UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Audio-magnetotelluric Sounding and Telluric Traverse Data Release for the Farlin Creek Wilderness Study Area, Beaverhead County, Montana

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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Introduction

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and subsequent related legislation, the U.S. Geological Survey (USGS) and the U.S. Bureau of Mines (USBM) have been conducting mineral surveys of wilderness and primitive areas, and other public lands being considered for wilderness designation. This report presents the audio-magnetotelluric (AMT) sounding data and telluric traverse (TT) data obtained in and near the Farlin Creek, Montana (MT-076-034) BLM wilderness study area. The data are presented with little interpretation to effect timely release of the data.

The Audio-magnetotelluric Method

Magnetotellurics (MT) is an electromagnetic sounding method in which variations in earth resistivity as a function of depth are measured (Keller and Frischknecht, 1966). These soundings are obtained by measuring the earth's surface electromagnetic fields at different frequencies. Because lower frequencies penetrate further into the earth before they are absorbed relative to higher frequencies, measurement of the electromagnetic fields over a broad frequency range gives information on resistivity variations with depth. If these measurements are made in the audio-frequency range then the technique is called audio-magnetotellurics (AMT). This method is discussed in detail by Strangway and others (1973) and application and details of the USGS AMT system are given by Hoover and others (1976, 1978) and Hoover and Long (1976).

The depth of exploration of AMT methods is not only a function of frequency, but also of the resistivity of the volume of earth sampled. For a homogeneous earth the maximum depth of exploration can be approximated by a relationship given by Bostick (1977):

$$D = 355\sqrt{\rho/f} \text{ meters}$$

where ρ is the half-space resistivity in ohm-m, and f is the frequency.

As in any sounding technique, it should be remembered that the earth is being sampled laterally as well as vertically below the measuring station. Thus, in areas of complex geology, simple one-dimensional model interpretations give, at best, only a crude average approximation of the vertical distribution of resistivity beneath the sounding site.

Signal sources of AMT may be either artificial or natural. The USGS equipment used in this survey has been designed for use with natural sources. The principal source of natural electromagnetic energy in the audio-frequencies is electrical discharge during lightning storms. Typically, signal strength is low except when generated by local storms, and data quality may be poor, especially in parts of the frequency spectrum where energy is more strongly attenuated (approximately 1 to 4 KHz). The limitations of natural source AMT exploration are discussed more fully by Hoover and others (1978).

The AMT soundings presented here used 25 m telluric dipoles except for soundings 63 and 69 which were made on the two telluric lines, and used the 250 m dipoles deployed on the line. The AMT and telluric systems used in this study are of USGS manufacture.

The Telluric Traverse Method

The telluric traverse (TT) method employs natural earth currents (telluric currents) at various frequencies to measure, indirectly, changes in earth resistivity along a traverse. It was used as early as 1921 (Leonardon, 1928) by C. Schlumberger, but until recently has been little used in the United States. Beyer (1977) discusses the method in some detail and presents a series of model results computed for two-dimensional structures. He concludes that the method is well suited for rapid reconnaissance of regions several hundred square-kilometers in area searching for targets such as hydrothermal systems. The method should be applicable as well to fossil hydrothermal systems, and related mineral deposits, because rock alteration will remain long after the hydrothermal convection cells have ceased.

In applying the technique a receiving array of three electrodes spaced equidistant and in-line is used. This array is, in effect, two colinear dipoles sharing a common electrode. The difference of electric potential across each dipole generated by telluric currents is then proportional to the component of the telluric electric field in the direction of the array. This configuration permits the measurement of the ratio of the telluric field at each dipole in the direction of the dipole line. The traverse data is extended by moving the three-electrode array forward one dipole length so that the forward electrode becomes the center electrode for the next ratio measurement. This process is repeated for as long as desired.

Telluric measurements are made in a narrow frequency band typically using micropulsations near 30 second periods (0.033 Hz), but may be made over a wide range of frequencies. Low frequency electromagnetic signals penetrate to greater depths than high frequencies, thus, a survey may be designed, within limits, to maximize the telluric response for each geologic environment. The relationship for maximum exploration depth is the same as for AMT work. Frequencies selected for this telluric work were 4.5, 7.5, 16.7 and 25 Hz. With resistivities generally over 1000 ohm-m in the survey area the maximum depth of exploration was in the range of 2-5 km.

Dipoles of 250 m were used on all traverses, one tenth or less of the maximum exploration depth. Short spacial wavelength anomalies seen on the traverse data imply shallow electrical features, or features whose top is nearer to the surface, exactly analogous to other potential field data. The close correlation seen between the curves at each frequency is typical of telluric data measured over a short frequency span and results from the measurements averaging the earth resistivity from the surface to the maximum depth of exploration. For electromagnetic fields in a non-layered earth the electric field at a point varies with the direction of measurement as does the resistivity. They are tensor quantities. The horizontal electric field variations rather than the magnetic field, in general, reflect the variations in earth resistivity. For two-dimensional structures it can be shown (Beyer, 1977) that the electric field measured normal to strike (the transverse magnetic TM mode) is proportional to the square root of the TM mode resistivity variation measured with the electric field normal to strike and the magnetic field parallel to strike. Because of this, telluric traverses are typically run normal to the expected regional trends in a survey area. The traverses are made in a straight line because of the tensor nature of the electric field.

Telluric traverse data are presented as curves of relative telluric voltage. A value of unity is arbitrarily assigned to one dipole on the traverse and, the value of all other dipoles are computed relative to it for each frequency. Without other information curves at different frequencies cannot be referenced to one another in an absolute sense. The curves presented in this report have been nested with an arbitrary shift between the initial values. The relative voltage is plotted on a logarithmic scale.

AMT and Telluric Data

Figure 1 shows the location of 12 AMT soundings and two telluric traverses made in the vicinity of the Farlin Creek Wilderness Study Area. All AMT sounding curves are shown in appendix 1 and tabulated values for the AMT soundings are given in appendix 2. Figure 2 shows the telluric data obtained on line 1 and figure 3 shows the results of TT line 2. Tabulated telluric data is given in appendix 3.

The west ends of both telluric lines show abrupt and large decreases in voltage which are related to a range-front fault which downdrops Polaris Valley on the west.

References

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Bostick, F. X., Jr., 1977, A simple and almost exact method of MT analysis: Geothermal Workshop Report, University of Utah, USGS contract 14-08-0001-6-359, p. 175-177.

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Keller, G. V., and Frischknecht, F. C., 1966, Electrical methods in geophysical prospecting: New York Pergamon Press, p. 197-250.

Leonardon, E. G., 1928, Source observations upon telluric currents and their applications to electrical prospecting: Terr. Mag., v. 33, p. 91-94.

Strangway, D. W., Swift, C. M., Jr., and Holmer, R. C., 1973, The application of audio-frequency magnetotelluric (AMT) to mineral exploration: Geophysics, v. 38, p. 1159-1175.

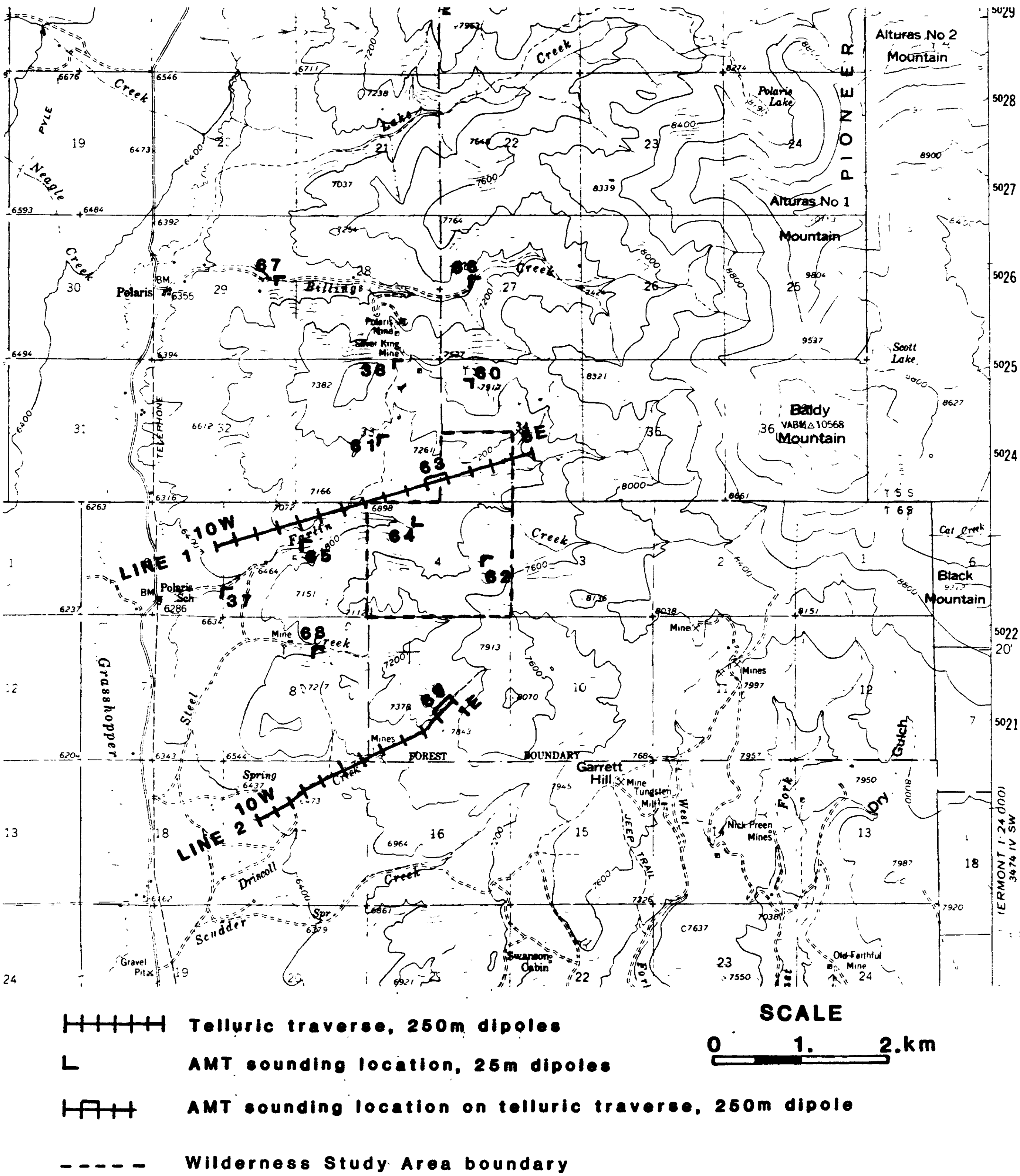


Figure 1. Audio-magnetotelluric sounding and telluric traverse location map Farlin Creek Area, Beaverhead County, Montana. Map base is part of the Polaris, Montana 15 minute quadrangle.

