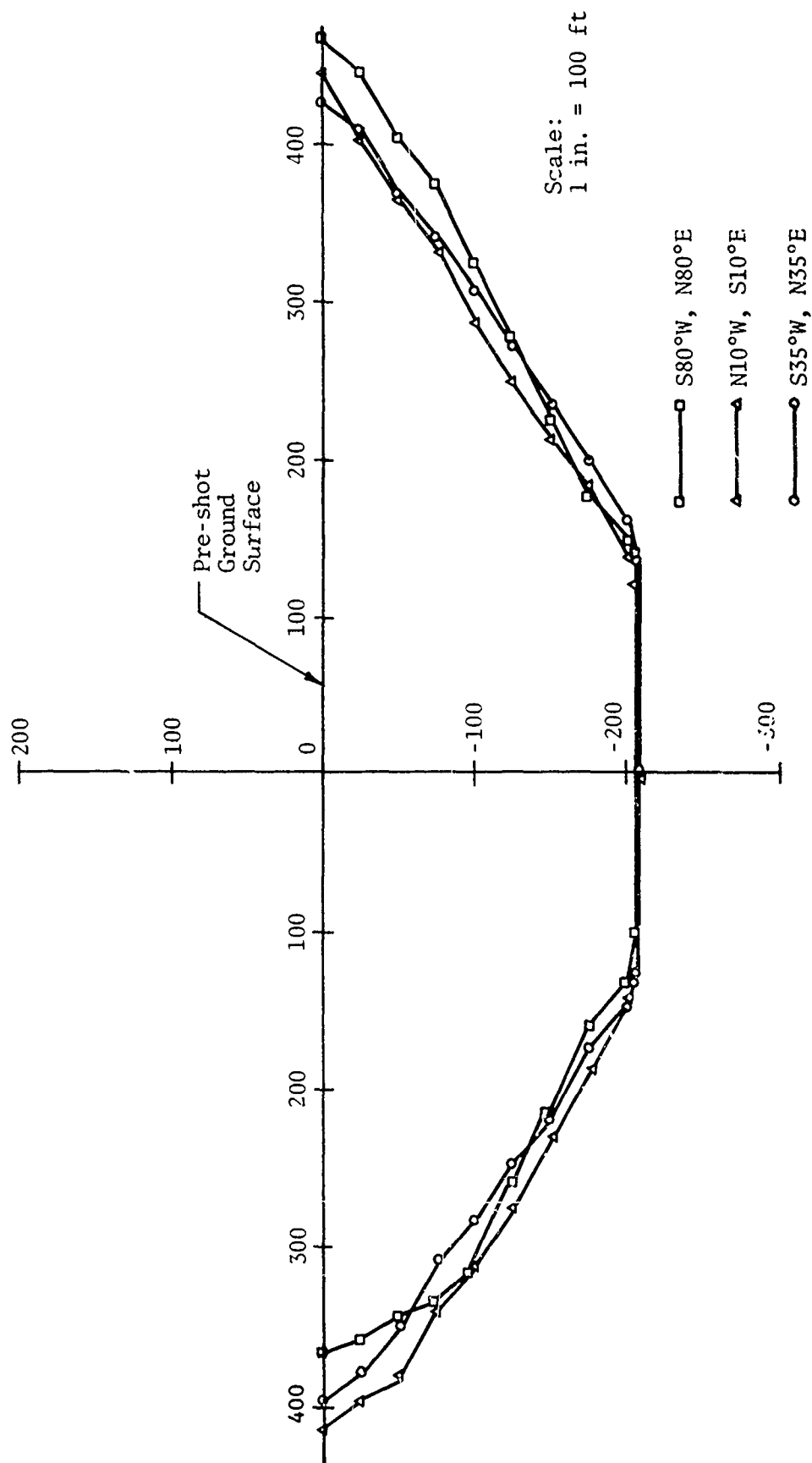


Figure 19. SCHOONER Apparent Crater Cross Sections

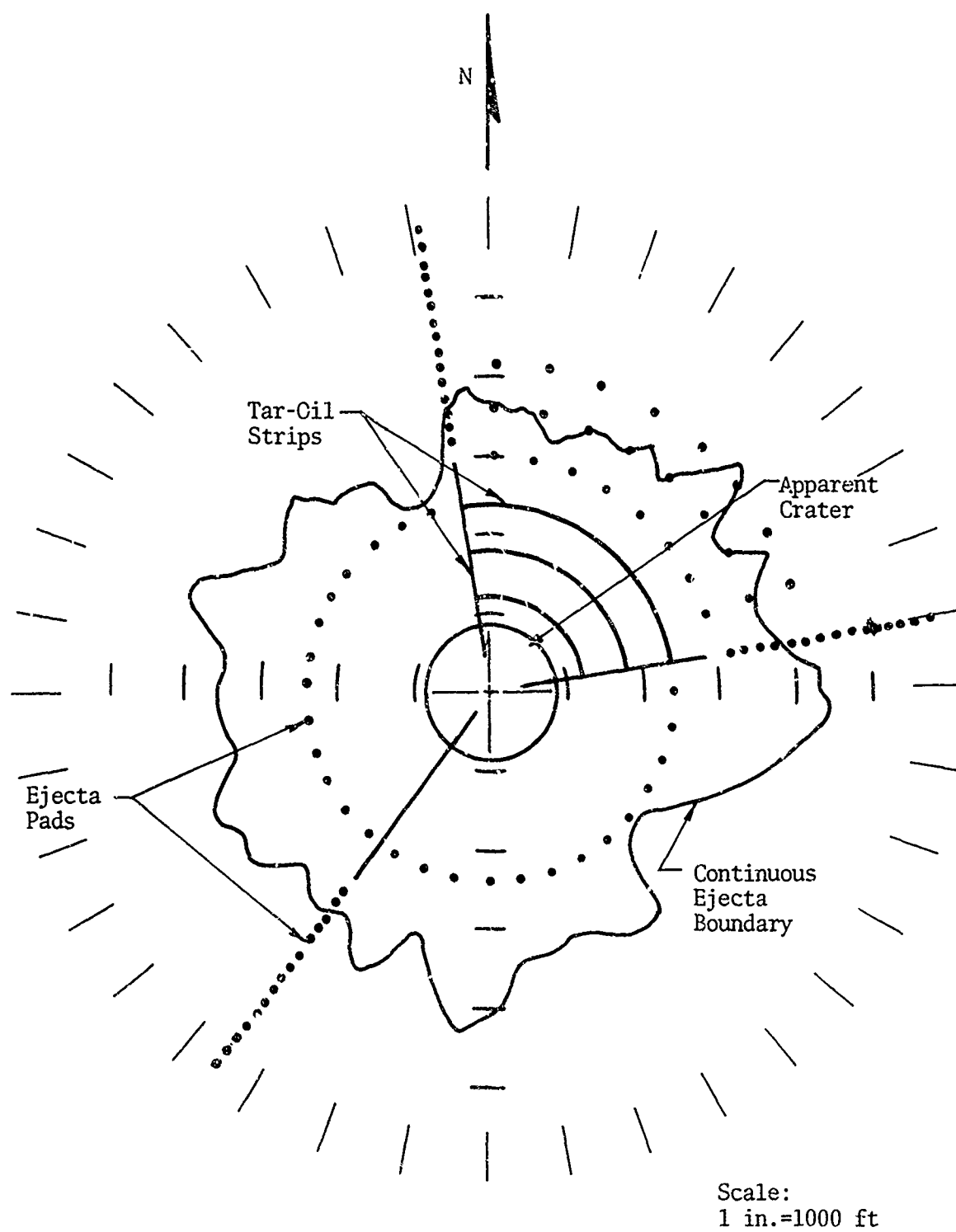


Figure 20. Apparent Crater and Continuous Ejecta Boundary

indicated by aerial photograph. No evidence of the tar strips has been found to date. At 1,500 feet along the S35°W radial there are at least 3 feet of ejecta and blocks over 5 feet across.

Field observation indicated that the areal density and size distribution of the ejecta population is highly asymmetrical both radially and circumferentially. The ejecta population is bimodal, consisting of discrete missiles and fines. It is hypothesized that nearly all the discrete missiles originated from the upper welded tuff and that the fines originated from the bedded tuff and the overburden.

