GEOPHYSICAL SURVEY
GROUND WATER EVALUATION
HALEAKALA RANCH
MAUI, HAWAII

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GROUND WATER EVALUATION
HALEAKALA RANCH, MAUI, HAWAII

Prepared For:

Baldwin Pacific
55 South Waikea Avenue
Kahului, HI 96732

Prepared By:

Blackhawk Geosciences, Inc.
17301 West Colfax Avenue, Suite 170
Golden, CO 80401

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(Our Project #90019)

Table of Contents

1.0 INTRODUCTION

This report contains the results of a geophysical survey for ground water resource evaluation on Haleakala Ranch property on the Island of Maui. The work was performed by Blackhawk Geosciences, Inc. (BGI) for Baldwin Pacific (BP) during May 1 to May 3, 1990.

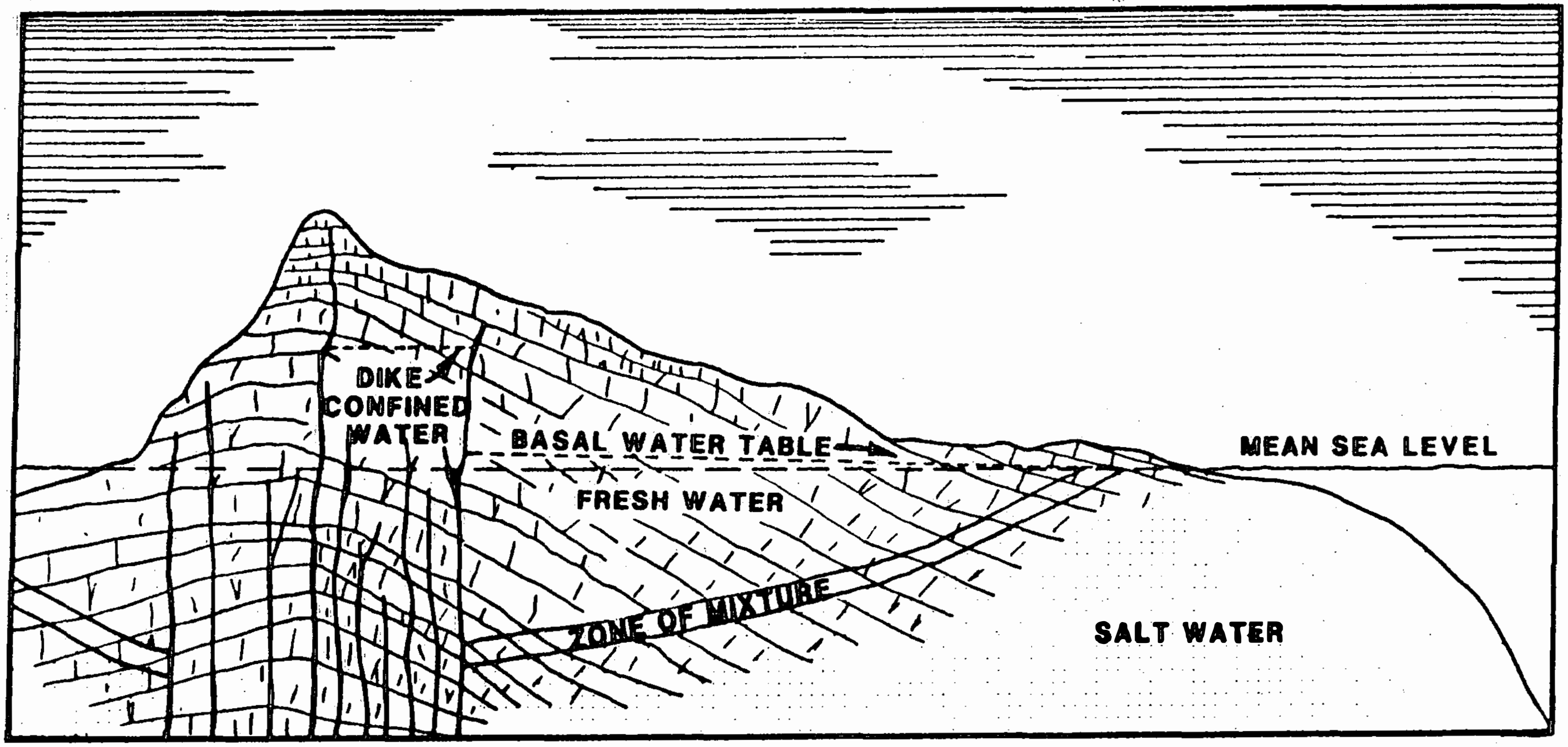
The general objective of the geophysical survey at Haleakala Ranch was to assist in characterizing the hydrologic regime in the study area. The main objectives for geophysical surveys for ground water evaluations on volcanic islands are illustrated in Figure 1-1. The volcanic rocks are generally highly permeable and this allows rainwater to percolate with little impedance directly downward through the island mass. The fresh water in these island settings is generally found in two environments:

1. Structurally-confined waters. Typically, within a rift zone, geologic structures such as intrusive dikes, originating from a magma source below, can form ground water dams, and behind these natural dams significant quantities of ground water can be stored.

2. Basal fresh water. The high permeability of the volcanic rocks allows sea water to enter freely under the island, and a delicate balance is reached where a lens of fresh water floats on sea water. In cases of hydrostatic equilibrium, the Ghyben-Herzberg relation states that for every foot of fresh water head above sea level there will be 40 ft of fresh water below sea level.

At Haleakala Ranch ground water was expected to occur mainly as basal fresh water. The impetus for using geophysics is that the cost of a geophysical station is about one-thousandth the cost of completing a well at elevations above 1,000 ft. Geophysical surveys, combined with other hydrogeologic information, are used to provide optimum locations for well placement and well completion depths.

The geophysical method employed was time domain electromagnetic (TDEM) soundings. This method was selected because it has proven effective in prior surveys in similar settings in Hawaii.



BLACKHAWK GEOSCIENCES, INC.

SCHEMATIC HYDRO-GEOLOGIC
CROSS SECTION
BALDWIN PACIFIC
HALEAKALA RANCH

PROJECT NO.: 90019 **FIGURE 1-1**

2.0 LOGISTICS AND DATA ACQUISITION

A brief description of the fundamentals of TDEM are given in Appendix A. Briefly, the logistics of a TDEM measurement consist of:

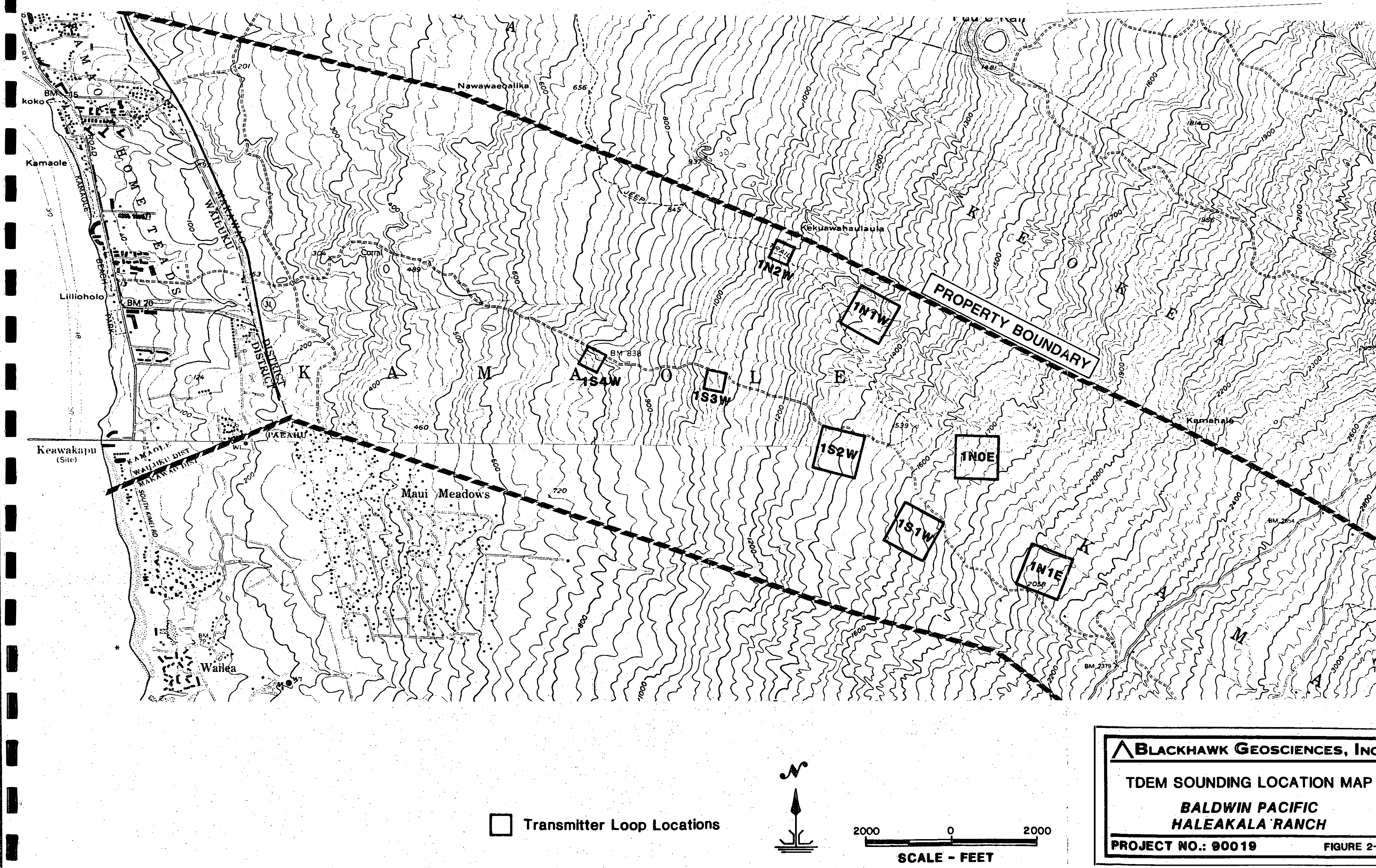
1. Laying out a square loop of insulated wire. A generator placed in the loop is used to drive current pulses through this closed loop. The dimensions of the square loops employed depend on the exploration depth requirements. The dimensions of the loops used for Haleakala Ranch were 1,000 ft by 1,000 ft or 500 ft by 500 ft.