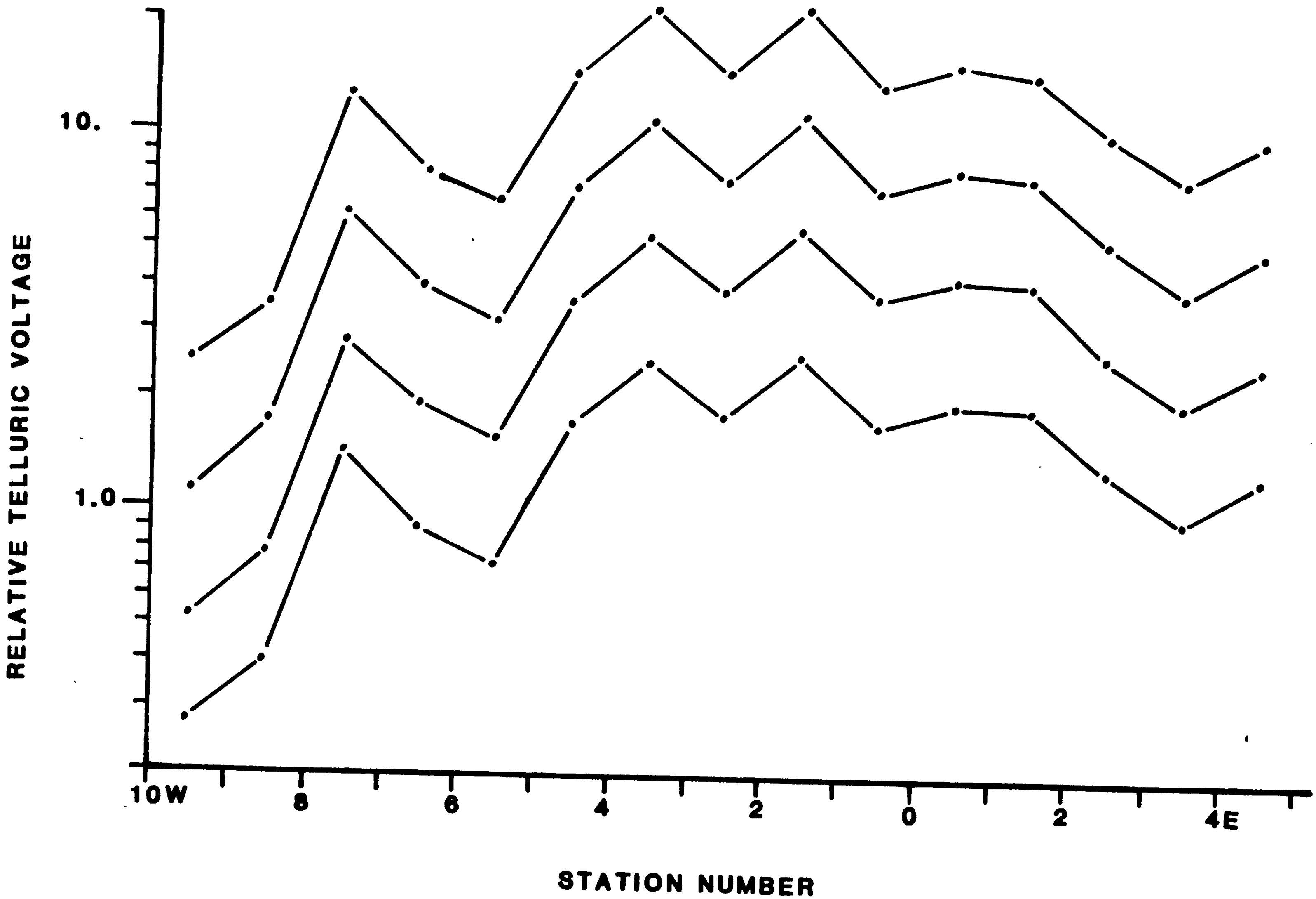


Figure 2. Telluric traverse data for line 1 Farlin Creek Area, Beaverhead County, Montana. Dipole length is 250 m. Curves at each frequency are plotted with an arbitrary shift between initial values.

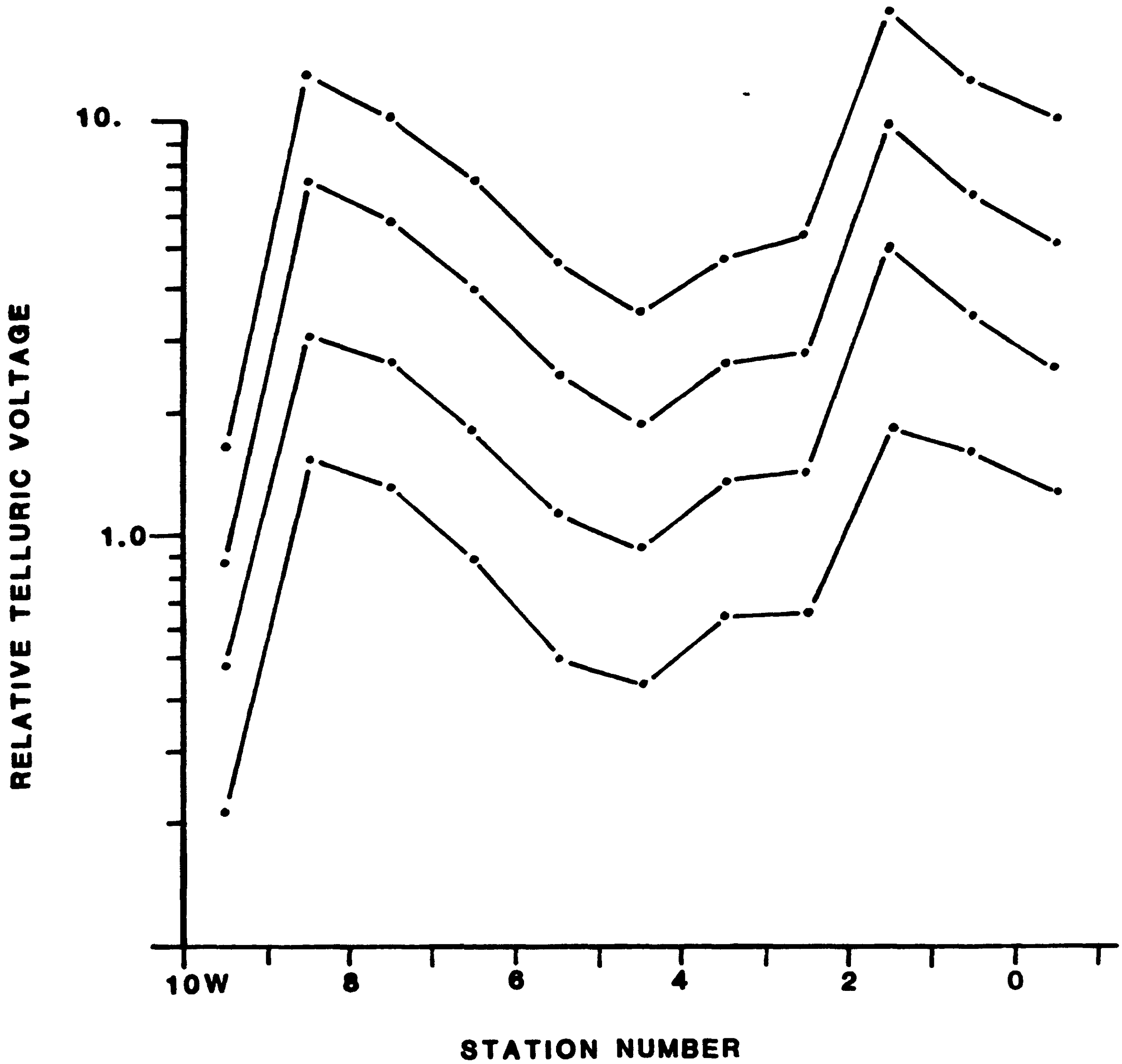
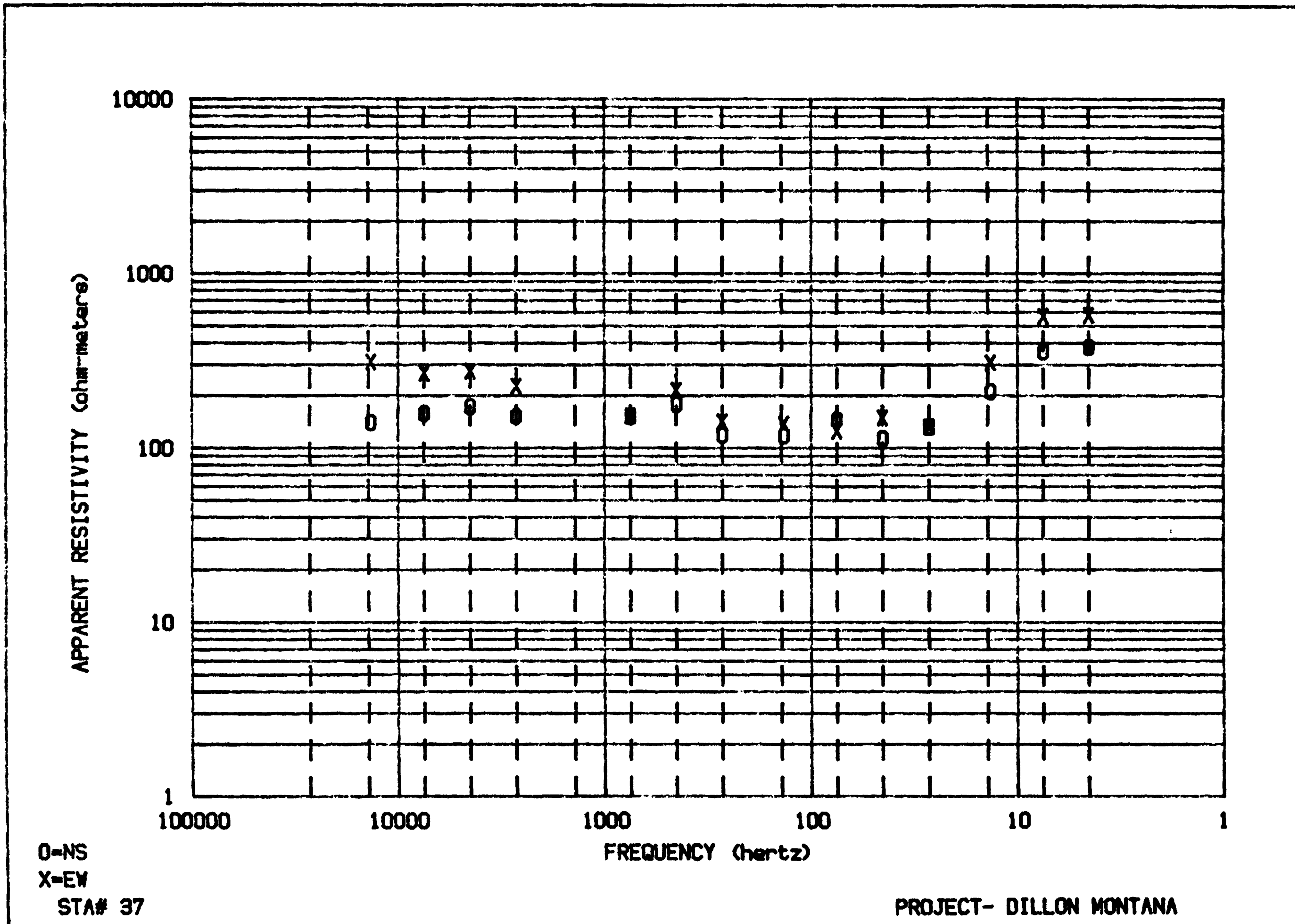