Three radial profiles of uplift and ejecta computed from the isopach map (fig. 15) are presented in figure 21. The demarcation between ejecta and uplift is merely conjecture. Figure 22 provides uplift-ejecta profiles on the three circumferential tar-oil strips at 600, 900, and 1,200 feet from Ground Zero.

Approximately fifty tupperware trays and canvas tarps beyond 1,500 feet have been located and either covered or removed; those located are primarily beyond the continuous ejecta boundary, as indicated on figure 20. Unless hit directly, the trays performed remarkably well; the tarps, however, were very difficult to locate and to recover. None of the stored samples have been analyzed at this time.

Figures 23 and 24 depict various views of the ejecta and missile population.

While it is suspected and can be faintly observed (fig. 15) that the ejecta was controlled to some degree by the joint system, the base surge and the ejecta fines appear to partially block out this effect.

3. Missiles.

Field observations indicate that missile shapes and sizes were strongly controlled by preexisting fractures and joints. Most missiles above 10 pounds exhibit at least one such controlled face; larger missiles exhibit an increase in this control. The maximum-size missile observed to date was roughly measured at 30 feet by 20 feet by 20 feet; lying on the crater edge, it is an almost perfectly shaped hexagonal block.

Table III lists some large missiles and secondary craters randomly obtained from aerial photographs. Measurements of missiles and craters are accurate to ± 1 foot.

A preliminary count of surface missiles was carried out over a 20-degree sector centered on the S25°W radial and extending from the crater edge to 1,200 feet

