

1984/81. SCHTRAV - A FORTRAN program to calculate apparent resistivities for traverses using the generalised Schlumberger array (Revision 1).

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Abstract

SCHTRAV is a FORTRAN program which interactively calculates and tabulates generalised Schlumberger array apparent resistivity values without approximating the geometrical factor. An automatic position facility (for equal interval traverses) is available during interactive data reduction. On line record editing and display options are also available.

INTRODUCTION

SCHTRAV is written in FORTRAN 77 and runs interactively through a .CSS on the Tasmania Department of Mines Perkin-Elmer 8/32 mini-computer. Field data from a generalised Schlumberger array are input and the program calculates the apparent resistivities. Previously the resultant file of apparent resistivities had to be edited later, if necessary, through the Perkin-Elmer edit facilities (Hudspeth, 1984) but editing may now be done interactively through the program while reducing data.

THE APPARENT RESISTIVITY FORMULA

Parasnis (1973) gives the apparent resistivity of the generalised Schlumberger resistivity array as

$$\rho_a = \frac{\pi}{2l} \cdot \frac{(L^2 - x^2)^2}{L^2 + x^2} \cdot \frac{\Delta V}{I}$$

provided that the potential probes are sufficiently far from either current electrode, say at least 10 times the distance $2l$. ΔV is the voltage between the potential electrodes, I is the current in the ground, L , l and x are as shown in Figure 1.

As programmable pocket calculators and computing facilities are now ubiquitous it seems unnecessary to use the above approximate formula. The apparent resistivity of any four electrode resistivity array is as follows

$$\rho_a = \frac{\Delta V}{I} \cdot 2\pi \frac{1}{\left(\frac{1}{C_1P_1} - \frac{1}{C_2P_1} - \frac{1}{C_1P_2} + \frac{1}{C_2P_2}\right)}$$

where P_1 , P_2 are the potential electrodes; C_1 , C_2 are the current electrodes; C_1P_1 is the distance between C_1 and P_1 , etc. The expression in this form is used by SCHTRAV to calculate the apparent resistivity. As a matter of interest, we shall now transform the expression, without approximation, so that it resembles the approximate formula.

$$\begin{aligned} \Delta V &= \frac{I\rho}{2\pi} \left\{ \left(\frac{1}{C_1P_1} - \frac{1}{C_2P_1}\right) - \left(\frac{1}{C_1P_2} - \frac{1}{C_2P_2}\right) \right\} \\ &= \frac{I\rho}{2\pi} \left(\frac{1}{L-l-x} - \frac{1}{L+l+x} - \frac{1}{L+l-x} + \frac{1}{L-l+x}\right) \quad \text{for } L \gg x \end{aligned}$$

$$\therefore \rho = \frac{2\pi\Delta V}{I} \frac{1}{\left(\frac{1}{L-(l+x)} - \frac{1}{L+(l+x)} - \frac{1}{L-(x-l)} + \frac{1}{L+(x-l)}\right)}$$

$$= \frac{2\pi\Delta V}{I} \frac{1}{\left(\frac{2(I+x)(L^2-(x-l)^2) + 2(l-x)(L^2-(l+x)^2)}{(L^2-(l+x)^2)(L^2-(x-l)^2)} \right)}$$

$$\therefore \rho = \frac{2\pi\Delta V}{I} \frac{L^4 - L^2[(I+x)^2 + (l-x)^2] + (I+x)^2(l-x)^2}{2l(L^2-(l-x)^2) + L^2-(l+x)^2 + 2x((I+x)^2 - (l-x)^2)}$$

$$\therefore \rho = \frac{2\pi\Delta V}{I} \frac{L^4 - 2(l^2+x^2)L^2 + l^4 - 2x^2l^2 + x^4}{4l(L^2 - l^2 - x^2 + 2x^2)}$$

$$\therefore \rho = \frac{\pi}{2l} \frac{\Delta V}{I} \frac{(L^2-x^2)^2}{L^2+x^2} \dots - \frac{2l^2L^2 + l^4 - 2x^2l^2}{-l^2}$$

which reduces to the approximate formula when $(L-x) \gg 2l$.