2. Making a measurement with a receiver in the center of the loop. The data acquired at each station was stored in the field on a solid state data logger and subsequently dumped to a computer at the end of each field day. The data acquired at each station usually consisted of measurements at several receiver gain settings and transmitter frequencies in order to assure data quality and to obtain data over the largest time range possible. Data quality was generally very good.

During the 3 days of field work 8 stations (soundings) were completed. A daily log of field activity is given in Table 2-1. Figure 2-1 shows the location of the soundings conducted for Baldwin Pacific.

Table 2-1. Daily log of field activity

Date (1990)	Activity
April 30	Mobilize to Maui from Hawaii.
May 1	TDEM soundings 1N1E and 1N0E.
May 2	TDEM soundings 1N1W, 1N2W and 1S1W.
May 3	TDEM soundings 1S2W, 1S3W and 1S4W.
May 4	Demobilize crew and equipment.



BLACKHAWK GEOSCIENCES, INC.

TDEM SOUNDING LOCATION MAP

BALDWIN PACIFIC
HALEAKALA RANCH

PROJECT NO.: 90019

FIGURE 2-1

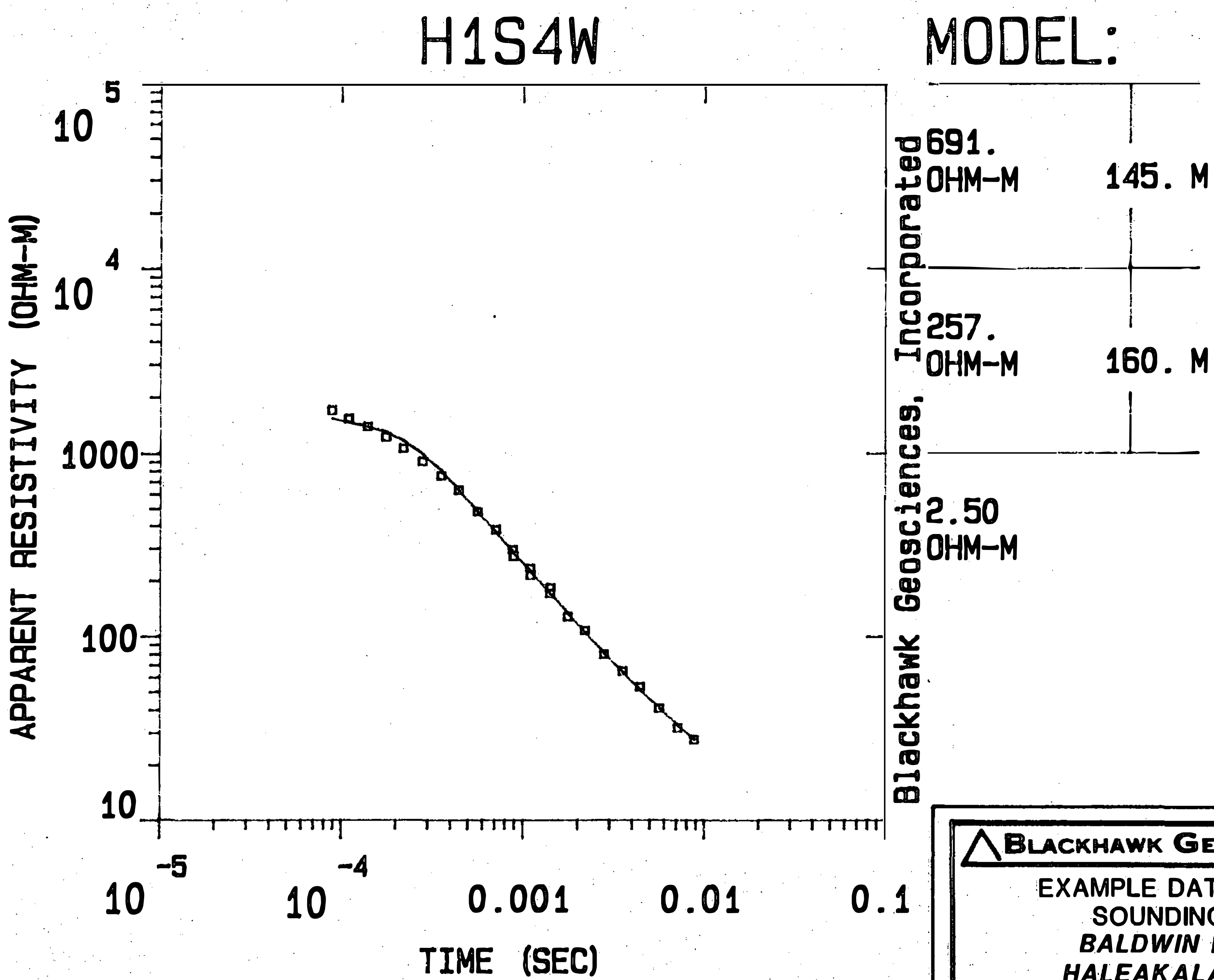
3.0 DATA PROCESSING

The field data acquired each day was transferred from the DAS-54 data logger to a computer in the field office. The data for each sounding location is edited and combined (both 3 Hz and 30 Hz frequencies) to produce a transient decay curve. This decay curve is transformed into an apparent resistivity curve, which is entered into an Automatic Ridge Regression Transient Inversion Program. From the apparent resistivity curve a one-dimensional model of resistivities and thicknesses is calculated.

The inversion program requires an initial estimate of the geoelectric section, including the number of layers, and the resistivities and thicknesses of each of the layers. The program then adjusts these parameters so that the model curve converges to best fit the curve formed by the field data set. The inversion program does not change the total number of layers within the model, but allows all other parameters to float freely.

An example data set is given in Figures 3-1 and 3-2 for sounding 1S4W. Figure 3-1 shows the measured data points (in terms of apparent resistivity) superimposed on a solid line. The solid line represents the computed behavior of the true resistivity layering shown on the right. Figure 3-2 lists in column 4 the error between measured and computed data in each time gate.

The apparent resistivity curves and data sheets for all soundings are contained in Appendix B.



BLACKHAWK GEOSCIENCES, INC.

EXAMPLE DATA SET FOR
SOUNDING 1S4W
BALDWIN PACIFIC
HALEAKALA RANCH

PROJECT NO.: 90019

FIGURE 3-1

H1S4W

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		234.7	770.0		
690.76	144.9	89.8	294.7	0.2	0.2
257.41	159.8	-69.9	-229.5	0.6	0.8
2.50					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	1.70E+03	1.55E+03	10.038	
2	1.10E-04	1.53E+03	1.46E+03	5.264	
3	1.40E-04	1.39E+03	1.38E+03	0.683	
4	1.77E-04	1.22E+03	1.29E+03	-5.496	
5	2.20E-04	1.06E+03	1.16E+03	-8.548	
6	2.80E-04	8.99E+02	9.79E+02	-8.142	
7	3.55E-04	7.49E+02	7.94E+02	-5.632	
8	4.43E-04	6.25E+02	6.25E+02	0.035	
9	5.64E-04	4.78E+02	4.74E+02	0.741	
10	7.13E-04	3.81E+02	3.66E+02	4.109	
11	8.81E-04	2.96E+02	2.87E+02	3.115	
12	8.90E-04	2.71E+02	2.84E+02	-4.280	
13	1.10E-03	2.34E+02	2.24E+02	4.479	
14	1.10E-03	2.15E+02	2.23E+02	-3.605	
15	1.40E-03	1.70E+02	1.70E+02	-0.069	
16	1.41E-03	1.83E+02	1.69E+02	8.503	
17	1.77E-03	1.27E+02	1.32E+02	-3.598	
18	2.20E-03	1.08E+02	1.04E+02	3.167	
19	2.80E-03	8.00E+01	8.12E+01	-1.486	
20	3.55E-03	6.50E+01	6.37E+01	2.034	
21	4.43E-03	5.34E+01	5.12E+01	4.205	
22	5.64E-03	4.10E+01	4.08E+01	0.459	
23	7.13E-03	3.19E+01	3.29E+01	-3.055	
24	8.81E-03	2.76E+01	2.74E+01	0.447	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
TDHZ ARRAY, 24 DATA POINTS, RAMP: 140.0 MICROSEC, DATA: H1S4W
0305 001S 004W Z OPR XTL H 5 8+100
Ch.21 = 0.14 Ch.22 = 0.089 Ch.23 = 22 Ch.24 = 2
RMS LOG ERROR: 3.08E-02, ANTILOG YIELDS 7.3519 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.33				
P 2	0.26	0.26			
F 3	0.00	0.00	0.00		
T 1	0.20	0.21	0.00	0.62	
T 2	-0.20	-0.18	0.00	0.34	0.66
	P 1	P 2	F 3	T 1	T 2

BLACKHAWK GEOSCIENCES, INC.