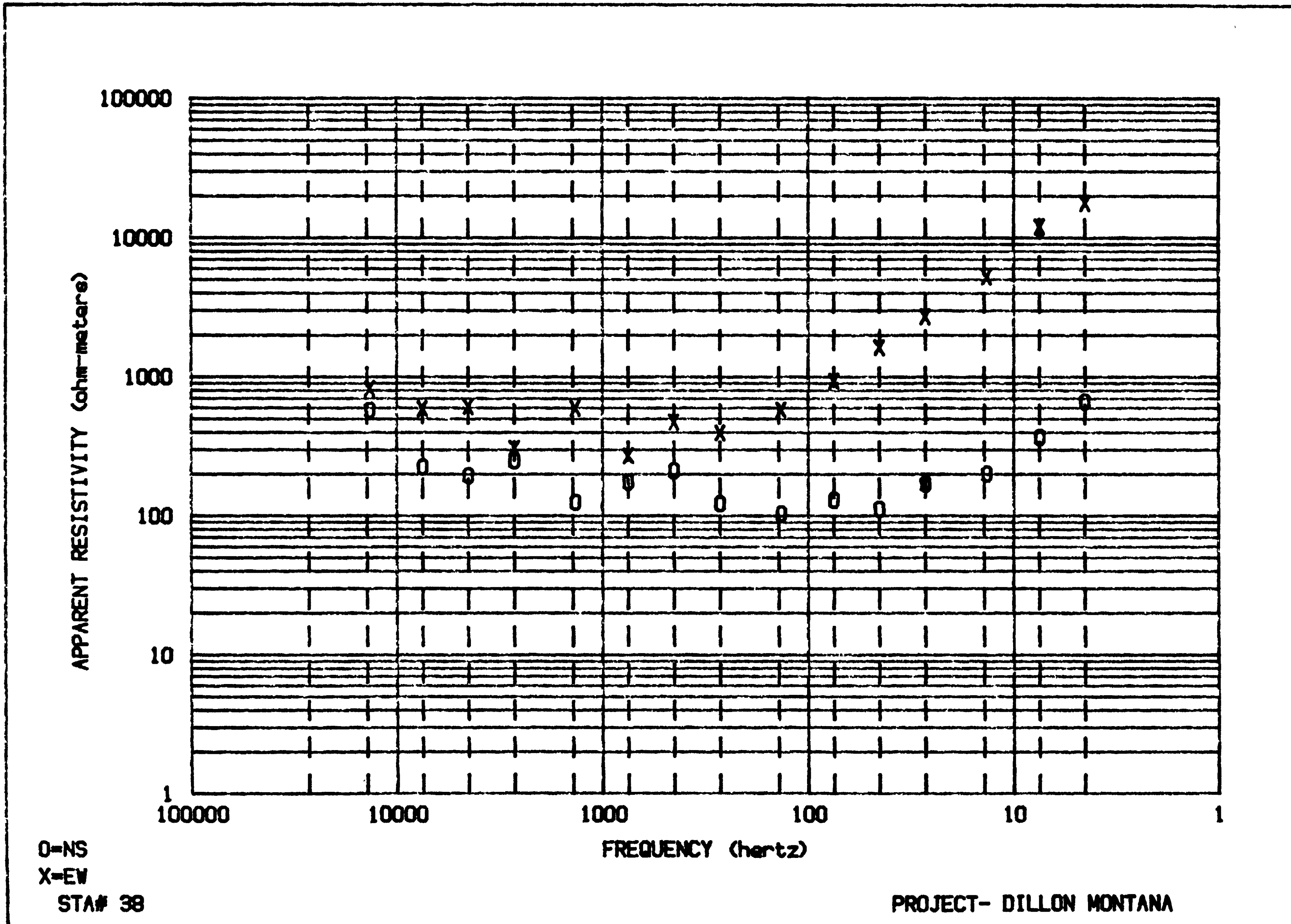
Figure 3. Telluric traverse data for line 2 Farlin Creek Area, Beaverhead County, Montana. Dipole length is 250 m. Curves at each frequency are plotted with an arbitrary shift between initial values.

Appendix 1

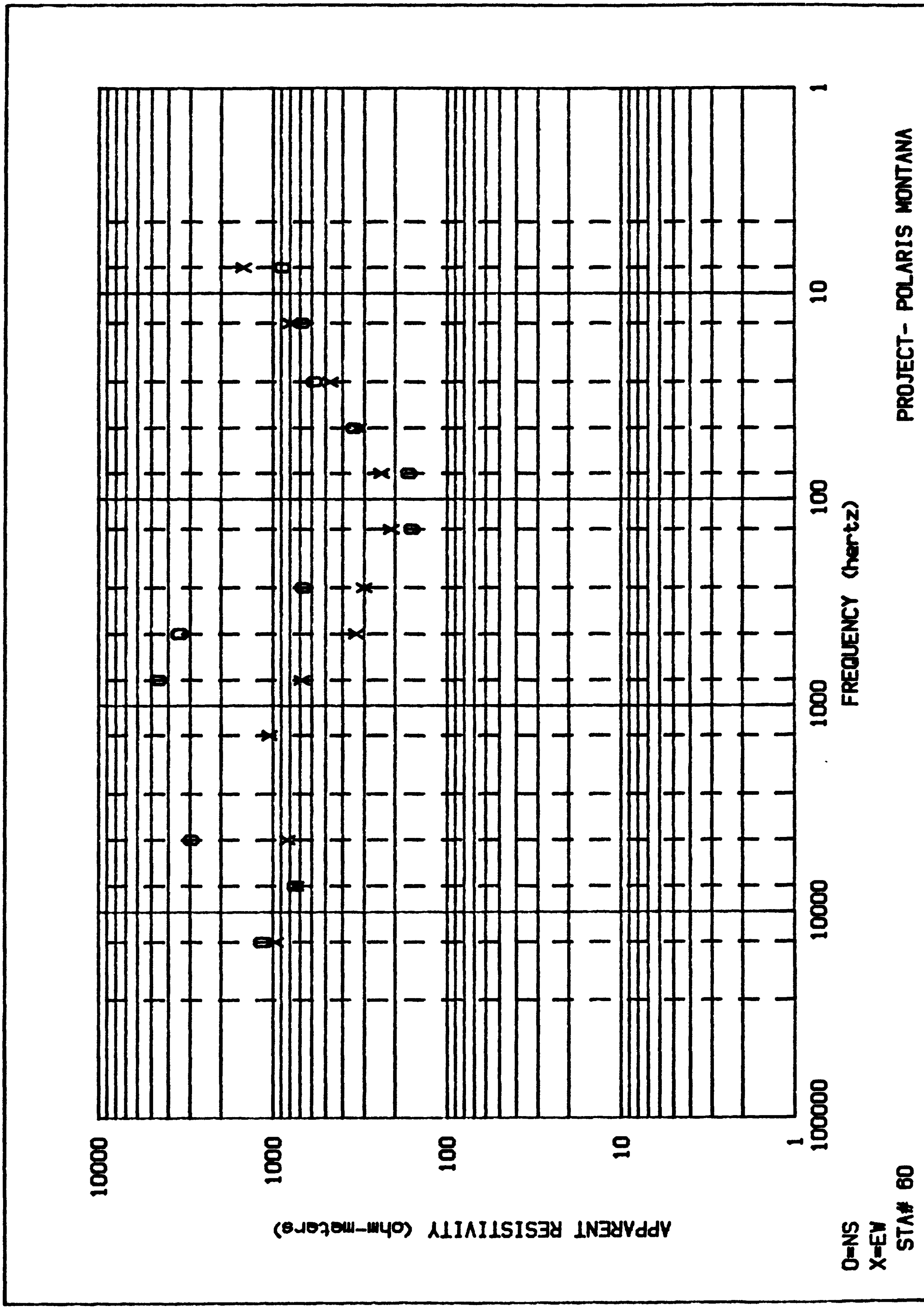
Plots of AMT sounding data. Each plot shows apparent resistivity versus frequency for the two scalar soundings at each location. The O (NS) is for a north-south orientation of the telluric dipole and an X is for an east-west orientation. Note that frequency decreases to the right side of the figure corresponding to increasing depth.

Soundings 63 and 69 were made on the telluric line using 250 meter dipoles.