INTERACTIVE RUNNING

To start the program type 'SCHTRAV X.Y', where X.Y is the name you give to the file which will contain the reduced data. The screen will respond with

"THIS IS AN ASYMMETRICAL SCHLUMBERGER ARRAY PROGRAM.
 IF YOUR ARRAY IS NOT SCHLUMBERGER THEN YOU HAVE THE
 WRONG PROGRAM.
 ENTER NAME AND NUMBER OF TRAVERSE (80 CHARACTERS MAXIMUM)"

Enter name and number of traverse (80 characters maximum), then enter title/number etc. of traverse and this will be written as the first line of your file, followed by the line:

"ASYMMETRICAL SCHLUMBERGER ARRAY"

and the screen will then respond with:

"DO YOU WISH TO ENTER FURTHER INFORMATION?
 (E.G. DATE, LOCATION, COMMENT)"

If your reply is "Y" for yes the response is:

"ENTER A LINE OF INFO., 80 CHARS.MAX."

and you should then enter up to 80 characters of information. The screen will continue to request a line (80 characters) of header information while you continue to respond with "Y" to "DO YOU WISH TO ENTER FURTHER INFORMATION?" In response to "N", the screen will ask for field data, beginning with:

"ENTER HALF CURRENT ELECTRODE SPACING"

followed by:

"ENTER HALF POTENTIAL ELECTRODE SPACING"

The required values should be in metres, and will be written into the file header information.

The next screen response is:

"DO YOU WISH TO ENTER DATA IN AUTOMATIC OR MANUAL MODE?" (A/M)

If you answer A (for AUTOMATIC) the computer will display successive potential electrode positions and you will only have to enter $\Delta V/I$. If you answer M (for MANUAL) the computer will require you to enter both the mean position of the potential electrodes and $\Delta V/I$.

The screen response to A is:

"ENTER FIRST (CENTRE) POSITION OF POTENTIAL ELECTRODES
AND POSITION INCREMENT, IN METRES
POSITIVE FOR N OR E, NEGATIVE FOR S OR W
INCREMENT MUST HAVE APPROPRIATE SIGN
..... POSITIVE IF MOVING TO MORE POSITIVE POSITION
AND NEGATIVE IF MOVING TO MORE NEGATIVE POSITION"

After entering these values the screen response is:

"ENTER RESISTANCE VALUE FOR ELECTRODE POSITIONS
x1 AND x2 TYPE 0.0 TO QUIT OR EDIT",

where x1 and x2 appear as the appropriate numbers.

Entering the resistance value will cause the screen to display the calculated apparent resistivity, the potential probes centre position, the positions of the potential probes, and the resistance value ($\Delta V/I$).

The program will continue to type the next potential probe positions and prompt for the resistance value unless the user suspends the automatic mode by typing "0.0".

If you answer M (for MANUAL) then the screen response will be:

"ENTER POTENTIAL PROBE POSITION FROM CENTRE, RESISTANCE
TYPE 0.0, 0.0 TO QUIT OR EDIT".

"Centre" is the midpoint of the current electrodes.

In response to these values the request will be repeated until "0.0,0.0" is entered, upon which the manual mode will be suspended.

The user is protected throughout the program against failure to supply an answer known to the computer. For example, failure to respond with A or M to the query about automatic or manual mode will invoke the response:

"ANSWER A or M"

INTERACTIVE RUNNING - EDITING

When either mode (automatic or manual) is suspended the screen response is

"DISPLAY, EDIT OR QUIT? (D/E/Q)".