EXAMPLE DATA SET FOR SOUNDING 1S4W
BALDWIN PACIFIC HALEAKALA RANCH

PROJECT NO.: 90019 **FIGURE 3-2**

4.0 INTERPRETATION RESULTS

4.1 GENERAL

The main objective of the geophysical survey is not to obtain the resistivity layering of the subsurface, but to infer from the resistivity layering information about the elevation and thickness of the fresh water resource. The translation of resistivity layering into meaningful hydrogeologic information is generally accomplished in two ways:

1. Using available knowledge about the relation between resistivity values and hydrogeology. For example, in the volcanic rocks of Hawaii, rocks saturated with salt water will generally have resistivities less than 5 ohm-m. On the other hand, dry and fresh water/brackish water saturated volcanic rocks and intrusives have very high resistivities (typically greater than 100 ohm-m).

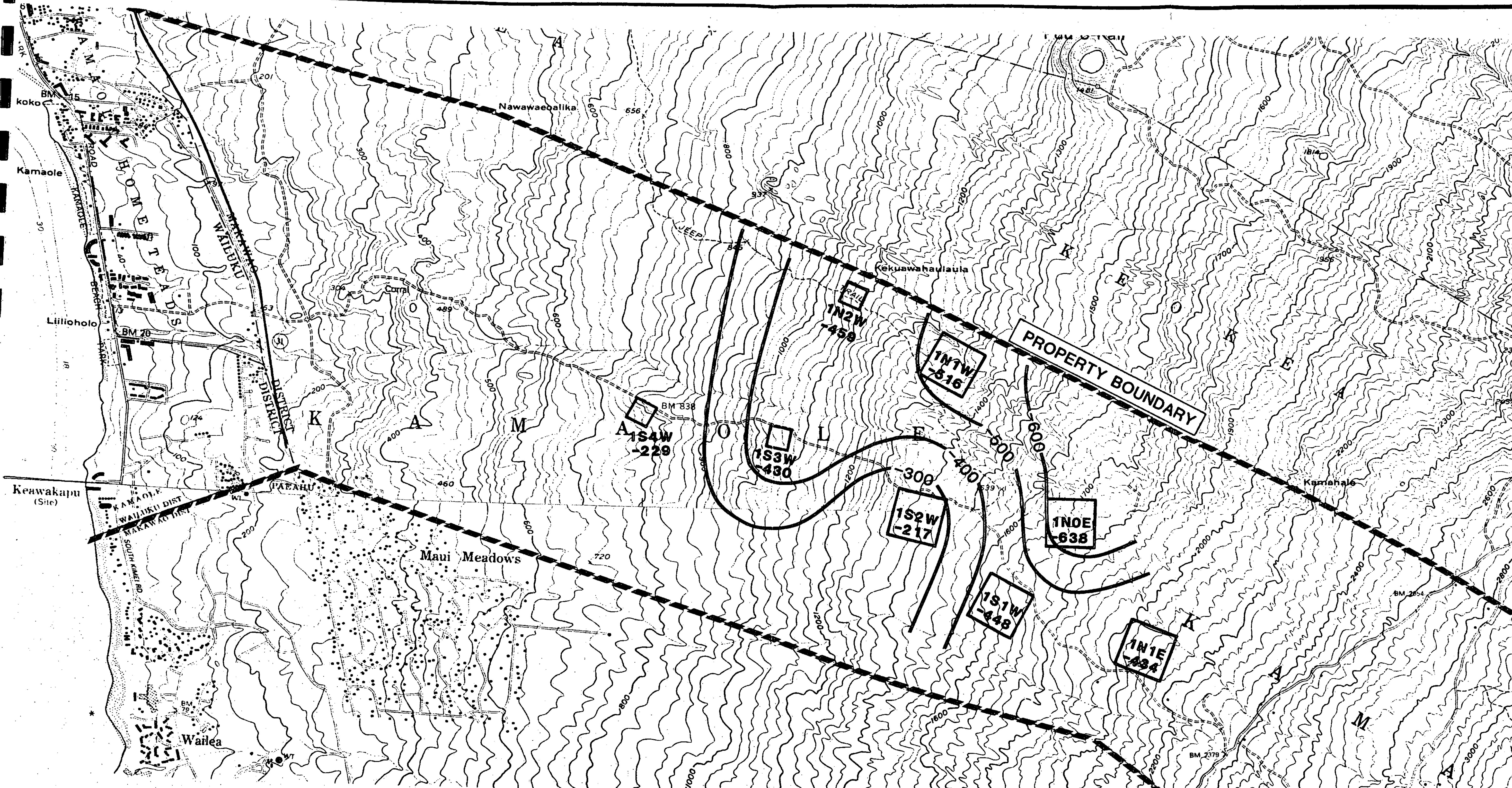
2. Calibrating the geophysical interpretation at a well. Because no wells were available for calibration, this method could not be applied.

When a very conductive layer is detected below sea level in the TDEM interpretation, the layer is interpreted to be caused by saline saturated volcanics.

4.2 INTERPRETATION MAP

For all eight soundings taken on the Haleakala Ranch property a conductive layer was interpreted to exist below sea level. (The results of the inversions of the individual soundings are given in Appendix B). This conductive layer is interpreted to represent saline saturated volcanics, and the fresh/brackish water resource can be estimated as the volume between sea level and the elevation of this saline water layer. It is important to note that the fresh/brackish water layer is not determined directly from the resistivity interpretation but is inferred to lie above the interpreted saline water layer from hydrologic considerations. In Figure 4-1 a contour map of the elevation of the saline water layer is given. The contour map shows the depth to saline water to generally increase to the east towards station 1N0E and to be deeper along the north side of the property boundary. The depth pattern shown on Figure 4-1 is relatively complex with depth to saline water relatively shallower near 1S2W (elevation ≈ 1,400 ft) bracketed by deeper measurements both uphill (1S1W) and downhill (1S3W). This complex pattern may indicate that geologic structures (e.g., dikes, intrusives, etc.) or lithologic changes influence the basal ground water regime. The large depths to saline water near 1N2W and 1S3W at a relatively low elevation (< 1,100 ft), however, indicate a good potential ground water resource in this area.

It is difficult to determine from the TDEM data the chloride concentration of the ground water resource above the saline water. The reason for this is that, at relative low chloride concentrations (e.g., less than 500 ppm), in addition to dissolved solids in ground water, other factors such as porosity and lithology also influence the resistivity. At the Haleakala Ranch property the fact that the depth to saline water is generally large, infers that the ground water resource is likely fresh water.



-434 Elevation (feet) of interpreted Saline Water

Transmitter Loop Locations

N

2000 0 2000

SCALE - FEET

BLACKHAWK GEOSCIENCES, INC.