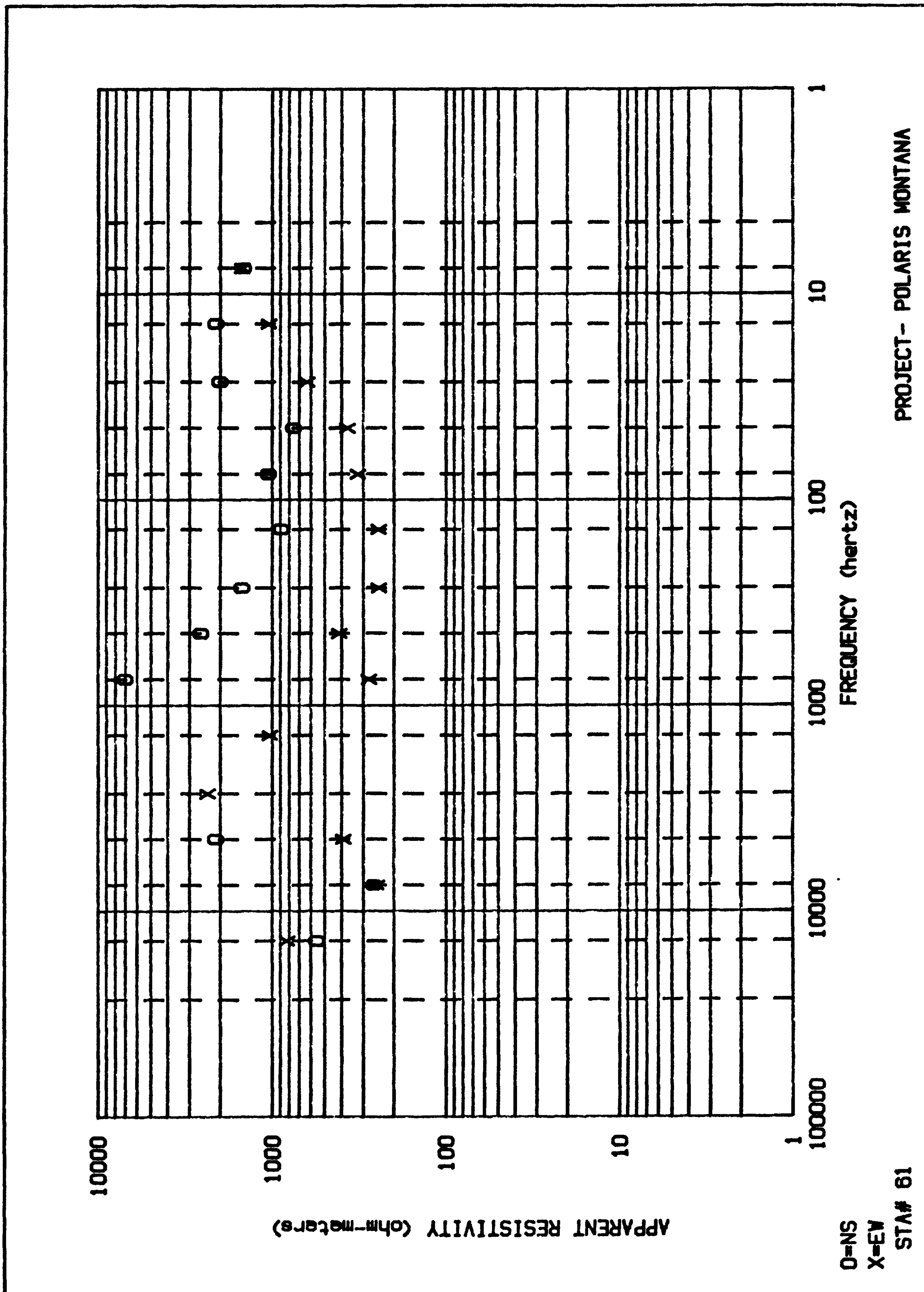

10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# 37
PROJECT- DILLON MONTANA

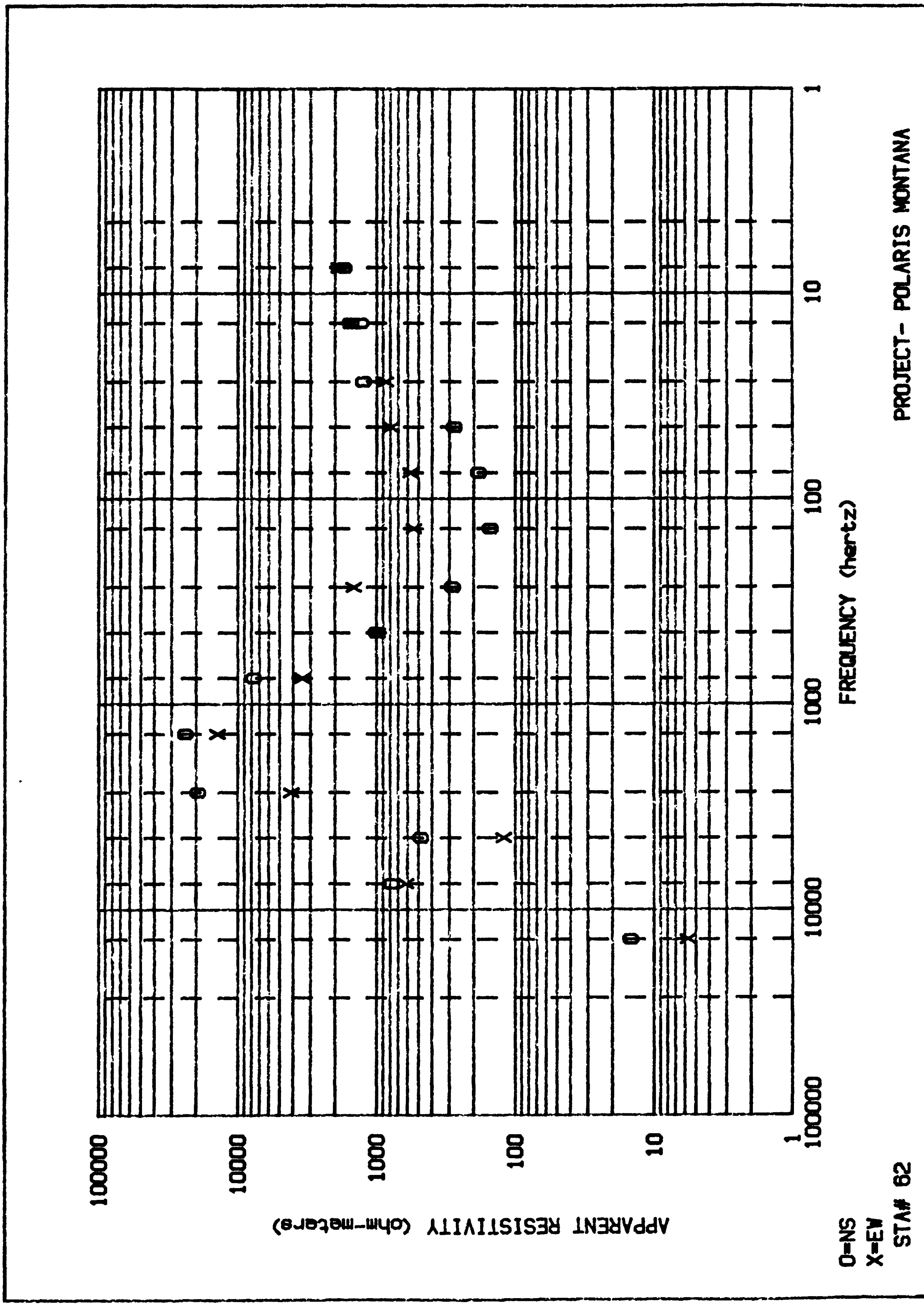


APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
100000
10000
1000
100
10
1
FREQUENCY (hertz)
O=NS
X=EW
STA# 38
PROJECT- DILLON MONTANA