Responding with "Q" will terminate the program. Responding with "D" will cause the screen response

"ENTER START AND FINISH NUMBERS FOR DISPLAY"

to which you should respond with the start and finish record numbers

defining the range you wish to see, e.g. 3,22. It should be noted that the number of records contained in the header will be seven plus however many "further information" records you have written. The requested records will be displayed on the screen. If the finish number you have entered does not exist, then the message

"ATTEMPT TO READ PAST END OF FILE"

will be displayed but program execution will not be affected. Responding with "E" will cause the screen to ask

"CHANGE, REPEAT, DISPLAY OR EXIT-EDIT?
(C , R , D OR X)"

The "D" option here is the same as the "D" option already described. Responding with "X" will cause the data entry mode (manual or automatic) to resume where it left off when it was suspended. Respond with "C" if you wish to change a record and the screen prompt will be

"ENTER POTENTIAL PROBE POSITION FROM CENTRE, RESISTANCE
OF ENTRY TO BE CHANGED".

(If you are not sure of the incorrect values currently residing in the record to be corrected, then you should use the display option to find out before using the change option. If you select "C" and then realise you do not know the required values, enter any pair of values which are not on a record and you will then be able to select "D" immediately after the search is complete).

Upon entry of these values the records will be searched from the last entry backwards until either the specified record is found or illegal characters are encountered (e.g. the search examines the last header record). If illegal characters are encountered the screen message is

"ILLEGAL CHARACTERS OR VALUES NOT FOUND"

which in the vast majority of cases will mean that the record required was not found and the search terminated when the "illegal" characters of the last header record were found. During the search the record number, potential probes centre position and the resistance of each record examined is displayed, together with the target position and resistance. When the record for correction is located it is displayed together with the message

"THIS IS THE LINE TO BE CHANGED ENTER CORRECT
VALUES FOR POSITION AND RESISTANCE".

When this has been done, the option "R" may be selected, in which case the record following the record just corrected is now displayed for correction together with the correction prompt used for "C". "R" may only be selected following selection of either "R" or "C".

REFERENCES

PARASNIS, D.S. 1983. *Mining geophysics. Methods in geochemistry and geophysics 3*. Elsevier : Amsterdam.

HUDSPETH, J.W. 1984. SCHTRAV - a FORTRAN program to calculate apparent resistivity arrays using the generalised Schlumberger array. *Unpubl. Rep.Dep.Mines Tasm.* 1984/1.

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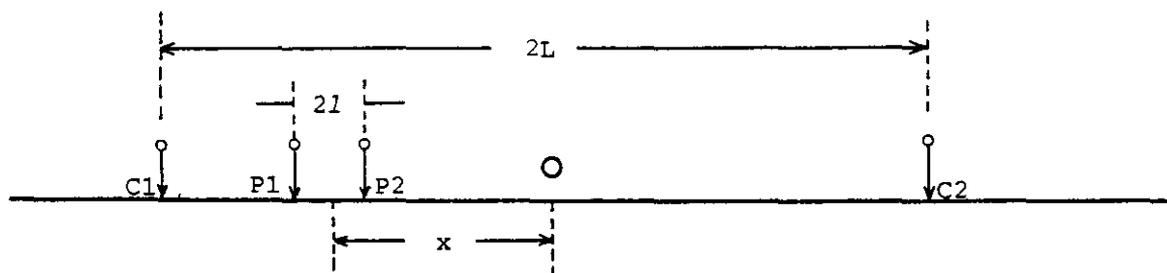
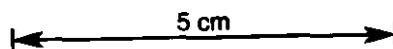


Figure 1.



