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WADD-TR-60-470, PART III

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AUTOMATIC RUNWAY PROFILE MEASURING INSTRUMENTATION AND RUNWAY PROPERTIES

PART III — BASE SURVEYS

TECHNICAL DOCUMENTARY REPORT WADD-TR-60-470, PART III

JULY 1963

AF FLIGHT DYNAMICS LABORATORY
AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

Project No. 1367, Task No. 136701



Prepared under Contract AF 33(616)-7851
by

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FOREWORD

This report was prepared for the Vehicle Dynamics Division, AF Flight Dynamics Laboratory, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio, by Midwest Research Institute. This research is part of a continuing effort to provide a more rational and reliable theoretical method for establishing design criteria in the specific area of shock and impact for flight vehicles which is part of the Air Force Systems Command's Applied Research Program 750A, the Mechanics of Flight. The research work was accomplished under Air Force Contract No. AF33(616)-7851 initiated under Project No. 1367 "Structural Design Criteria," Task No. 136701, "Design Criteria for Ground Induced Dynamic Loads." The work was administered under the direction of the Aerospace Dynamics Branch, Vehicle Dynamics Division with Walter F. Dunn acting as project engineer.

This report covers work from February 1961 to December 1962. This report is Part III of a three part report, the others being Part I, "Equipment" and Part II "Equipment Trials."

The Aeronautical Systems Division as an in-house effort programmed the IBM 7090 digital computer, and reduced the data presented in this report. The following persons are responsible for this effort, Mr. Franklin E. Fisher, Mr. John E. Derrickson, Mr. Warren G. Smith, Mr. Jim N. Marable, and Mr. John P. Dollinger.

The author wishes to acknowledge the cooperation and assistance of Air Force personnel of the bases surveyed.

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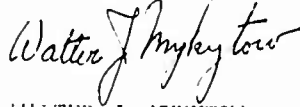
ABSTRACT

Runway roughness data from surveys of runways, taxiways, and selected parking ramps of 17 Air Force bases in the United States of America are presented in the form of profile and power spectral density plots. Tabulated data and base maps are included to describe the length of the surveys and their location. The method used to calculate the power spectral density is enclosed.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER



WALTER J. MYKYTON
Actg. Associate Director
Vehicle Dynamics Division
AF Flight Dynamics Laboratory

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I. INTRODUCTION

The high speed of modern flight vehicles requires careful design of the flight vehicle structure. A flight vehicle analysis for ground operations requires knowledge of the frequency phasing and amplitude of the loads. Accurate predictions of the loads imposed during ground operation have not been possible because of the limited knowledge of the characteristics of the surfaces used by a flight vehicle during its operational life. The power spectral density calculated from these surfaces indicates how the average power or amplitude is distributed with reduced frequency. When adequate description of the surfaces have been obtained, methods may be developed to predict loads during ground operation of flight vehicles.

II. EQUIPMENT AND PROCEDURE

Adequate description of the many different pavement types and surface condition requires a vast amount of profile information. In the course of this project, nearly 2 million profile height readings were recorded from 187 miles of runways and taxiways. Special automatic equipment was used to efficiently measure and record the profile data in a form compatible with high speed digital computers.

The runway profile instrumentation system used in this project is composed of a collimator and a profile recorder (see Figure 1). The collimator is used to project a well-defined beam of light down the runway to establish a horizontal reference line. The profile recorder is towed down the surface to be measured, recording the profile elevations.

Before initiating the survey of the bases, a special analog profile recording unit was added to the runway instrumentation system (see Figure 2). A standard strip chart was used to plot the vertical profile indicated by a potentiometer mounted on the sensing head. The chart is advanced every 6 inches of travel on the runway by a stepping motor. The drive between the motor and the recorder is designed to produce a horizontal scale of 1 inch = 100 feet of runway. The vertical scale is 1 inch = 1 foot change in elevation. The analog plot proved to be extremely useful to the survey crew in monitoring the operation of the entire unit.

A surveying procedure was developed to obtain as much information as possible from a limited number of survey runs. Cross-runs, or lines of survey

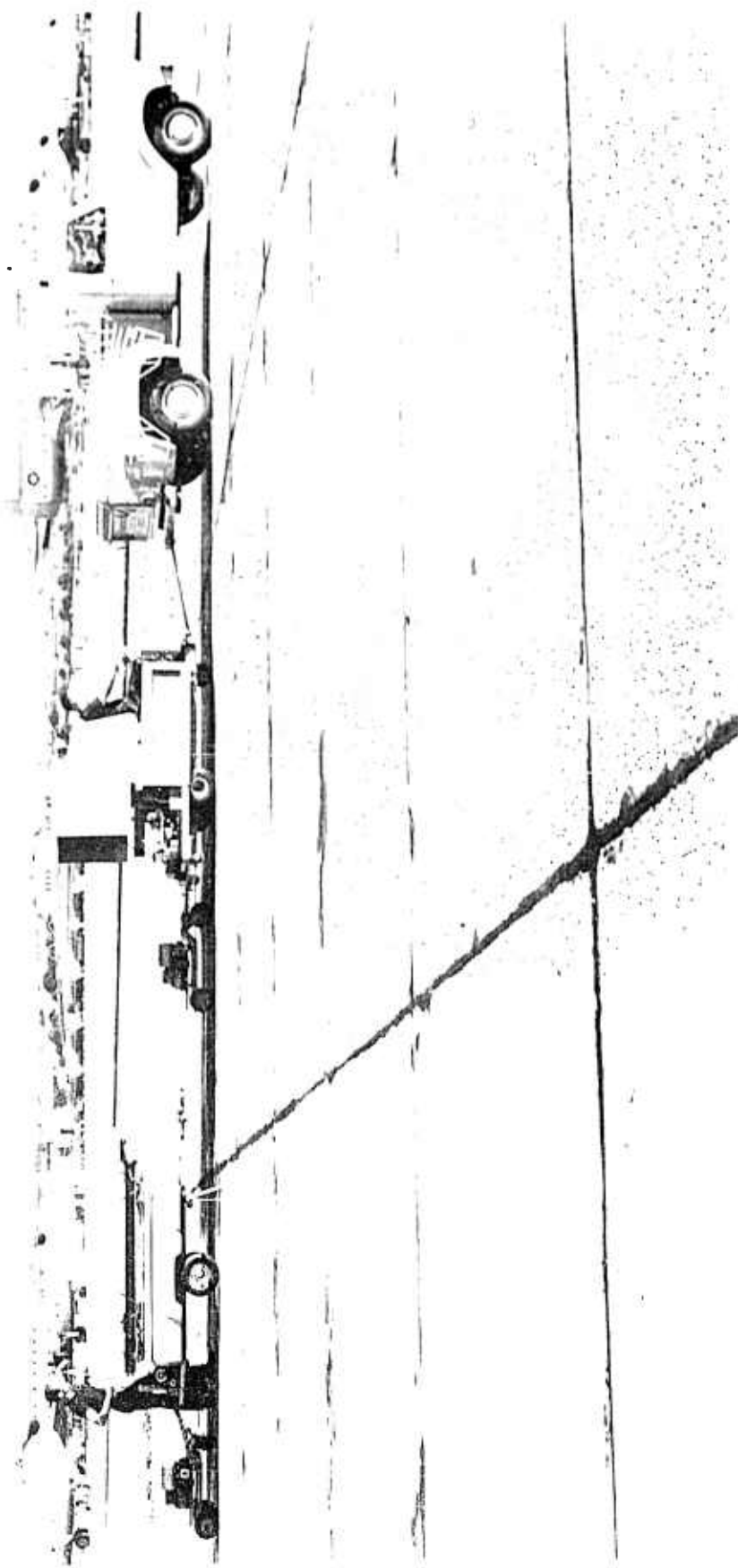
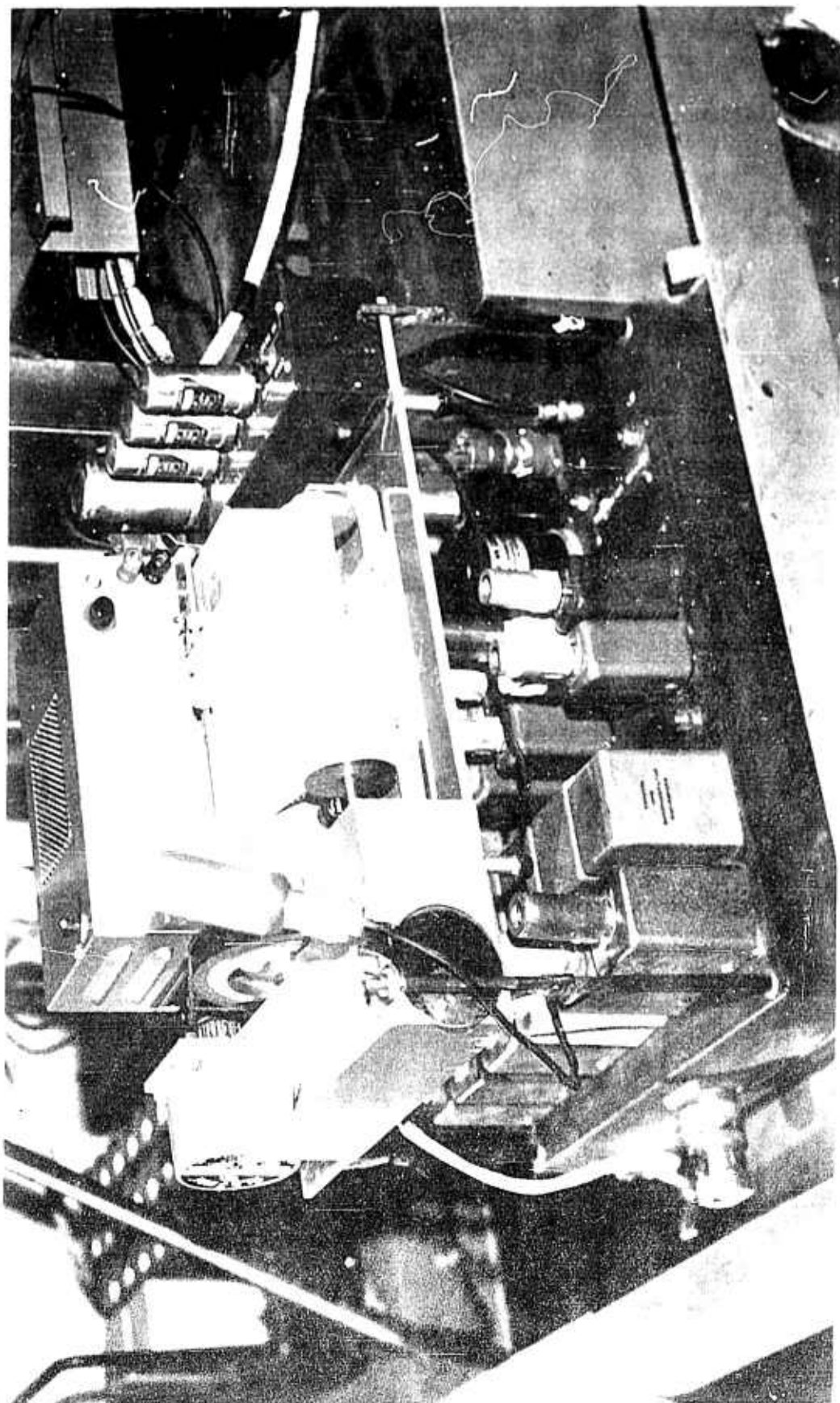


Figure 1 - Runway in the foreground. Interpretation.



perpendicular to the center line of the runway or taxiway, were made at both ends and adjacent to the 1,000-ft. runway markers. These profiles show the drainage slope. The final step consisted of three runs; center line, right hand side, and left hand side the length of the surface. The distance from the seam at the threshold to the starting point of each longitudinal run was recorded to permit repeating the survey at a later date. The distances from the start of each longitudinal run to the intersection with the cross runs were also recorded. These distances were measured by a switch on the profile follower wheel advancing a counter as an odometer at 6-in. intervals to aid in measuring the survey distances. The odometer count locating the center line of the surface on cross runs, as well as the intersection points and total length of each run, is listed in Appendix IV. This cross reference between the three longitudinal surveys and the cross runs can be used to reconstruct the surface profile in three-dimensional form as shown schematically in Figure 3.

The runway roughness instrumentation is similar to conventional equipment in that the accuracy of the survey depends on the accuracy in establishing the horizontal reference. A standard surveying equipment spirit level with an accuracy to within 20 sec. of arc is used to indicate the horizontal. Before initiating the survey of each base, an identical portion of a runway was surveyed in both directions. A comparison of the profile plots from the profile chart recorder indicated the repeatability of the entire system disclosed infrequent or random malfunctions which would not be encountered in routine check-out operation, and permitted a fairly accurate estimate of the slope error. Examination of the profile charts obtained from a number of these test runs disclosed a small error in the initial mounting of the level vial. The recorded slope was found to have an error of 2-3 in/1,000 ft. No attempt was made to improve this calibration under field conditions. A deviation in over-all slope would not change the power spectrum calculations. However, if an accurate vertical relationship between the survey paths is required, it can be obtained with the relationship established by the cross run.

III. DISCUSSION OF RESULTS

A general study of ground loading effects must be based on surface information. The 17 bases surveyed were chosen from all parts of the continental United States to provide a sampling of surface conditions. The raw profile data obtained have been processed by the computer facility at the Aeronautical Systems Division.

The power spectral density curves in Appendix I represent the roughness properties of the runways from a statistical standpoint. It has been noted that the power spectral density plots of some concrete surfaces show a

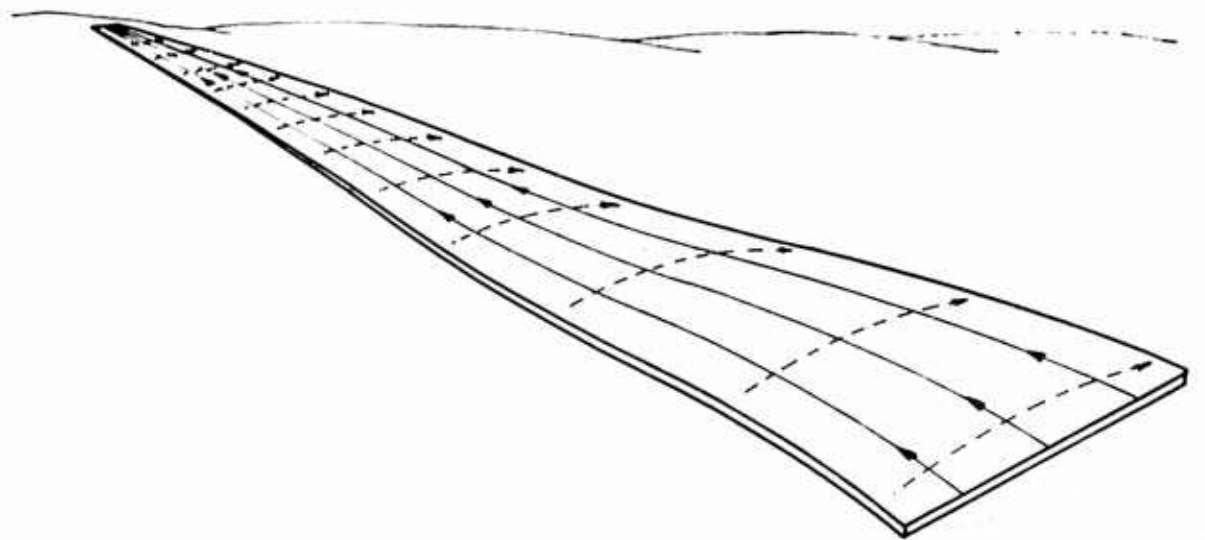


Figure 3 - Relationship between Cross Run Profiles and Longitudinal Profiles

peak or unusually high reading at a wavelength corresponding to the length of the slabs in the pavement. The tar strip at the joints appears as a high point on the profile which reoccurs at regular intervals. Power spectral density analysis of the profile data must interpret this occurrence as a surface undulation and shows it as such on the plot and often the second and third harmonics of the slab length disturbance can be seen on the plot. Another series of peaks, resulting from an occasional overshoot of the photoelectric sensor in maintaining its position at the center of the light beam, can be noted at extremely short wavelengths. Apparent profile undulation with a wavelength of 2 to 3 feet is produced from servo system characteristics coupled with a constant surveying speed.

Appendix II, scale plots of the profiles measured, shows the length, total change in elevation, maximum grade and length of the profile. These condensed profiles show the linear trend, profile end-point to end-point grade, the effect of which was removed from the power spectral density. Further the effect of the large amplitude low-frequency content of the profile, which biases the power spectral density value corresponding to the lowest plotted reduced frequency, can be qualitatively evaluated. The cross run profiles show the crown of the surface. The profiles of two 1,000-ft. surveys of parking ramps from each base are also included.

Further detailed information of the location and length of each survey is given in tabular form in Appendix IV. The information given for each longitudinal survey includes the designation of the surface, the location with respect to center line, the distance from the threshold joint to the starting point, and the odometer count at the intersection point of each cross run. The odometer count represents 6-in. intervals, divided by two to obtain feet. The last figure given is the total odometer count of the run or twice the length of the run in feet. Cross run information includes the location with respect to the end of the surface, the odometer count at the intersection of the cross run and the longitudinal center line of the surface and the final count or total length.

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APPENDIX I

POWER SPECTRAL DENSITY PLOTS

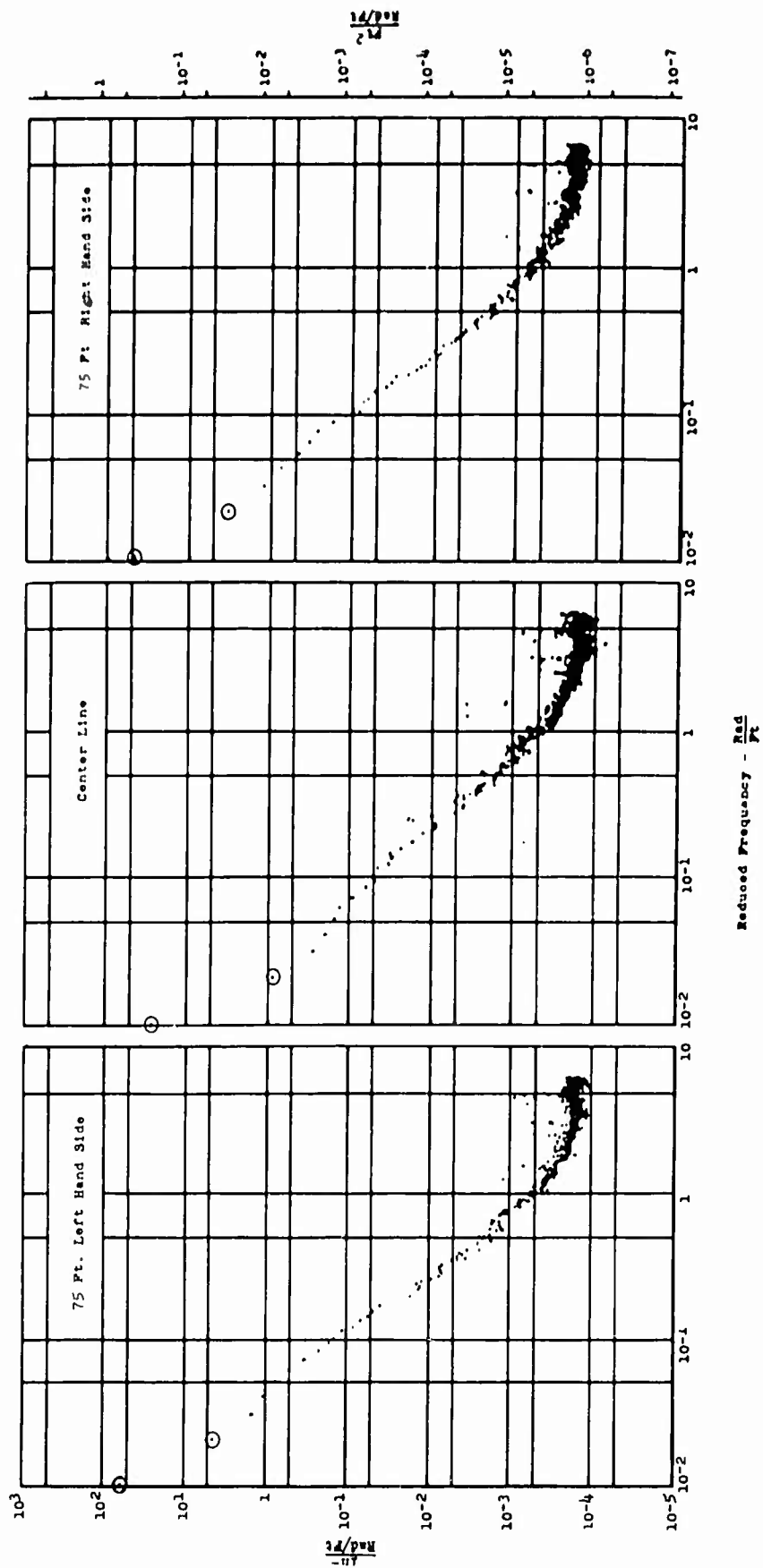
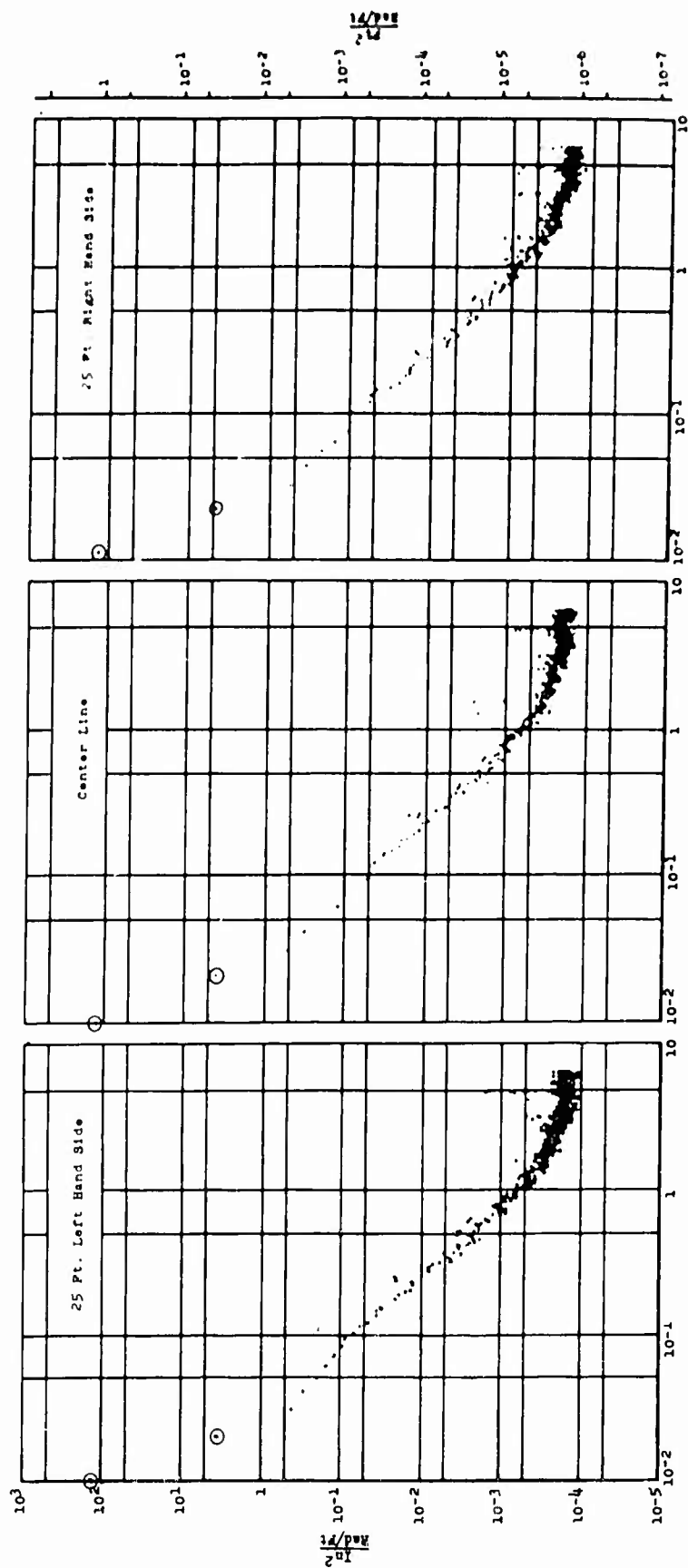


Figure 4 - Power Spectral Density, Runway 35, Altus Air Force Base



Reduced Frequency - $\frac{Rad}{Pt}$

Figure 5 - Power Spectral Density, Taxiway 5, Altus Air Force Base

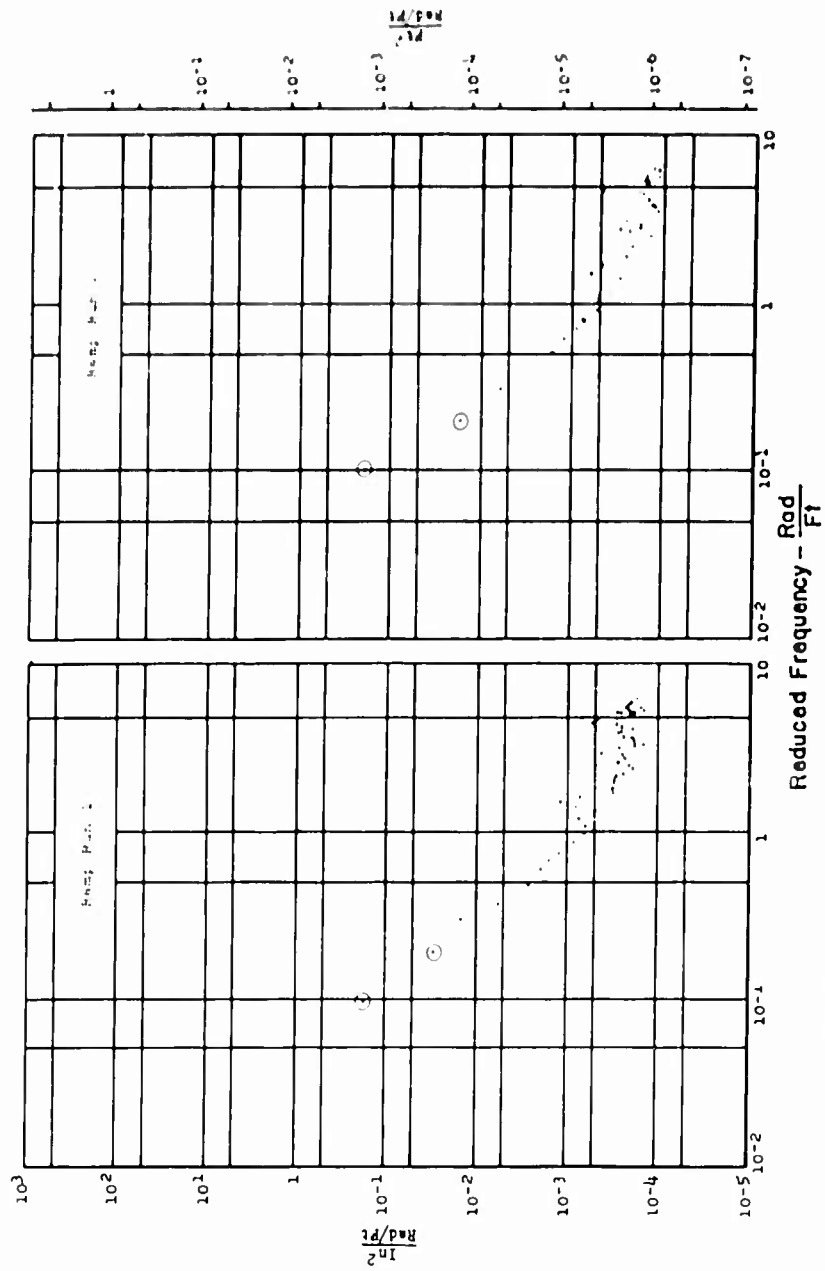
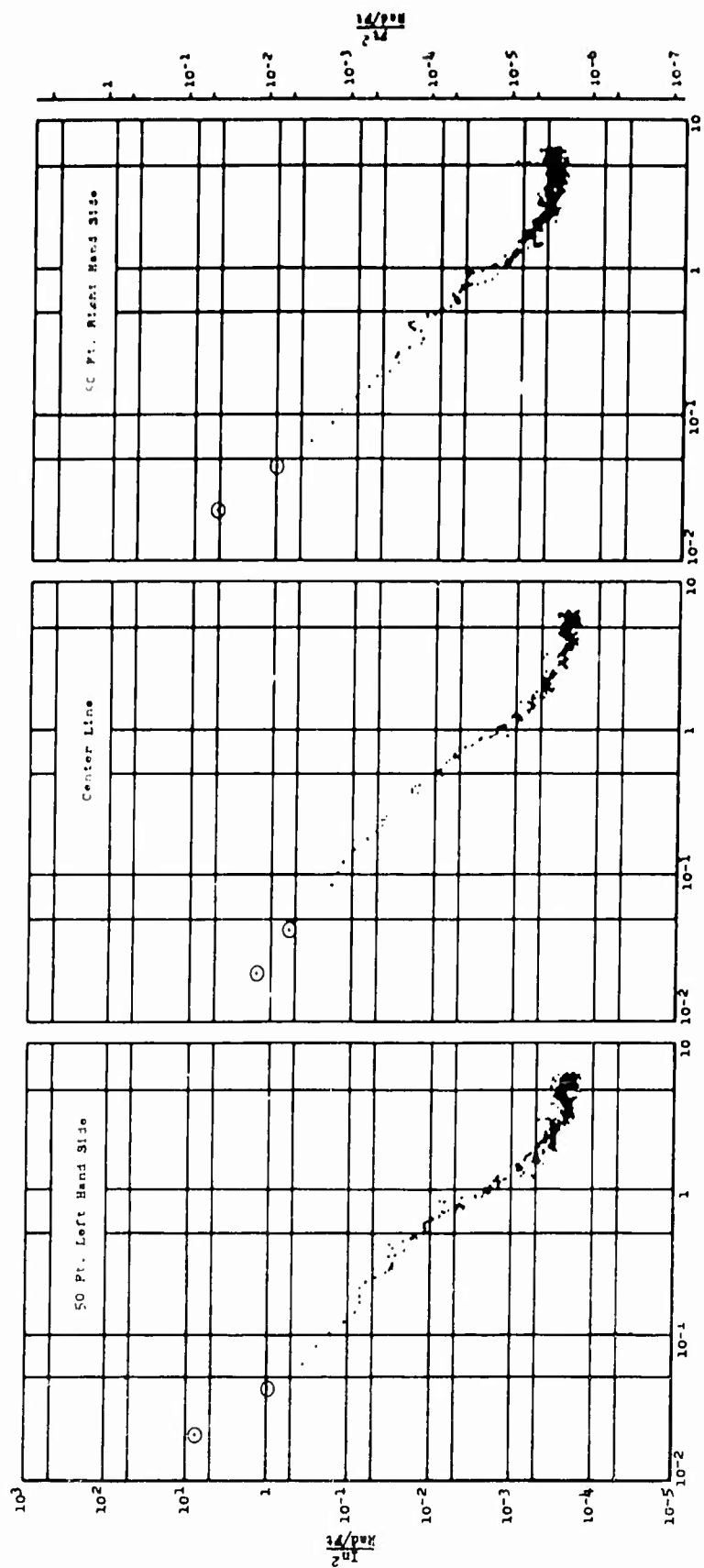
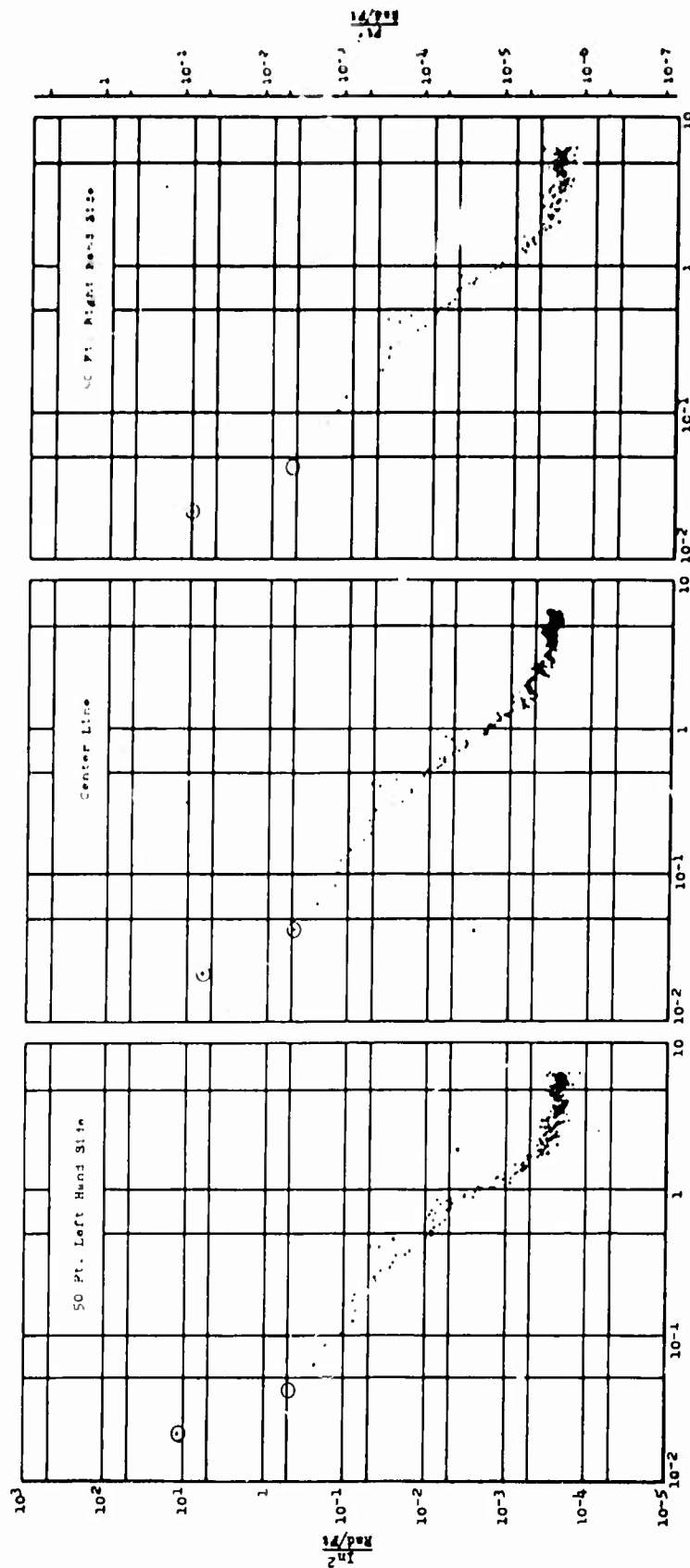


Figure 6 - Power Spectral Density, Altus Air Force Base



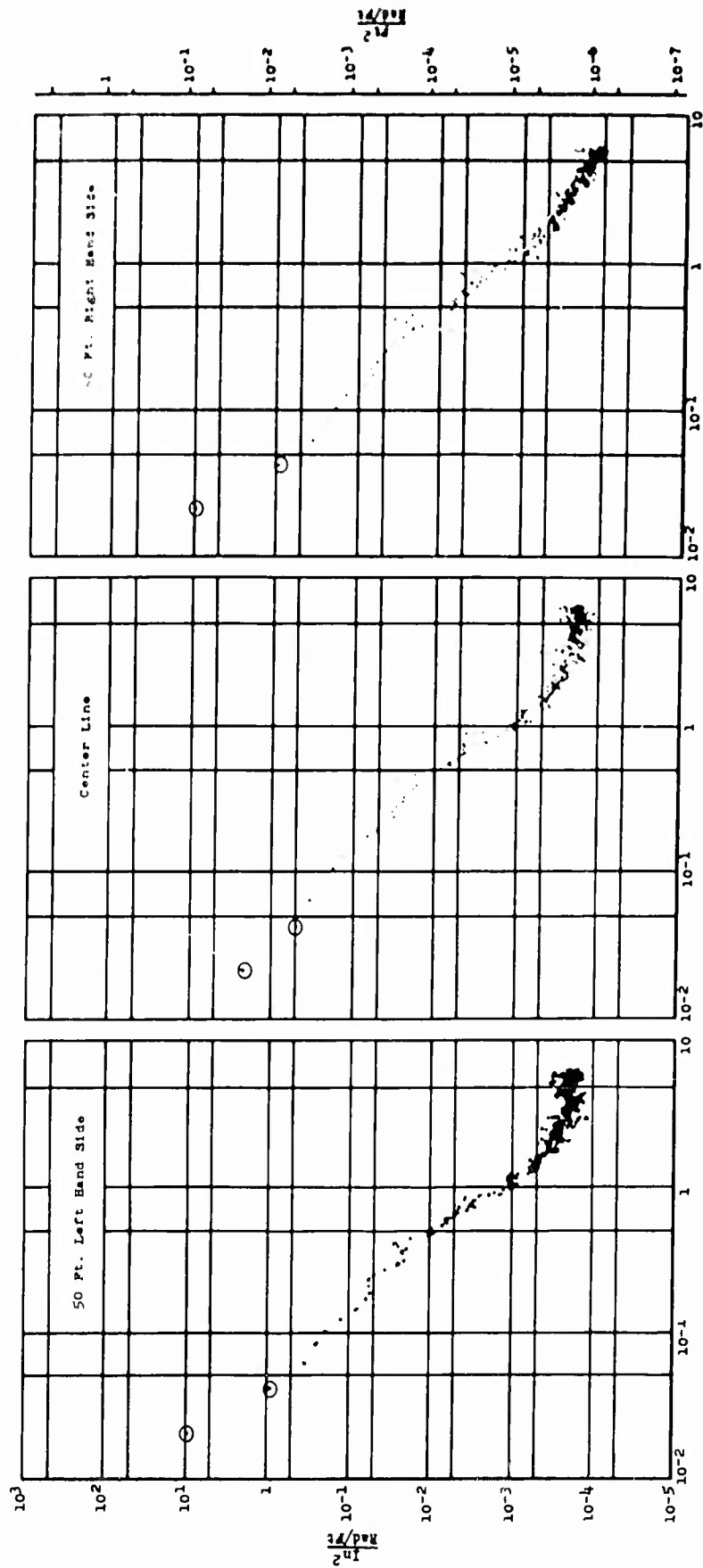
Reduced Frequency - $\frac{f \cdot d}{V}$

Figure 7 - Power Spectral Density, Runway 13, Bakalar Air Force Base



Reduced Frequency - $\frac{f}{P_t}$

Figure 8 - Power Spectral Density, Runway 18, Bakalar Air Force Base



Reduced Frequency - $\frac{f}{ft}$

Figure 9 - Power Spectral Density, Runway 22, Babalar Air Force Base

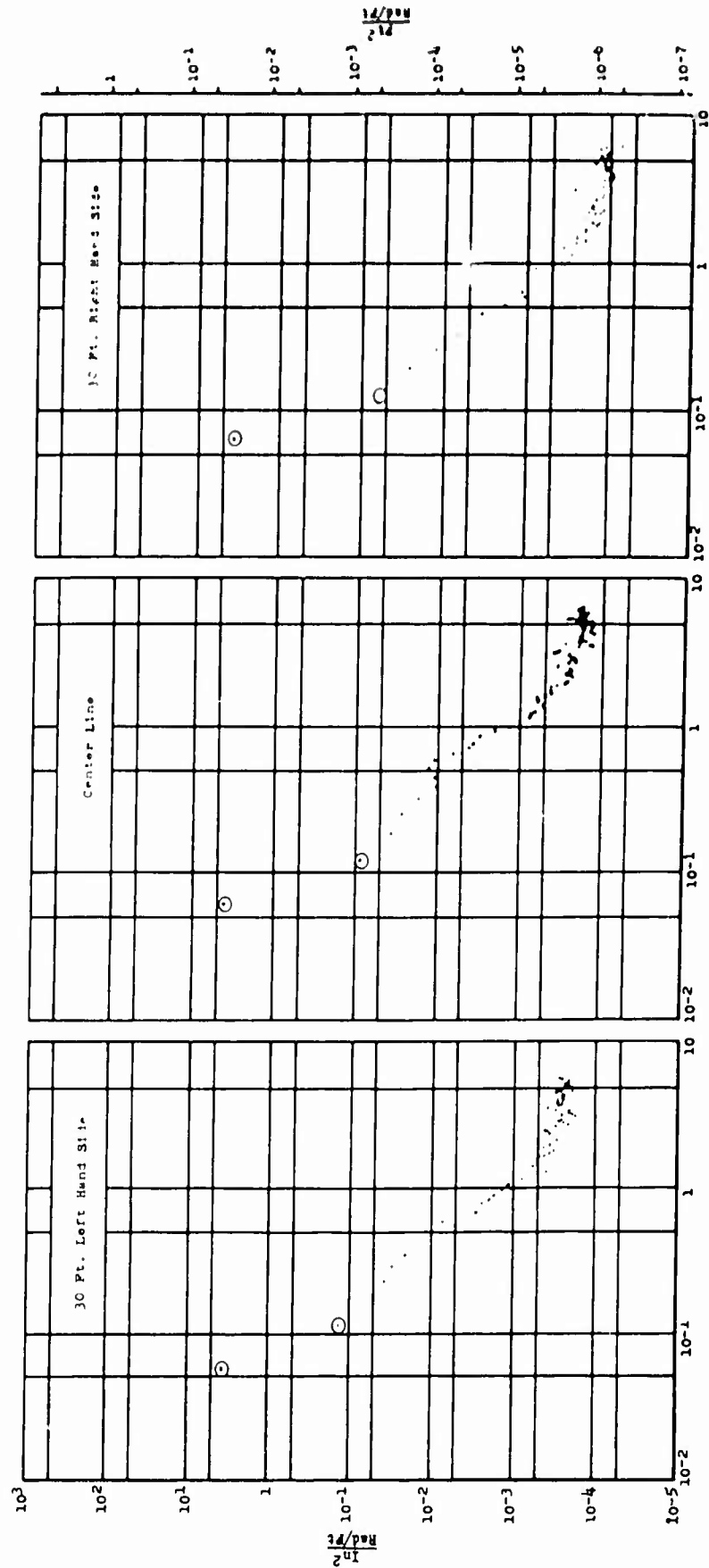


Figure 10 - Power Spectral Density, Taxiway 3, Bakalar Air Force Base

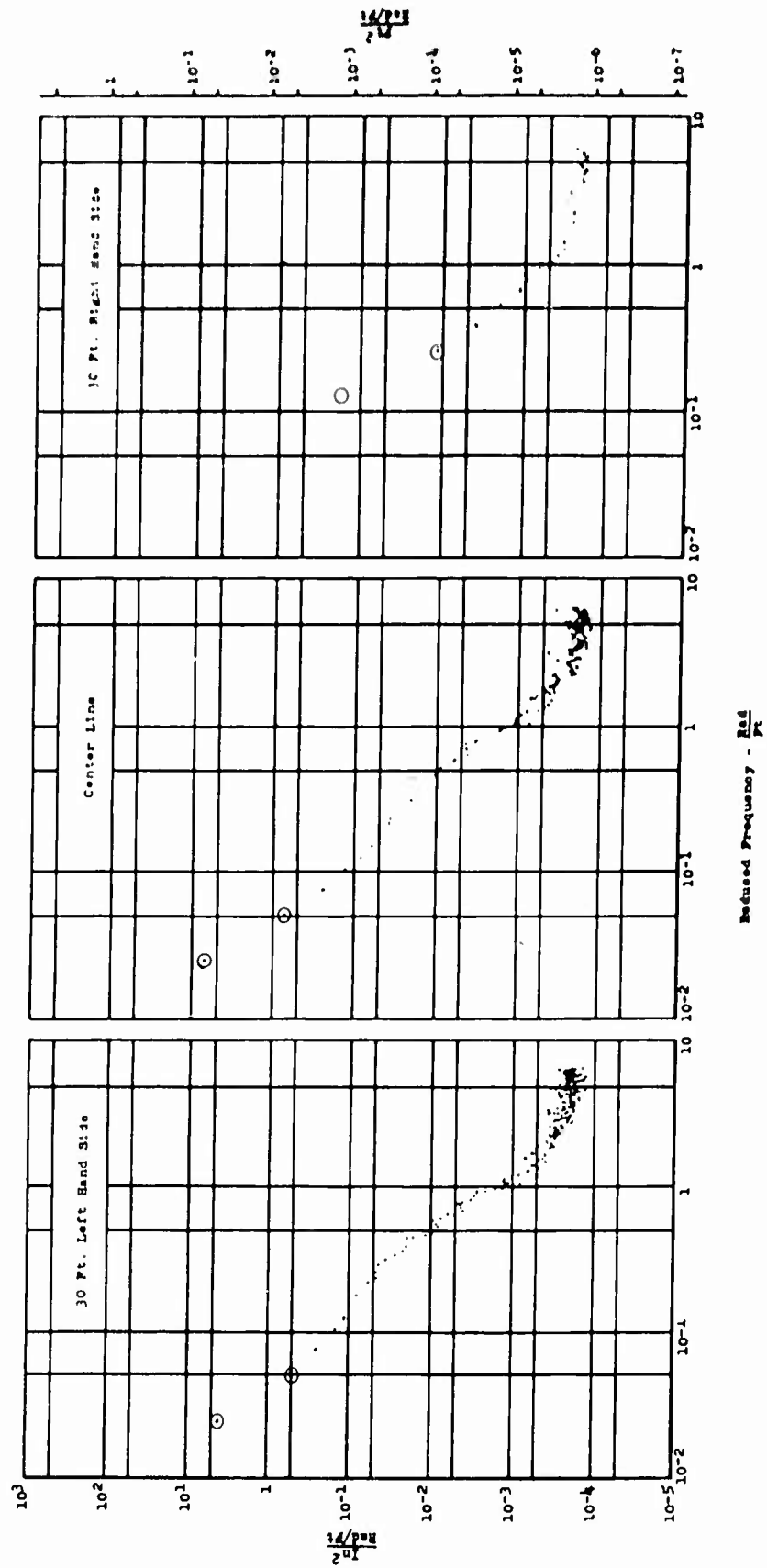


Figure 11 - Power Spectral Density, Taxiway 27, Bakalar Air Force Base

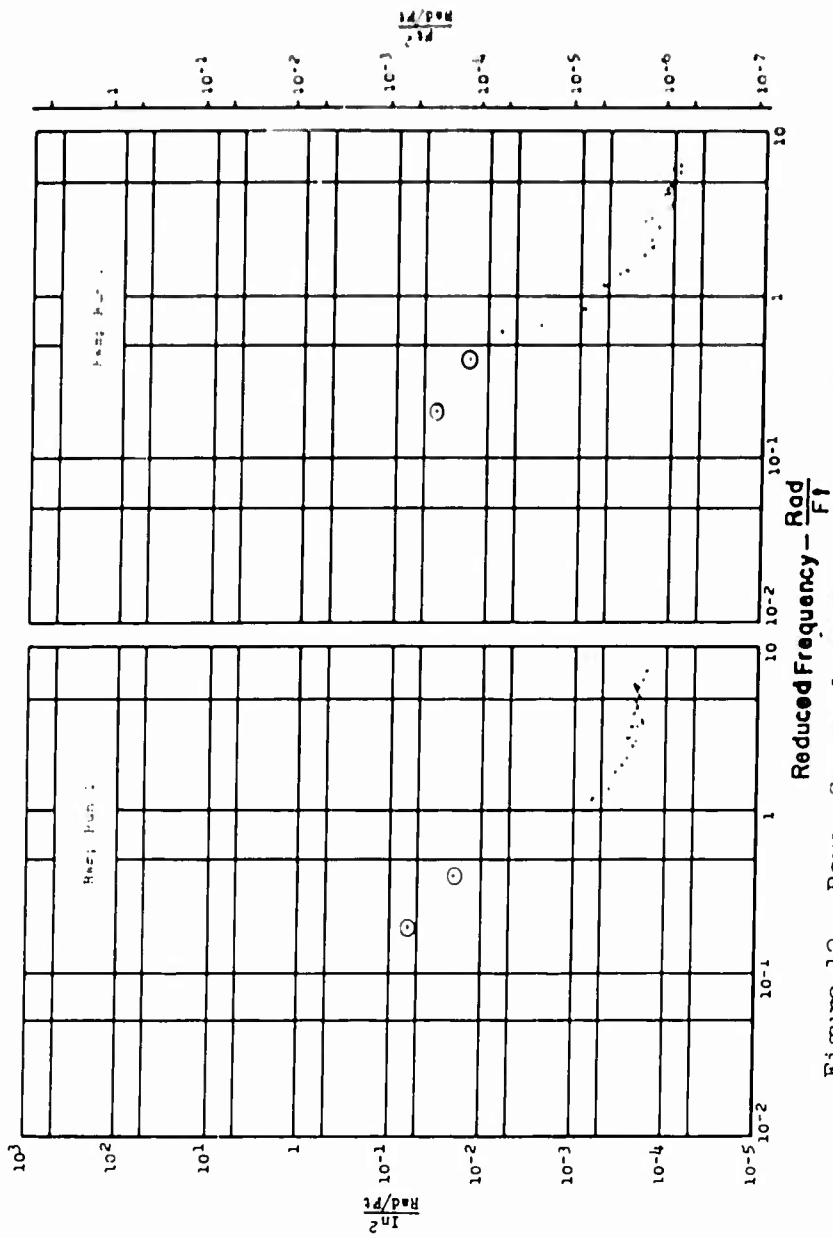


Figure 12 - Power Spectral Density, Bakalar Air Force Base

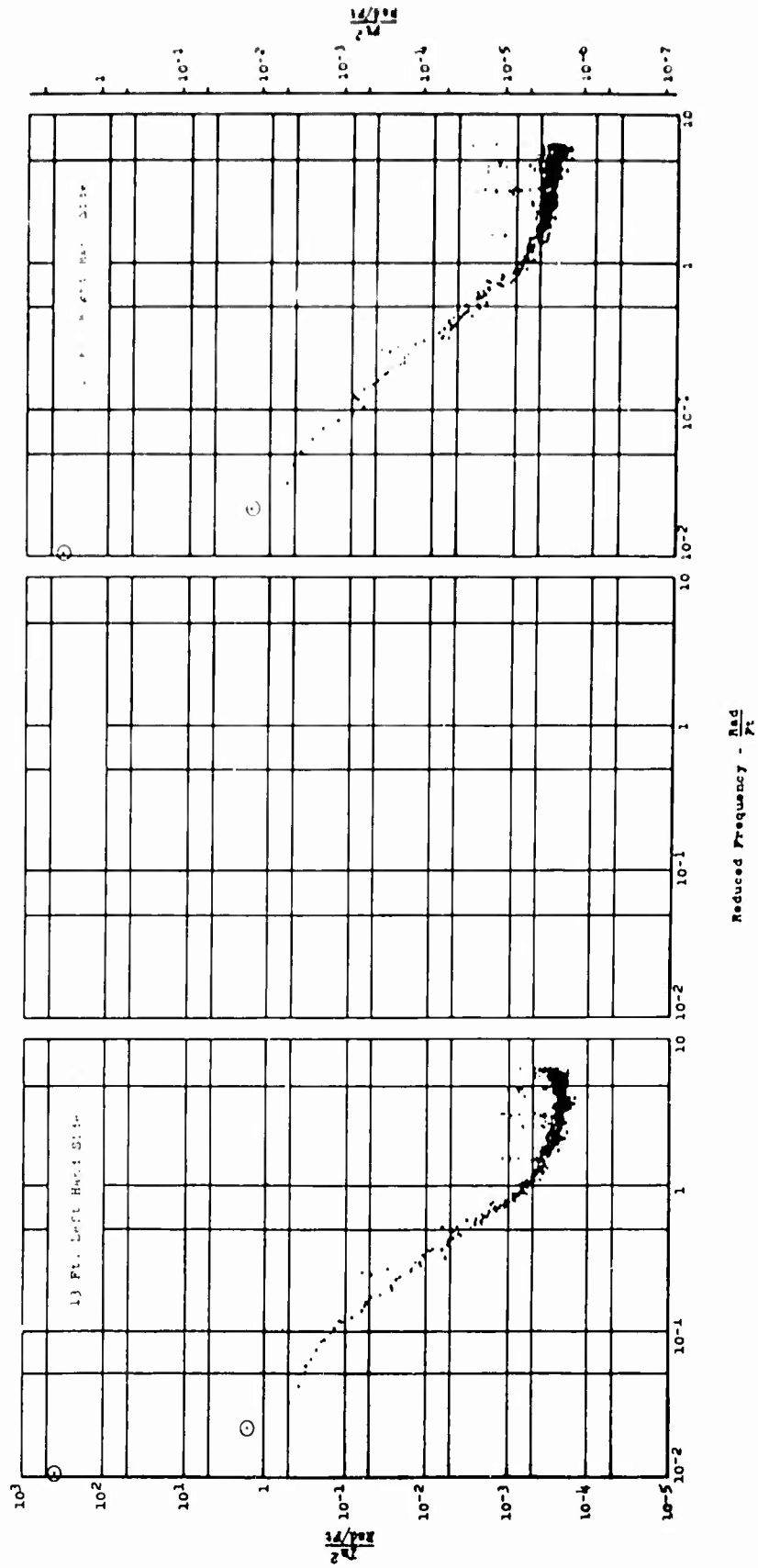


Figure 13 - Power Spectral Density, Runway 17, Carswell Air Force Base

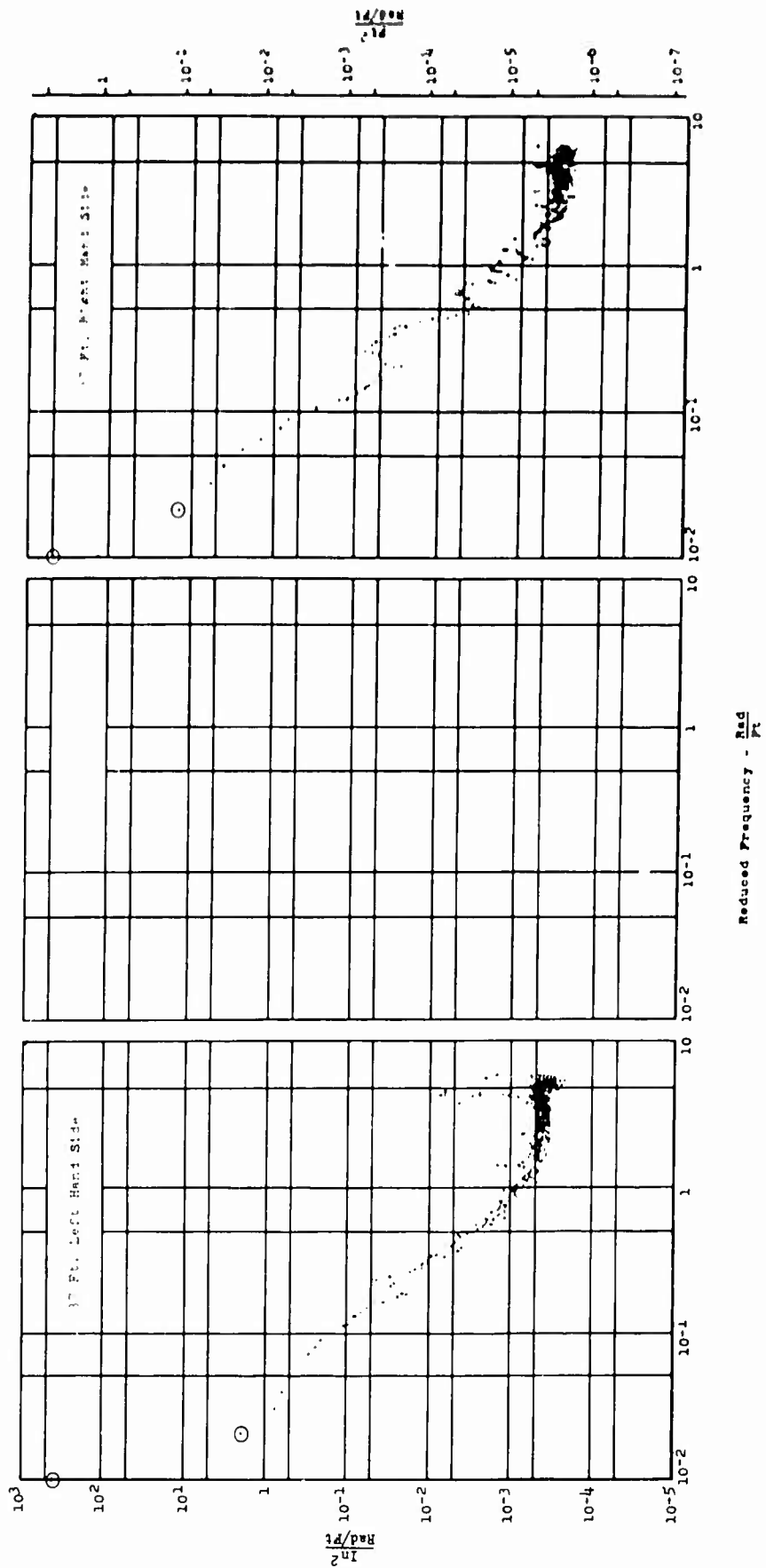


Figure 14 - Power Spectral Density, Runway 17, Carswell Air Force Base

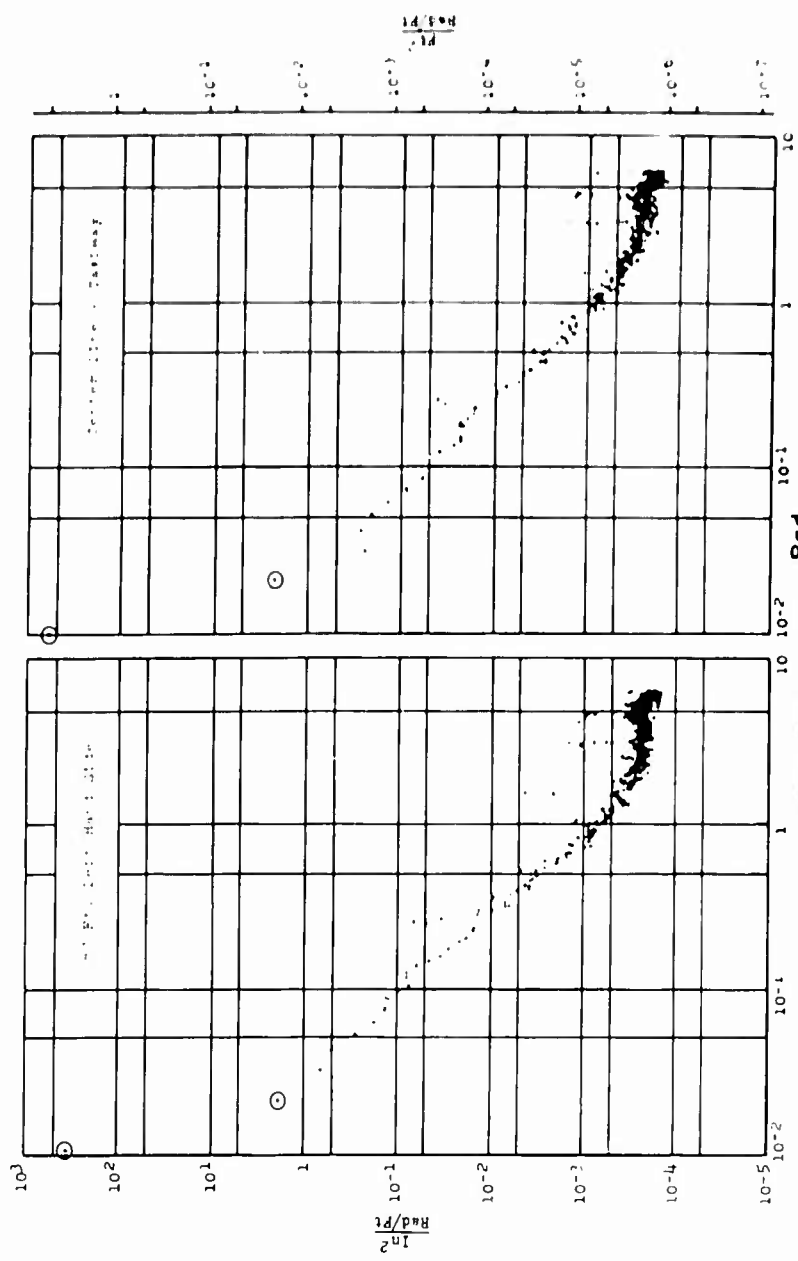


Figure 15 - Power Spectral Density
Side Run Runway 17 - Centerline Taxiway
Carswell Air Force Base

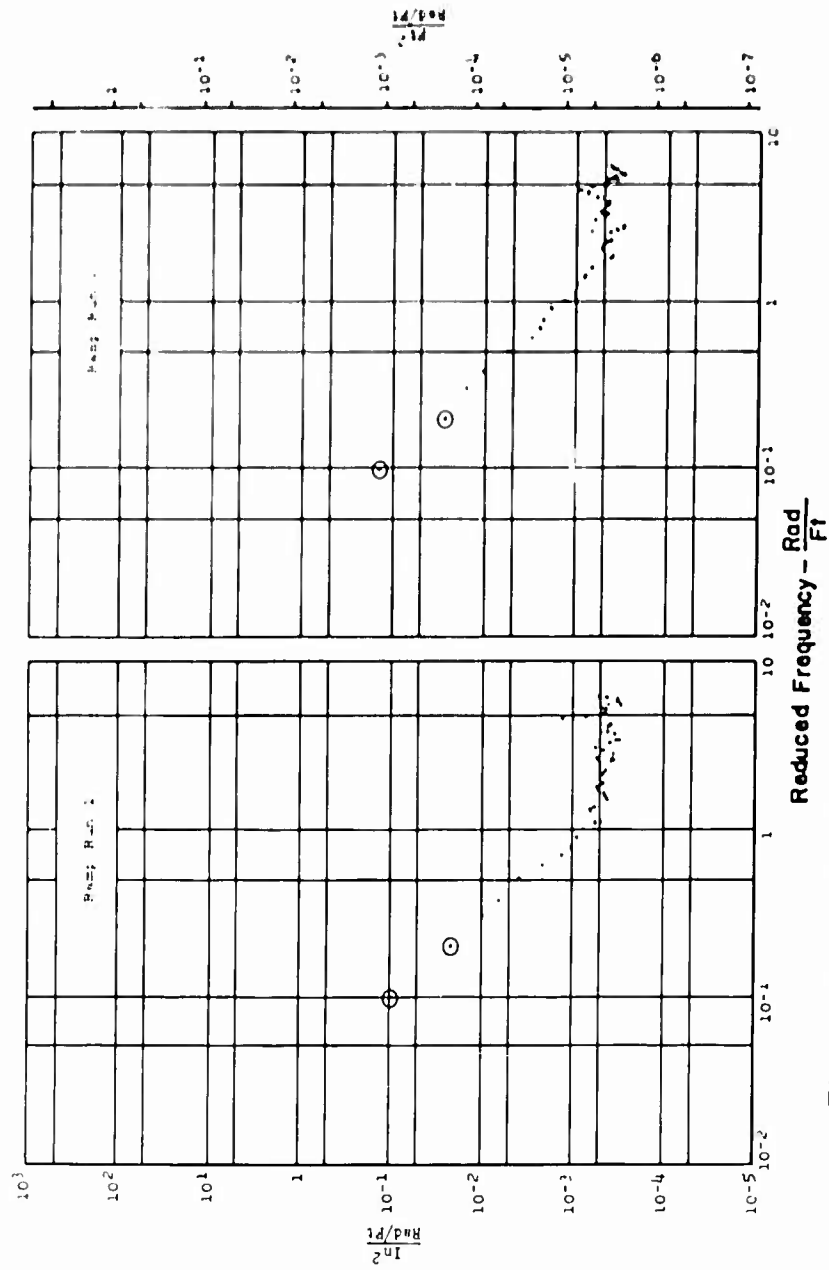
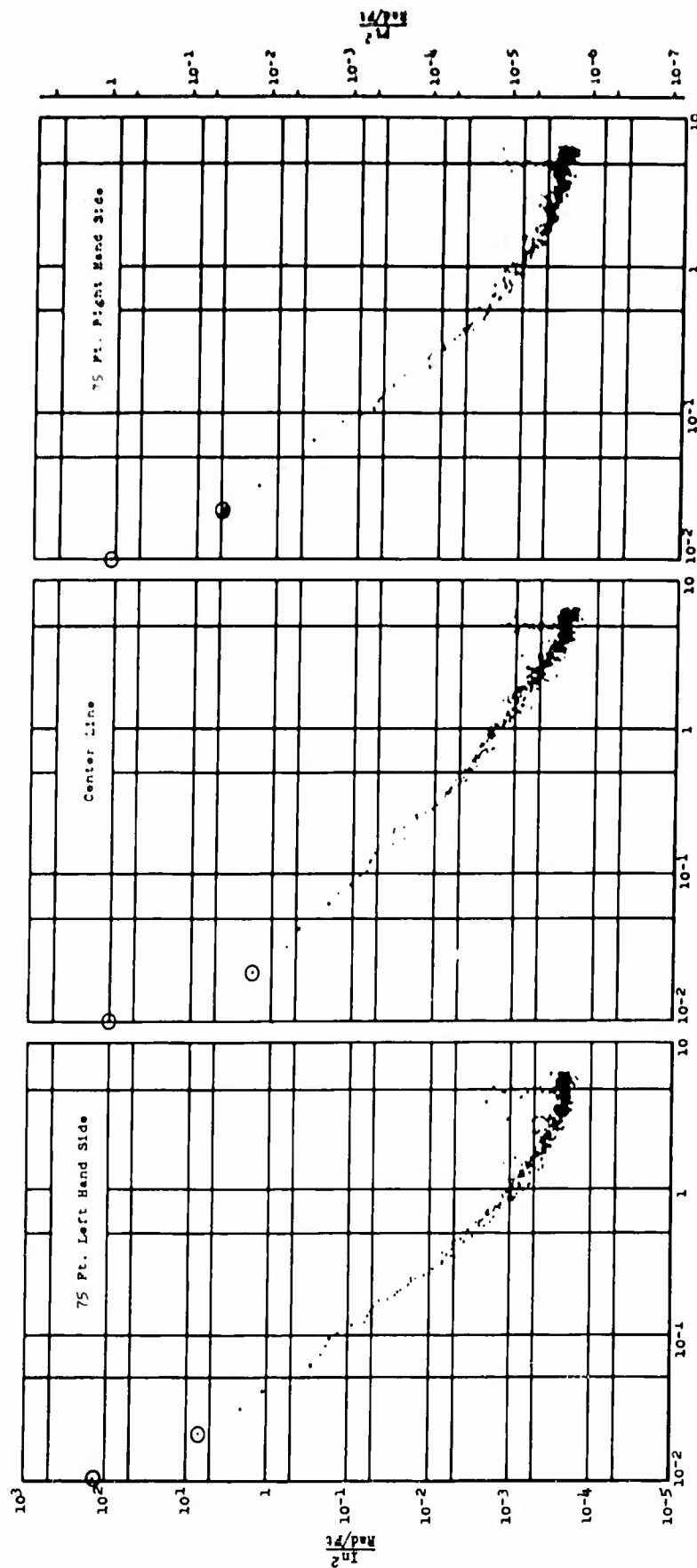