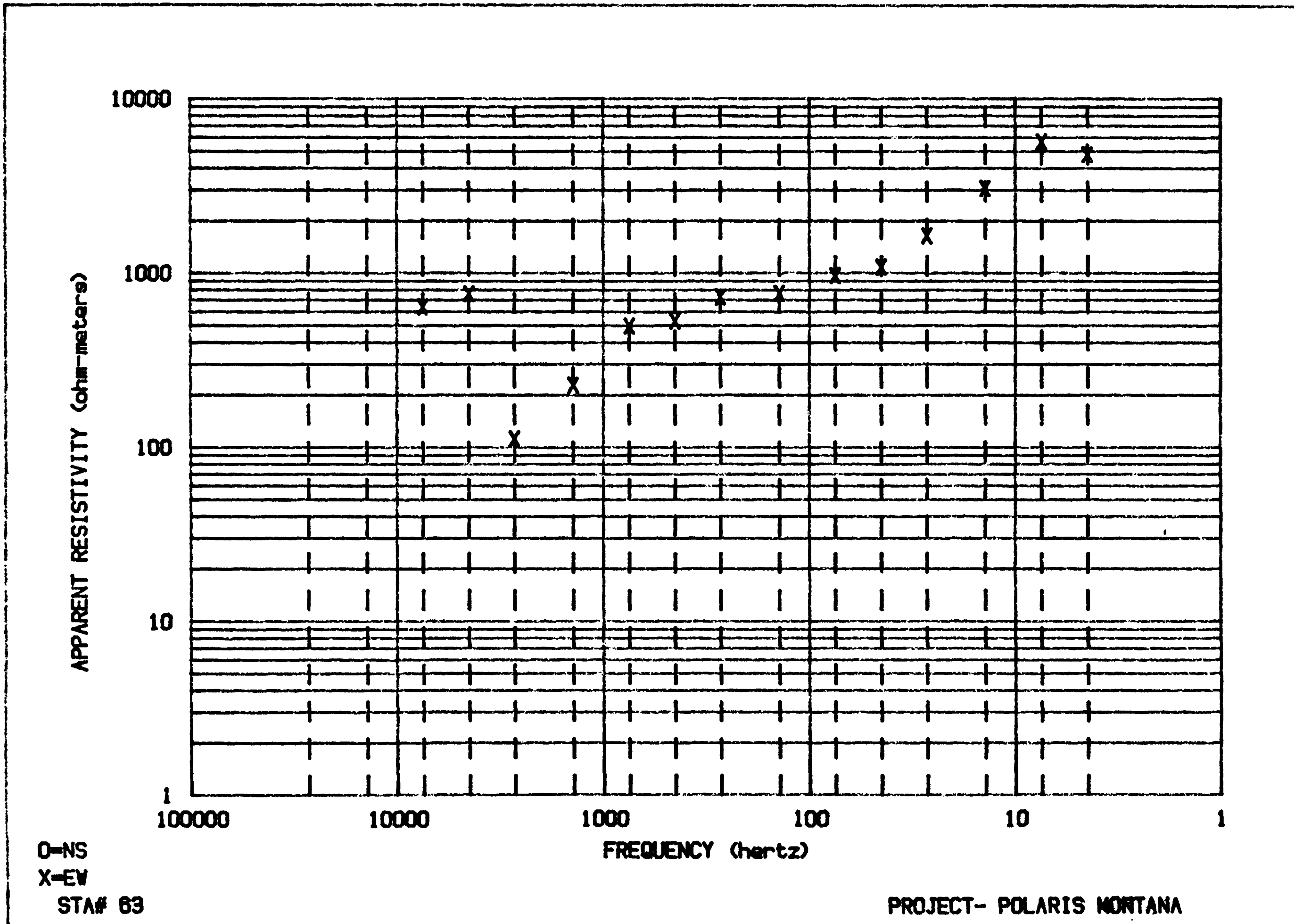


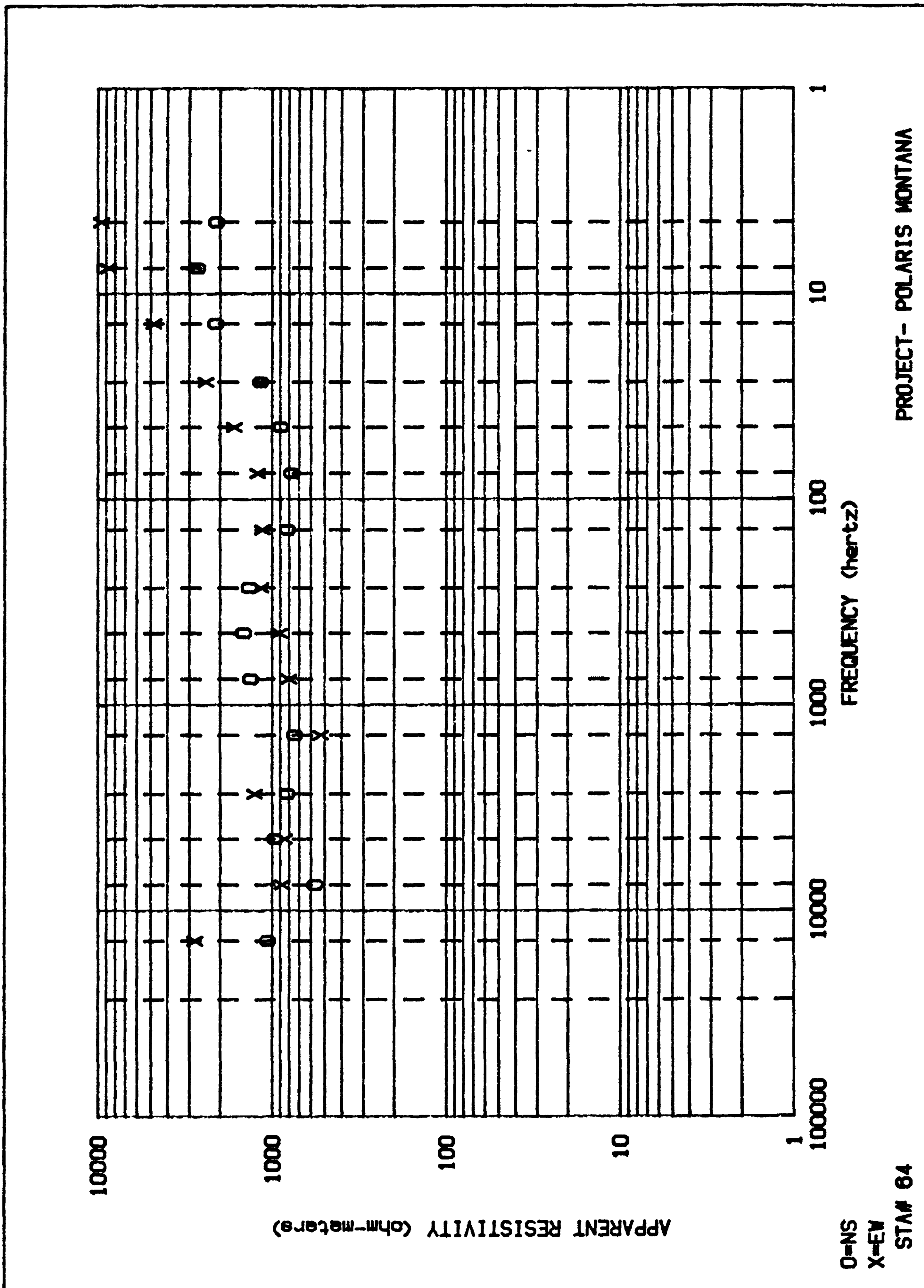
APPARENT RESISTIVITY (ohm-meters)
10000
1000
100
10
1
FREQUENCY (hertz)
1
10
100
1000
10000
100000
PROJECT- POLARIS MONTANA
O=NS
X=EW
STA# 60

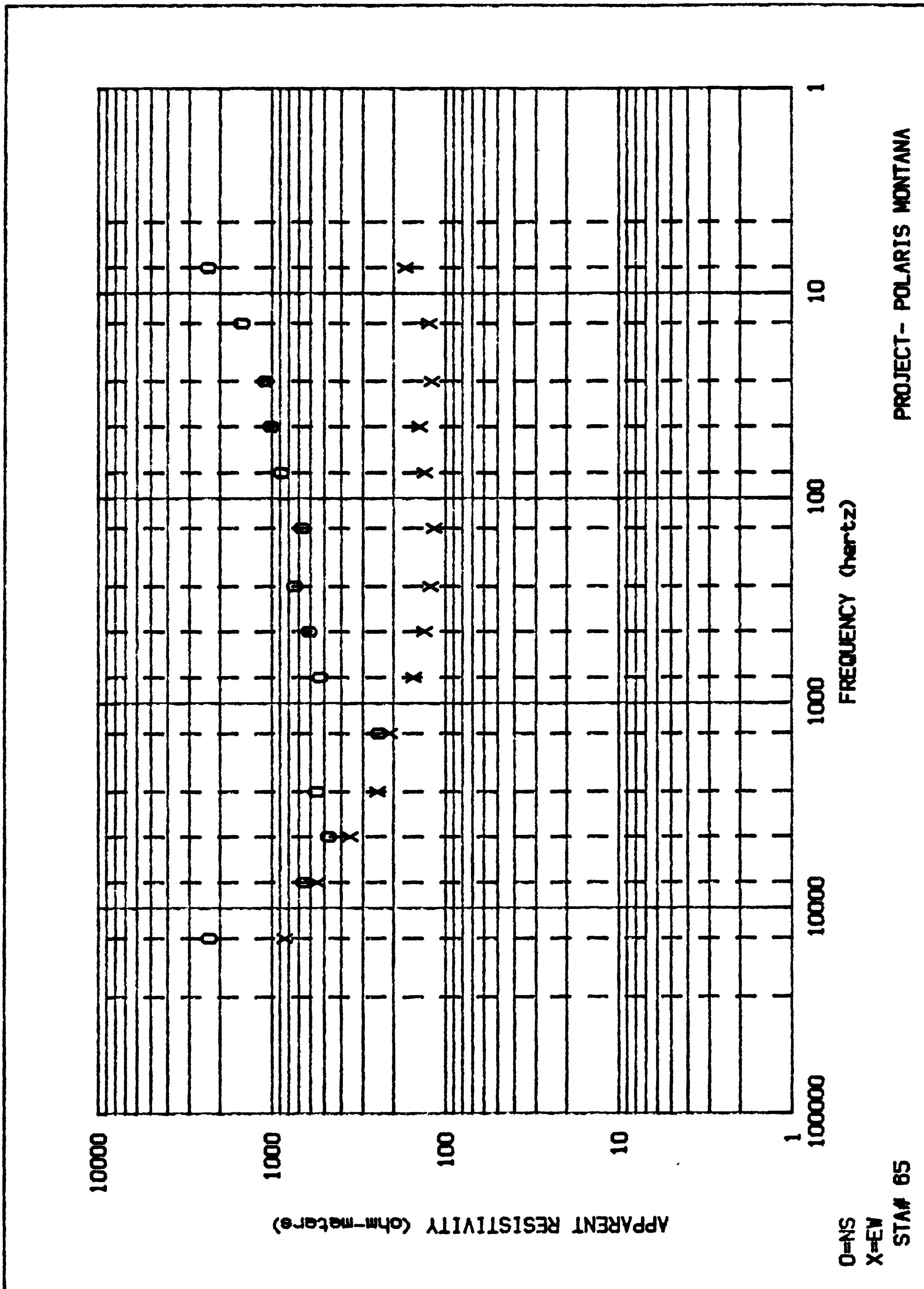

PROJECT- POLARIS MONTANA
APPARENT RESISTIVITY (ohm-meters)
FREQUENCY (hertz)
10000
1000
100
10
1
100000
O=NS
X=EW
STA# 61