APPENDIX 1
SCHTRAV listing

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C PROGRAM SCHTRAV
C A PROGRAM TO CALCULATE APPARENT RESISTIVITIES
C FOR THE GENERALISED SCHLUMBERGER ARRAY
C POTSPH IS THE HALF POTENTIAL ELECTRODE SPACING,
C CURSPH IS THE HALF CURRENT ELECTRODE SPACING, YEWRES IS
C DELTA-V ON I (SUPPLIED DIRECTLY AS 'RESISTANCE' READING
C FROM YEW RESISTIVITY METER. THE APPARENT RESISTIVITY
C AND THE CORRESPONDING HALF CURRENT ELECTRODE SPACING
C ARE WRITTEN TO A FILE ASSIGNED TO LU3. JWH,7-83.
C CHARACTER#1 ANS,MODE,EDIT
C CHARACTER#80 HEADER,ALINE
C PI=3.141
C IREC=1
C EDIT='X'
C FACT=PI/4.0
C
C WRITE HEADER INFORMATION TO LU3
C
C WRITE (5,20)
C 20 FORMAT(1X,///, ' THIS IS AN ASYMMETRICAL SCHLUMBERGER ARRAY',
C 1 ' PROGRAM',///,
C 2 ' IF YOUR ARRAY IS NOT SCHLUMBERGER, THEN YOU HAVE THE',
C 3 ' WRONG PROGRAM.',///, ' ENTER NAME AND NUMBER OF ',
C 4 ' TRAVERSE (80 CHARACTERS MAXIMUM)')
C READ (5,22) HEADER
C 22 FORMAT (A80)
C WRITE (3,23) HEADER
C IREC=3
C 23 FORMAT(1X,A80,/, ' ASYMMETRICAL SCHLUMBERGER ARRAY')
C 24 WRITE (5,25)
C 25 FORMAT (1X, 'DO YOU WISH TO ENTER FURTHER INFORMATION?',/,
C 1 ' (E.G. DATE, LOCATION, COMMENT)')
C READ(5,26) ANS
C 26 FORMAT (A1)
C 27 IF (ANS.NE.'N'.AND.ANS.NE.'Y') THEN
C WRITE (5,28)
C 28 FORMAT(1X,'ANSWER N OR Y')
C READ(5,26) ANS
C GO TO 27
C ELSE
C IF(ANS.EQ.'Y') THEN
C WRITE (5,29)
C 29 FORMAT(1X,'ENTER A LINE OF INFO., 80 CHARS MAX.')
C READ(5,31) HEADER
C 31 FORMAT (A80)
C WRITE (3,33) HEADER
C IREC=IREC+1
C 33 FORMAT(1X,A80)
C GO TO 24
C ENDIF
C ENDIF
C
C ENTER ELECTRODE CONFIGURATION VALUES, ALSO ENTERED IN OUTPUT DATA
C FILE AS HEADER INFORMATION.
C
C 50 WRITE (5,100)
C 100 FORMAT(1X,'ENTER HALF CURRENT ELECTRODE SPACING')
C READ(5,*,ERR=50) CURSPH
C WRITE(3,101) CURSPH
C 101 FORMAT(' HALF CURRENT ELECTRODE SPACING IS',F8.1,' METRES')
C 103 WRITE (5,104)