Figure 16 - Power Spectral Density, Carswell Air Force Base



Reduced Frequency - $\frac{\text{Rad}}{\text{Hz}}$

Figure 17 - Power Spectral Density, Runway 30, Castle Air Force Base

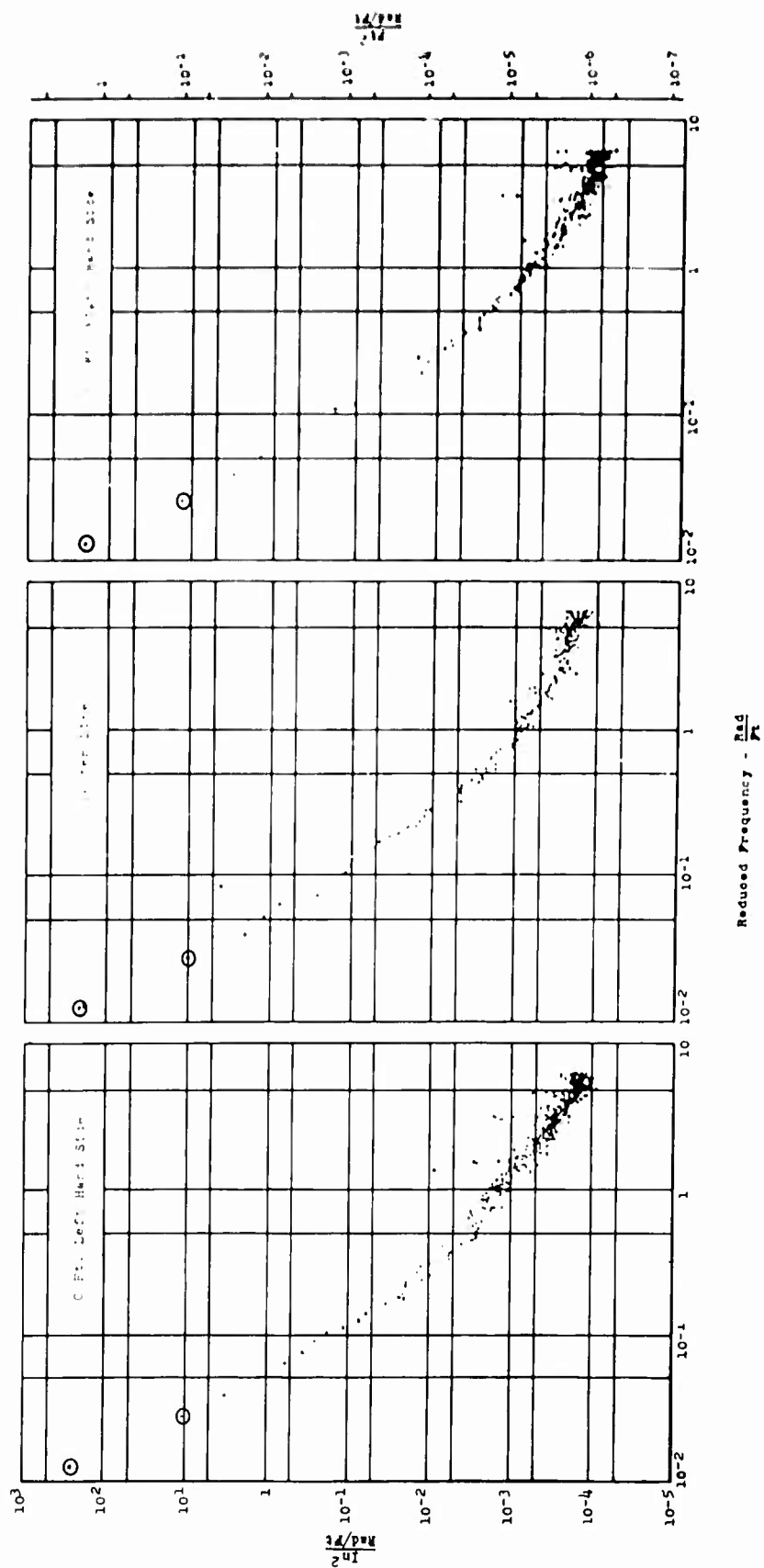


Figure 18 - Power Spectral Density, Taxiway 9, Castle Air Force Base

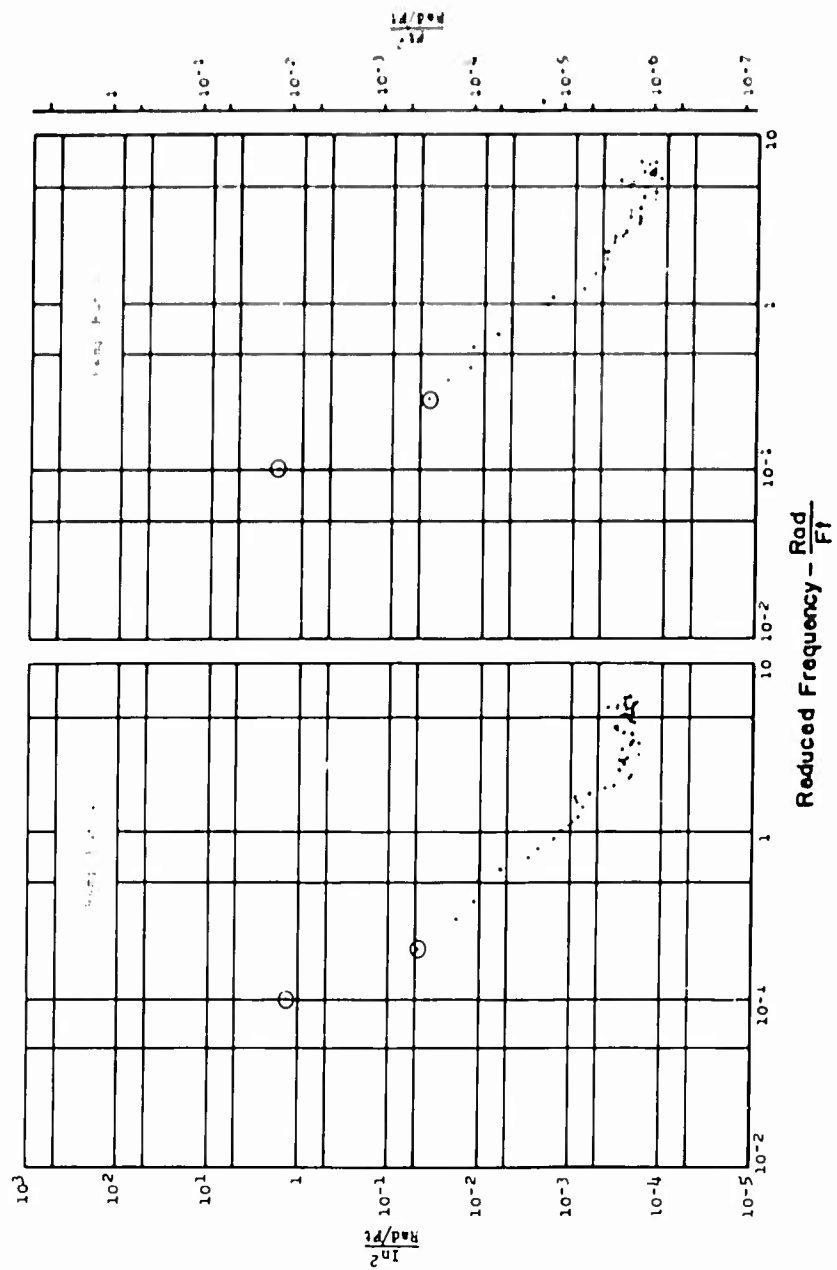


Figure 19 - Power Spectral Density, Castle Air Force Base

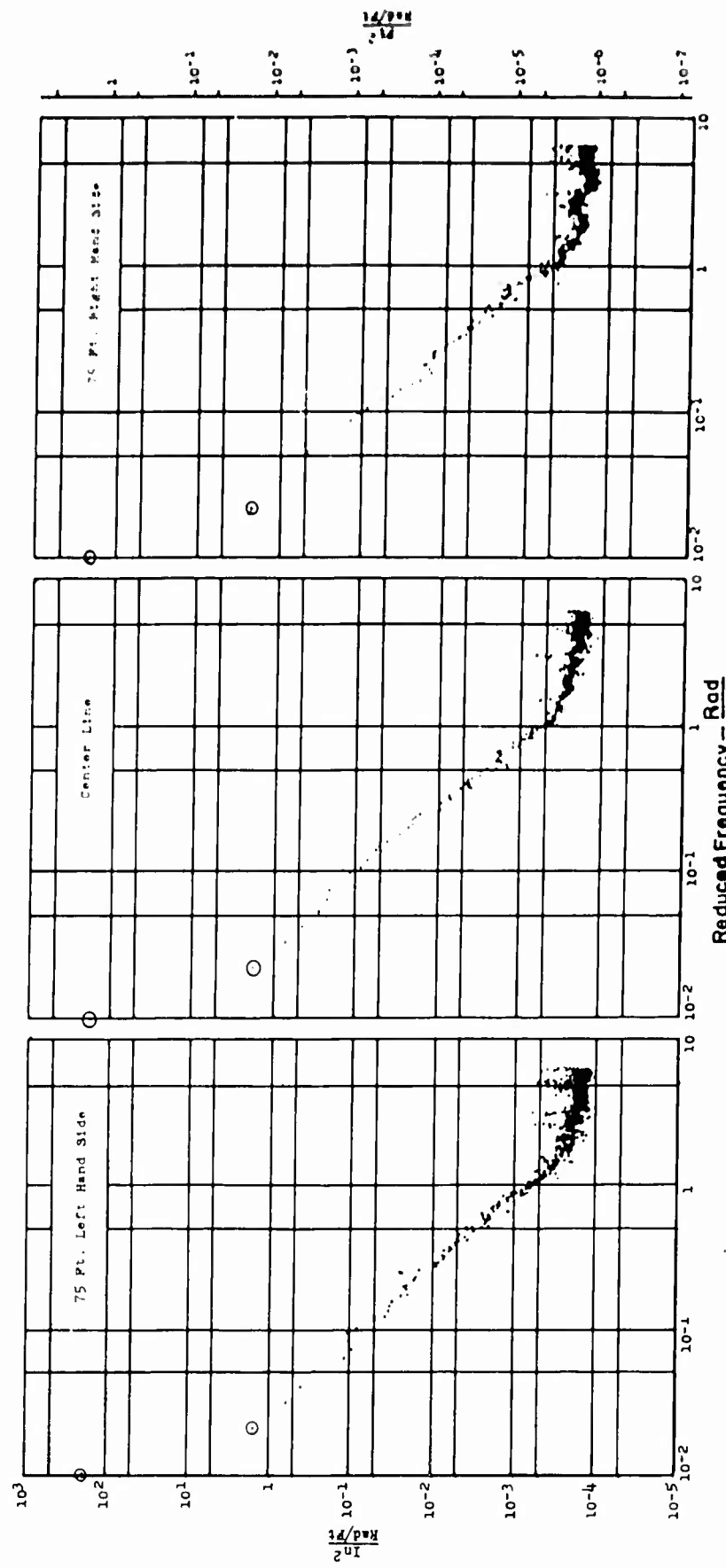


Figure 20 - Power Spectral Density, Runway 10, Dobbins Air Force Base

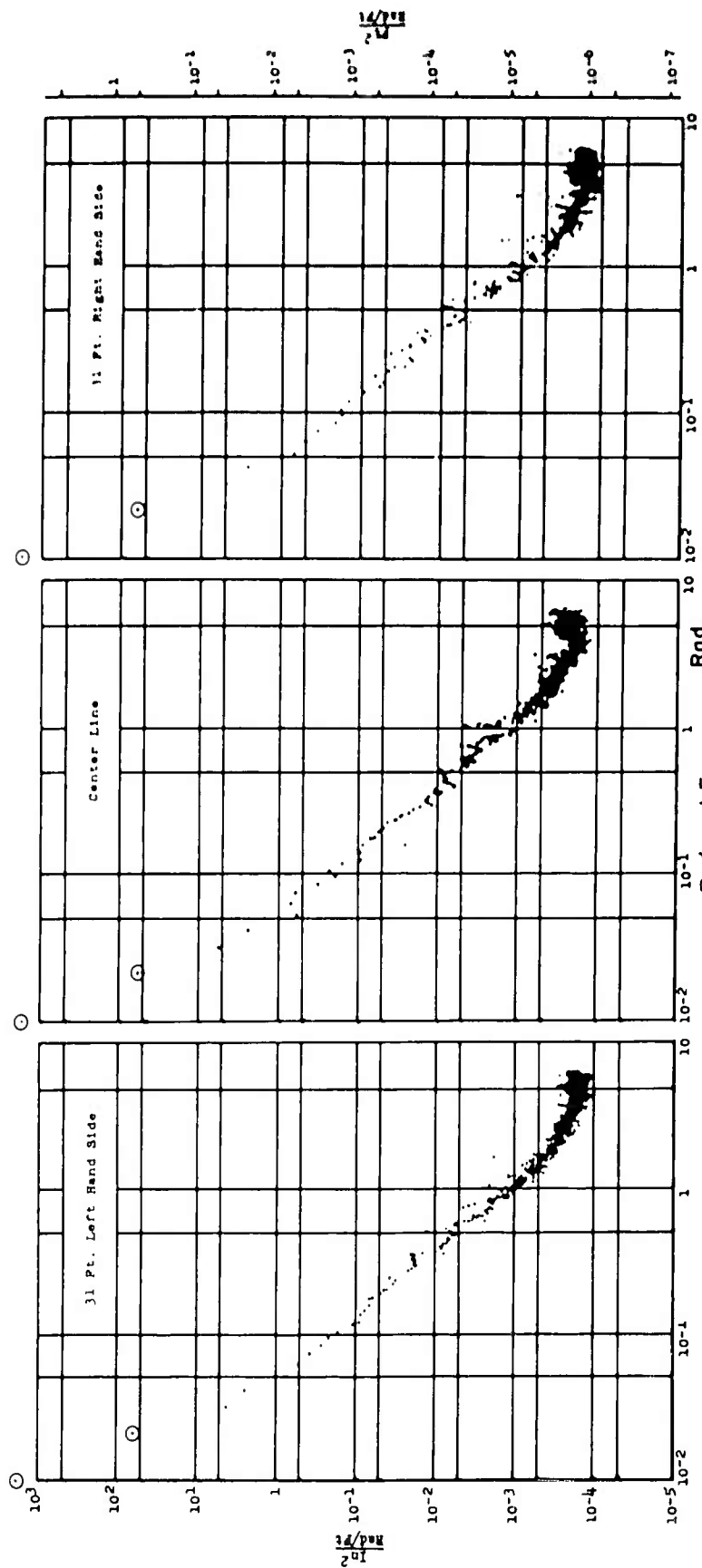


Figure 21 - Power Spectral Density, Taxiway 10, Dobbins Air Force Base

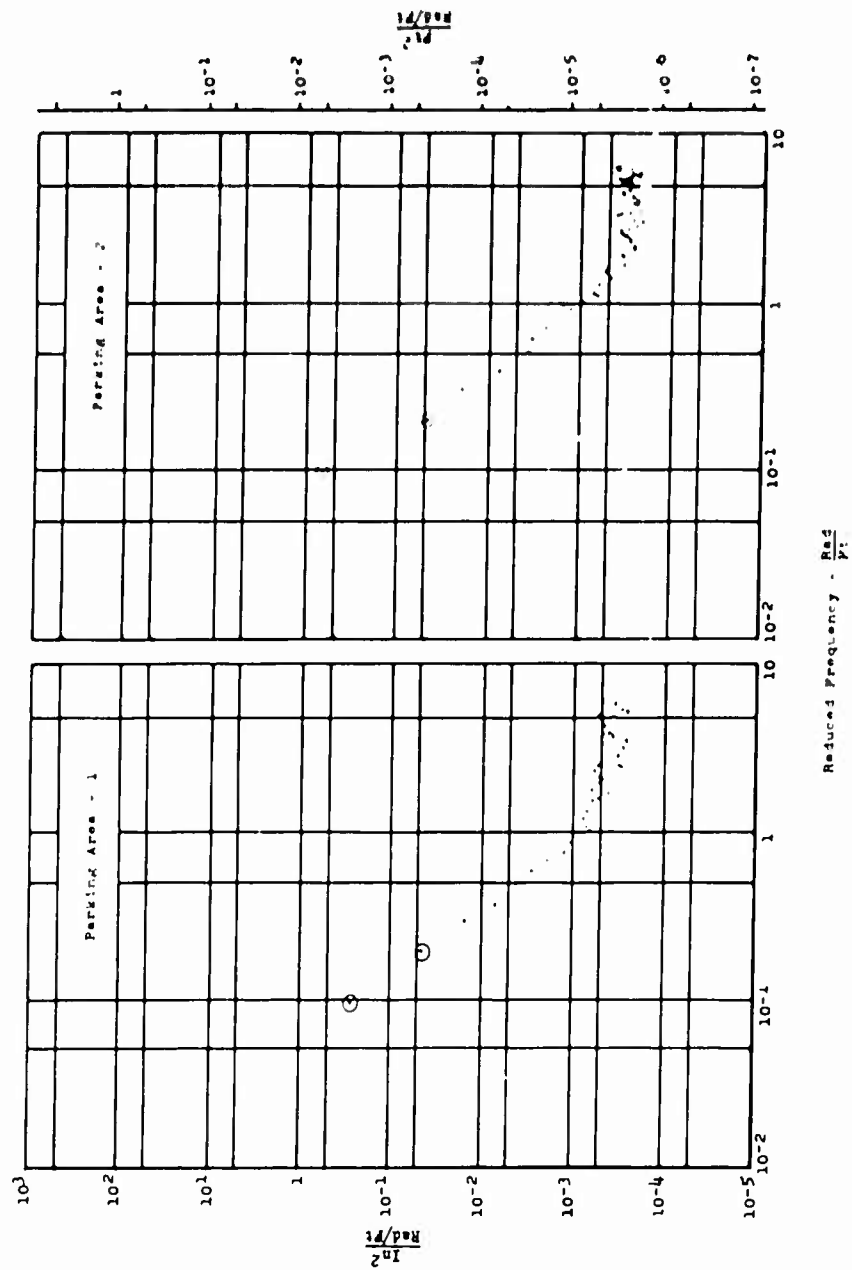


Figure 22 - Power Spectral Density, Dobbins Air Force Base

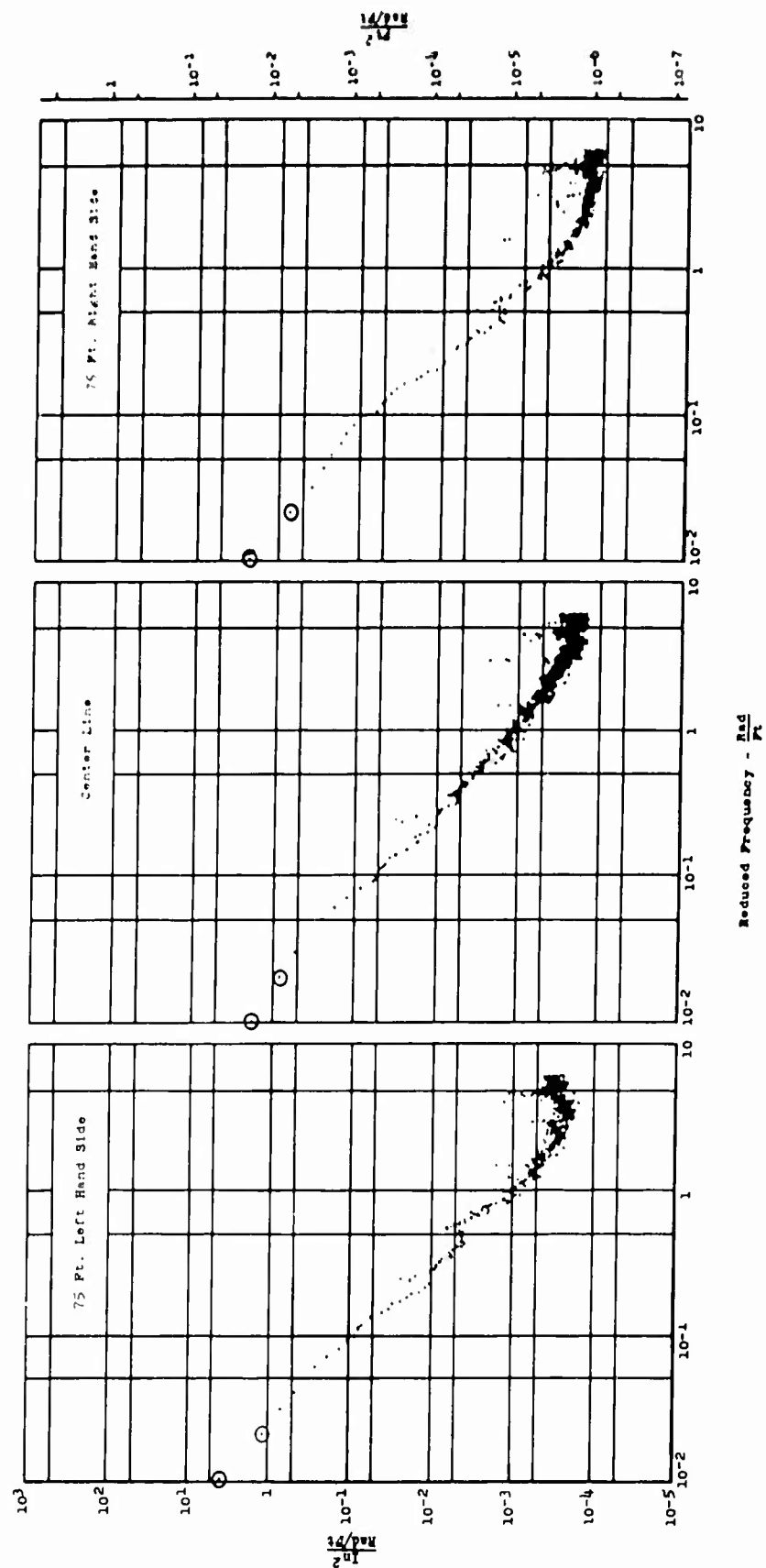


Figure 23 - Power Spectral Density, Runway 4, Edwards Air Force Base

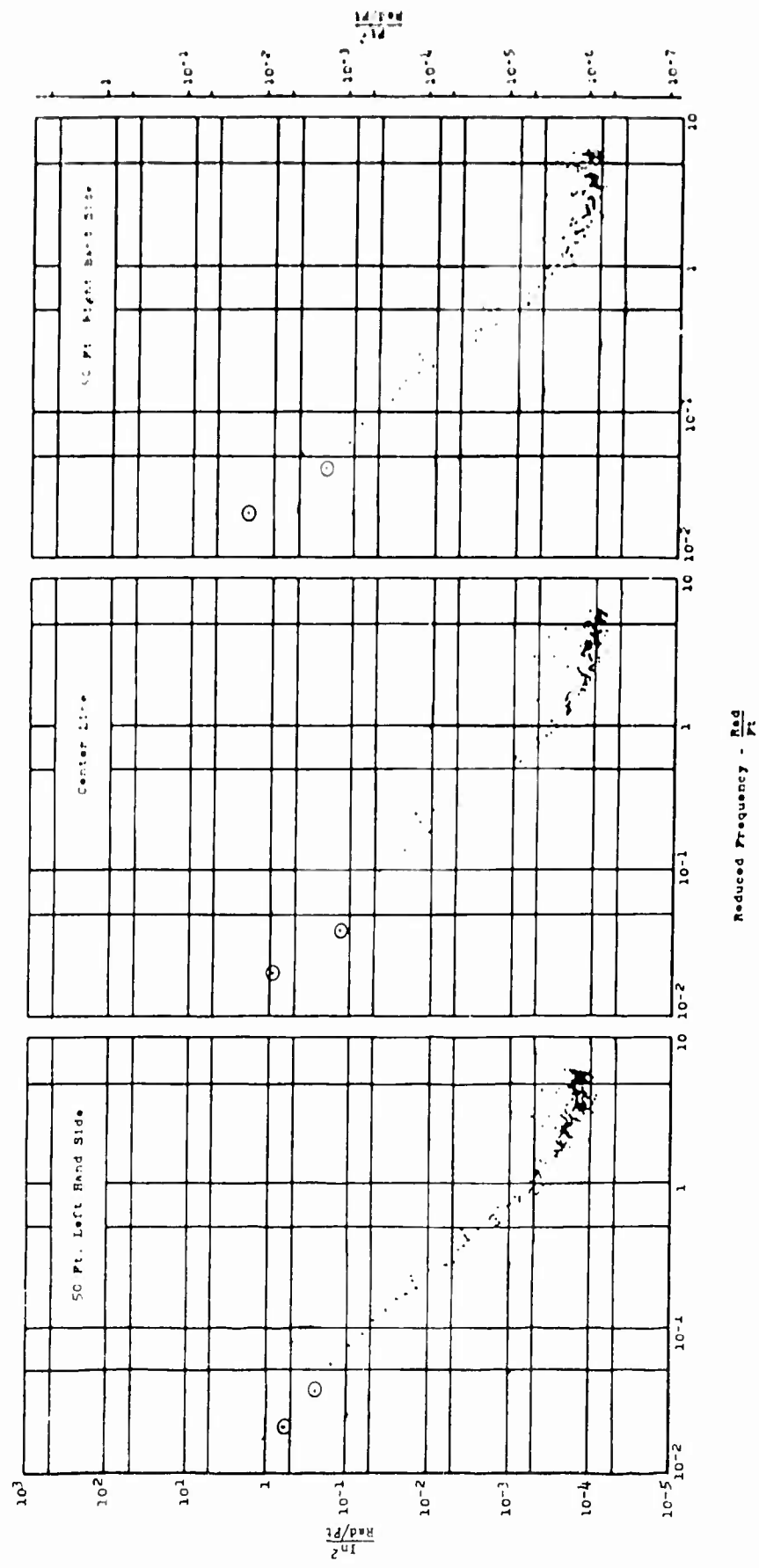


Figure 24 - Power Spectral Density, West Taxiway, Edwards Air Force Base

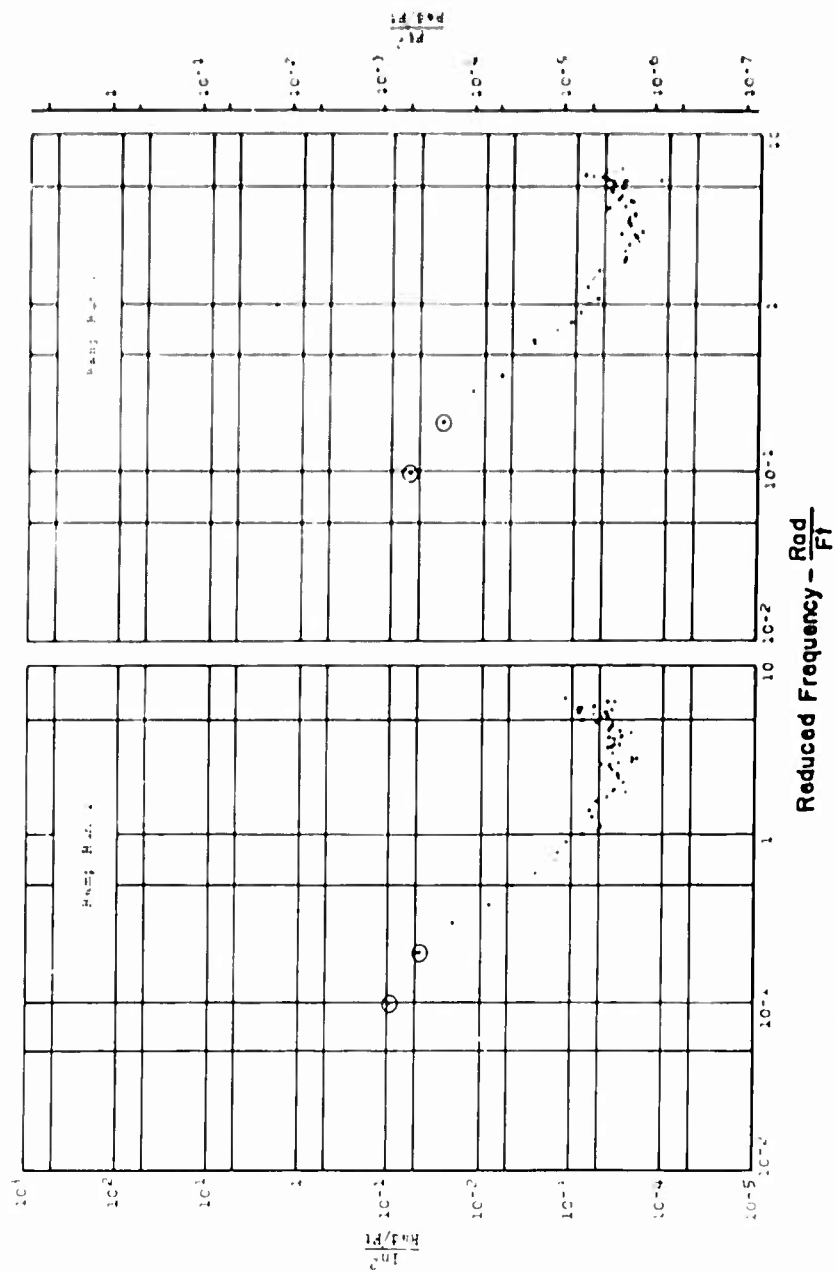


Figure 25 - Power Spectral Density, Edwards Air Force Base

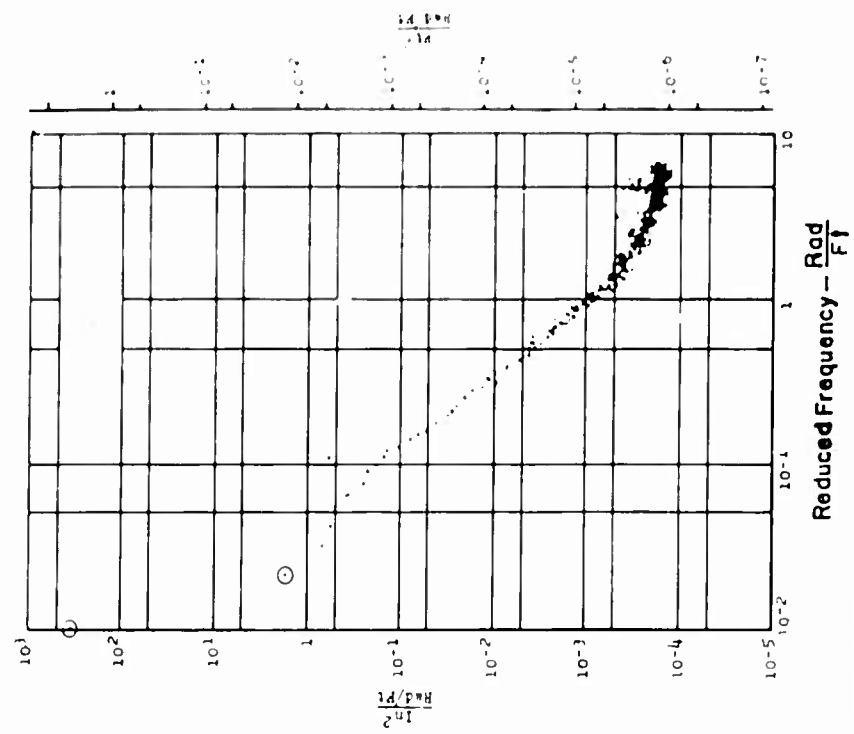


Figure 25 - Power Spectral Density, Runway 30, Ellsworth Air Force Base

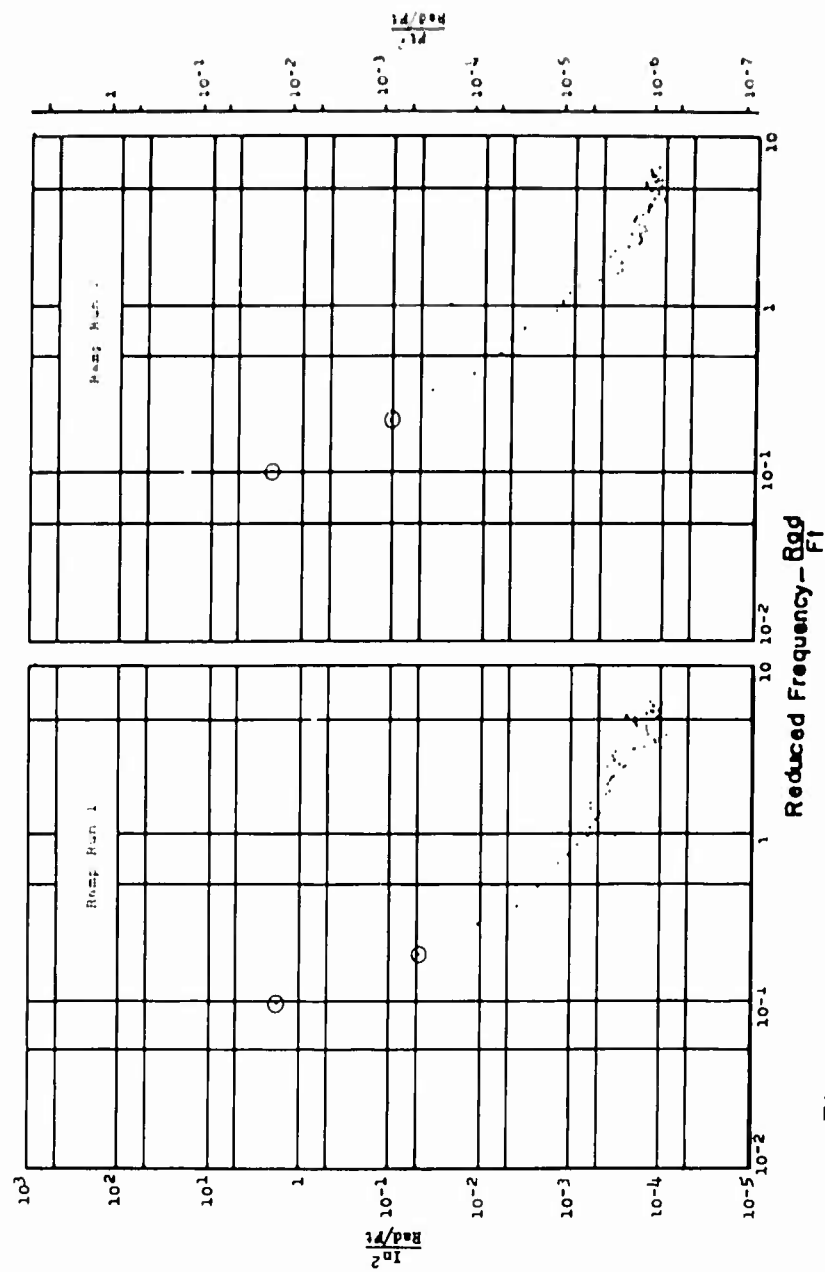


Figure 27 - Power Spectral Density, Ellsworth Air Force Base

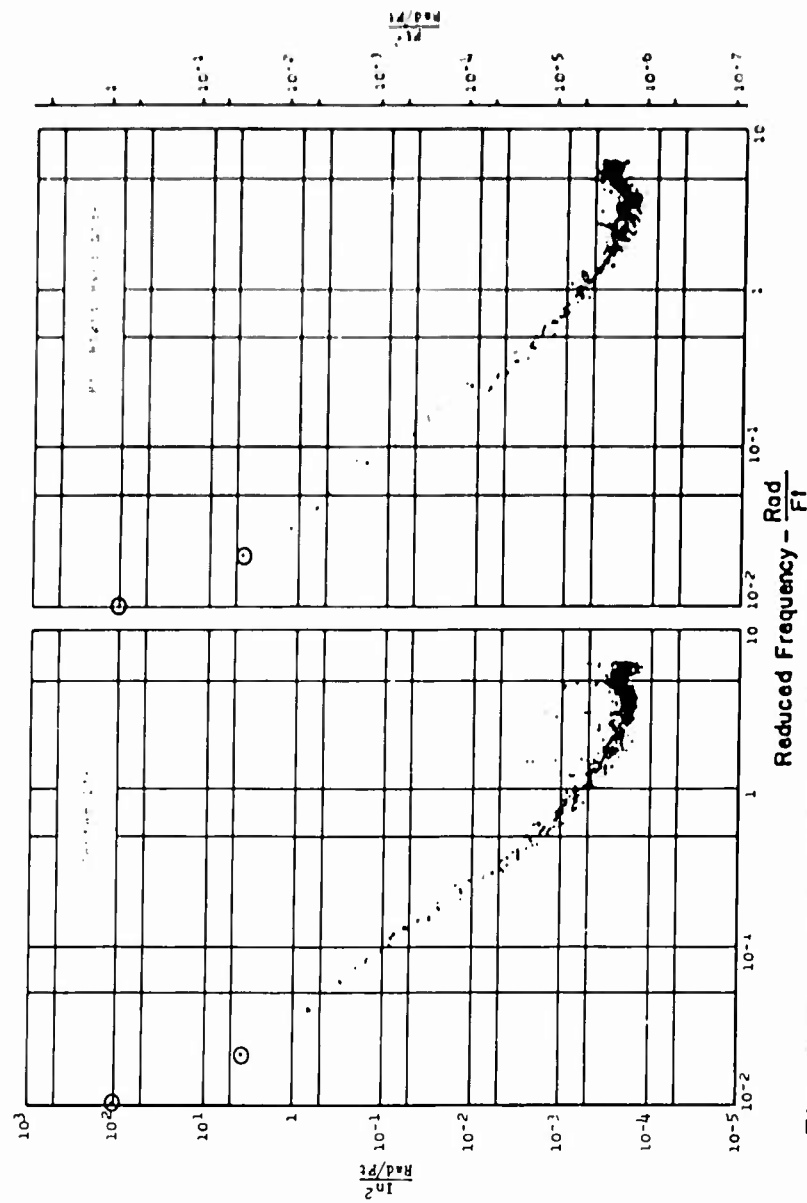


Figure 28 - Power Spectral Density, Runway 16, George Air Force Base

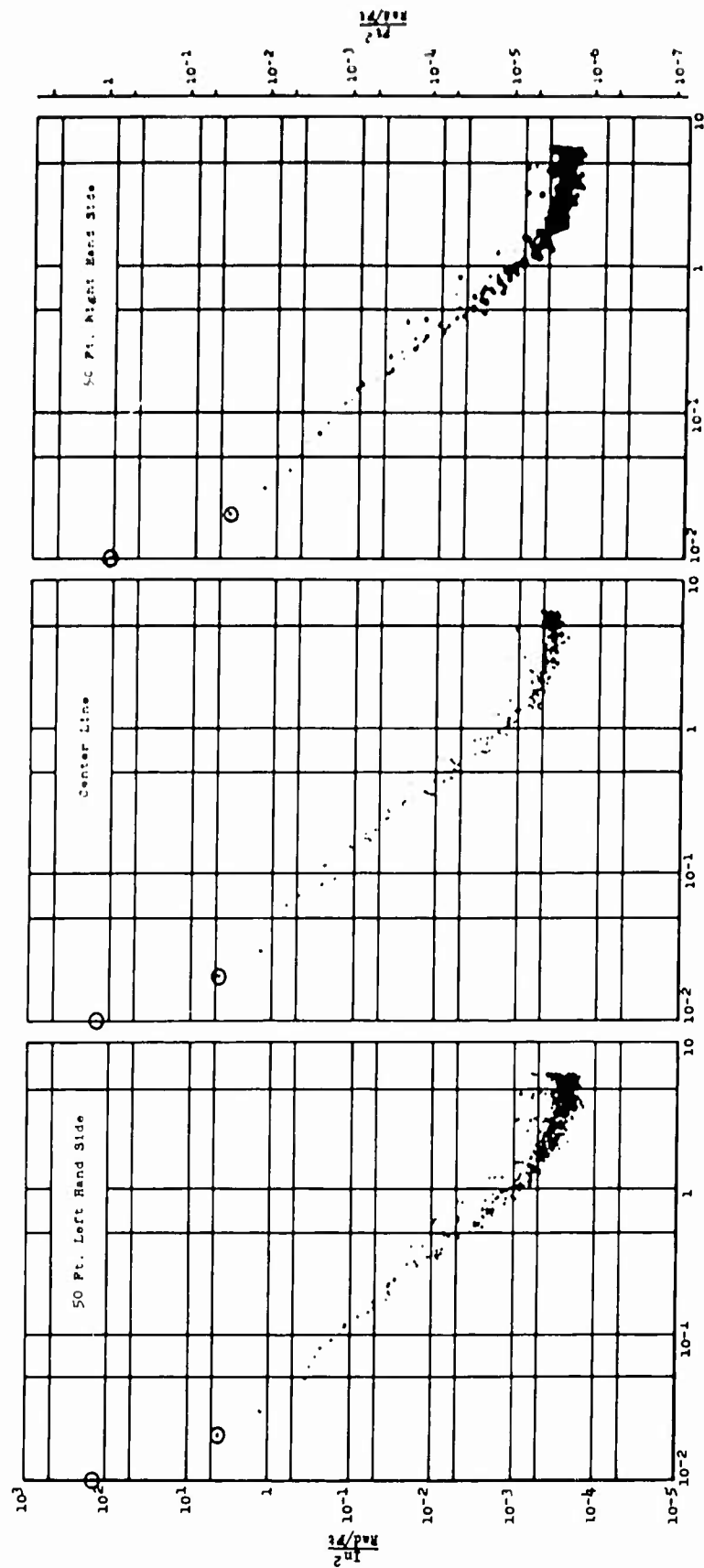


Figure 29 - Power Spectral Density, Runway 3, George Air Force Base

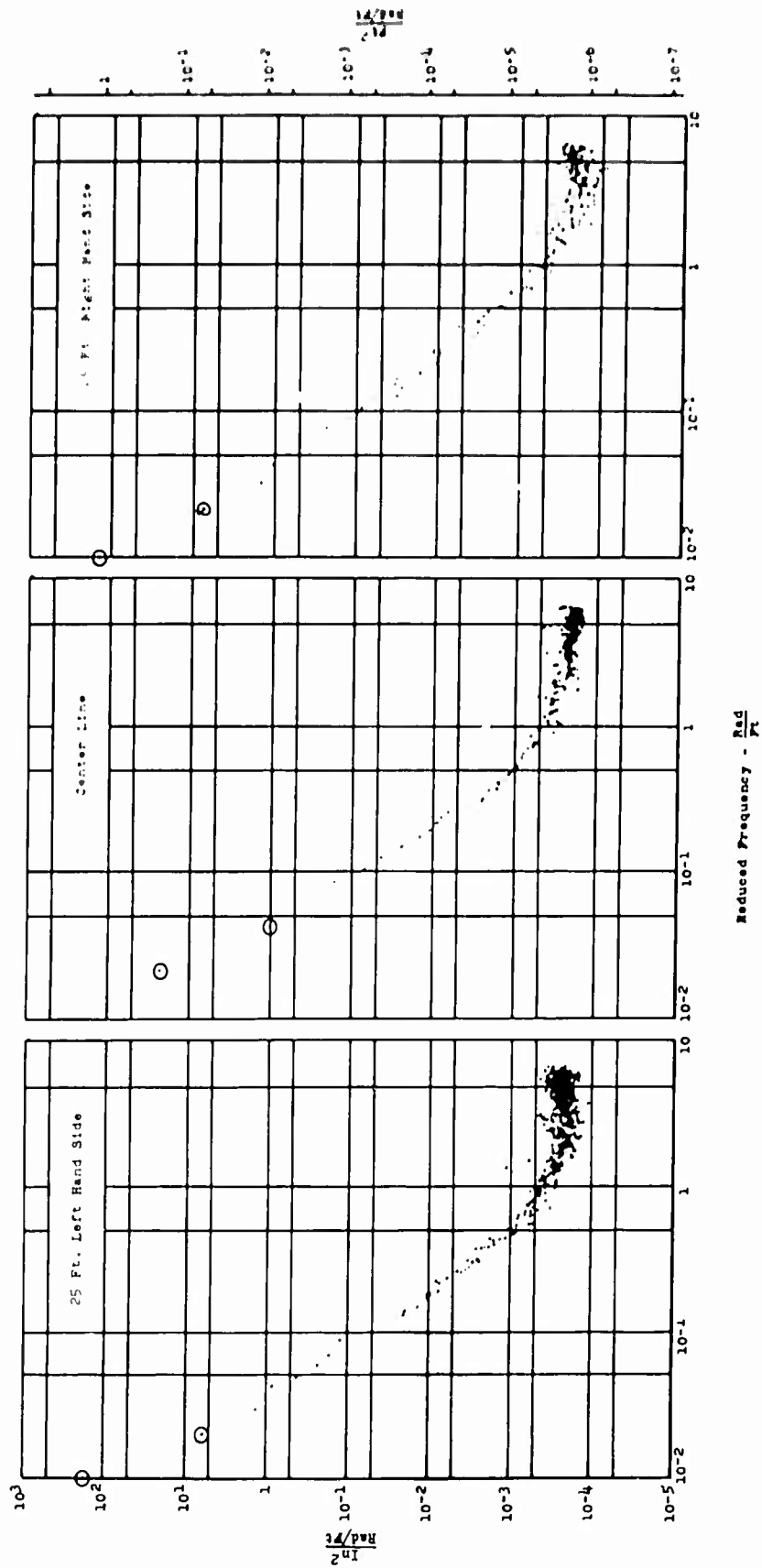


Figure 30 - Power Spectral Density, Taxiway 5, George Air Force Base

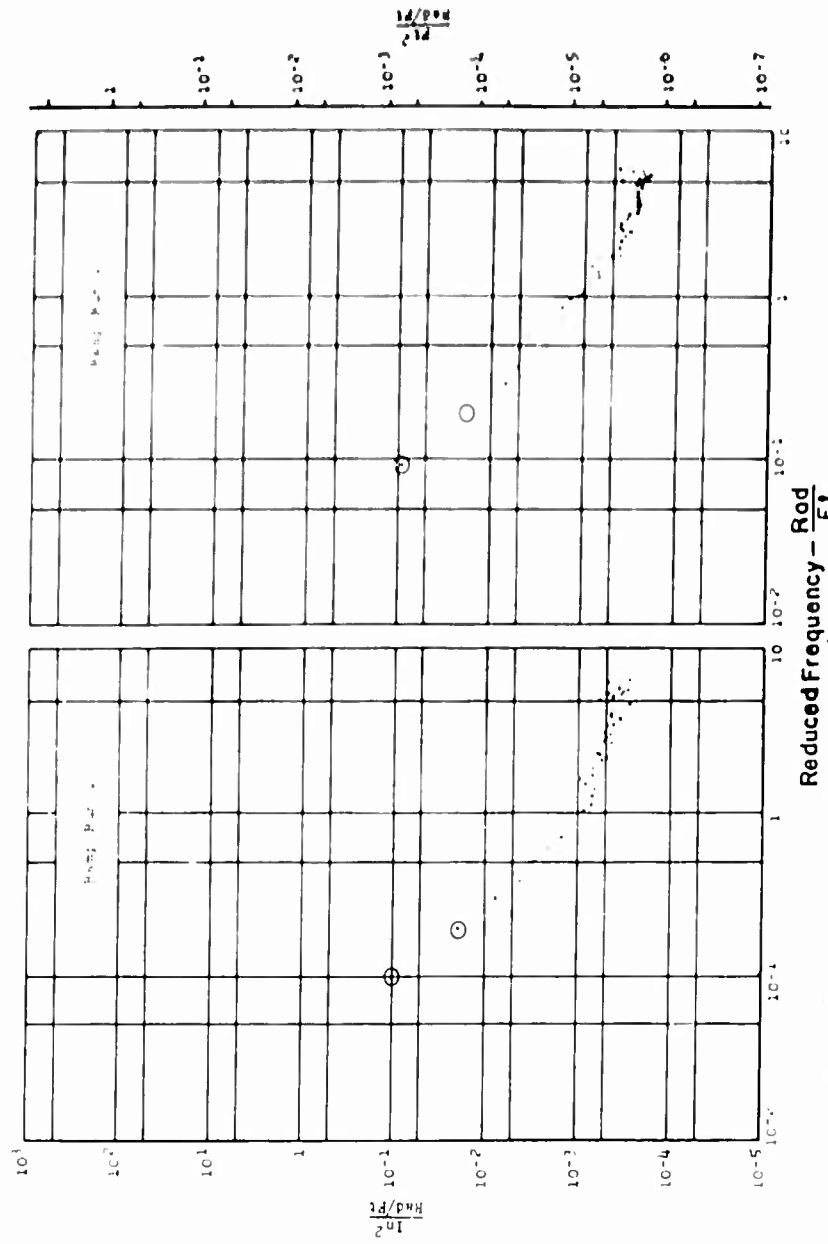


Figure 31 - Power Spectral Density, George Air Force Base

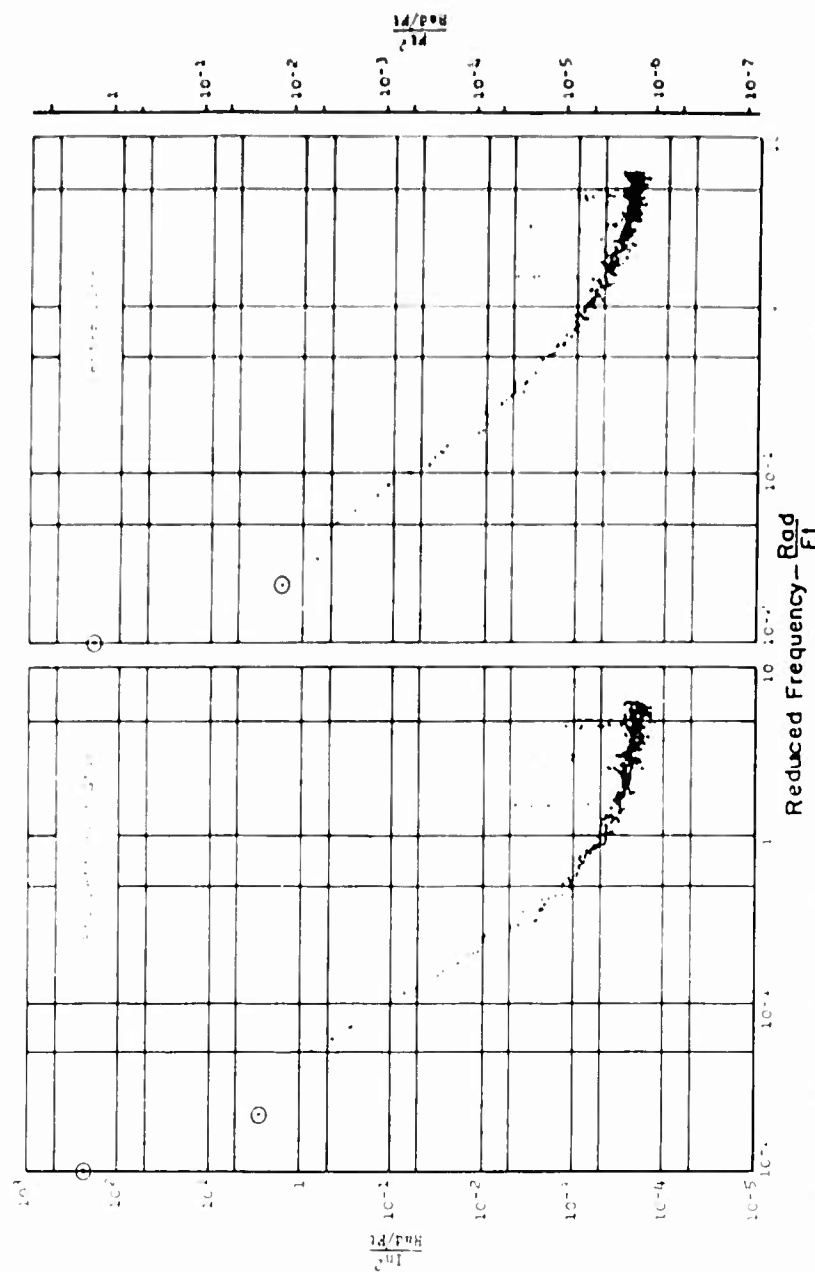


Figure 32 - Power Spectral Density, Runway 10, Glasgow Air Force Base

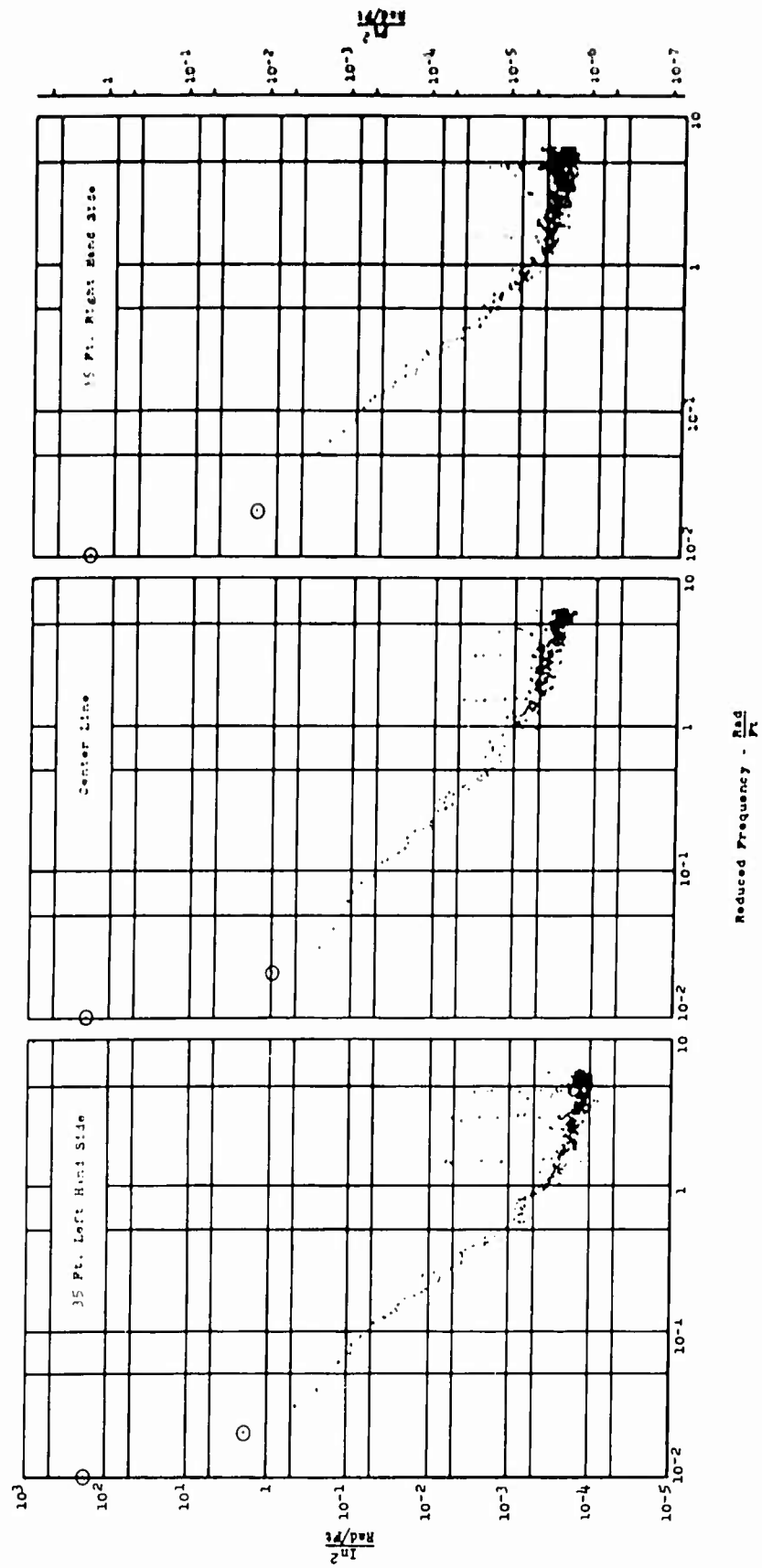


Figure 33 - Power Spectral Density, Taxiway 10, Glasgow Air Force Base

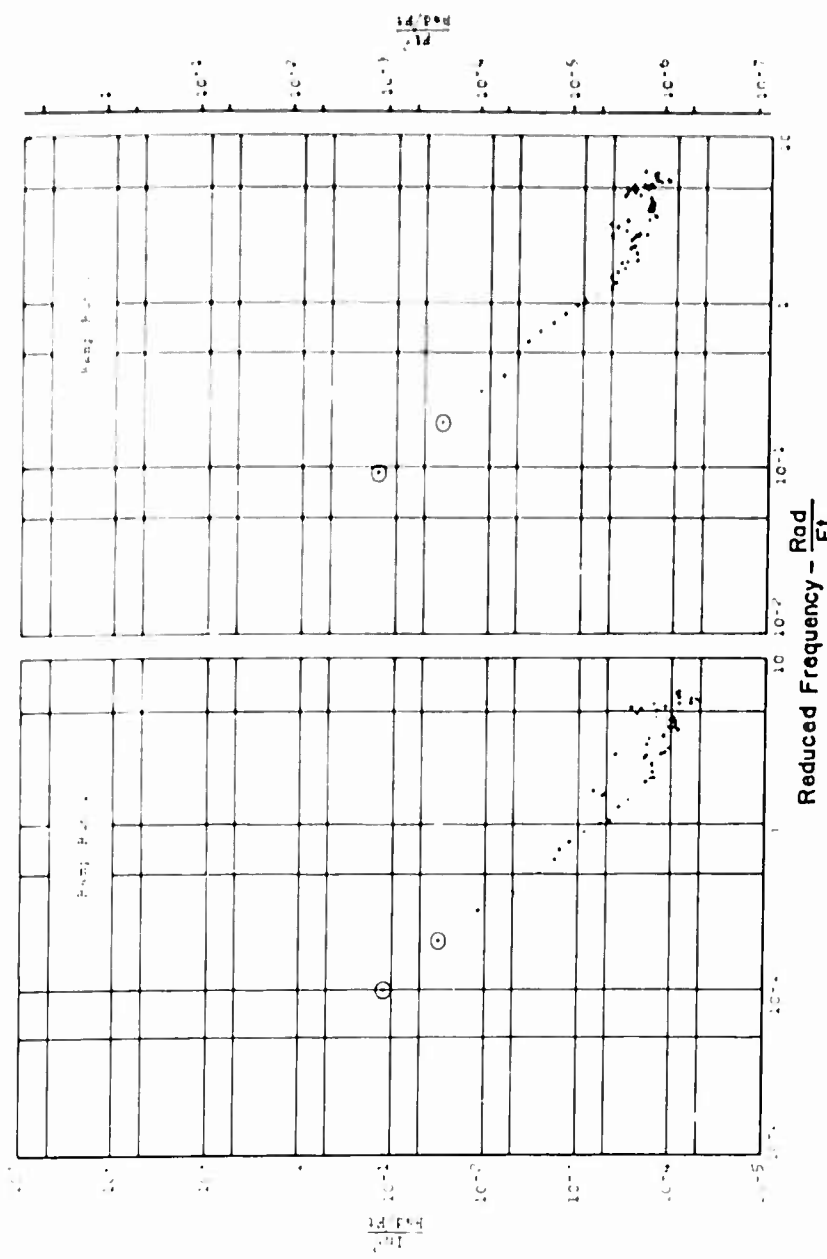


Figure 34 - Power Spectral Density, Glasgow Air Force Base

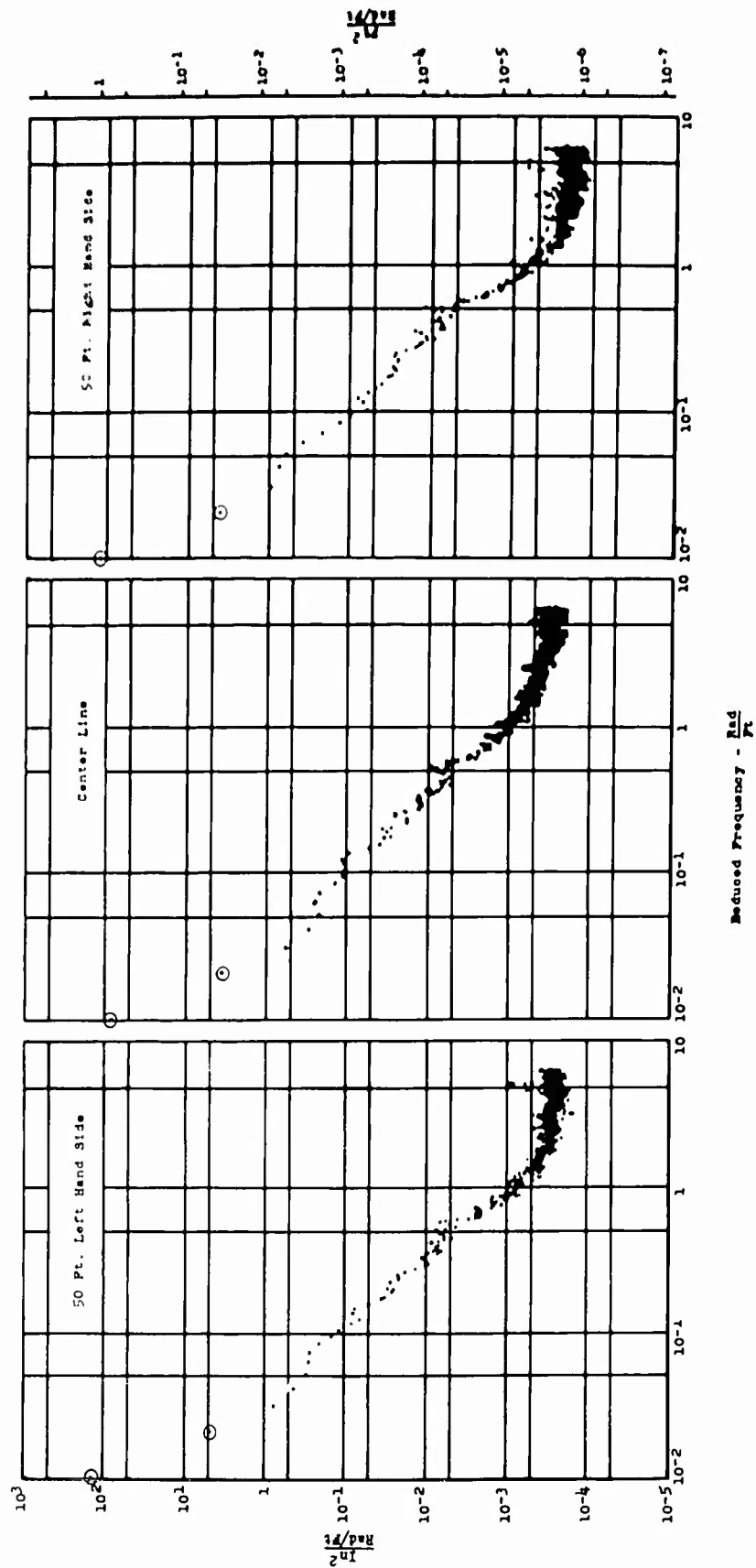


Figure 35 - Power Spectral Density, Runway 7, Langley Air Force Base

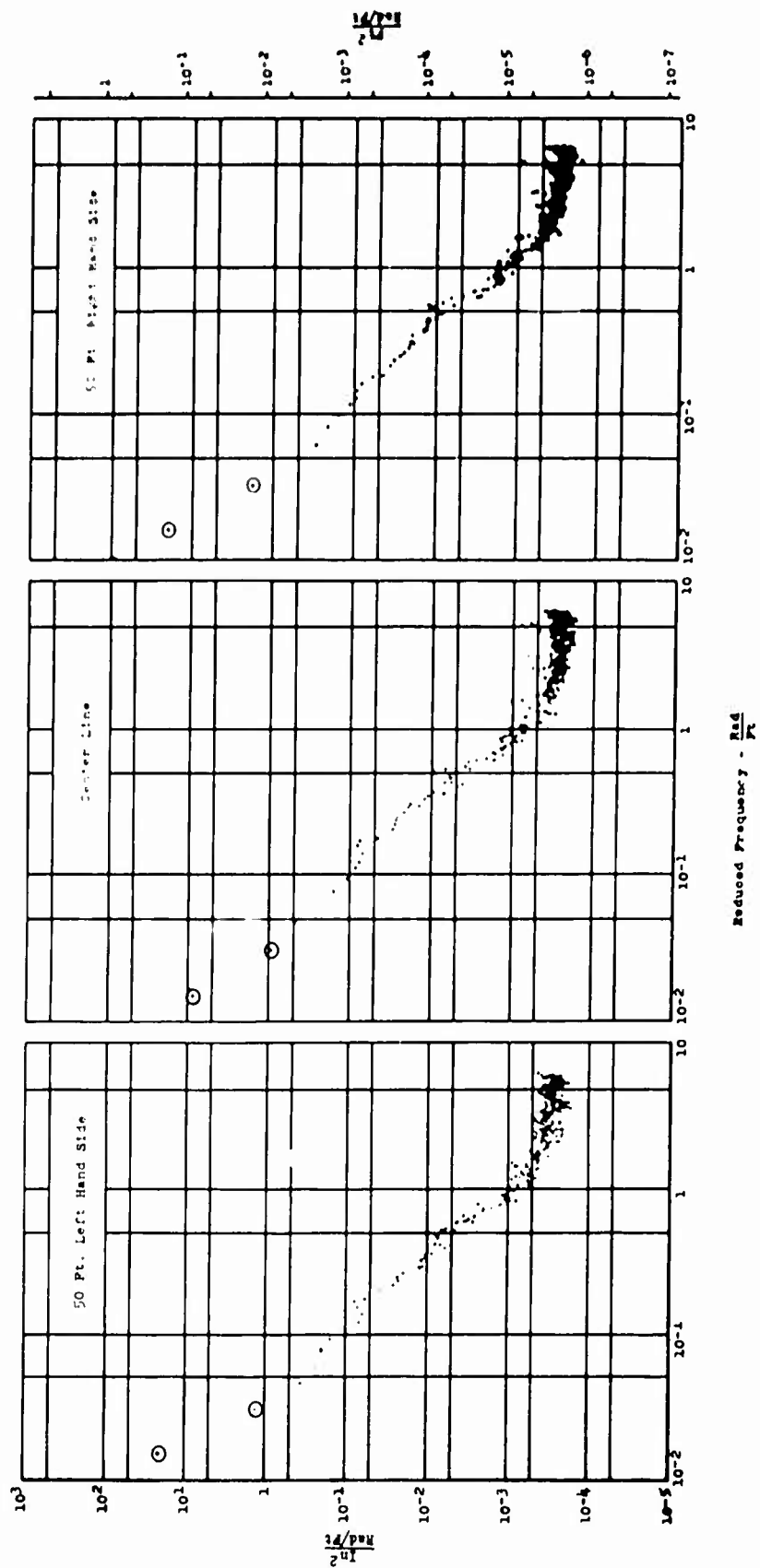


Figure 36 - Power Spectral Density, Runway 35, Langley Air Force Base

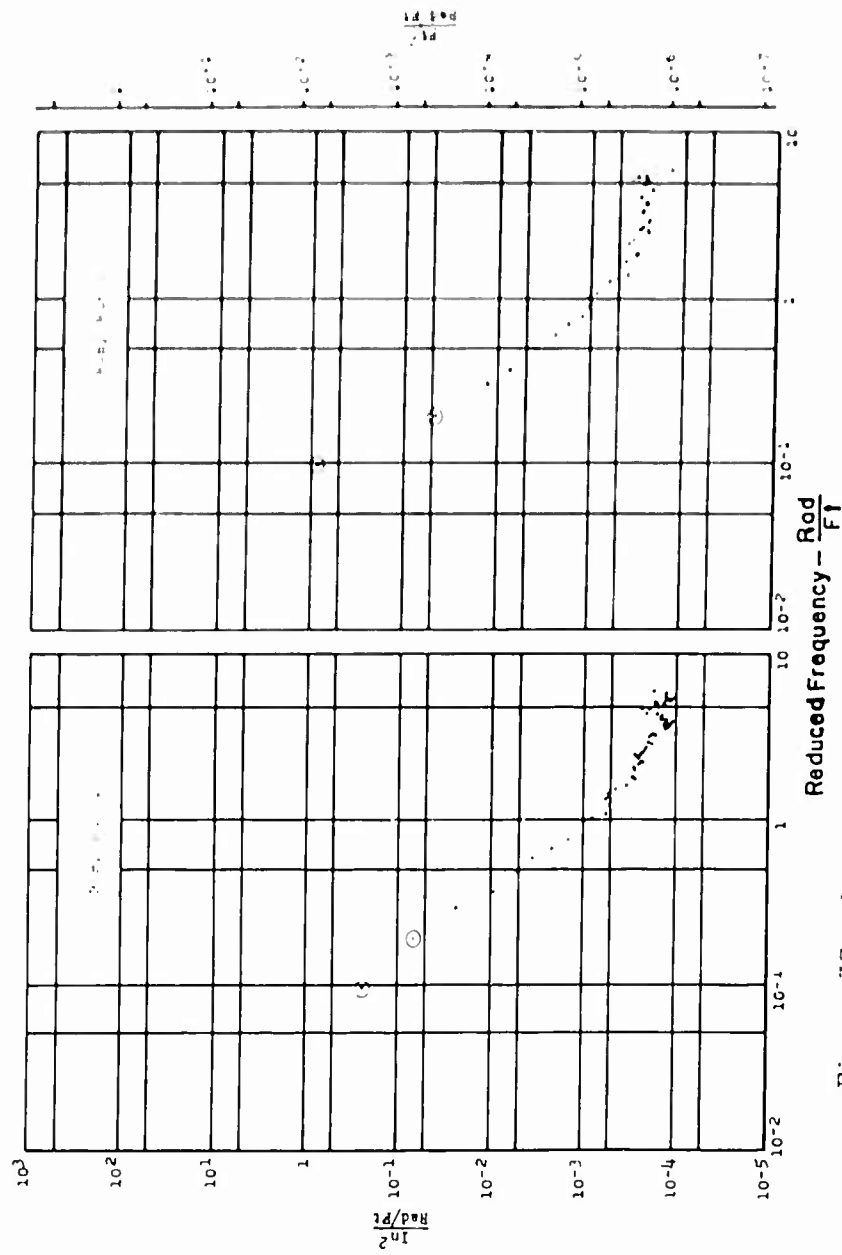


Figure 37 - Lower Spectral Density, Langley Air Force Base

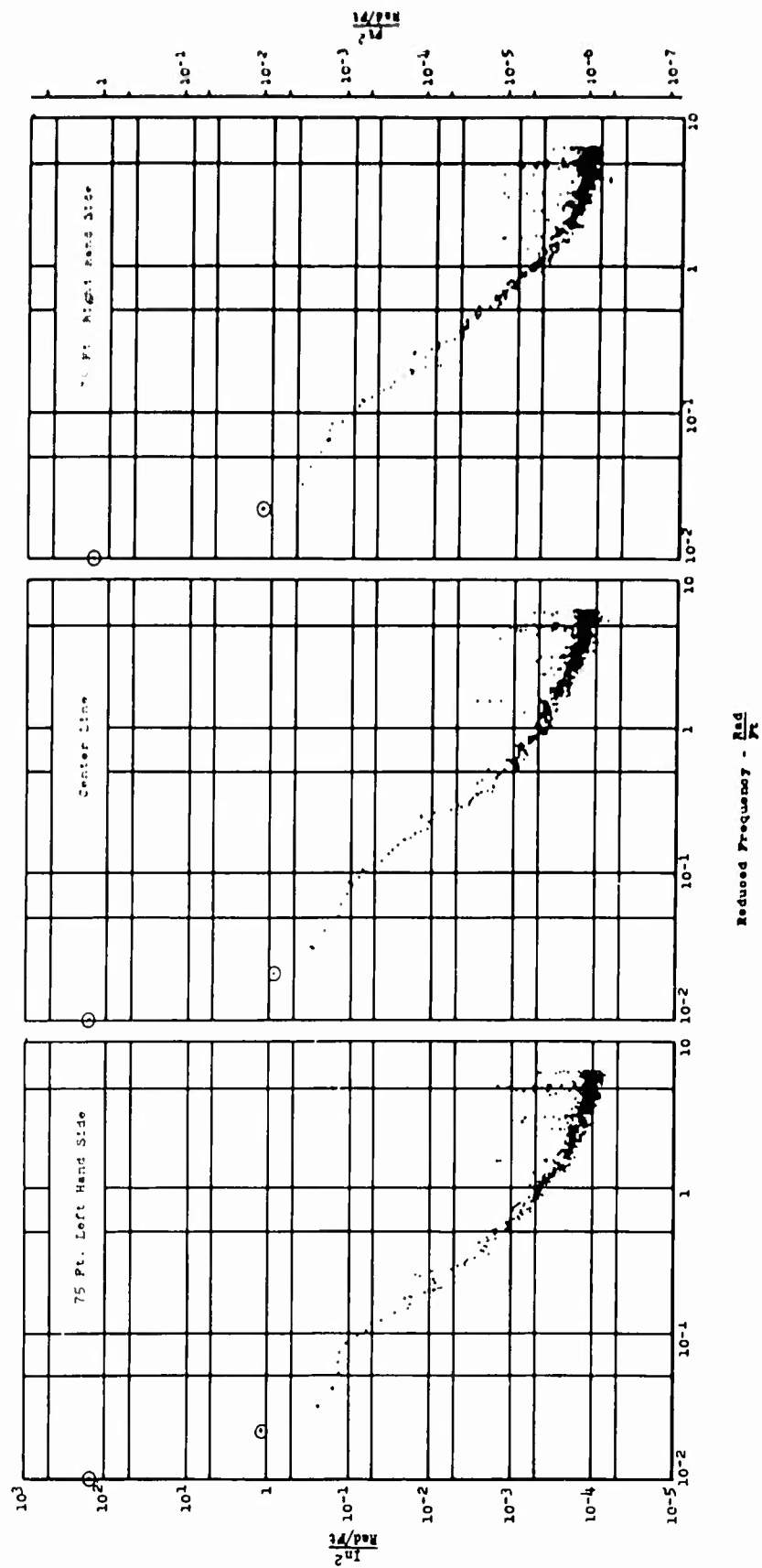


Figure 38 - Power Spectral Density, Runway 32, Larson Air Force Base

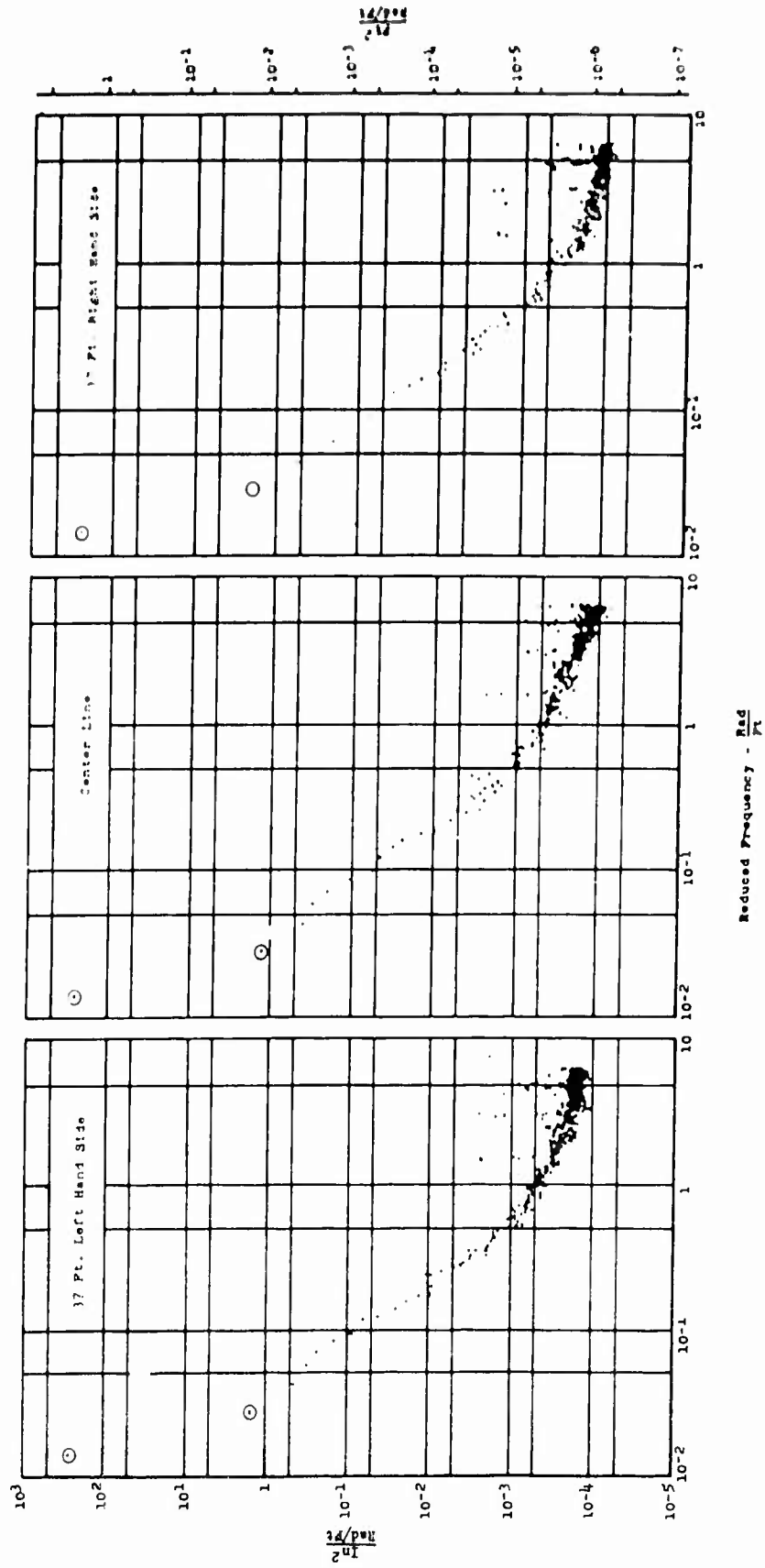


Figure 39 - Power Spectral Density, Taxiway 3, Larson Air Force Base

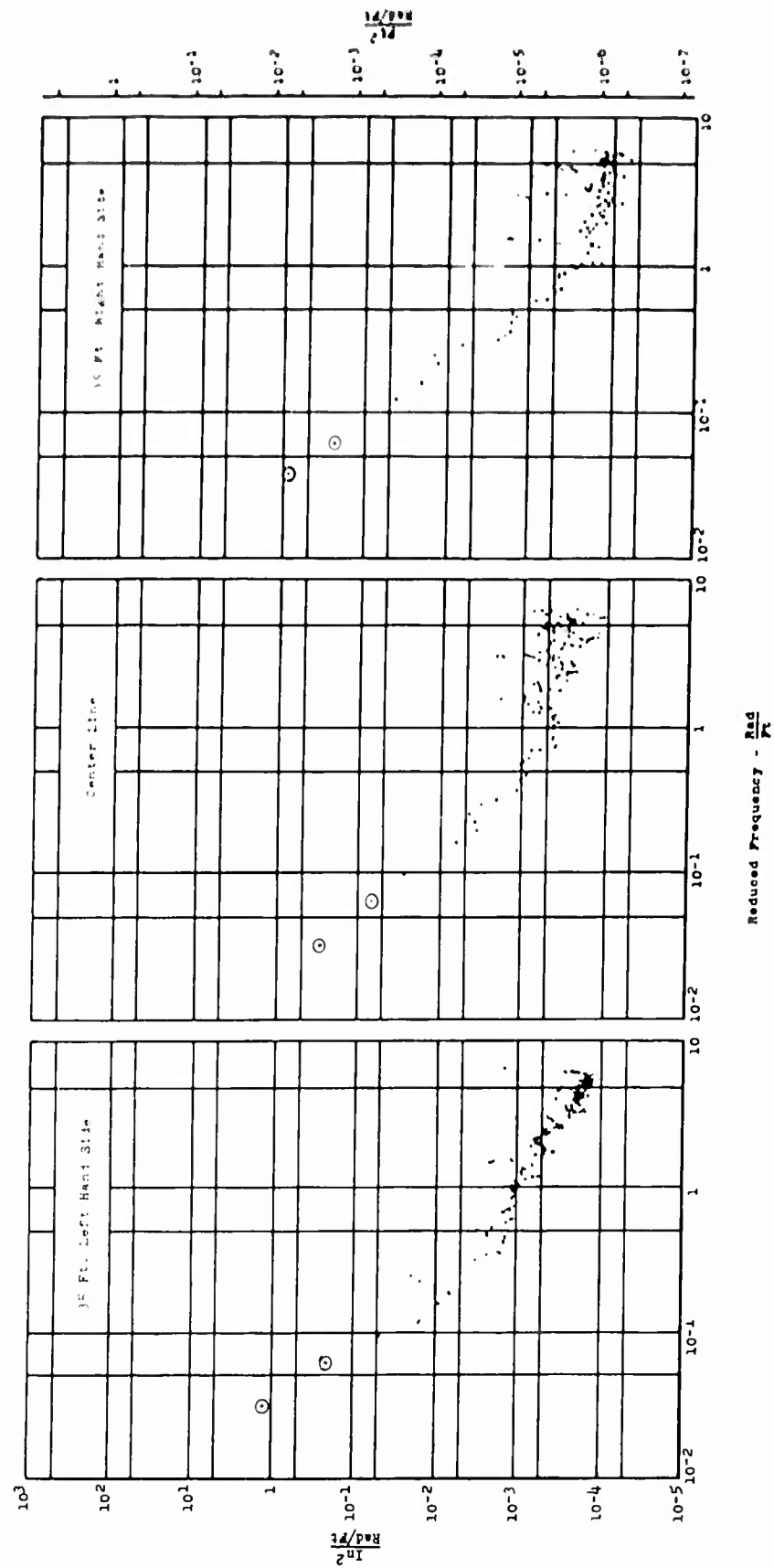


Figure 40 - Power Spectral Density, Taxiway 4, Larson Air Force Base

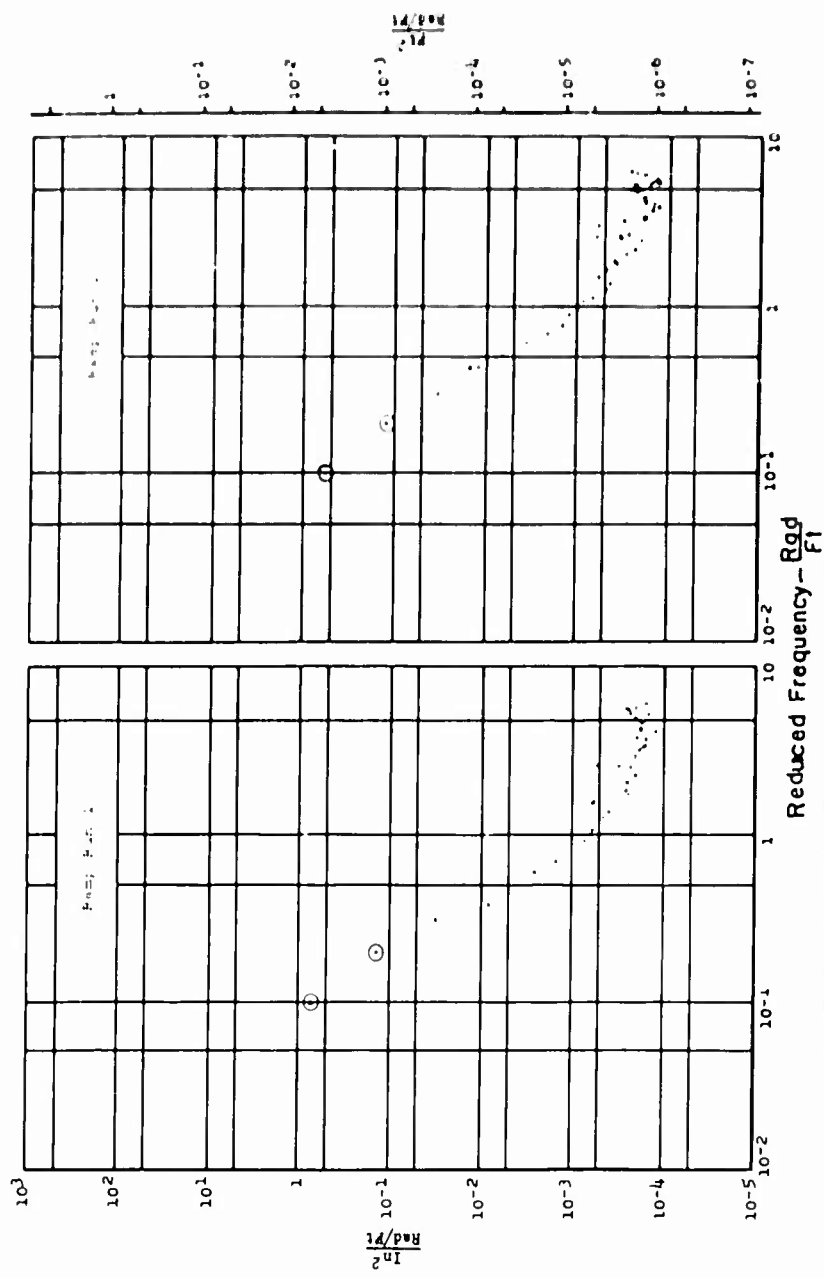


Figure 41 - Power Spectral Density, Larson Air Force Base

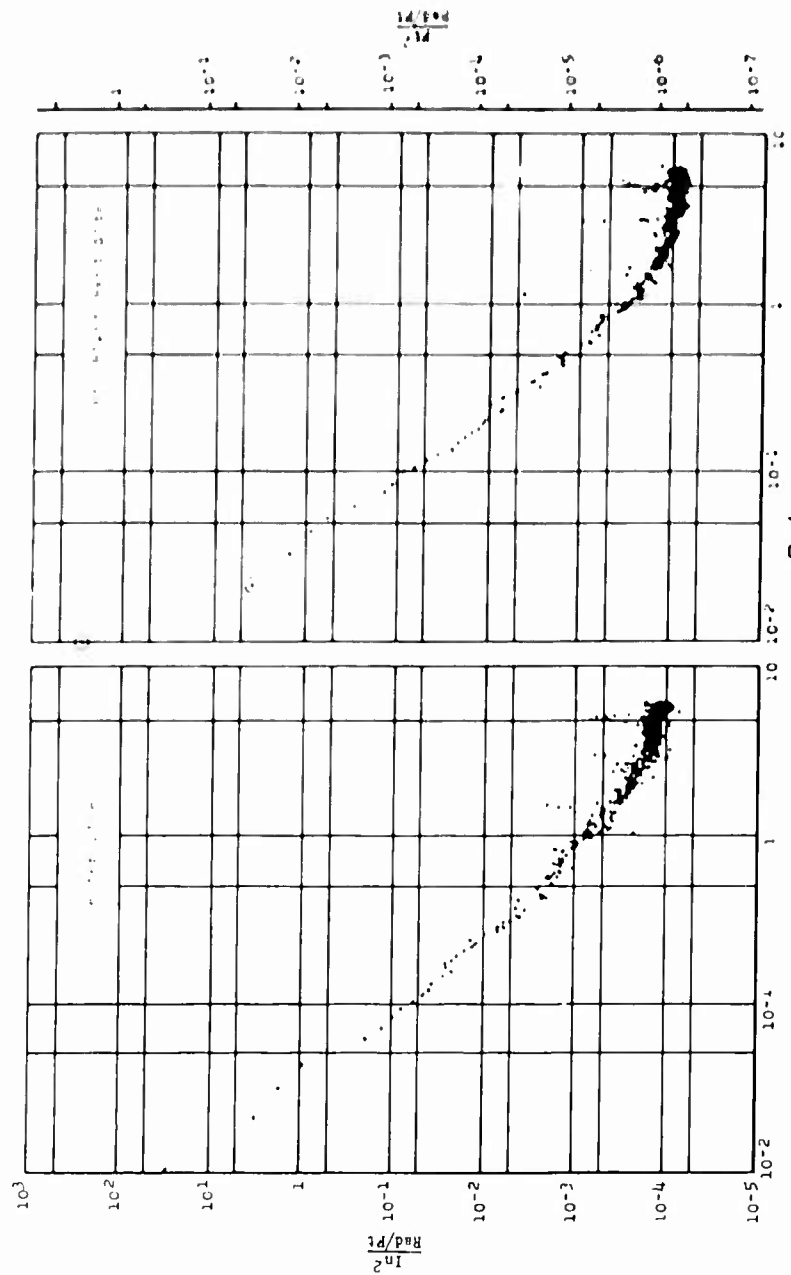


Figure 42 - Power Spectral Density, Runway 22 L, Mather Air Force Base

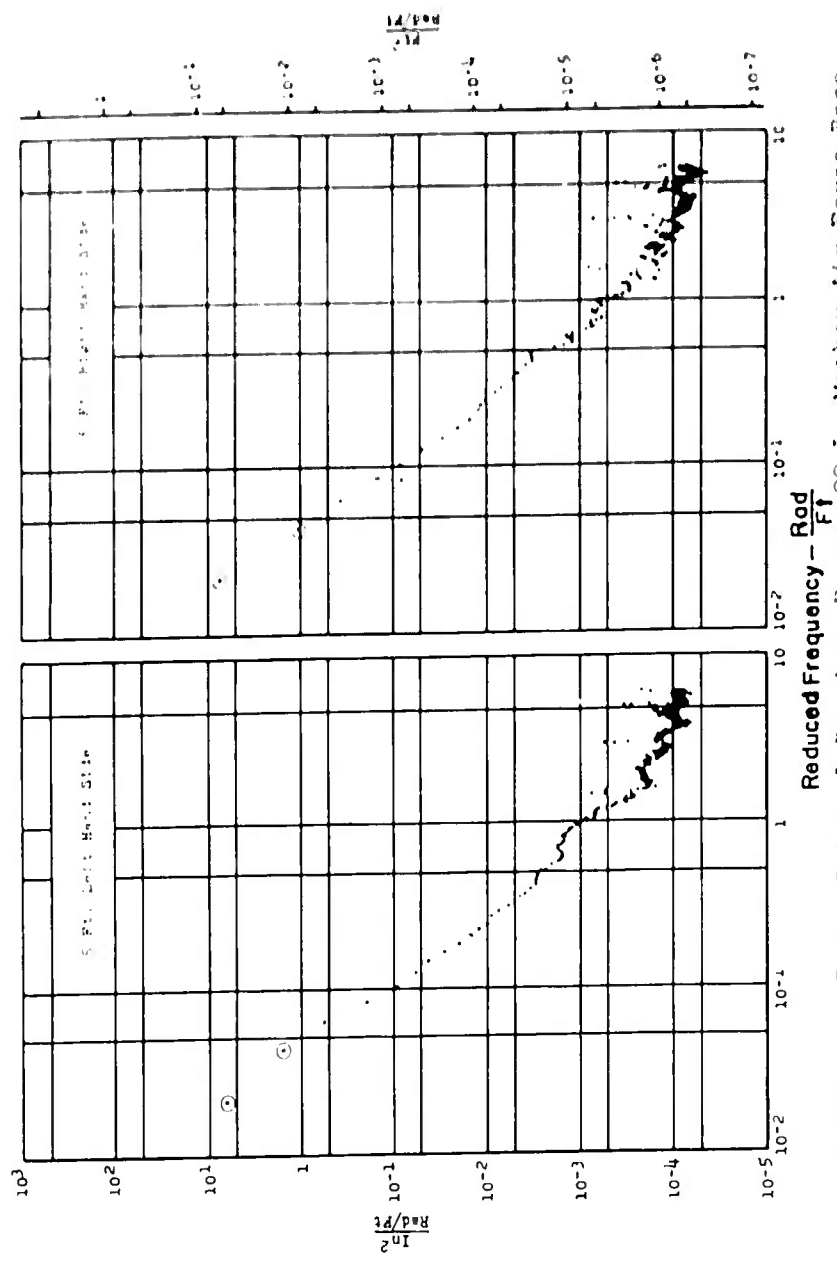


Figure 43 - Power Spectral Density, Runway 22 L, Mather Air Force Base

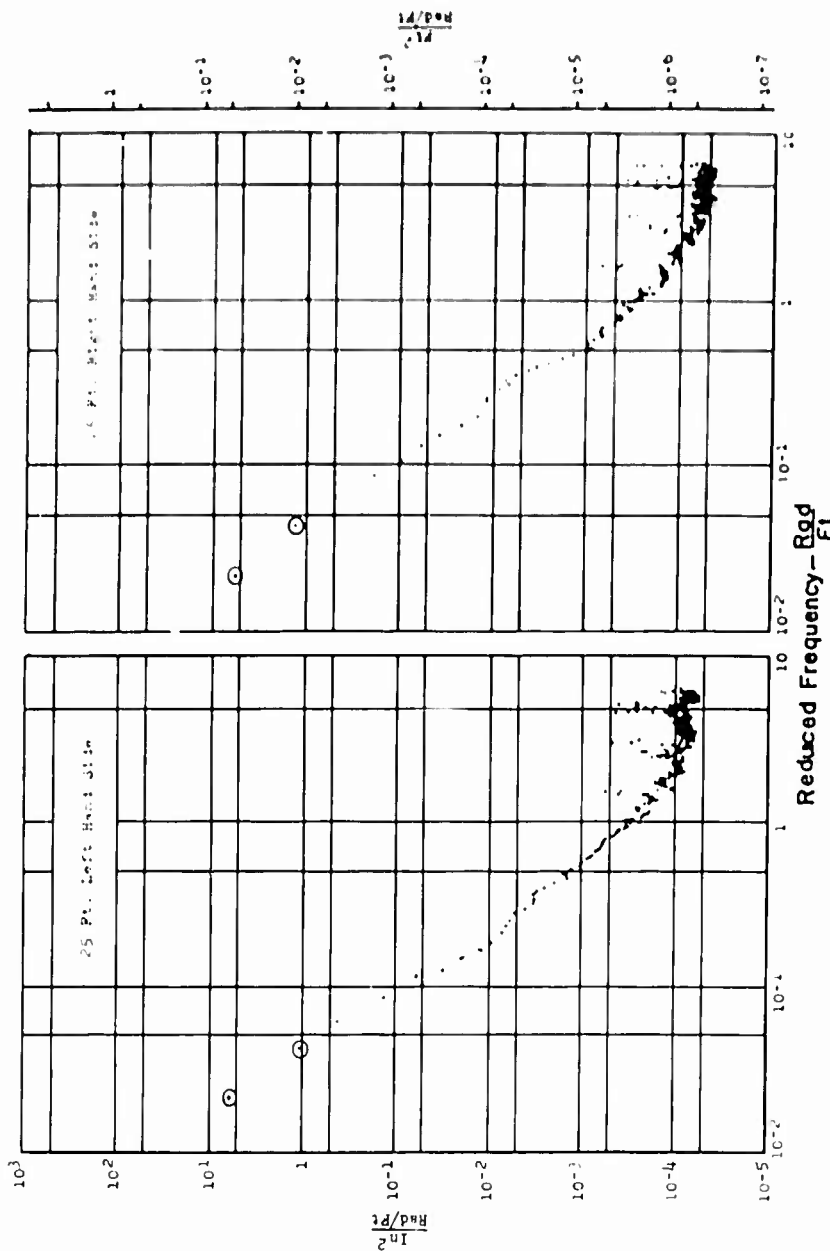


Figure 44 - Power Spectral Density, Runway 22 L, Mather Air Force Base

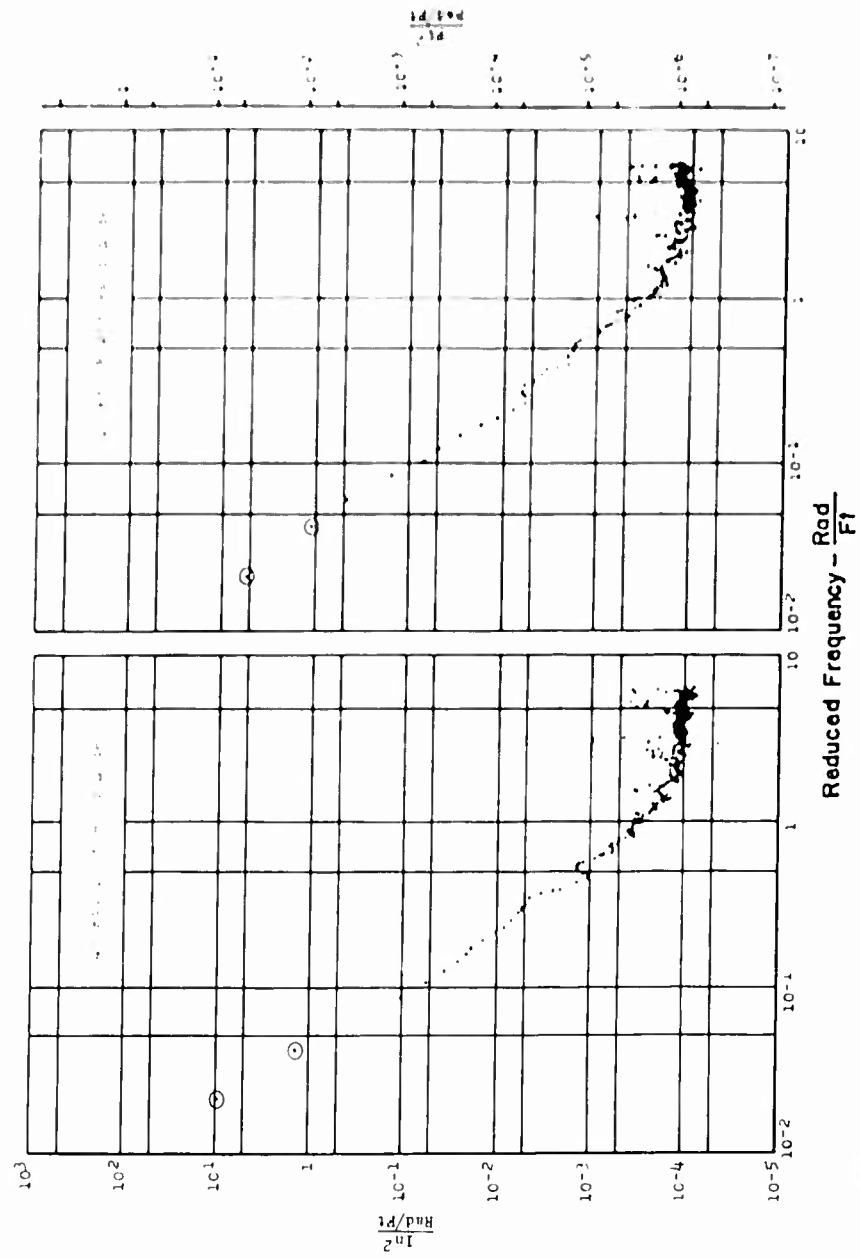


Figure 45 - Power Spectral Density, Runway 22 L, Mather Air Force Base

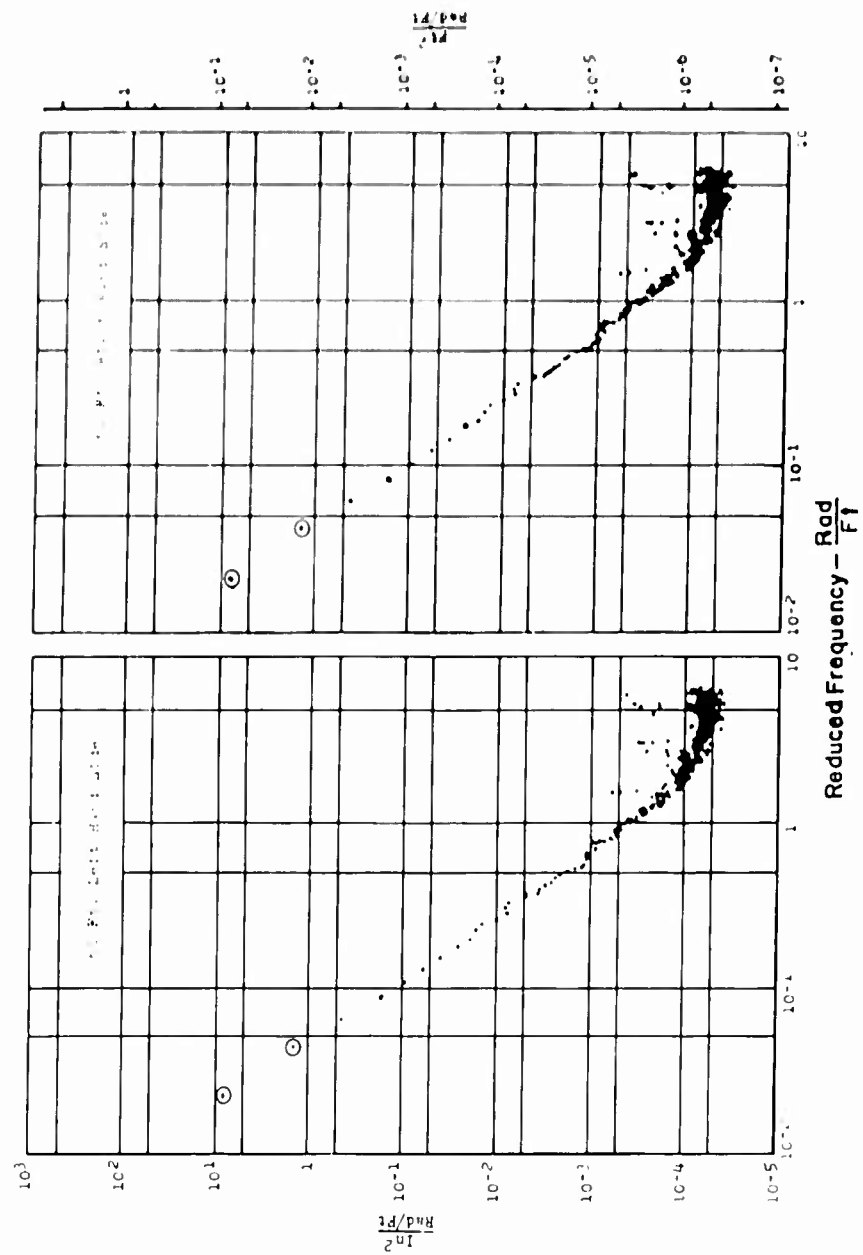


Figure 46 - Power Spectral Density, Runway 22 L, Mather Air Force Base

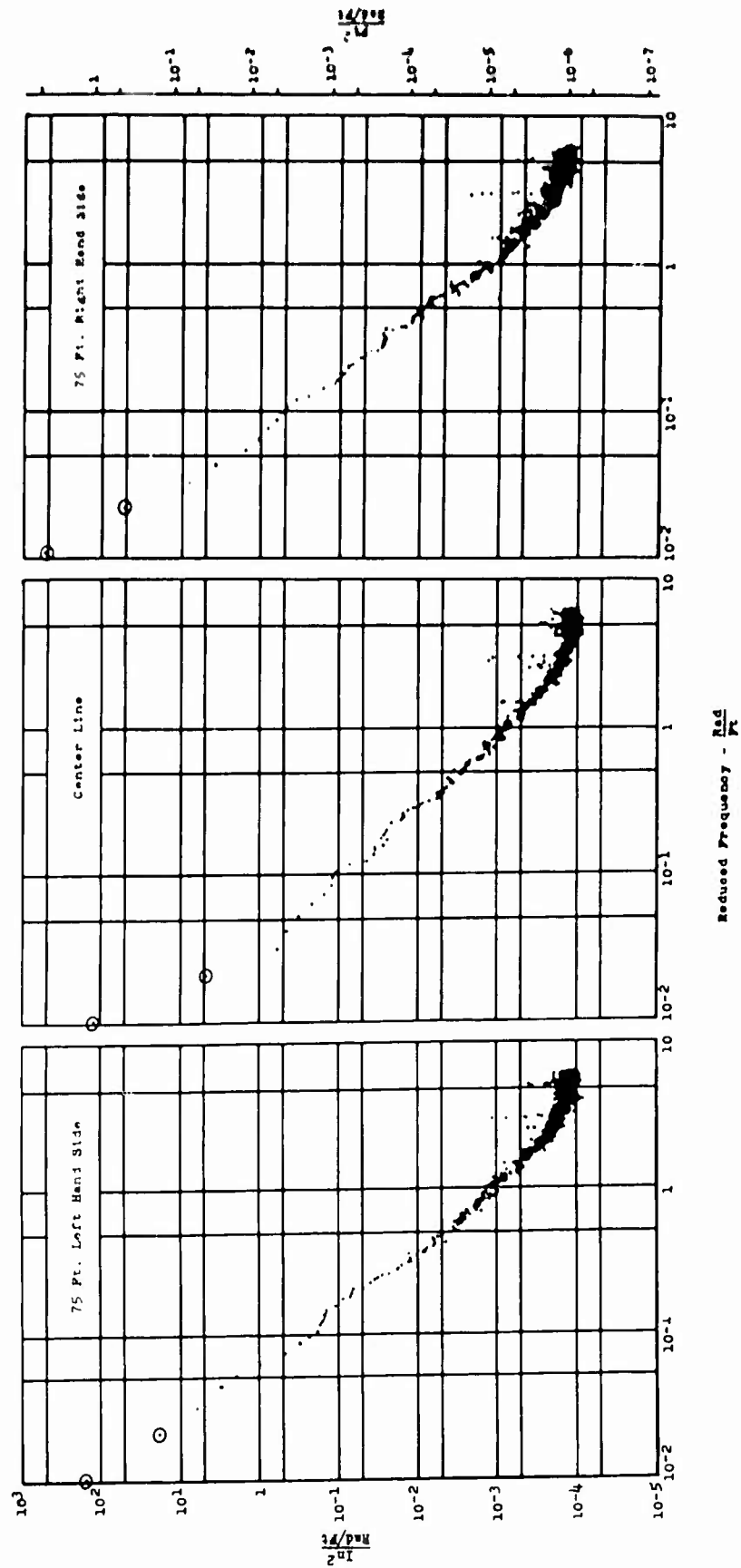


Figure 47 - Power Spectral Density, Taxiway 22, Mather Air Force Base

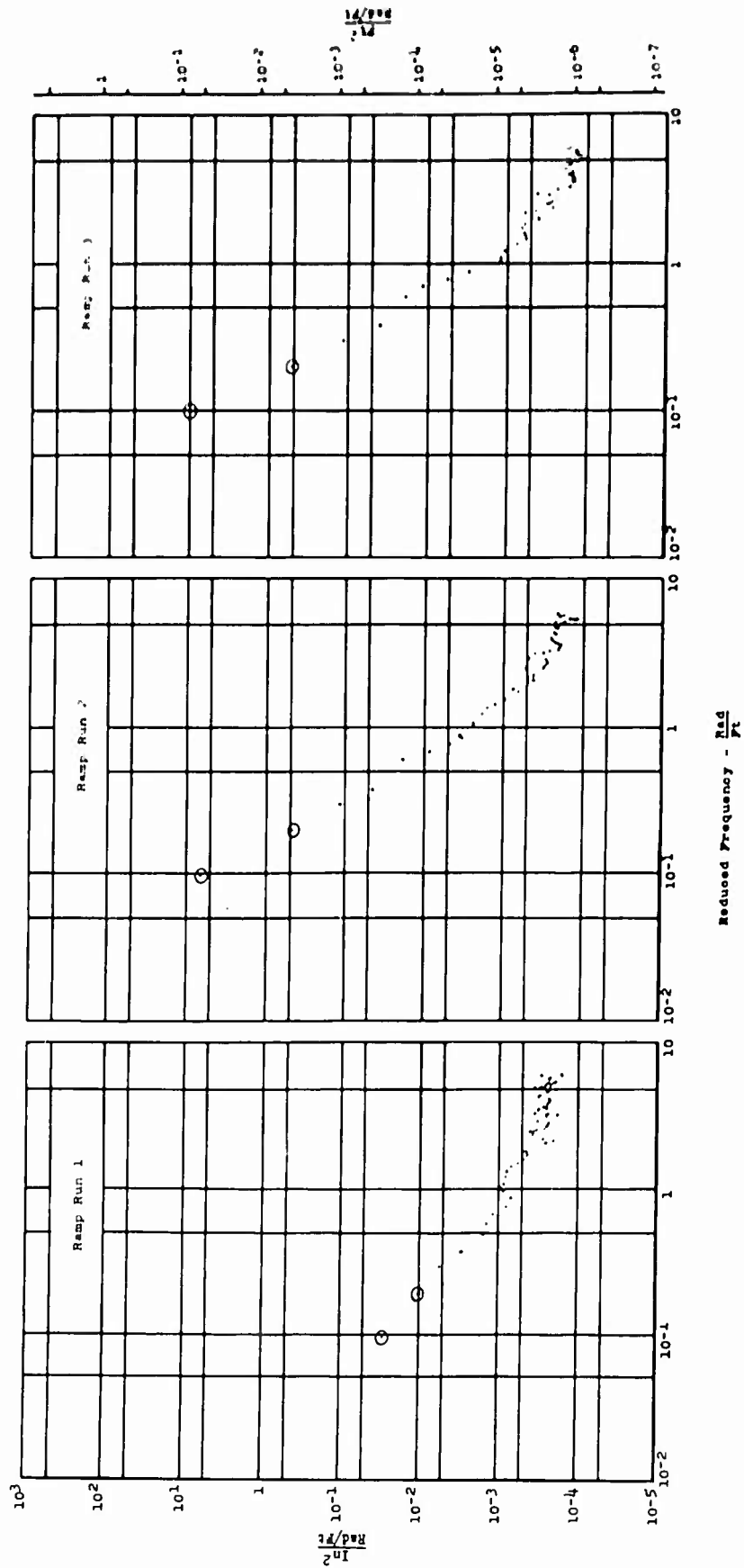


Figure 48 - Power Spectral Density, Mather Air Force Base

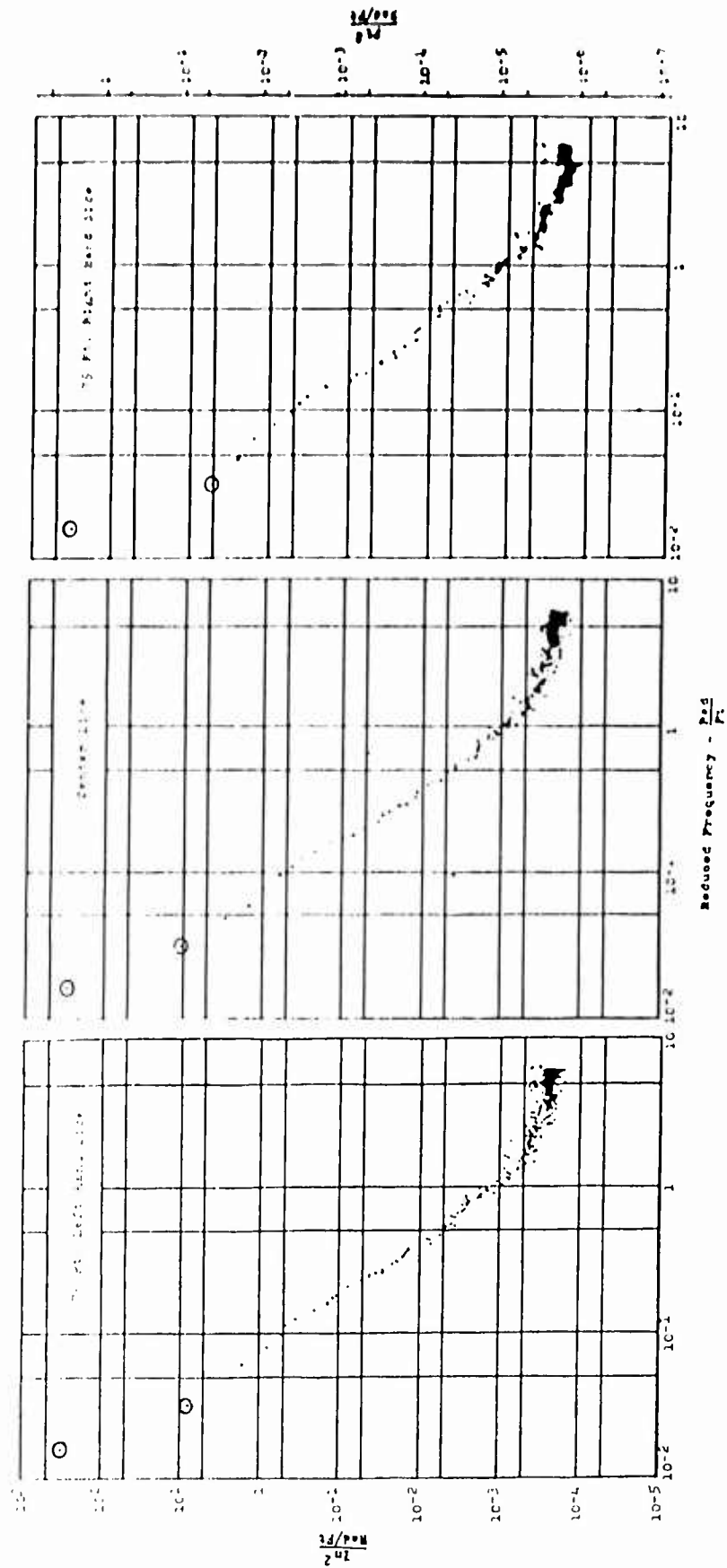


Figure 49 - Power Spectral Density, Runway 12, McGuire Air Force Base

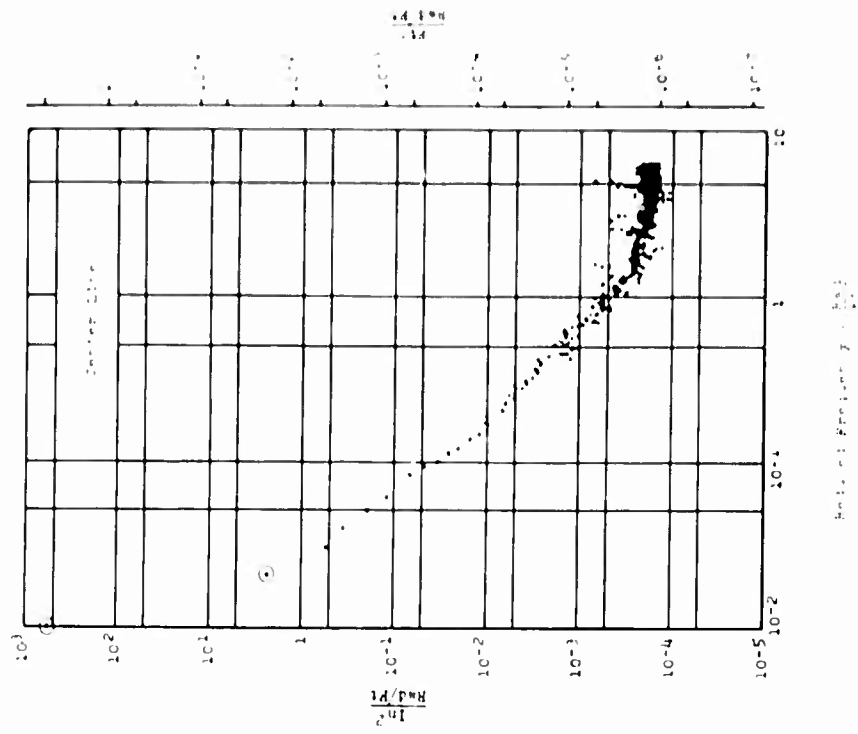


Figure 50 - Power Spectral Density, Runway 6, McGuire Air Force Base

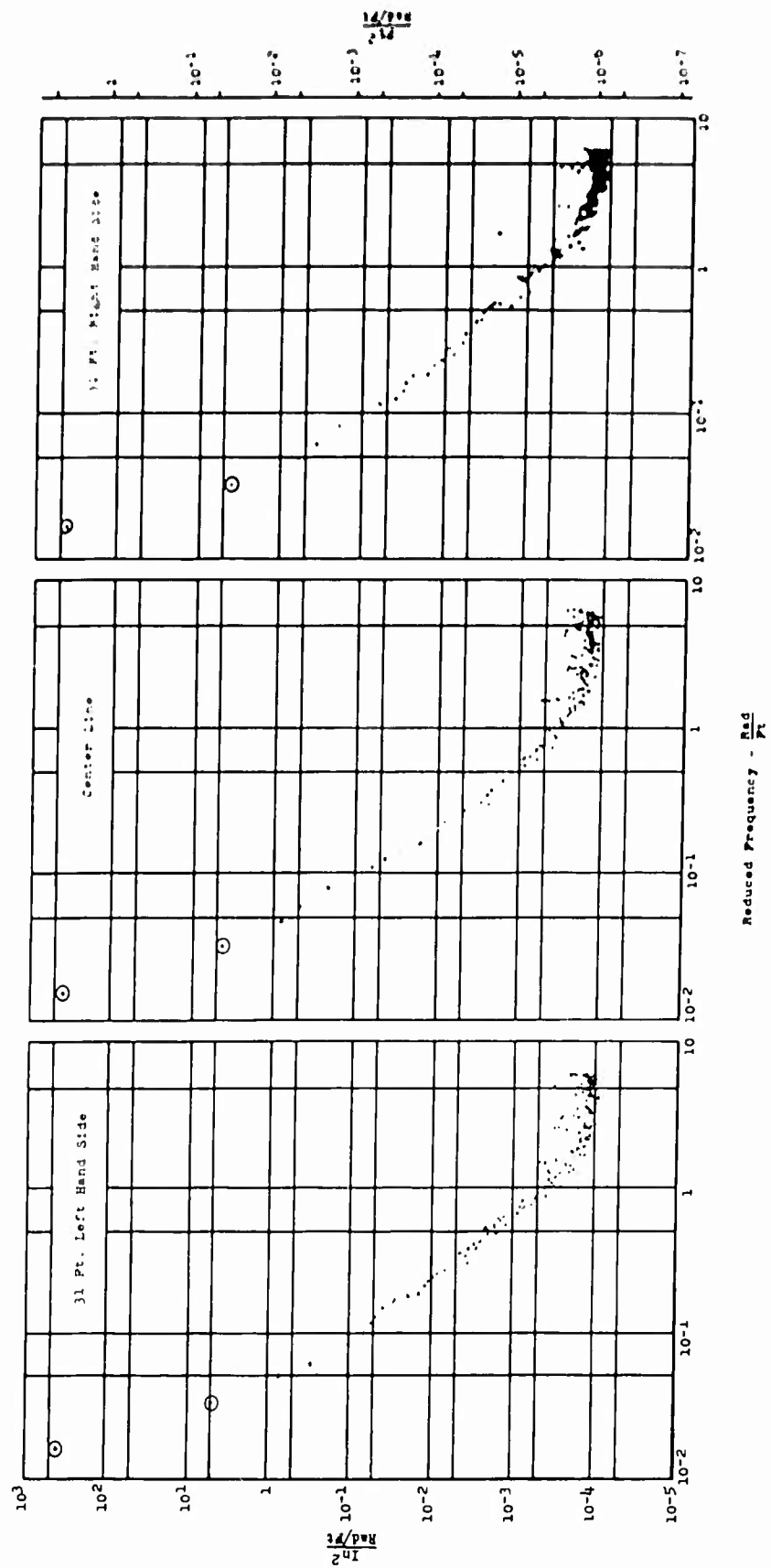


Figure 51 - Power Spectral Density, Taxiway 5, McGuire Air Force Base

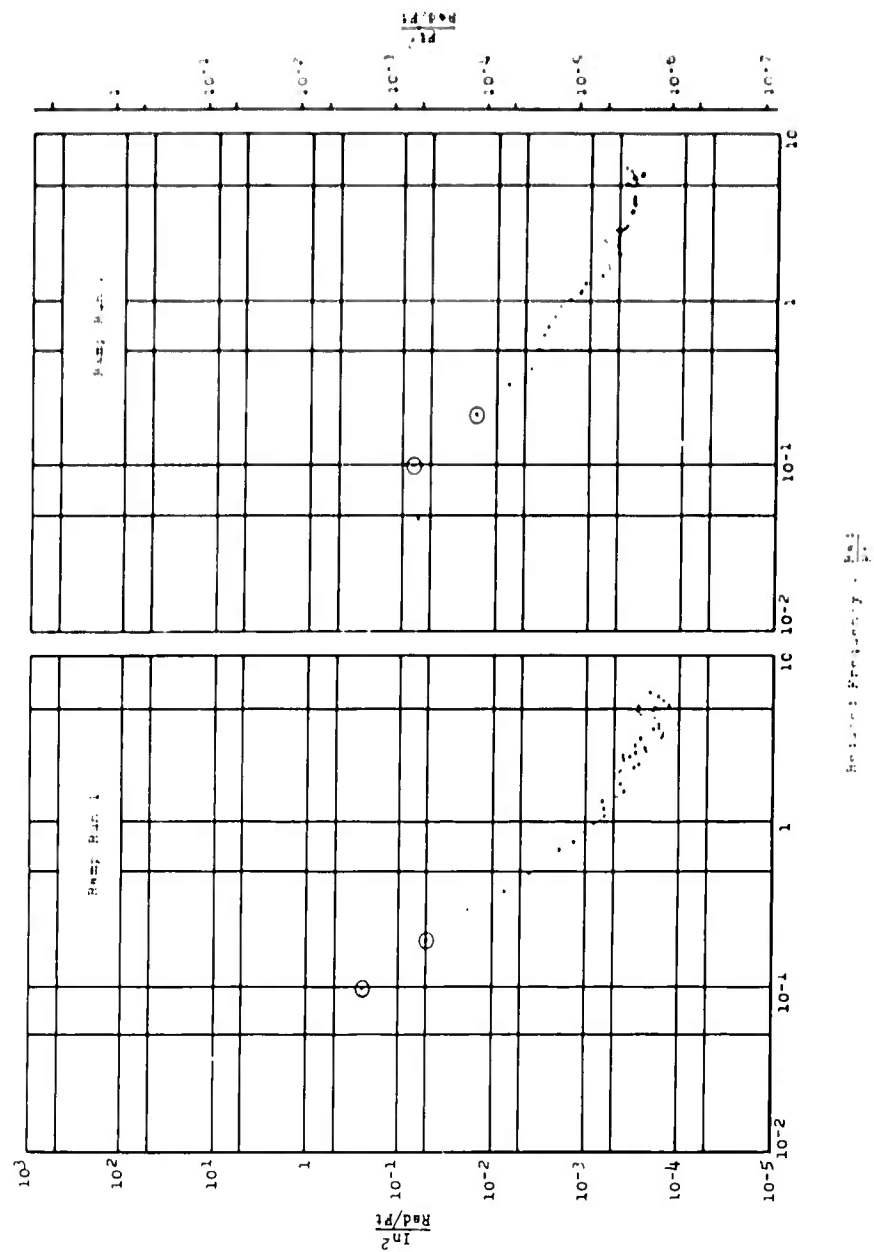


Figure 52 - Power Spectral Density, McGuire Air Force Base

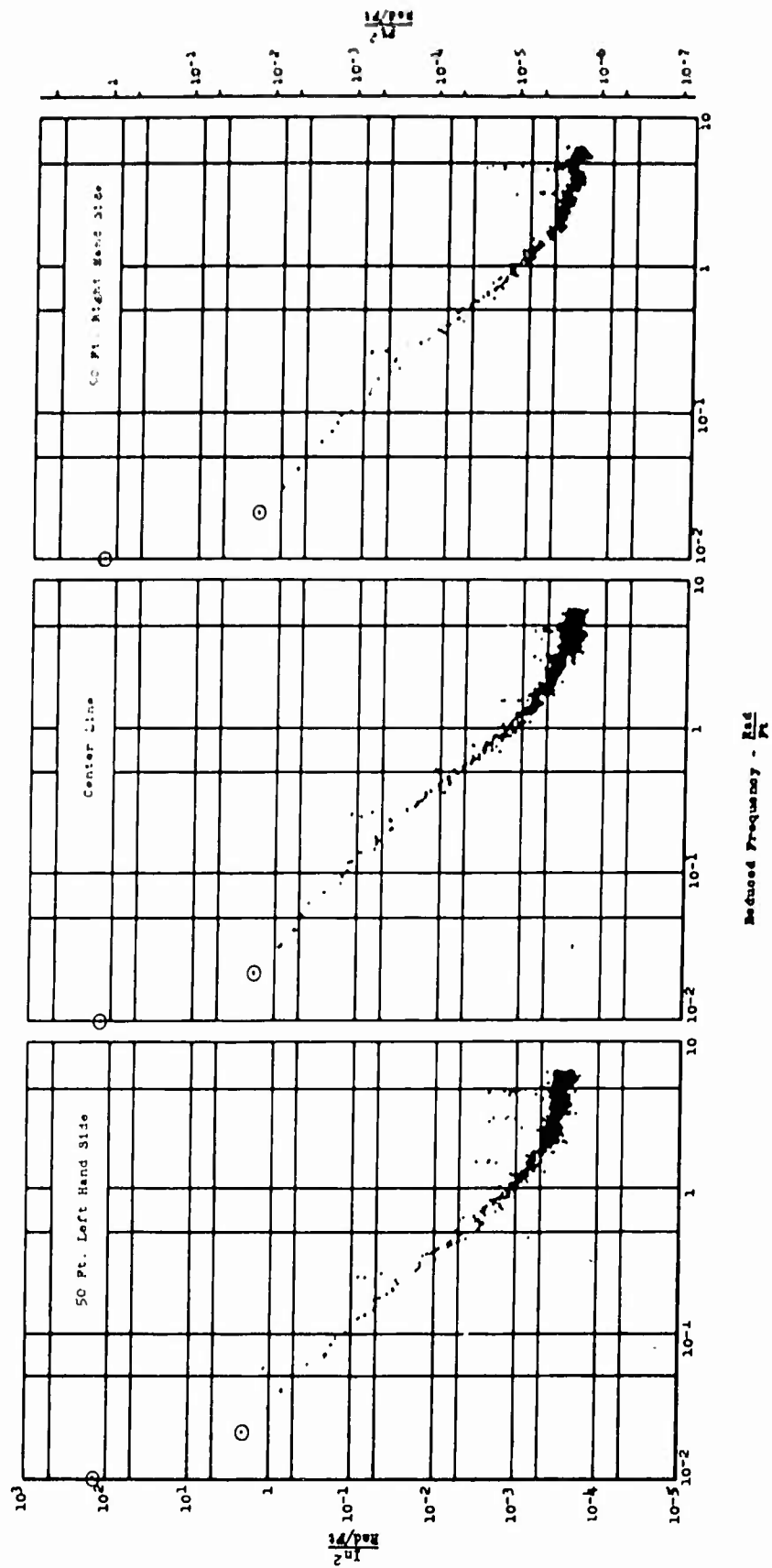


Figure 53 - Power Spectral Density, Runway 7, Palmdale Air Force Plant NR42

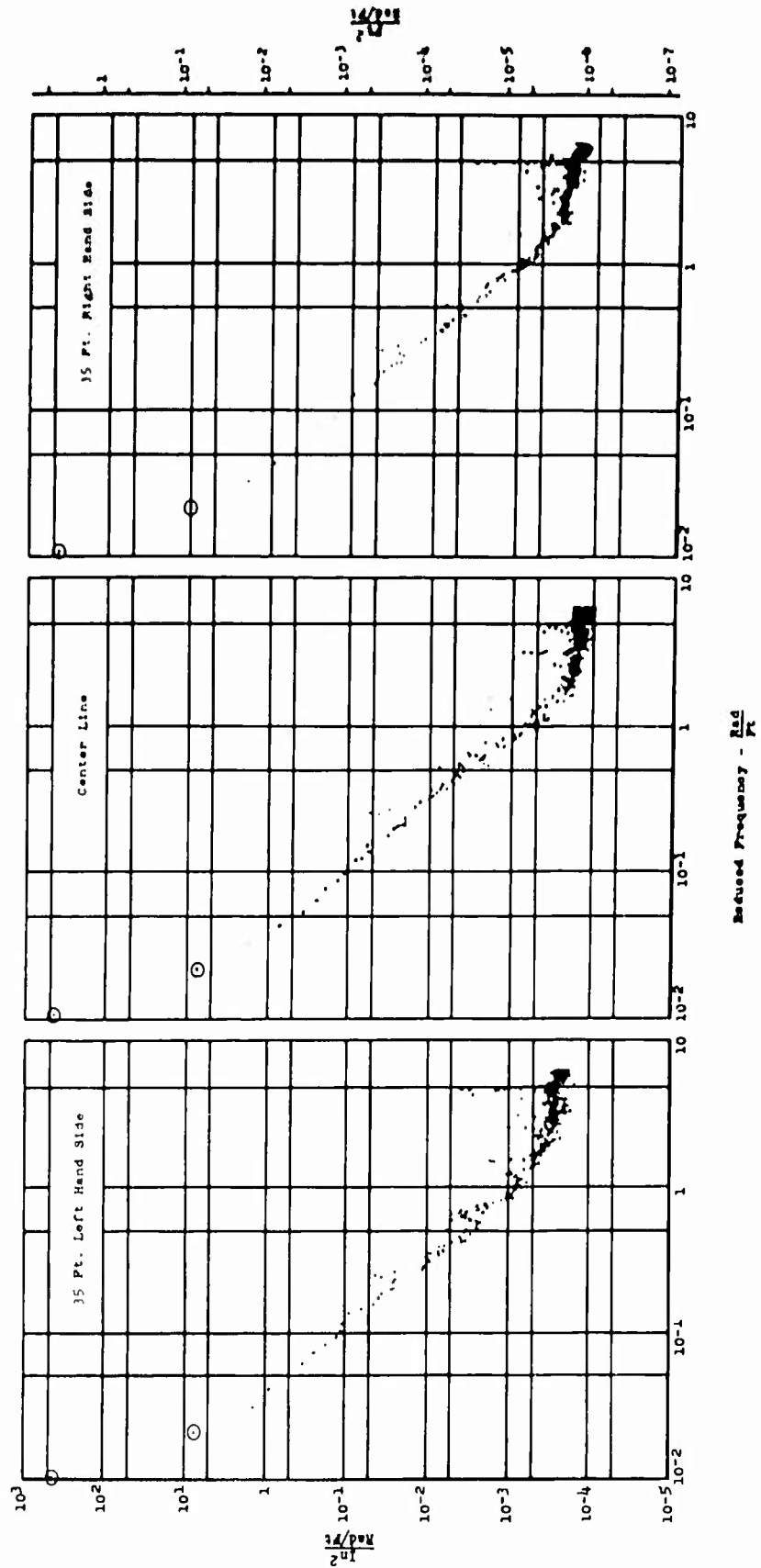


Figure 54 - Power Spectral Density, Taxiway B, Palmdale Air Force Plant NR42

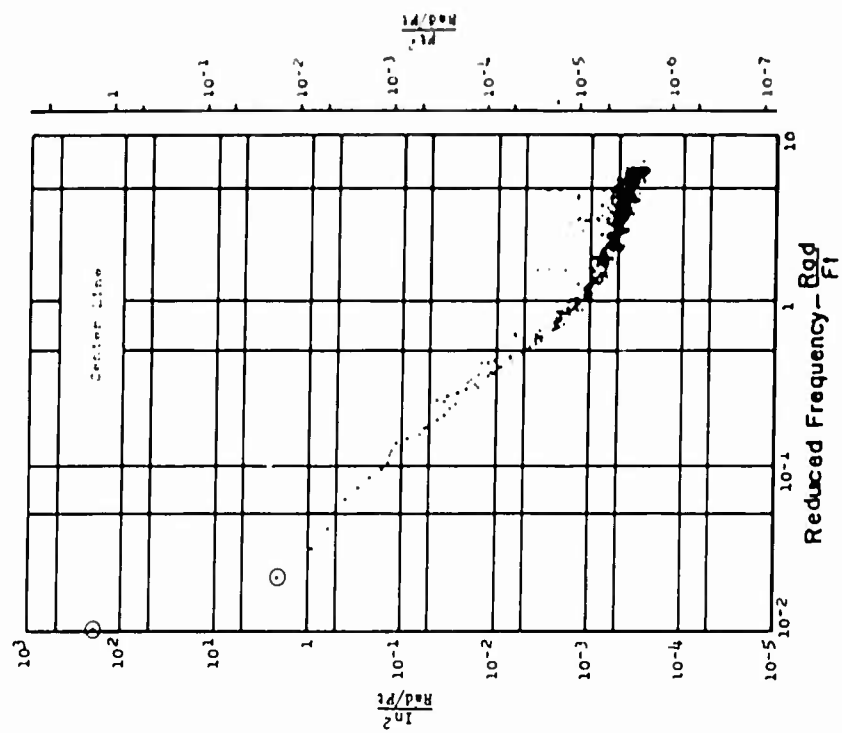


Figure 55 - Power Spectral Density, Runway 22, Palmdale Air Force Base, 1942

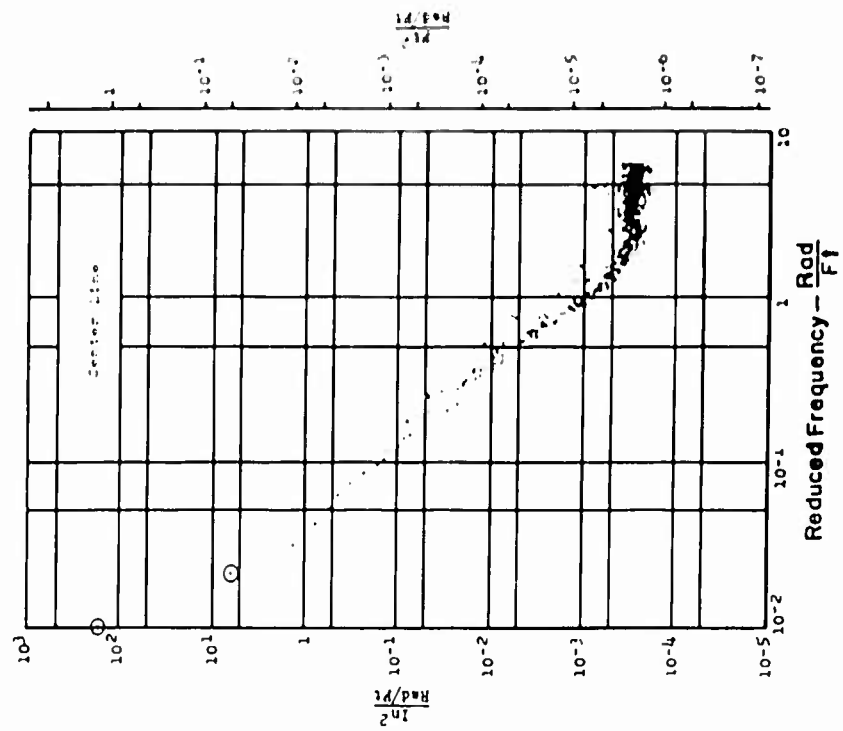


Figure 56 - Power Spectral Density, Taxiway E, Palmdale Air Force Plant 1342

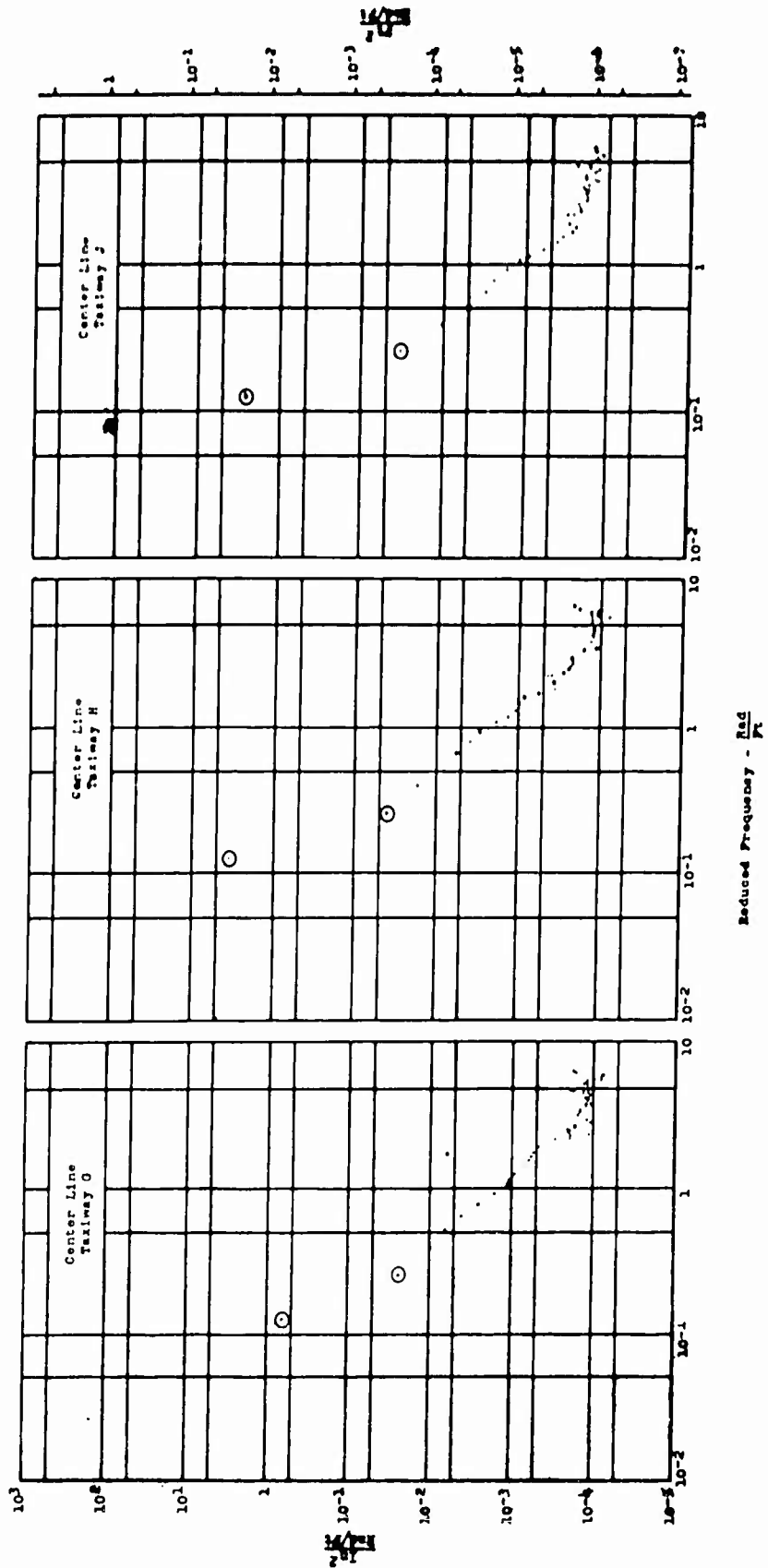


Figure 57 - Power Spectral Density, Palmdale Air Force Plant MR42

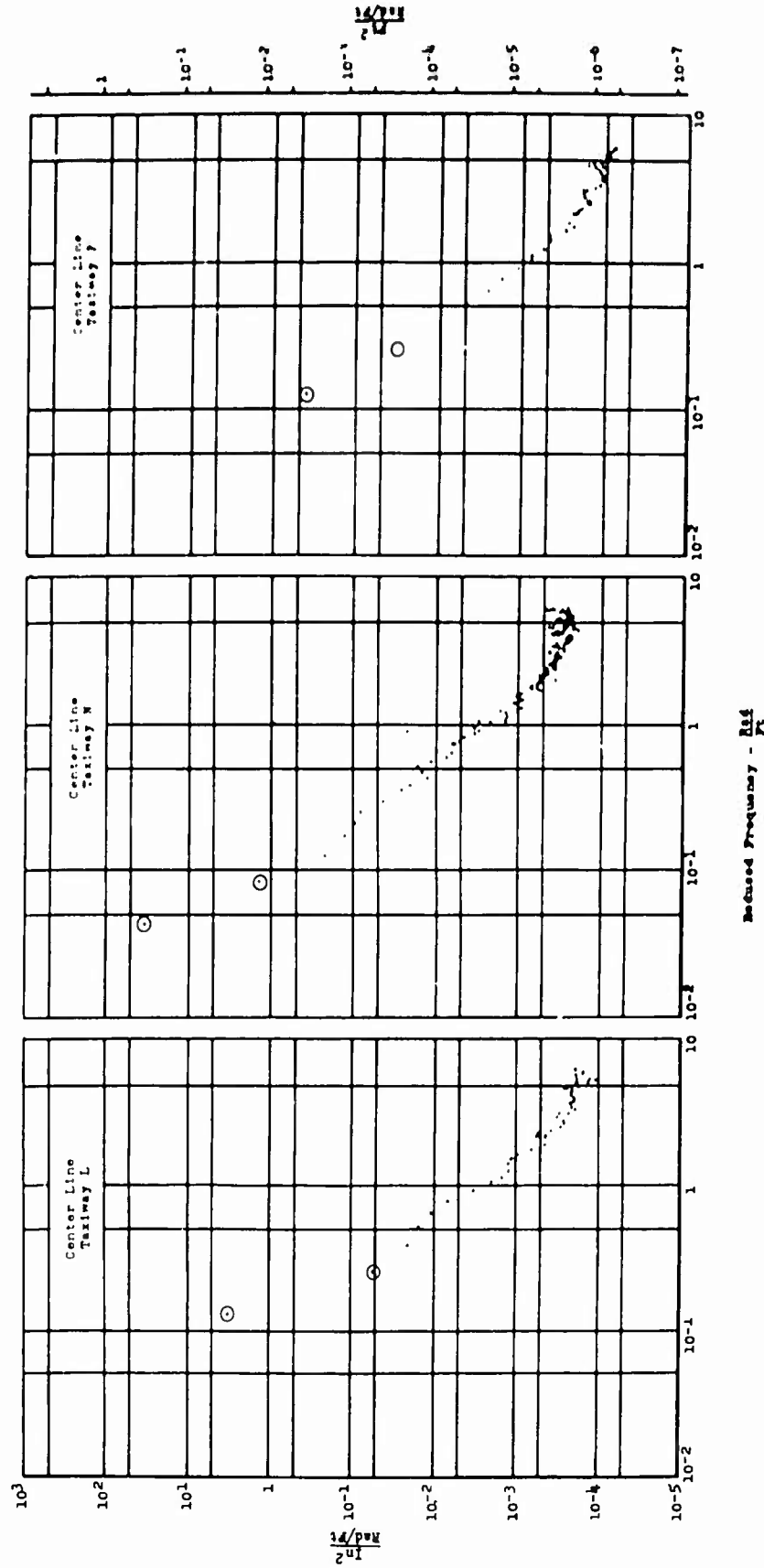


Figure 58 - Power Spectral Density, Palmdale Air Force Plant MR42

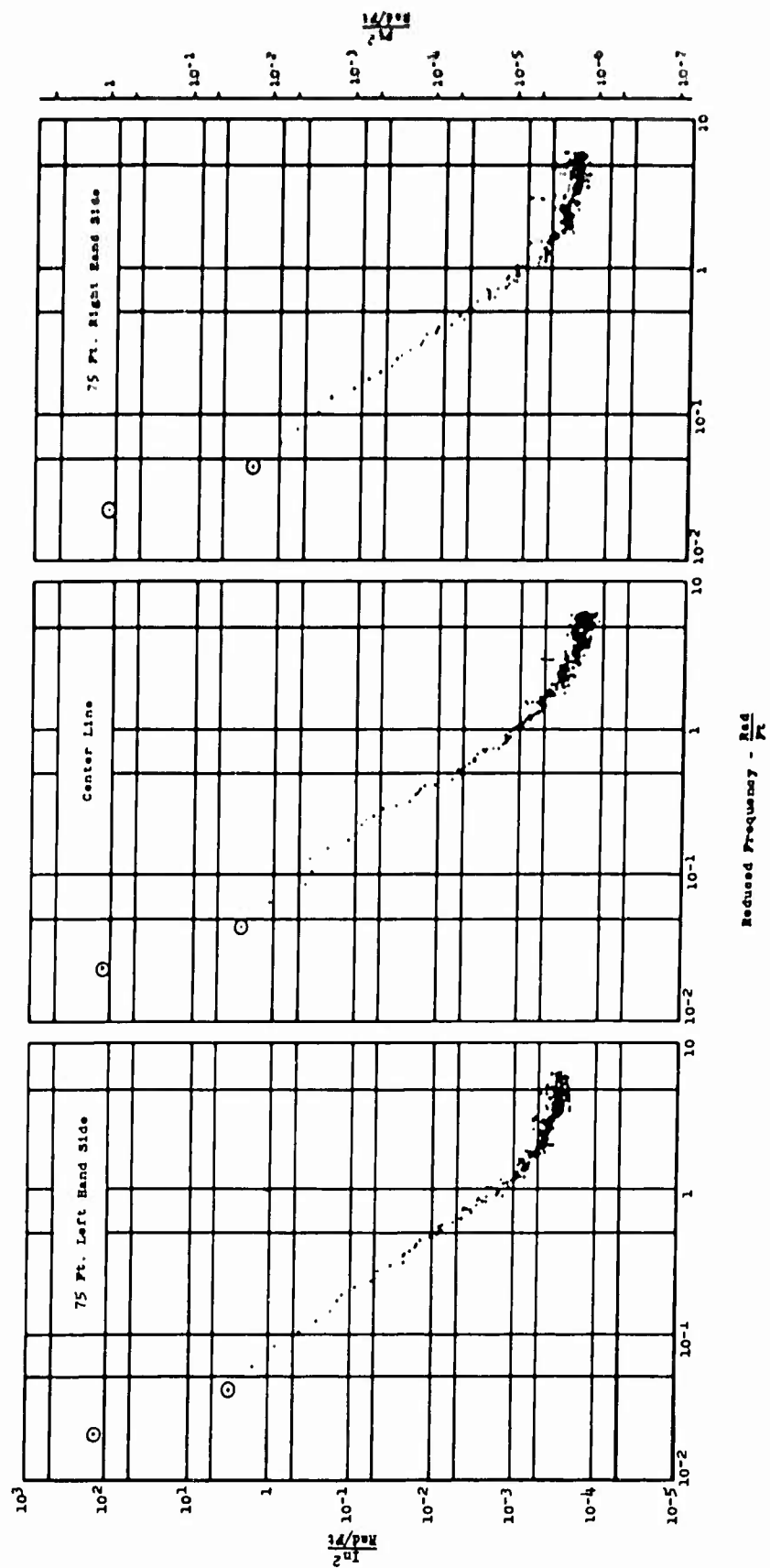


Figure 59 - Power Spectral Density, Runway 18, Sewart Air Force Base

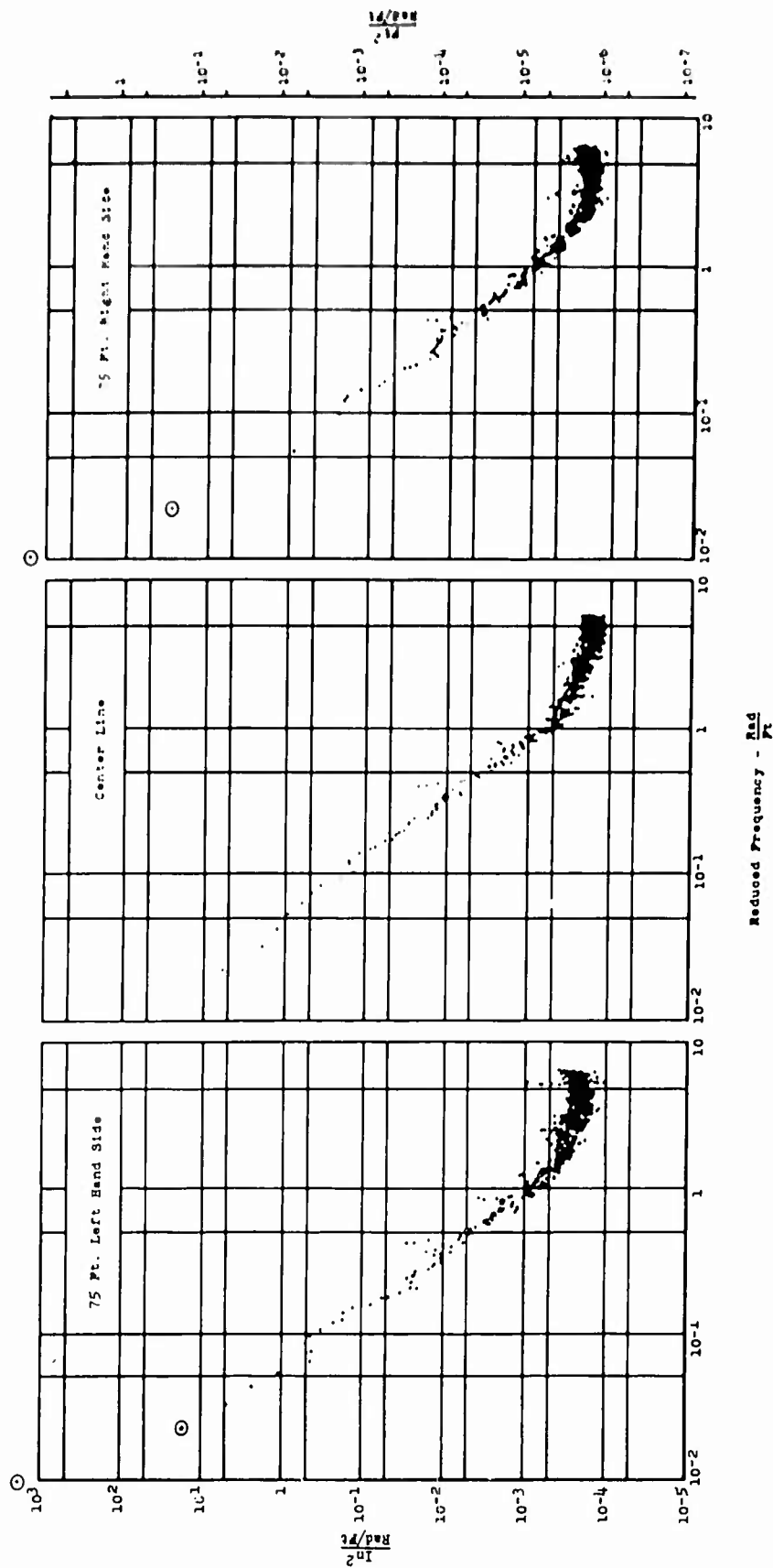


Figure 60 - Power Spectral Density, Runway 14, Sewart Air Force Base

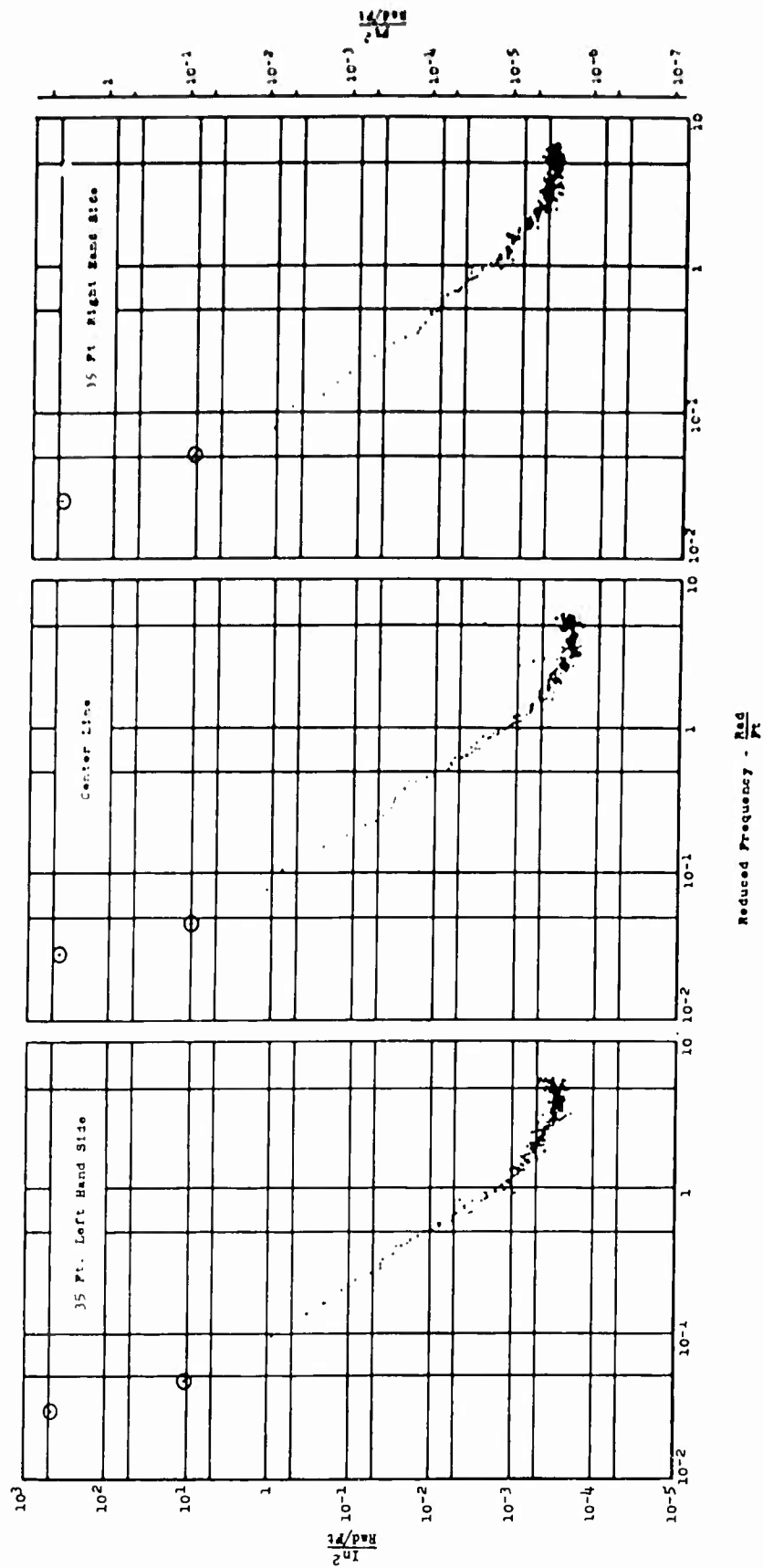


Figure 61 - Power Spectral Density, Taxiway 2, Sewart Air Force Base

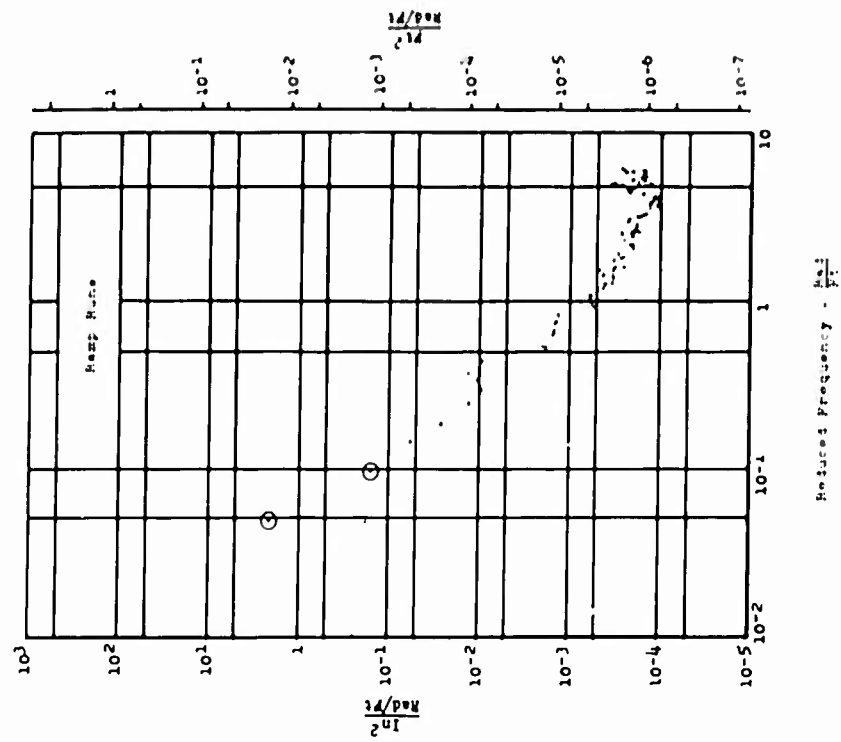


Figure 62 - Power Spectral Density, Sewart Air Force Base

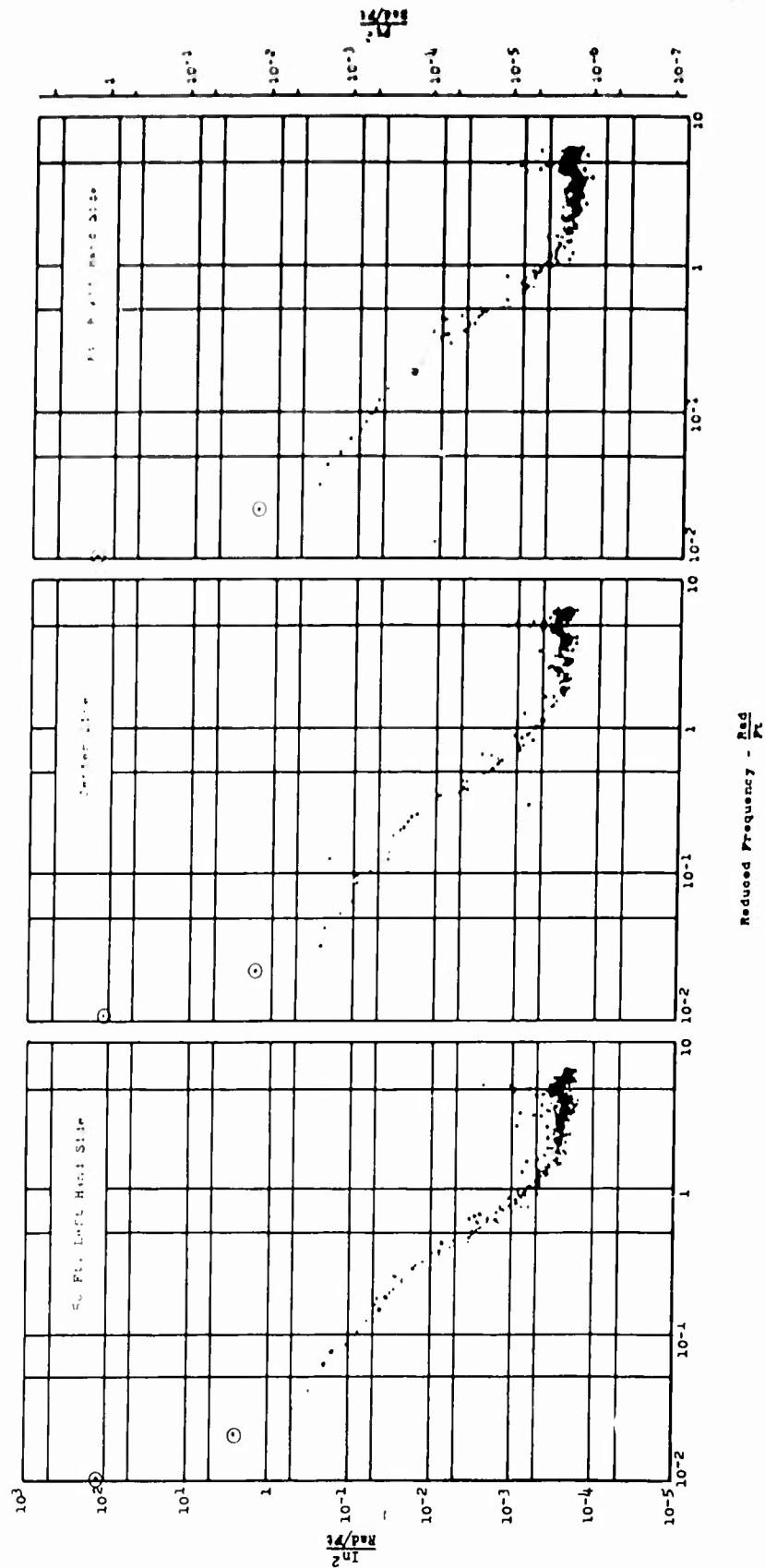


Figure 63 - Power Spectral Density, Runway 4, Shaw Air Force Base

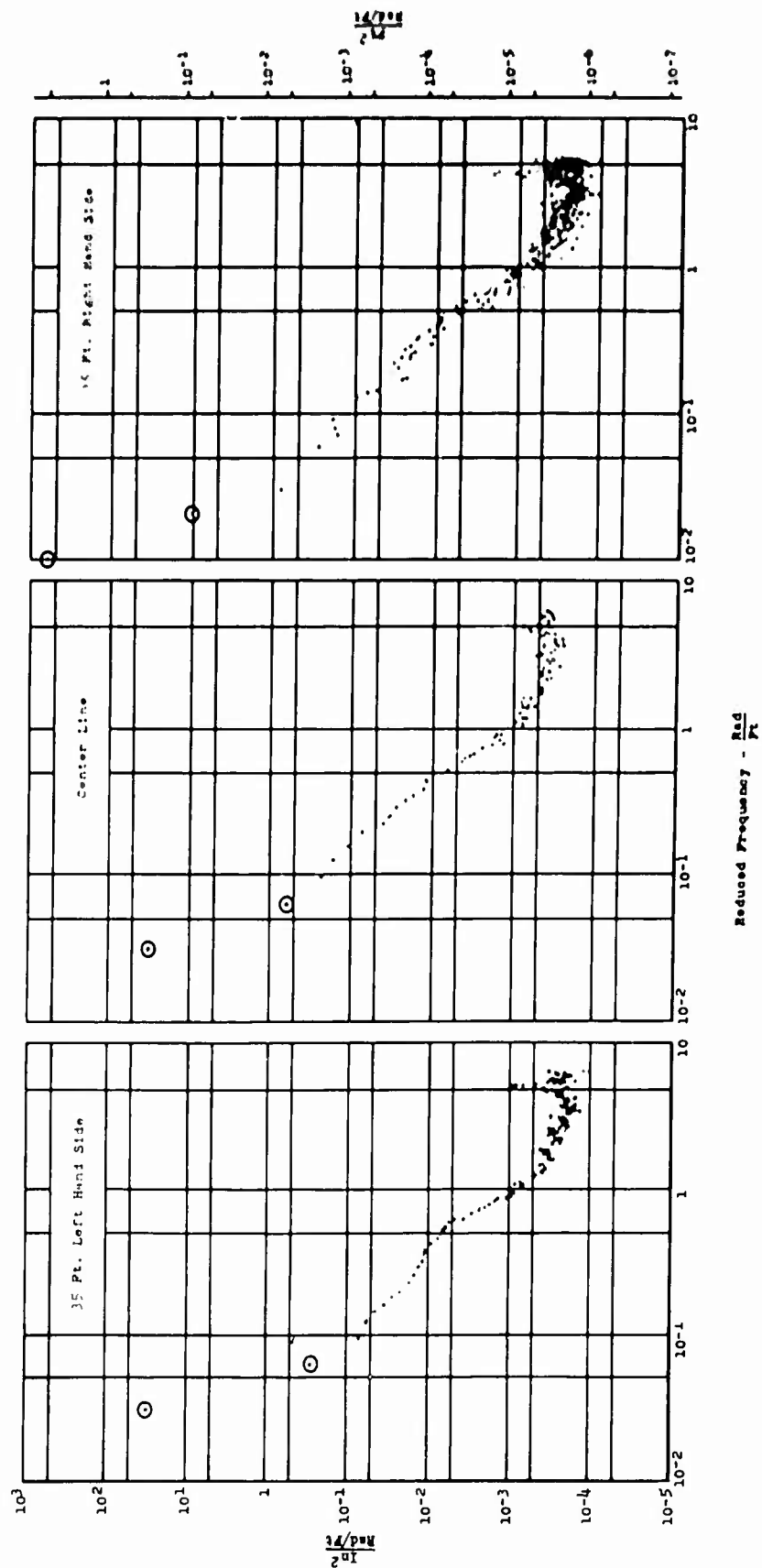


Figure 64 - Power Spectral Density, Taxiway, Shaw Air Force Base

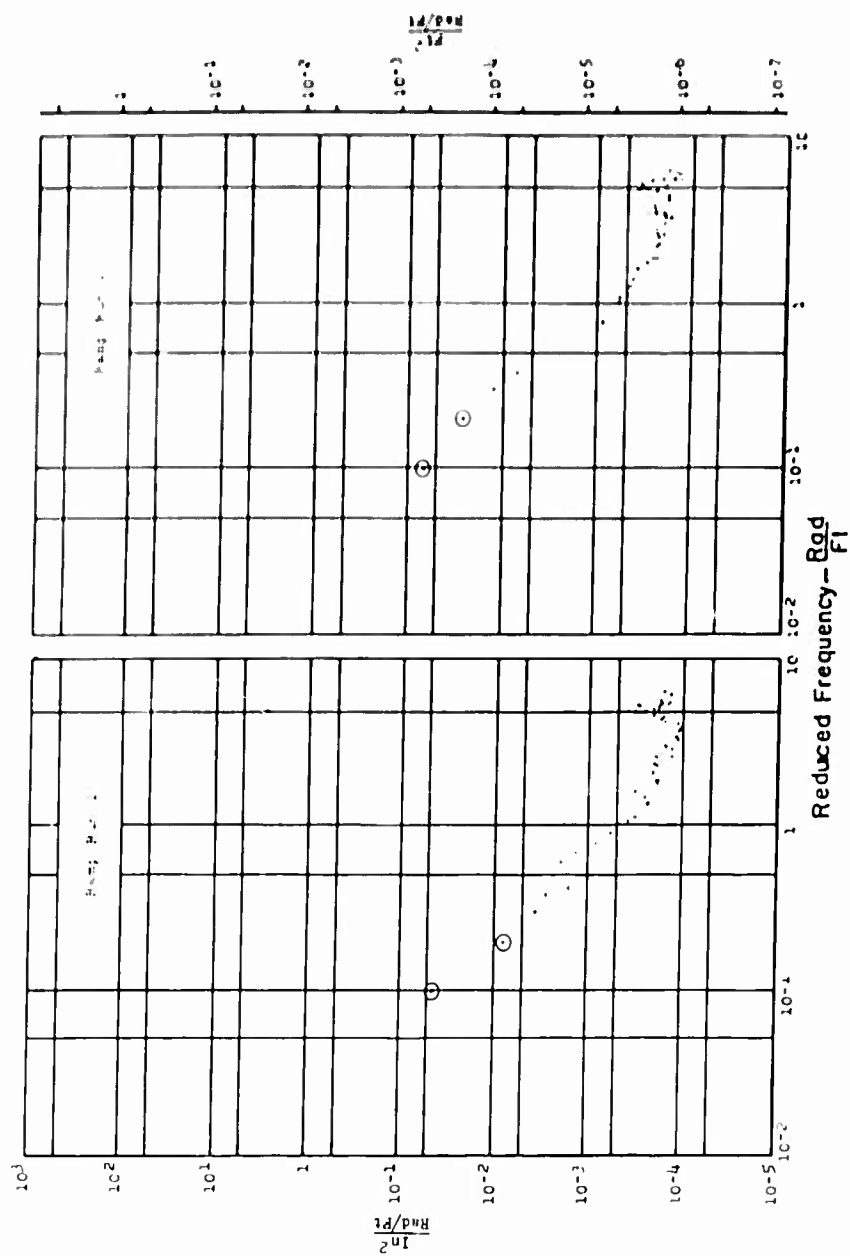


Figure 65 - Power Spectral Density, Shaw Air Force Base

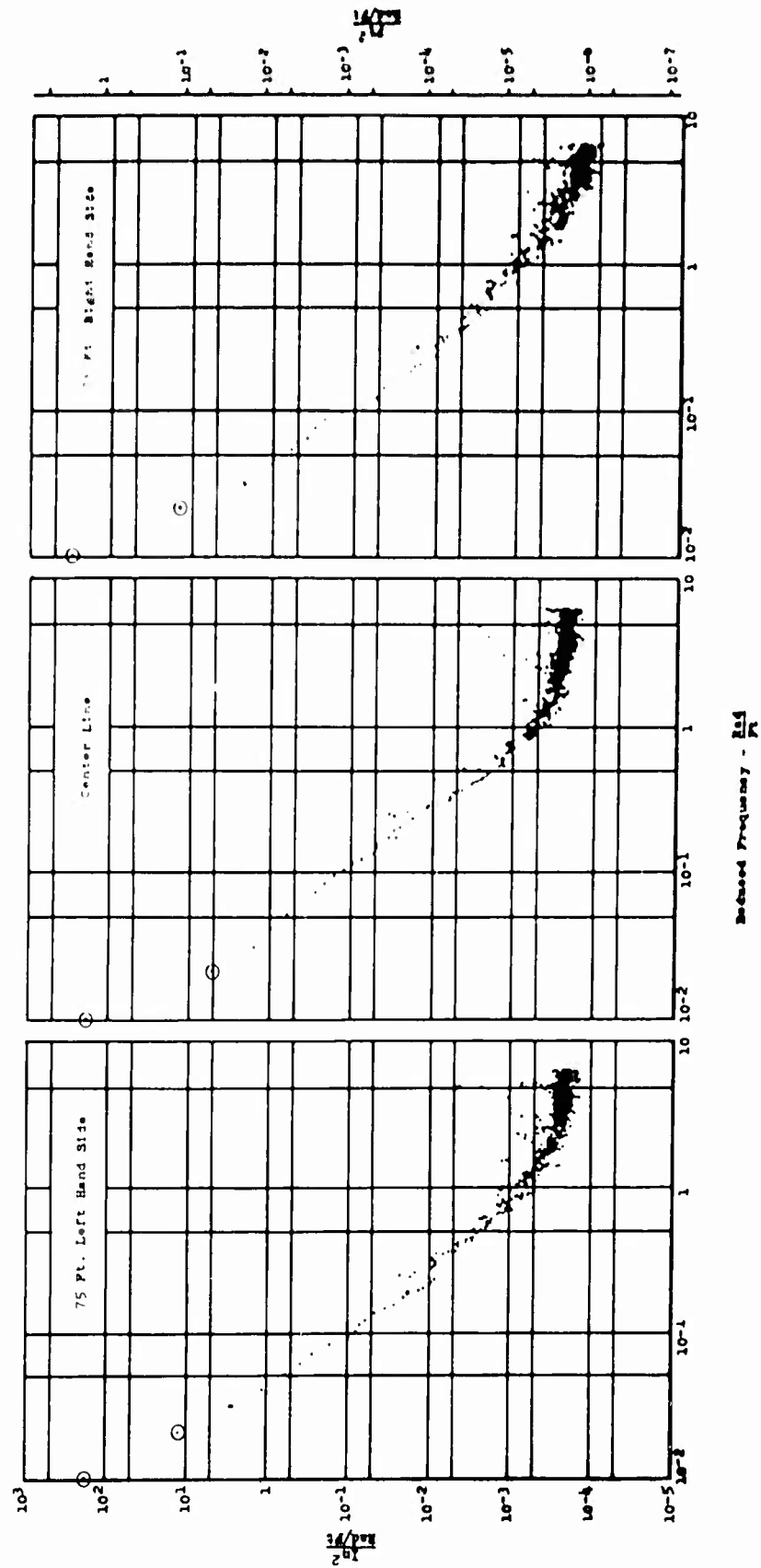


Figure 66 - Power Spectral Density, Runway 21, Travis Air Force Base

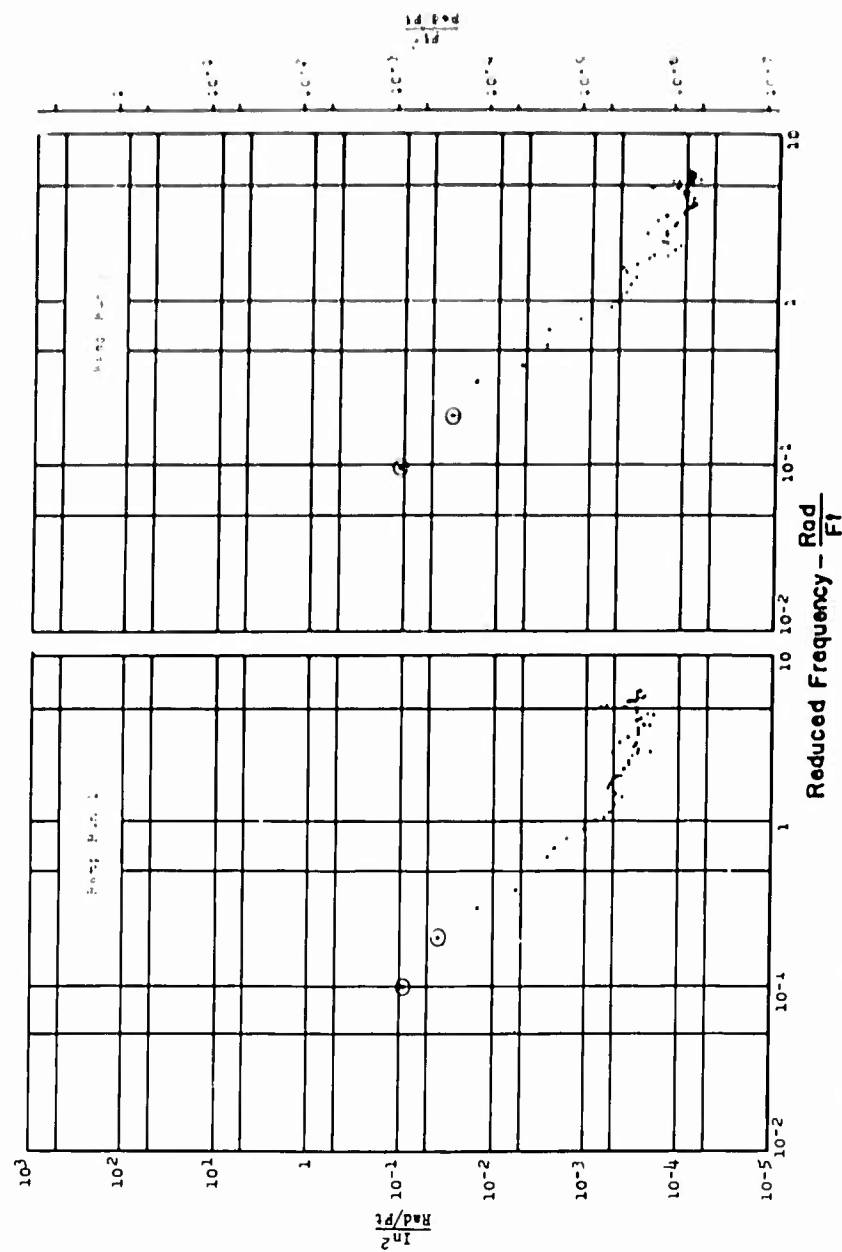


Figure 67 - Power Spectral Density, Travis Air Force Base

APPENDIX II

PROFILE PLOTS

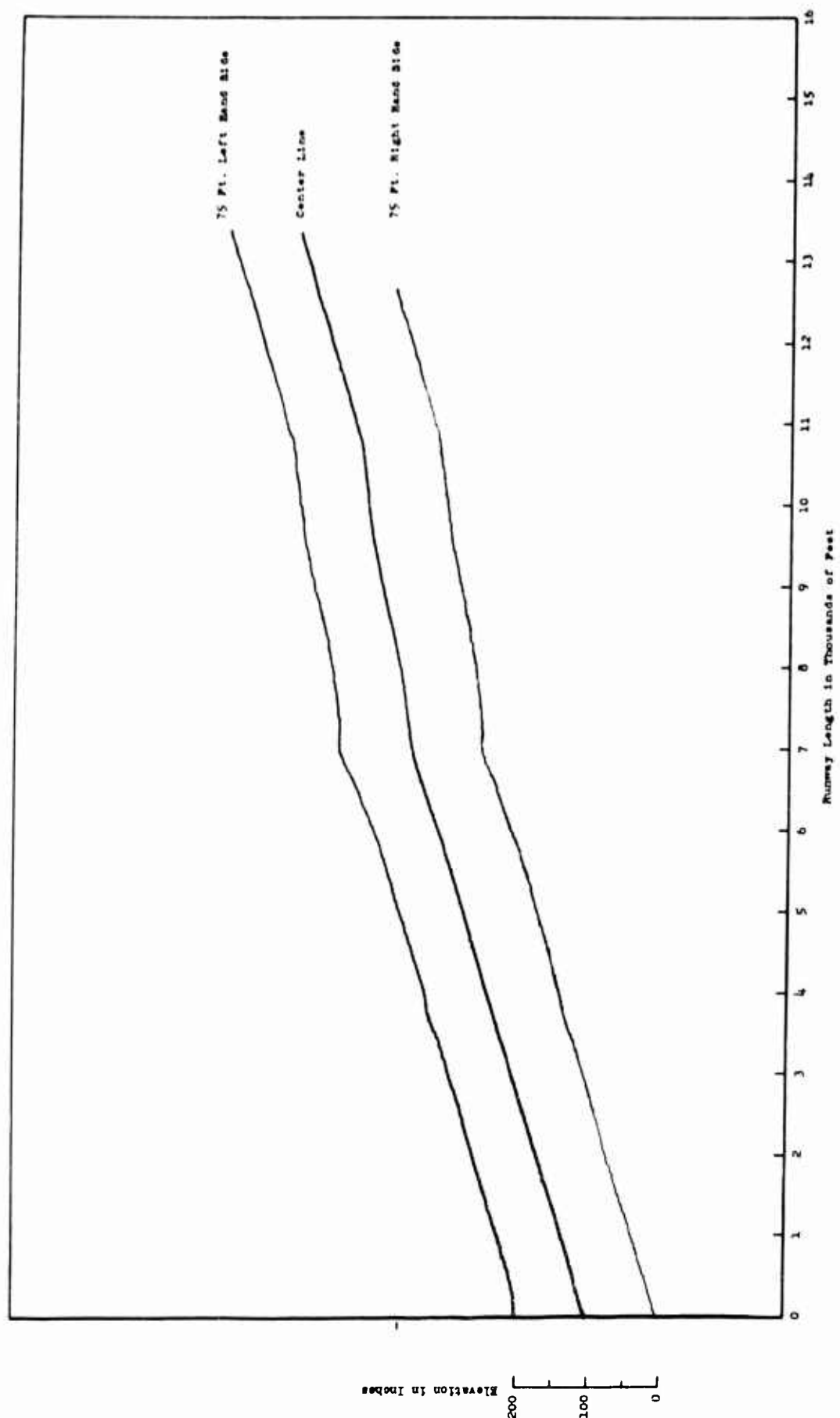


Figure 68 - Profiles, Runway 35, Altus Air Force Base

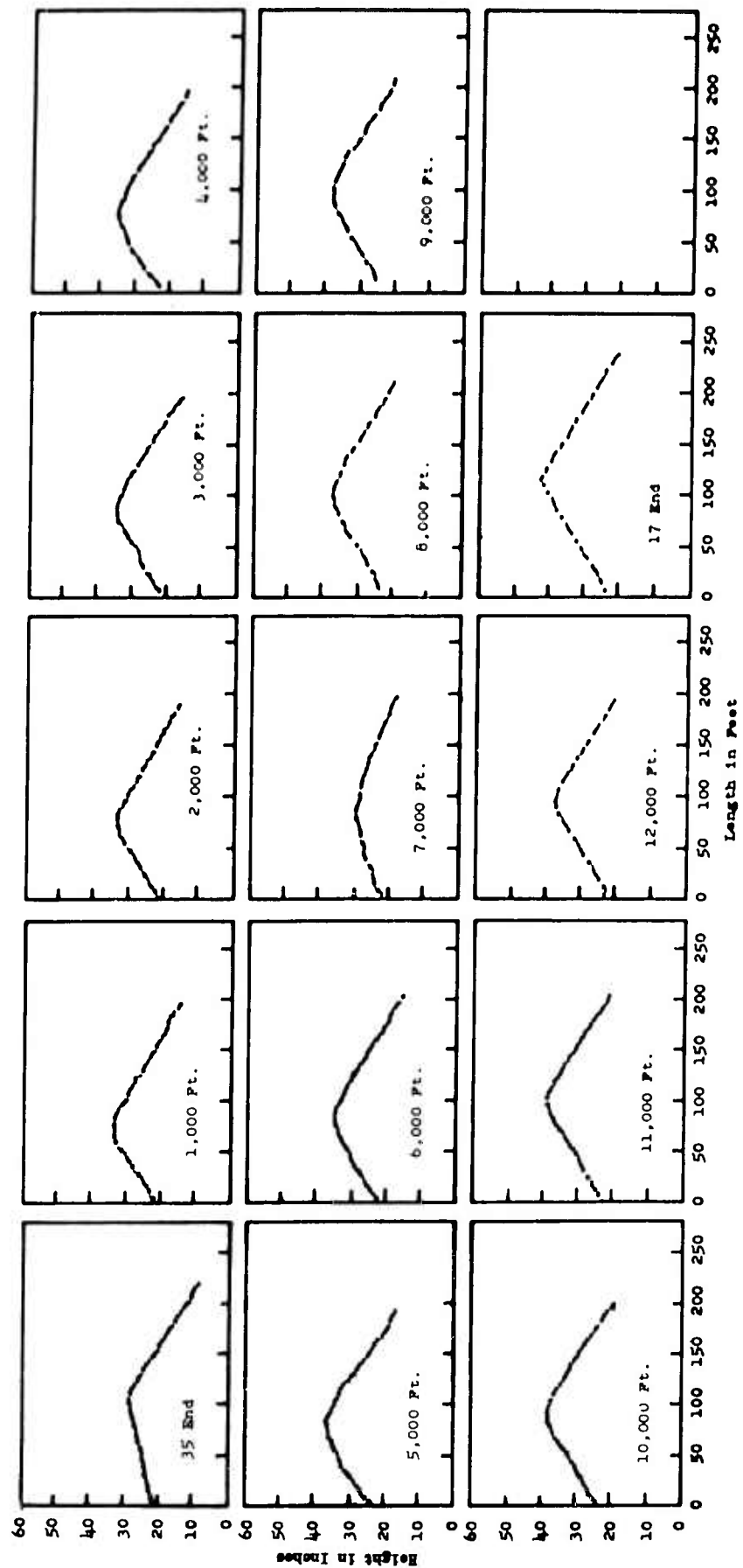


Figure 69 - Cross Run Profiles, Runway 35, Altus Air Force Base

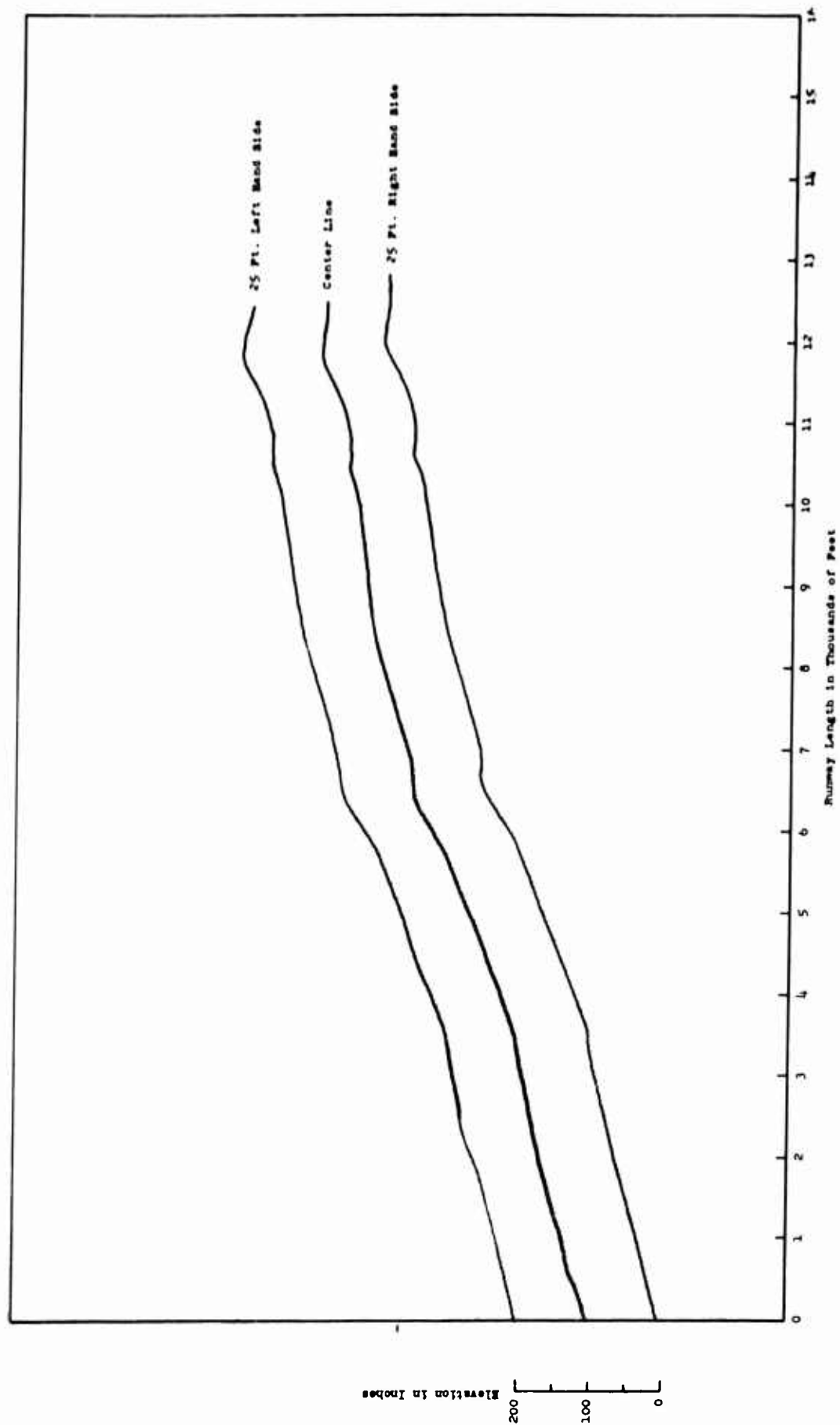


Figure 70 - Profiles, Taxiway 5, Altus Air Force Base

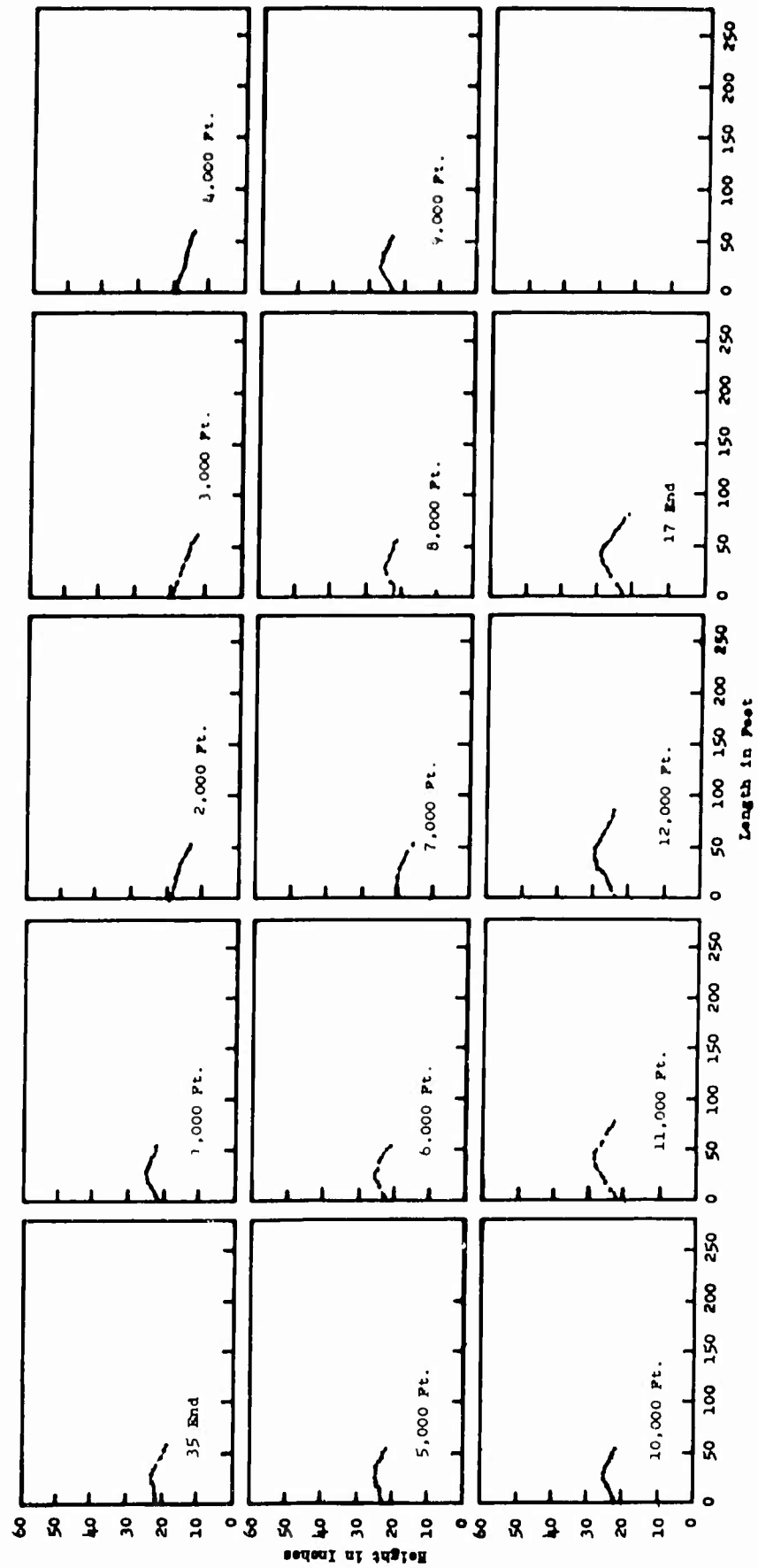


Figure 71 - Cross Run Profiles, Taxiway 5, Altus Air Force Base

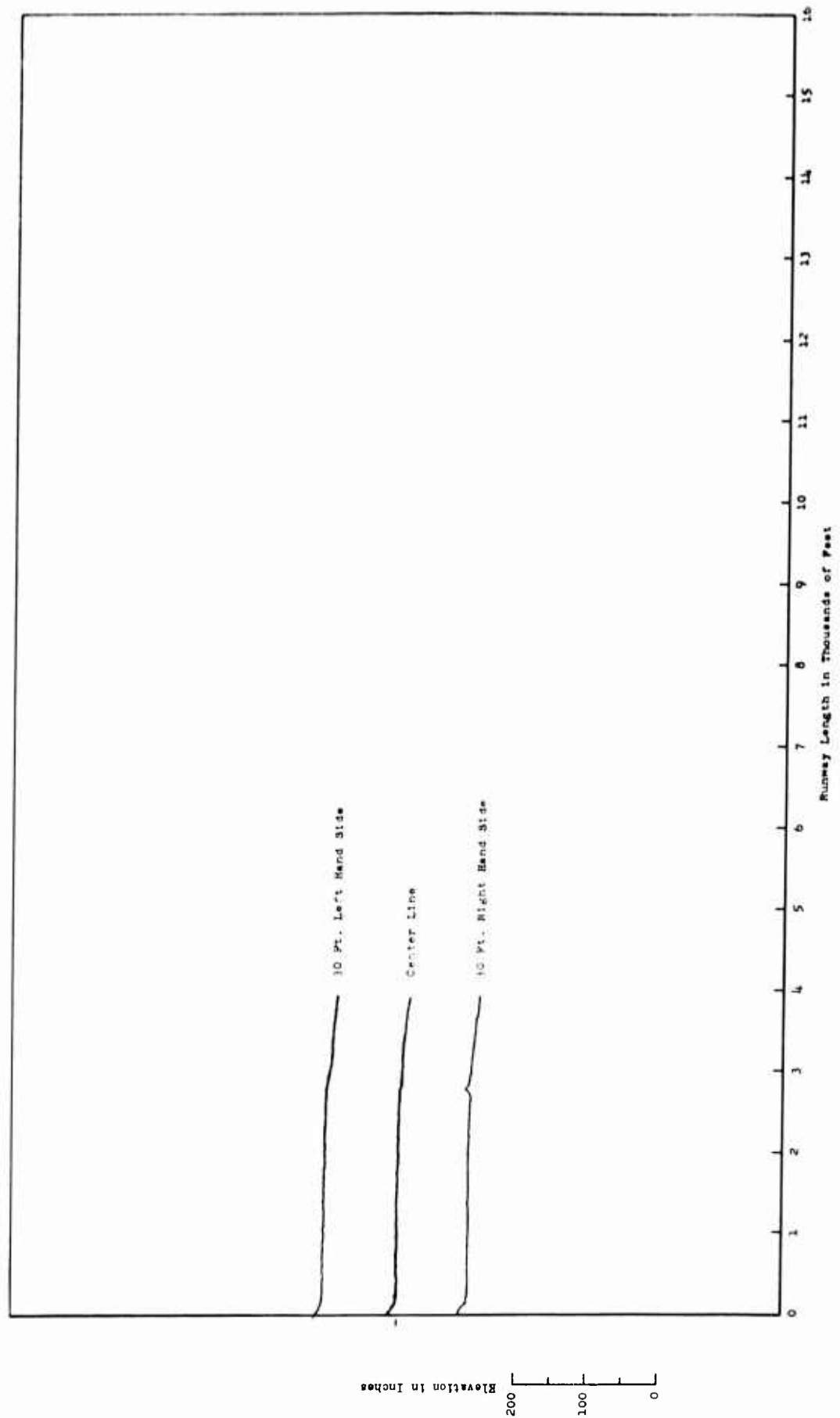


Figure 72 - Profiles, Taxiway 27, Bakalar Air Force Base

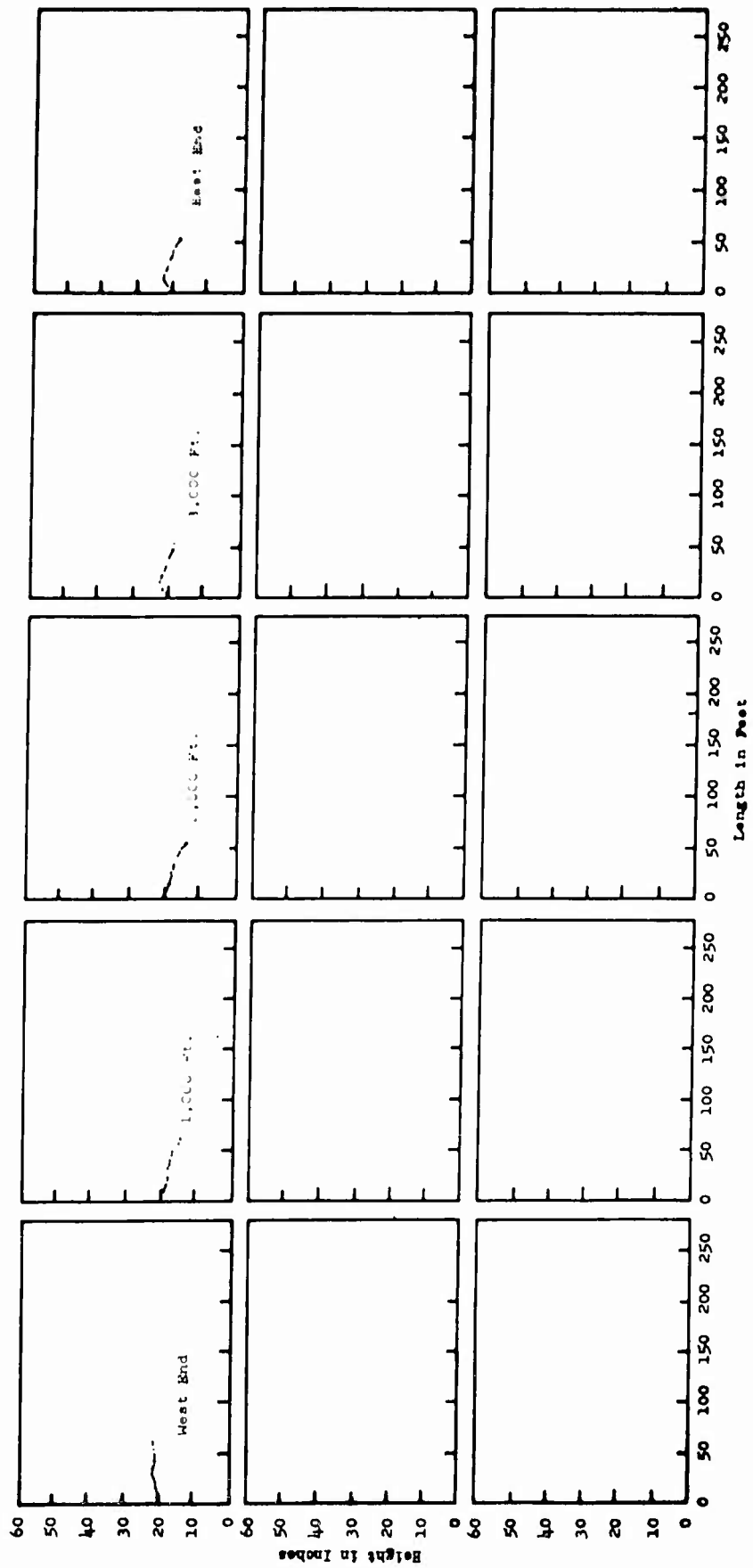


Figure 73 - Cross Run Profiles, Taxiway 27, Babalar Air Force Base

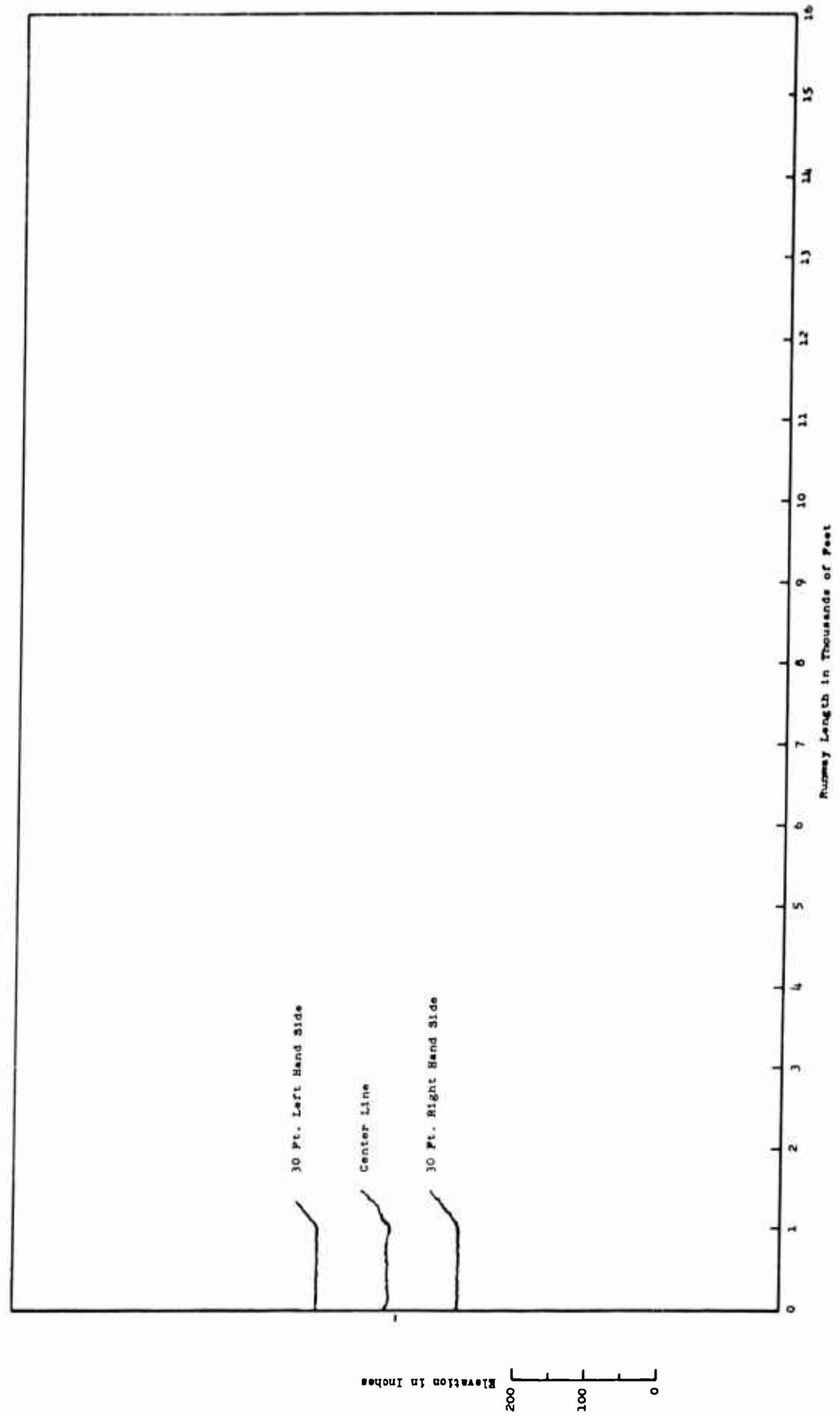


Figure 74 - Profiles, Taxiway 3, Bakalar Air Force Base

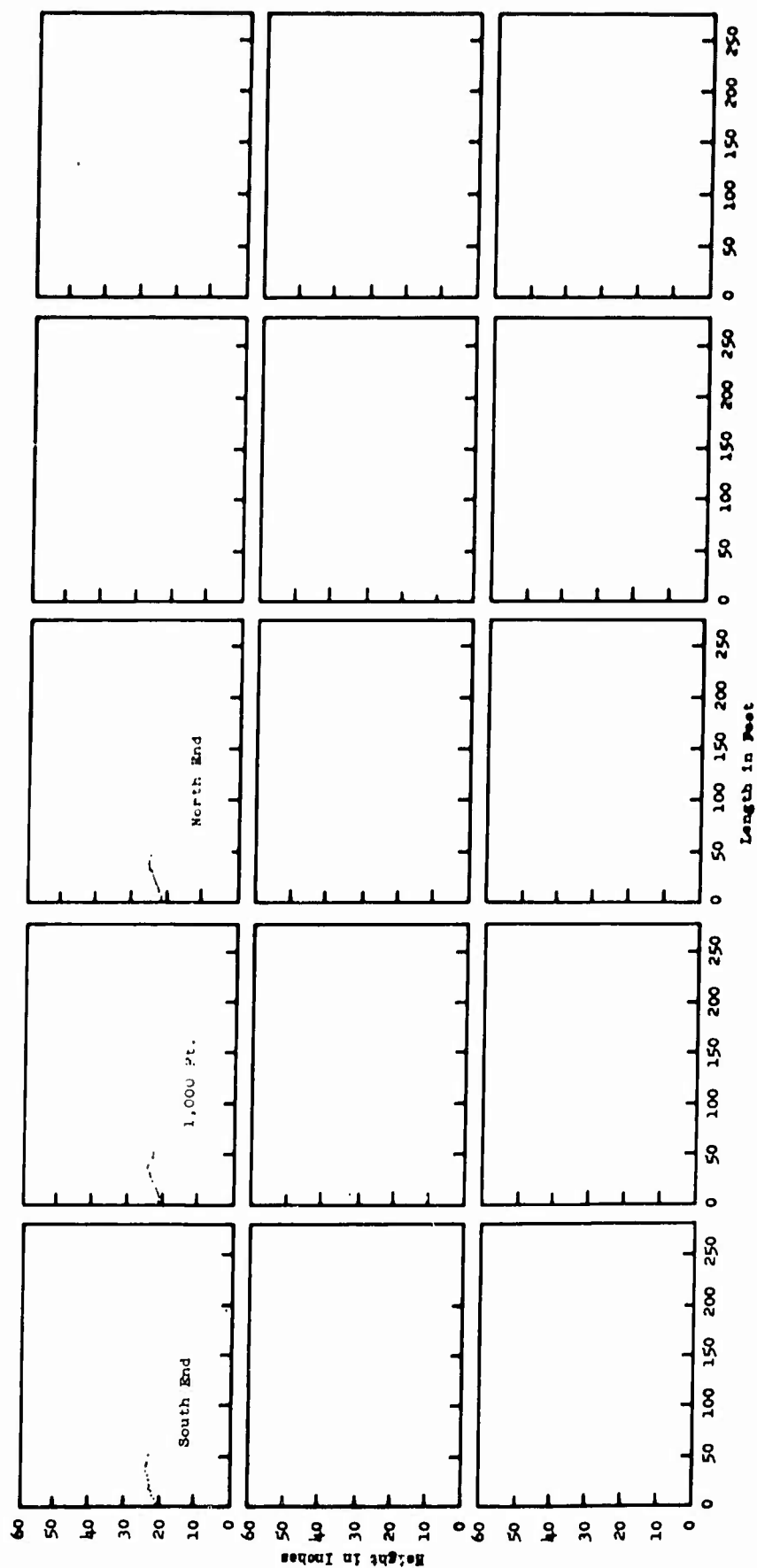


Figure 75 - Cross Run Profiles, Taxiway 3, Bakalar Air Force Base