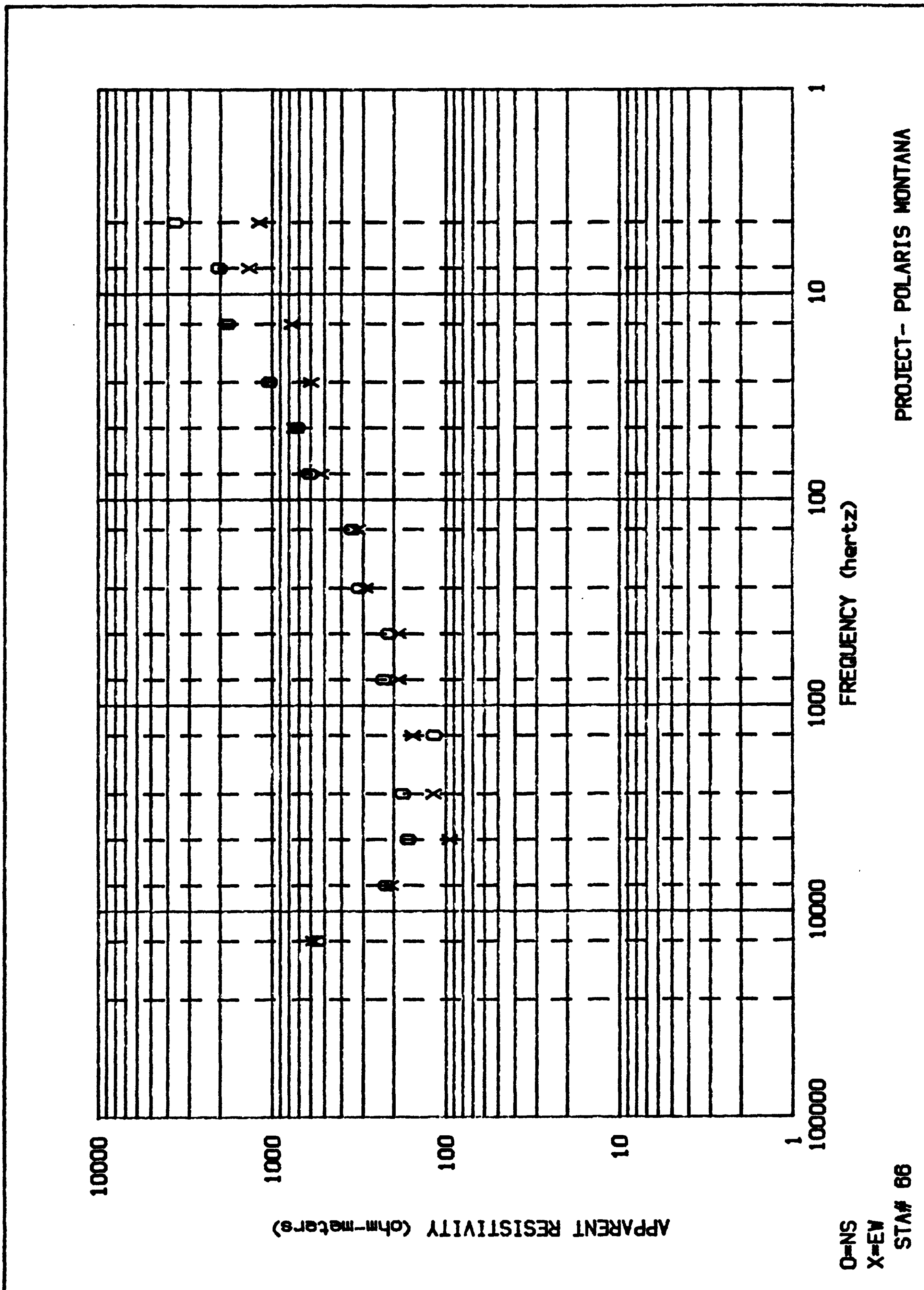


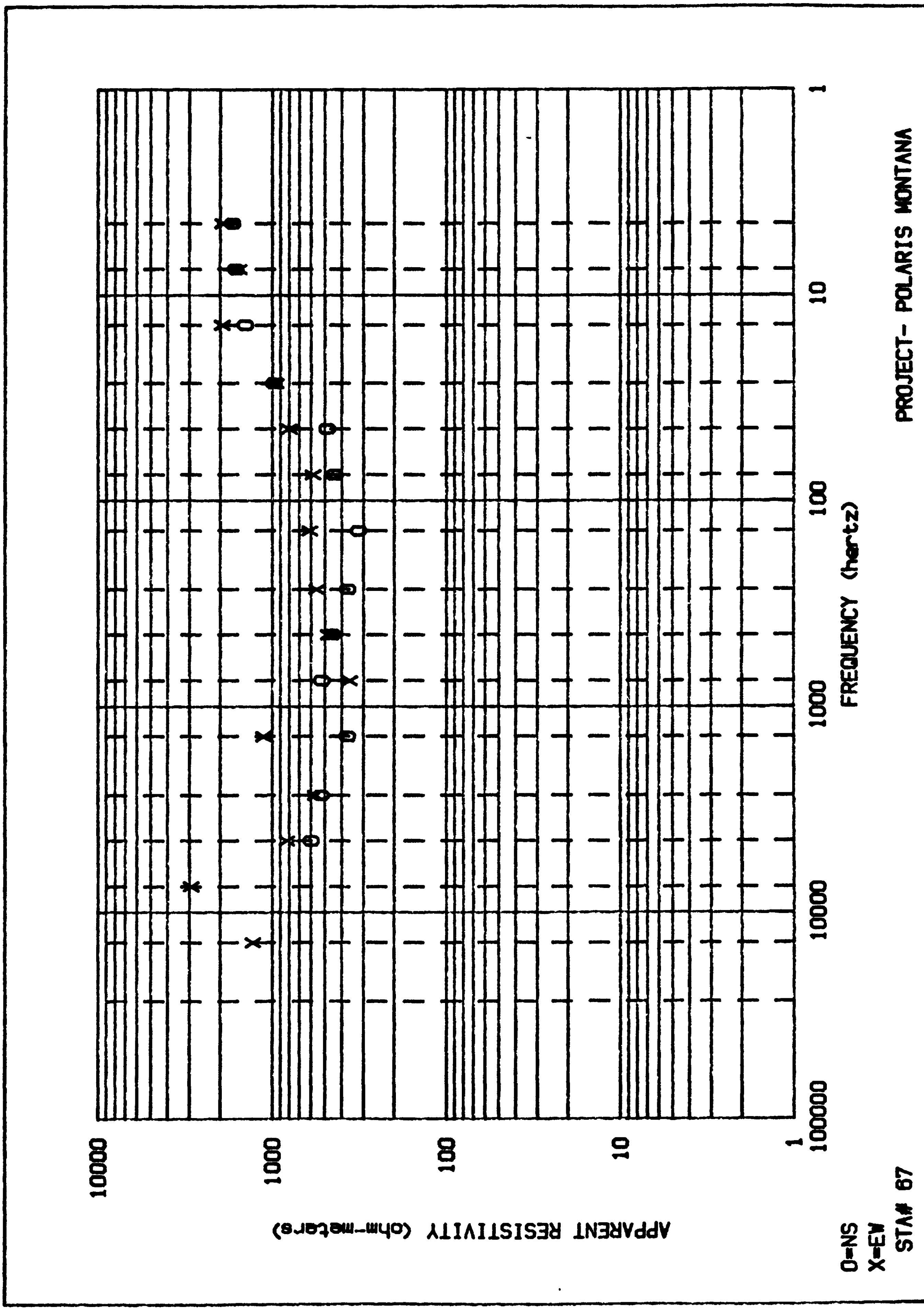
APPARENT RESISTIVITY (ohm-meters)
100000
10000
1000
100
10
1
FREQUENCY (hertz)
100000
10000
1000
100
10
1
O=NS
X=EW
STA# 62
PROJECT- POLARIS MONTANA


10000
1000
100
10
1
100000
10000
1000
100
10
1
APPARENT RESISTIVITY (ohm-meters)
FREQUENCY (hertz)
O=NS
X=EW
STA# 63
PROJECT- POLARIS MONTANA

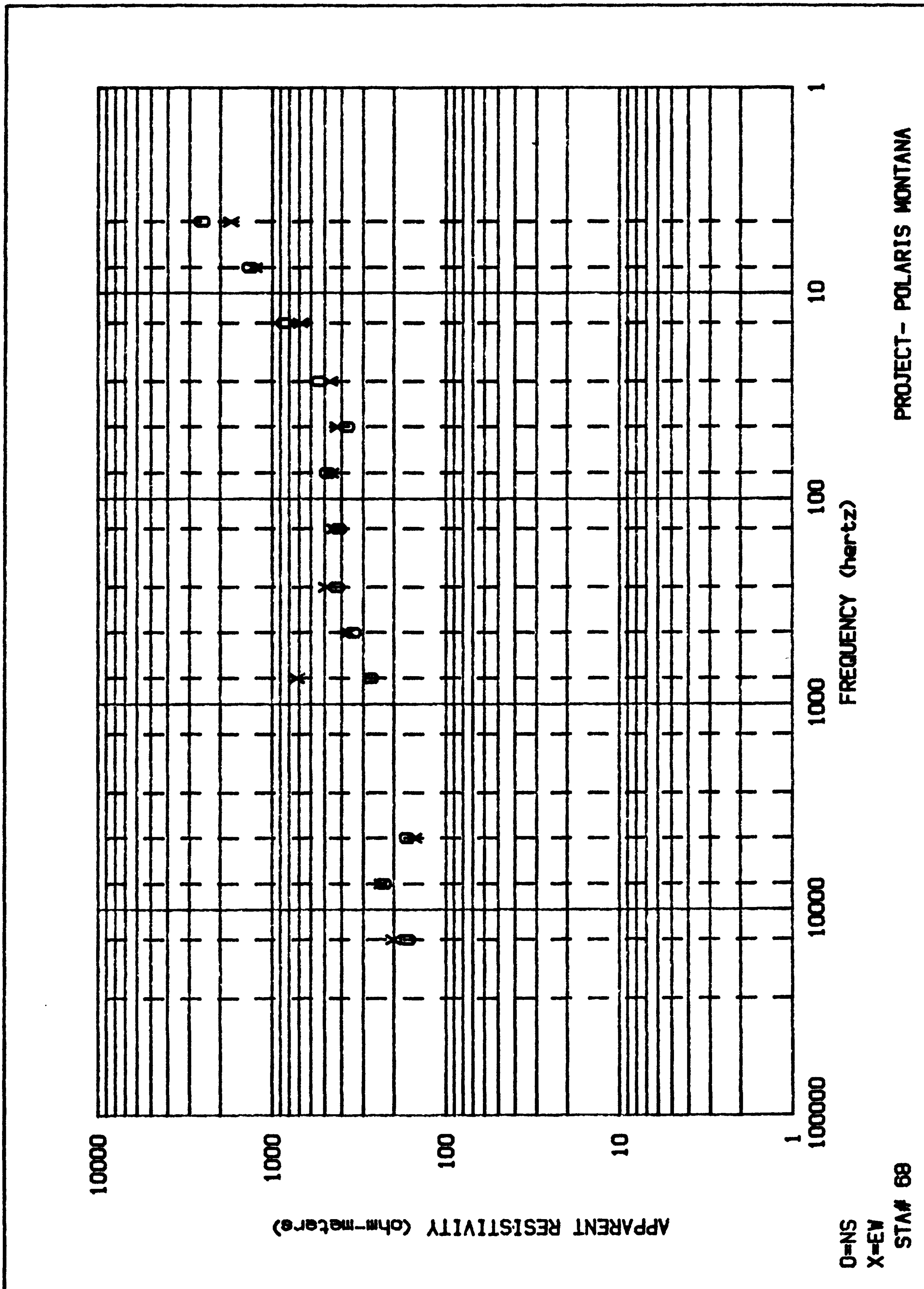

APPARENT RESISTIVITY (ohm-meters)
10000
1000
100
10
1
FREQUENCY (hertz)
100000
10000
1000
100
10
1
PROJECT- POLARIS MONTANA
O=NS
X=EW
STA# 64


APPARENT RESISTIVITY (ohm-meters)
10000
1000
100
10
1
FREQUENCY (hertz)
100000
10000
1000
100
10
1
PROJECT- POLARIS MONTANA
O=NS
X=EW
STA# 65