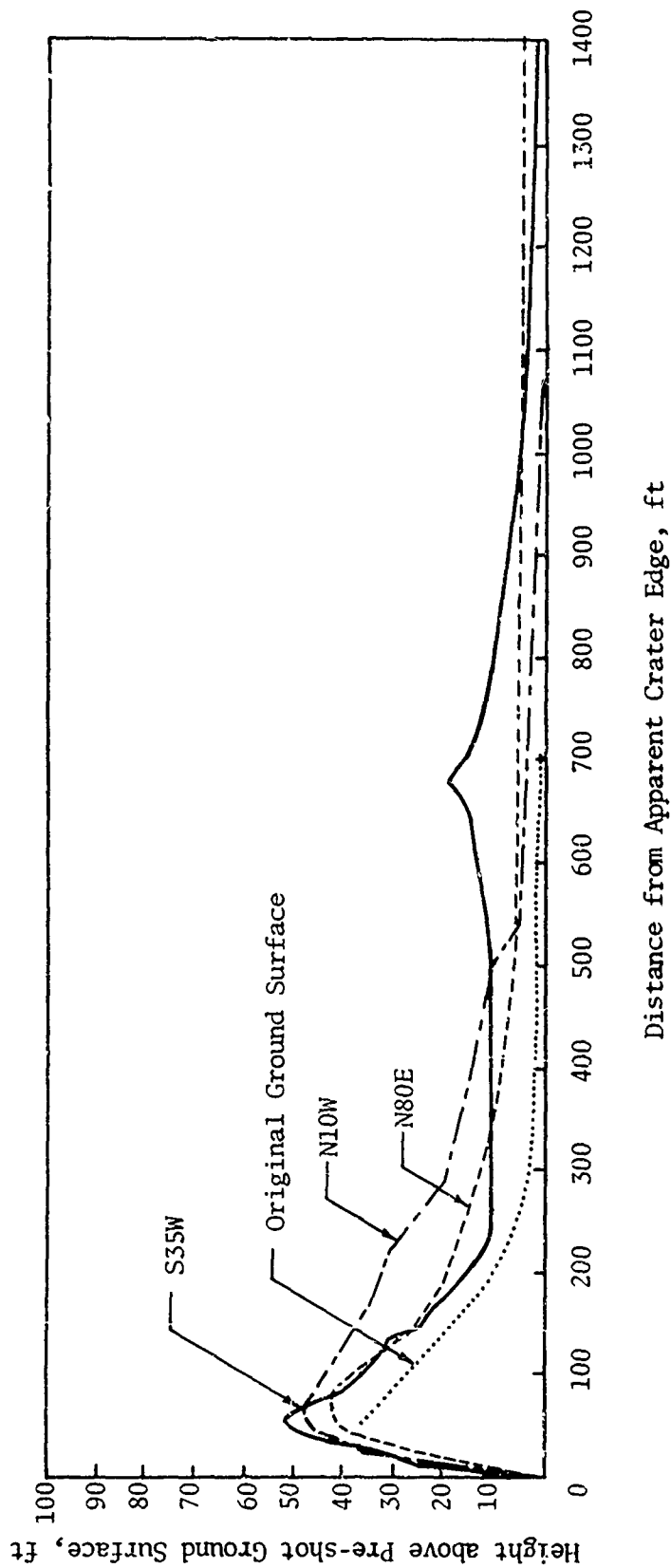


Figure 21. Ejecta Profiles along Three Radials

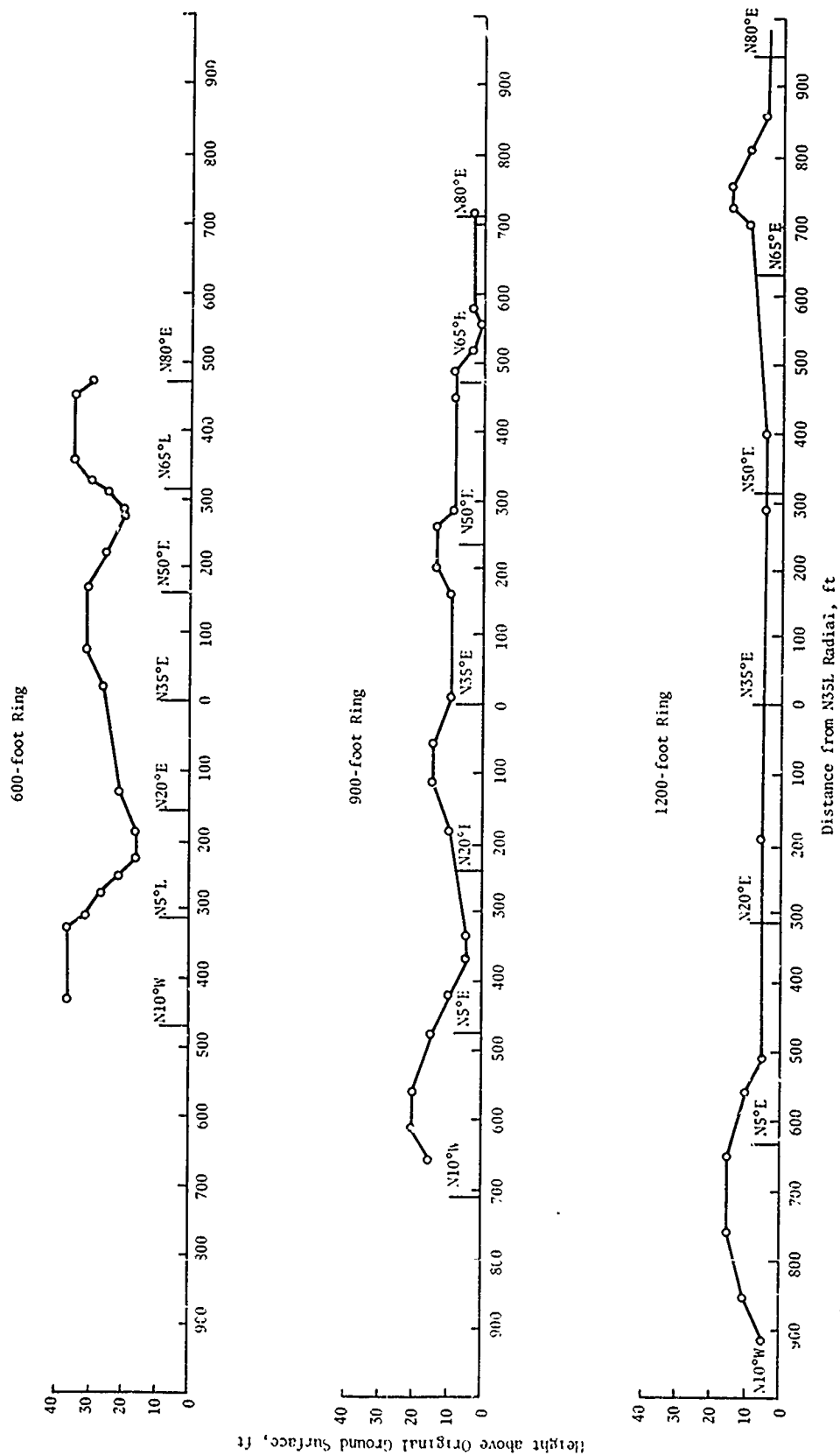
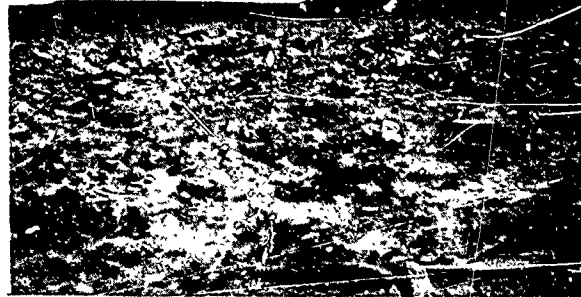