ELEVATION OF
INTERPRETED SALINE WATER
BALDWIN PACIFIC
HALEAKALA RANCH

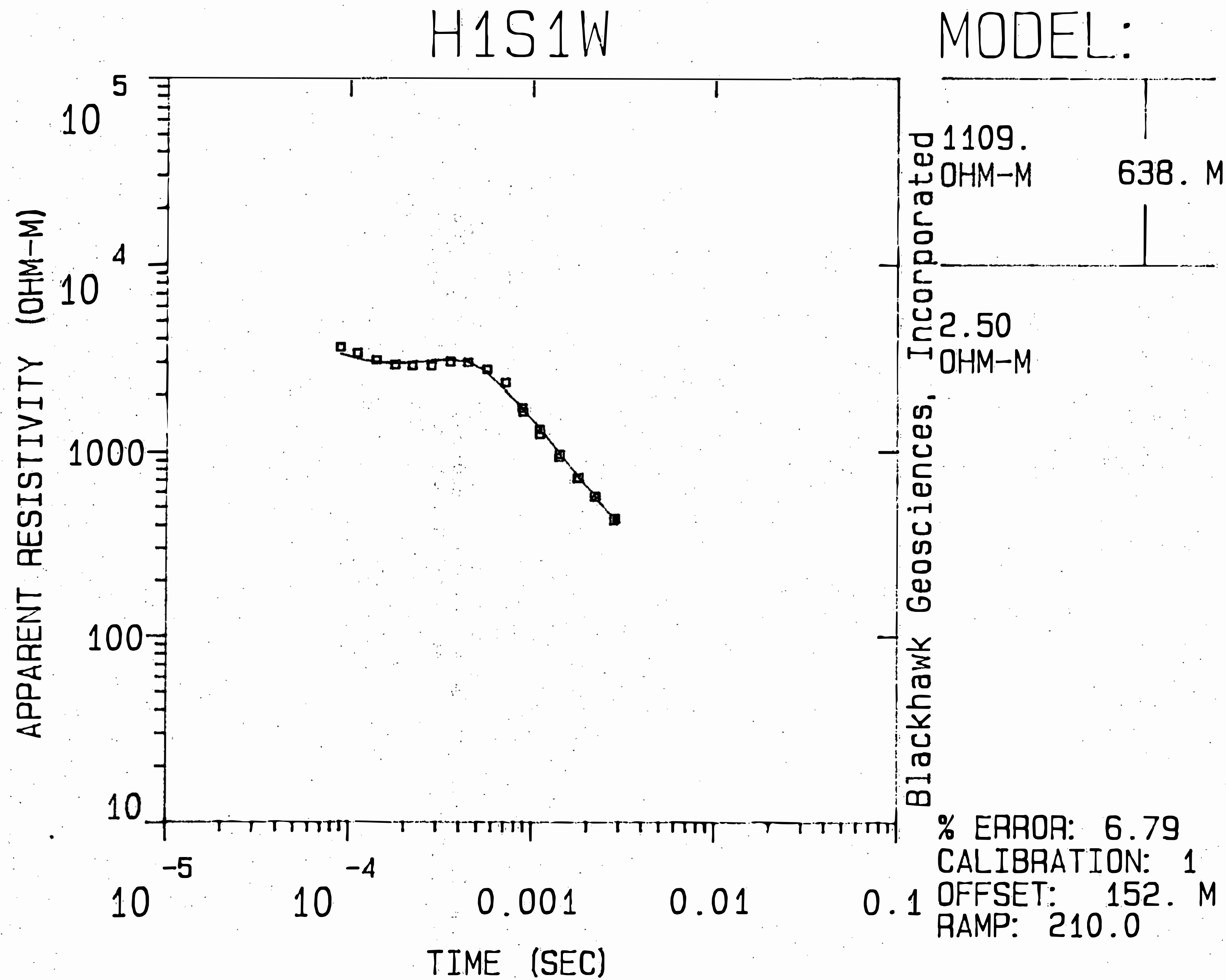
PROJECT NO.: 90019 FIGURE 4-1

5.0 CONCLUSIONS AND RECOMMENDATIONS

The results of the TDEM survey at the Haleakala Ranch property east of Wailea Maui are given in Figure 4-1. This map shows contours of the elevation of the interpreted top to the saline water across the property. The fresh water resource is expected to be the volume between sea level and the elevation of the interpreted top of saline water. Due to the relatively complex nature of the behavior of these elevation contours, geologic structures or lithologic changes may be present which may limit the applicability of the Ghyben-Herzberg relation for calculating static water levels.

Across the study area the depth to saline water is in excess of 200 ft below sea level, with the deepest portions (greater than 600 ft) towards the north and towards station 1N0E. Because of these relatively large depths, fresh water rather than brackish water is inferred.

The relatively small depth to saline water at high elevation (≈ 1,400 ft) near station 1S2W may infer a geologic structure in this area. Additional data, south of this station, would help to better define this potential structure.



H1S1W
MODEL:
1109.
OHM-M
638. M
2.50
OHM-M
Blackhawk Geosciences, Incorporated
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
% ERROR: 6.79
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

H1S1W

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		501.4	1645.0		
1108.58	638.0	-136.6	-448.1	0.6	0.6
2.50					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.59E+03	3.33E+03	7.760	
2	1.10E-04	3.34E+03	3.12E+03	7.049	
3	1.40E-04	3.08E+03	2.98E+03	3.094	
4	1.77E-04	2.89E+03	2.95E+03	-1.914	
5	2.20E-04	2.86E+03	3.00E+03	-4.416	
6	2.80E-04	2.86E+03	3.07E+03	-6.812	
7	3.55E-04	3.02E+03	3.10E+03	-2.689	
8	4.43E-04	2.98E+03	3.01E+03	-0.997	
9	5.64E-04	2.73E+03	2.64E+03	3.498	
10	7.13E-04	2.32E+03	2.08E+03	11.505	
11	8.81E-04	1.70E+03	1.68E+03	1.292	
12	8.90E-04	1.61E+03	1.66E+03	-2.879	
13	1.10E-03	1.30E+03	1.31E+03	-0.653	
14	1.10E-03	1.23E+03	1.31E+03	-6.176	
15	1.40E-03	9.26E+02	9.70E+02	-4.448	
16	1.41E-03	9.60E+02	9.60E+02	-0.061	
17	1.77E-03	7.12E+02	7.33E+02	-2.828	
18	1.80E-03	7.16E+02	7.21E+02	-0.749	
19	2.20E-03	5.67E+02	5.67E+02	-0.105	
20	2.22E-03	5.71E+02	5.60E+02	1.904	
21	2.80E-03	4.22E+02	4.26E+02	-0.921	
22	2.85E-03	4.32E+02	4.17E+02	3.608	

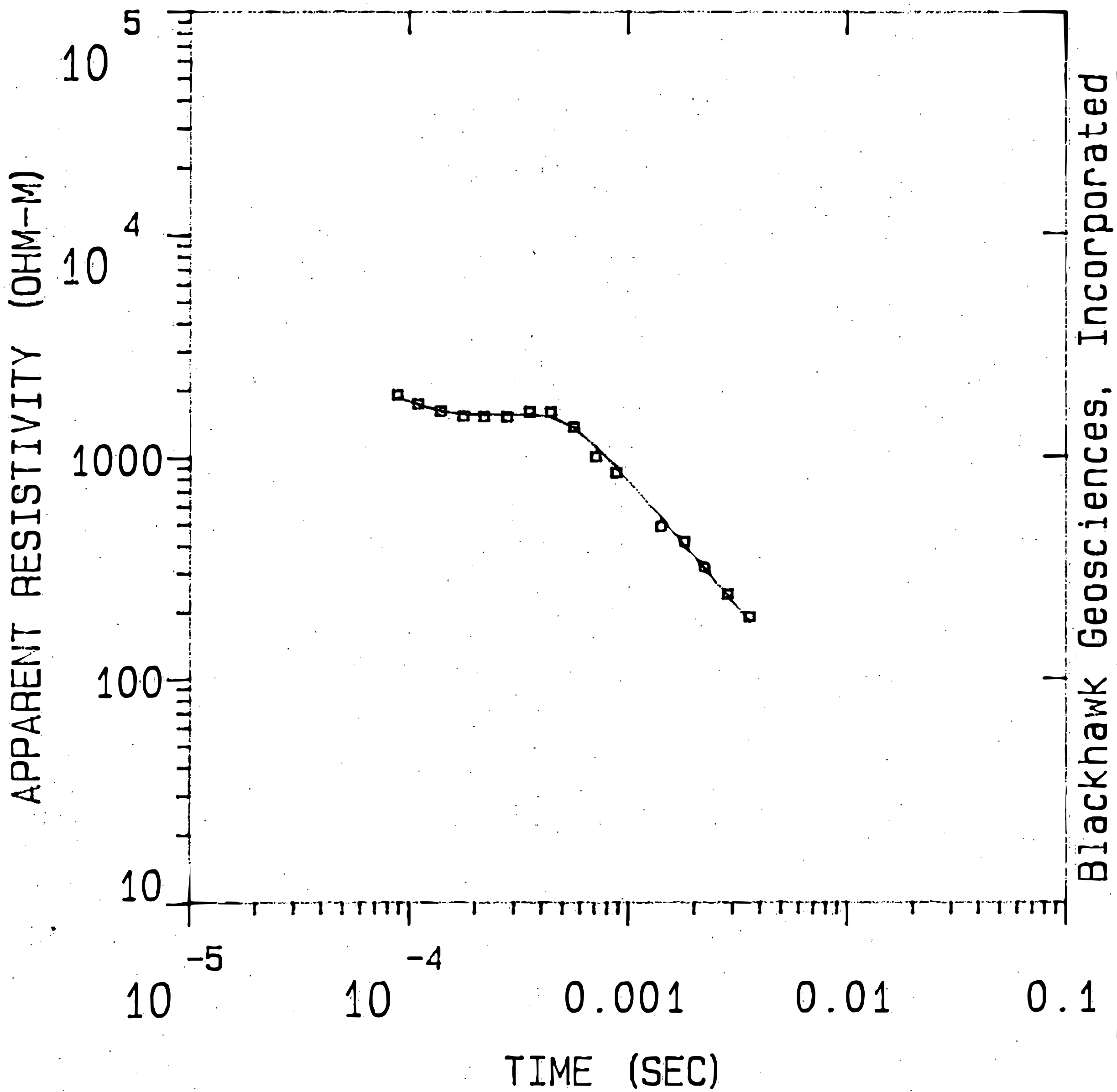
R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 22 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: H1S1W
0205 001S 001W Z OPR XTL L 6 8+100
Ch.21 = 0.21 Ch.22 = 0.89 Ch.23 = 21 Ch.24 = 92
RMS LOG ERROR: 2.85E-02, ANTILOG YIELDS 6.7902 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.16		
F 2	0.00	0.00	
T 1	-0.03	0.00	0.44
	P 1	F 2	T 1

H1S2W



MODEL:

604.
OHM-M

496. M

2.50
OHM-M

% ERROR: 6.62
CALIBRATION: 1
OFFSET: 152. M
RAMP: 220.0

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		429.8	1410.0		
603.53	496.0	-66.2	-217.2	0.8	0.8
2.50					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	1.90E+03	1.86E+03	2.329	
2	1.10E-04	1.73E+03	1.71E+03	1.129	
3	1.40E-04	1.60E+03	1.60E+03	-0.036	
4	1.77E-04	1.52E+03	1.55E+03	-1.840	
5	2.20E-04	1.51E+03	1.54E+03	-1.927	
6	2.80E-04	1.51E+03	1.55E+03	-2.627	
7	3.55E-04	1.59E+03	1.55E+03	3.016	
8	4.43E-04	1.58E+03	1.50E+03	5.277	
9	5.64E-04	1.36E+03	1.35E+03	0.792	
10	7.13E-04	9.99E+02	1.09E+03	-8.587	
11	8.81E-04	8.45E+02	8.90E+02	-5.125	
12	1.41E-03	4.86E+02	5.22E+02	-7.027	
13	1.80E-03	4.16E+02	3.96E+02	5.045	
14	2.22E-03	3.18E+02	3.10E+02	2.398	
15	2.85E-03	2.40E+02	2.33E+02	2.957	
16	3.60E-03	1.90E+02	1.79E+02	6.147	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
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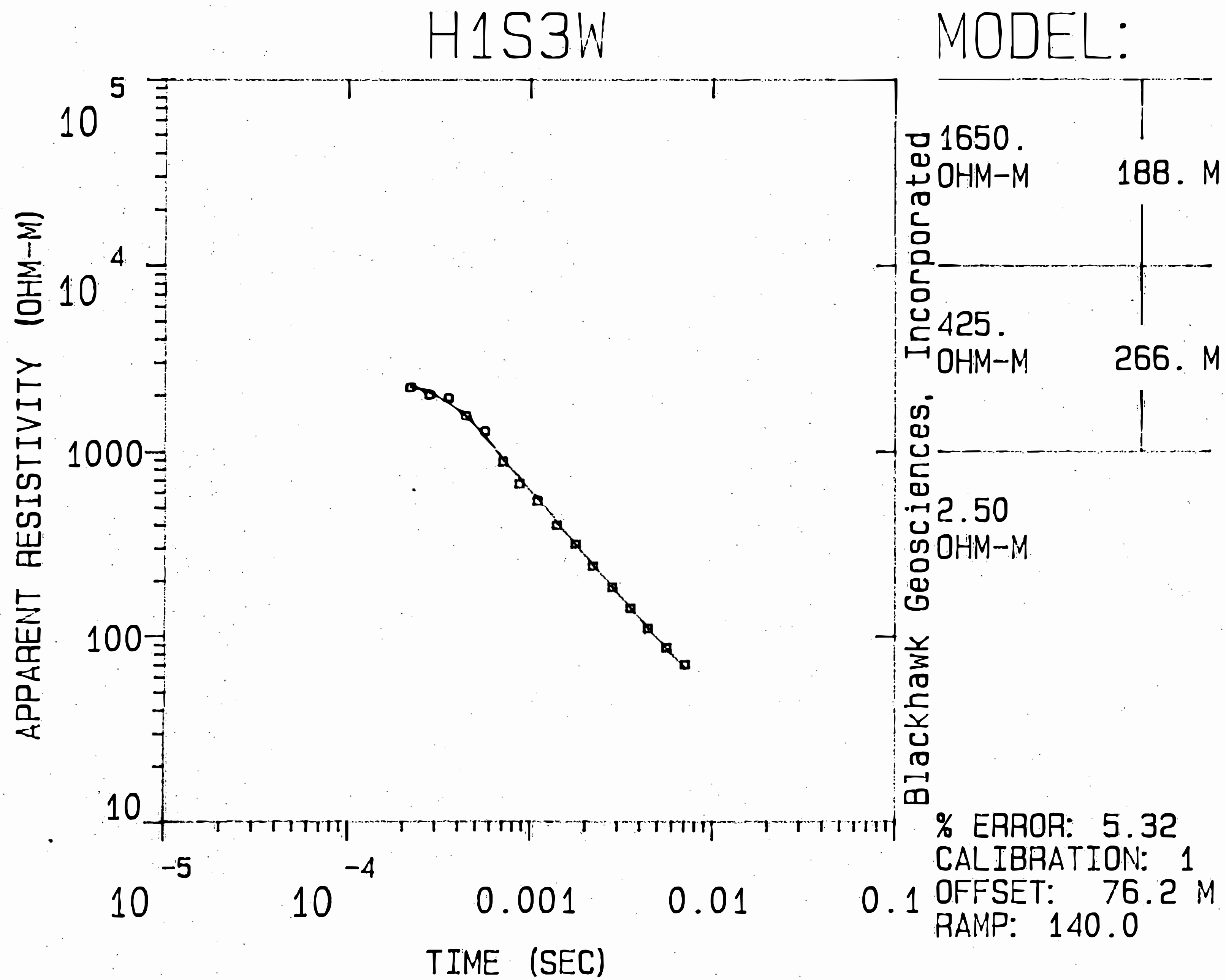
0305 001S 002W Z OPR XTL H 5 8+100
Ch.21 = 0.22 Ch.22 = 0.089 Ch.23 = 18.5 Ch.24 =
RMS LOG ERROR: 2.78E-02, ANTILOG YIELDS 6.6187 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	1.00		
F 2	0.00	0.00	
T 1	0.00	0.00	1.00
	P 1	F 2	T 1



H1S3W
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 5
10 4
1000
100
10
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
1650.
OHM-M
188. M
425.
OHM-M
266. M
2.50
OHM-M
% ERROR: 5.32
CALIBRATION: 1
OFFSET: 76.2 M
RAMP: 140.0

H1S3W

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		323.1	1060.0		
1649.73	188.4	134.7	441.9	0.1	0.1
425.46	265.9	-131.2	-430.4	0.6	0.7
2.50					

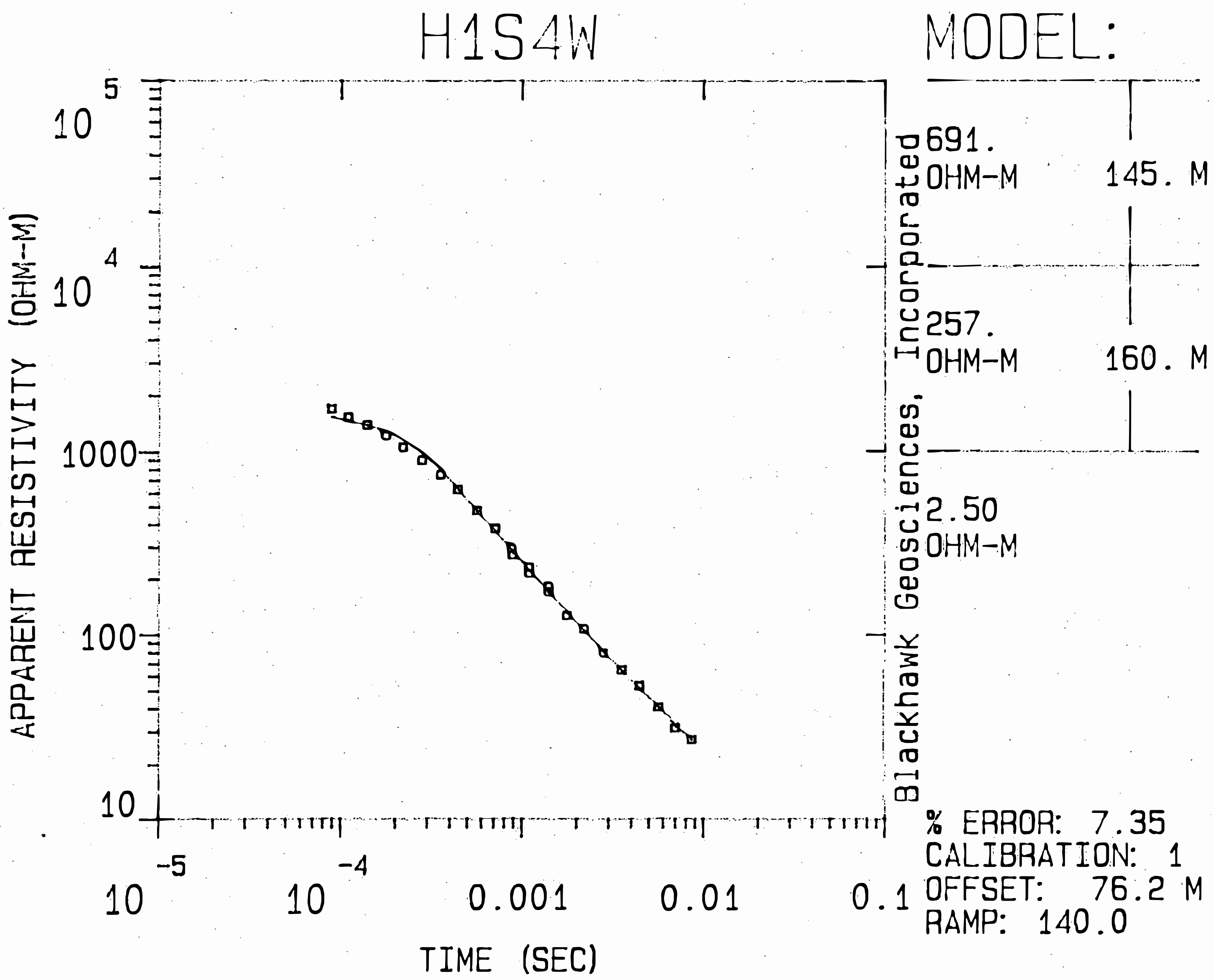
	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.20E-04	2.21E+03	2.23E+03	-1.185	
2	2.80E-04	2.01E+03	2.07E+03	-2.709	
3	3.55E-04	1.94E+03	1.82E+03	6.719	
4	4.43E-04	1.55E+03	1.54E+03	0.680	
5	5.64E-04	1.29E+03	1.21E+03	6.889	
6	7.13E-04	8.87E+02	9.12E+02	-2.719	
7	8.81E-04	6.77E+02	7.20E+02	-5.876	
8	1.10E-03	5.40E+02	5.58E+02	-3.169	
9	1.41E-03	4.08E+02	4.18E+02	-2.494	
10	1.80E-03	3.18E+02	3.13E+02	1.664	
11	2.22E-03	2.42E+02	2.45E+02	-1.053	
12	2.85E-03	1.85E+02	1.84E+02	0.354	
13	3.60E-03	1.42E+02	1.42E+02	0.070	
14	4.49E-03	1.11E+02	1.11E+02	-0.297	
15	5.70E-03	8.75E+01	8.59E+01	1.828	
16	7.19E-03	7.09E+01	6.73E+01	5.265	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
TDHZ ARRAY, 16 DATA POINTS, RAMP: 140.0 MICROSEC, DATA: H1S3W
0305 001S 003W Z OPR XTL H 6 8+100
Ch.21 = 0.14 Ch.22 = 0.089 Ch.23 = 22 Ch.24 = 2
RMS LOG ERROR: 2.25E-02, ANTILOG YIELDS 5.3162 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.11				
P 2	0.12	0.38			
F 3	0.00	0.00	0.00		
T 1	0.09	0.33	0.00	0.61	
T 2	-0.10	-0.22	0.00	0.27	0.78
	P 1	P 2	F 3	T 1	T 2