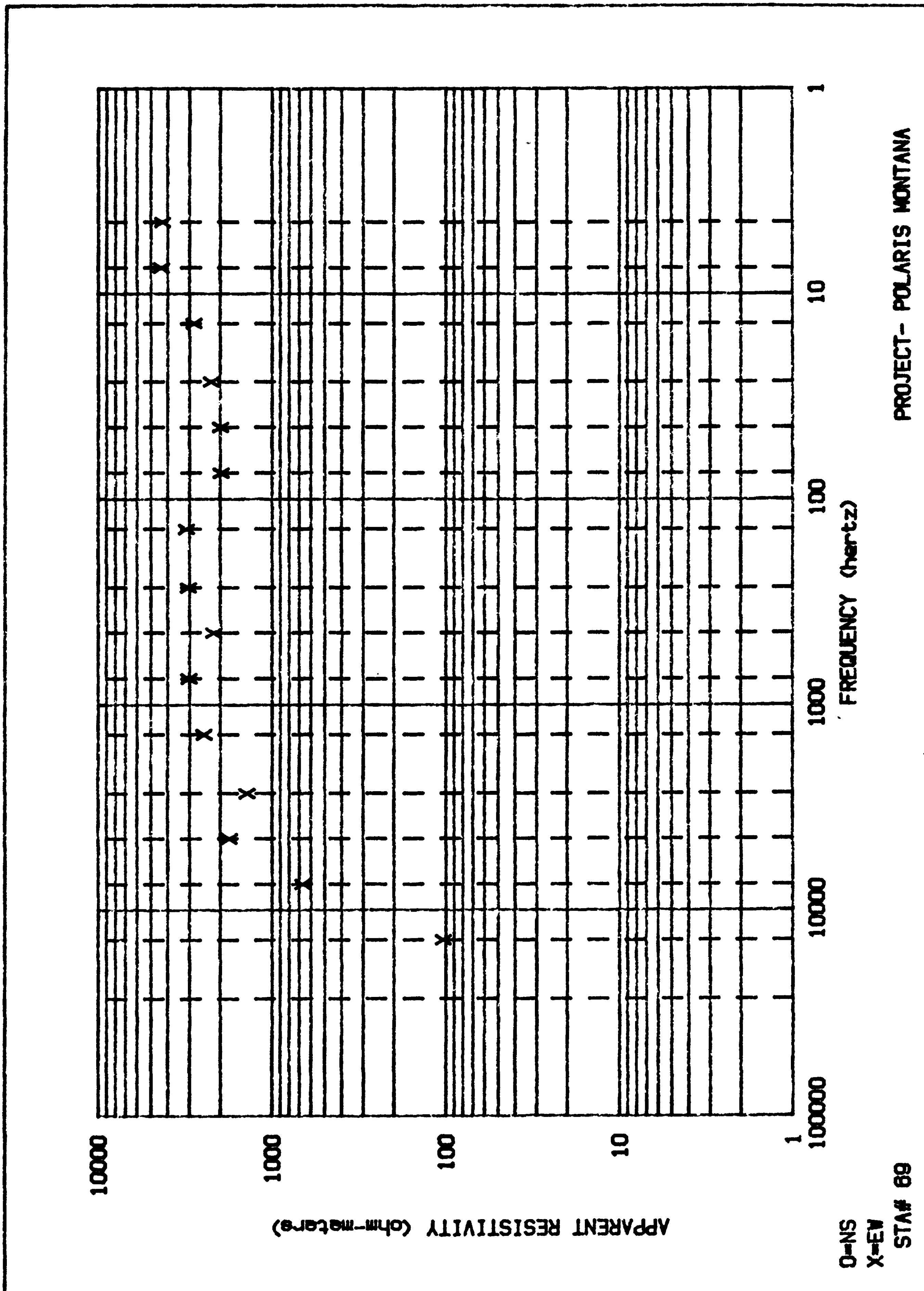

APPARENT RESISTIVITY (ohm-meters)
10000
1000
100
10
1
FREQUENCY (hertz)
100000
10000
1000
100
10
1
O=NS
X=EW
STA# 66
PROJECT- POLARIS MONTANA



APPARENT RESISTIVITY (ohm-meters)
10000
1000
100
10
1
FREQUENCY (hertz)
100000
10000
1000
100
10
1
PROJECT- POLARIS MONTANA
O=NS
X=EW
STA# 67



APPARENT RESISTIVITY (ohm-meters)
10000
1000
100
10
1
FREQUENCY (hertz)
100000
10000
1000
100
10
1
PROJECT- POLARIS MONTANA
O=NS
X=EW
STA# 68


PROJECT- POLARIS MONTANA
APPARENT RESISTIVITY (ohm-meters)
FREQUENCY (hertz)
10000
1000
100
10
1
100000
10000
1000
100
10
1
O=NS
X=EW
STA# 69

Appendix 2

Tabulated AMT data. At each station two independent scalar soundings are presented. The computer printout lists the orientation of the telluric line for each sounding (NS or EW). The tabulation gives the station number, orientation, and number of frequencies observed; followed by a table showing the frequency, apparent resistivity, number of individual events used to calculate the apparent resistivity, and the standard error for each frequency.

OUTPUT FROM PRINT

PROJECT=DILLON MONTANA

STATION ID_37 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	377.68	10	83.89
7.5	355.42	10	38.36
13.6	209.62	10	21.56
27.0	131.09	10	10.19
45.0	113.01	10	6.46
75.0	144.67	10	6.30
136.0	117.27	10	9.46
270.0	118.19	10	2.73
450.0	177.55	10	6.57
750.0	151.15	10	9.74
2700.0	151.53	2	24.77
4500.0	172.54	10	4.36
7500.0	157.23	10	1.40
13600.0	139.56	10	3.22

STATION ID_37 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
4.5	576.40	11	112.66
7.5	568.71	10	52.75
13.6	306.95	10	15.50
27.0	131.60	10	13.99
45.0	148.35	10	5.91
75.0	124.70	10	6.98
136.0	136.86	10	12.88
270.0	140.84	10	6.00
450.0	214.18	10	14.37
750.0	152.37	10	5.42
2700.0	225.46	5	26.40
4500.0	274.65	10	5.27
7500.0	266.59	10	5.33
13600.0	310.12	10	4.56

OUTPUT FROM PRINT

PROJECT=DILLON MONTANA

STATION ID_38 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	664.33	7	125.73
7.5	369.42	9	61.22
13.6	200.66	9	17.44
27.0	169.62	10	14.65
45.0	111.99	10	5.37
75.0	130.05	10	8.09
136.0	103.76	10	9.58
270.0	122.54	10	3.81
450.0	211.39	10	19.22
750.0	175.28	10	8.28
1360.0	125.36	10	14.69
2700.0	248.95	4	69.55
4500.0	194.39	10	17.55
7500.0	225.00	10	28.65
13600.0	577.45	8	48.80

STATION ID_38 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	17754.00	7	1735.90
7.5	12021.00	10	758.26
13.6	5232.60	10	202.91
27.0	2704.50	10	86.02
45.0	1630.50	10	57.85
75.0	930.54	10	45.20
136.0	578.02	10	37.49
270.0	395.16	10	16.31
450.0	474.37	10	20.33
750.0	270.08	10	8.82
1360.0	595.12	10	27.62
2700.0	305.96	6	35.42
4500.0	612.06	9	11.18
7500.0	592.32	10	17.24
13600.0	822.22	10	84.35

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

STATION ID_60 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
7.5	885.32	6	214.62
14.0	683.98	9	259.14
27.0	580.23	12	150.24
45.0	344.36	7	125.72
75.0	166.47	9	21.91
140.0	159.59	11	15.80
270.0	673.71	12	135.98
450.0	3423.10	4	2018.70
450.0	3465.50	9	1156.60
750.0	4543.80	6	3426.30
4500.0	2950.00	10	524.48
7500.0	744.78	11	86.43
14000.0	1161.90	8	167.86

STATION ID_60 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
7.5	1479.20	6	481.26
14.0	792.03	12	42.61
27.0	467.98	11	30.28
45.0	324.61	12	21.16
75.0	237.81	10	13.81
140.0	208.85	11	18.38
270.0	300.79	11	28.30
450.0	332.94	5	51.42
750.0	682.97	6	413.10
1400.0	1047.30	1	0.00
4500.0	824.04	8	86.74
7500.0	734.02	13	47.39
14000.0	963.95	9	31.91

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

STATION ID_61 NS NO FREQ= 12

FREQ	AP-RES	N OBS	STD ERR
7.5	1468.90	7	228.87
14.0	2113.40	10	522.98
27.0	2006.30	8	2536.90
45.0	753.47	9	278.55
75.0	1052.90	9	237.68
140.0	892.41	10	155.95
270.0	1498.20	12	192.32
450.0	2582.10	6	626.81
750.0	7011.70	10	842.93
4500.0	2117.70	9	589.47
7500.0	260.72	12	24.25
14000.0	555.87	12	37.71

STATION ID_61 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
7.5	1492.10	5	299.86
14.0	1043.40	14	70.49
27.0	630.47	12	44.37
45.0	369.54	13	24.70
75.0	322.15	10	15.44
140.0	244.60	16	16.42
270.0	243.30	16	13.92
450.0	412.01	5	79.91
750.0	277.16	4	6.46
1400.0	1030.70	5	194.08
2700.0	2356.20	1	0.00
4500.0	390.66	9	91.26
7500.0	250.27	11	16.18
14000.0	822.58	9	79.51

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

STATION ID_62 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
7.5	1722.60	7	763.89
14.0	1301.50	4	344.40
14.0	1532.40	5	498.16
27.0	1245.90	9	326.37
45.0	275.22	10	65.69
75.0	183.67	8	50.62
140.0	151.07	6	56.46
270.0	284.25	6	72.40
450.0	998.80	8	625.87
750.0	7706.90	10	1369.90
1400.0	23840.00	9	6655.70
2700.0	19311.00	1	0.00
4500.0	479.68	6	187.57
7500.0	778.64	5	399.80
14000.0	14.70	8	2.39

STATION ID_62 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
7.5	1877.30	9	320.26
14.0	1528.40	13	284.16
27.0	856.98	11	151.28
45.0	786.91	12	121.13
75.0	568.74	14	102.60
140.0	538.68	15	33.67
270.0	1459.00	12	216.63
450.0	977.60	10	214.03
750.0	3416.40	11	570.25
1400.0	14014.00	4	6312.50
2700.0	4089.30	3	769.15
4500.0	120.52	10	17.43
7500.0	613.05	13	30.53
14000.0	5.67	11	.22