Figure 22. Uplift-ejecta Profiles along Three Circumferential Rings



Toward GZ (2000 ft, S10E)



Away from GZ (2000 ft, S10E)



Crater (S35W)



From Crater Edge along S10E Radial



Facing NW (700 ft, N45E)



Joint Controlled Blocks
(600 ft, N45E)

Figure 23. Selected Photographs of SCHOONER Ejecta Population



Ejecta Distribution @ 180°, 2000 ft



Missile Encased in Fused Glass



Ejecta Tray @ 215°, 2800 ft



Ejecta Tray @ 215°, 2500 ft



Ejecta Tarp @ 215°, 2400 ft



Ejecta Tarp @ 80°, 2100 ft

Figure 24. Selected Photographs of SCHOONER Missile Population

Table III
SELECTED DISCRETE MISSILES
AND SECONDARY CRATERS

Distance from GZ, ft	Missiles, ft	Secondary craters, ft
500-1000	30x25, 20x20, 20x18	
1000-1500	17x10, 13x7, 10x8	44x40, 28x28, 24x24
1500-2000	14x14, 14x7, 14x6	36x28, 21x21, 20x20
2000-2500	14x7, 11x8, 9x8	23x17, 16x14, 14x13
2500-3000	13x7, 8x7, 7x7	42x42, 42x28, 14x11
3000-3500	12x8, 11x7, 9x8	20x20, 19x18, 17x17
3500-4000	13x8, 12x9, 8x7	16x16, 15x14, 14x14
4000-4500	3x3, 2x2	
4500-5000	3x2	

in 100-foot increments. Missiles were counted from an aerial photograph scaled at 1 inch equal to 200 feet; minimum size counted was 2 feet by 2 feet. Missiles were measured along their longest dimensions and perpendicular to that direction; the third dimension was assumed to be equal to the perpendicular dimension. Missile weights were computed by using a density of 125 pcf and grouped into a weight-frequency table for analysis. The results obtained are very tentative, being subject to a number of obvious measurement and analysis limitations.

Table IV presents some basic statistics on the missiles studied. Figure 25 presents a plot of cumulative percent as a function of missile weight, missile volume, and nominal missile size for each 100-foot interval. Figure 26 presents areal density as a function of radial distance.

Three incandescent discrete missiles in the 5-to 10-foot size class were tracked on high-speed movies as they exited from the top of the fireball; corrected velocities ranged from 1,100 to 1,200 fps.

Table IV

SELECTED STATISTICS FOR SURFACE MISSILES
2 FEET BY 2 FEET AND LARGER AT S15W-S35W

Distance from GZ	Number	Total Weight, lb	Maximum Weight, lb	Mean Weight, lb	Median Weight, lb
500-600	37	7,860,250	2,345,750	212,439	5,000
600-700	41	4,334,750	1,000,000	105,720	2,000
700-800	46	2,391,375	1,000,000	51,986	1,500
800-900	73	1,846,250	250,000	25,291	1,400
900-1000	66	955,750	200,000	14,481	1,120
1000-1100	61	347,625	80,000	5,698	900
1100-1200	106	258,875	80,000	2,442	800
1200-1300	125	177,375	16,000	1,419	770
Total	555	18,172,250			