H1S4W
MODEL:
691.
OHM-M
145. M
257.
OHM-M
160. M
2.50
OHM-M
APPARENT RESISTIVITY (OHM-M)
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 7.35
CALIBRATION: 1
OFFSET: 76.2 M
RAMP: 140.0

H1S4W

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		234.7	770.0		
690.76	144.9	89.8	294.7	0.2	0.2
257.41	159.6	-69.9	-229.5	0.6	0.8
2.50					

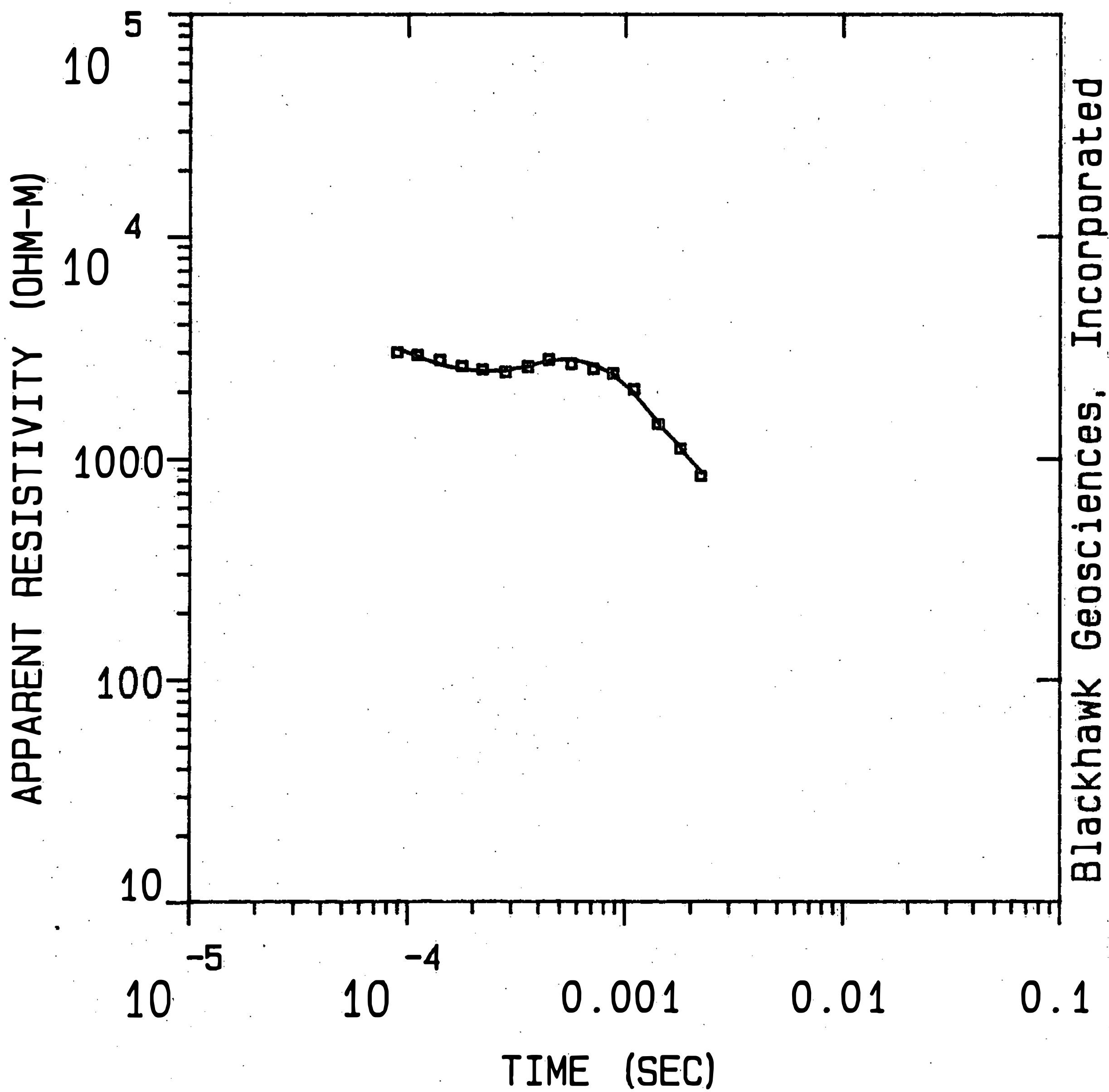
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	1.70E+03	1.55E+03	10.038	
2	1.10E-04	1.53E+03	1.46E+03	5.264	
3	1.40E-04	1.39E+03	1.38E+03	0.683	
4	1.77E-04	1.22E+03	1.29E+03	-5.496	
5	2.20E-04	1.06E+03	1.16E+03	-8.548	
6	2.80E-04	8.99E+02	9.79E+02	-8.142	
7	3.55E-04	7.49E+02	7.94E+02	-5.632	
8	4.43E-04	6.25E+02	6.25E+02	0.035	
9	5.64E-04	4.78E+02	4.74E+02	0.741	
10	7.13E-04	3.81E+02	3.66E+02	4.109	
11	8.81E-04	2.96E+02	2.87E+02	3.115	
12	8.90E-04	2.71E+02	2.84E+02	-4.280	
13	1.10E-03	2.34E+02	2.24E+02	4.479	
14	1.10E-03	2.15E+02	2.23E+02	-3.605	
15	1.40E-03	1.70E+02	1.70E+02	-0.069	
16	1.41E-03	1.83E+02	1.69E+02	8.503	
17	1.77E-03	1.27E+02	1.32E+02	-3.598	
18	2.20E-03	1.08E+02	1.04E+02	3.167	
19	2.80E-03	8.00E+01	8.12E+01	-1.486	
20	3.55E-03	6.50E+01	6.37E+01	2.034	
21	4.43E-03	5.34E+01	5.12E+01	4.205	
22	5.64E-03	4.10E+01	4.08E+01	0.459	
23	7.13E-03	3.19E+01	3.29E+01	-3.055	
24	8.81E-03	2.76E+01	2.74E+01	0.447	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
TDHZ ARRAY, 24 DATA POINTS, RAMP: 140.0 MICROSEC, DATA: H1S4W
0305 0015 004W Z OFR XTL H 5 8+100
Ch.21 = 0.14 Ch.22 = 0.089 Ch.23 = 22 Ch.24 = 2
RMS LOG ERROR: 3.08E-02, ANTILOG YIELDS 7.3519 %
LATE TIME PARAMETERS

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.33				
P 2	0.26	0.26			
F 3	0.00	0.00	0.00		
T 1	0.20	0.21	0.00	0.62	
T 2	-0.20	-0.18	0.00	0.34	0.66
	P 1	P 2	F 3	T 1	T 2

H1N1E



MODEL:

1112.
OHM-M

768. M

2.50
OHM-M

% ERROR: 4.89
CALIBRATION: 1
OFFSET: 152. M
RAMP: 210.0

HINIE

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		635.5	2085.0		
1112.11	767.7	-132.2	-433.7	0.7	0.7
2.50					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.99E+03	3.13E+03	-4.468	
2	1.10E-04	2.91E+03	2.85E+03	2.006	
3	1.40E-04	2.77E+03	2.63E+03	5.128	
4	1.77E-04	2.59E+03	2.50E+03	3.540	
5	2.20E-04	2.51E+03	2.46E+03	2.043	
6	2.80E-04	2.45E+03	2.49E+03	-1.751	
7	3.55E-04	2.59E+03	2.61E+03	-0.748	
8	4.43E-04	2.79E+03	2.76E+03	0.905	
9	5.64E-04	2.66E+03	2.81E+03	-5.475	
10	7.13E-04	2.53E+03	2.63E+03	-3.946	
11	8.81E-04	2.41E+03	2.38E+03	1.330	
12	1.10E-03	2.05E+03	1.95E+03	4.921	
13	1.41E-03	1.43E+03	1.44E+03	-0.629	
14	1.78E-03	1.11E+03	1.12E+03	-0.228	
15	2.21E-03	8.39E+02	8.63E+02	-2.846	