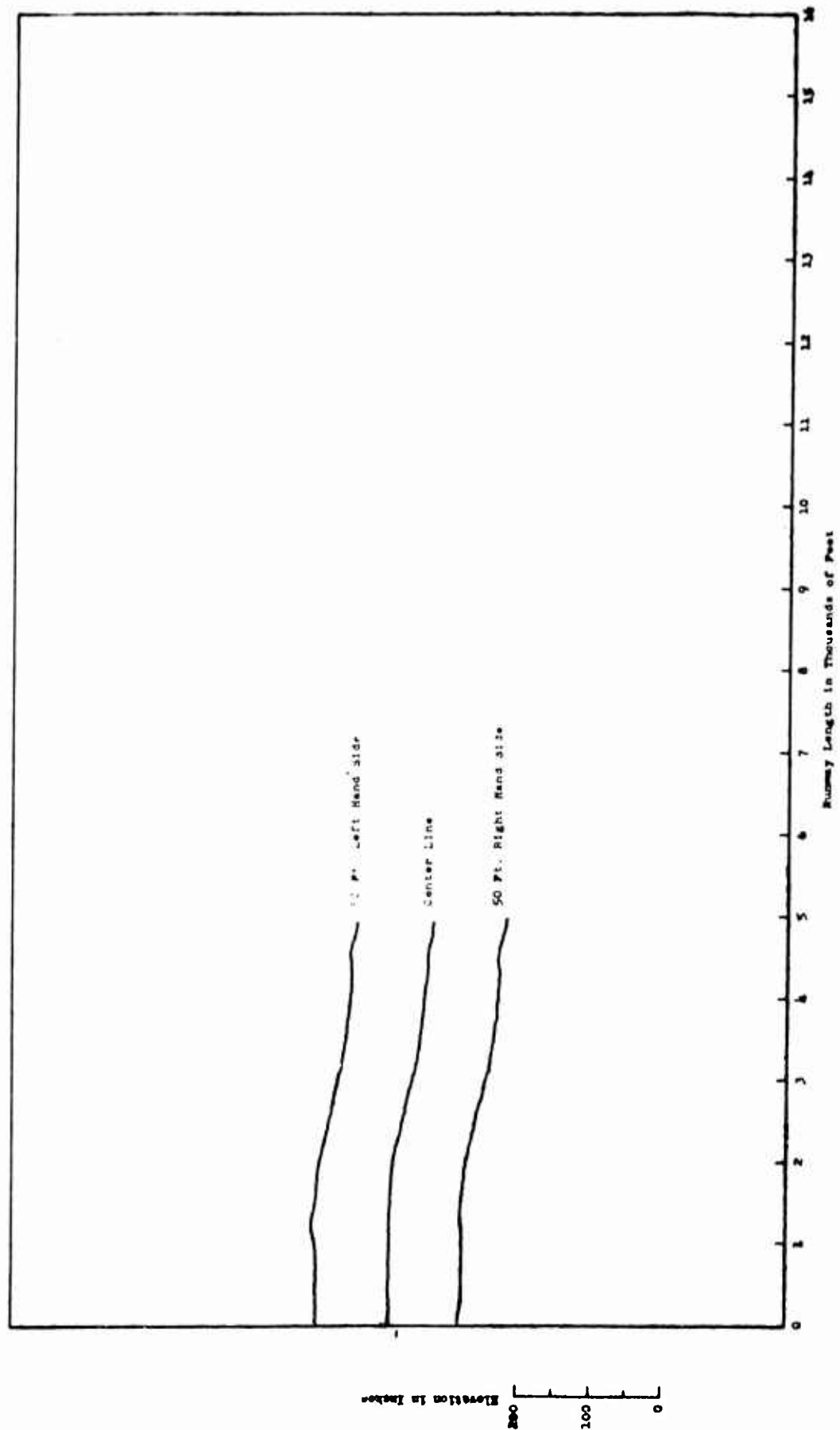


Figure 76 - Profiles, Runway 18, Bakalar Air Force Base

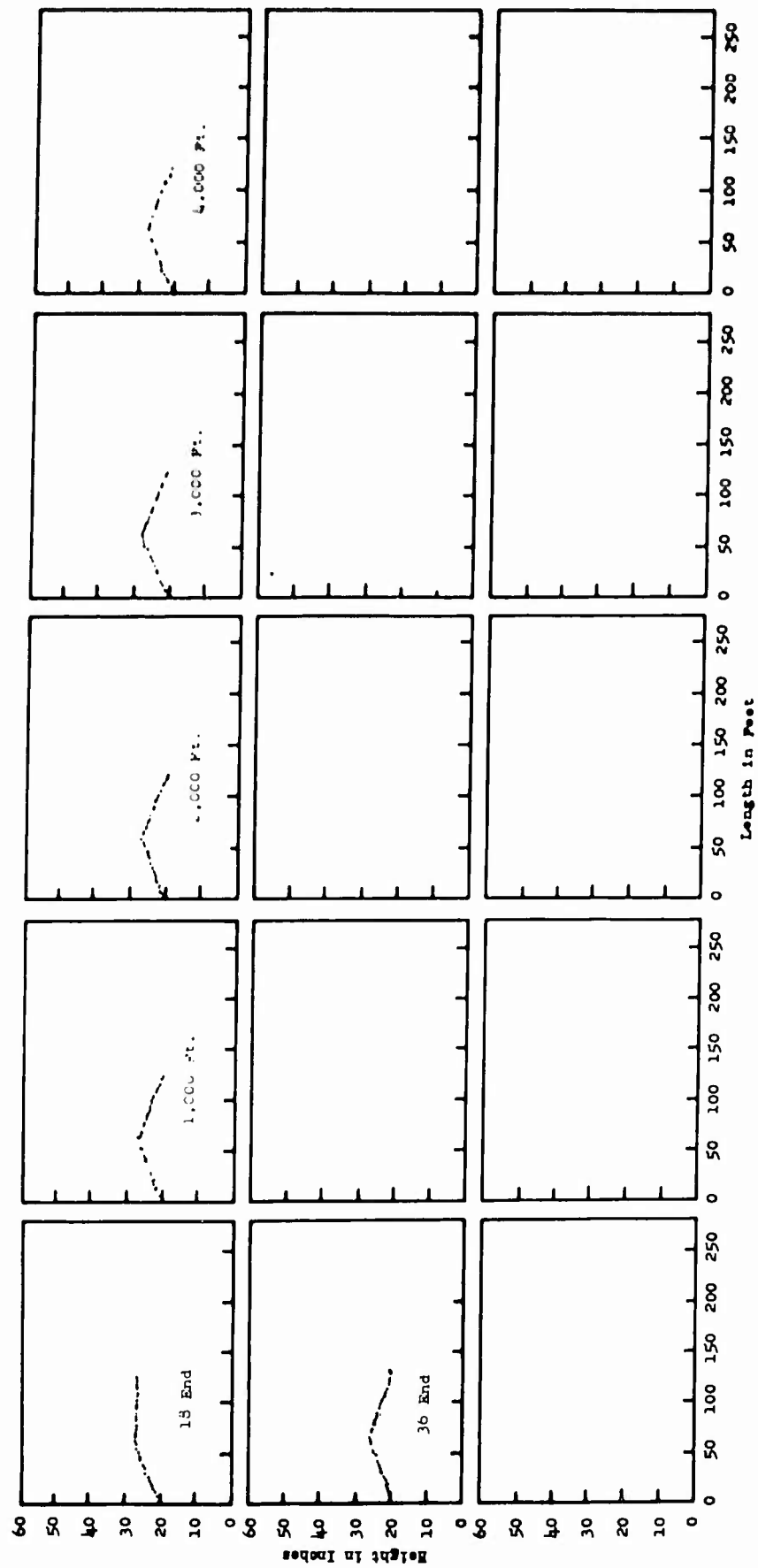


Figure 77 - Cross Run Profiles, Runway 18, Bakalar Air Force Base

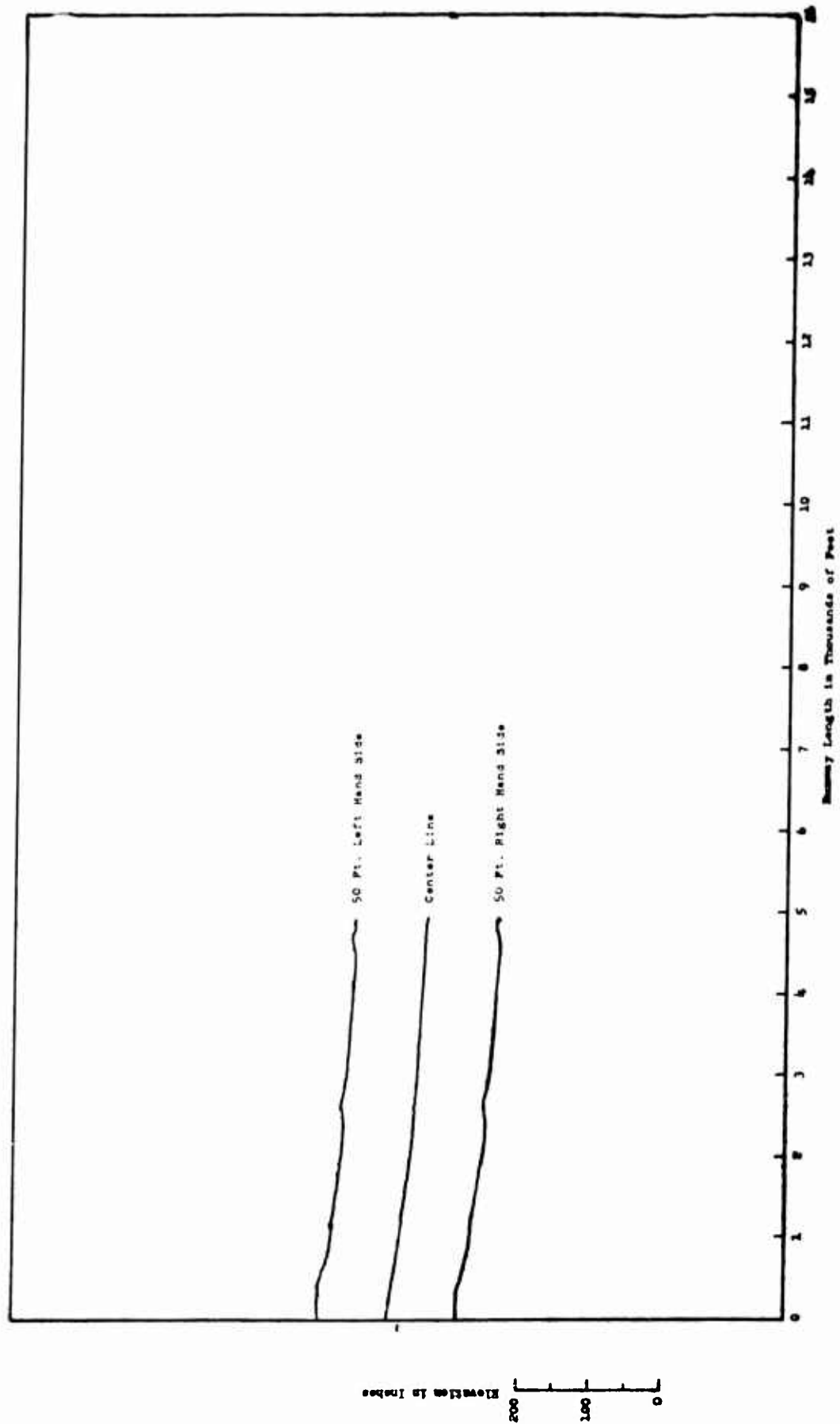


Figure 78 - Profiles, Runway 22, Babalar Air Force Base

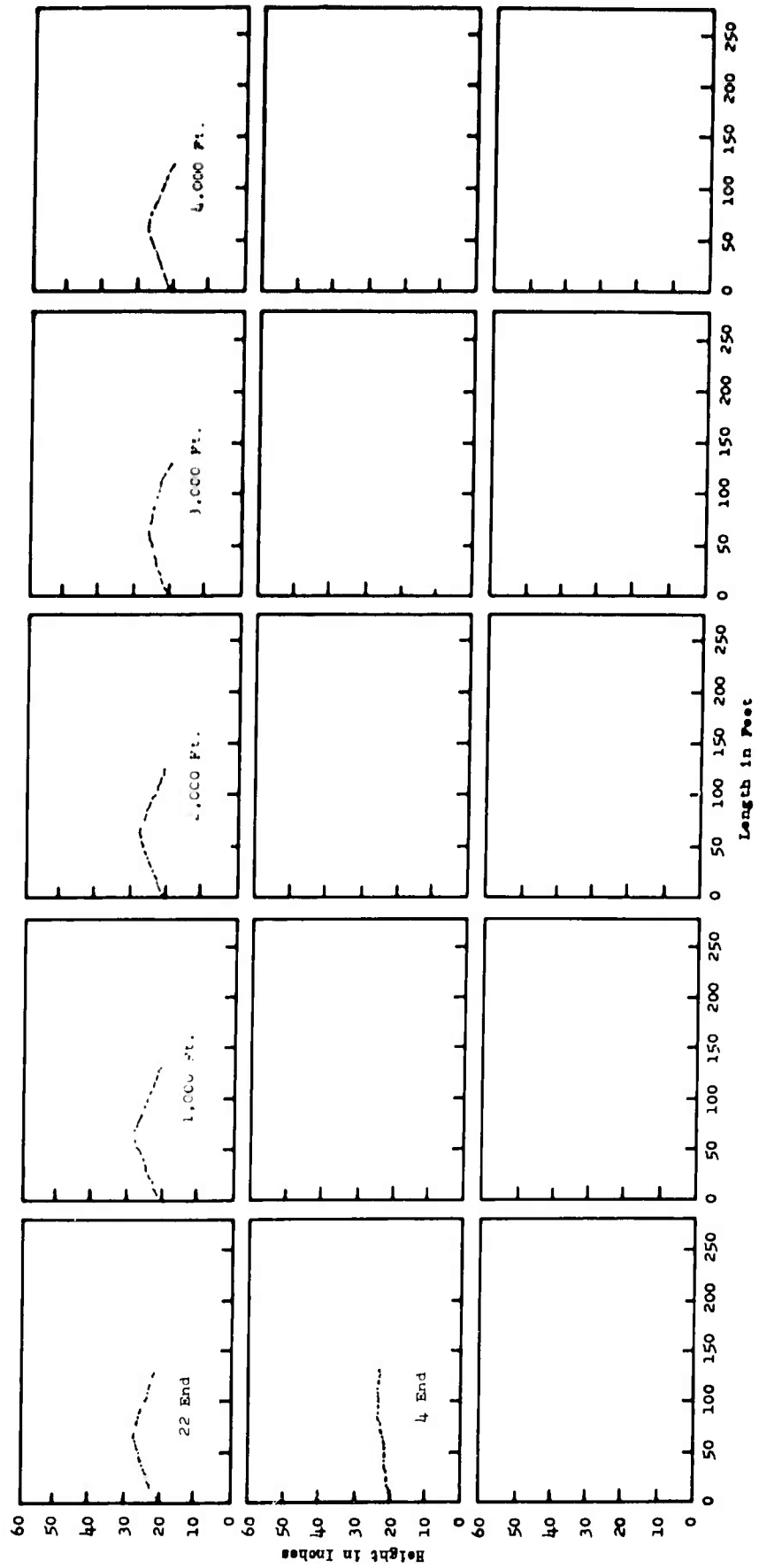


Figure 79 - Cross Run Profiles, Runway 22, Bakalar Air Force Base

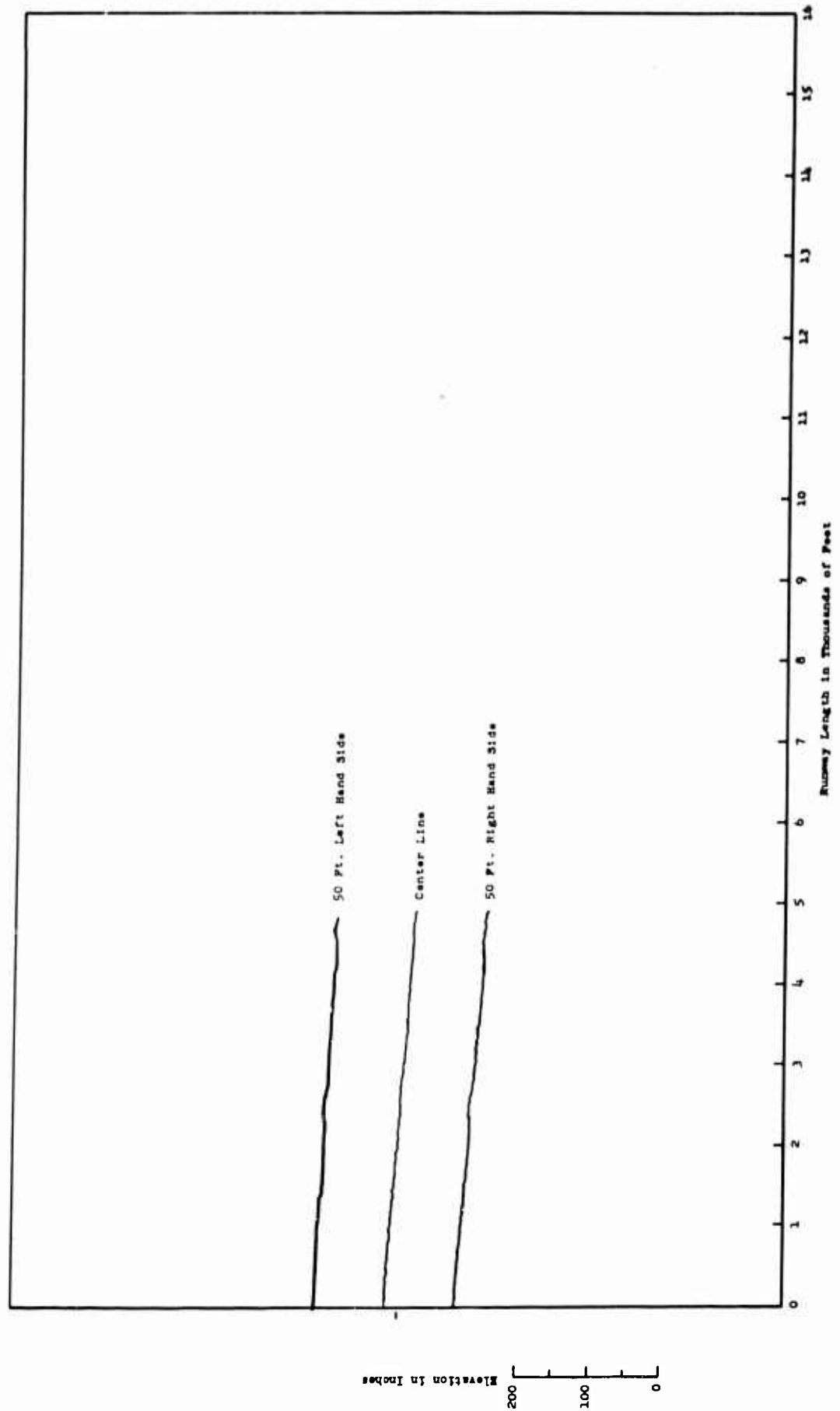


Figure 80 - Profiles, Runway 13, Bakalar Air Force Base

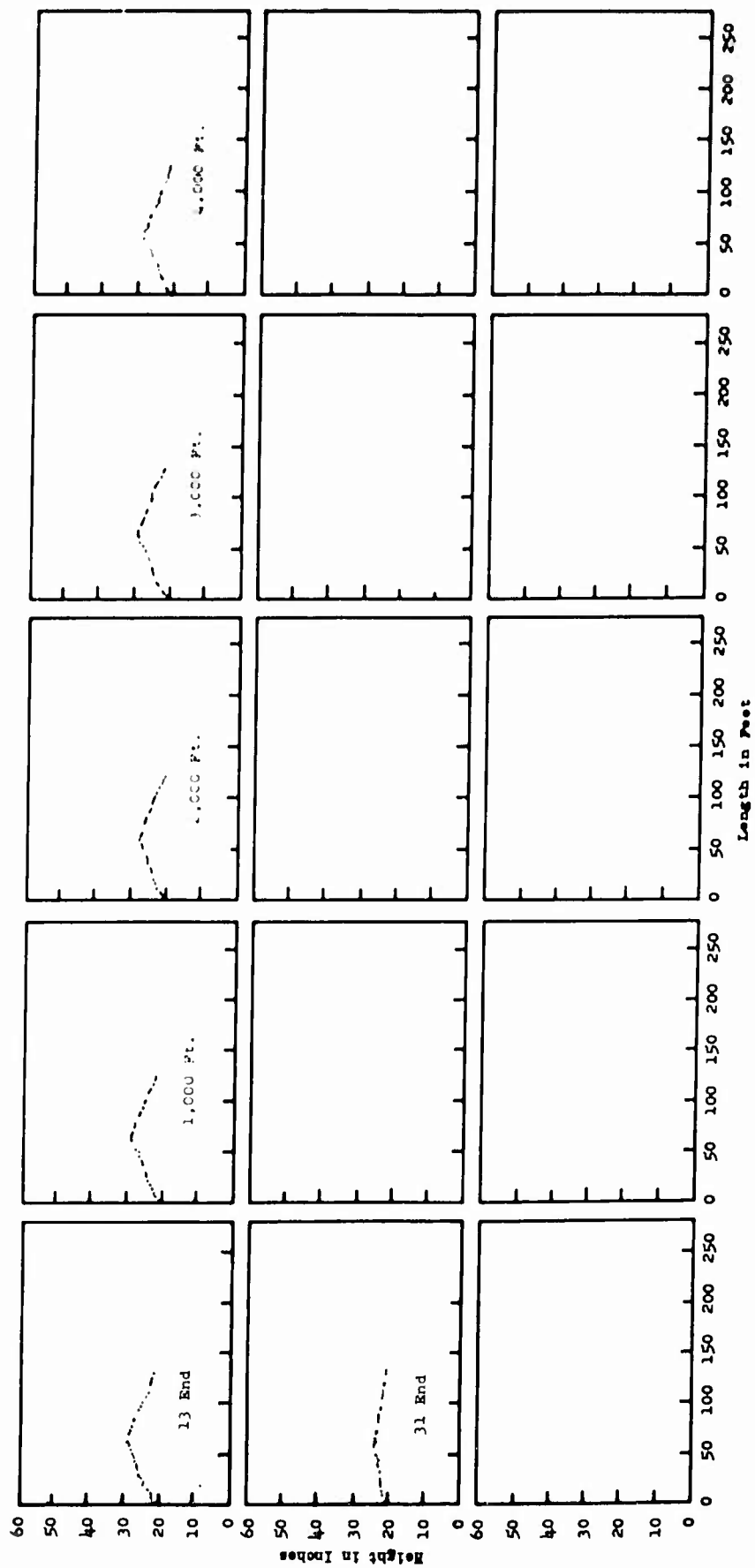


Figure 81 - Cross Run Profiles, Runway 13, Babalar Air Force Base

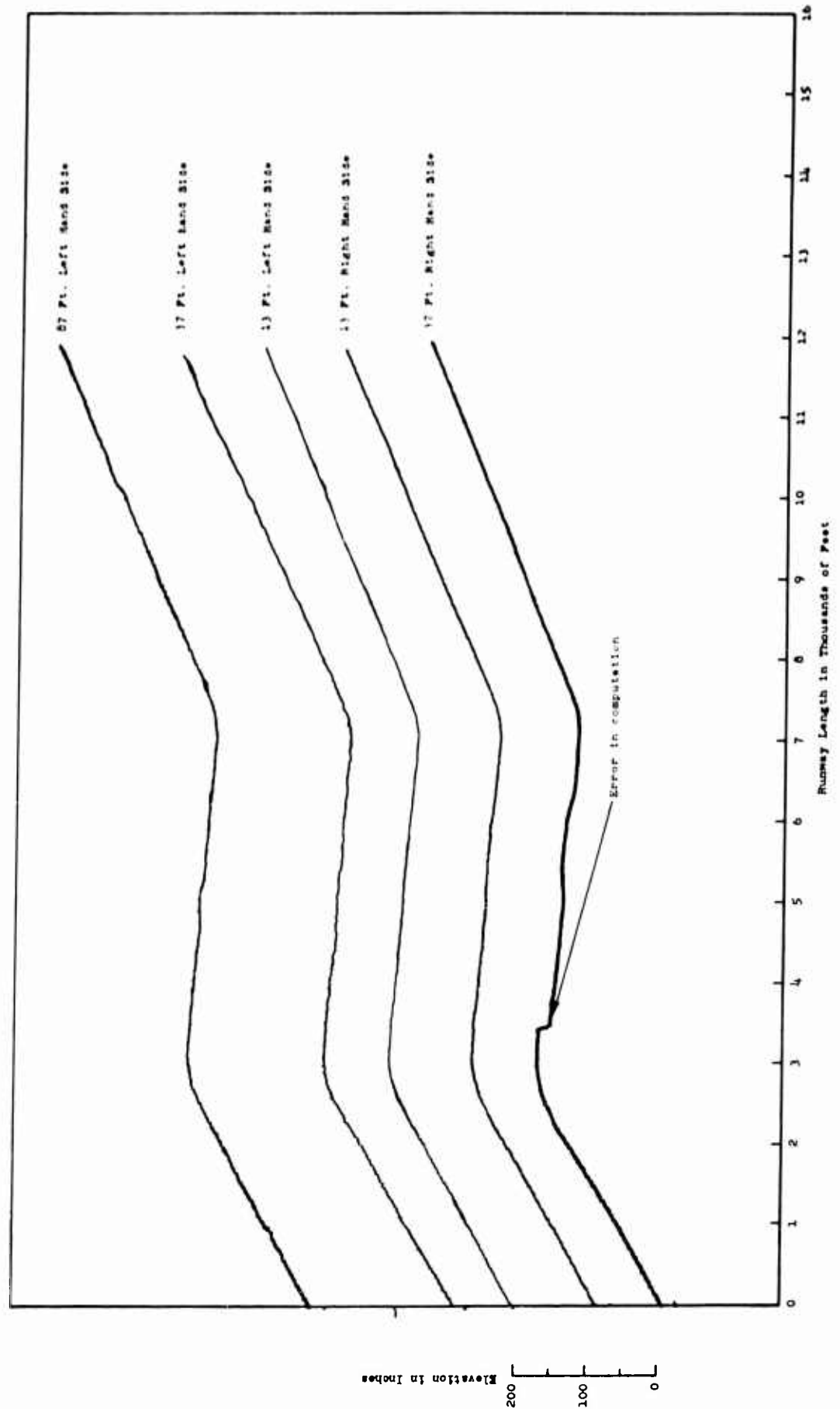


Figure 82 - Profiles, Runway 17, Carswell Air Force Base

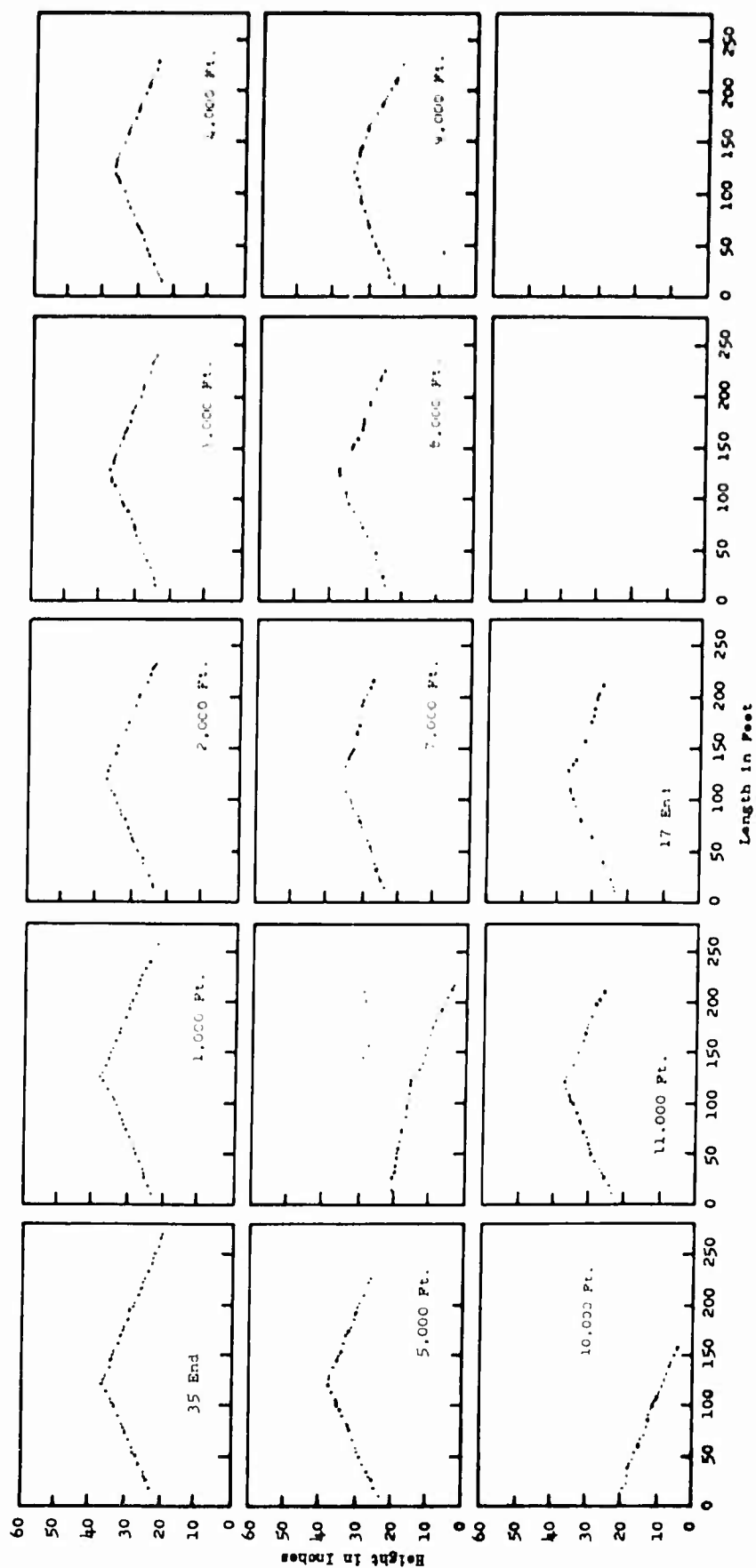


Figure 83 - Cross Run Profiles, Runway 17, Carswell Air Force Base

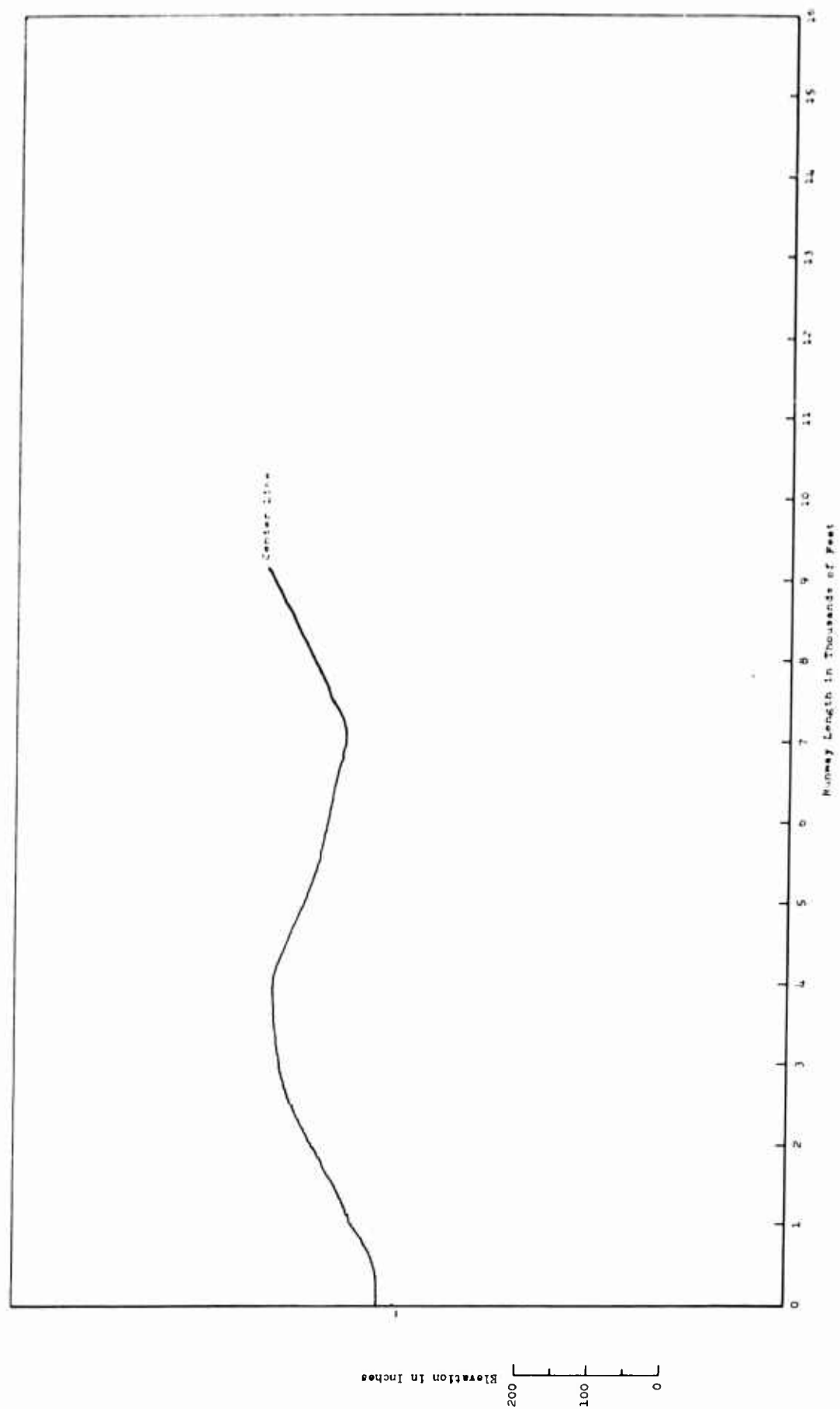


Figure 84 - Profile, Taxiway 17, Carswell Air Force Base

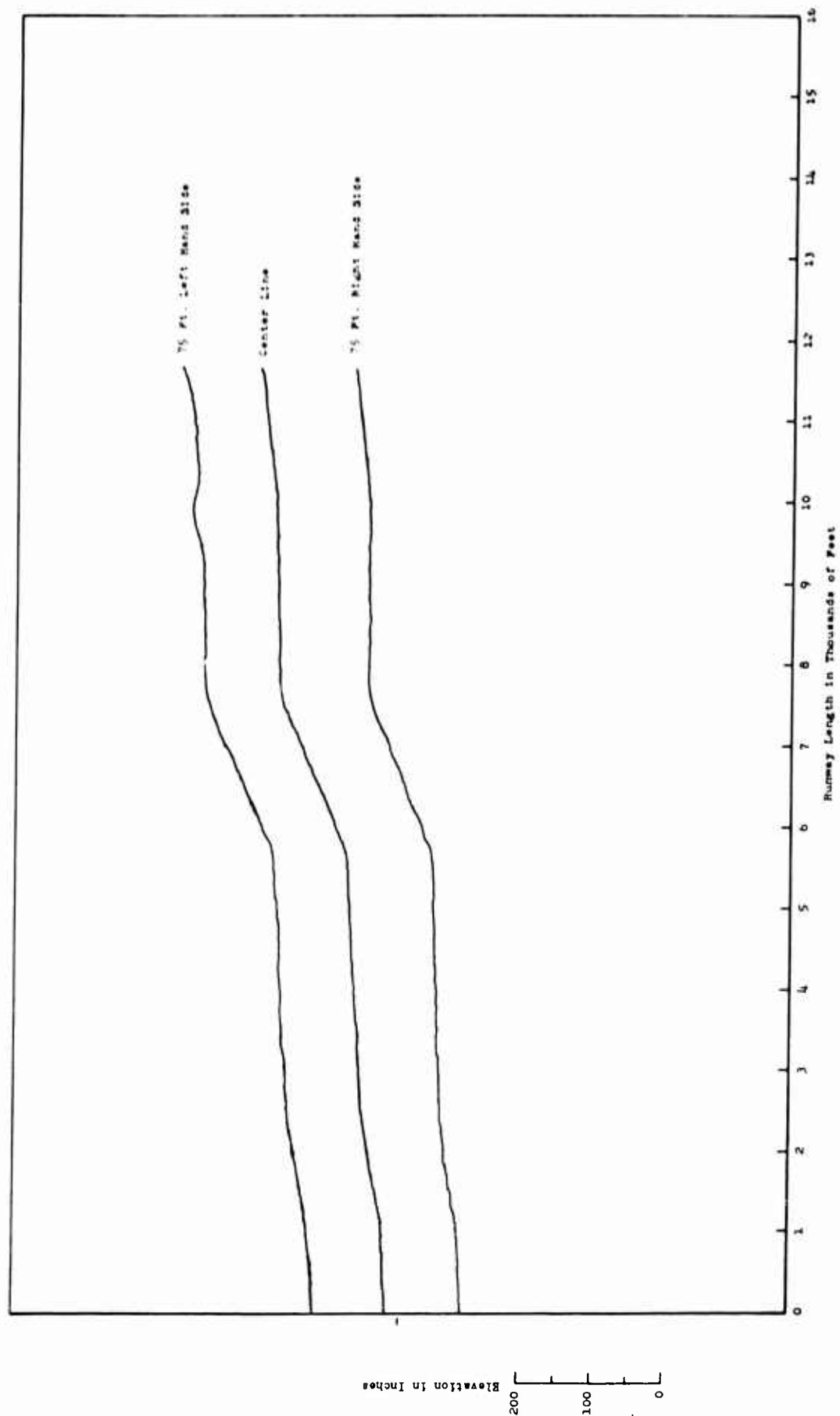


Figure 85 - Profiles, Runway 30, Castle Air Force Base

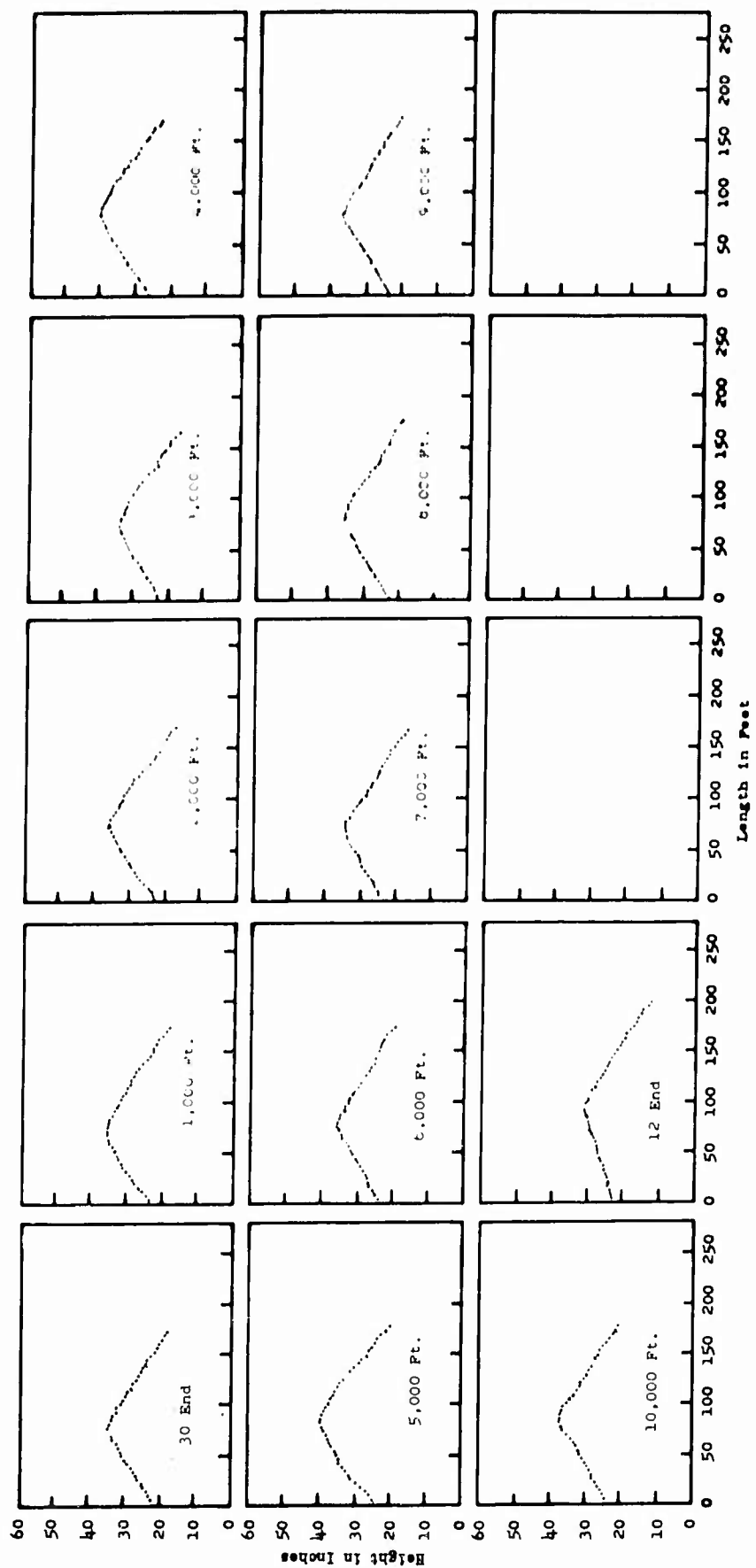


Figure 86 - Cross Run Profiles, Runway 30, Castle Air Force Base

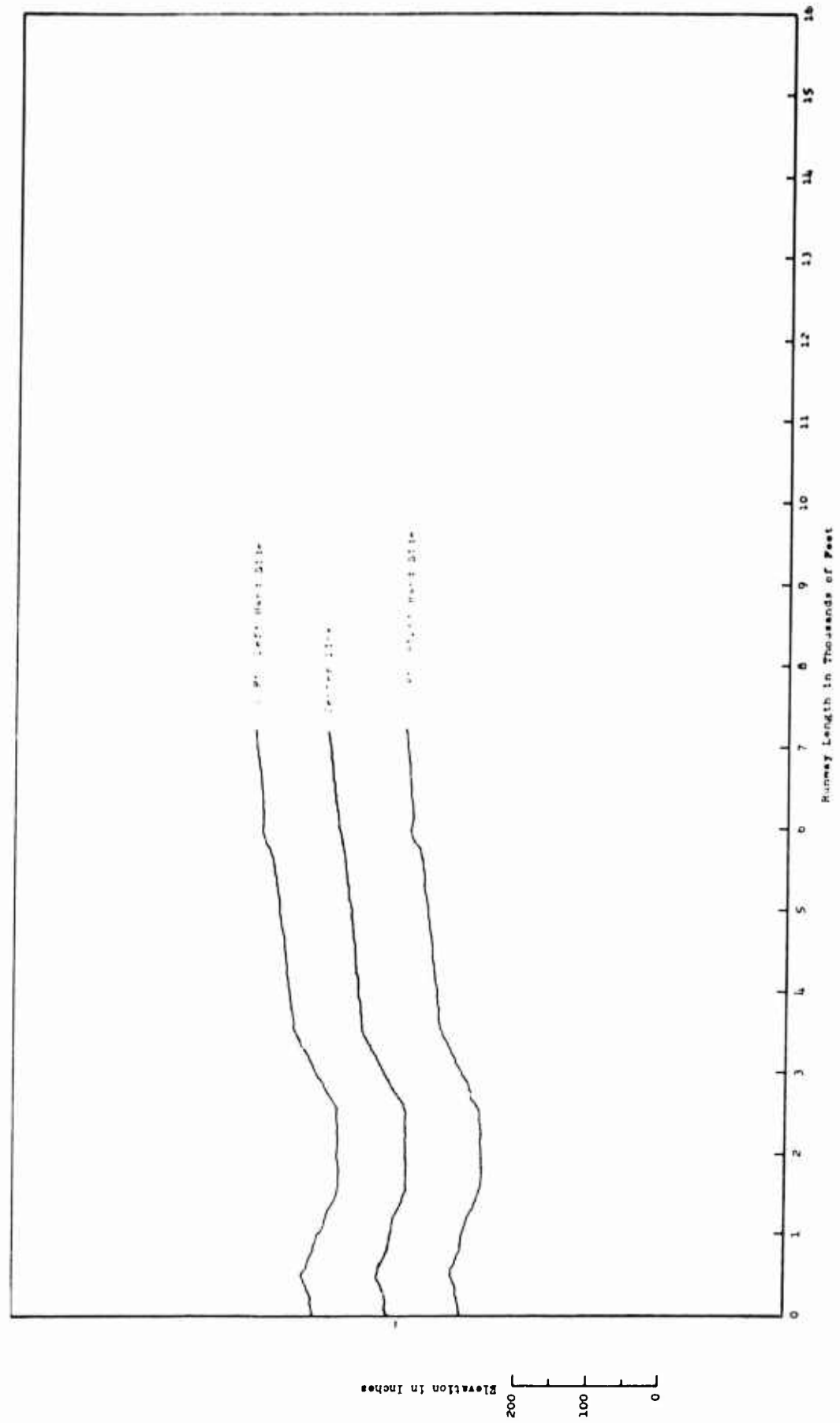


Figure 87 - Profiles, Taxiway 9, Castle Air Force Base

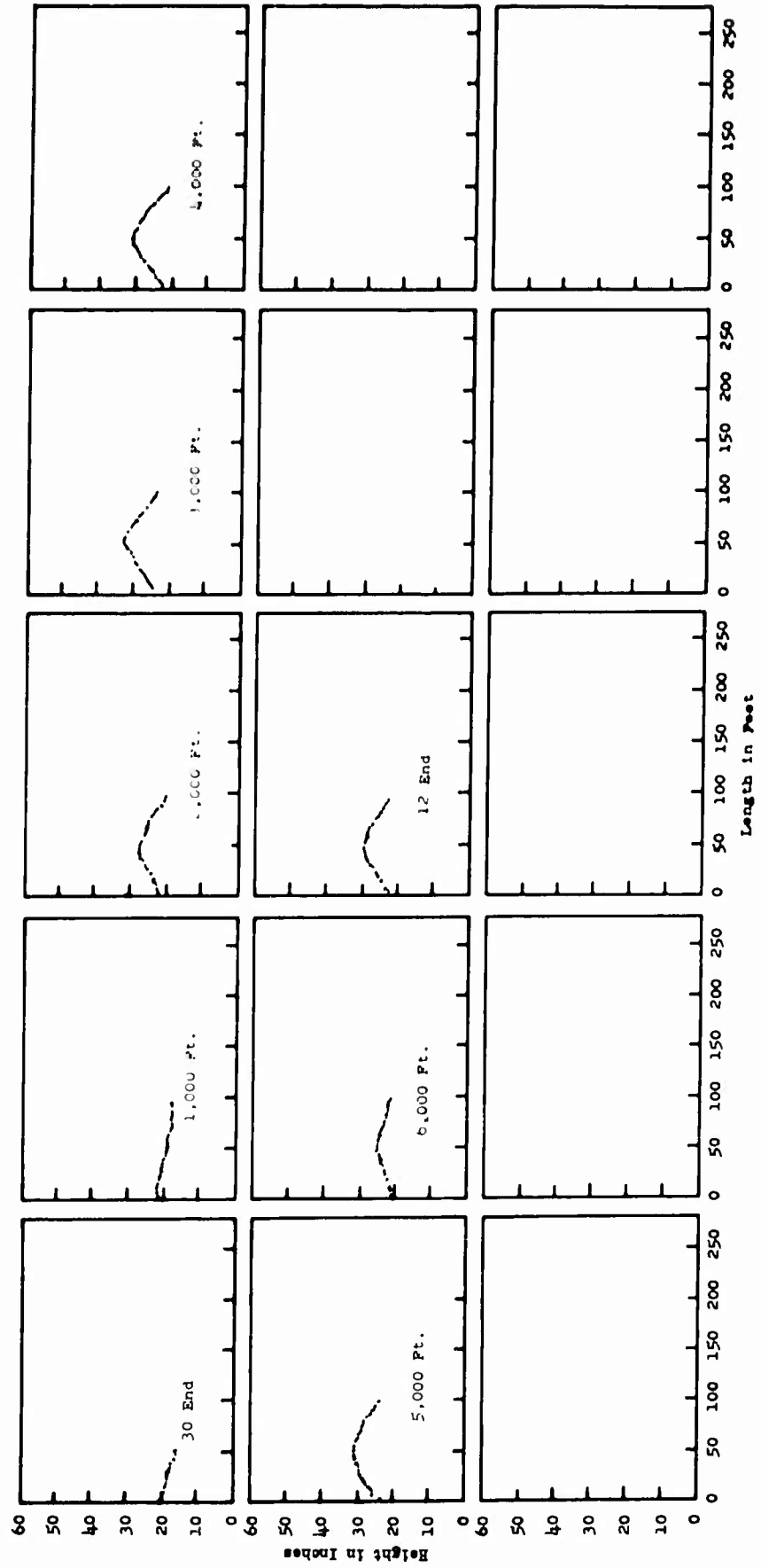


Figure 88 - Cross Run Profiles, Taxiway 9, Castle Air Force Base

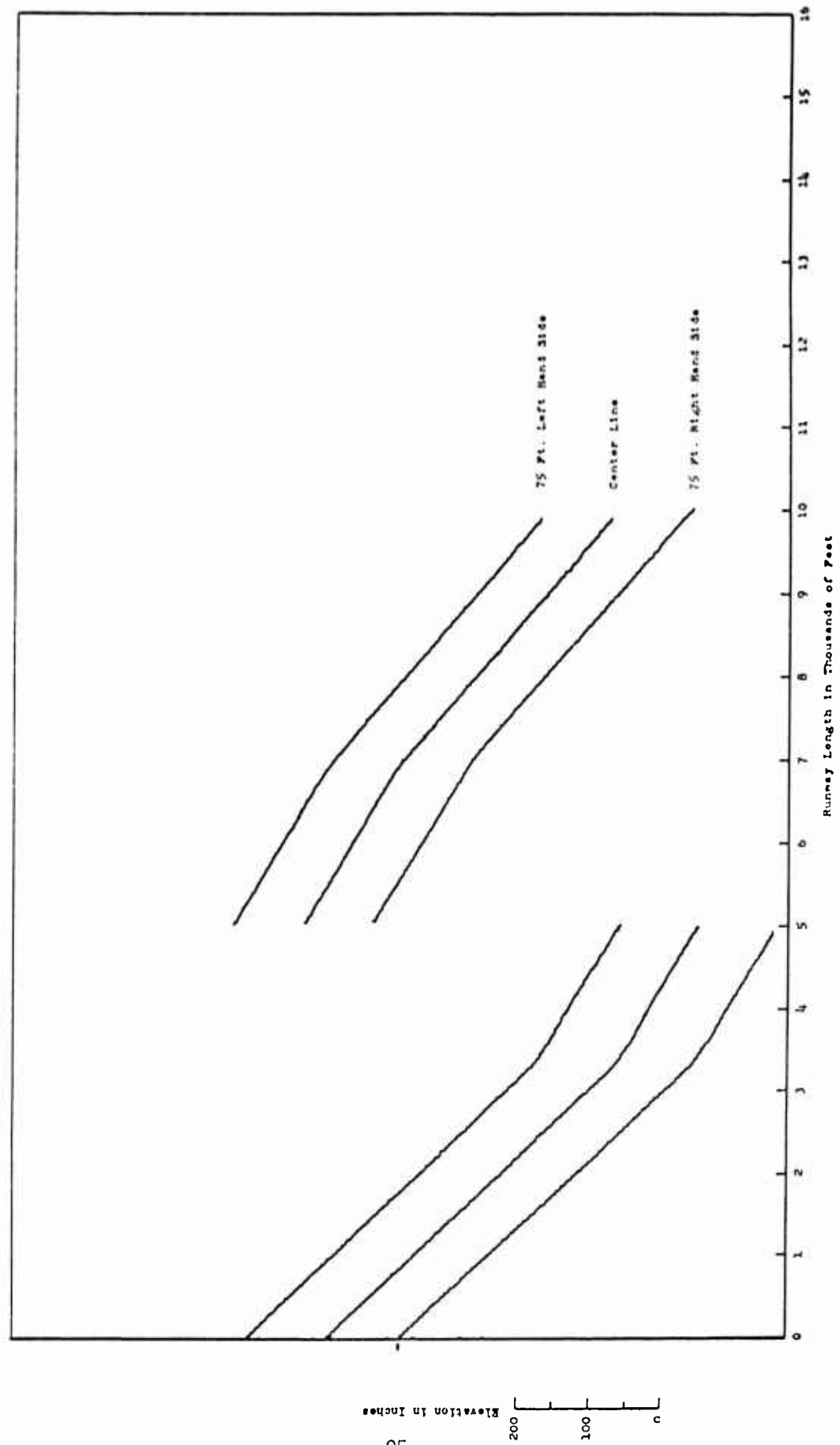


Figure 89 - Profiles, Runway 10, Dobbins Air Force Base

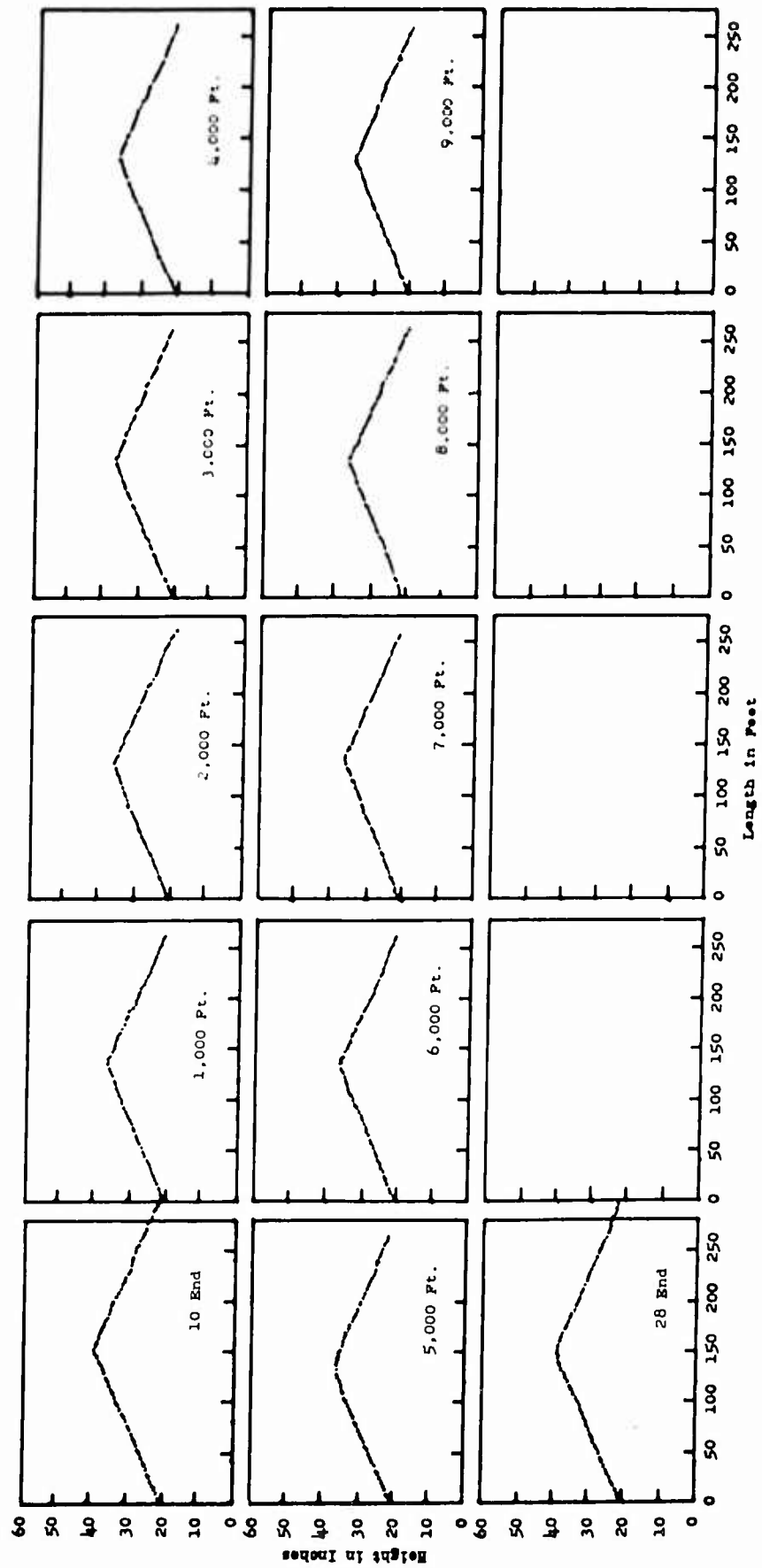


Figure 90 - Cross Run Profiles, Runway 10, Dobbins Air Force Base

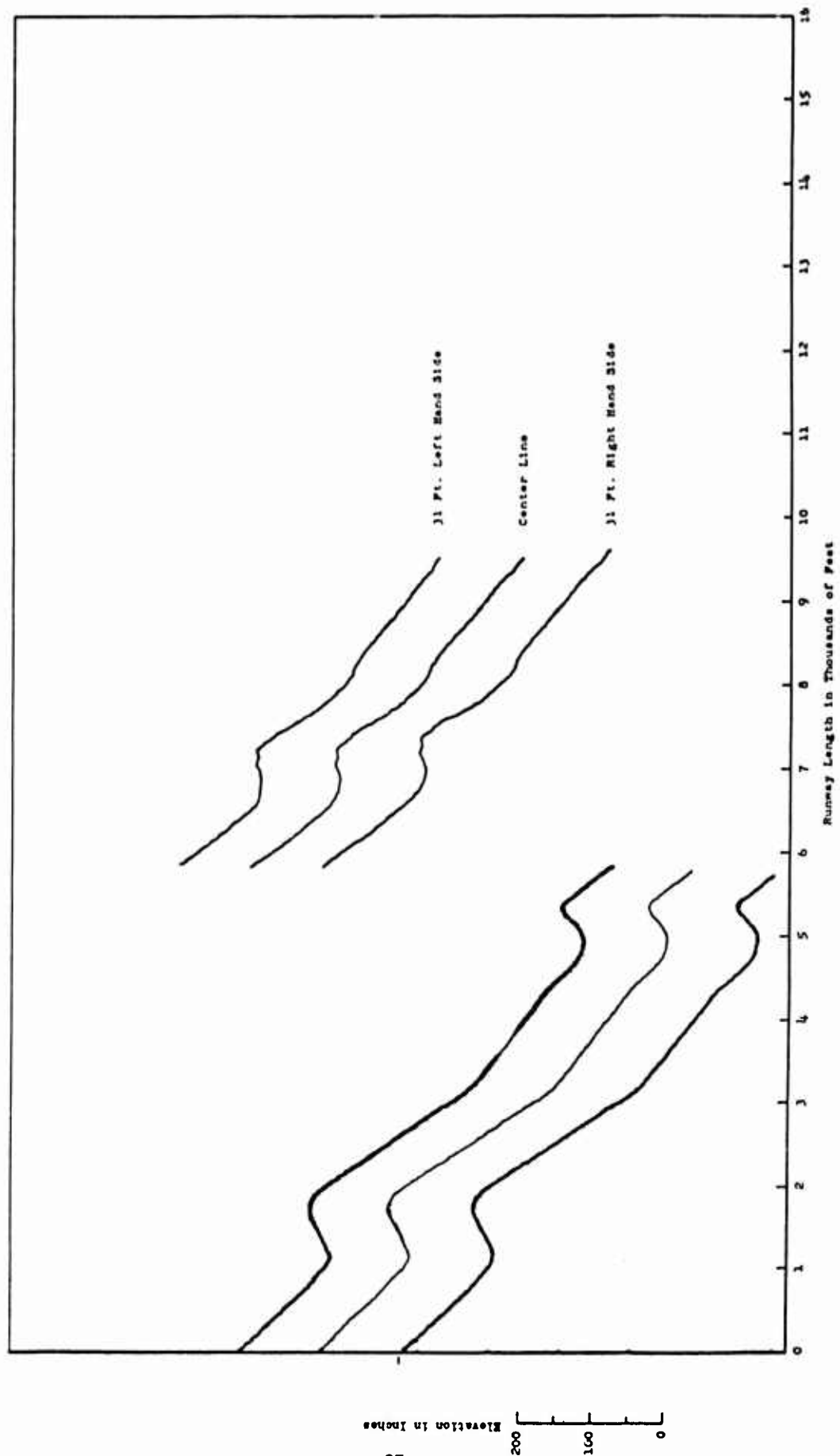


Figure 91 - Profiles, Taxiway 10, Dobbins Air Force Base

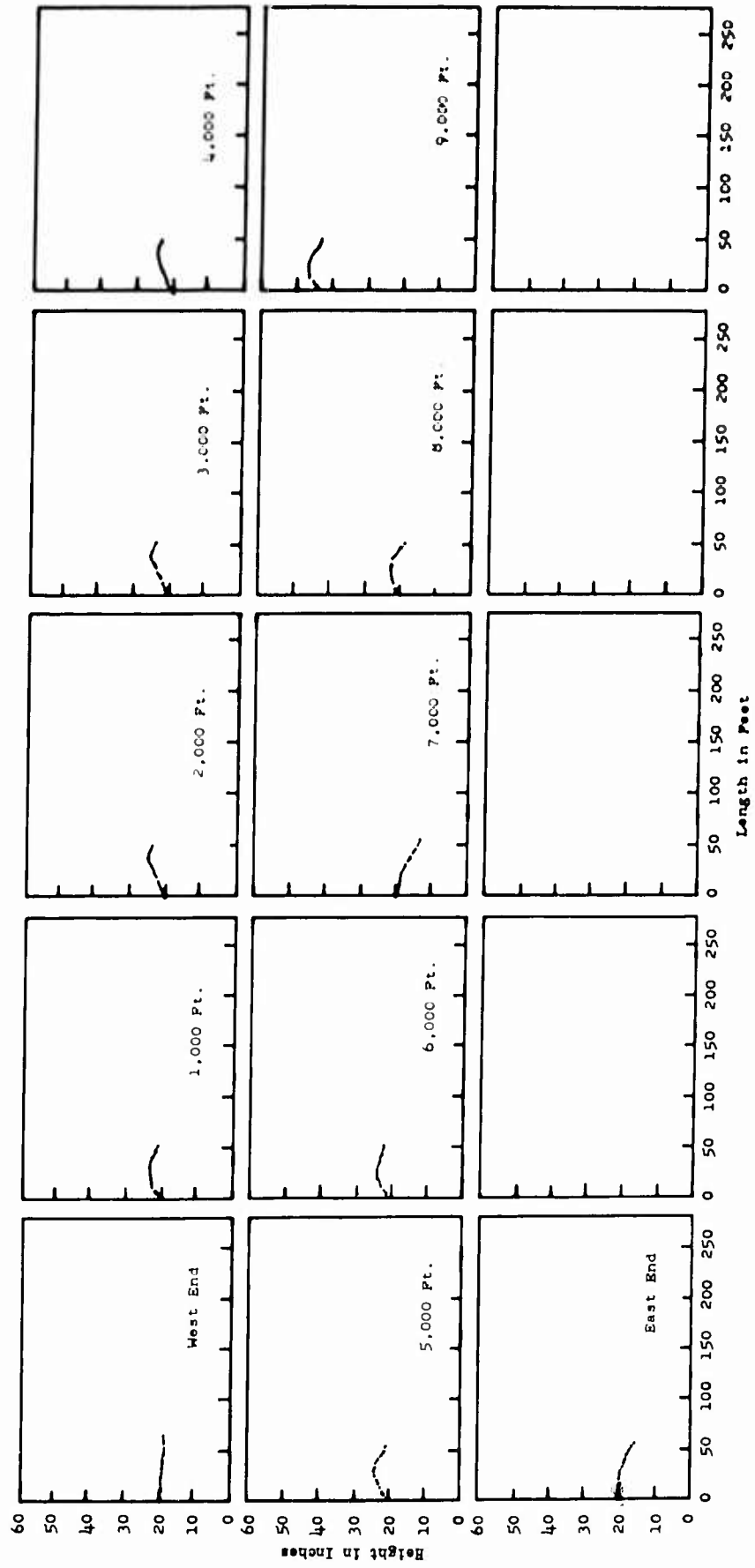


Figure 92 - Cross Run Profiles, Taxiway 10, Dobbins Air Force Base

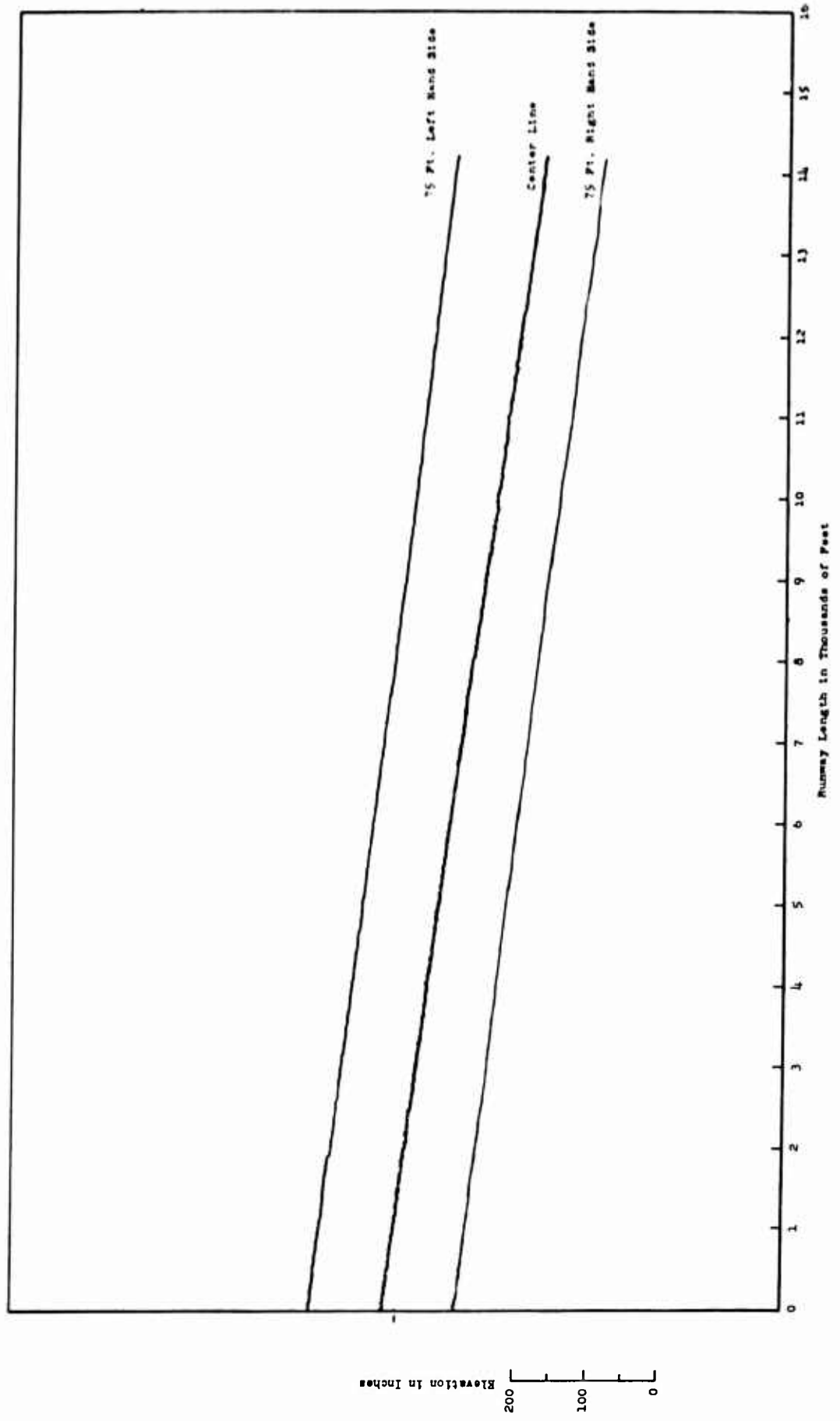


Figure 93 - Profiles, Runway 4, Edwards Air Force Base

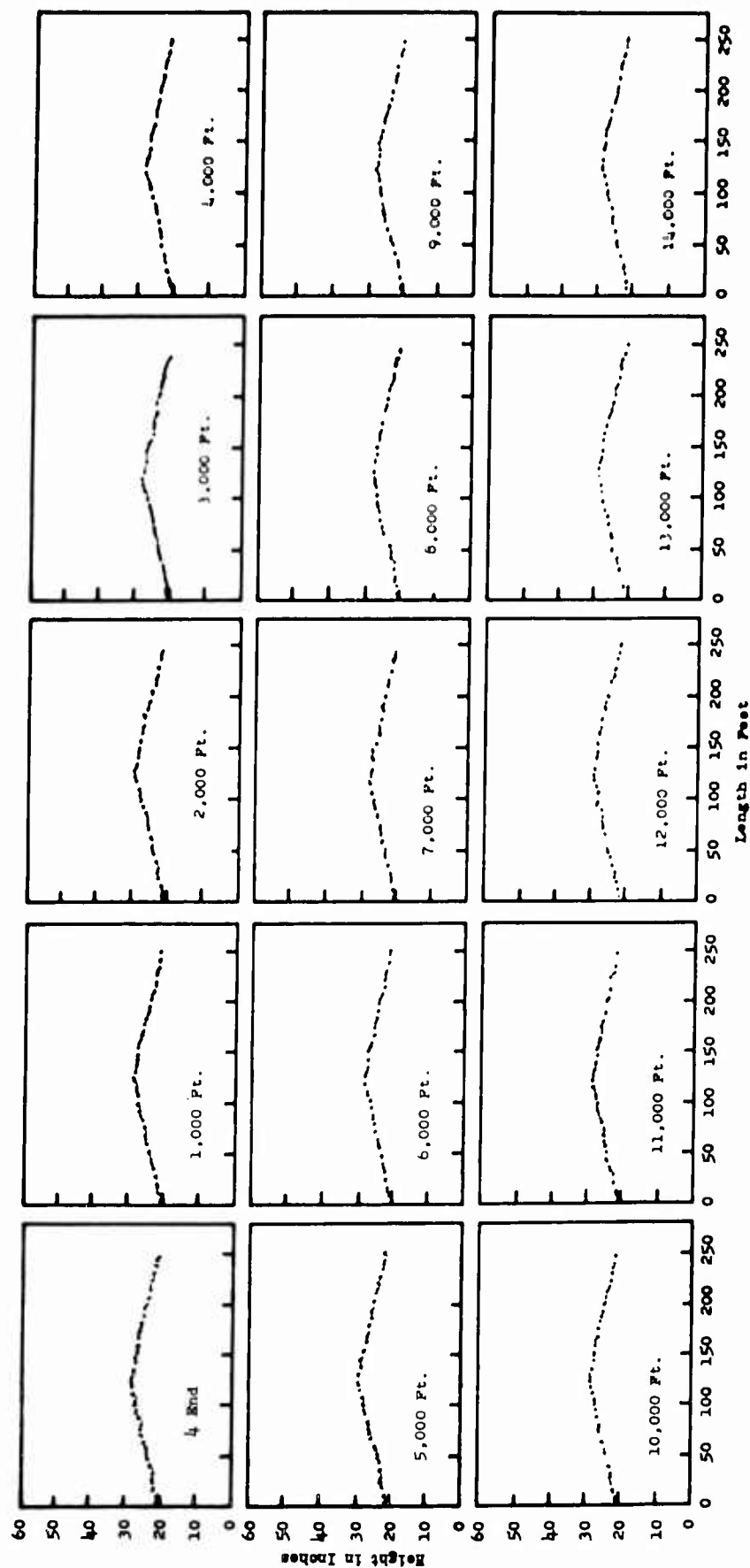


Figure 94 - Cross Run Profiles, Runway 4, Edwards Air Force Base

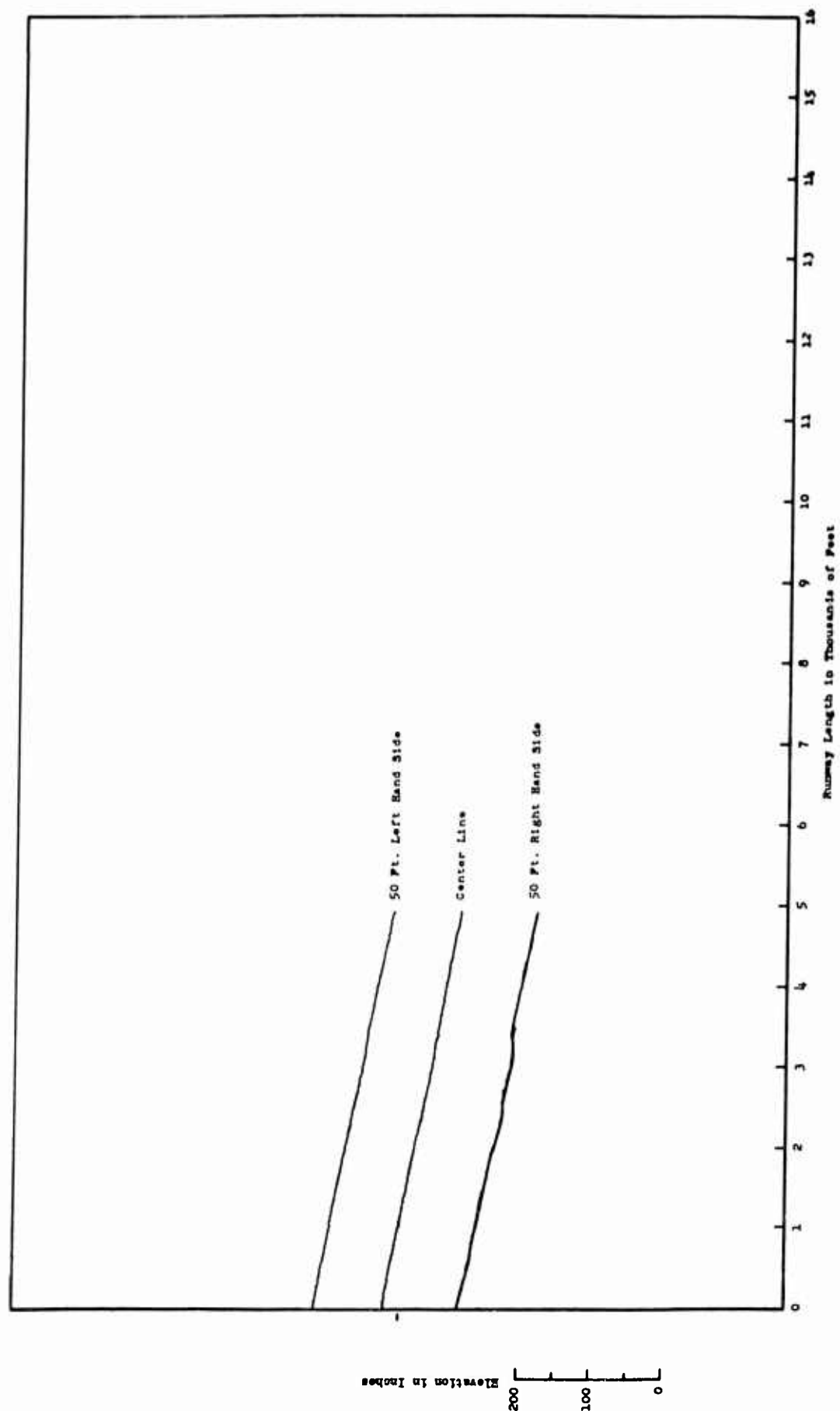


Figure 95 - Profiles, West Taxiway, Edwards Air Force Base

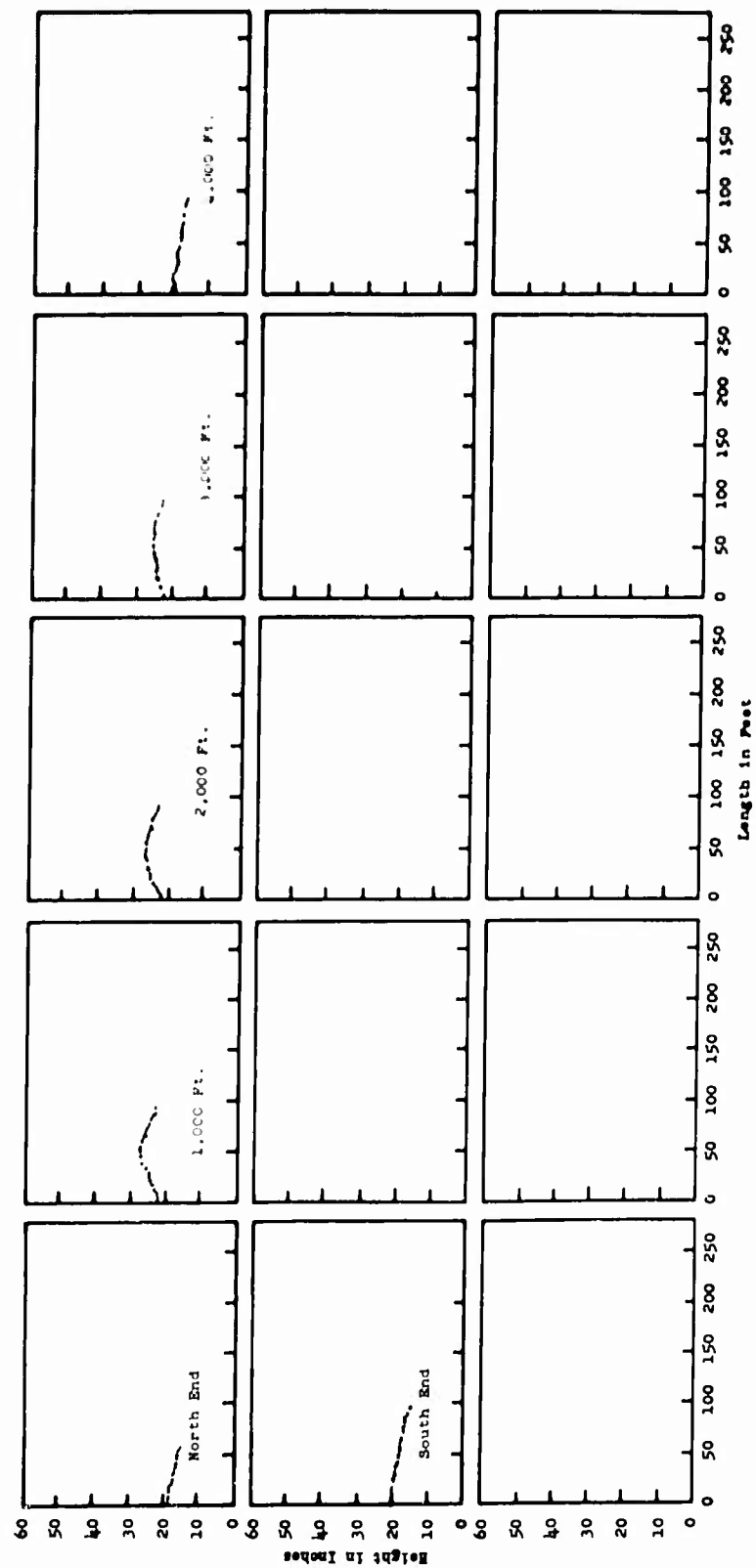


Figure 96 - Cross Run Profiles, West Taxiway, Edwards Air Force Base

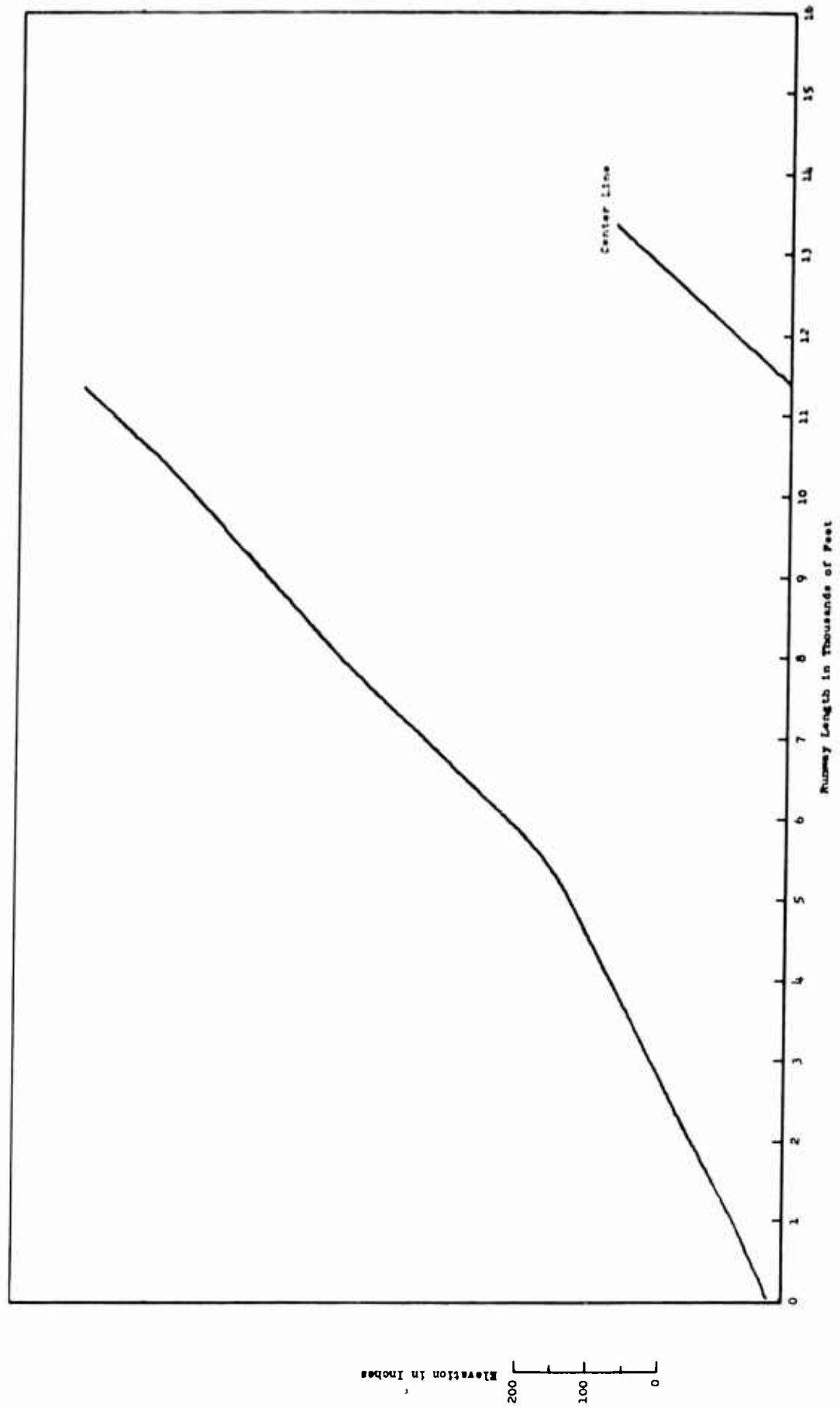


Figure 97 - Profiles, Runway 30, Ellsworth Air Force Base

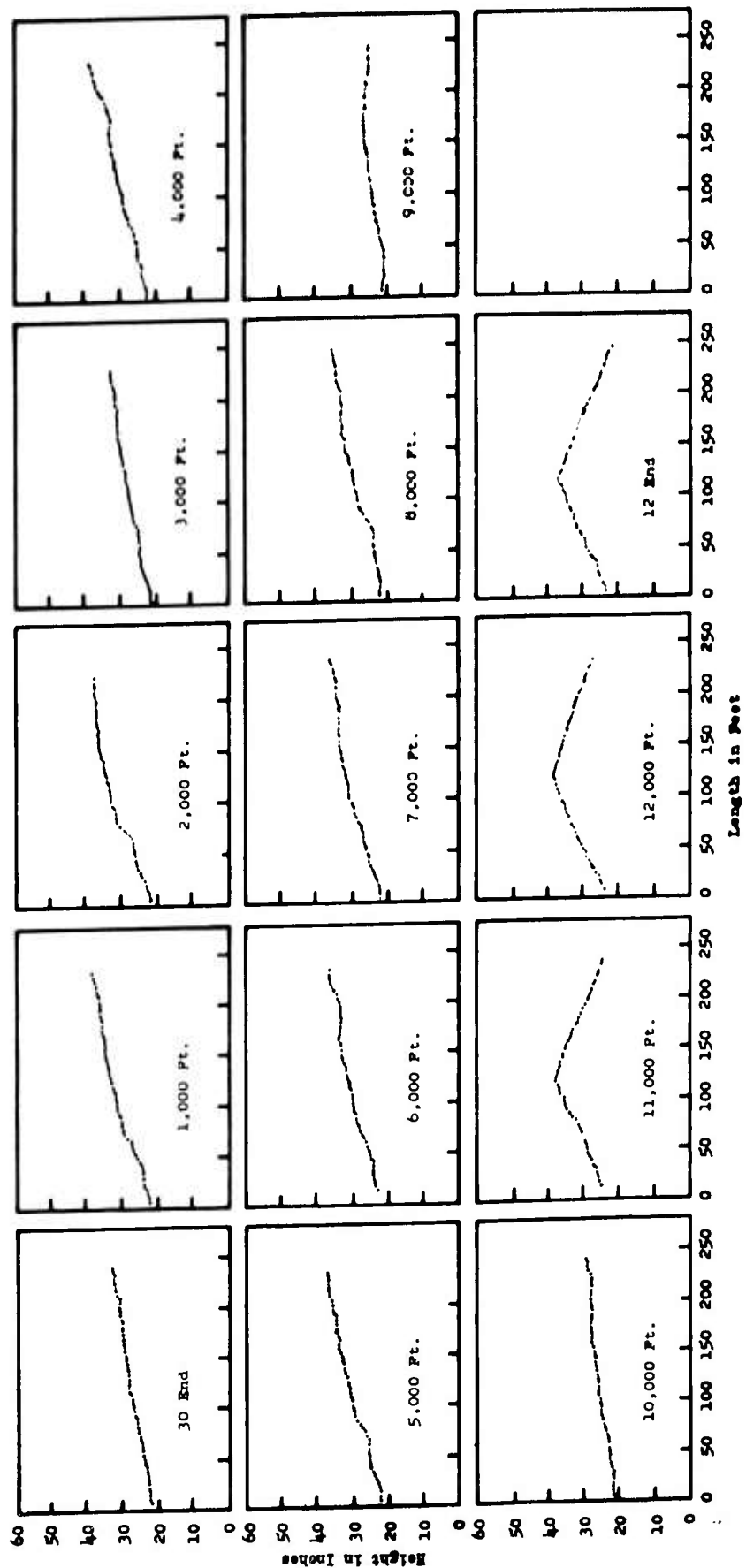


Figure 98 - Cross Run Profiles, Runway 30, Ellsworth Air Force Base

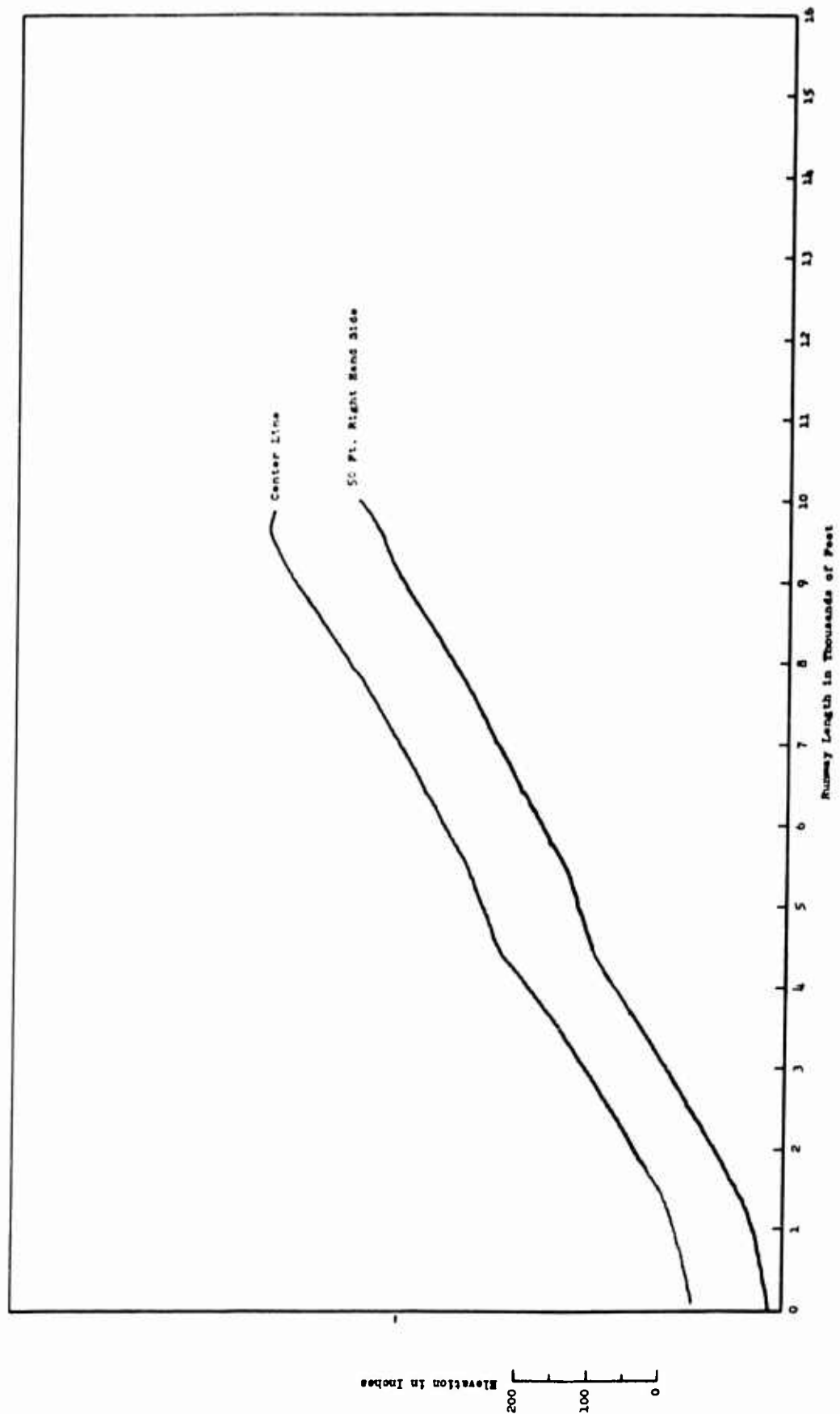


Figure 99 - Profiles, Runway 16, George Air Force Base

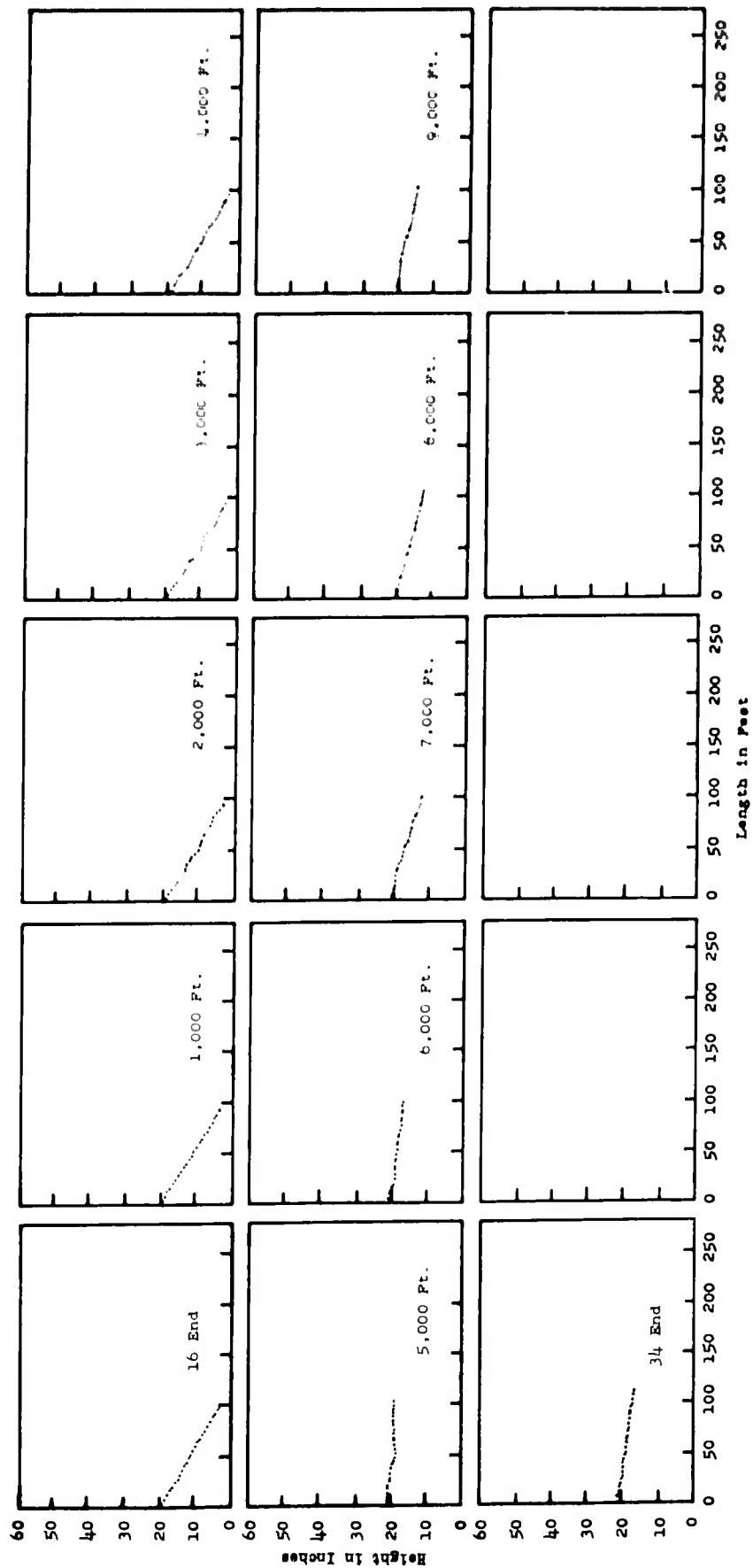


Figure 100 - Cross Run Profiles, Runway 16, George Air Force Base

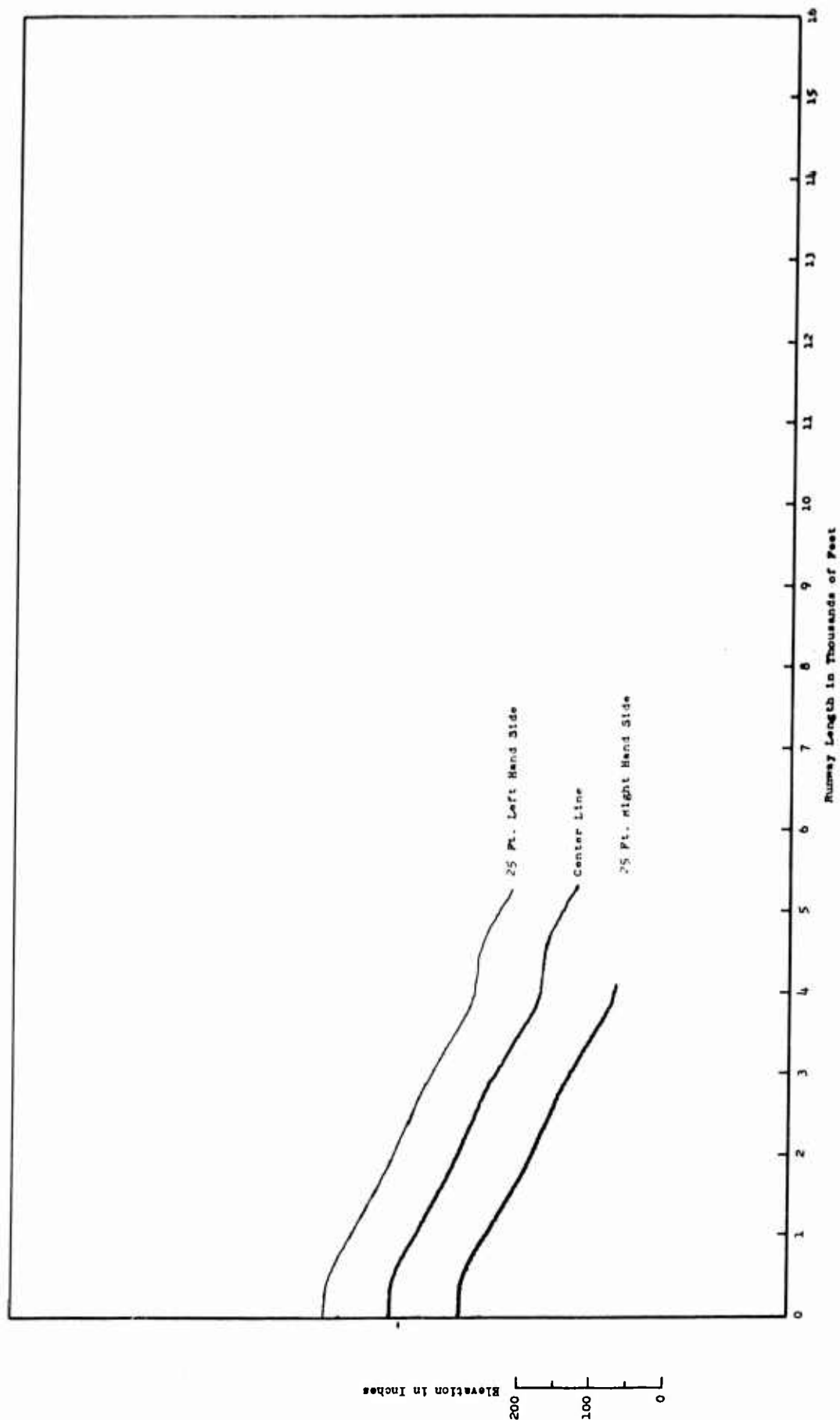


Figure 101 - Profiles, Taxiway 5, George Air Force Base

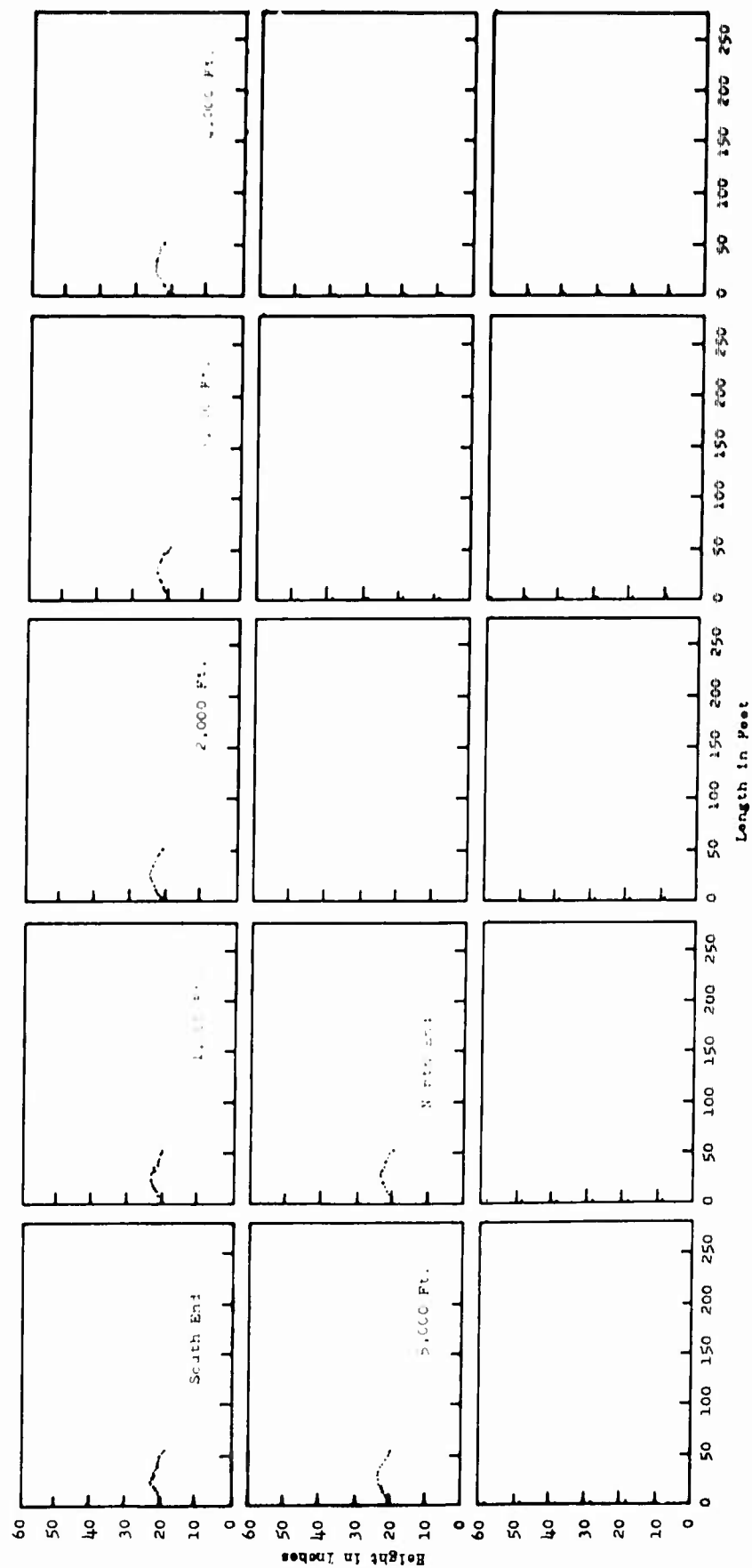


Figure 102 - Cross Run Profiles, Taxiway 5, George Air Force Base

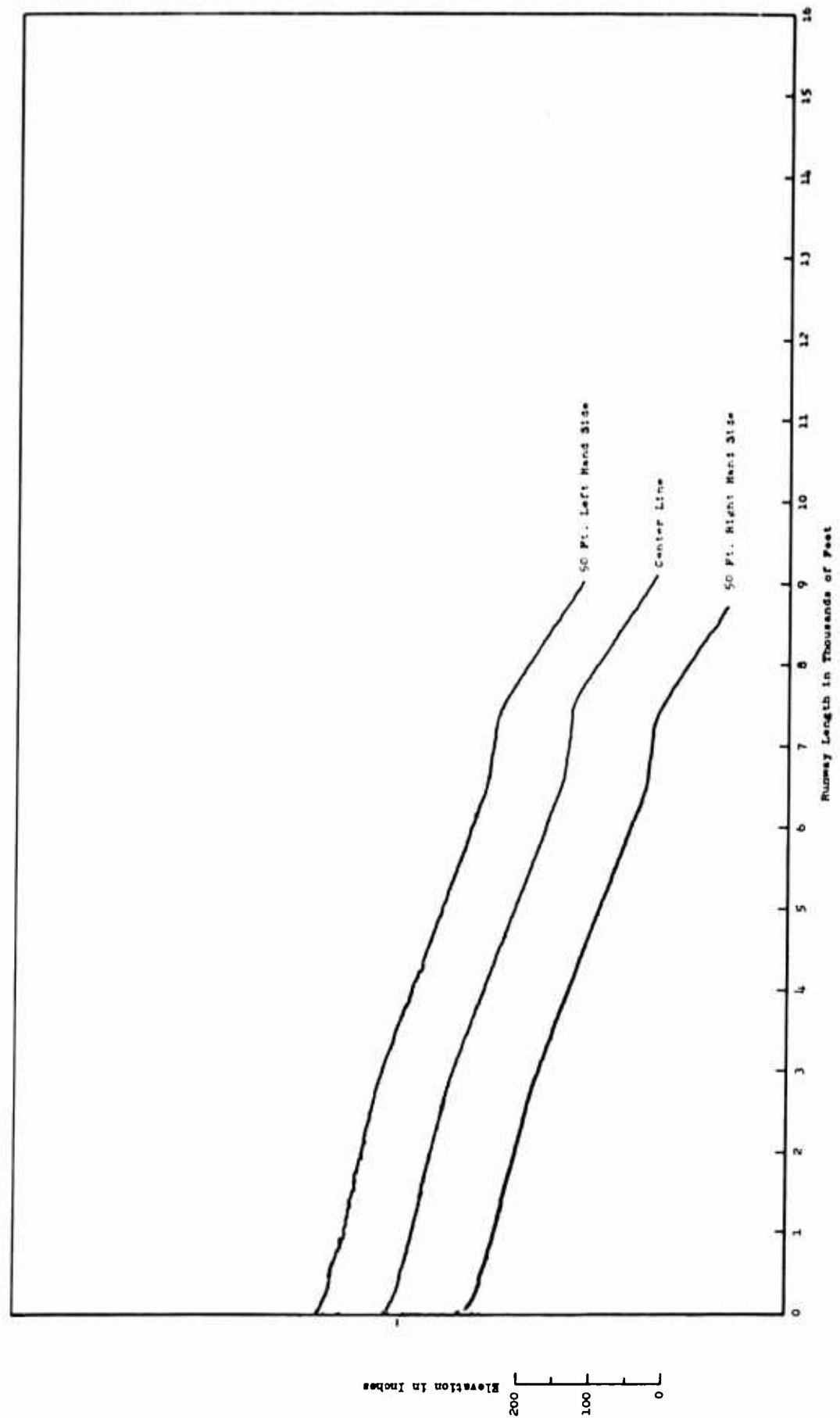


Figure 103 - Profiles, Runway 3, George Air Force Base

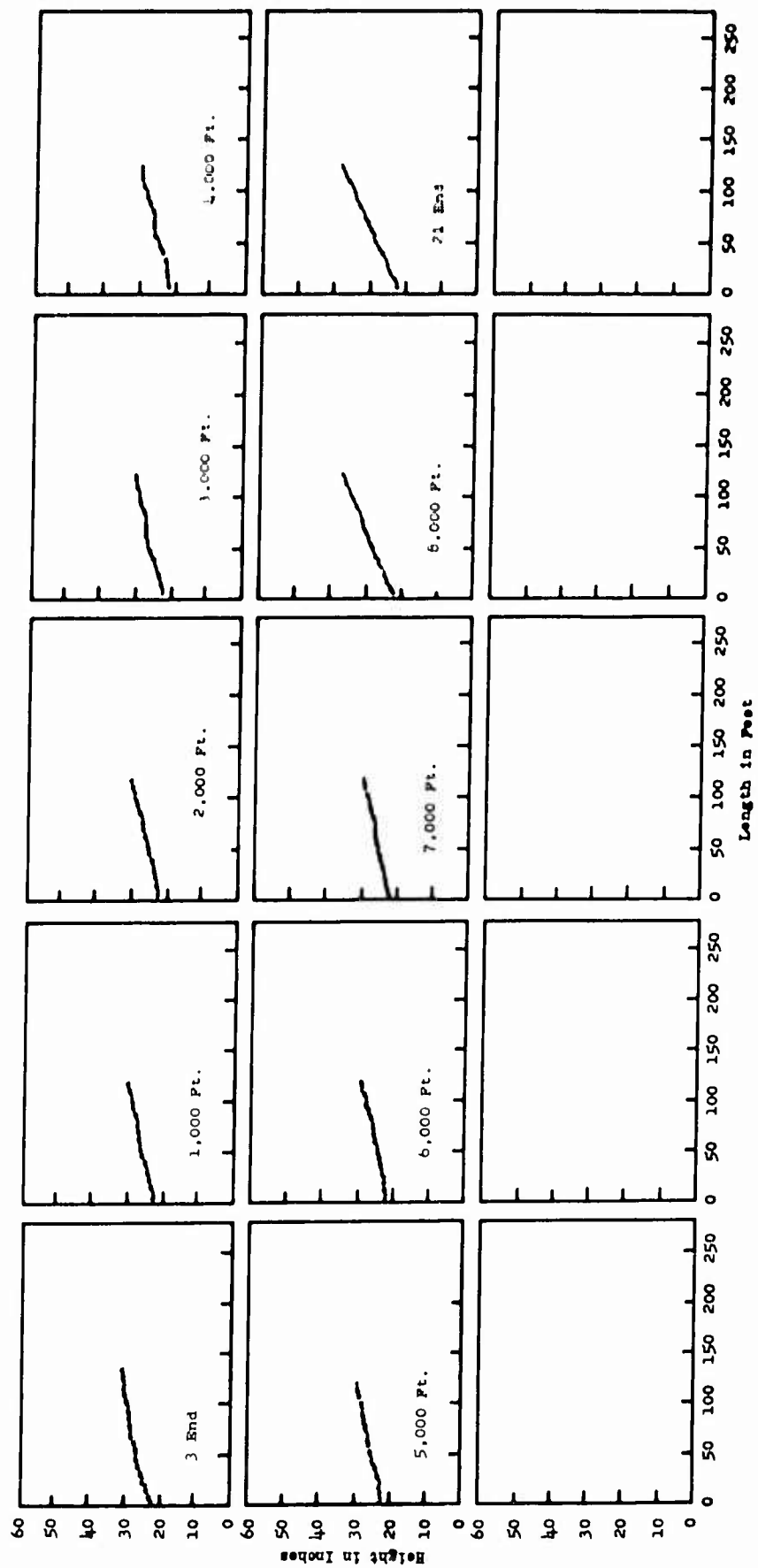


Figure 104 - Cross Run Profiles, Runway 3, George Air Force Base

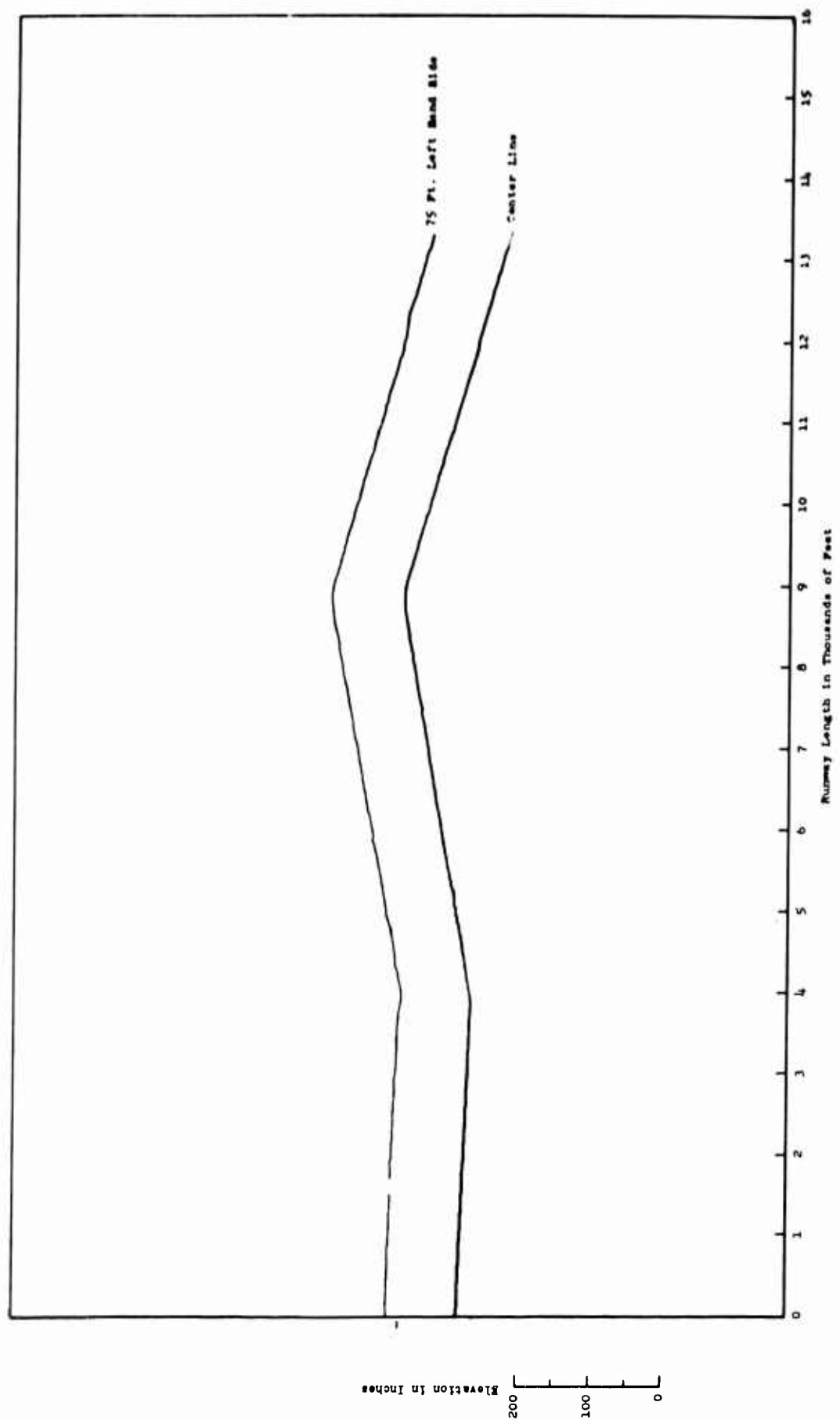


Figure 105 - Profiles, Runway 10, Glasgow Air Force Base

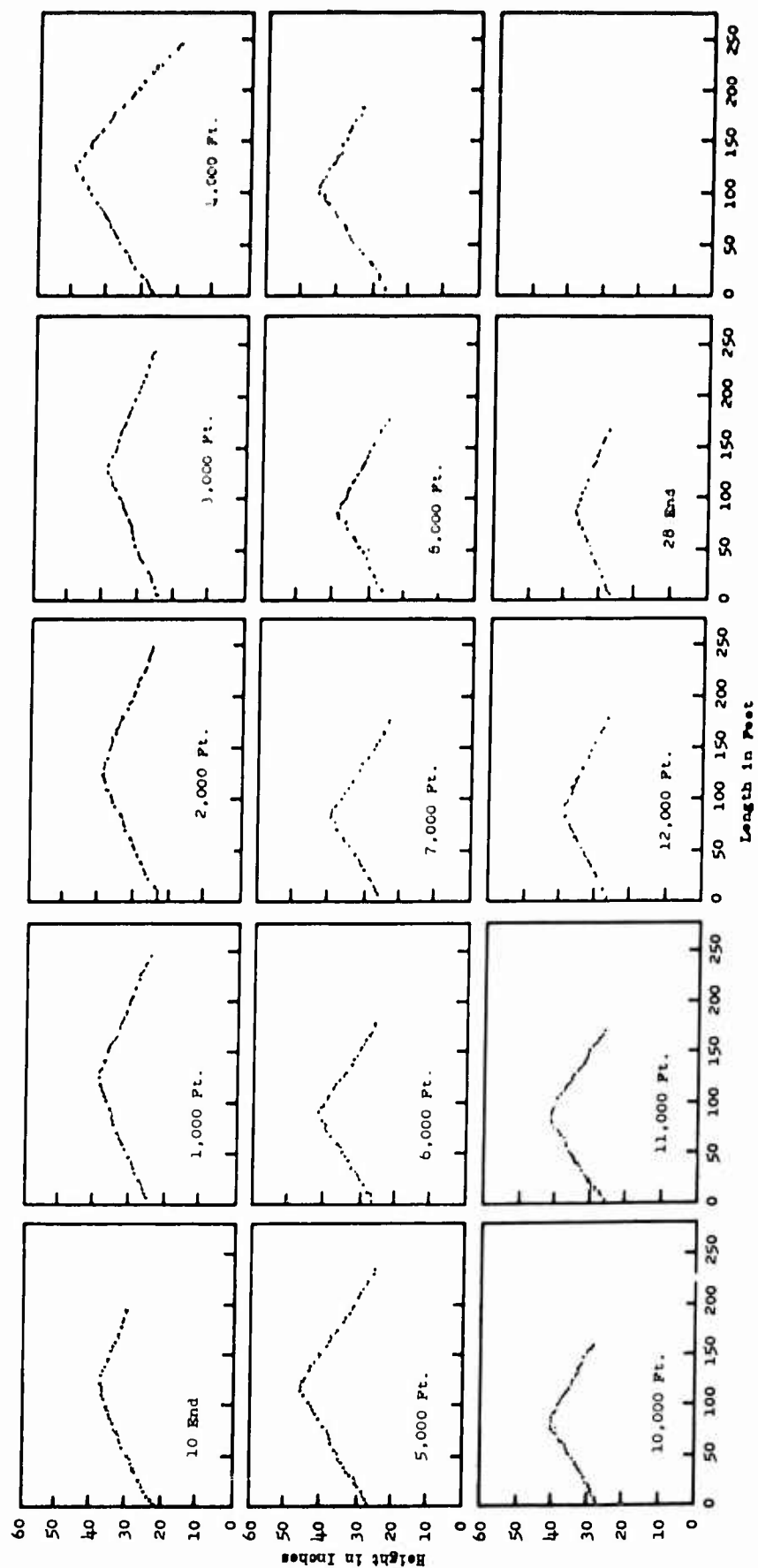


Figure 106 - Cross Run Profiles, Runway 10, Glasgow Air Force Base

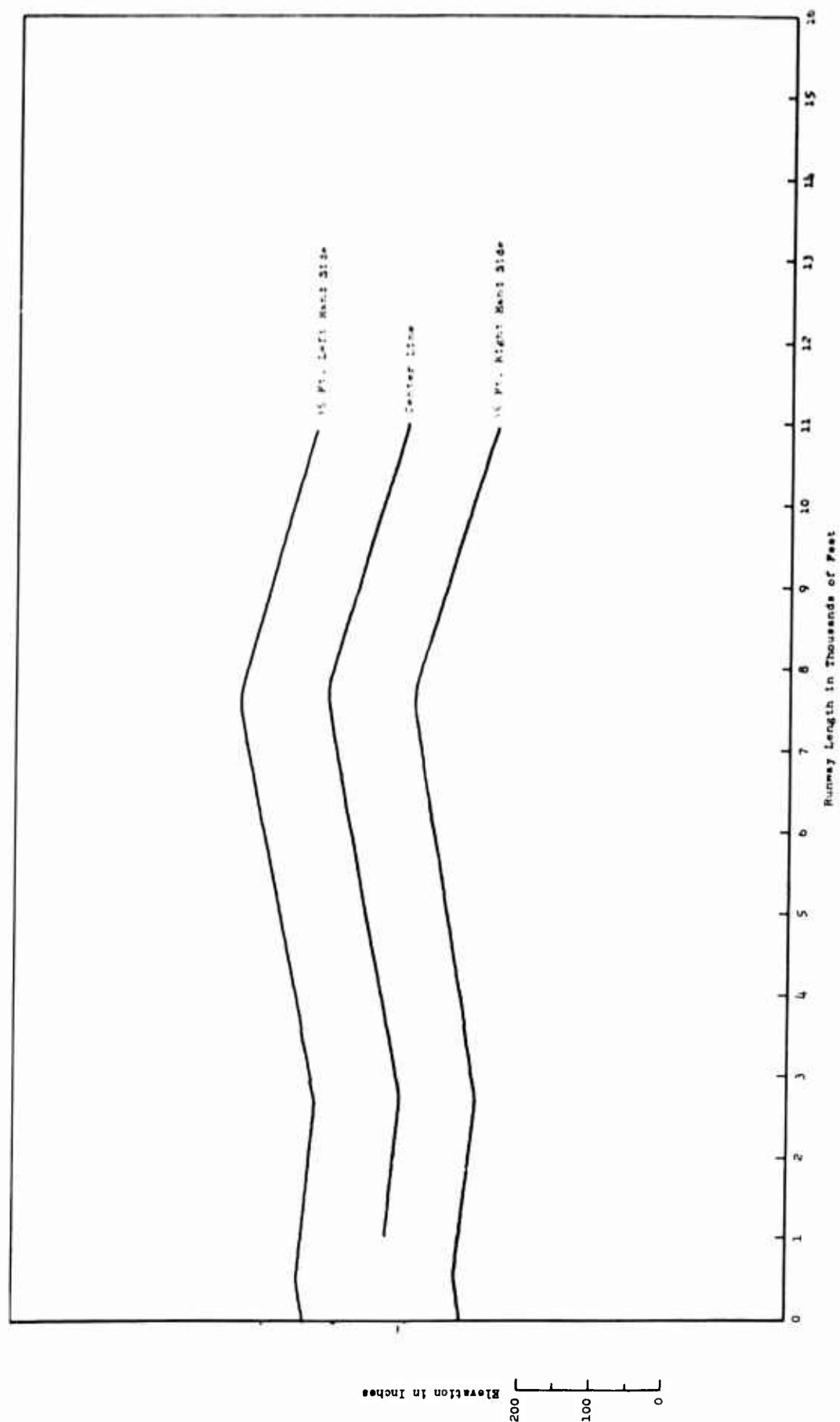


Figure 107 - Profiles, Taxiway 10, Glasgow Air Force Base

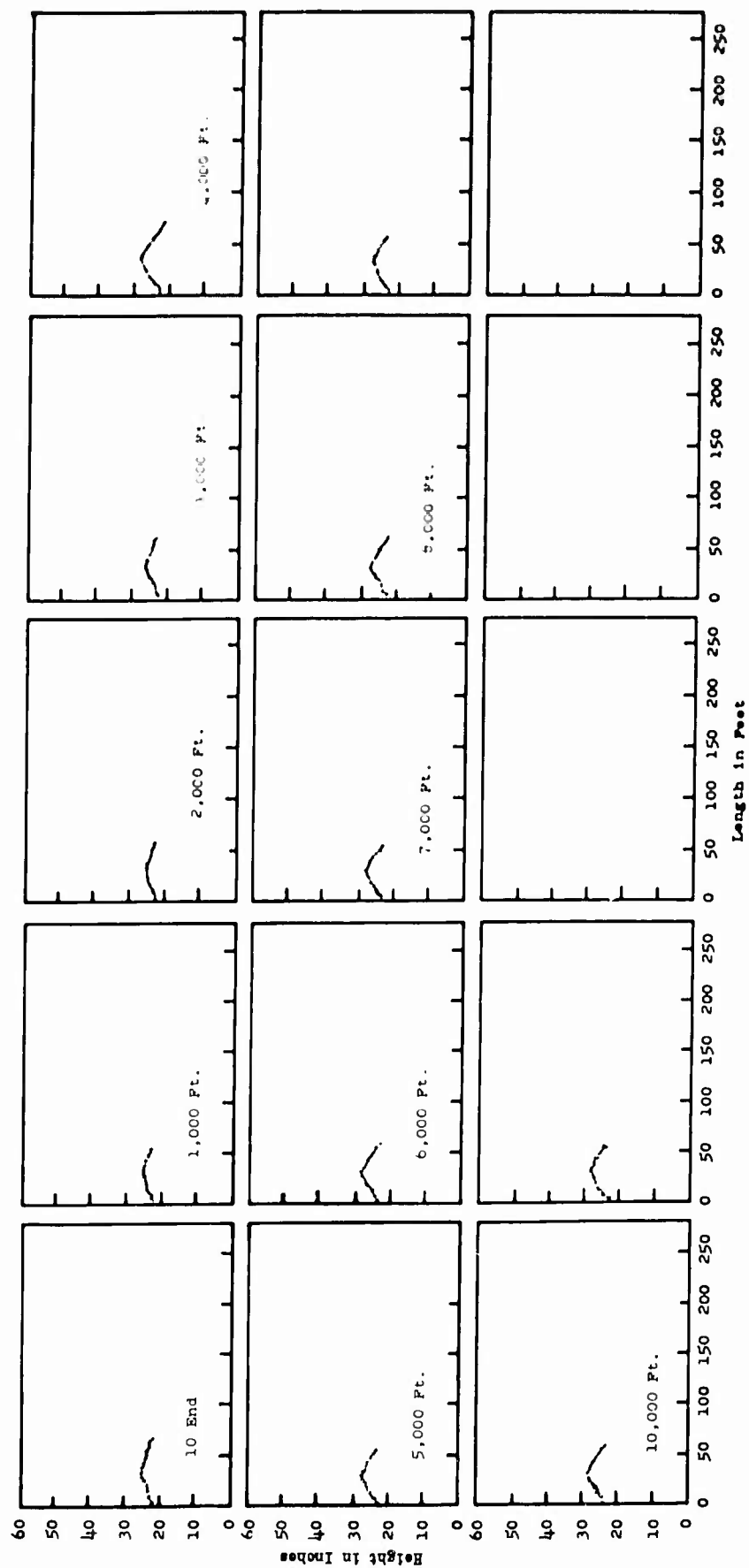


Figure 108 - Cross Run Profiles, Taxiway 10, Glasgow Air Force Base

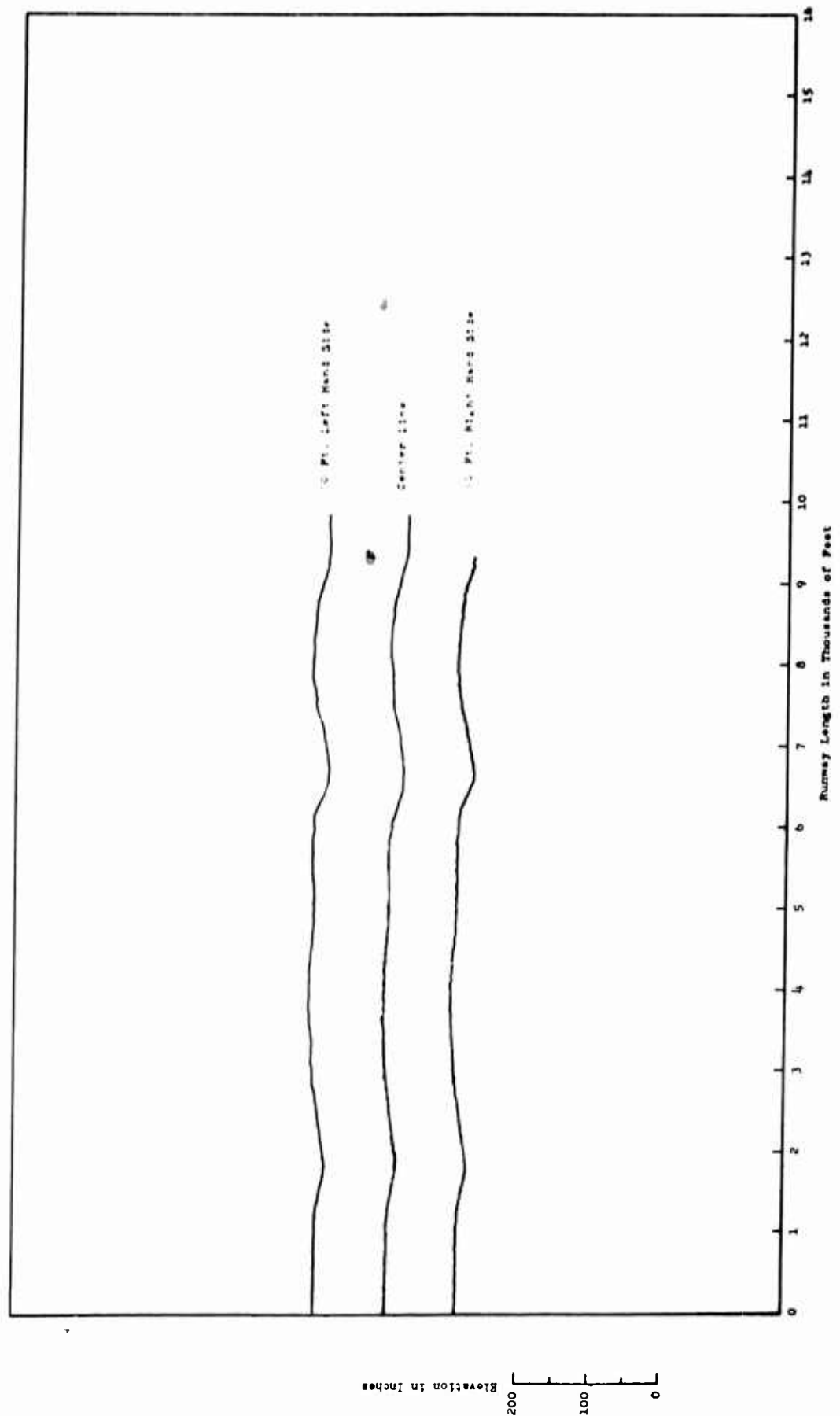


Figure 109 - Profiles, Runway 7, Langley Air Force Base

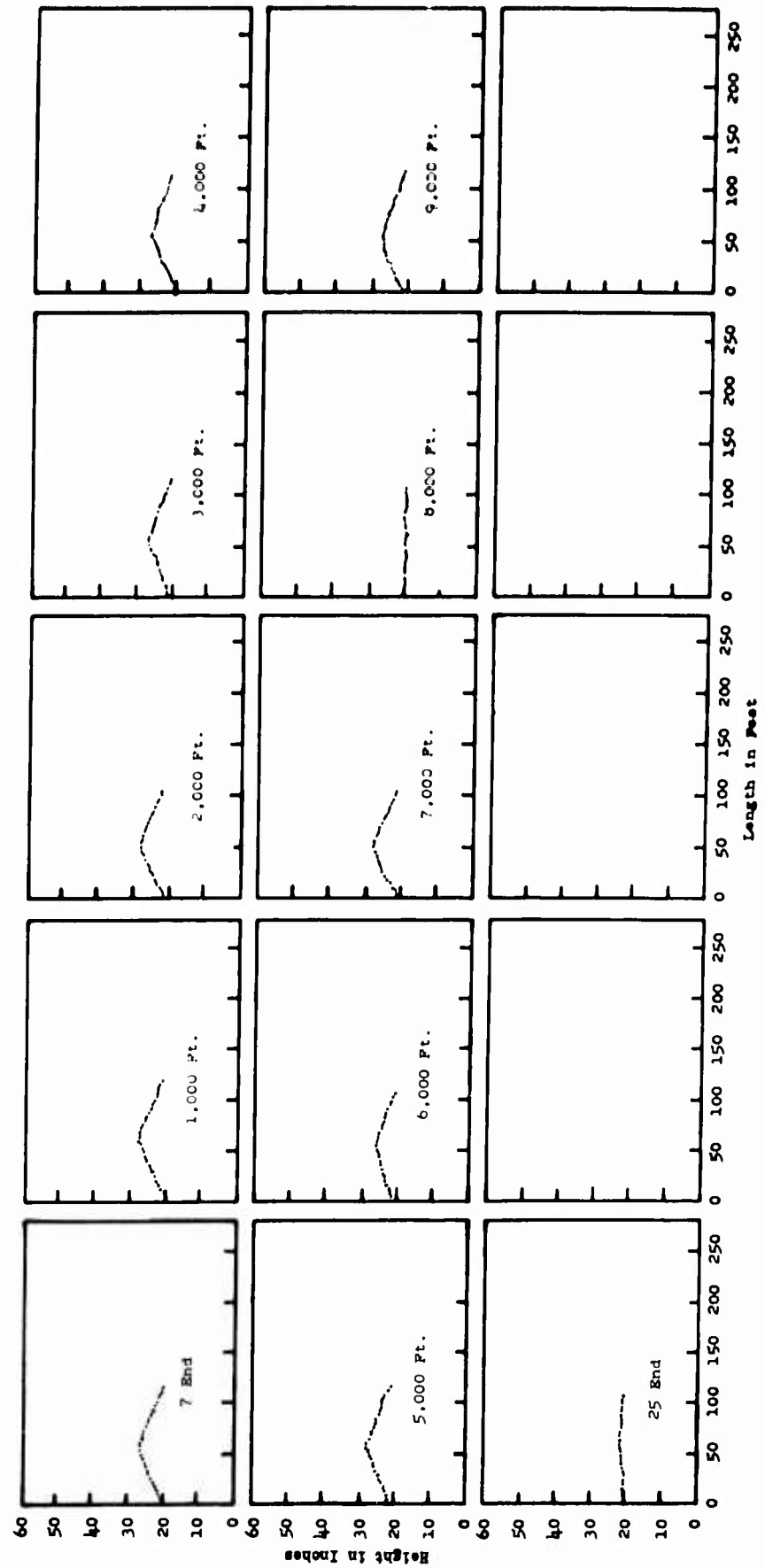


Figure 110 - Cross Run Profiles, Runway 7, Langley Air Force Base

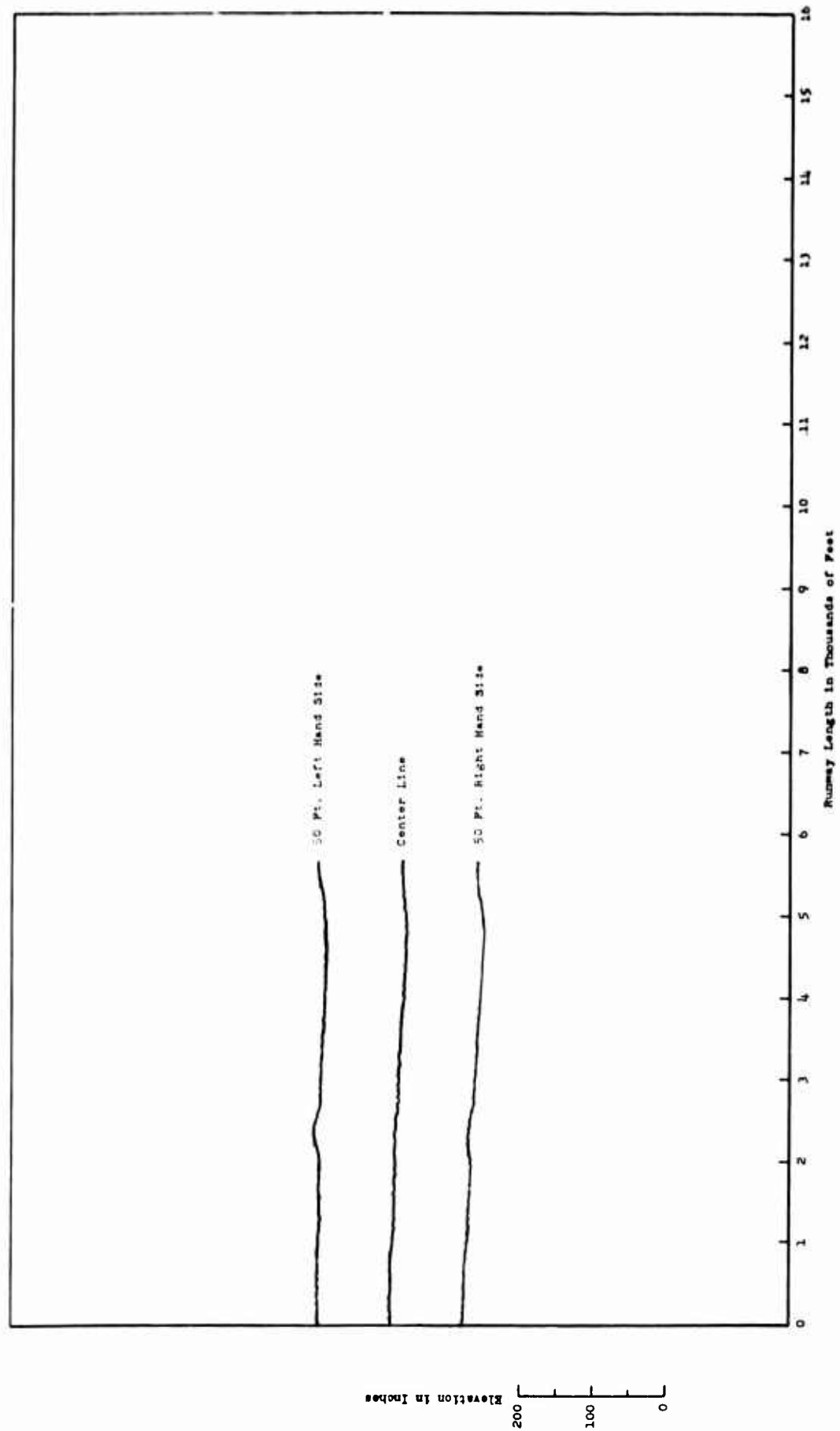


Figure 111 - Profiles, Runway 35, Langley Air Force Base

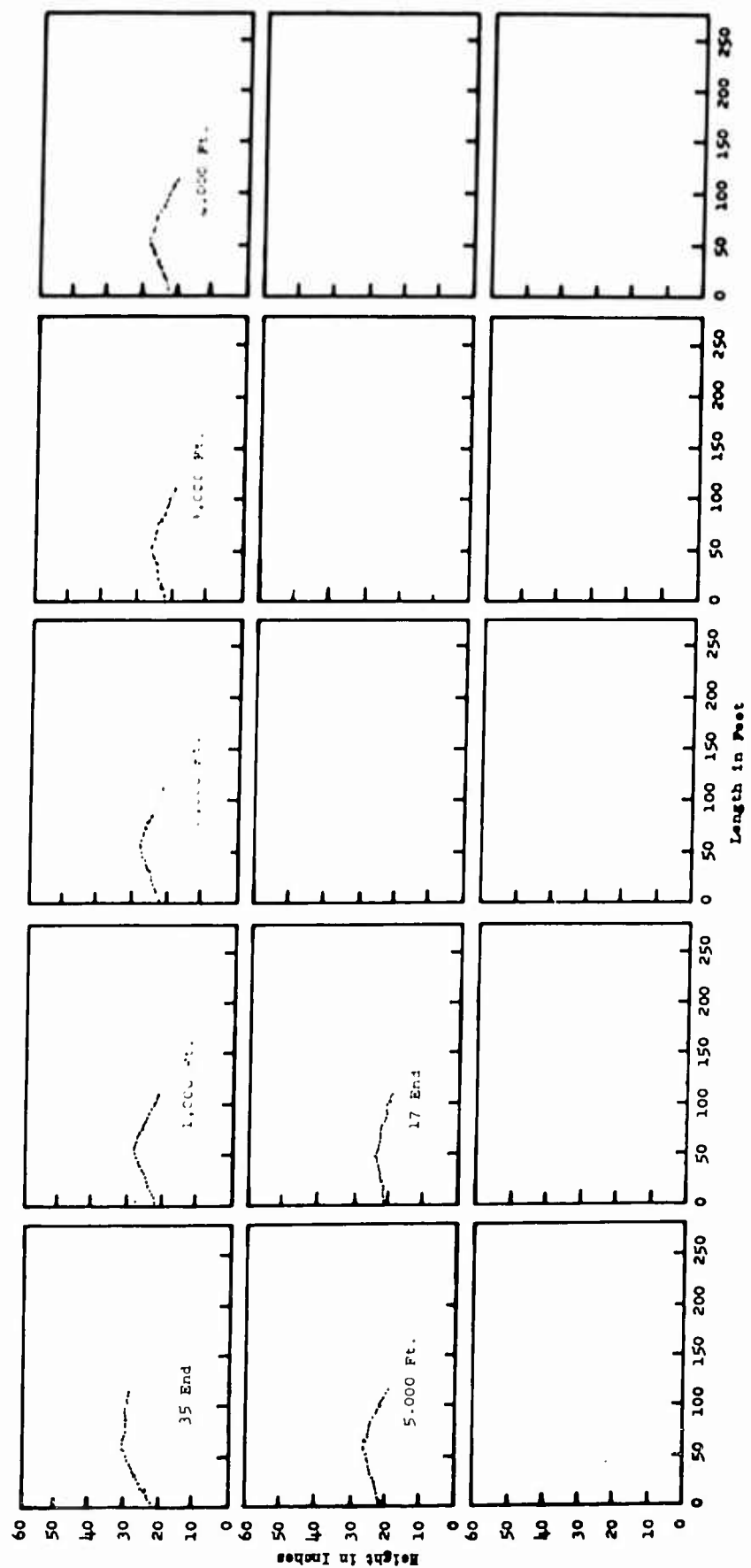


Figure 112 - Cross Run Profiles, Runway 35, Langley Air Force Base

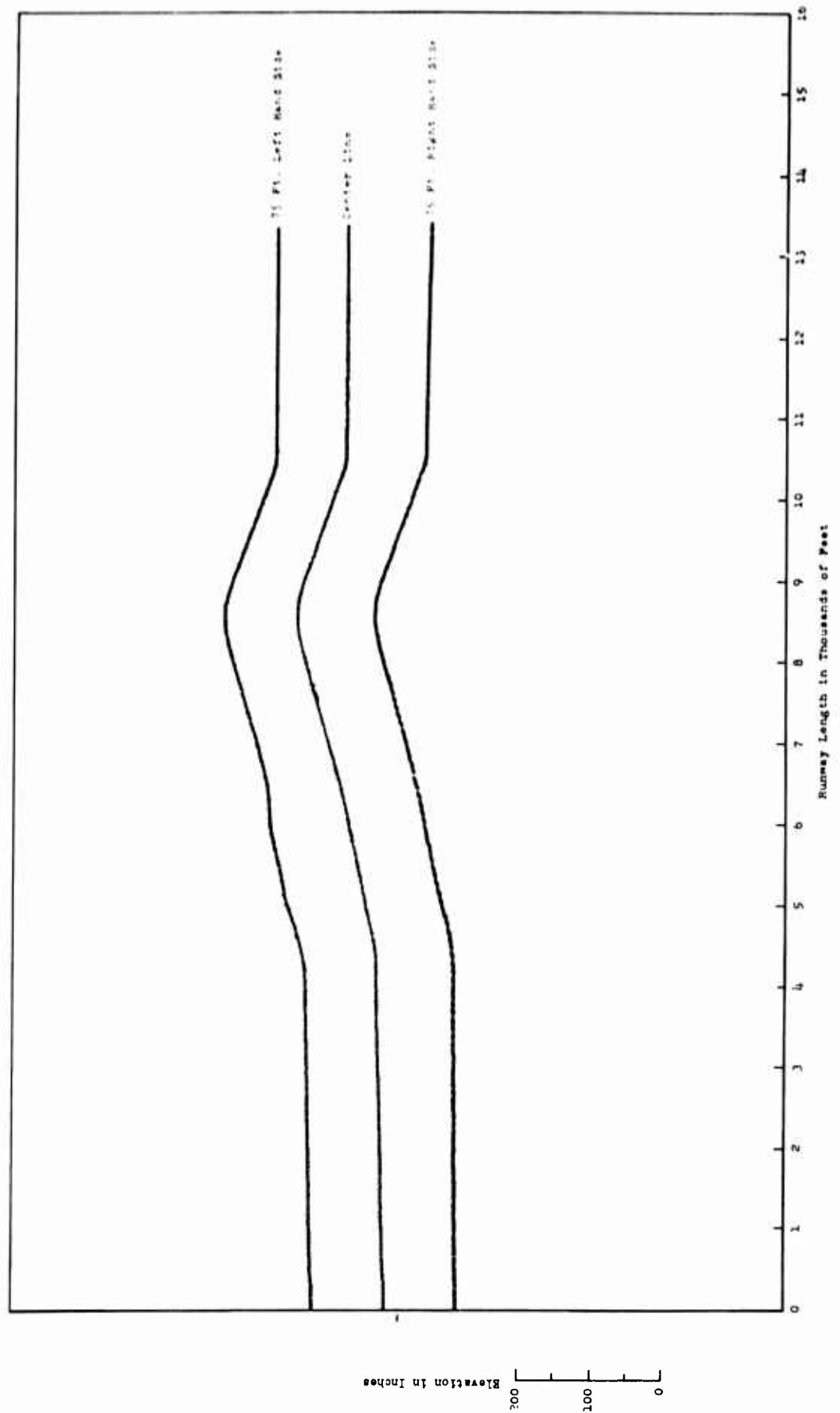


Figure 113 - Profiles, Runway 32, Larson Air Force Base

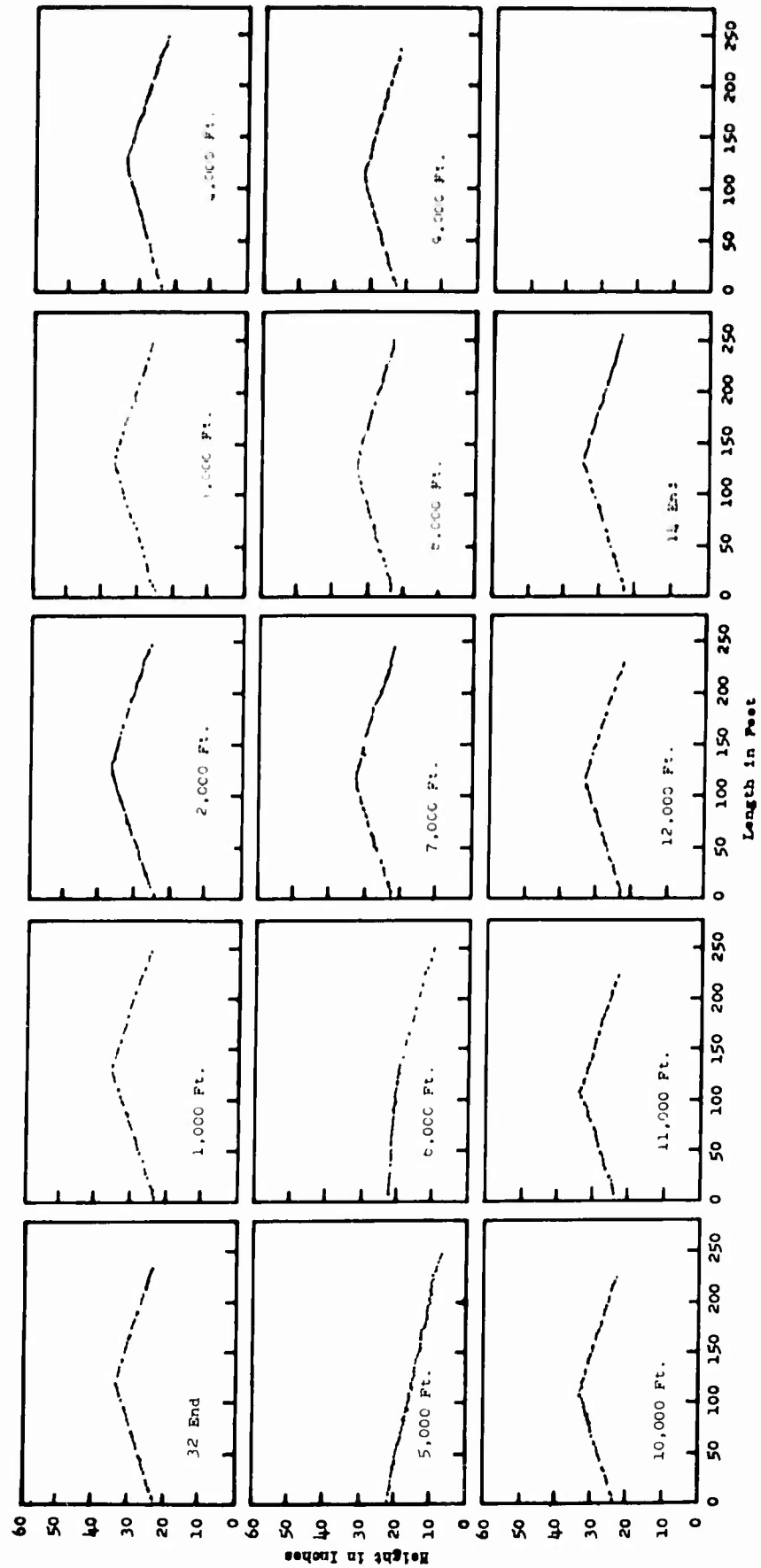


Figure 114 - Cross Run Profiles, Runway 32, Larson Air Force Base

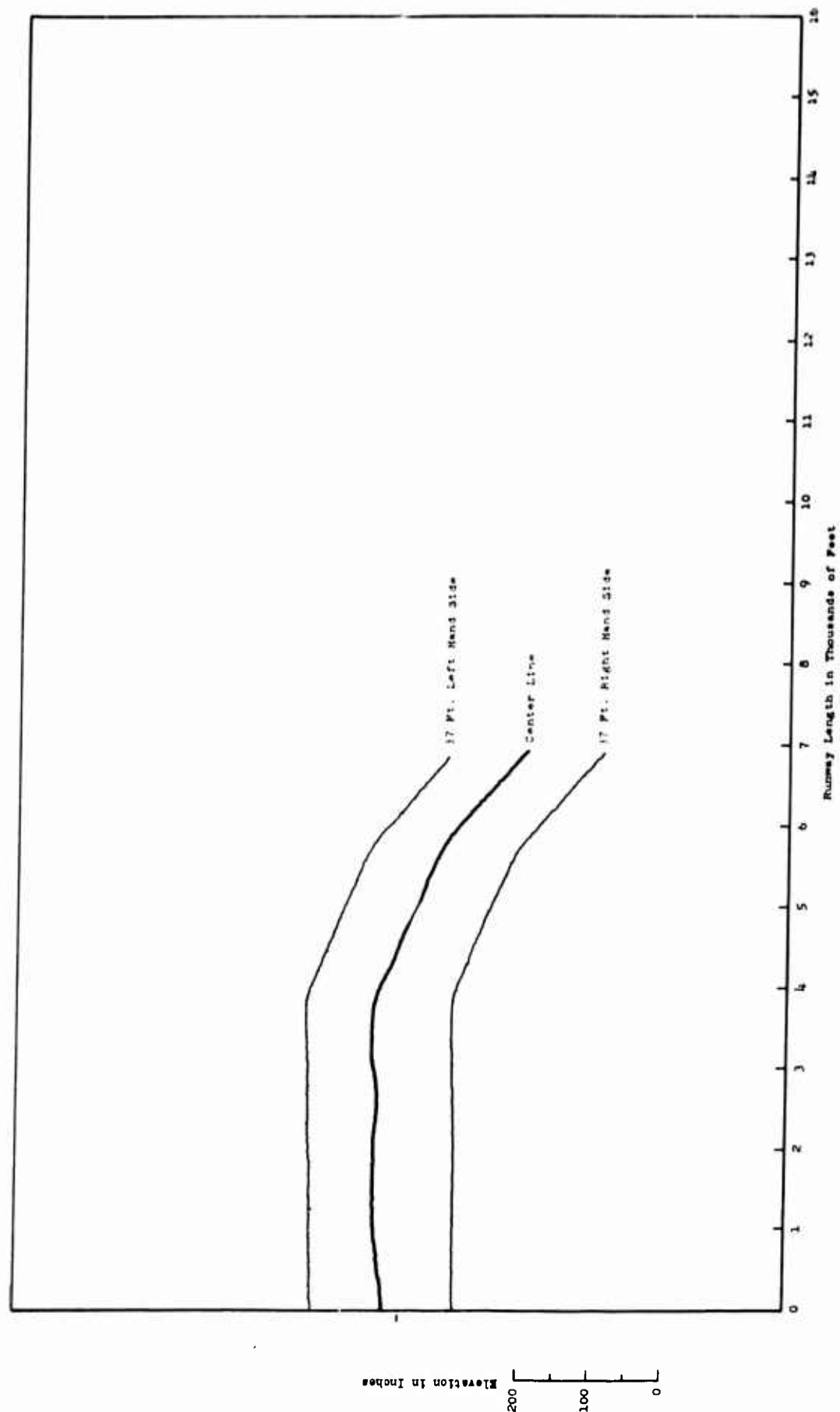


Figure 115 - Profiles, Taxiway 3, Larson Air Force Base

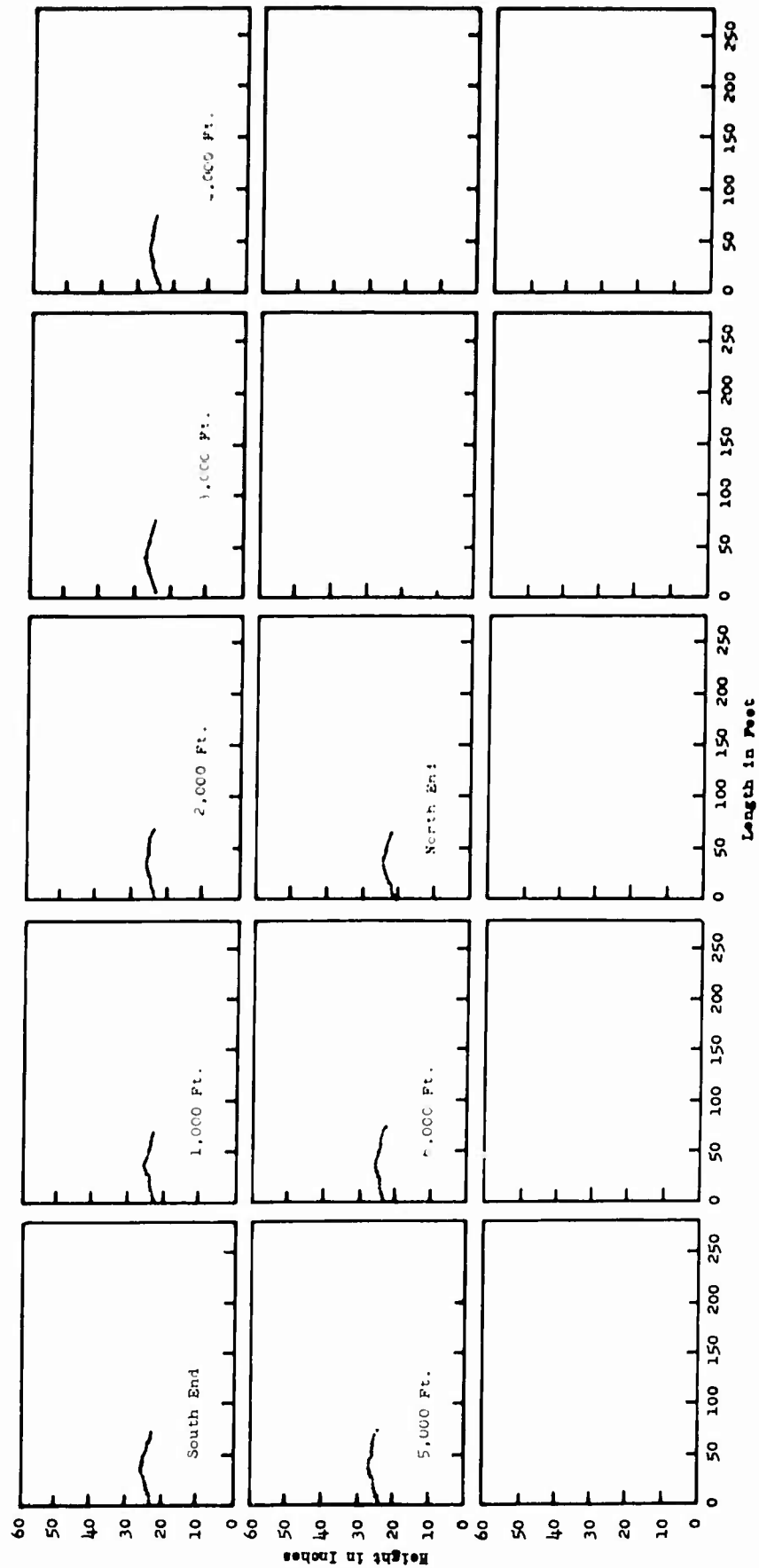


Figure 116 - Cross Run Profiles, Taxiway 3, Larson Air Force Base

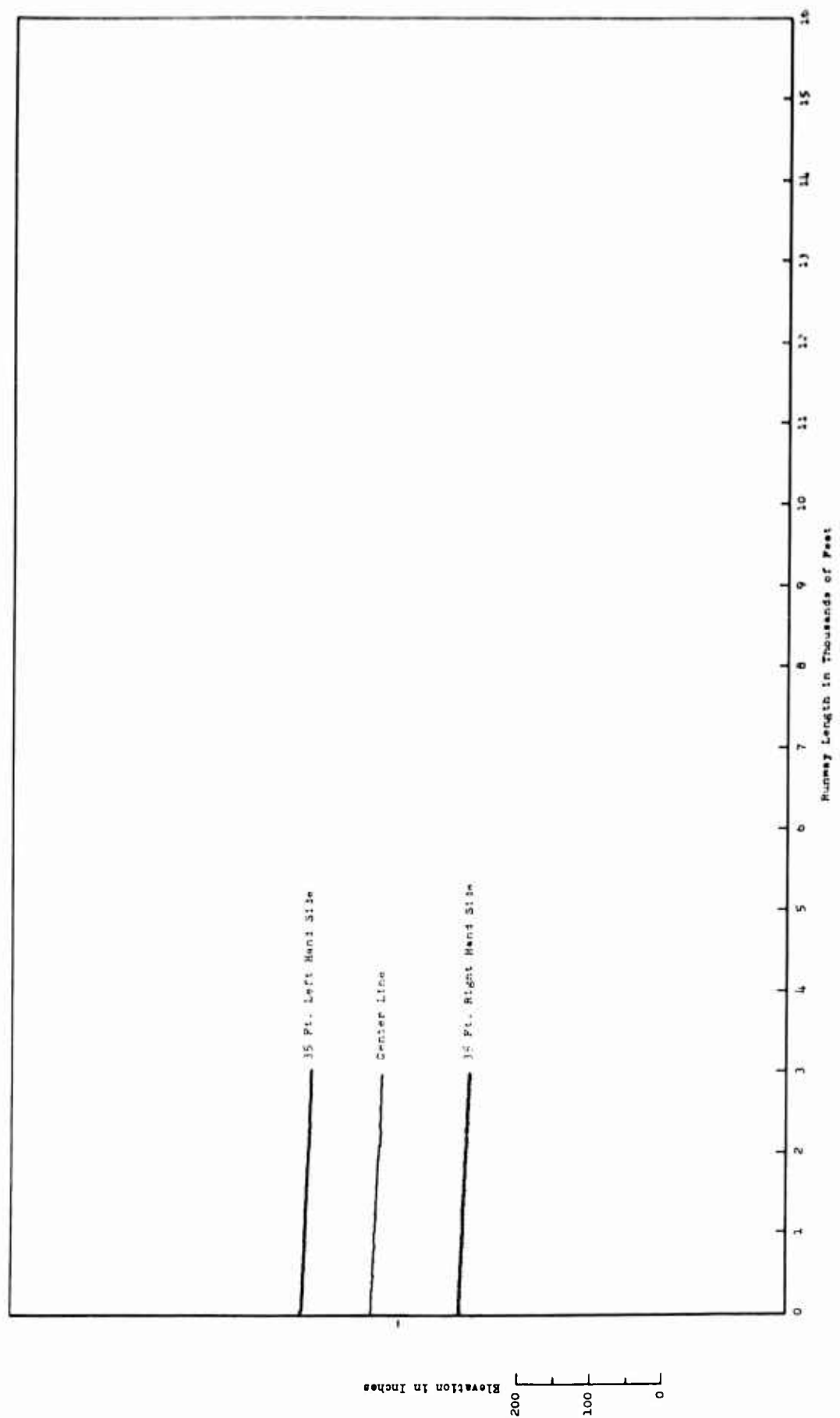


Figure 117 - Profiles, Taxiway 4, Larson Air Force Base

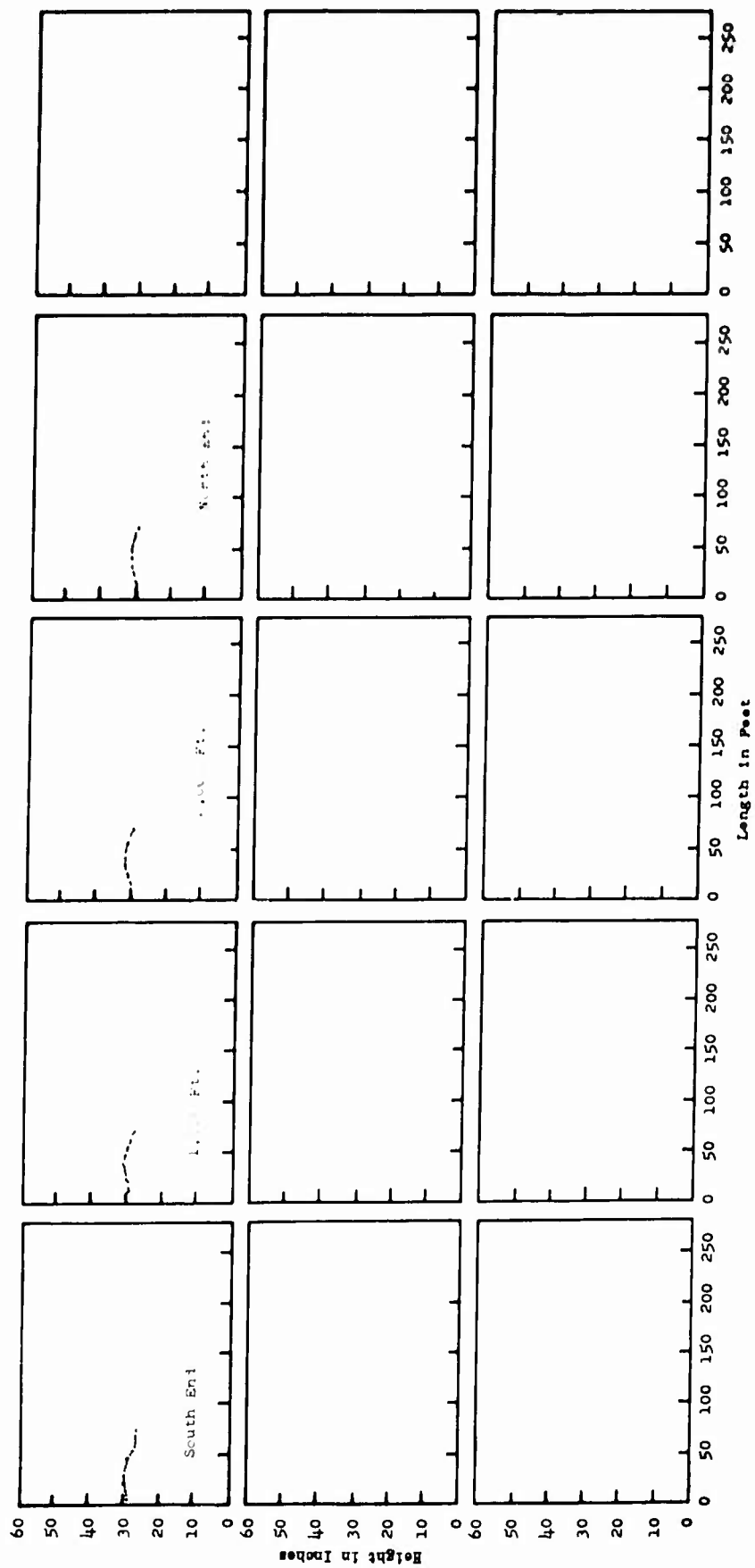


Figure 118 - Cross Run Profiles, Taxiway 4, Larson Air Force Base

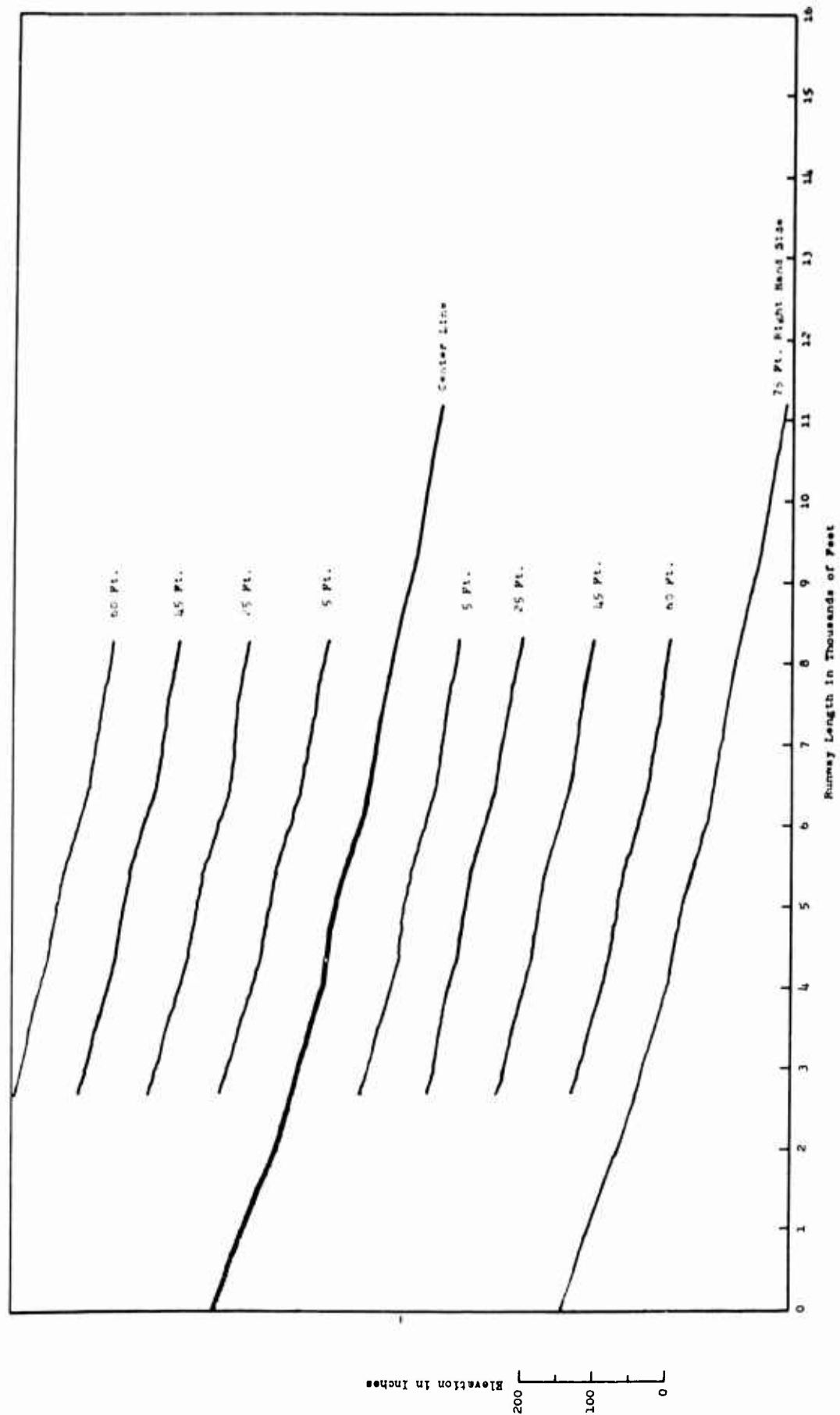


Figure 119 - Profiles, Runway 22L, Mather Air Force Base

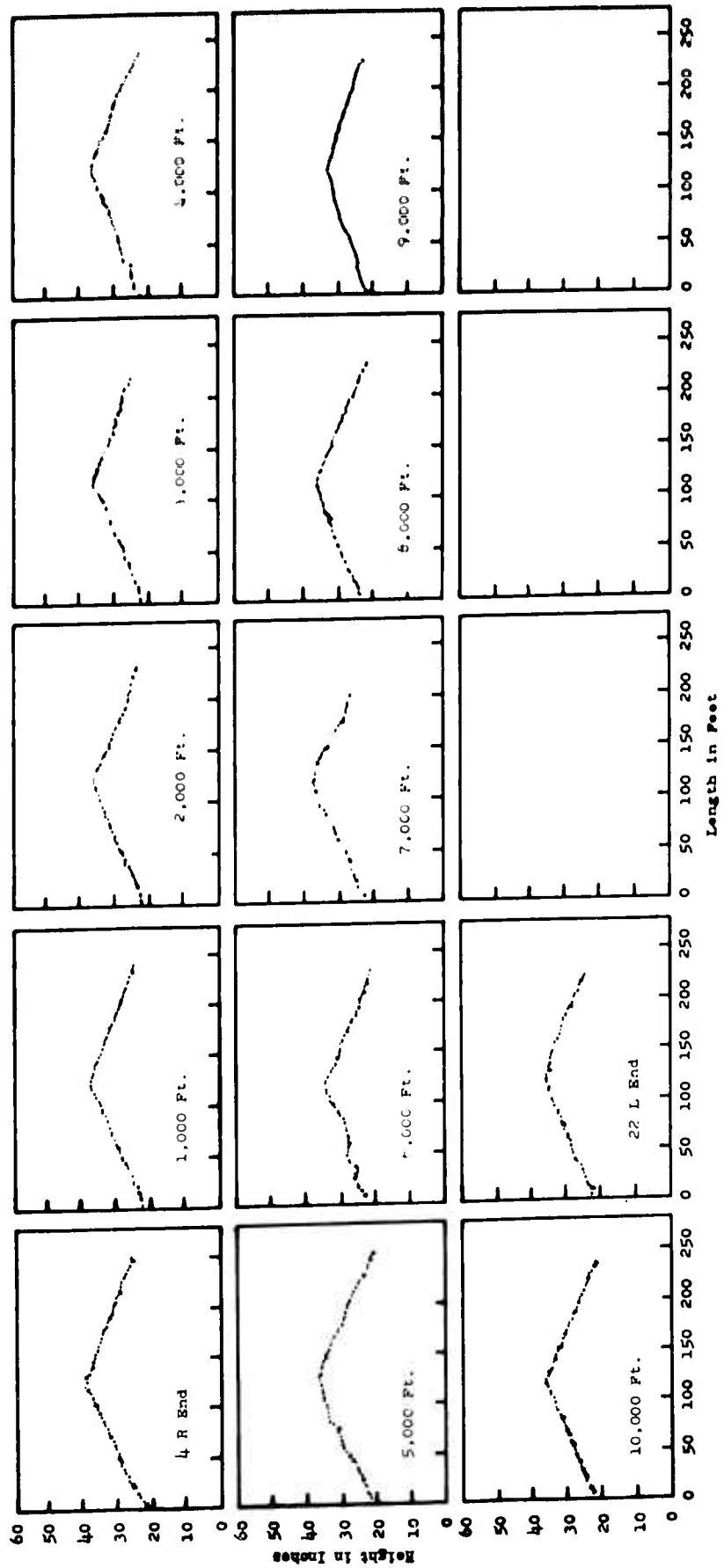


Figure 120 - Cross Run Profiles, Runway 22L, Mather Air Force Base

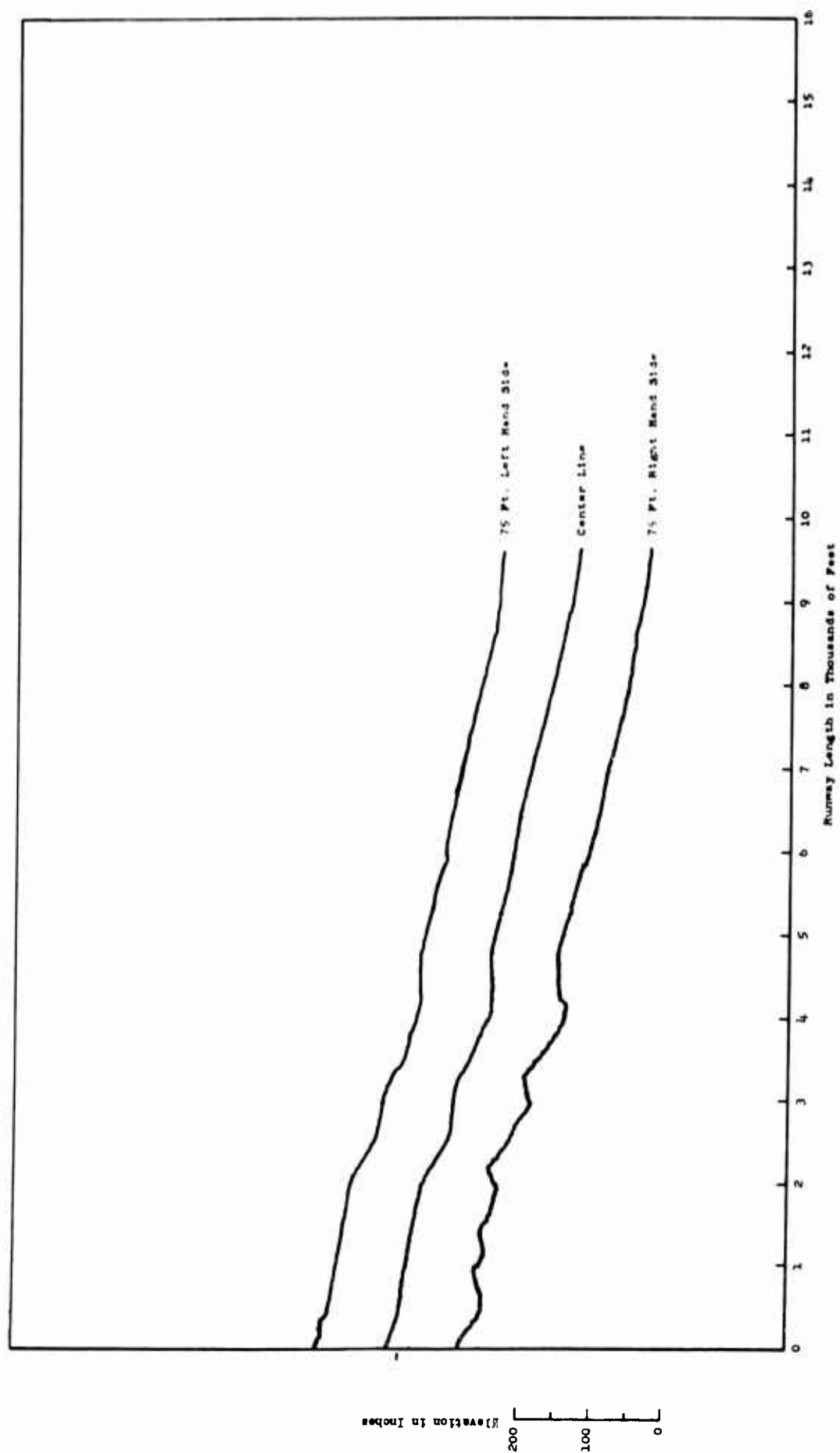


Figure 121 - Profiles, Taxiway 22, Mather Air Force Base

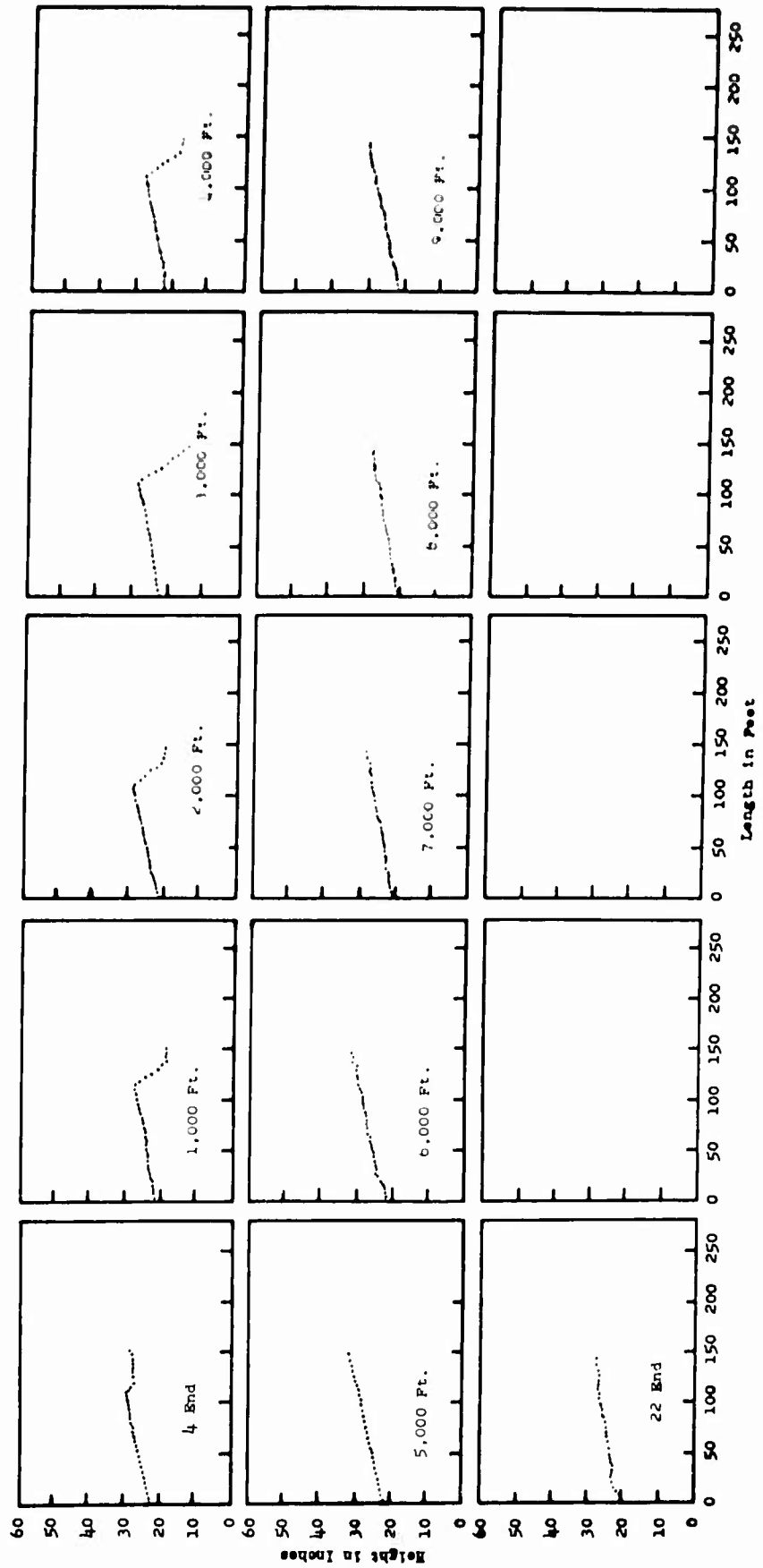


Figure 122 - Cross Run Profiles, Taxiway 22, Mather Air Force Base

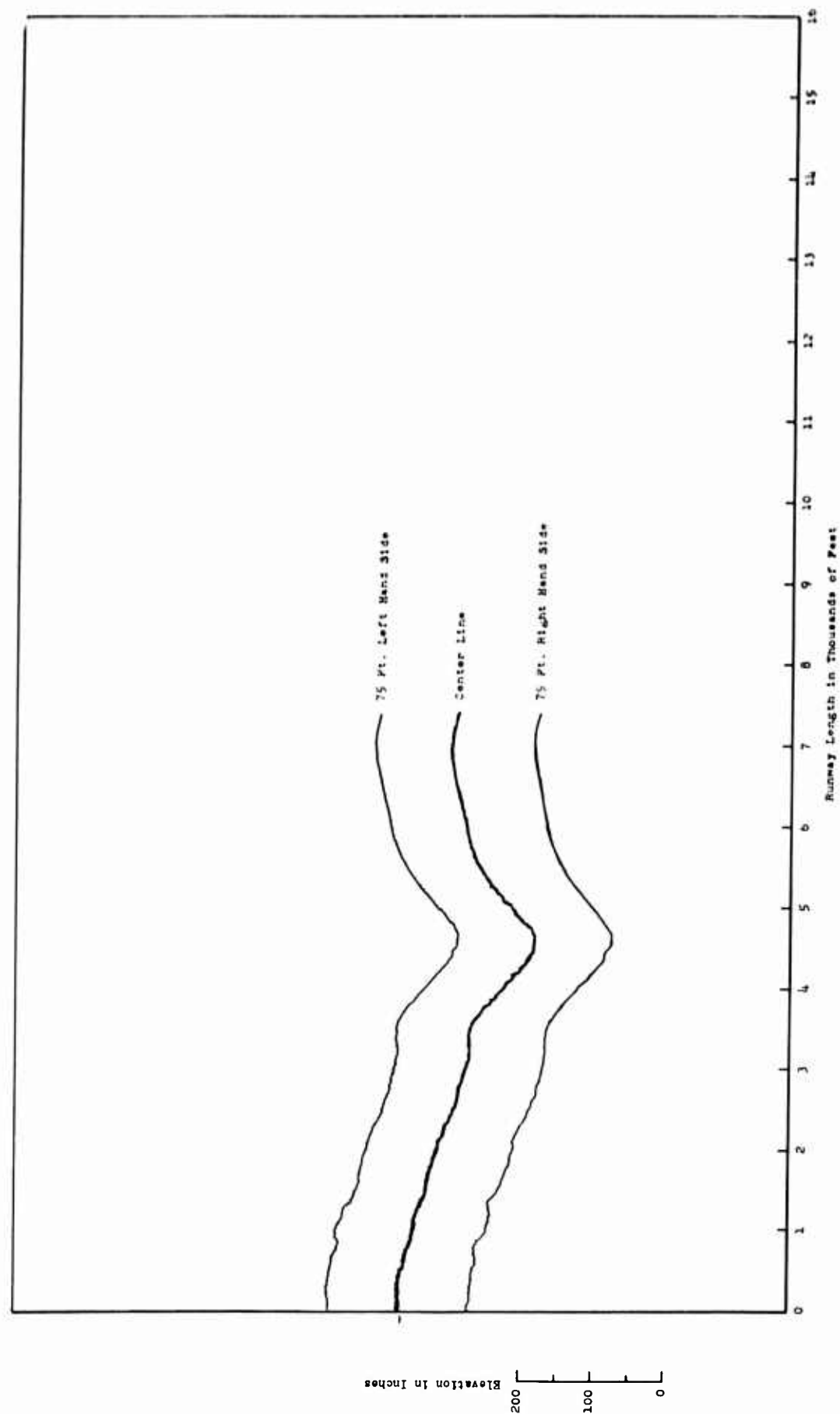


Figure 123 - Profiles, Runway 12, McGuire Air Force Base

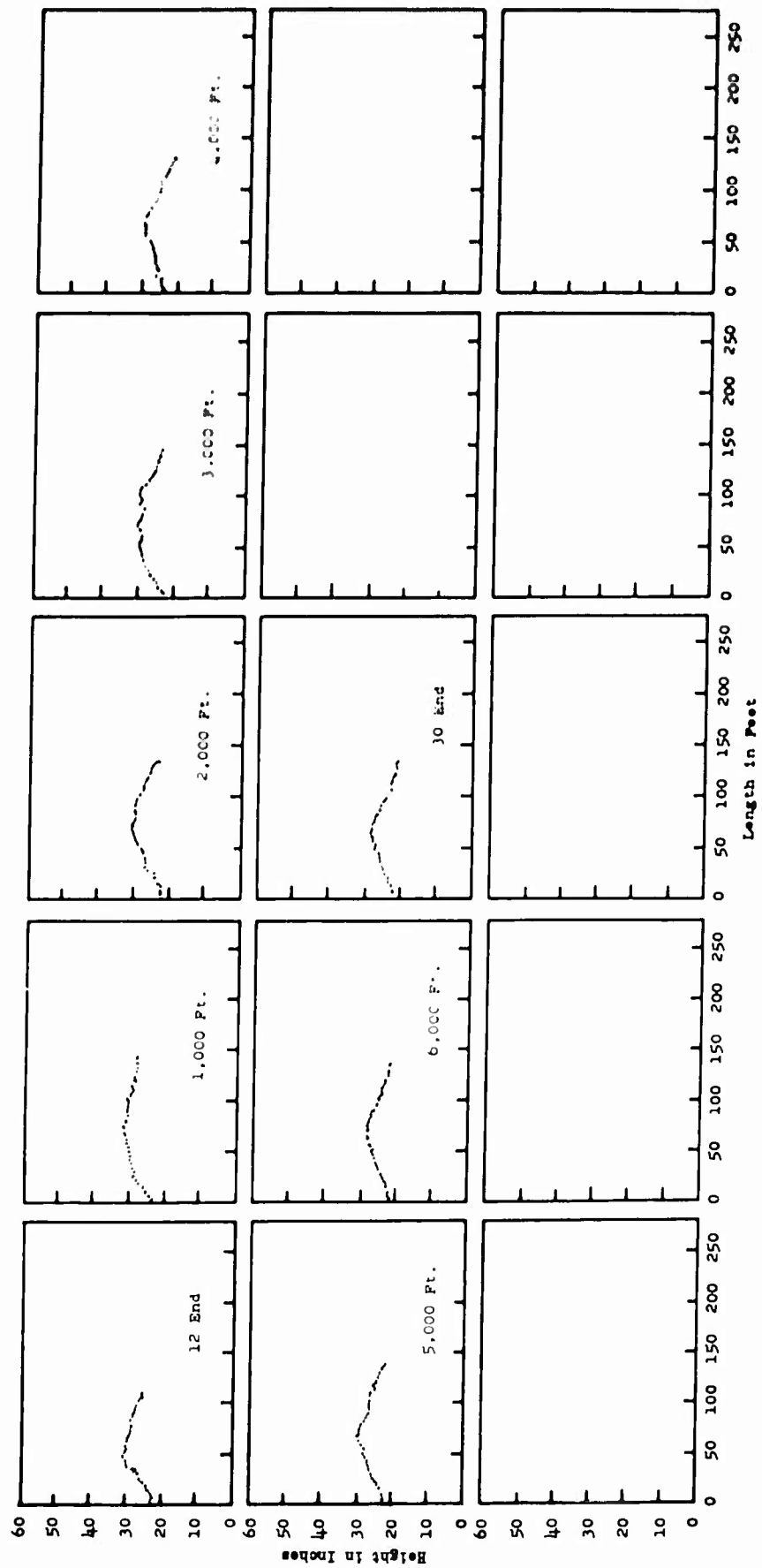


Figure 124 - Cross Run Profiles, Runway 12, McGuire Air Force Base

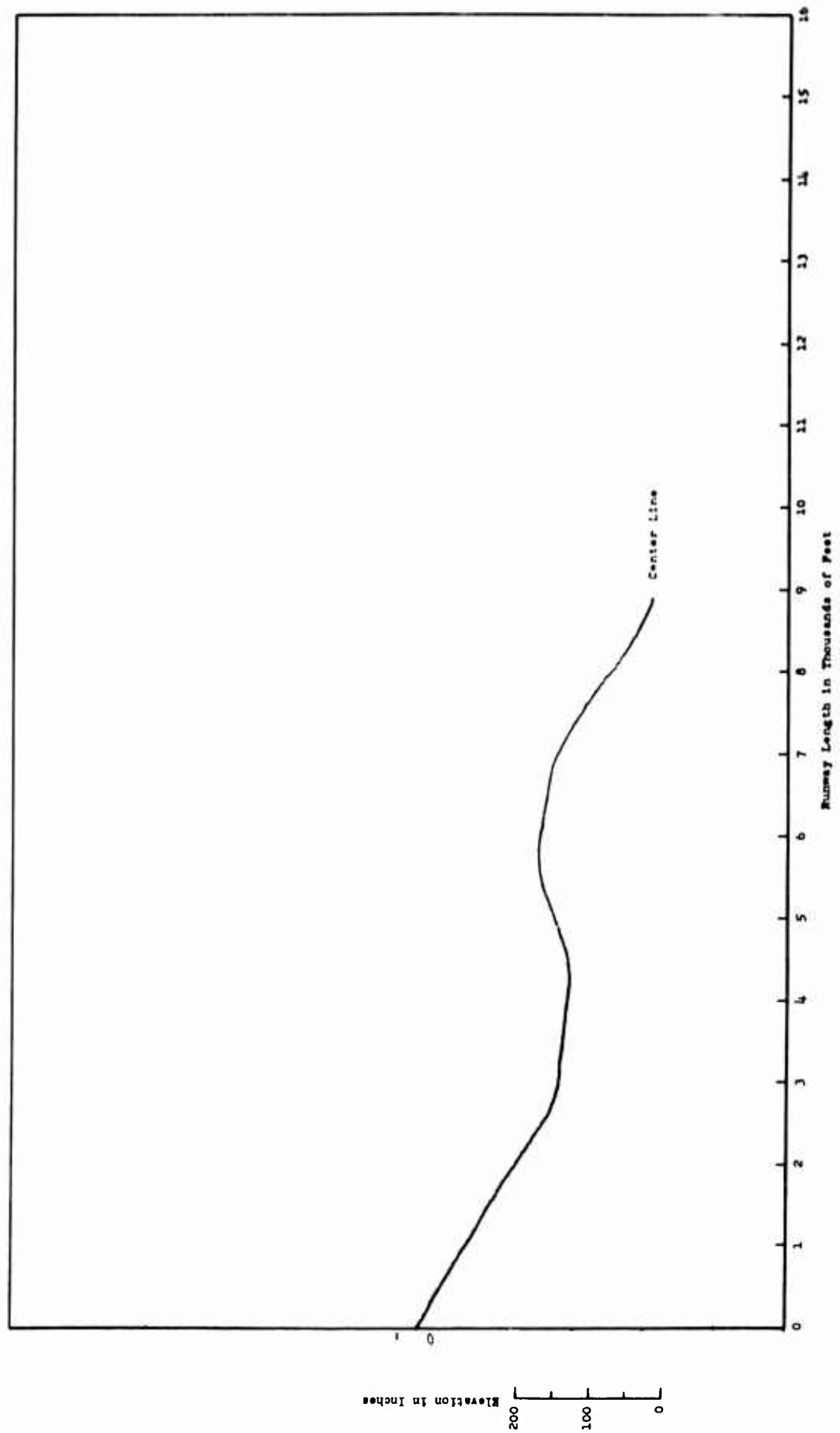


Figure 125 - Profile, Runway 6, McGuire Air Force Base

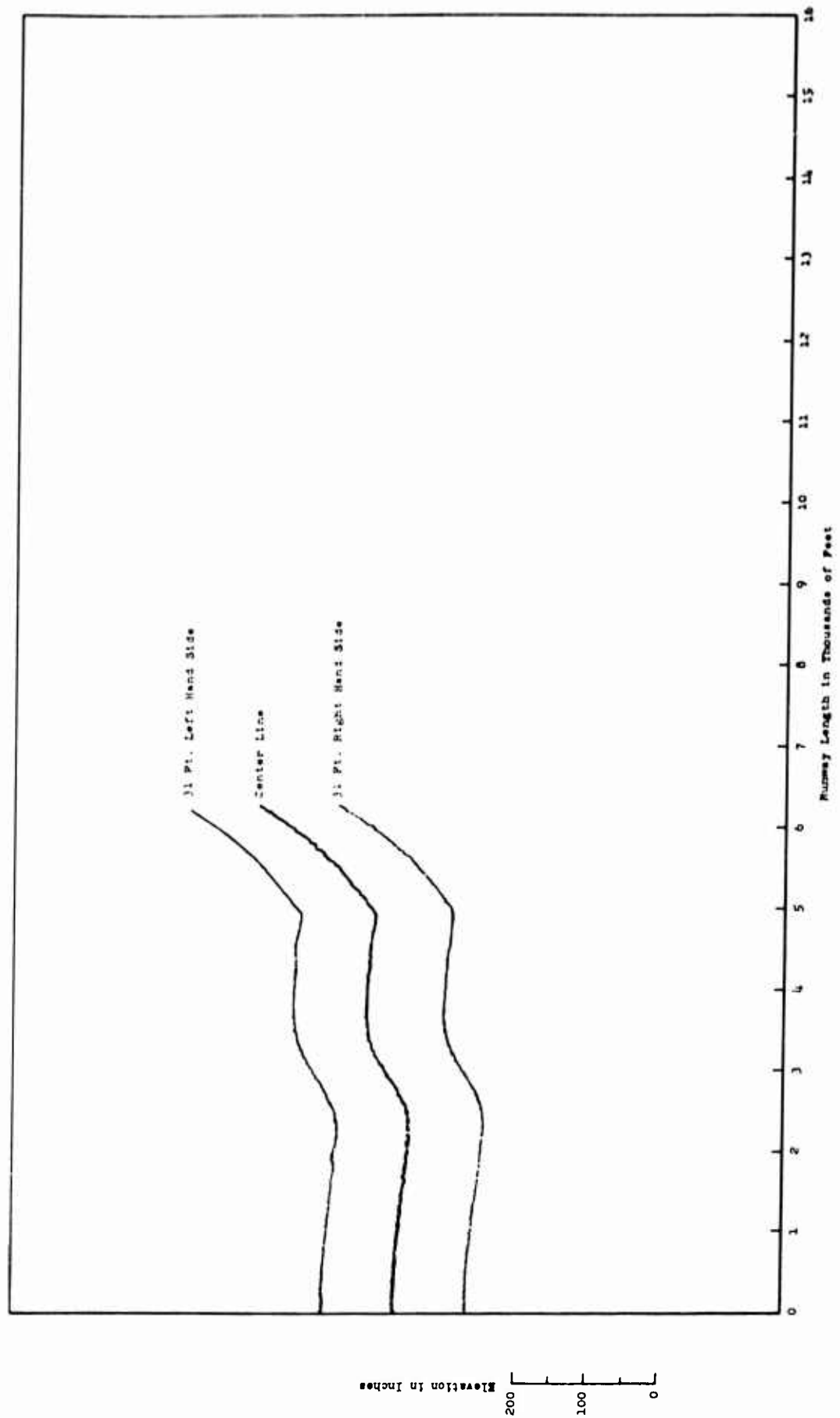


Figure 126 - Profiles, Taxiway, McGuire Air Force Base

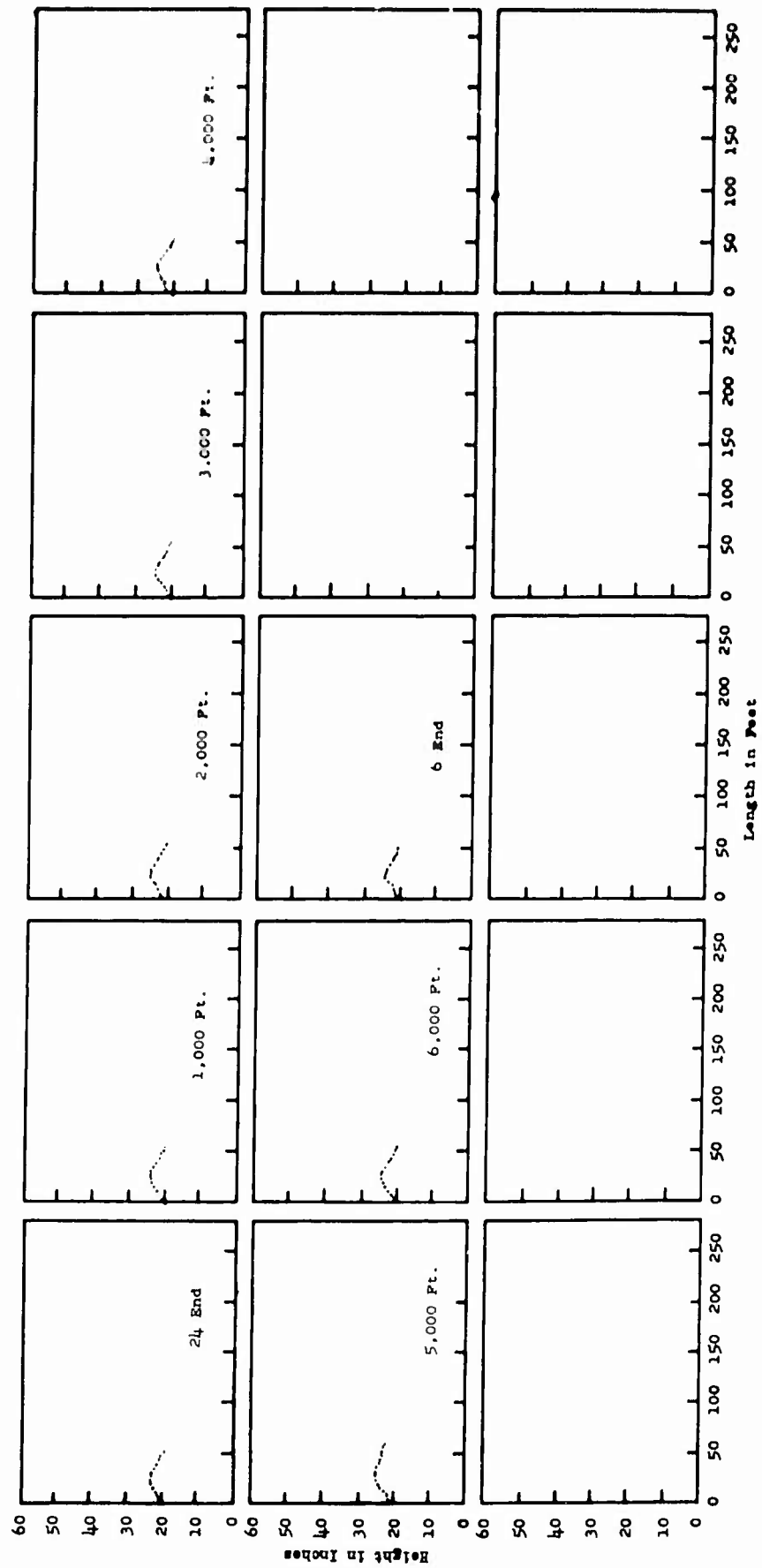


Figure 127 - Cross Run Profiles, Taxiway, McGuire Air Force Base

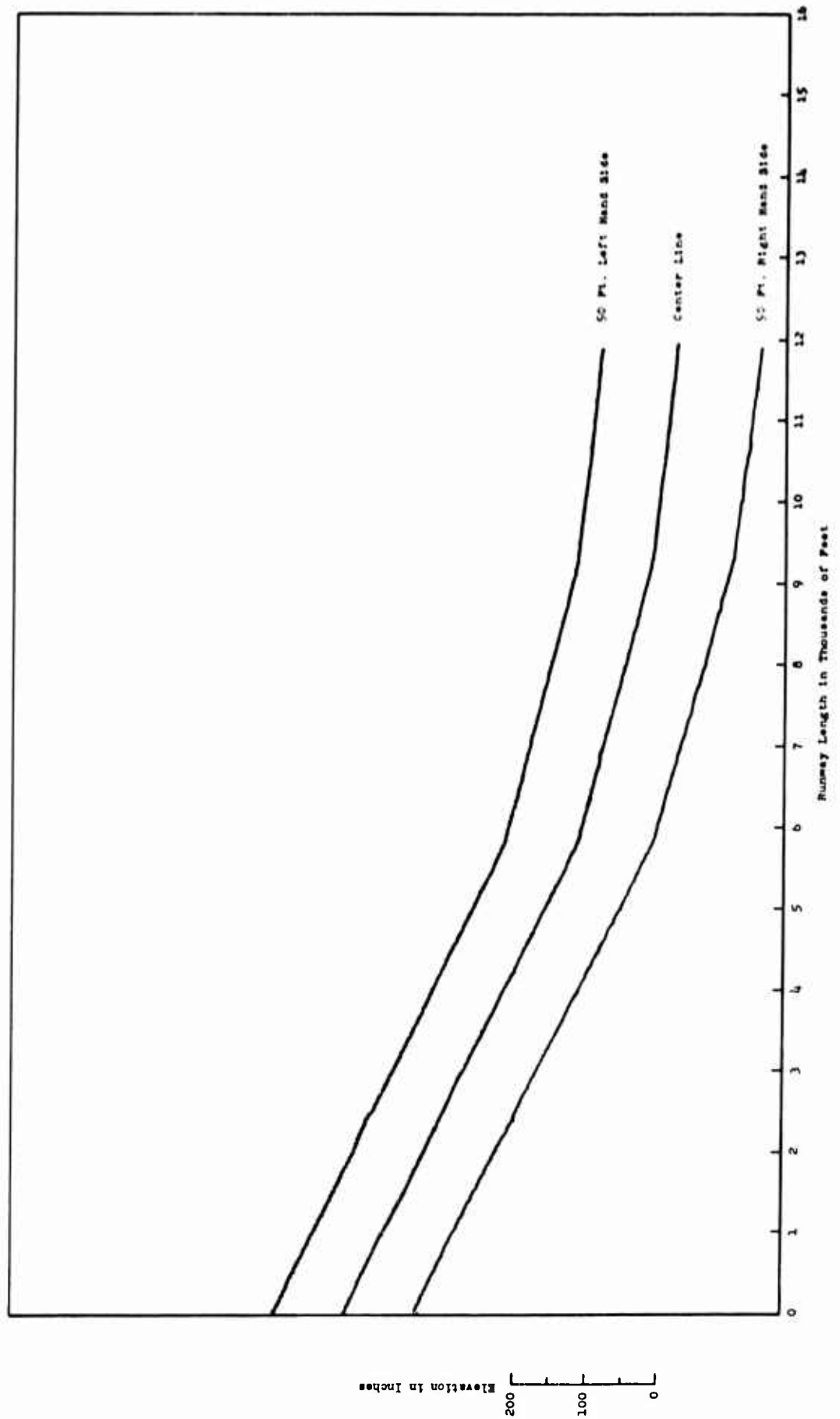


Figure 128 - Profiles, Runway 7, Palmdale Air Force Plant MR42

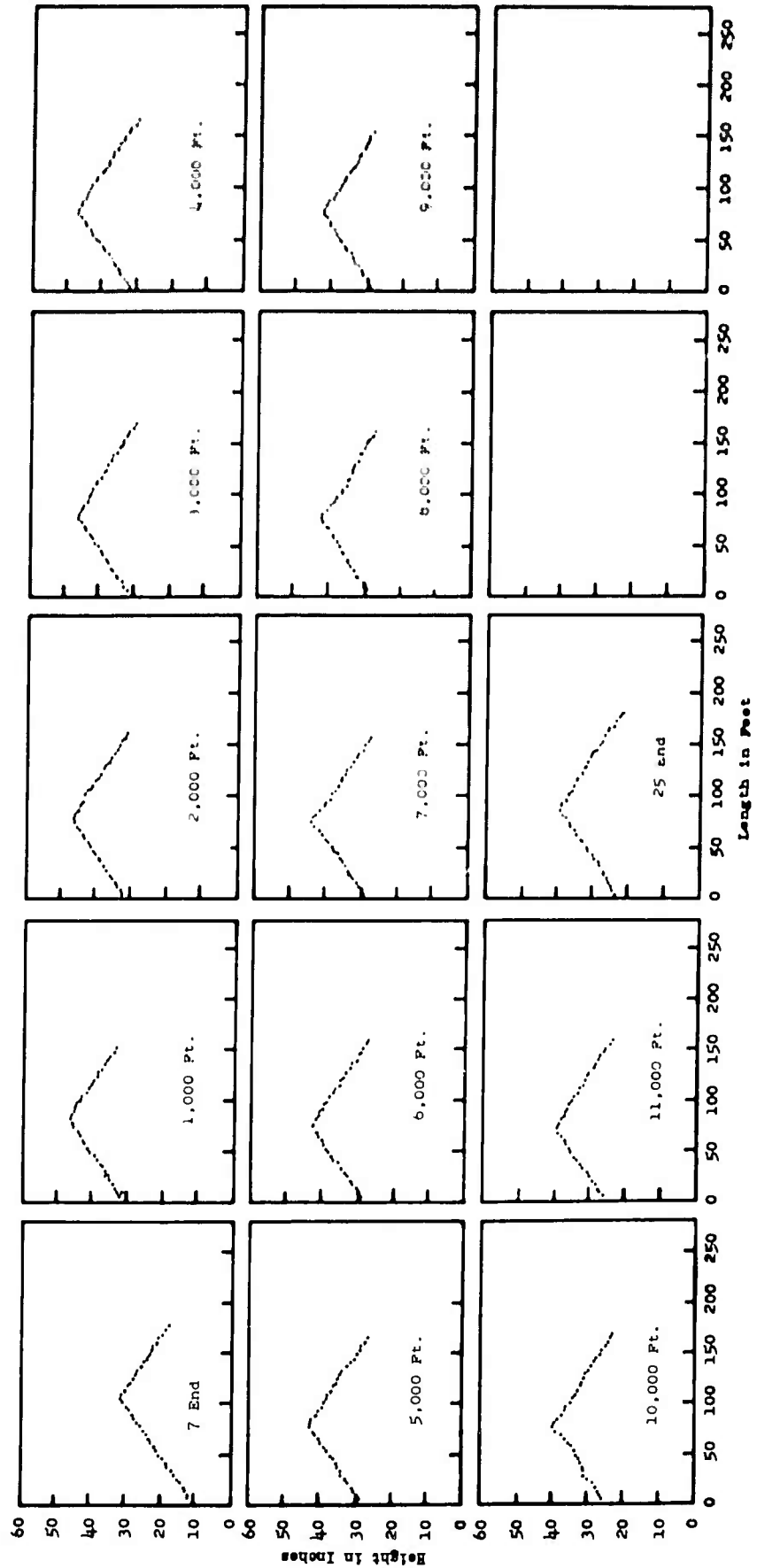


Figure 129 - Cross Run Profiles, Runway 7, Palmdale Air Force Plant NR42

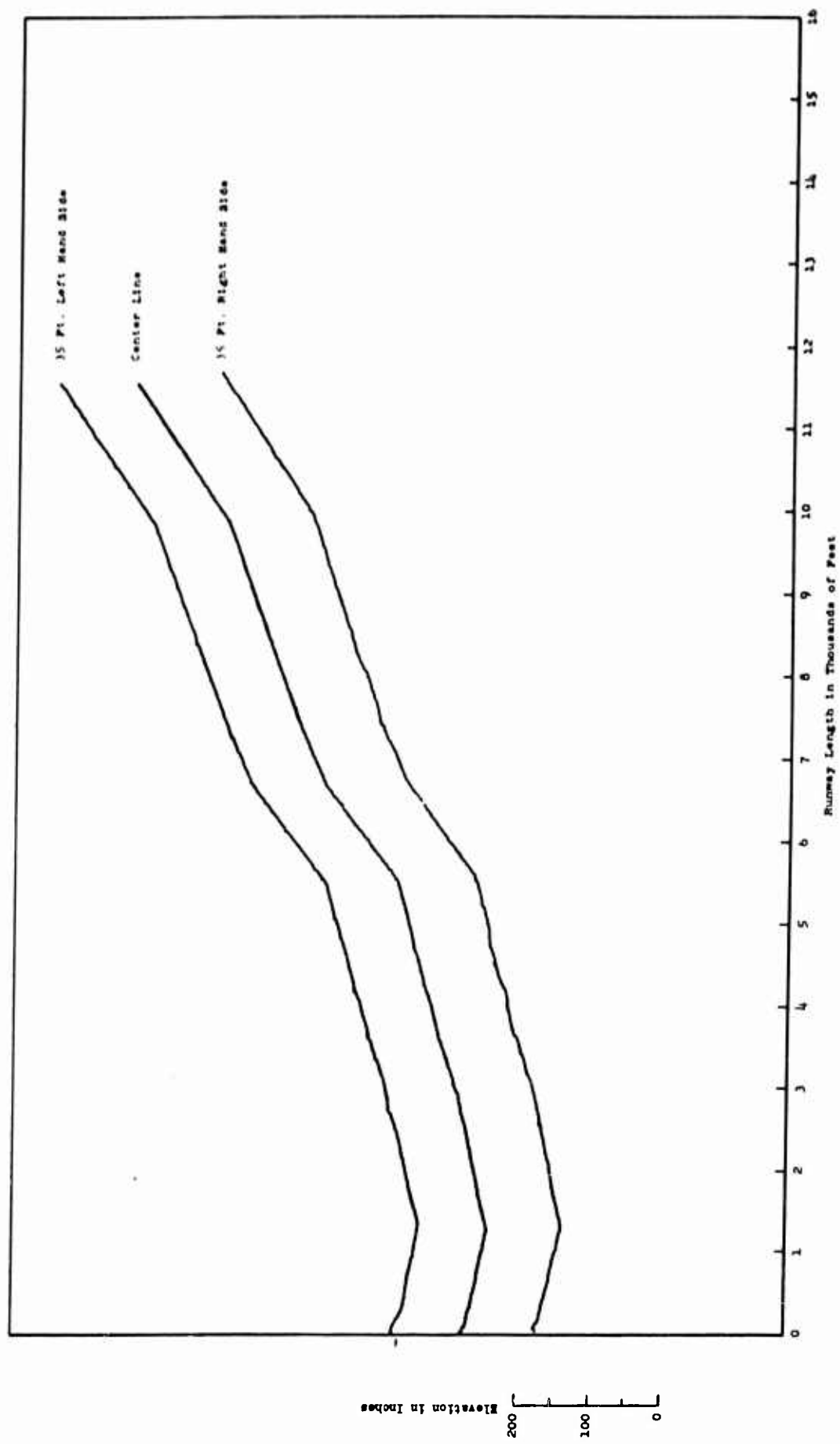


Figure 130 - Profiles, Taxiway B, Palmdale Air Force Plant NR42

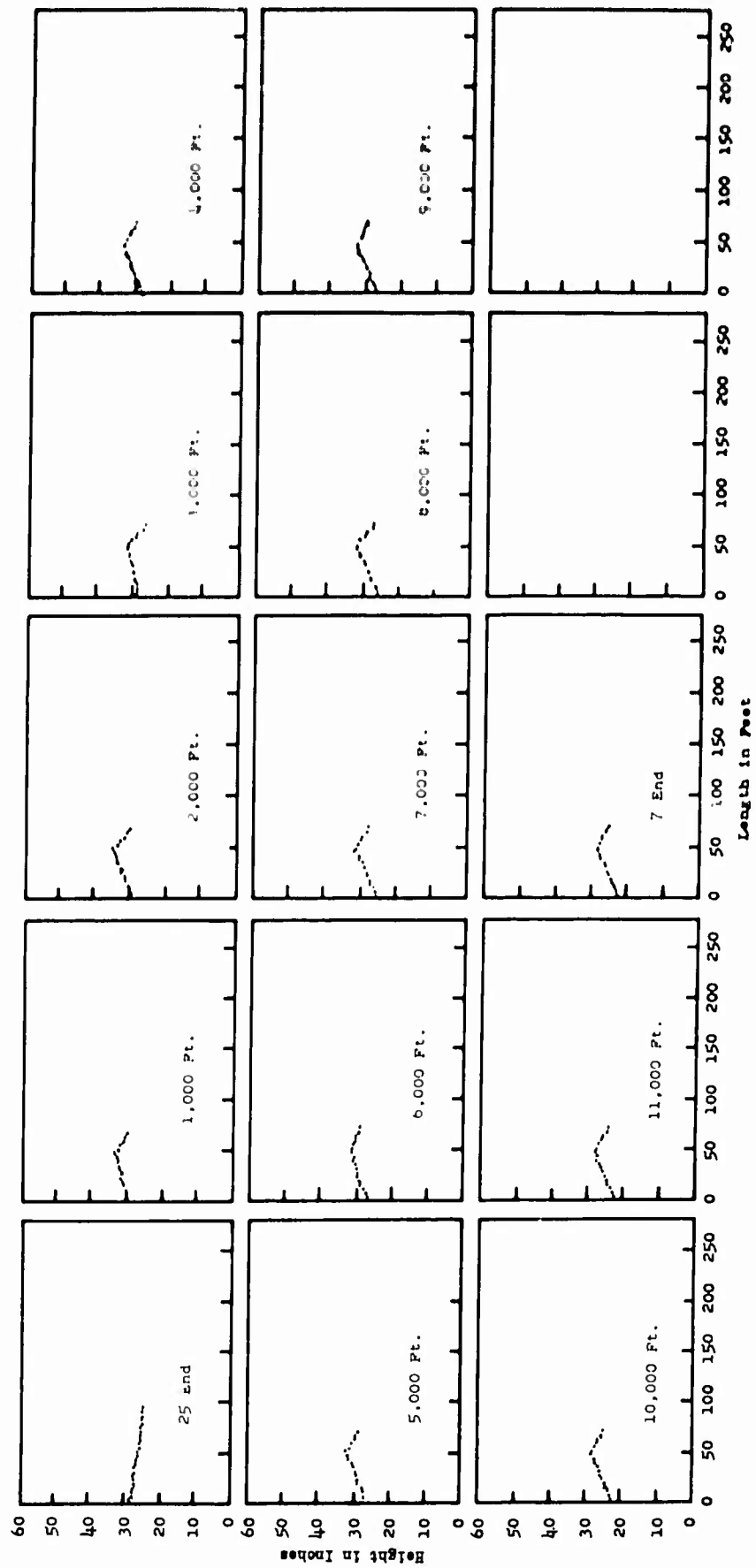


Figure 131 - Cross Run Profiles, Taxiway B, Palmdale Air Force Plant NR42

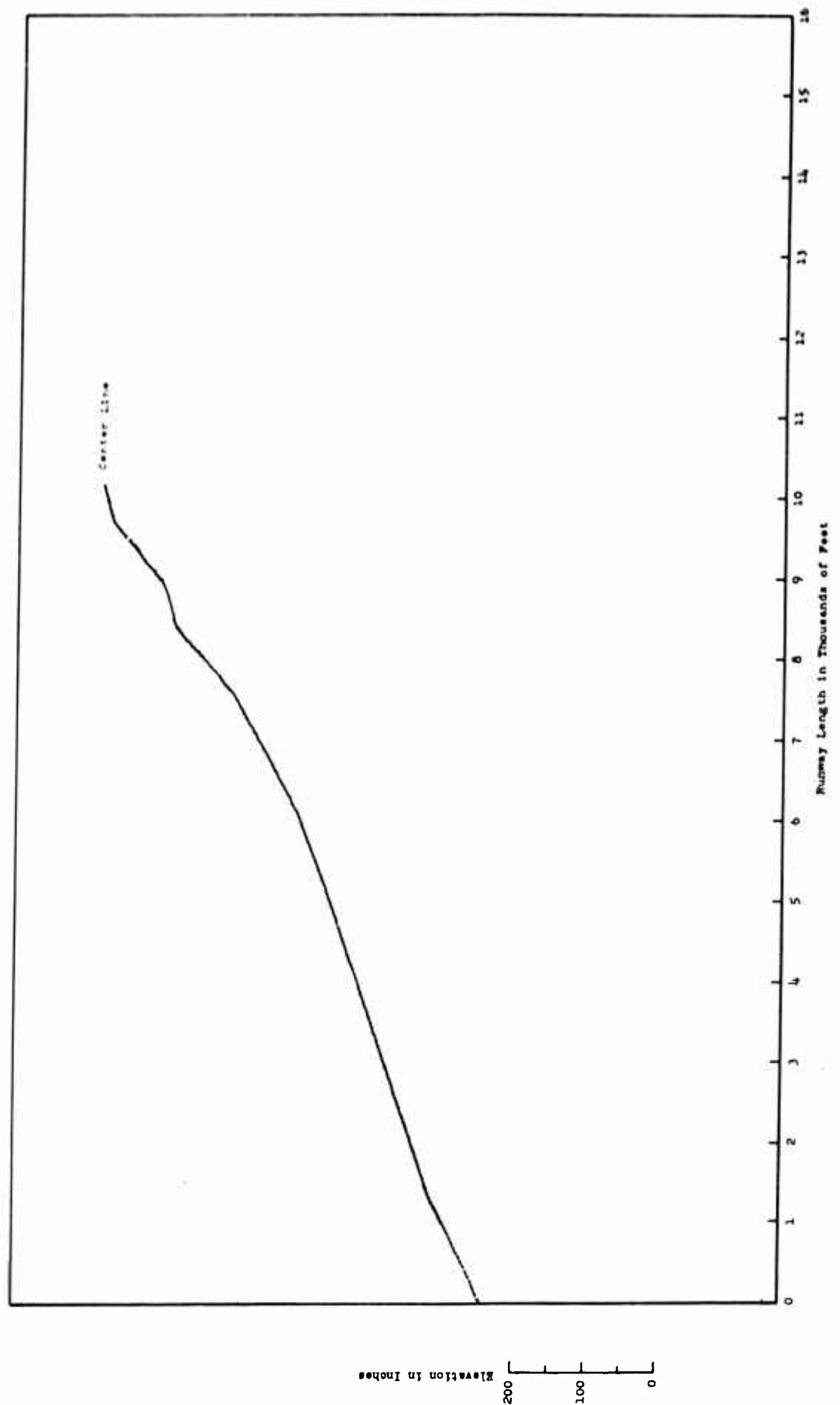


Figure 132 - Profile, Taxiway E, Palmdale Air Force Plant NR42

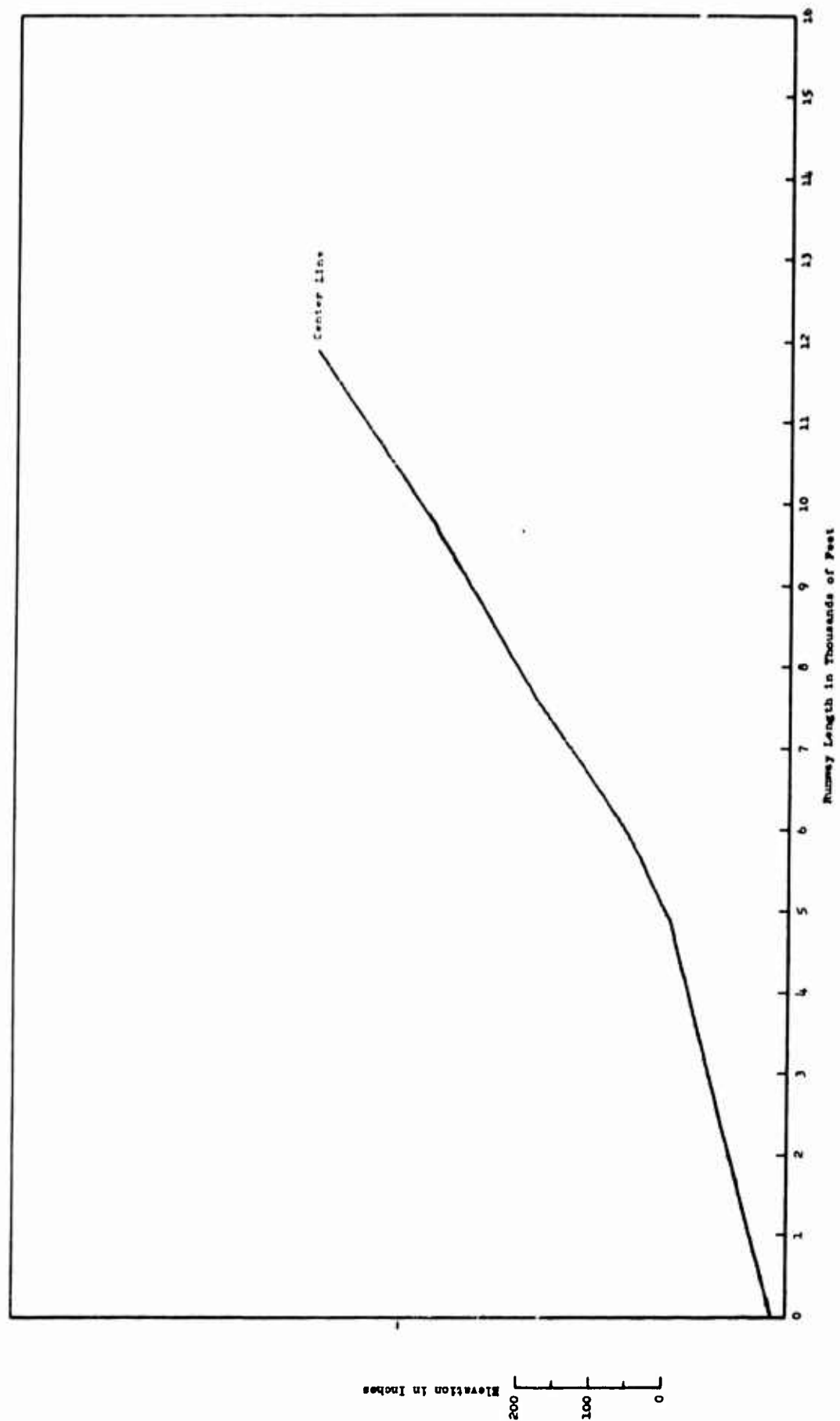


Figure 133 - Profile, Runway 22, Palmdale Air Force Plant NR42

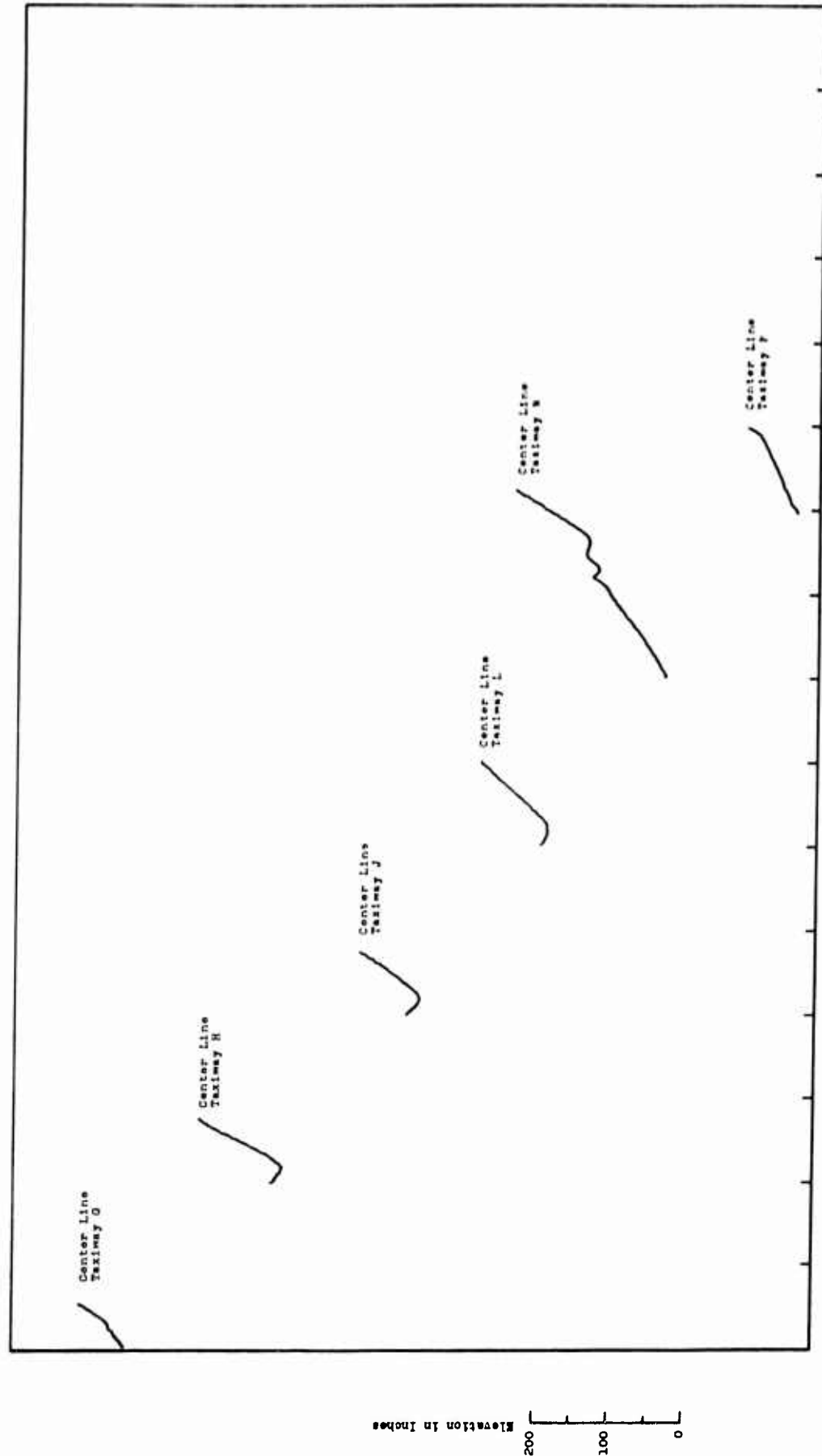


Figure 134 - Profiles, Taxiways, Palmdale Air Force Plant NR42

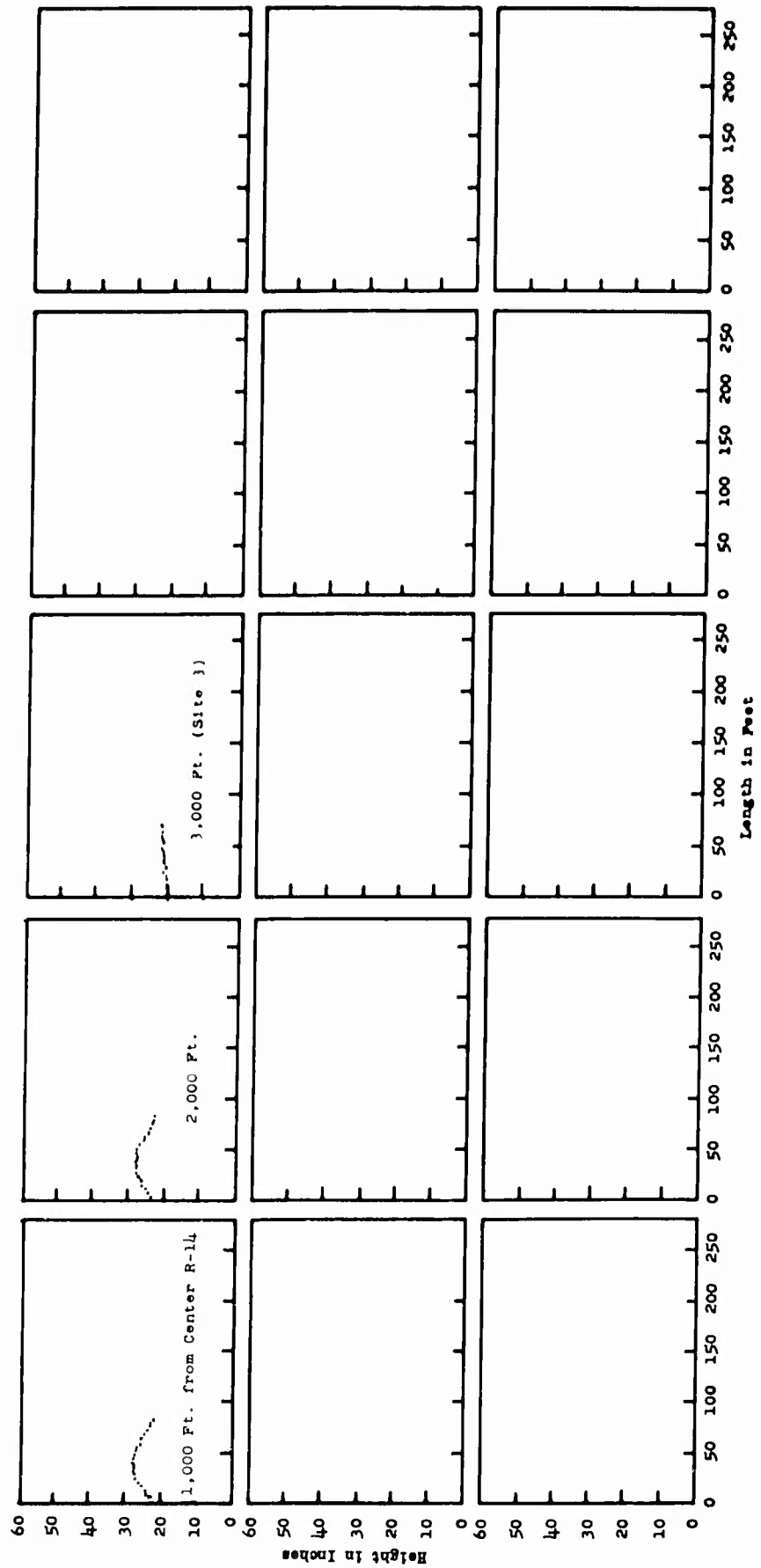


Figure 135 - Cross Run Profiles, Taxiway N, Palmdale Air Force Plant NR42

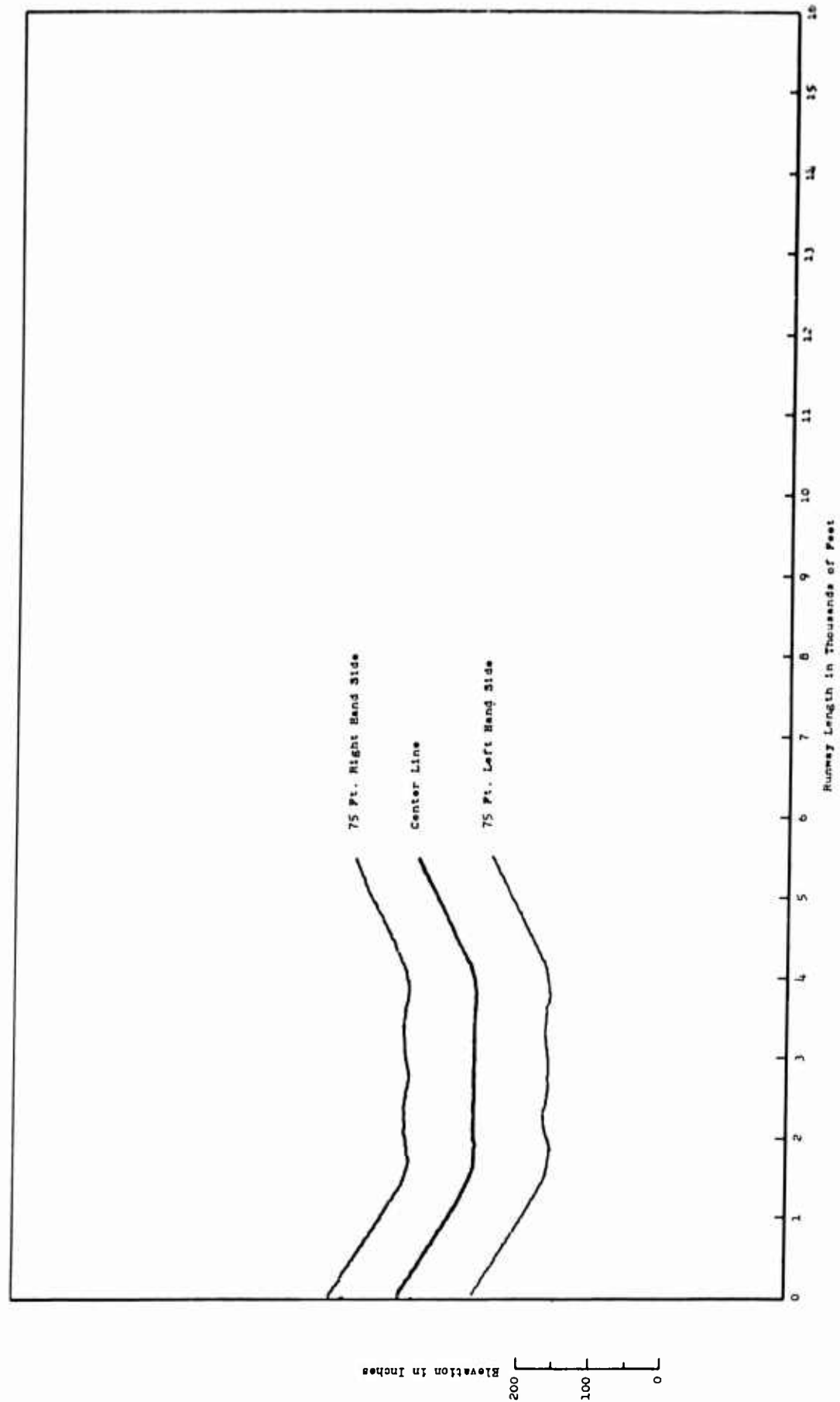


Figure 136 - Profiles, Runway 18, Stewart Air Force Base

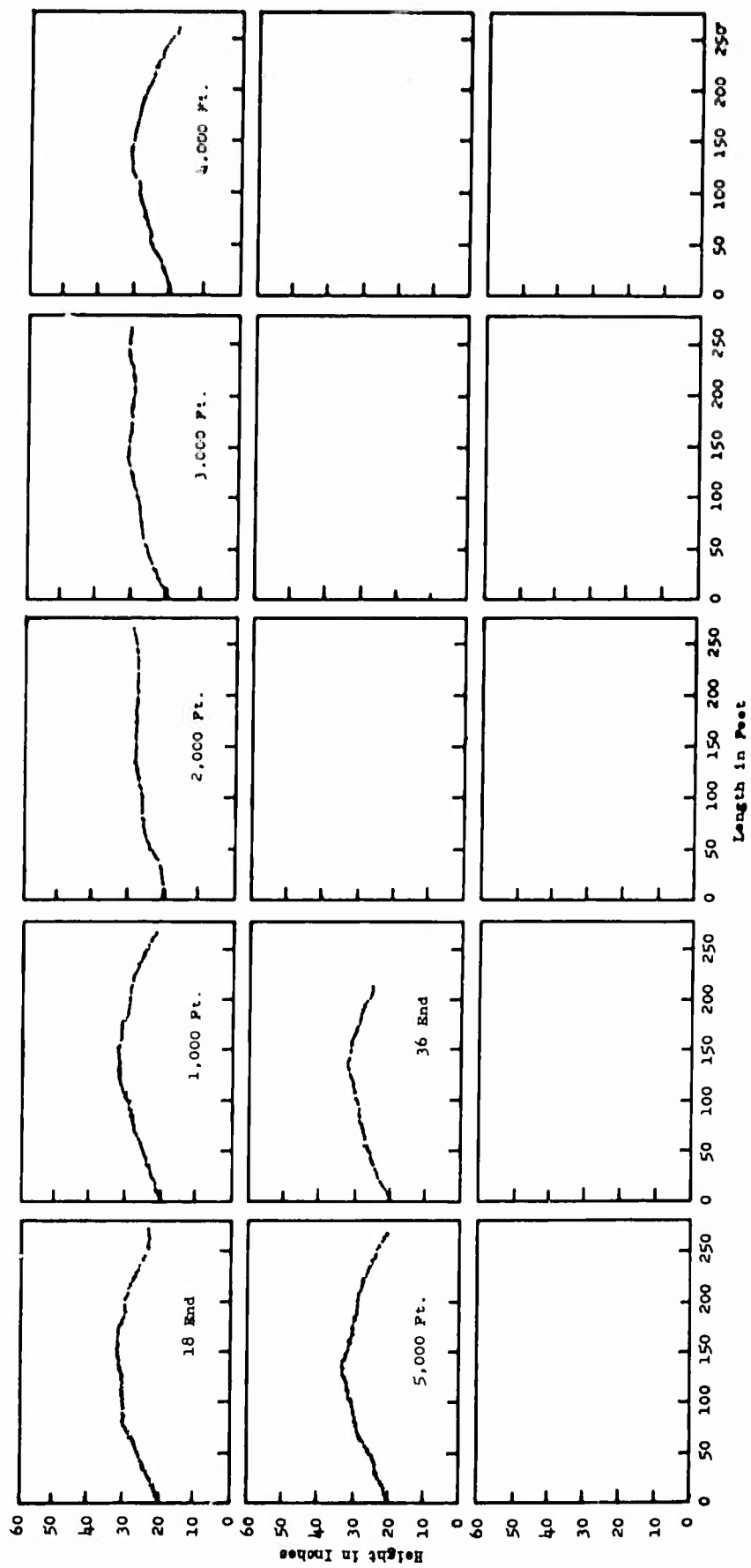


Figure 137 - Cross Run Profiles, Runway 18, Severt Air Force Base

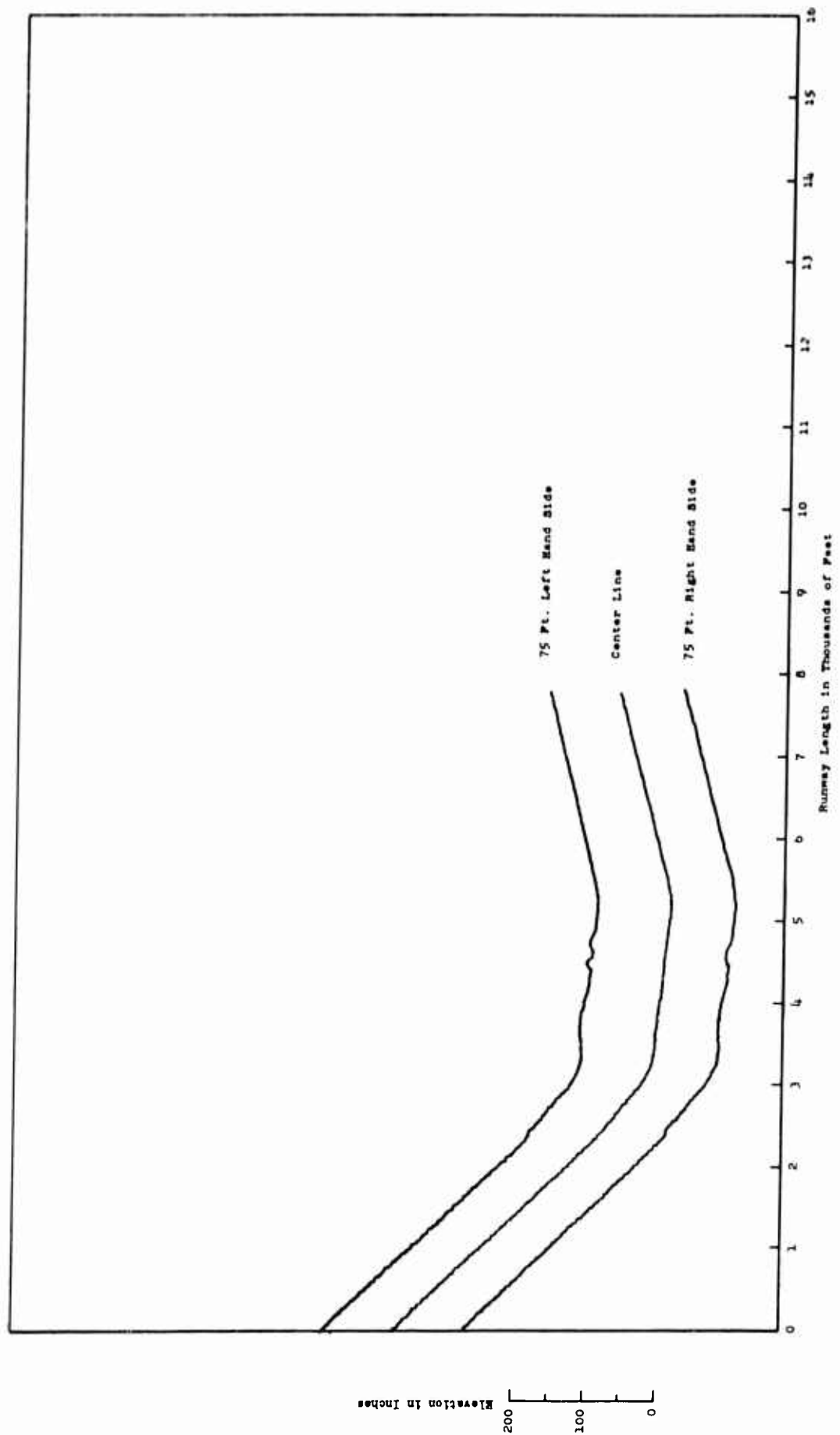