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

NO DATA N-S

STATION ID_63 EW NO FREQ= 12

FREQ	AP-RES	N OBS	STD ERR
4.5	4777.80	9	1762.10
7.5	5664.50	9	731.72
14.0	3051.80	13	174.46
27.0	1634.30	12	124.25
45.0	1077.50	10	76.45
75.0	961.55	14	49.63
140.0	763.36	11	34.46
270.0	726.43	13	31.22
450.0	528.53	10	32.80
750.0	496.29	10	42.58
4500.0	758.48	9	85.33
7500.0	637.08	10	66.47

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

STATION ID_64 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	2091.90	7	895.28
7.5	2687.70	14	261.29
14.0	2113.90	13	147.88
27.0	1164.00	14	82.07
45.0	895.77	10	104.33
75.0	771.59	17	51.21
140.0	818.03	12	44.80
270.0	1359.00	12	52.29
450.0	1465.20	14	68.60
750.0	1330.80	13	72.26
1400.0	740.54	10	69.33
2700.0	817.23	13	164.56
4500.0	965.99	13	67.37
7500.0	568.49	10	125.91
14000.0	1063.80	7	536.98

STATION ID_64 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	9575.40	9	1272.80
7.5	8739.10	10	379.29
14.0	4793.60	10	403.91
27.0	2408.60	10	67.36
45.0	1651.10	14	152.09
75.0	1212.90	9	126.11
140.0	1139.40	12	49.34
270.0	1159.10	12	70.93
450.0	908.09	10	72.22
750.0	800.69	15	88.98
1400.0	526.93	11	41.99
2700.0	1263.40	10	98.77
4500.0	847.75	10	118.05
7500.0	877.26	10	76.69
14000.0	2792.70	6	657.05

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

STATION ID_65 NS NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
7.5	2330.60	9	650.58
14.0	1490.30	15	157.55
27.0	1089.60	10	144.00
45.0	1011.50	15	84.65
75.0	881.43	10	43.96
140.0	671.01	10	11.68
270.0	738.15	10	70.96
450.0	610.84	10	29.65
750.0	527.49	12	60.22
1400.0	241.93	10	25.53
2700.0	554.07	12	29.66
4500.0	471.88	10	25.05
7500.0	654.13	12	35.86
14000.0	2300.30	10	268.28

STATION ID_65 EW NO FREQ= 14

FREQ	AP-RES	N OBS	STD ERR
7.5	170.83	16	16.21
14.0	123.67	11	8.86
27.0	120.03	17	18.13
45.0	141.00	11	30.34
75.0	131.63	13	11.97
140.0	116.29	11	15.78
270.0	121.74	8	11.16
450.0	132.61	13	5.68
750.0	152.98	11	9.84
1400.0	209.72	12	19.99
2700.0	247.13	11	3.63
4500.0	354.52	13	69.47
7500.0	548.41	11	25.44
14000.0	842.61	11	65.21

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

STATION ID_66 NS NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	3623.40	9	346.31
7.5	2023.70	13	195.45
14.0	1809.70	15	165.60
27.0	1036.40	16	42.60
45.0	712.81	14	23.83
75.0	609.56	11	16.28
140.0	346.28	10	21.69
270.0	315.14	12	7.93
450.0	212.83	12	10.81
750.0	228.68	11	8.99
1400.0	116.97	11	11.74
2700.0	177.37	13	8.02
4500.0	165.13	10	15.24
7500.0	220.27	10	12.38
14000.0	548.02	8	71.01

STATION ID_66 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	1189.00	10	220.74
7.5	1356.40	10	241.00
14.0	767.22	8	86.54
27.0	596.10	11	60.50
45.0	743.01	7	112.61
75.0	522.06	12	65.89
140.0	322.68	6	34.63
270.0	289.80	7	33.48
450.0	187.54	11	36.92
750.0	187.54	11	36.92
1400.0	154.63	11	16.34
2700.0	117.50	10	9.09
4500.0	94.77	13	12.42
7500.0	207.73	7	33.72
14000.0	579.59	9	138.27

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

STATION ID_67 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	1692.30	10	327.27
7.5	1622.20	10	163.68
14.0	1431.50	12	89.39
27.0	974.45	10	27.65
45.0	485.04	10	23.75
75.0	441.42	10	37.57
140.0	319.77	10	24.01
270.0	369.82	10	21.47
450.0	453.46	10	22.82
750.0	520.47	10	43.89
1400.0	369.82	14	22.64
2700.0	524.64	12	31.48
4500.0	598.11	10	36.29

STATION ID_67 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	1928.80	10	276.21
7.5	1555.60	11	187.36
14.0	1942.50	10	357.32
27.0	948.36	10	120.40
45.0	798.00	10	71.76
75.0	584.51	14	45.59
140.0	609.85	10	40.45
270.0	557.34	10	14.47
450.0	478.02	11	15.29
750.0	359.96	10	14.15
1400.0	1122.60	10	64.72
2700.0	566.36	10	39.17
4500.0	823.08	10	335.71
7500.0	2918.70	10	316.86
14000.0	1292.30	10	85.65

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

STATION ID_68 NS NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	2539.60	10	238.19
7.5	1348.10	13	152.42
14.0	851.27	12	85.57
27.0	535.80	12	35.75
45.0	372.22	14	28.80
75.0	481.70	10	39.96
140.0	416.51	18	24.90
270.0	427.85	15	23.84
450.0	342.34	12	70.90
750.0	270.78	5	46.84
4500.0	167.39	10	94.44
7500.0	228.51	10	34.69
14000.0	166.18	5	22.10

STATION ID_68 EW NO FREQ= 13

FREQ	AP-RES	N OBS	STD ERR
4.5	1729.60	12	127.79
7.5	1270.50	11	81.06
14.0	685.58	10	55.57
27.0	464.66	10	26.53
45.0	420.54	14	31.62
75.0	461.04	11	27.54
140.0	438.77	11	34.48
270.0	490.52	9	22.84
450.0	362.88	10	71.70
750.0	718.95	4	111.24
4500.0	152.74	12	23.46
7500.0	233.22	13	31.90
14000.0	200.12	10	10.14

OUTPUT FROM PRINT

PROJECT=POLARIS MONTANA

NO DATA N-S

STATION ID_69 EW NO FREQ= 15

FREQ	AP-RES	N OBS	STD ERR
4.5	4275.90	8	2193.70
7.5	4339.30	13	656.20
14.0	2810.80	11	473.52
27.0	2241.20	13	167.63
45.0	1979.50	12	365.46
75.0	1969.80	12	222.88
140.0	3116.40	13	297.22
270.0	3033.50	13	279.71
450.0	2172.60	12	292.70
750.0	3008.60	10	316.58
1400.0	2464.90	10	586.42
2700.0	1396.70	9	576.54
4500.0	1761.50	13	149.79
7500.0	663.64	10	55.02
14000.0	103.30	8	1.82

Appendix 3

Tabulated telluric data. The tabulation shows for each station and for each frequency, the average telluric voltage ratio between adjacent dipoles and the standard deviation of the ratio. Next for each dipole and each frequency, the computed relative telluric voltage referenced to the first station which is arbitrarily set to one.

Farlin Creek, Montana
Telluric Line 1

Station No.	Ratio/Std. Deviation				Relative Voltage			
	25Hz	16.7Hz	7.5Hz	4.5Hz	25Hz	16.7Hz	7.5Hz	4.5Hz
					1	1	1	1
4E	0.76/.02	0.78/.02	0.79/.01	0.77/.03				
					.76	.78	.79	.77
3E	0.76/.02	0.74/.01	0.74/.03	0.74/.03				
					1.00	1.05	1.07	1.04
2E	1.46/.01	1.45/.01	1.52/.03	1.44/.02				
					1.46	1.53	1.62	1.50
1E	0.96/.01	0.96/.00	0.96/.01	0.98/.01				
					1.52	1.59	1.69	1.53
0	0.88/.01	0.89/.01	0.88/.01	0.89/.02				
					1.34	1.42	1.49	1.36
1W	0.62/.00	0.63/.01	0.65/.01	0.65/.01				
					2.16	2.25	2.29	2.09
2W	0.66/.01	0.66/.00	0.67/.00	0.68/.01				
					1.42	1.48	1.53	1.42
3W	0.67/.00	0.68/.01	0.70/.01	0.71/.01				
					2.13	2.18	2.19	2.00
4W	0.66/.01	0.65/.00	0.66/.00	0.68/.02				
					1.40	1.42	1.45	1.36
5W	2.17/.04	2.25/.03	2.33/.06	2.38/.10				
					.65	.63	.62	.57
6W	1.22/.01	1.23/.02	1.25/.03	1.27/.01				
					.79	.78	.78	.73
7W	0.63/.01	0.64/.01	0.70/.02	0.63/.02				
					1.25	1.21	1.11	1.15
8W	0.27/.01	0.28/.01	0.29/.01	0.29/.00				
					.34	.34	.32	.33
9W	1.37/.02	1.55/.03	1.53/.06	1.53/.06				
					.25	.22	.21	.22

Telluric Line 2

Station No.	25Hz	16.7Hz	7.5Hz	4.5Hz	25Hz	16.7Hz	7.5Hz	4.5Hz
					1	1	1	1
0	0.81/.06	0.77/.03	0.74/.01	0.78/.05				
					1.23	1.30	1.35	1.28
1W	1.46/.02	1.49/.02	1.49/.05	1.53/.03				
					1.80	1.93	2.01	1.96
2W	3.55/.03	3.56/.08	3.60/.02	3.77/.05				
					0.51	0.54	0.56	0.52
3W	0.91/.00	0.95/.01	0.95/.02	0.98/.04				
					0.46	0.52	0.53	0.51
4W	1.34/.04	1.40/.01	1.45/.02	1.47/.02				
					0.34	0.37	0.37	0.35
5W	1.33/.07	1.33/.03	1.24/.03	1.20/.02				
					0.46	0.49	0.45	0.42
6W	0.65/.03	0.62/.01	0.63/.01	0.59/.02				
					0.71	0.79	0.72	0.70
7W	1.42/.03	1.44/.02	1.43/.03	1.47/.01				
					1.00	1.14	1.03	1.04
8W	0.77/.01	0.79/.01	0.82/.00	0.85/.01				
					1.30	1.44	1.26	1.22
9W	0.12/.01	0.12/.01	0.15/.01	.14/.02				
					0.16	0.17	0.19	0.17