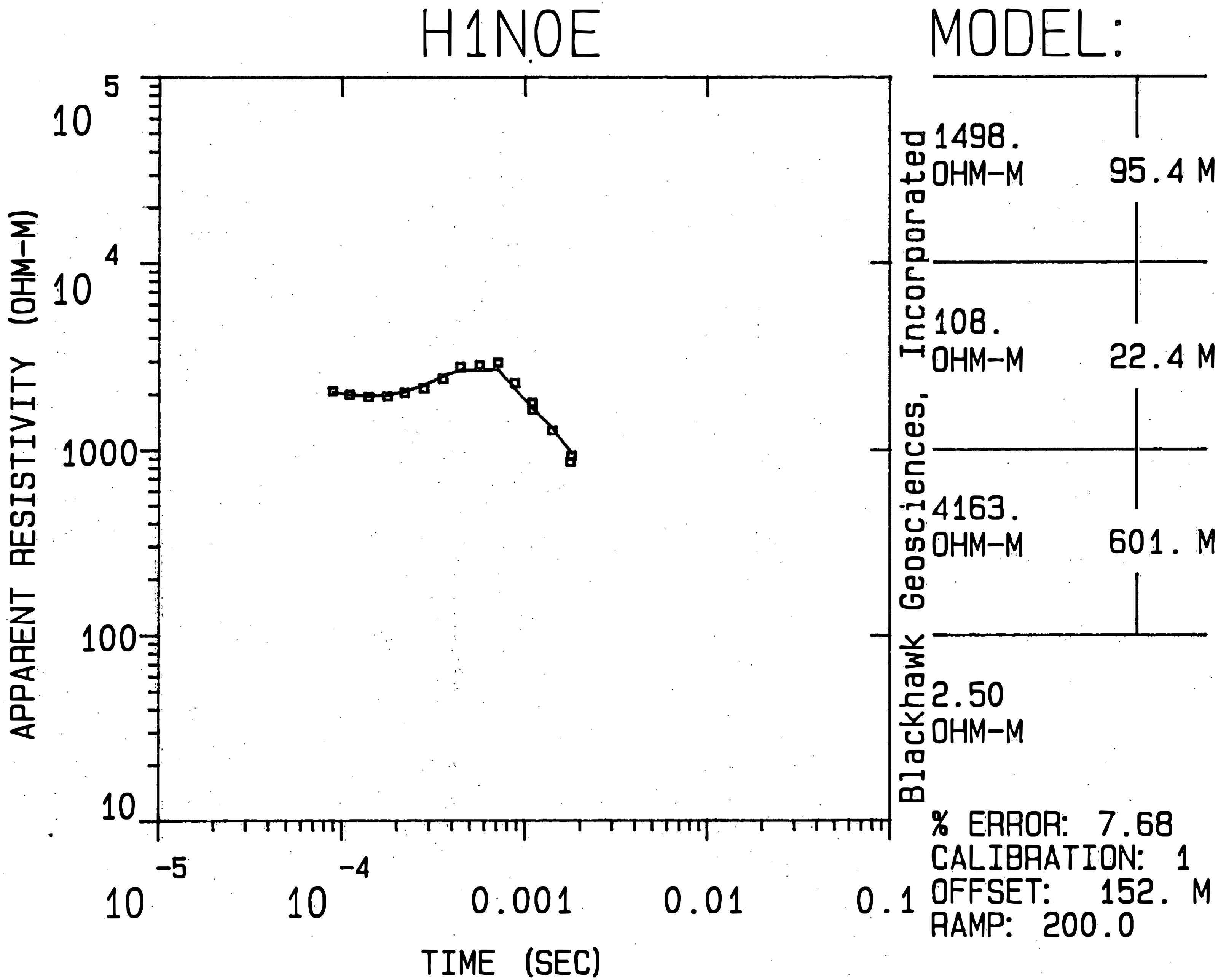
R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
CLHZ ARRAY, 15 DATA POINTS, RAMP: 210.0 MICROSEC, DATA: H1N1E

RMS LOG ERROR: 2.07E-02, ANTILOG YIELDS 4.8916 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.29		
F 2	0.00	0.00	
T 1	-0.08	0.00	0.35
	P 1	F 2	T 1



H1N0E
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 5
10 4
1000
100
10
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
1498.
OHM-M
95.4 M
108.
OHM-M
22.4 M
4163.
OHM-M
601. M
2.50
OHM-M
% ERROR: 7.68
CALIBRATION: 1
OFFSET: 152. M
RAMP: 200.0

H1NOE

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		524.3	1720.0		
1498.12	95.4	428.9	1407.0	0.1	0.1
108.16	22.4	406.4	1333.5	0.2	0.3
4162.64	601.0	-194.6	-638.3	0.1	0.4
2.50					

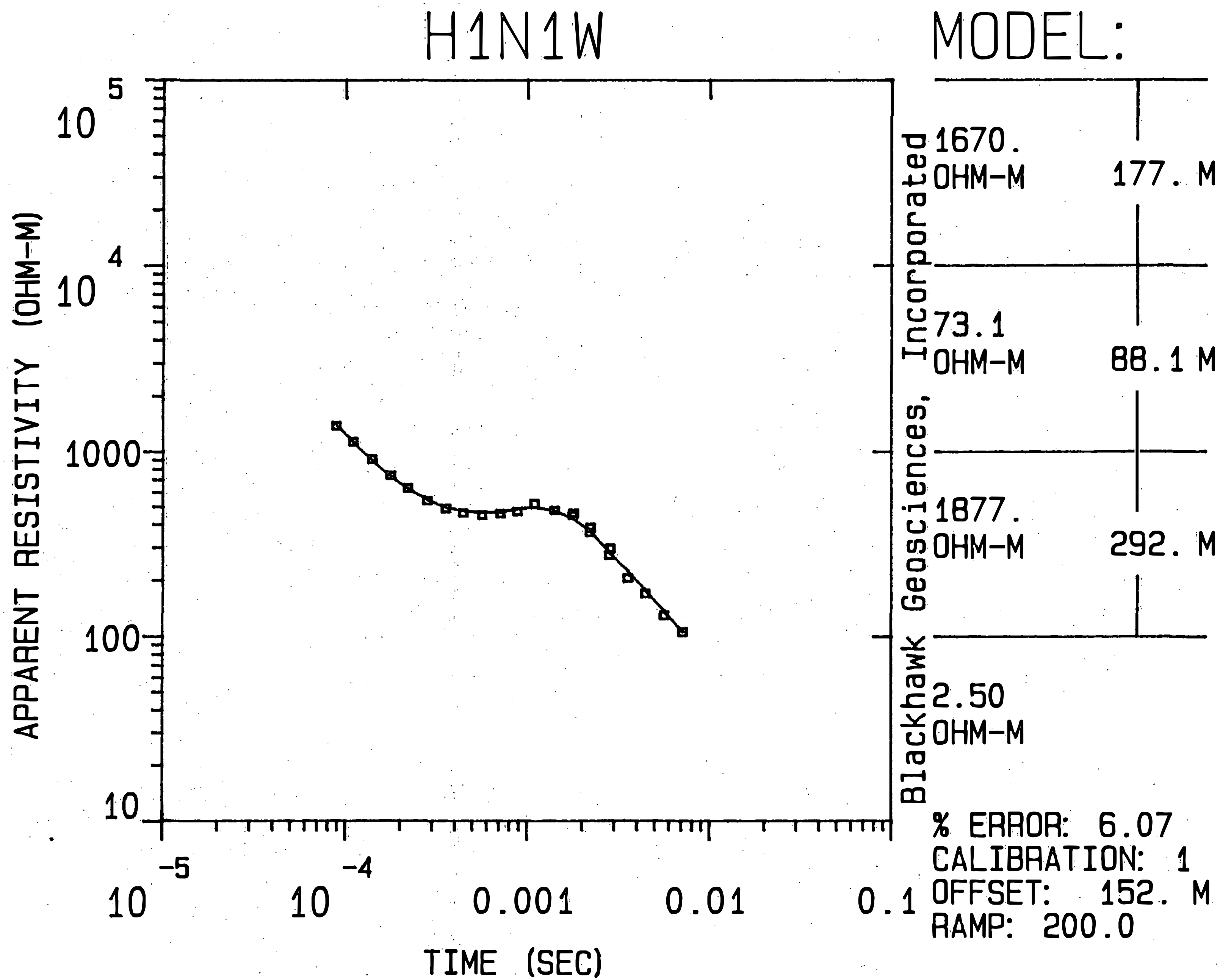
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.07E+03	2.06E+03	0.541	
2	1.10E-04	1.98E+03	1.98E+03	0.285	
3	1.40E-04	1.93E+03	1.94E+03	-0.458	
4	1.77E-04	1.94E+03	1.98E+03	-1.965	
5	2.20E-04	2.04E+03	2.07E+03	-1.605	
6	2.80E-04	2.16E+03	2.25E+03	-3.774	
7	3.55E-04	2.43E+03	2.53E+03	-3.916	
8	4.43E-04	2.80E+03	2.70E+03	3.645	
9	5.64E-04	2.86E+03	2.69E+03	6.134	
10	7.13E-04	2.95E+03	2.72E+03	8.373	
11	8.81E-04	2.30E+03	2.14E+03	7.412	
12	1.10E-03	1.80E+03	1.69E+03	6.306	
13	1.10E-03	1.65E+03	1.68E+03	-1.962	
14	1.41E-03	1.28E+03	1.31E+03	-2.328	
15	1.77E-03	8.67E+02	9.74E+02	-10.964	
16	1.80E-03	9.34E+02	9.57E+02	-2.411	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 16 DATA POINTS, RAMP: 200.0 MICROSEC, DATA: H1NOE
0105 001N 000E Z OPR XTL H 5 8+100
Ch.21 = 0.2 Ch.22 = 0.089 Ch.23 = 20.5 Ch.24 =
RMS LOG ERROR: 3.21E-02, ANTILOG YIELDS 7.6830 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.42						
P 2	0.09	0.48					
P 3	0.01	0.08	0.03				
F 4	0.00	0.00	0.00	0.00			
T 1	0.02	0.04	-0.02	0.00	0.11		
T 2	-0.08	-0.45	-0.09	0.00	0.00	0.45	
T 3	0.01	0.00	0.01	0.00	0.14	0.01	0.94
	P 1	P 2	P 3	F 4	T 1	T 2	T 3