Figure 138 - Profiles, Runway 14, Severt Air Force Base

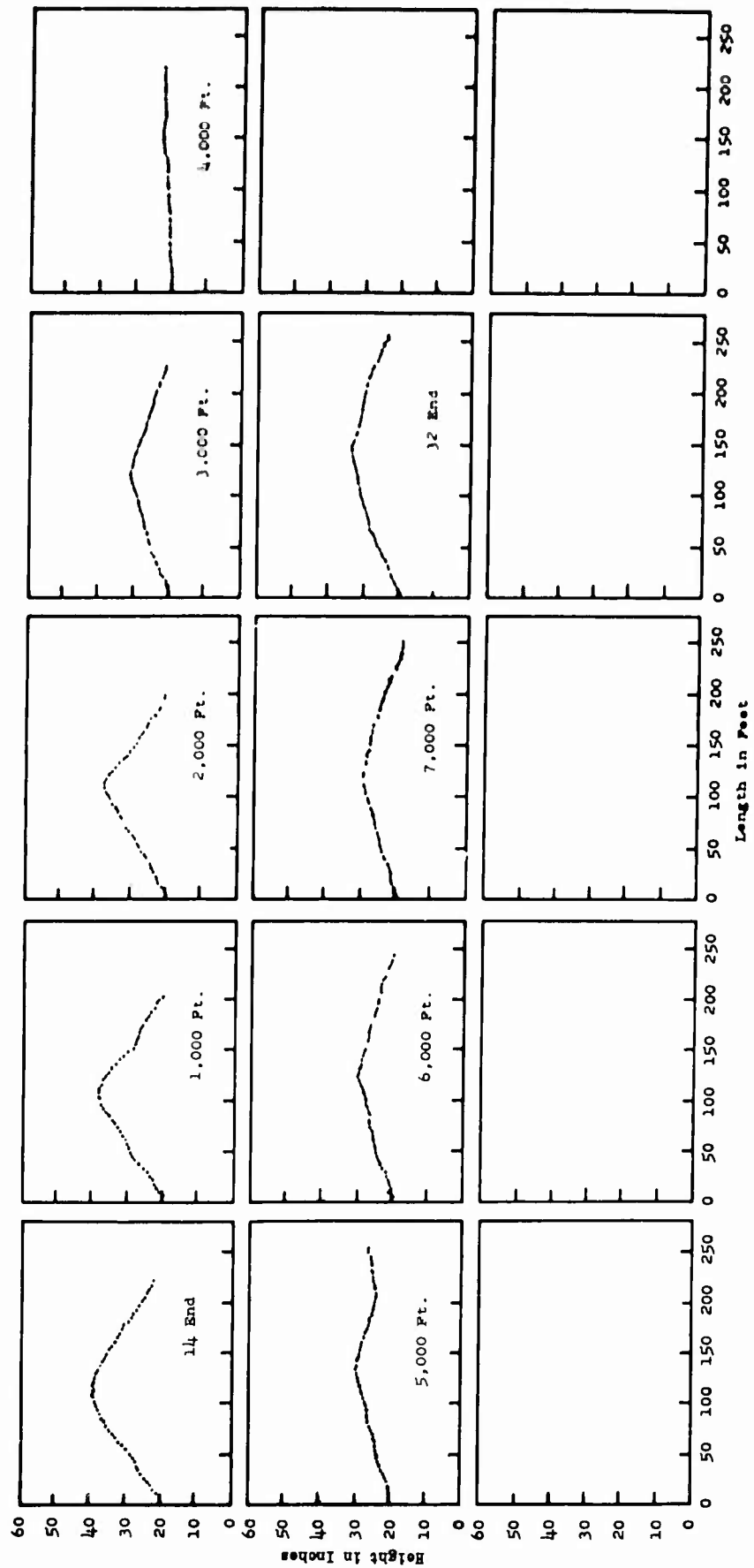


Figure 139 - Cross Run Profiles, Runway 14, Severt Air Force Base

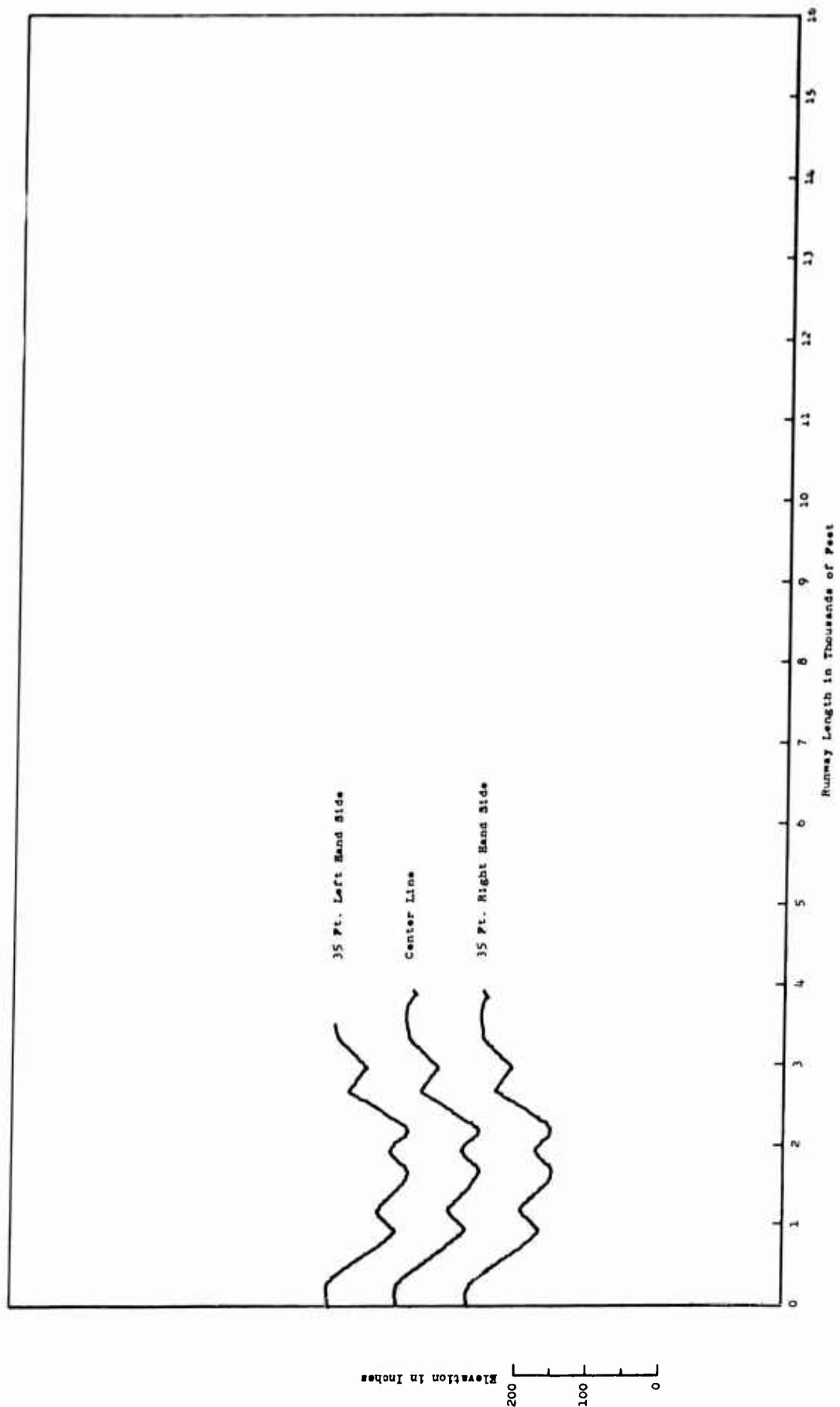


Figure 140 - Profiles, Taxiway 2, Sewart Air Force Base

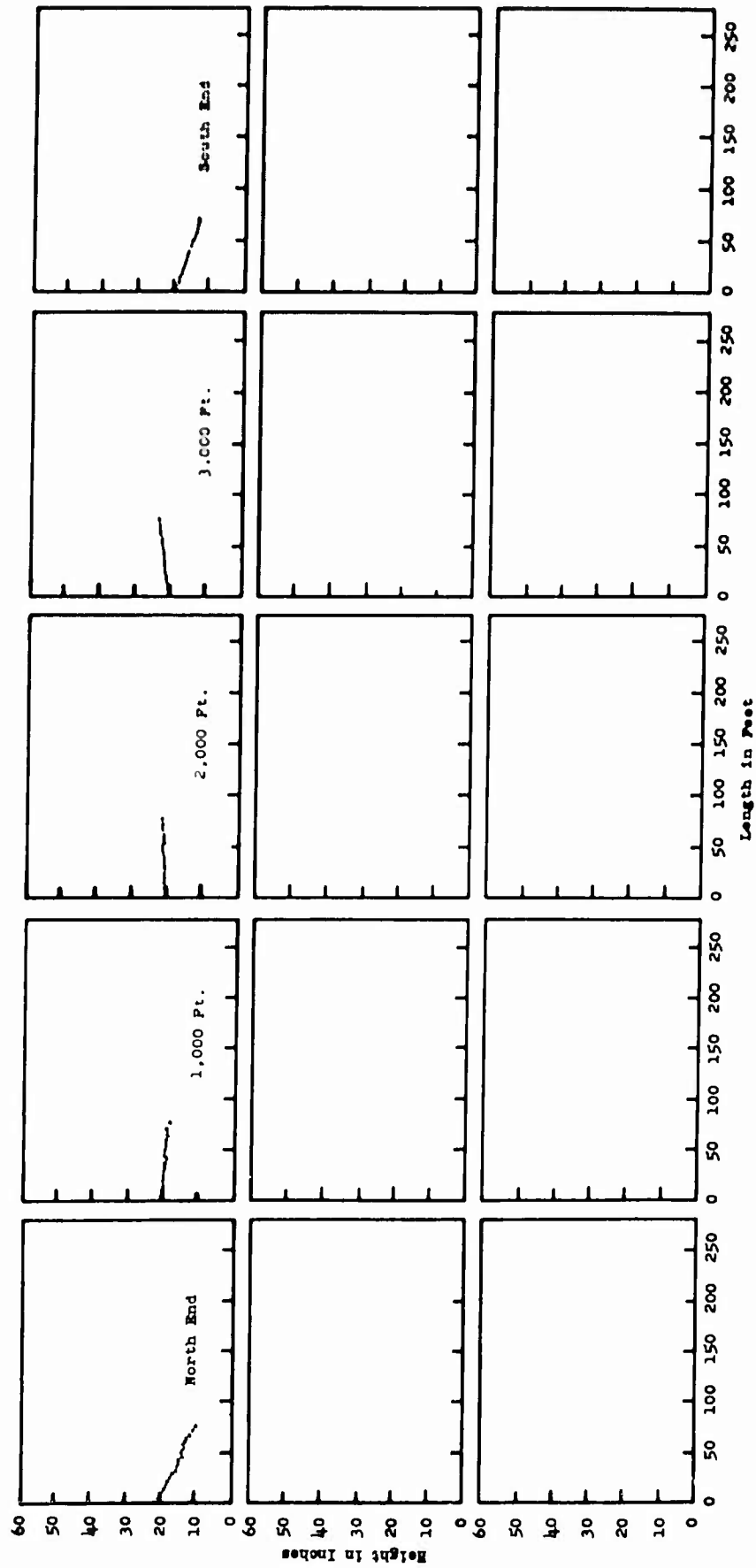


Figure 141 - Cross Run Profile, Taxiway 2, Sewart Air Force Base

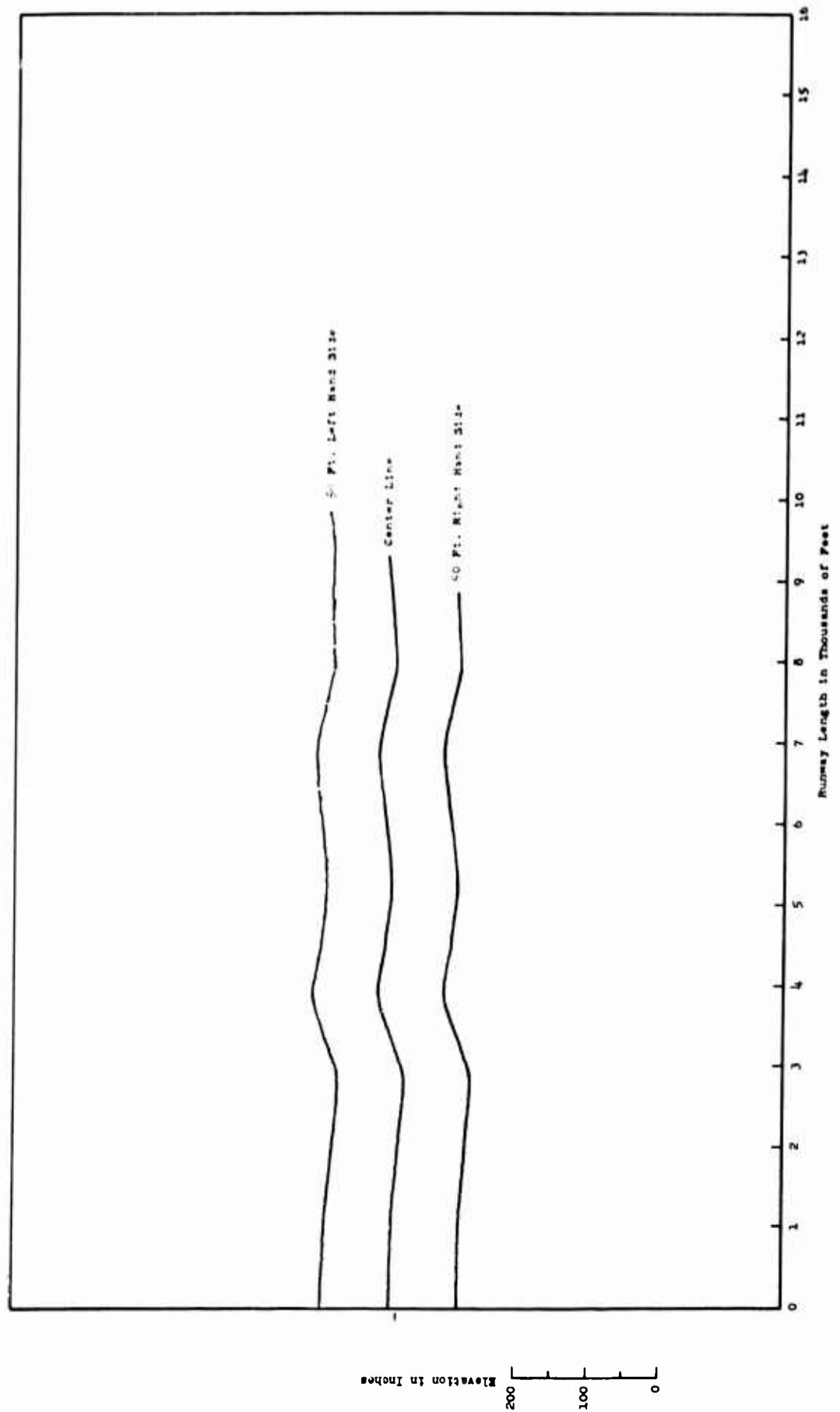


Figure 142 - Profiles, Runway 4, Shaw Air Force Base

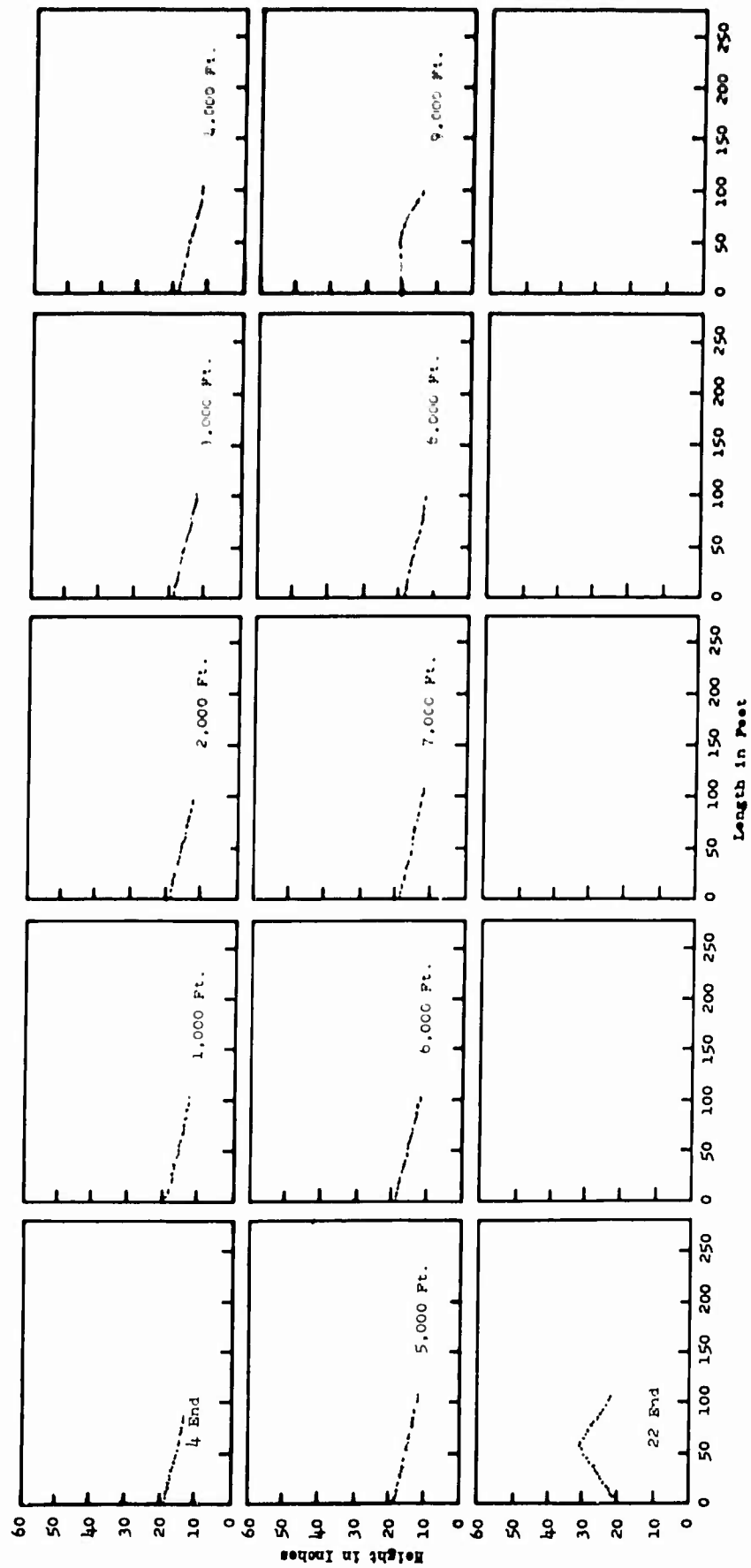


Figure 143 - Cross Run Profiles, Runway 4, Shaw Air Force Base

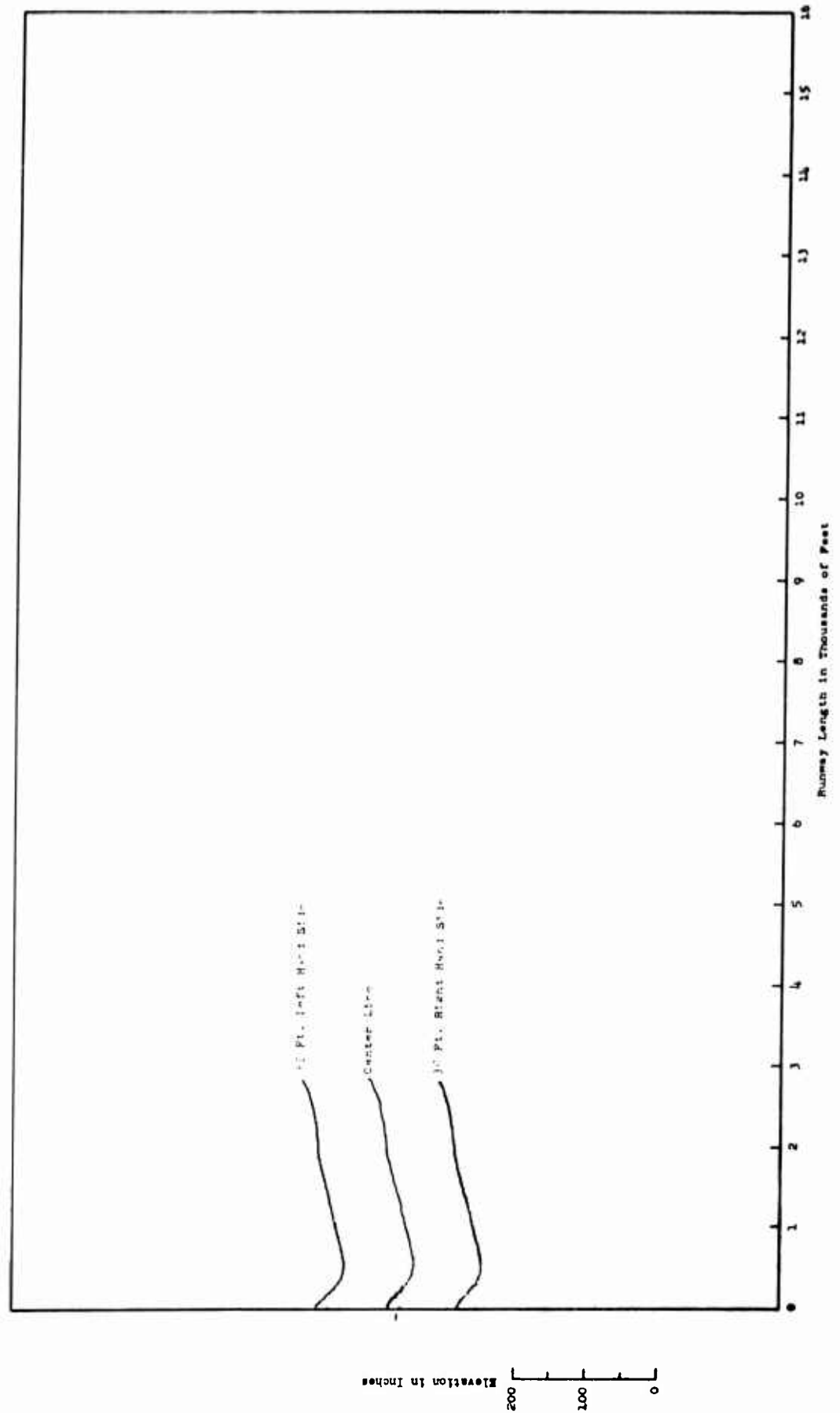


Figure 144 - Profiles, Taxiway, Shaw Air Force Base

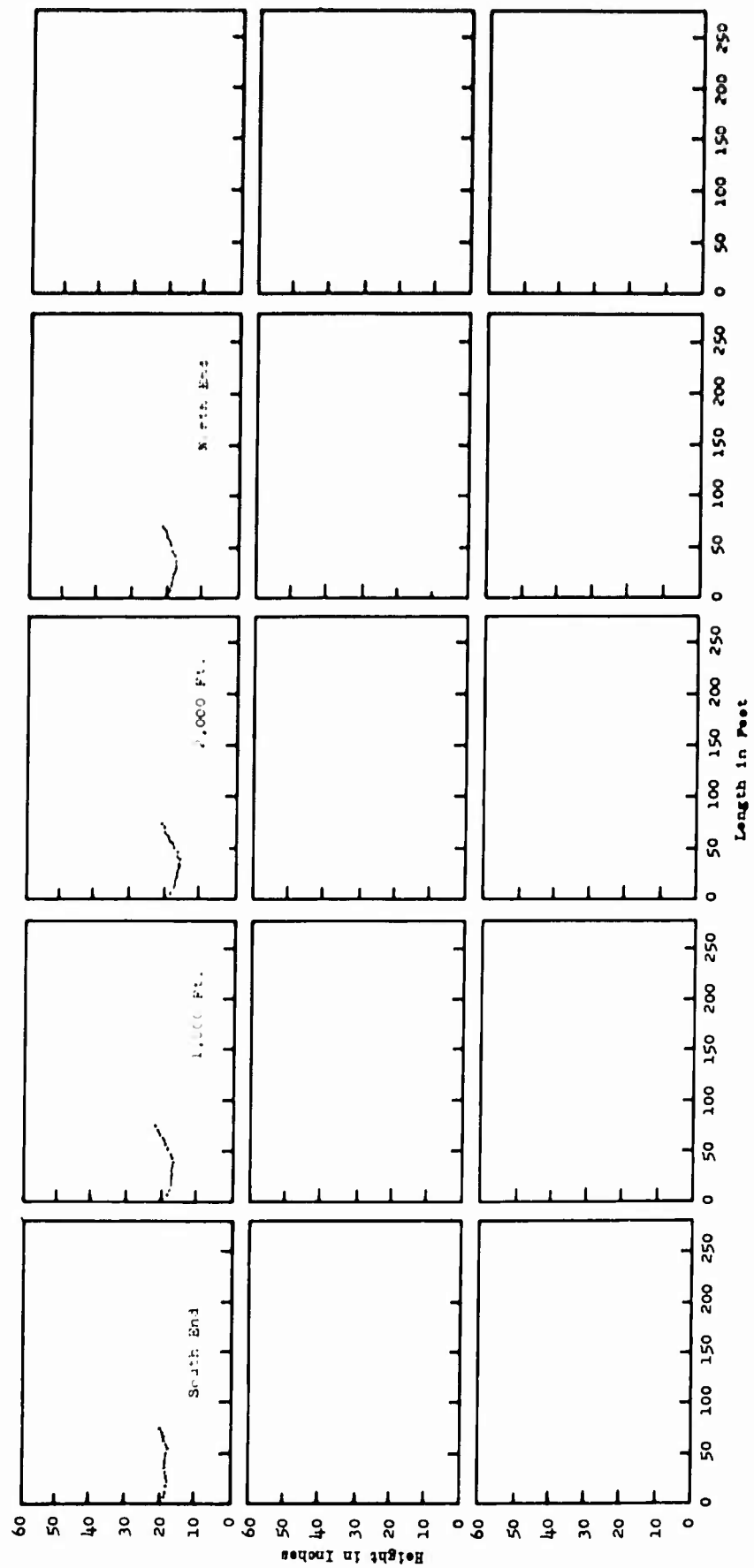


Figure 145 - Cross Run Profiles, Taxiway, Shaw Air Force Base

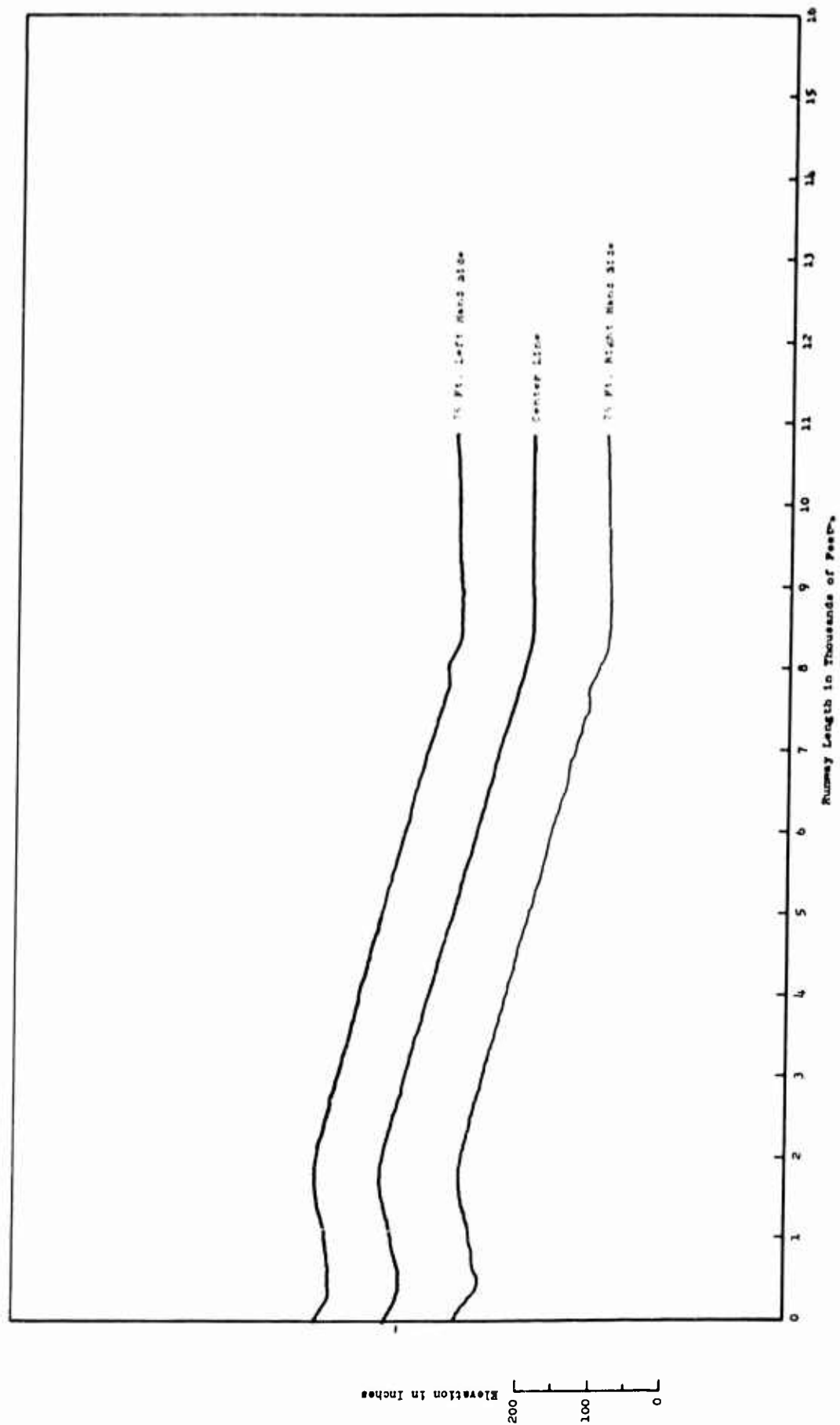


Figure 146 - Profiles, Runway 21R, Travis Air Force Base

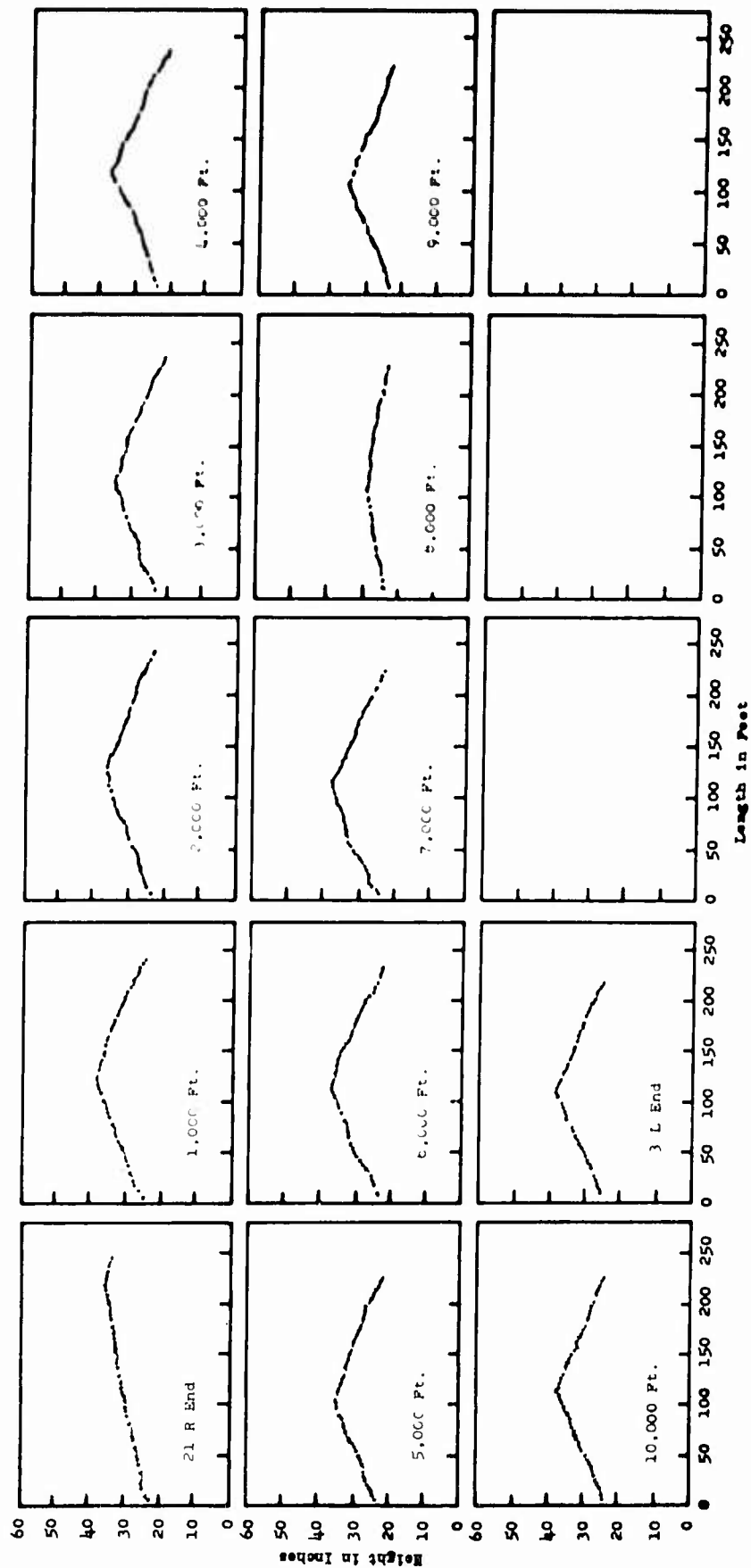


Figure 147 - Cross Run Profiles, Runway 21R, Travis Air Force Base

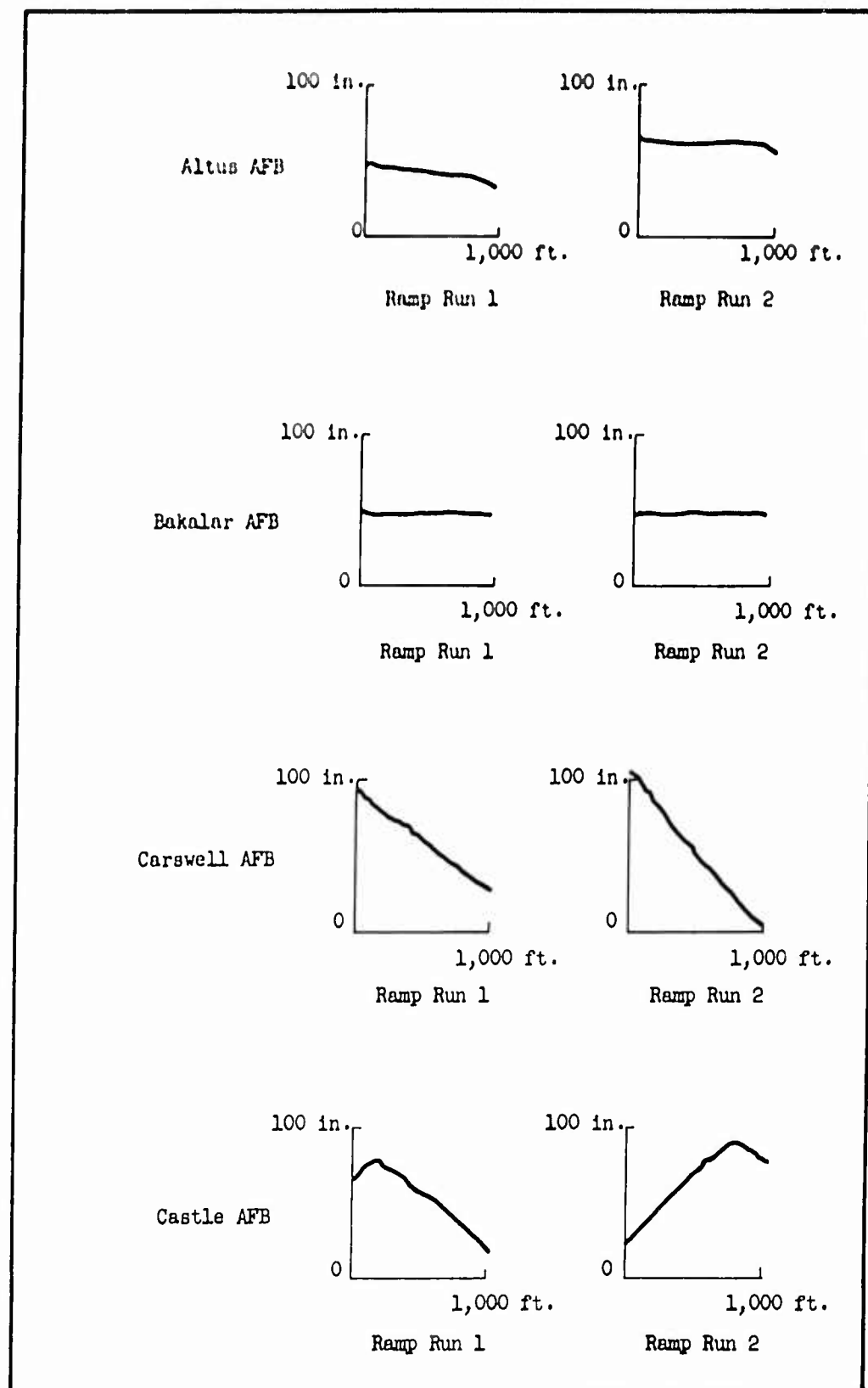


Figure 148 - Ramp Run Profiles

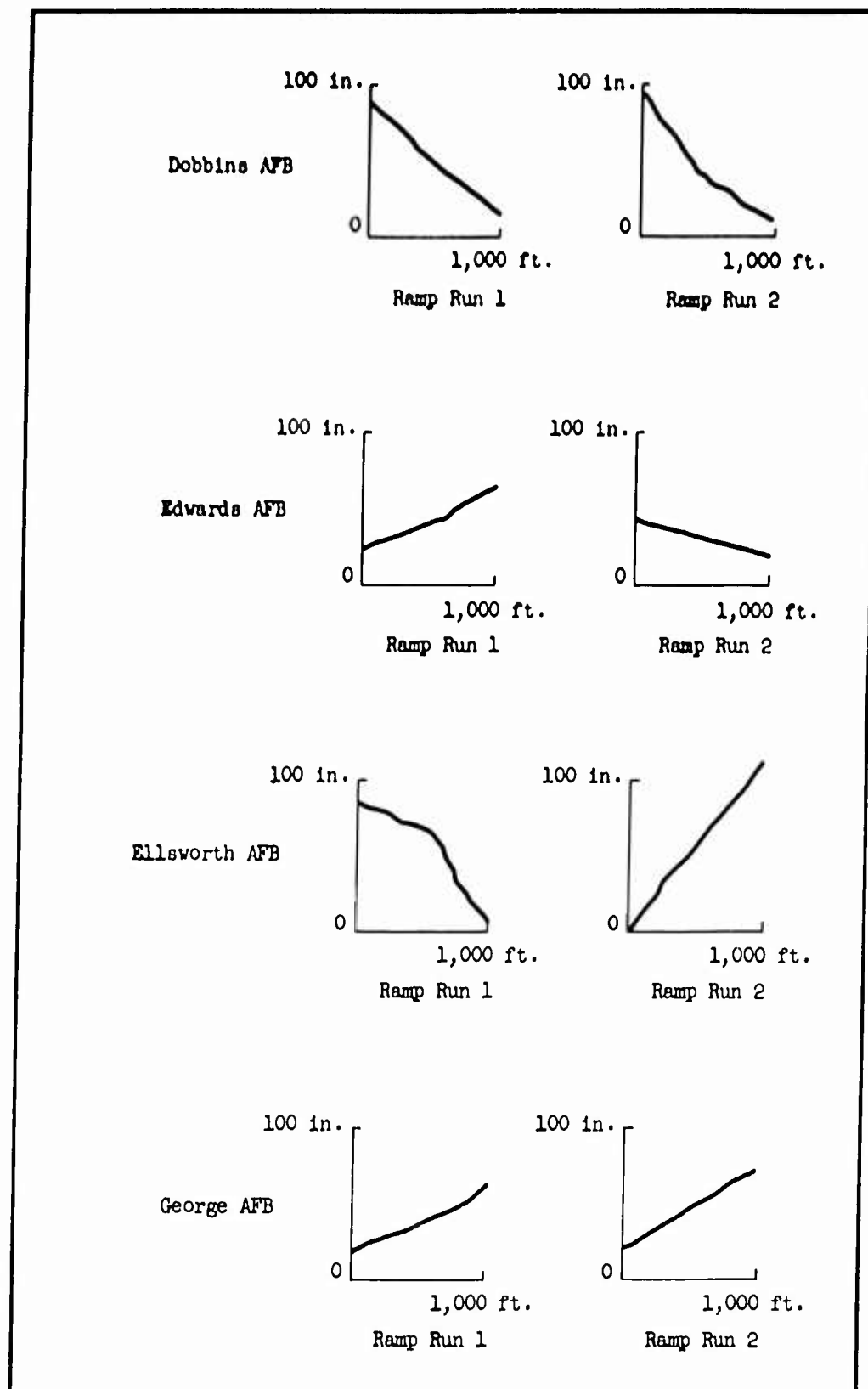


Figure 149 - Ramp Run Profiles

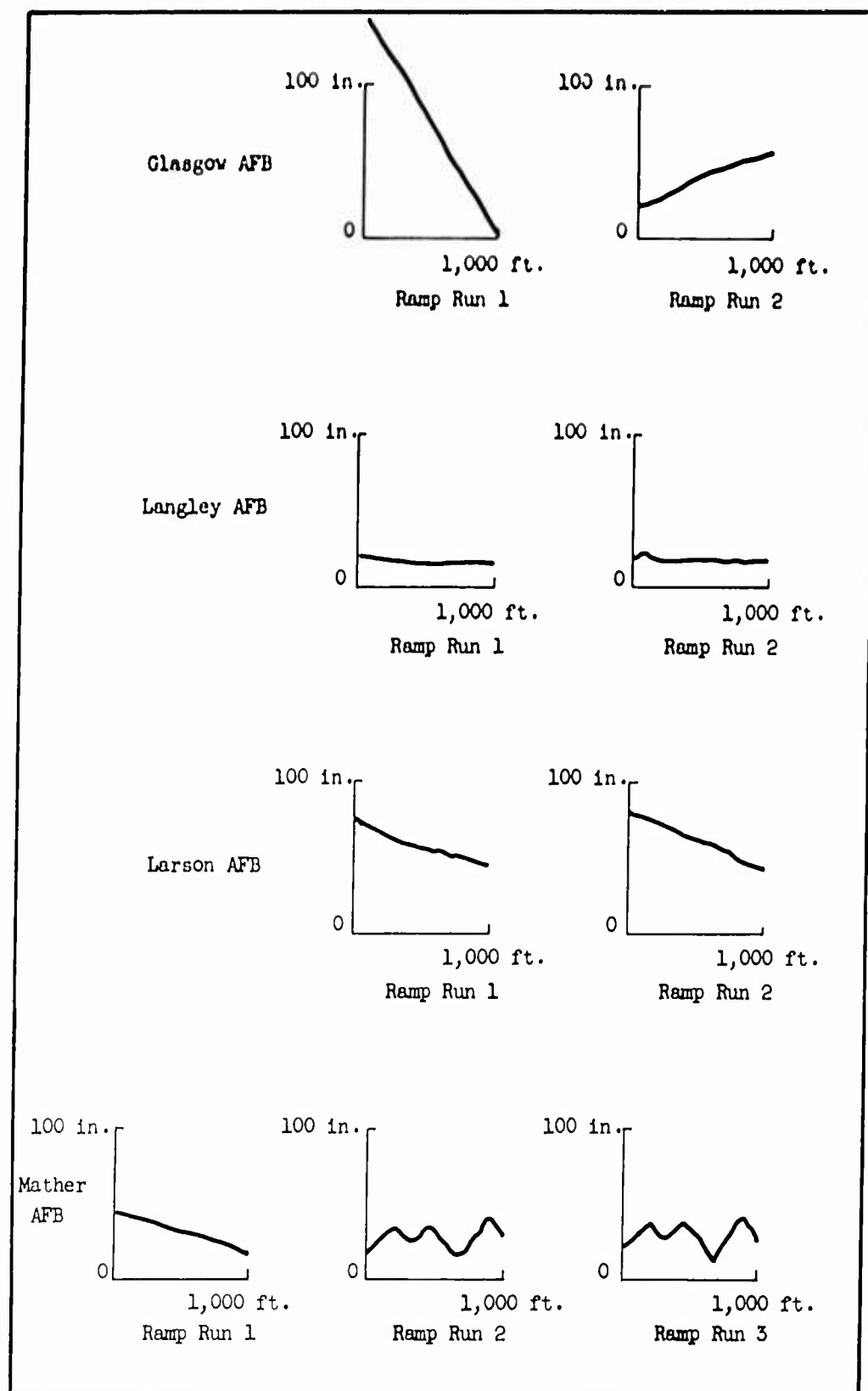


Figure 150 - Ramp Run Profiles

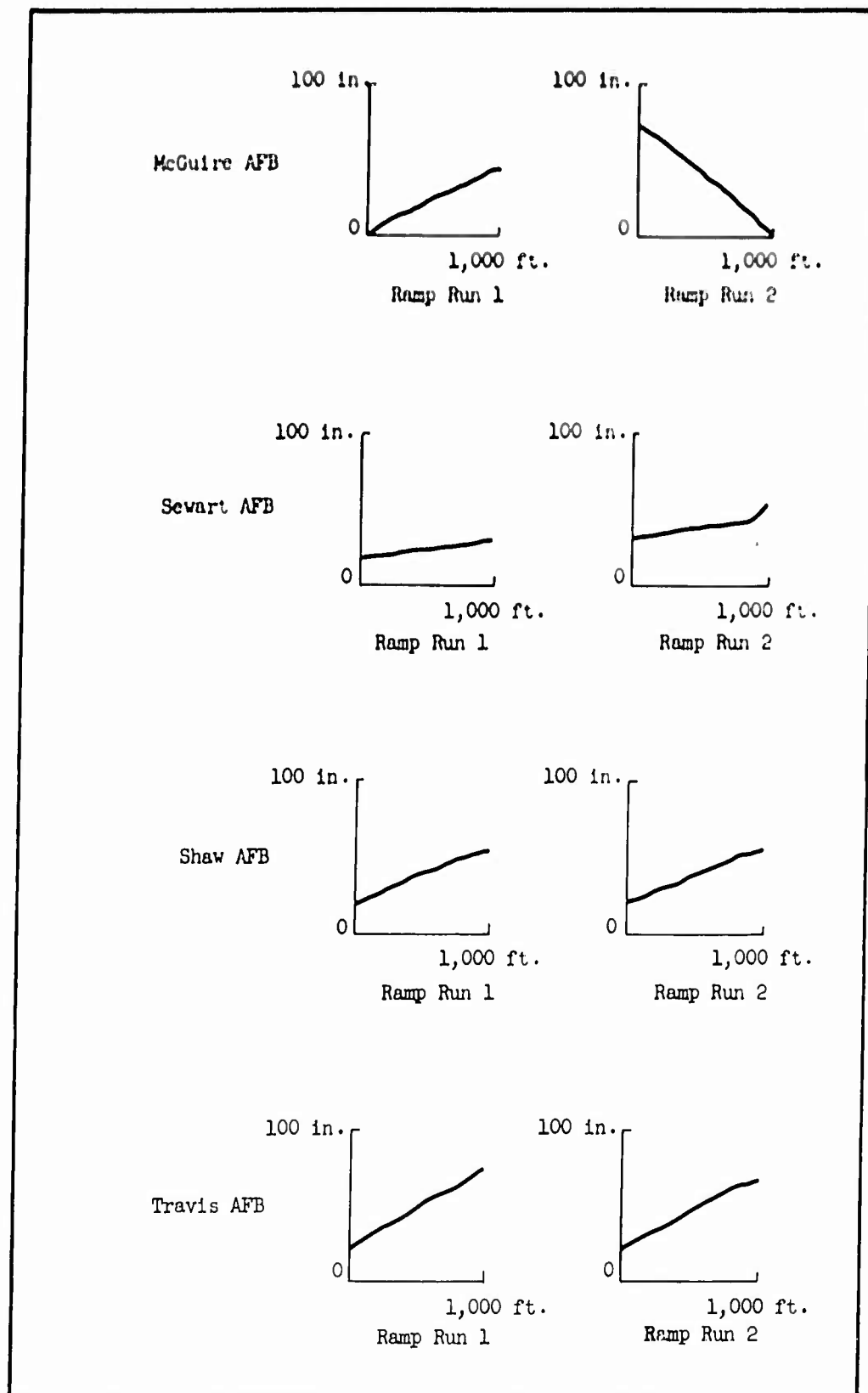


Figure 151 - Ramp Run Profiles

APPENDIX III

BASE MAPS



Figure 152 - Locations of Bases Surveyed

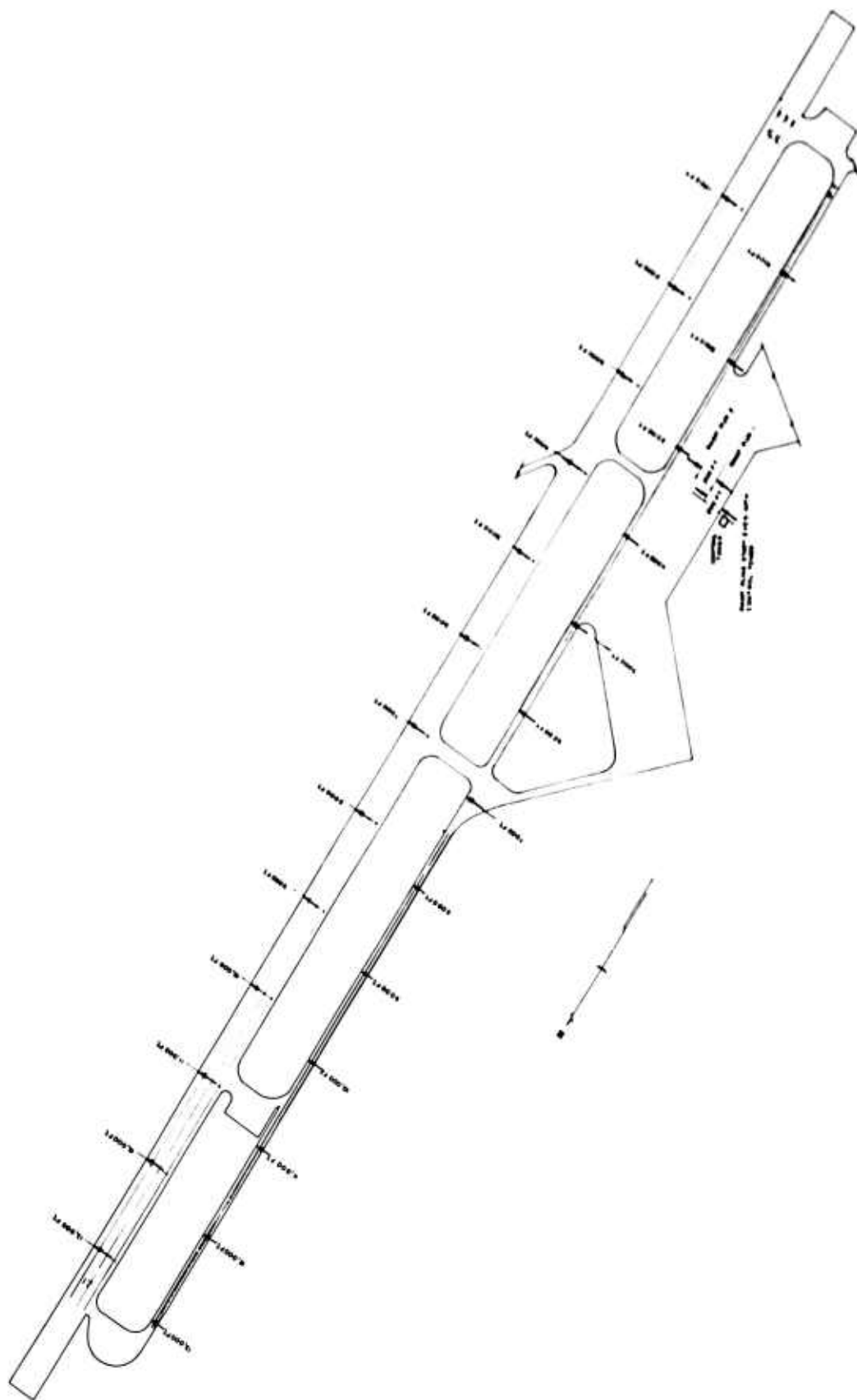


Figure 153 - Location of Lines of Survey, Altus Air Force Base

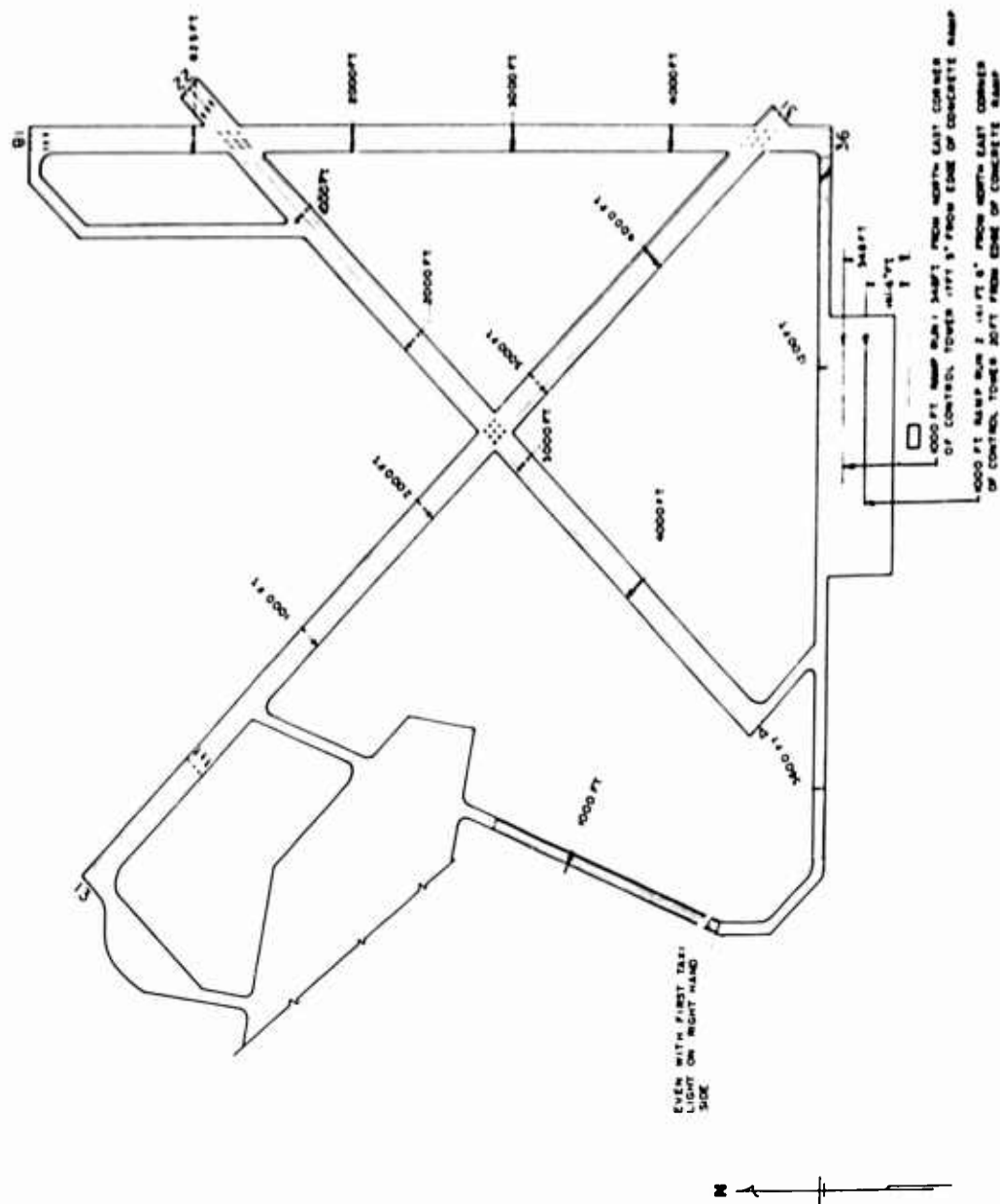


Figure 154 - Location of Lines of Survey, Bakalar Air Force Base

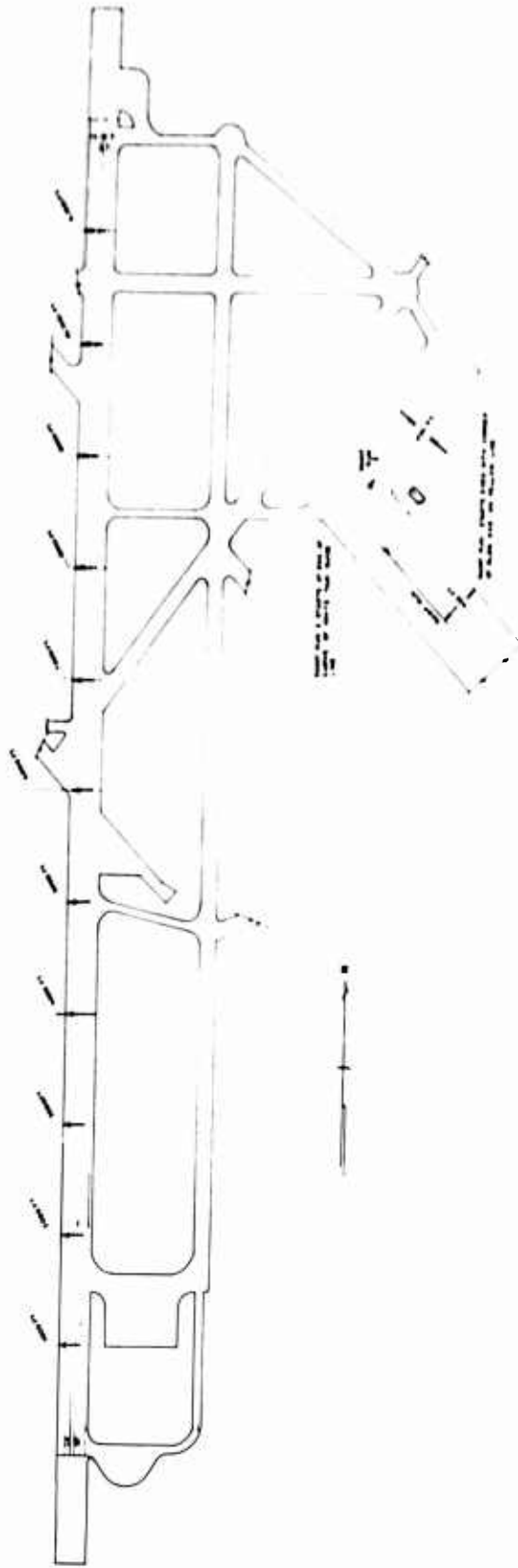


Figure 155 - Location of Lines of Survey, Carswell Air Force Base

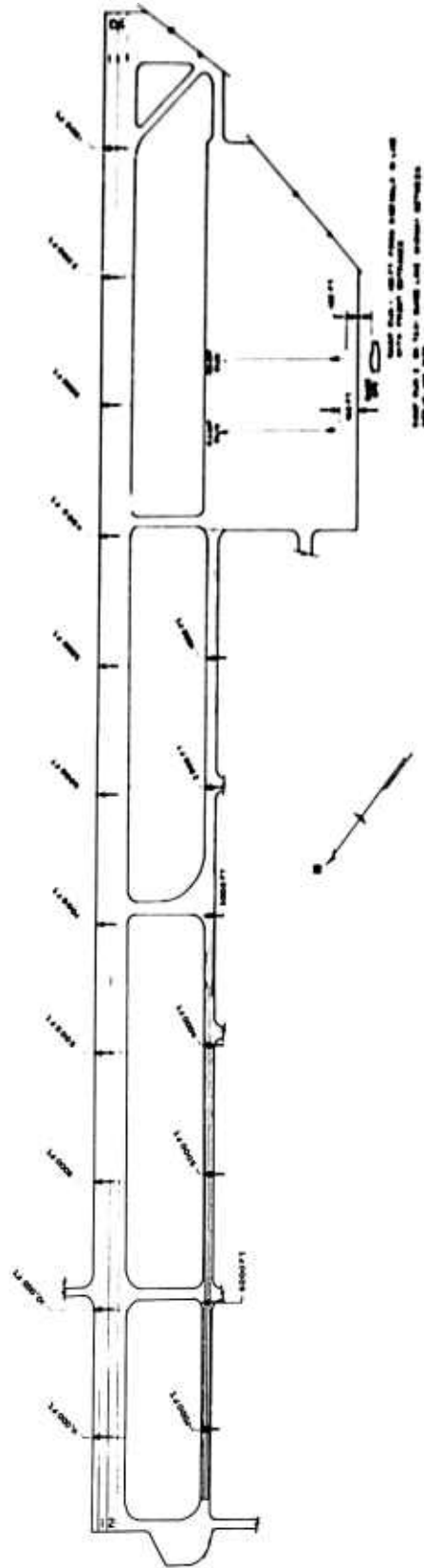


Figure 156 - Location of Lines of Survey, Castle Air Force Base

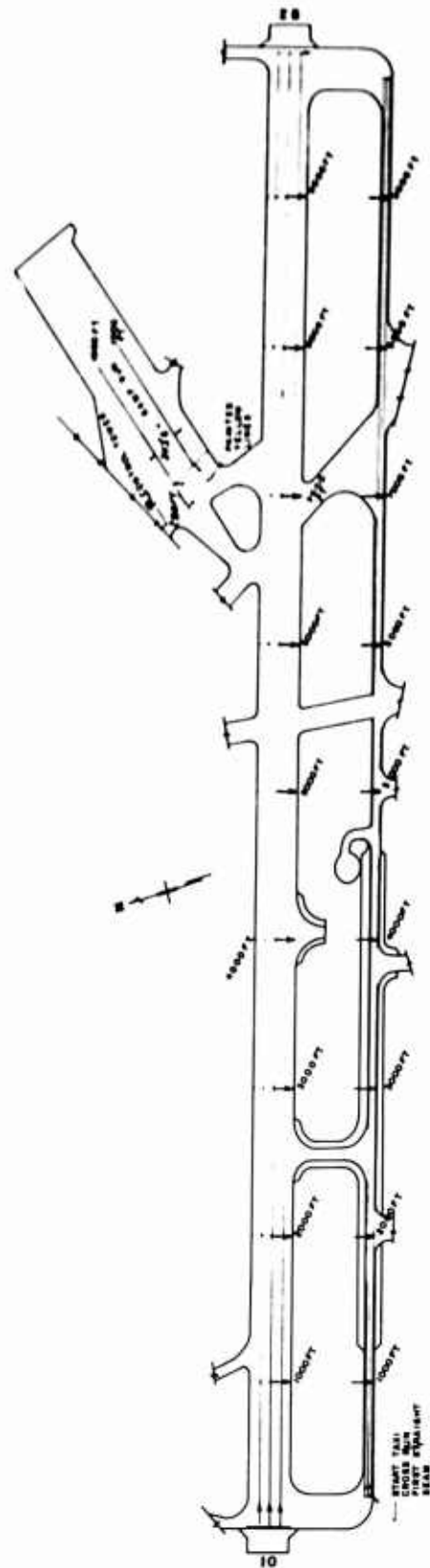


Figure 157 - Location of Lines of Survey, Dobbins Air Force Base

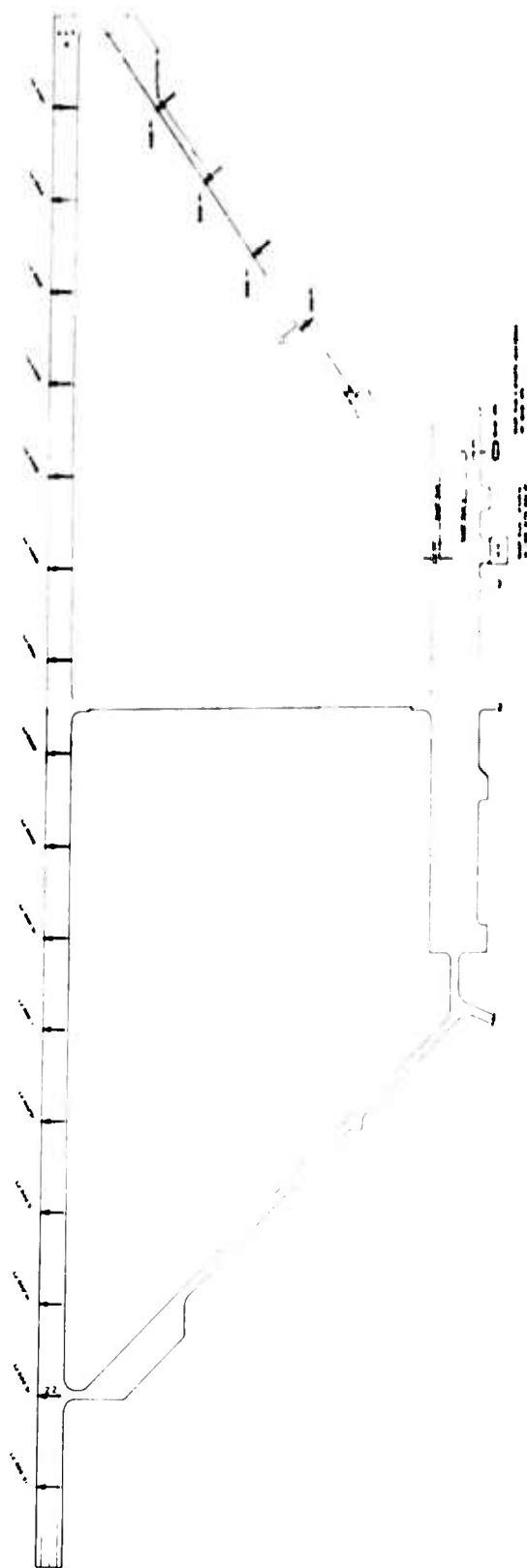


Figure 158 - Location of Lines of Survey, Edwards Air Force Base

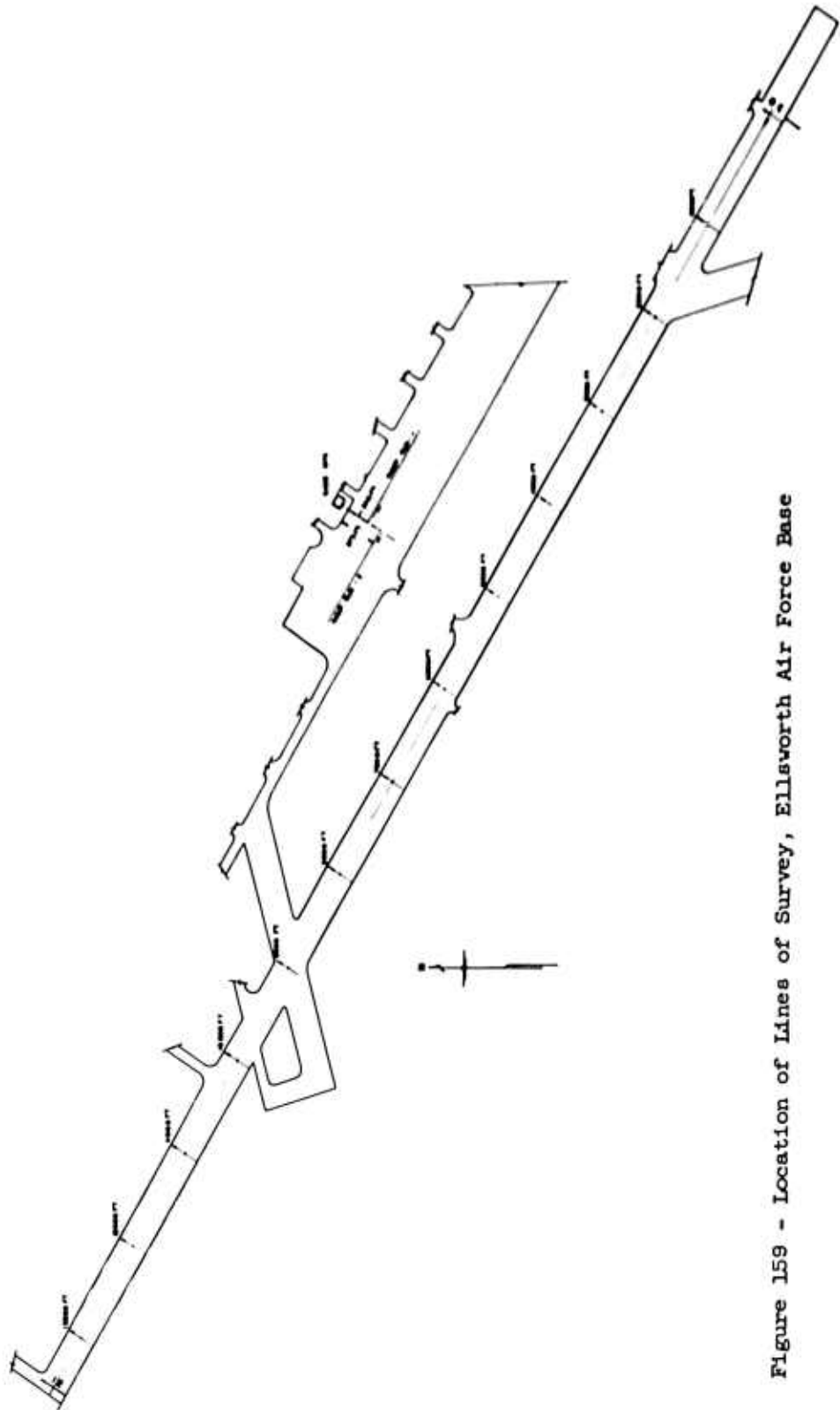


Figure 159 - Location of Lines of Survey, Ellsworth Air Force Base

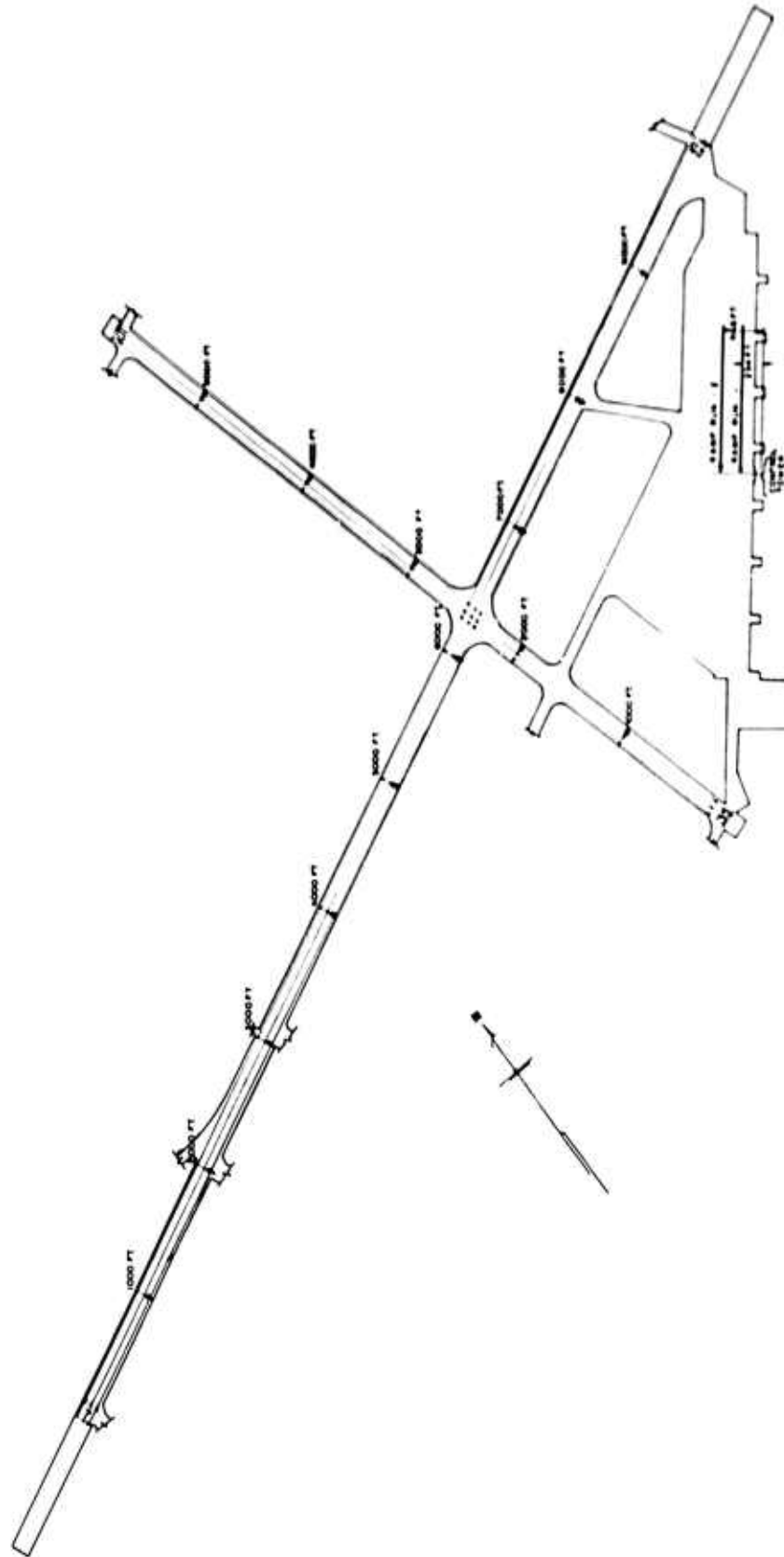


Figure 162 - Location of Lines of Survey, Langley Air Force Base

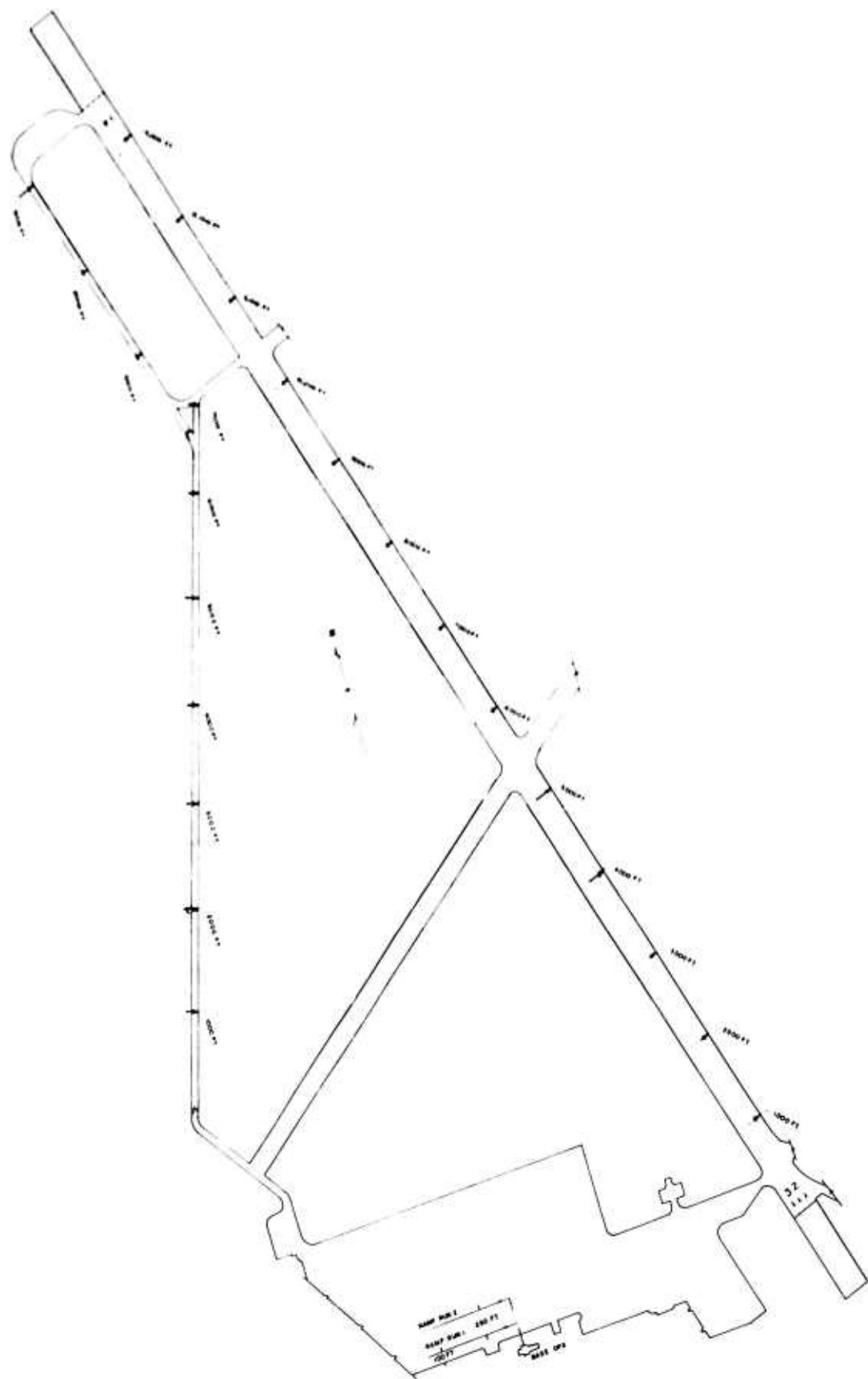


Fig. 163 - Location of Lines of Survey, Larson Air Force Base

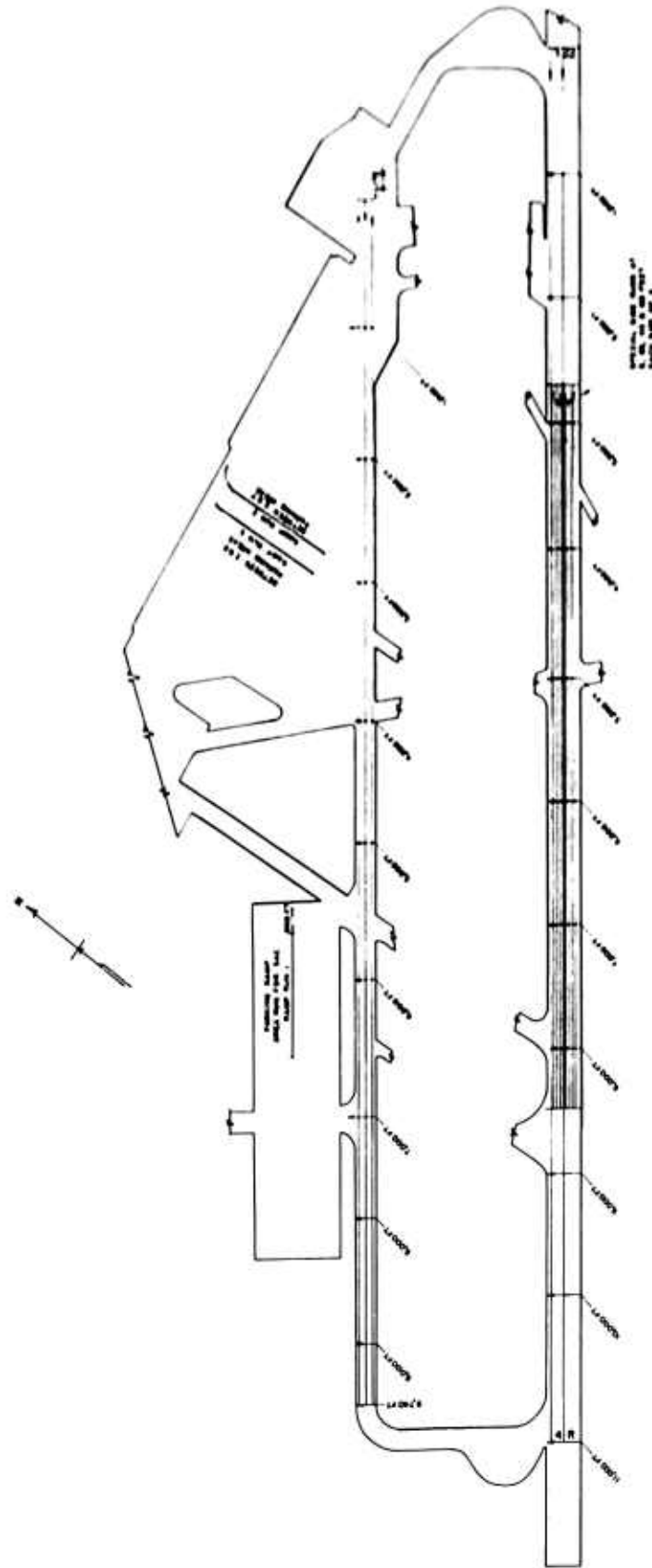


Figure 164 - Location of Lines of Survey, Mather Air Force Base

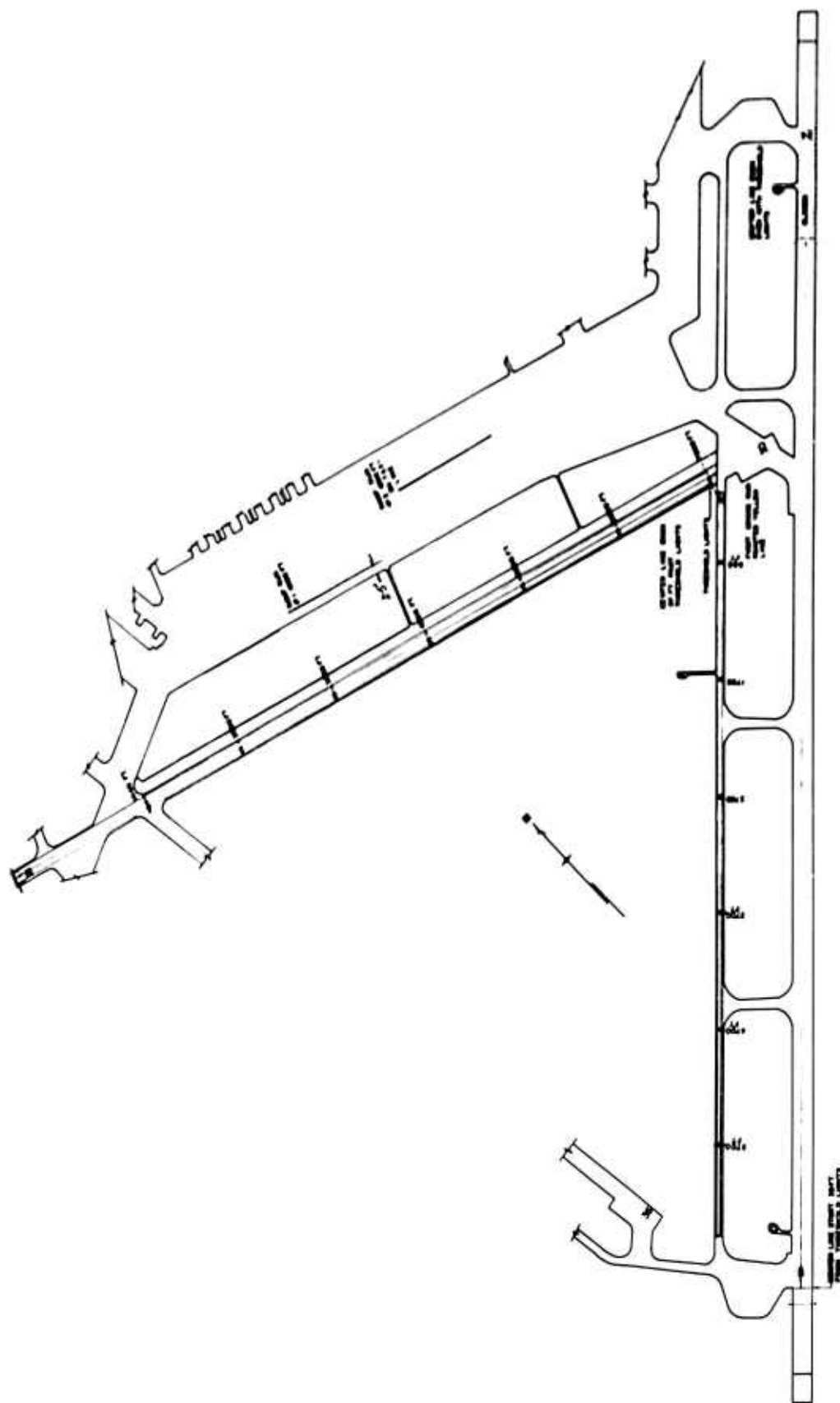
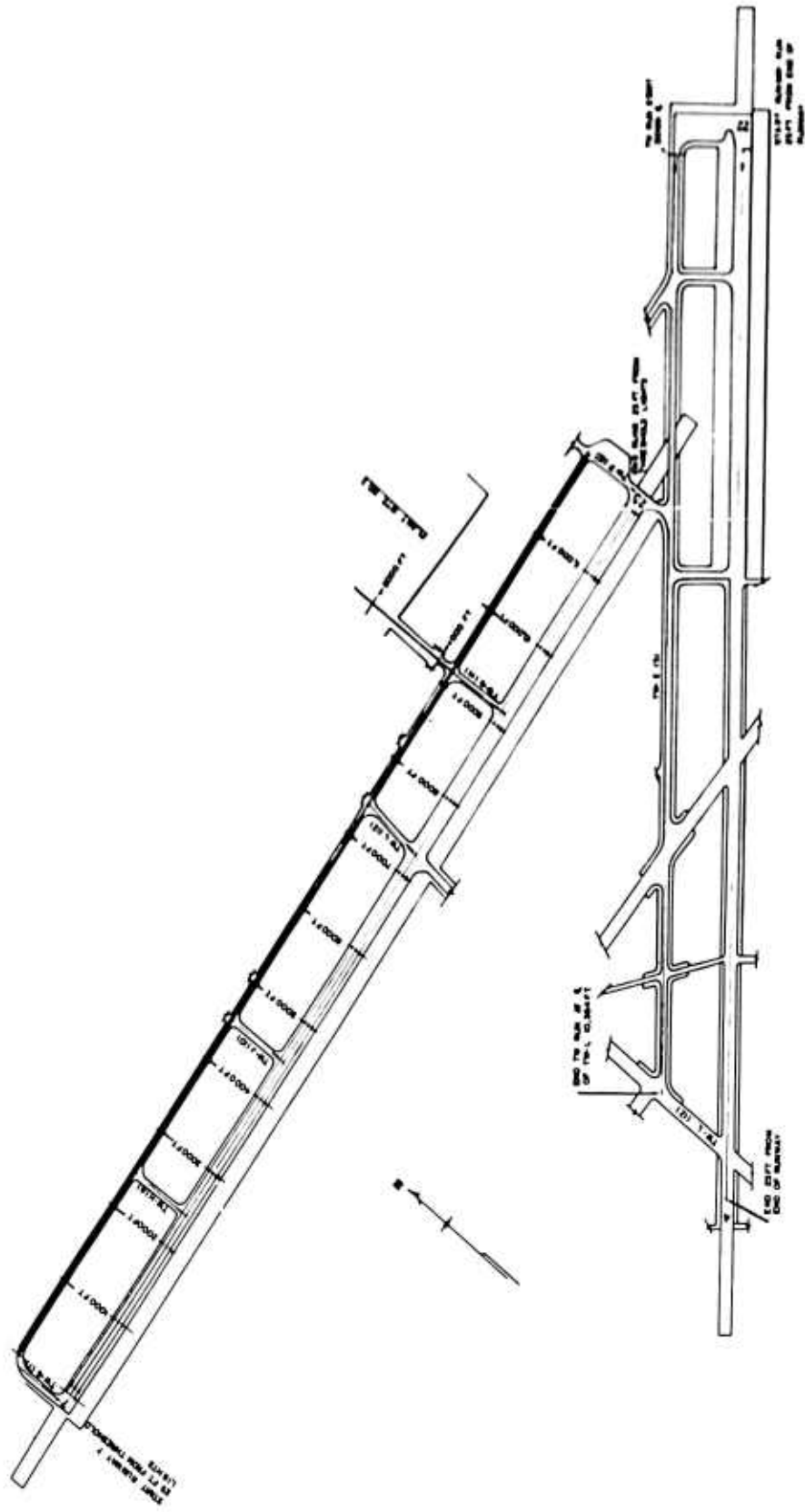


Figure 165 - Location of Lines of Survey, McGuire Air Force Base



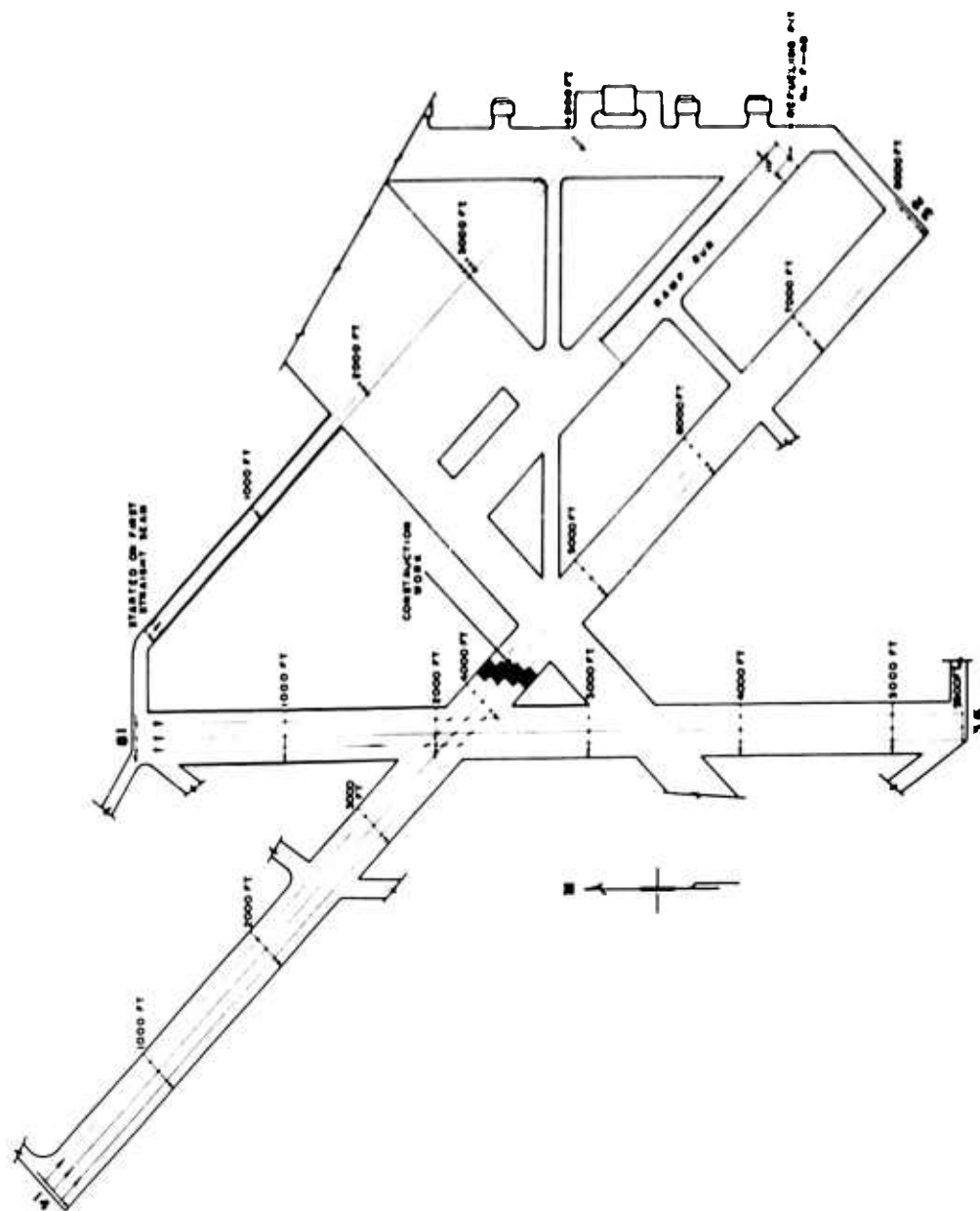


Figure 167 - Location of Lines of Survey, Severt Air Force Base

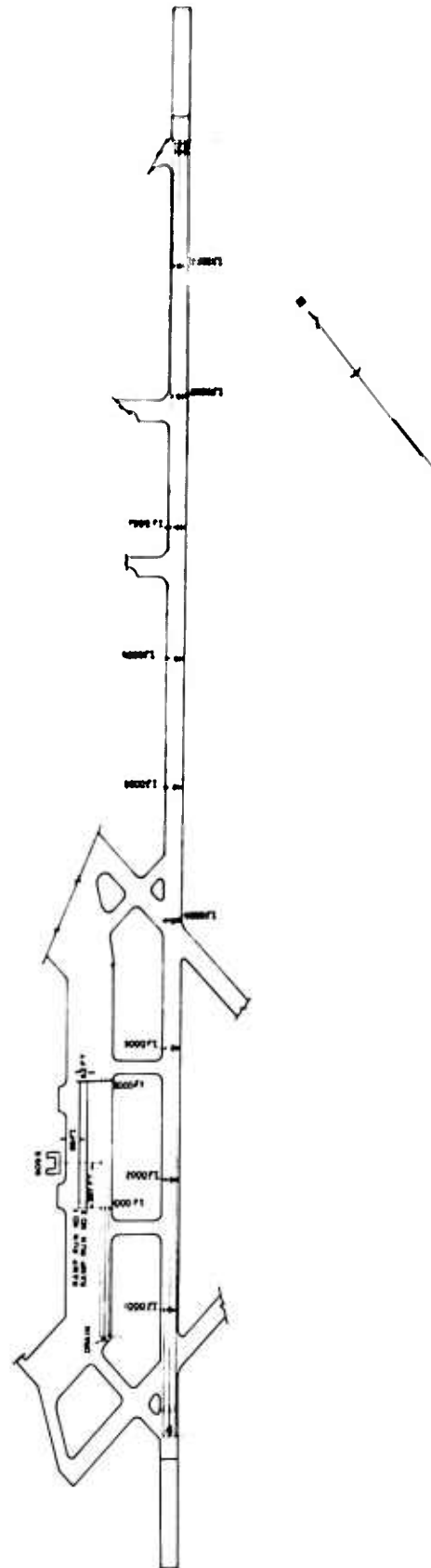


Figure 168 - Location of Lines of Survey, Shaw Air Force Base

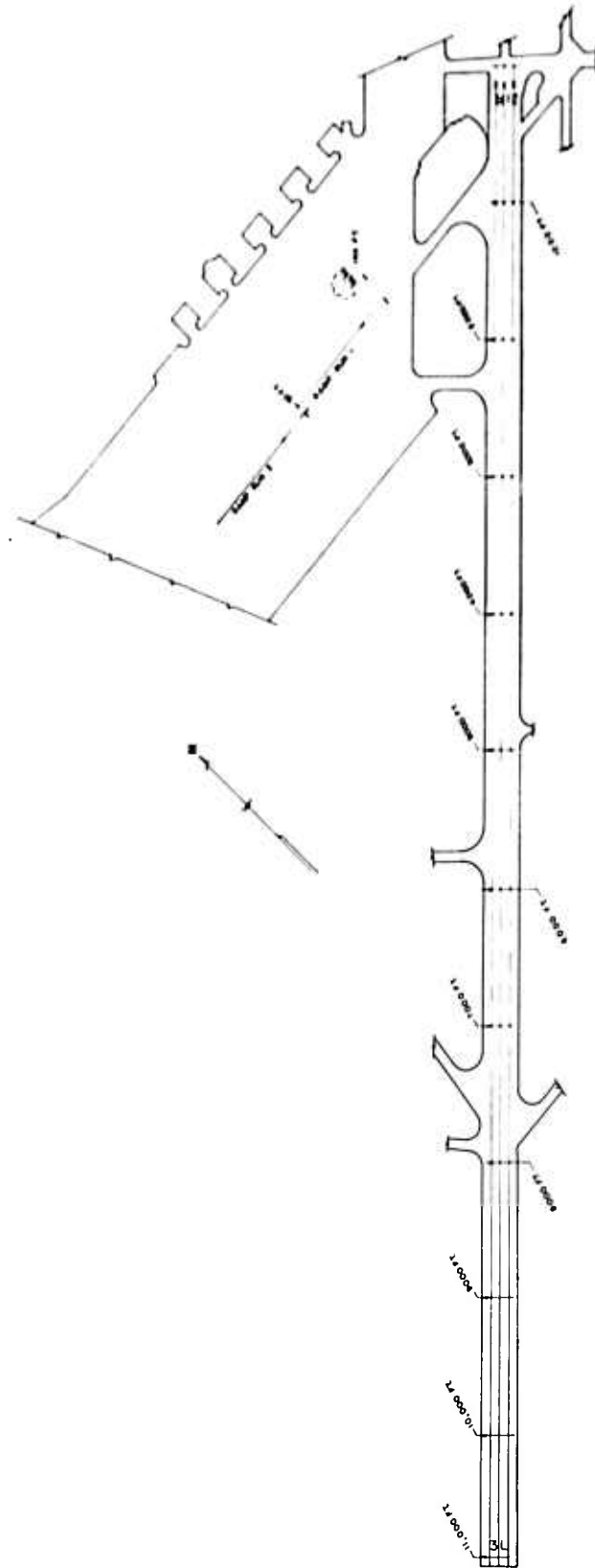


Figure 169 - Location of Lines of Survey, Travis Air Force Base

APPENDIX IV

LISTING OF SURVEY INFORMATION

TABLE 1
ALTUS AIR FORCE BASE
ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R35 75' LH 25'	R35 Center Line 25'	R35 75' RH 25'	T5 25' LH See map	T5 Center Line See map	T5 25' RH See map
Run Location						
Starting Point*						
Cross Run Location						
1,000 ft.	2,412	2,408	2,403	2,010	2,006	2,011
2,000 ft.	4,419	4,415	4,416	4,023	4,017	4,016
3,000 ft.	6,437	6,427	6,428	6,013	6,001	6,008
4,000 ft.	8,444	8,438	8,432	7,979	7,967	7,972
5,000 ft.	10,441	10,440	10,446	9,935	9,925	9,929
6,000 ft.	12,475	12,467	12,463	11,947	11,936	11,939
7,000 ft.	14,471	14,468	14,469	13,959	13,945	13,950
8,000 ft.	16,479	16,476	16,477	15,969	15,952	15,963
9,000 ft.	18,499	18,497	18,495	17,983	17,960	17,974
10,000 ft.	20,516	20,505	20,502	19,993	19,971	19,982
11,000 ft.	22,519	22,511	22,510	21,935	21,907	21,922
12,000 ft.	24,543	24,530	24,531	23,951	23,916	23,934
13,000 ft.	26,926	26,917	26,916	25,560	25,529	25,544
14,000 ft.						
15,000 ft.						

*Distance from threshold lights to start of run.

TABLE 2

ALTUS AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 35	35 End	214	441
	1,000 ft.	144	393
	2,000 ft.	149	390
	3,000 ft.	164	393
	4,000 ft.	148	398
	5,000 ft.	154	390
	6,000 ft.	163	413
	7,000 ft.	167	401
	8,000 ft.	191	421
	9,000 ft.	189	421
	10,000 ft.	176	402
	11,000 ft.	195	411
	12,000 ft.	186	403
	17 End	228	472
Taxiway 5	35 End	56	126
	1,000 ft.	54	114
	2,000 ft.	54	112
	3,000 ft.	57	121
	4,000 ft.	61	121
	5,000 ft.	56	111
	6,000 ft.	52	112
	7,000 ft.	53	115
	8,000 ft.	52	116
	9,000 ft.	52	117
	10,000 ft.	55	112
	11,000 ft.	80	164*
	12,000 ft.	85	177
	17 End	77	164

*Taxi wider from this point.

TABLE 3
BAKALAR AIR FORCE BASE
ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R13	R13	R13	R18	R18	R18	R18	R22	R22	R22
Run Location	50' LH	Center Line	50' RH	50' LH	Center Line	50' RH	50' LH	Center Line	50' RH	50' RH
Starting Point*	39'6"	39'	40'4"	18'	18'	18'10"	27'5"	25'	24'	
Cross Run Location										
1,000 ft.	2,031	2,035	2,030	1,667	1,662	1,655	1,624	1,631	1,633	
2,000 ft.	4,097	4,103	4,092	3,713	3,711	3,707	3,687	3,692	3,686	
3,000 ft.	6,174	6,180	6,176	5,756	5,756	5,753	5,917	5,928	5,926	
4,000 ft.	8,235	8,242	8,229	7,762	7,767	7,759	7,967	7,977	7,960	
5,000 ft.	10,014	10,019	10,006	10,015	10,018	10,007	9,990	10,009	10,003	
6,000 ft.										
7,000 ft.										
8,000 ft.										
9,000 ft.										
10,000 ft.										
11,000 ft.										
12,000 ft.										
13,000 ft.										
14,000 ft.										
15,000 ft.										

*Distance from threshold lights to start of run.

TABLE 3 (Concluded)

BAKALAR AIR FORCE BASE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	T27	T27	T27	T3	T3	T3	T3
Run Location	30' LH	Center Line	30' RH	30' LH	Center Line	30' RH	
Starting Point*	See map	See map	See map	See map	See map	See map	
Cross Run Location							
1,000 ft.	2,404	2,406	2,383	1,998	1,999	1,990	
2,000 ft.	4,823	4,821	4,793	2,991	3,011	3,002	
3,000 ft.	7,223	7,222	7,201				
4,000 ft.	7,941	7,943	7,927				
5,000 ft.							
6,000 ft.							
7,000 ft.							
8,000 ft.							
9,000 ft.							
10,000 ft.							
11,000 ft.							
12,000 ft.							
13,000 ft.							
14,000 ft.							
15,000 ft.							

*Distance from threshold lights to start of run.

TABLE 4

BAKALAR AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 13	13 End	122	257
	1,000 ft.	124	255
	2,000 ft.	119	250
	3,000 ft.	125	259
	4,000 ft.	122	257
	31 End	119	263
Runway 18	18 End	105	254
	1,000 ft.	120	253
	2,000 ft.	116	249
	3,000 ft.	122	252
	4,000 ft.	121	253
	36 End	120	260
Runway 22	22 End	125	258
	1,000 ft.	123	263
	2,000 ft.	124	259
	3,000 ft.	121	258
	4,000 ft.	123	257
	4 End	146	258
Taxiway 27	West End	46	120
	1,000 ft.	63	119