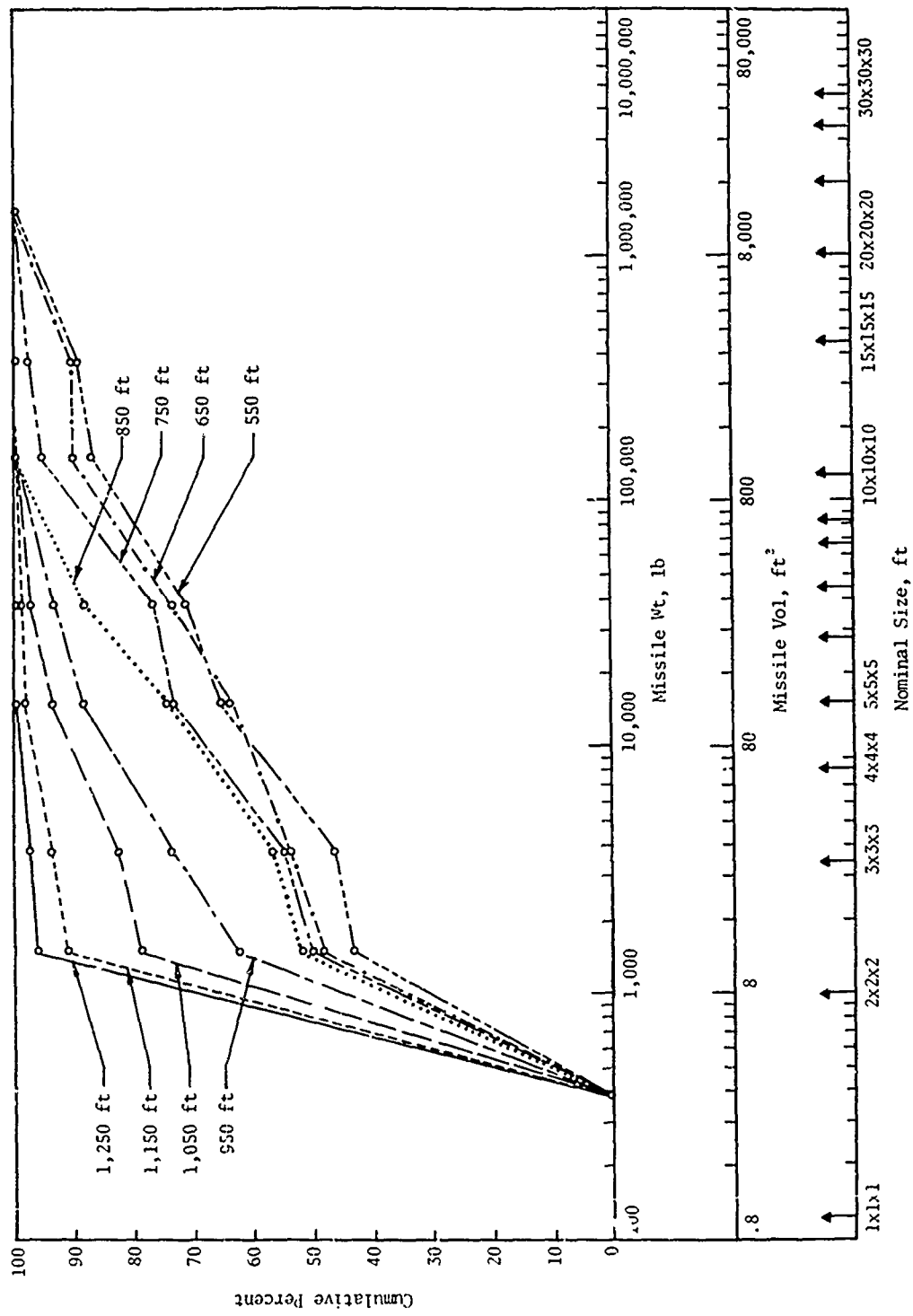


Figure 25. Size Distribution of Missiles
2 Feet by 2 Feet by 2 Feet and Larger

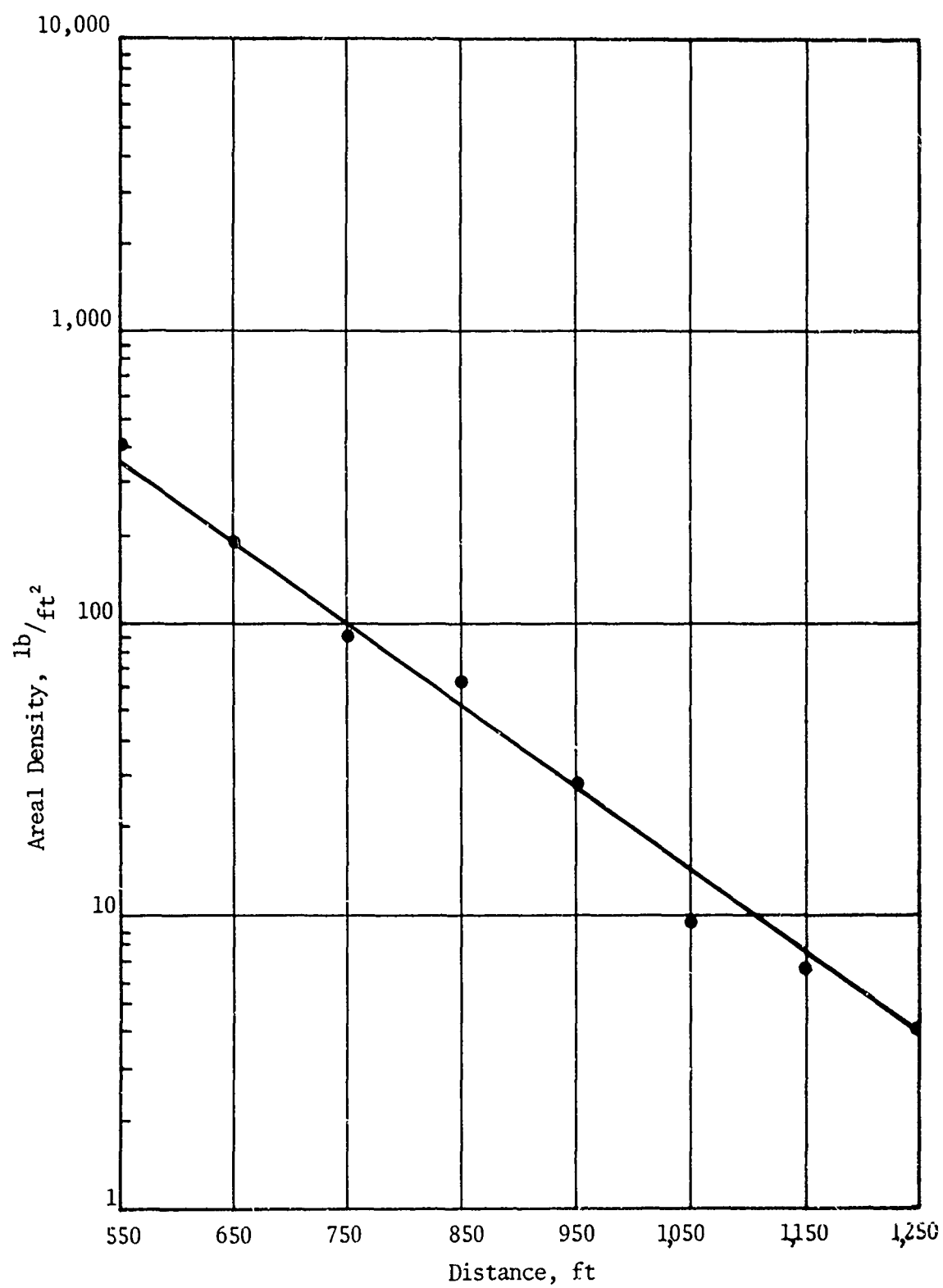


Figure 26. Areal Density of Missiles 2 Feet by 2 Feet by 2 Feet and Larger

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13. ABSTRACT Distribution Limitation Statement No. 2 Project SCHOONER was a 35-KT nuclear cratering Plowshare experiment detonated in a layered tuffaceous medium. This paper briefly summarizes the Air Force Weapons Laboratory (AFWL) technical effort on Project SCHOONER as conducted by the Eric H. Wang Civil Engineering Research Facility (CERF). Early observations, data, and analysis on site, crater, ejecta, missiles, and cloud are presented. The apparent crater was 426 feet in radius and 208 feet in depth. The continuous ejecta limit was asymmetrical, varying between 1,700 and 2,700 feet. Maximum missile range exceeded 6,000 feet. (			

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