H1N1W
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
1670. OHM-M
177. M
73.1 OHM-M
88.1 M
1877. OHM-M
292. M
2.50 OHM-M
% ERROR: 6.07
CALIBRATION: 1
OFFSET: 152. M
RAMP: 200.0

H1N1W

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		399.3	1310.0		
1670.48	176.8	222.4	729.8	0.1	0.1
73.06	88.1	134.4	440.9	1.2	1.3
1876.68	291.6	-157.2	-515.7	0.2	1.5
2.50					

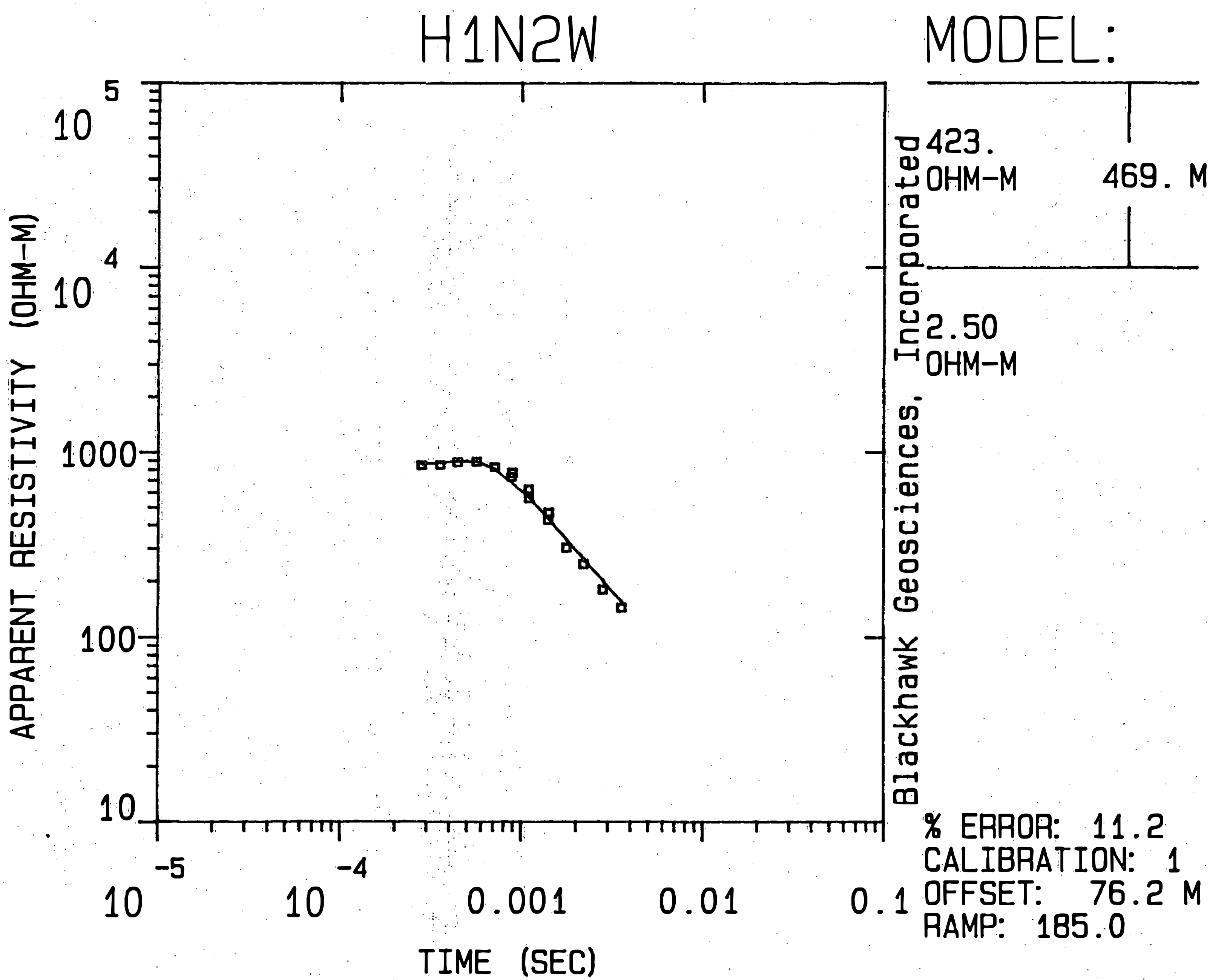
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	1.38E+03	1.41E+03	-2.173	
2	1.10E-04	1.13E+03	1.13E+03	0.563	
3	1.40E-04	9.10E+02	8.90E+02	2.179	
4	1.77E-04	7.42E+02	7.29E+02	1.747	
5	2.20E-04	6.31E+02	6.24E+02	1.075	
6	2.80E-04	5.39E+02	5.44E+02	-0.911	
7	3.55E-04	4.89E+02	4.95E+02	-1.229	
8	4.43E-04	4.63E+02	4.74E+02	-2.266	
9	5.64E-04	4.49E+02	4.62E+02	-2.748	
10	7.13E-04	4.59E+02	4.67E+02	-1.897	
11	8.81E-04	4.71E+02	4.91E+02	-4.139	
12	1.10E-03	5.20E+02	4.98E+02	4.451	
13	1.41E-03	4.78E+02	4.73E+02	1.039	
14	1.77E-03	4.47E+02	4.28E+02	4.545	
15	1.80E-03	4.59E+02	4.25E+02	8.119	
16	2.20E-03	3.61E+02	3.68E+02	-1.747	
17	2.22E-03	3.85E+02	3.64E+02	5.899	
18	2.80E-03	2.73E+02	2.83E+02	-3.613	
19	2.85E-03	2.98E+02	2.78E+02	7.228	
20	3.55E-03	2.05E+02	2.23E+02	-8.022	
21	4.43E-03	1.69E+02	1.76E+02	-3.841	
22	5.64E-03	1.29E+02	1.35E+02	-4.314	
23	7.13E-03	1.06E+02	1.06E+02	0.164	

R: 152. X: 0. Y: 152. DL: 305. REQ: 169. CF: 1.0000
TDHZ ARRAY, 23 DATA POINTS, RAMP: 200.0 MICROSEC, DATA: H1N1W
0205 001N 001W Z DPR XTL H 5 8+100
Ch.21 = 0.2 Ch.22 = 0.089 Ch.23 = 19 Ch.24 = 92
RMS LOG ERROR: 2.56E-02, ANTILOG YIELDS 6.0659 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.13						
P 2	0.03	0.52					
P 3	0.00	0.02	0.00				
F 4	0.00	0.00	0.00	0.00			
T 1	0.05	0.16	0.00	0.00	0.84		
T 2	-0.03	-0.41	-0.02	0.00	0.06	0.43	
T 3	-0.03	0.01	0.01	0.00	0.06	0.09	0.87
	P 1	P 2	P 3	F 4	T 1	T 2	T 3


H1N2W
MODEL:
423.
OHM-M
469. M
2.50
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^5
10^4
1000
100
10
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 11.2
CALIBRATION: 1
OFFSET: 76.2 M
RAMP: 185.0

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		329.2	1080.0		
422.66	469.1	-139.9	-459.0	1.1	1.1
2.50					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.80E-04	8.52E+02	8.70E+02	-2.050	
2	3.55E-04	8.52E+02	8.86E+02	-3.878	
3	4.43E-04	8.83E+02	9.02E+02	-2.084	
4	5.64E-04	8.89E+02	8.93E+02	-0.433	
5	7.13E-04	8.29E+02	8.02E+02	3.390	
6	8.81E-04	7.32E+02	6.81E+02	7.497	
7	8.90E-04	7.73E+02	6.75E+02	14.476	
8	1.10E-03	6.27E+02	5.66E+02	10.921	
9	1.10E-03	5.58E+02	5.64E+02	-0.946	
10	1.405E-03	4.27E+02	4.34E+02	-1.622	
11	1.41E-03	4.69E+02	4.30E+02	8.991	
12	1.77E-03	3.03E+02	3.33E+02	-9.132	
13	2.20E-03	2.47E+02	2.62E+02	-5.969	
14	2.30E-03	1.80E+02	2.01E+02	-10.237	
15	3.55E-03	1.44E+02	1.54E+02	-6.837	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
TDHZ ARRAY, 15 DATA POINTS, RAMP: 185.0 MICROSEC, DATA: H1N2W
0205 001N 002W Z OPR XTL L 6 8+100
Ch.21 = 0.185 Ch.22 = 0.89 Ch.23 = 25 Ch.24 = 2
RMS LOG ERROR: 4.61E-02, ANTILOG YIELDS 11.2070 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.15		
F 2	0.00	0.00	
T 1	-0.01	0.00	0.45
	P 1	F 2	T 1