	2,000 ft.	47	104
	3,000 ft.	47	102
	East End	49	106
Taxiway 3	South End	46	106
	1,000 ft.	43	103
	North End	46	106

TABLE 5
CARSWELL AIR FORCE BASE
ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R17 87' LH	R17 37' LH	R17 13' LH	R17 13' RH	R17 37' RH				
Run Location	25'	25'	25'	25'	25'				
Starting Point*									
Cross Run Location									
1,000 ft.	1,966	1,964	1,963	1,965	1,965				
2,000 ft.	3,978	3,979	3,976	3,981	3,980				
3,000 ft.	5,994	5,990	5,988	5,994	5,991				
4,000 ft.	8,010	7,999	8,001	8,009	8,005				
5,000 ft.	10,025	10,010	10,013	10,023	10,018				
6,000 ft.	12,039	12,023	12,024	12,036	12,030				
7,000 ft.	14,051	14,033	14,034	14,049	14,043				
8,000 ft.	16,064	16,044	16,045	16,057	16,055				
9,000 ft.	18,077	18,056	18,055	18,067	18,067				
10,000 ft.	20,095	20,071	20,065	20,078	20,078				
11,000 ft.	22,106	22,081	22,074	22,089	22,092				
12,000 ft.	24,068	24,043	24,037	24,052	24,051				
13,000 ft.									
14,000 ft.									
15,000 ft.									

*Distance from threshold lights to start of run.

TABLE 6

CARSWELL AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Count-12-1/2 IN Side</u>	<u>Final Count</u>
Runway 35	35 End	259	528
	1,000 ft.	268	511
	2,000 ft.	262	470
	3,000 ft.	257	477
	4,000 ft.	259	453
	5,000 ft.	257	442
	6,000 ft.	254	429
	7,000 ft.	248	430
	8,000 ft.	250	441
	9,000 ft.	250	440
	10,000 ft.	251	310
	11,000 ft.	243	425
	7 End	252	435

TABLE 7
CASTLE AIR FORCE BASE
ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R30	R30	R30	T9	T9	T9	T9
Run Location	75' IH	Center Line	75' RH	50' IH	Center Line	50' RH	
Starting Point*	40'	40'	40'	See map	See map	See map	
Cross Run Location							
1,000 ft.	2,761	2,757	2,762	1,914	1,907	1,914	
2,000 ft.	4,749	4,749	4,750	3,914	3,911	3,915	
3,000 ft.	6,761	6,762	6,761	6,025	6,016	6,016	
4,000 ft.	8,775	8,771	8,775	8,126	8,123	8,128	
5,000 ft.	10,783	10,782	10,785	10,141	10,134	10,136	
6,000 ft.	12,792	12,790	12,792	12,283	12,279	12,284	
7,000 ft.	14,814	14,803	14,822	14,685	14,662	14,676	
8,000 ft.	16,818	16,815	16,830				
9,000 ft.	18,833	18,828	18,837				
10,000 ft.	20,836	20,831	20,840				
11,000 ft.	23,636	23,606	23,647				
12,000 ft.							
13,000 ft.							
14,000 ft.							
15,000 ft.							

*Distance from threshold lights to start of run.

TABLE 8

CASTLE AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 30	30 End	145	348
	1,000 ft.	149	355
	2,000 ft.	151	354
	3,000 ft.	151	351
	4,000 ft.	169	359
	5,000 ft.	154	351
	6,000 ft.	152	354
	7,000 ft.	148	358
	8,000 ft.	156	366
	9,000 ft.	163	361
	10,000 ft.	161	353
	12 End	183	405
Taxiway 9	30 End	100	196
	1,000 ft.	92	204
	2,000 ft.	96	200
	3,000 ft.	99	201
	4,000 ft.	94	201
	5,000 ft.	99	201
	6,000 ft.	97	202
	12 End	98	195

TABLE 9
DOBBINS AIR FORCE BASE
ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R10 75' LH 39'9"	R10 Center Line 39'10"	R10 75' RH 39'1"	T10 31' LH See map	T10 Center Line See map	T10 31' RH See map		
Run Location								
Starting Point*								
Cross Run Location								
1,000 ft.	1,980	1,984	1,982	1,562	1,557	1,562		
2,000 ft.	3,992	3,985	3,993	3,568	3,569	3,568		
3,000 ft.	6,001	6,003	6,000	5,574	5,575	5,575		
4,000 ft.	8,012	8,018	8,015	7,584	7,581	7,582		
5,000 ft.	10,022	10,024	10,025	9,583	9,578	9,583		
6,000 ft.	12,032	12,036	12,033	11,600	11,596	11,597		
7,000 ft.	14,045	14,048	14,046	13,498	13,493	13,496		
8,000 ft.	16,053	16,055	16,055	15,618	15,611	15,617		
9,000 ft.	18,064	18,068	18,066	17,625	17,620	17,623		
10,000 ft.	20,062	20,046	20,048	19,235	19,226	19,228		
11,000 ft.								
12,000 ft.								
13,000 ft.								
14,000 ft.								
15,000 ft.								

*Distance from threshold lights to start of run.

TABLE 10

DOBBINS AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 10	10 End	298	608
	1,000 ft.	266	531
	2,000 ft.	266	538
	3,000 ft.	265	535
	4,000 ft.	266	541
	5,000 ft.	267	533
	6,000 ft.	263	530
	7,000 ft.	264	534
	8,000 ft.	264	529
	9,000 ft.	263	531
	28 End	294	592
Taxiway 10	West End	75	128
	1,000 ft.	40	110
	2,000 ft.	50	103
	3,000 ft.	51	109
	4,000 ft.	50	104
	5,000 ft.	49	105
	6,000 ft.	49	106
	7,000 ft.	55	111
	8,000 ft.	49	109
	9,000 ft.	48	104
	East End	61	118

TABLE 11
EDWARDS AIR FORCE BASE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R4	R4	R4	R4	T-West	T-West	T-West	T-West
Run Location	75' LH	Center Line	75' RH	50' LH	Center Line	50' RH	See map	
Starting Point*	50'	50'	50'	See map	See map	See map	See map	
Cross Run Location								
1,000 ft.	1,910	1,905	1,913	2,007	2,008	2,013		
2,000 ft.	3,925	3,924	3,924	4,019	4,017	4,021		
3,000 ft.	5,929	5,927	5,930	6,026	6,025	6,030		
4,000 ft.	7,937	7,938	7,941	8,040	8,036	8,040		
5,000 ft.	9,949	9,947	9,956	10,046	10,045	10,047		
6,000 ft.	11,951	11,958	11,957					
7,000 ft.	13,958	13,962	13,965					
8,000 ft.	15,967	15,969	15,973					
9,000 ft.	17,975	17,977	17,983					
10,000 ft.	19,993	19,983	19,996					
11,000 ft.	21,990	21,991	22,003					
12,000 ft.	23,995	23,997	24,010					
13,000 ft.	26,002	26,003	26,019					
14,000 ft.	28,008	28,009	28,029					
15,000 ft.	30,015	30,020	30,037					

*Distance from threshold lights to start of run.

TABLE 12

EDWARDS AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 4	4 End	246	504
	1,000 ft.	246	507
	2,000 ft.	246	504
	3,000 ft.	249	506
	4,000 ft.	243	503
	5,000 ft.	247	504
	6,000 ft.	241	505
	7,000 ft.	237	494
	8,000 ft.	243	502
	9,000 ft.	243	500
	10,000 ft.	248	505
	11,000 ft.	240	500
	12,000 ft.	250	511
	13,000 ft.	250	503
	14,000 ft.	247	507
	35 End	248	501
West Taxiway	North End	100	202
	1,000 ft.	99	198
	2,000 ft.	99	196
	3,000 ft.	100	198
	4,000 ft.	102	199
	South End	100	201

TABLE 14

ELLISWORTH AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 30	30 End	245	481
	1,000 ft.	245	464
	2,000 ft.	211	464
	3,000 ft.	258	479
	4,000 ft.	235	474
	5,000 ft.	233	468
	6,000 ft.	232	466
	7,000 ft.	241	482
	8,000 ft.	253	500
	9,000 ft.	248	500
	10,000 ft.	237	482
	11,000 ft.	232	475
	12,000 ft.	235	477
	12 End	242	489

TABLE 15

GEORGE AIR FORCE BASE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R16		R16		R3		R3		R3		T		T	
Run Location	Center Line	50' RH	50' LH	Center Line	50' RH	50' LH	Center Line	50' RH	50' LH	Center Line	50' RH	50' LH	Center Line	50' RH
Starting Point*	25'	25'	25'	25'	25'	25'	25'	25'	25'	25'	25'	25'	25'	25'
Cross Run Location														
1,000 ft.	1,970	1,972	1,902	1,904	1,902	1,902	1,904	1,902	1,993	2,000	1,999			
2,000 ft.	3,980	3,972	3,993	3,991	3,993	3,993	3,991	3,993	3,996	4,000	4,002			
3,000 ft.	6,018	6,021	5,766	5,767	5,766	5,767	5,767	5,771	5,995	6,000	5,999			
4,000 ft.	8,048	8,049	7,707	7,698	7,707	7,707	7,698	7,703	7,996	8,001	8,006			
5,000 ft.	10,186	10,188	9,887	9,892	9,887	9,887	9,892	9,895	9,991	10,000	9,999			
6,000 ft.	12,112	12,112	11,942	11,950	11,942	11,942	11,950	11,955	10,630	10,641	10,241			
7,000 ft.	14,150	14,150	13,975	13,978	13,975	13,975	13,978	13,990						
8,000 ft.	16,191	16,193	16,035	16,034	16,035	16,035	16,034	16,050						
9,000 ft.	18,183	18,185	18,280	18,275	18,280	18,280	18,275	18,292						
10,000 ft.	20,134	20,128												
11,000 ft.														
12,000 ft.														
13,000 ft.														
14,000 ft.														
15,000 ft.														

*Distance from threshold lights to start of run.

TABLE 16
GEORGE AIR FORCE BASE
CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 16	16 End	102	202
	1,000 ft.	100	186
	2,000 ft.	100	198
	3,000 ft.	100	190
	4,000 ft.	99	192
	5,000 ft.	97	212
	6,000 ft.	92	202
	7,000 ft.	106	213
	8,000 ft.	115	215
	9,000 ft.	105	215
	34 End	109	226
Runway 3	3 End	131	273
	1,000 ft.	112	241
	2,000 ft.	110	245
	3,000 ft.	112	246
	4,000 ft.	111	249
	5,000 ft.	111	246
	6,000 ft.	112	246
	7,000 ft.	109	244
	8,000 ft.	111	246
	21 End	110	249
Taxiway 5		50	108
	1,000 ft.	49	110
	2,000 ft.	51	108
	3,000 ft.	52	108
	4,000 ft.	51	107
		49	107

TABLE 17
GLASGOW AIR FORCE BASE
ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	RLO	RLO	TLO	TLO	TLO	TLO	TLO
Run Location	75' LH	Center Line	35' LH	Center Line	35' RH		
Starting Point*	40'	40'	See map	See map	See map		
Cross Run Location							
1,000 ft.	2,451	2,457	2,007	2,008	2,010		
2,000 ft.	4,466	4,467	4,018	4,014	4,013		
3,000 ft.	6,467	6,467	6,027	6,022	6,027		
4,000 ft.	8,482	8,501	8,033	8,030	8,035		
5,000 ft.	10,496	10,496	10,041	9,992	10,042		
6,000 ft.	12,496	12,494	12,008	12,047	12,028		
7,000 ft.	14,525	14,517	14,069	14,061	14,061		
8,000 ft.	16,532	16,533	16,078	16,101	16,077		
9,000 ft.	18,521	18,521	18,110	18,114	18,118		
10,000 ft.	20,539	20,539	20,128	20,116	20,129		
11,000 ft.	22,546	22,545	22,142		22,140		
12,000 ft.	24,543	24,543					
13,000 ft.	26,950	26,990					
14,000 ft.							
15,000 ft.							

*Distance from threshold lights to start of run.

TABLE 18

GLASGOW AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 10	10 End	249	392
	1,000 ft.	246	497
	2,000 ft.	251	500
	3,000 ft.	251	499
	4,000 ft.	252	502
	5,000 ft.	234	472
	6,000 ft.	179	363
	7,000 ft.	170	365
	8,000 ft.	166	360
	9,000 ft.	200	380
	10,000 ft.	164	331
	11,000 ft.	167	348
	12,000 ft.	177	368
	28 End	162	342
Taxiway 10	10 End	69	140
	1,000 ft.	61	125
	2,000 ft.	61	126
	3,000 ft.	63	127
	4,000 ft.	69	145
	5,000 ft.	58	122
	6,000 ft.	57	122
	7,000 ft.	57	121
	8,000 ft.	59	122
	9,000 ft.	60	121
	10,000 ft.	60	122
	28 End	62	125

TABLE 19
 LANGLEY AIR FORCE BASE
 ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R7	R7	R7	R35	R35	R35	R35
Run Location	50' LH	Center Line	50' RH	50' LH	Center Line	50' RH	
Starting Point*	19'	18'2"	32'2"	66'	55'10"	59'6"	
Cross Run Location							
1,000 ft.	1,965	1,962	1,965	1,933	1,951	1,962	
2,000 ft.	3,669	3,672	3,658	3,940	3,955	3,954	
3,000 ft.	6,214	6,219	6,207	5,942	5,969	5,953	
4,000 ft.	7,999	8,003	7,994	7,952	7,974	7,964	
5,000 ft.	10,001	10,003	9,987	9,990	10,008	9,993	
6,000 ft.	12,023	12,027	12,021				
7,000 ft.	14,019	14,021	14,010				
8,000 ft.	15,955	15,960	15,950				
9,000 ft.	18,039	18,052	18,035				
10,000 ft.	20,021	20,031	18,988**				
11,000 ft.							
12,000 ft.							
13,000 ft.							
14,000 ft.							
15,000 ft.							

*Distance from threshold lights to start of run.
 **Short run due to construction work.

TABLE 20

LANGLEY AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 7	7 End	106	237
	1,000 ft.	120	241
	2,000 ft.	109	222
	3,000 ft.	111	233
	4,000 ft.	113	239
	5,000 ft.	112	233
	6,000 ft.	108	223
	7,000 ft.	105	221
	8,000 ft.	104	219
	9,000 ft.	113	241
	25 End	111	227
Runway 35	35 End	116	237
	1,000 ft.	106	228
	2,000 ft.	110	234
	3,000 ft.	104	233
	4,000 ft.	109	232
	5,000 ft.	113	233
	17 End	101	225

TABLE 21

LARSON AIR FORCE BASE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R32	R32	T4	T4	T4	T3	T3	T3	T3
Run Location	75' LH	Center Line	75' RH	35' LH	Center Line	35' RH	37' LH	Center Line	37' RH
Starting Point*	40'	40'	40'	See map	See map	See map	See map	See map	See map
Cross Run Location									
1,000 ft.	2,450	2,443	2,451	2,093	2,092	2,093	1,996	1,994	1,995
2,000 ft.	4,472	4,459	4,481	4,098	4,098	4,099	3,989	3,981	3,990
3,000 ft.	6,478	6,469	6,480	6,123	6,126	6,124	5,953	5,974	5,990
4,000 ft.	8,484	8,475	8,483				7,977	7,965	7,973
5,000 ft.	10,497	10,484	10,500				9,970	9,957	9,965
6,000 ft.	12,504	12,485	12,505				11,961	11,950	11,965
7,000 ft.	14,518	14,496	14,529				13,955	13,946	13,962
8,000 ft.	16,543	16,521	16,545						
9,000 ft.	18,560	18,535	18,563						
10,000 ft.	20,570	20,544	20,571						
11,000 ft.	22,572	22,547	22,581						
12,000 ft.	24,594	24,560	24,608						
13,000 ft.	27,033	27,002	27,046						
14,000 ft.									
15,000 ft.									

*Distance from threshold lights to start of run.

TABLE 22

LARSON AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 32	32 End	236	478
	1,000 ft.	255	501
	2,000 ft.	264	505
	3,000 ft.	259	501
	4,000 ft.	245	506
	5,000 ft.	260	503
	6,000 ft.	230	505
	7,000 ft.	231	501
	8,000 ft.	237	499
	9,000 ft.	213	478
	10,000 ft.	215	453
	11,000 ft.	213	447
	12,000 ft.	229	476
	14 End	243	512
Taxiway 4	South End	67	149
	1,000 ft.	64	149
	2,000 ft.	71	148
	North End	71	143
Taxiway 3	South End	74	156
	1,000 ft.	74	149
	2,000 ft.	75	151
	3,000 ft.	75	152
	4,000 ft.	75	151
	5,000 ft.	74	151
	6,000 ft.	75	157
	North End	75	150

TABLE 23

MATHER AIR FORCE BASE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R22L	R22L	R22L	T22	T22	T22	T22
Run Location	Center Line	75' RH	75' LH	Center Line	75' RH	75' RH	
Starting Point*	34'7"	24'4"	See map	See map	See map	See map	
Cross Run Location							
1,000 ft.	2,249	2,265	2,003	2,007	2,012	2,012	
2,000 ft.	4,252	4,291	4,011	4,018	4,013	4,013	
3,000 ft.	6,275	6,291	6,019	6,024	6,030	6,030	
4,000 ft.	8,287	8,302	8,054	8,035	8,041	8,041	
5,000 ft.	10,298	10,306	10,040	10,043	10,050	10,050	
6,000 ft.	12,308	12,336	12,042	12,052	12,060	12,060	
7,000 ft.	14,315	14,323	14,049	14,059	14,063	14,063	
8,000 ft.	16,318	16,325	16,059	16,070	16,072	16,072	
9,000 ft.	18,331	18,333	18,066	18,078	18,077	18,077	
10,000 ft.	20,339	20,347	19,480	19,486	19,490	19,490	
11,000 ft.	22,634	22,641					
12,000 ft.							
13,000 ft.							
14,000 ft.							
15,000 ft.							

*Distance from threshold lights to start of run.

TABLE 24

MATHER AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 22L	22L End	248	505
	1,000 ft.	254	491
	2,000 ft.	177	484
	3,000 ft.	233	445
	4,000 ft.	252	490
	5,000 ft.	248	509
	6,000 ft.	233	463
	7,000 ft.	233	421
	8,000 ft.	221	471
	9,000 ft.	238	460
	10,000 ft.	232	476
	4R End	237	461
Taxiway 22	22 End	148	305
	1,000 ft.	153	310
	2,000 ft.	148	303
	3,000 ft.	149	304
	4,000 ft.	153	310
	5,000 ft.	144	300
	6,000 ft.	147	301
	7,000 ft.	147	302
	8,000 ft.	144	300
	9,000 ft.	145	301
	4 End	145	303

TABLE 25
McGUIRE AIR FORCE BASE
ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R12 75' IH 40'	R12 Center Line 42'5"	R12 75' RH 43'5"	T5 31' IH See Map	T5 Center Line See Map	T5 31' RH See Map		
Run Location								
Starting Point*								
Cross Run Location								
1,000 ft.	2,885	2,880	2,881	1,405	1,396	1,409		
2,000 ft.	4,497	4,491	4,503	3,426	3,422	3,430		
3,000 ft.	6,561	6,542	6,562	5,441	5,429	5,436		
4,000 ft.	8,629	8,617	8,631	7,433	7,426	7,435		
5,000 ft.	10,699	10,683	10,695	9,434	9,429	9,439		
6,000 ft.	12,748	12,731	12,749	11,450	11,448	11,458		
7,000 ft.	14,941	15,054	14,930	12,757	12,754	12,761		
8,000 ft.								
9,000 ft.								
10,000 ft.								
11,000 ft.								
12,000 ft.								
13,000 ft.								
14,000 ft.								
15,000 ft.								

*Distance from threshold lights to start of run.

TABLE 26

McGUIRE AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 12	12 End	109	223
	1,000 ft.	140	288
	2,000 ft.	140	287
	3,000 ft.	141	288
	4,000 ft.	128	277
	5,000 ft.	139	283
	6,000 ft.	137	287
	30 End	131	287
Taxiway 5	24 End	48	105
	1,000 ft.	48	113
	2,000 ft.	50	112
	3,000 ft.	49	114
	4,000 ft.	49	115
	5,000 ft.	50	121
	6,000 ft.	49	116
	6 End	48	114

TABLE 27

USAF PLANT NO. 42
FAIRDALE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R7	R7	R7	T-B (2)	T-B (2)	T-B (2)	T-B (2)	T-N (14)	T-N
Run Location	50' LH	Center Line	50' RH	35' LH	Center Line	35' RH	Center Line	Center Line	T-N
Starting Point*	25'	25'	25'	See map	See map	See map	See map	See map	
Cross Run Location									
1,000 ft.	1,961	1,965	1,964	2,000	2,000	2,007	2,000		
2,000 ft.	3,969	3,976	3,982	4,001	4,001	4,000	4,002		
3,000 ft.	5,959	5,968	5,967	6,002	6,001	6,000			
4,000 ft.	7,976	7,974	7,980	8,002	8,001	8,003			
5,000 ft.	9,989	9,988	9,988	10,005	10,000	10,000			
6,000 ft.	11,990	11,997	12,004	12,005	12,001	12,001			
7,000 ft.	14,008	14,007	14,006	14,000	14,000	14,000			
8,000 ft.	16,016	16,016	16,018	16,009	16,000	16,001			
9,000 ft.	18,034	18,038	18,042	18,008	18,005	18,006			
10,000 ft.	20,034	20,034	20,035	20,000	20,000	19,998			
11,000 ft.	22,046	22,044	22,045	22,001	22,001	22,003			
12,000 ft.	24,024	24,022	24,027	23,357	23,347	23,365			
13,000 ft.									
14,000 ft.									
15,000 ft.									

*Distance from threshold lights to start of r.c.

TABLE 28

USAF PLANT NO. 42

FAIRDALE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 7	7 End	199	350
	1,000 ft.	155	310
	2,000 ft.	155	331
	3,000 ft.	155	340
	4,000 ft.	154	343
	5,000 ft.	153	329
	6,000 ft.	147	321
	7,000 ft.	154	324
	8,000 ft.	148	321
	9,000 ft.	152	317
	10,000 ft.	153	339
	11,000 ft.	140	322
	25 End	175	370
Taxiway B(7)	25 End	74	197
	1,000 ft.	65	139
	2,000 ft.	71	146
	3,000 ft.	75	145
	4,000 ft.	73	146
	5,000 ft.	74	145
	6,000 ft.	71	145
	7,000 ft.	72	146
	8,000 ft.	72	145
	9,000 ft.	72	145
	10,000 ft.	71	145
	11,000 ft.	73	145
	7 End	74	147
Taxiway N(14)	7 - 25 End	75	173
	1,000 ft.	76	170
	Site 3 End	75	148

TABLE 29

SEWART AIR FORCE BASE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R14	R14	R14	R18	R18	R18	R18	R18	T2	T2	T2
Run Location	75' IH	Center Line	75' RH	75' IH	Center Line	75' RH	75' IH	Center Line	T2	Center Line	T2
Starting Point*	45' 4"	37' 3"	47' 8"	23'	24' 4"	24'	35' IH	See map	See map	See map	35' RH
Cross Run Location											
1,000 ft.	2,004	2,012	1,999	1,970	1,963	1,968	2,001	2,010	2,003		
2,000 ft.	4,025	4,022	4,018	3,983	3,976	3,987	4,008	4,021	4,009		
3,000 ft.	6,012	6,006	6,002	6,000	5,989	5,998	6,015	6,032	6,026		
4,000 ft.	7,855	7,851	7,844	8,004	7,994	8,014	8,022	8,039	8,026		
5,000 ft.	10,036	9,982	10,005	10,019	10,011	10,017					
6,000 ft.	11,629	11,591	11,622								
7,000 ft.	13,641	13,607	13,653								
8,000 ft.	15,873	15,831	15,855								
9,000 ft.											
10,000 ft.											
11,000 ft.											
12,000 ft.											
13,000 ft.											
14,000 ft.											
15,000 ft.											

*Distance from threshold lights to start of run.

TABLE 30

SEWART AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 14	14 End	217	438
	1,000 ft.	195	404
	2,000 ft.	200	405
	3,000 ft.	226	451
	4,000 ft.	220	446
	5,000 ft.	253	499
	6,000 ft.	238	485
	7,000 ft.	257	507
	32 End	282	515
Runway 18	18 End	265	539
	1,000 ft.	266	529
	2,000 ft.	266	537
	3,000 ft.	267	530
	4,000 ft.	264	530
	5,000 ft.	263	532
	36 End	266	431
Taxiway 2	North End	72	150
	1,000 ft.	72	147
	2,000 ft.	73	153
	3,000 ft.	66	151
	South End	68	150

TABLE 31

SHAW AIR FORCE BASE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R4	R4	R4	T	T	T	T
Run Location	50' LH	Center Line	50' RH	35' LH	Center Line	35' RH	
Starting Point*	26' 11"	24'	23' 8"	See map	See map	See map	
Cross Run Location							
1,000 ft.	1,988	1,995	1,991	1,997	2,004	2,014	
2,000 ft.	3,999	4,002	3,998	4,001	4,012	4,021	
3,000 ft.	5,992	5,983	5,999	5,703	5,716	5,735	
4,000 ft.	7,940	7,925	7,940				
5,000 ft.	10,010	10,001	10,018				
6,000 ft.	12,021	12,013	12,030				
7,000 ft.	14,033	14,019	14,037				
8,000 ft.	16,044	16,034	16,054				
9,000 ft.	18,045	18,030	18,045				
10,000 ft.	20,054	20,044	20,055				
11,000 ft.							
12,000 ft.							
13,000 ft.							
14,000 ft.							
15,000 ft.							

*Distance from threshold lights to start of run.

TABLE 32

SHAW AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 4	4 End	131	241
	1,000 ft.	106	211
	2,000 ft.	111	214
	3,000 ft.	107	211
	4,000 ft.	109	218
	5,000 ft.	105	215
	6,000 ft.	102	211
	7,000 ft.	106	230
	8,000 ft.	108	212
	9,000 ft.	103	211
	22 End	112	214
Taxiway	South End	75	147
	1,000 ft.	74	143
	2,000 ft.	75	149
	North End	77	146

TABLE 33

TRAVIS AIR FORCE BASE

ODOMETER COUNT AT CROSS RUN LOCATIONS

Surface Designation	R2LR 75' LH 40'	R2LR Center Line 40'	R2LR 75' RH 40'						
Run Location									
Starting Point*									
Cross Run Location									
1,000 ft.	2,001	2,001	2,001						
2,000 ft.	4,004	4,004	4,004						
3,000 ft.	6,005	6,003	6,003						
4,000 ft.	8,007	8,007	8,007						
5,000 ft.	10,023	10,019	10,024						
6,000 ft.	12,031	12,020	12,031						
7,000 ft.	14,036	14,034	14,034						
8,000 ft.	16,053	16,052	16,052						
9,000 ft.	18,058	18,053	18,053						
10,000 ft.	20,082	20,062	20,063						
11,000 ft.	22,060	22,040	22,042						
12,000 ft.									
13,000 ft.									
14,000 ft.									
15,000 ft.									

*Distance from threshold lights to start of run.

TABLE 34

TRAVIS AIR FORCE BASE

CROSS RUN INFORMATION

	<u>Run Location</u>	<u>Center Line Count</u>	<u>Final Count</u>
Runway 21R	21R End	233	491
	1,000 ft.	243	484
	2,000 ft.	247	501
	3,000 ft.	226	464
	4,000 ft.	238	470
	5,000 ft.	209	450
	6,000 ft.	218	465
	7,000 ft.	212	452
	8,000 ft.	198	435
	9,000 ft.	207	442
	10,000 ft.	222	449
	3L End	215	438

APPENDIX V

POWER SPECTRAL DENSITY CALCULATIONS

The power spectral density (PSD) characteristics of the runways have been calculated in the usual manner as the Fourier transform of the autocovariance functions. This procedure is described in the literature and, therefore, will only be outlined here.

$$y'_n = y_{n+1} - y_n \quad (1)$$

$$y'(x) = y(x) - y(x-\Delta x) \quad (2)$$

This operation of "prewhitening" is equivalent to multiplying the power spectrum by the function

$$F(h\Delta\Omega) = 1 - e^{-j(h\Delta\Omega)\Delta x} \quad (3)$$

$$F(\Omega) = 1 - e^{-j\Omega\Delta x} \quad (4)$$

Next, the mean lagged products R_p were determined:

$$R_p = \frac{1}{n-p} \sum_{q=1}^{n-p} y'_q y'_{q+p} - \frac{1}{(n-p)^2} \sum_{q=1}^{n-p} y'_q \sum_{q=1}^{n-p} y'_{q+p} \quad (5)$$

$$\begin{aligned} R(p+\Delta x) &= \frac{1}{(n-p)\Delta x} \int_0^{(n-p)\Delta x} y'(x) y'(x+p\Delta x) dx \\ &- \frac{1}{(n-p)^2 \Delta x^2} \int_0^{(n-p)\Delta x} y'(x) dx \int_0^{(n-p)\Delta x} y'(x+p\Delta x) dx \end{aligned} \quad (6)$$

This function $R(p+\Delta x)$ or R_p is also known as the autocovariance function. The number n is equal to the total number of values y'_q . R_p has been calculated for all values of p ranging from zero to m where m is determined by:

$$m = \frac{n}{30.75} \quad (7)$$

Next the "raw" estimates of the PSD have been formed.

$$L_h = \frac{2\Delta x}{\pi} \sum_{p=0}^m \epsilon_p R_p \cos \frac{h p \pi}{m} \begin{cases} h = (0, 1, 2, \dots, m) \\ \epsilon_p = 1 ; 0 < p < m \\ \epsilon_p = 1/2 ; p = 0 \text{ or } m \end{cases} \quad (8)$$

$$L(h\Delta\Omega) = \frac{2}{\pi} \int_0^{\pi} R(p) \cos(h\Delta\Omega p) dp \quad (9)$$

The next operation is to form the "smoothed" estimates of the PSD.

$$\Phi_h = \frac{1}{2} L_0 + \frac{1}{2} L_1, \quad h = 0 \quad (10)$$

$$\Phi_h = \frac{1}{4} L_{h-1} + \frac{1}{2} L_h + \frac{1}{4} L_{h+1}, \quad 1 \leq h \leq m-1 \quad (11)$$

$$\Phi_h = \frac{1}{2} L_{m-1} + \frac{1}{2} L_m, \quad h = m \quad (12)$$

$$\Phi(h\Delta\Omega) = \frac{1}{4} L[(h-1)\Delta\Omega] + \frac{1}{2} L(h\Delta\Omega) + \frac{1}{4} L[(h+1)\Delta\Omega] \quad (13)$$

The last operation is to remove the effects of the "prewhitening" operation by dividing:

$$\Phi_h \text{ by } |F(h\Delta\Omega)|^2 = 2(1 - \cos h\Delta\Omega\Delta x) \quad (14)$$

$$\Phi(h\Delta\Omega) \text{ by } |F(\Omega)|^2 = 2(1 - \cos \Omega\Delta x) \quad (15)$$

Aeronautical Systems Division, AF Flight
Dynamics Lab, Wright-Patterson AFB, Ohio.

Rep No. WADD-TR-60-410, 1-111, AIR MAIL
RUNWAY PROFILE MEASURING INSTRUMENTATION AND
RUNWAY PROPERTIES: Part III - Data Summary
Final Report, Jul 63. 24p. 11 refs. 11 illus.,
tables, 5 refs.

Uninsured

The profiles of the runways and taxiways of
17 Air Force bases collected at runway ends
all sections of the runways and taxiways
were measured using special measuring equipment.

(over)

surveying instrument. The Aeronautical
Systems Division requires this data for
all types of surfaces in the development
a landing gear design criterion for all
flight vehicles. Profiles of runways and
results of a statistical analysis of the data
are appended.

Aeronautical Systems Division, AF Flight
Dynamics Lab, Wright-Patterson AFB, Ohio.

Rep No. WADD-TR-60-410, 1-111, AIR MAIL
RUNWAY PROFILE MEASURING INSTRUMENTATION AND
RUNWAY PROPERTIES: Part III - Data Summary
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Aeronautical Systems Division, AF Flight
Dynamics Lab, Wright-Patterson AFB, Ohio.

Ref No. WADD-TR-50-470, Part III, AIRWAY
RUNWAY PROFILE MEASURING INSTRUMENTATION AND
RUNWAY PROPERTIES: Part III - Runway
Final Report, Jul 63. 111 p. Includes
tables, 3 refs.

Unpublished.

The profiles of the runway and taxiway
at Air Force bases were measured using
all sections of the instrumented Chevrolet
were measured using special air photo

(over)

surveying instrumentation. The Aeronautical
Systems Division required this special
all types of surfaces in the development
a landing gear design criteria for
flight vehicles. Profiles of runway
surveys of a standard runway are
are appended.

Aeronautical Systems Division, AF Flight
Dynamics Lab, Wright-Patterson AFB, Ohio.

Ref No. WADD-TR-50-470, Part III, AIRWAY
RUNWAY PROFILE MEASURING INSTRUMENTATION AND
RUNWAY PROPERTIES: Part III - Runway
Final Report, Jul 63. 111 p. Includes
tables, 3 refs.

Unpublished.

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at Air Force bases were measured using
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(over)

surveying instrumentation. The Aeronautical
Systems Division required this special
all types of surfaces in the development
a landing gear design criteria for
flight vehicles. Profiles of runway
surveys of a standard runway are
are appended.

Aeronautical Systems Division, AF Flight
Dynamics Lab., Wright-Patterson AFB, Ohio.

Ref No. WADD-TR-60-110, P. 111, AERONAUTICAL
SYSTEMS DIVISION, WRIGHT-PATTERSON AFB, OHIO.
RUNWAY PROFILES MEASURING INSTRUMENTATION AND
DATA ANALYSIS: Part III - Data Summary.
Final Report, Jul 63. 21p. Incl. 11 illus.,
tables, 3 refs.

On Profile

The profiles of the runways at Wright-Patterson
AFB, Ohio, were measured using a special method.
all sections of the runway. The profiles
were measured using a special method.

(over)

Surveying instrumentation. The Aeronautical
Systems Division requires that all
all types of surfaces in the area of the
a landing gear design. The profiles of the
flight vehicles. Profiles of the
surveys of a statistical analysis of the
are appended.

Aeronautical Systems Division, AF Flight
Dynamics Lab., Wright-Patterson AFB, Ohio.

Ref No. WADD-TR-60-110, P. 111, AERONAUTICAL
SYSTEMS DIVISION, WRIGHT-PATTERSON AFB, OHIO.
RUNWAY PROFILES MEASURING INSTRUMENTATION AND
DATA ANALYSIS: Part III - Data Summary.
Final Report, Jul 63. 21p. Incl. 11 illus.,
tables, 3 refs.

On Profile

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(over)

Surveying instrumentation. The Aeronautical
Systems Division requires that all
all types of surfaces in the area of the
a landing gear design. The profiles of the
flight vehicles. Profiles of the
surveys of a statistical analysis of the
are appended.

Chemical Co., 1111 E. 11th St., Toledo, Ohio.

Jul 23.

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