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104 FORMAT (1X,'ENTER ',/,7X,'HALF POTENTIAL ELECTRODE SPACING')
C READ(5,*,ERR=103) POTSPH
C WRITE(3,105) POTSPH
105 FORMAT(' HALF POTENTIAL ELECTRODE SPACING IS',F8.1,' METRES')
C WRITE(3,36)
36 FORMAT(3X,'APPARENT',9X,'POSITION',16X,'POTENTIAL',17X,'YEW',
1/,2X,'RESISTIVITY',31X,'POSITIONS',15X,'READINGS')
C WRITE (3,37)
C IREC=IREC+5
37 FORMAT(1X,'XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX')
C
C END OF HEADER INFORMATION
C IN AUTOMATIC MODE THE POTENTIAL PROBES' CENTRE POSITION IS AUTOMATICALLY
C INCREMENTED AND DISPLAYED TOGETHER WITH A PROMPT TO ENTER THE
C CORRESPONDING RESISTANCE VALUE.
C IN MANUAL MODE BOTH RESISTANCE AND THE POTENTIAL PROBES' CENTRE POSITION
C MUST BE ENTERED FOR EACH CALCULATION.
C
C WRITE(5,110)
110 FORMAT(' DO YOU WISH TO ENTER DATA IN AUTOMATIC OR MANUAL',
1 ' MODE? (A/M)')
112 READ(5,113) ANS
113 FORMAT(A1)
C IF(ANS.EQ.'M') GO TO 140
C IF(ANS.NE.'A') THEN
C WRITE(5,115)
115 FORMAT(' ANSWER A OR M')
C GO TO 112
C ENDIF
118 WRITE(5,119)
119 FORMAT(' ENTER FIRST (CENTRE) POSITION OF POTENTIAL',
1 ' ELECTRODES',/, ' AND POSITION INCREMENT, IN METRES',
2/, ' POSITIVE FOR N OR E, NEGATIVE FOR S OR W.',/, ' INCREMENT',
3 ' MUST HAVE APPROPRIATE SIGN.',/, ' ....POSITIVE IF MOVING TO',
4 ' MORE POSITIVE POSITION',/, ' AND NEGATIVE IF MOVING',
5 ' TO MORE NEGATIVE POSITION.')
C READ(5,*,ERR=118) XINIT,XINC
C MODE='A'
C N=0
125 XDIST=XINIT+N*XINC
126 WRITE(5,127) XDIST-POTSPH,XDIST+POTSPH
127 FORMAT(' ENTER YEW RESISTANCE VALUE FOR ELECTRODE POSITIONS',
1/,F8.2,' AND',F8.2,9X,' TYPE 0.0 TO QUIT OR EDIT')
C READ(5,*,ERR=126) YEWRES
C GO TO 150
140 WRITE(5,141)
141 FORMAT(1X,'ENTER ',/,7X,'POTENTIAL PROBE POSITION FROM'
1 ' CENTRE, RESISTANCE',/, ' TYPE 0.0,0.0 TO QUIT OR EDIT')
C READ(5,*,ERR=140) XDIST,YEWRES
150 IF(YEWRES.EQ.0.0) GO TO 400
A=CURSPH-POTSPH-ABS(XDIST)
B=CURSPH+POTSPH+ABS(XDIST)
C=CURSPH+POTSPH-ABS(XDIST)
D=CURSPH-POTSPH+ABS(XDIST)
RHOAPP=2.0*PI*YEWRES*(1/(1/A-1/B-1/C+1/D))
C WRITE(5,200) RHOAPP,XDIST,XDIST-POTSPH,XDIST+POTSPH,YEWRES
C WRITE(3,220,REC=IREC) RHOAPP,XDIST,XDIST-POTSPH,XDIST+POTSPH
1,YEWRES
C IREC=IREC+1
200 FORMAT(1X,F5.0,5X,F12.4,5X,F5.1,'-',F5.1,5X,F12.4)
220 FORMAT(F12.4,4X,F12.4,3(4X,F12.4))
C IF(CHODE.EQ.'A') THEN
C N=N+1
C GO TO 125
C ENDIF
C GO TO 140

```

C
C TERMINATION OF RUN OR EDITING OF DATA WRITTEN TO LU3
C

```
400 WRITE(5,410)
410 FORMAT(' DISPLAY, EDIT OR QUIT' (D/E/Q)')
412 READ(5,413,ERR=400) ANS
413 FORMAT(A1)
IF(ANS.EQ.'Q') GOTO 900
IF(ANS.EQ.'D') GO TO 550
GO TO 570
550 WRITE(5,554)
554 FORMAT(1X,'ENTER START AND FINISH RECORD NUMBERS FOR DISPLAY')
READ(5,*) IST,IFIN
DO 560 IDREC=IST,IFIN
IF(IDREC.GT.IREC-1) THEN
WRITE(5,449)
GO TO 566
ENDIF
READ(3,450,REC=IDREC) ALINE
WRITE(5,452) ALINE
560 CONTINUE
566 IF(EDIT.EQ.'D') GO TO 419
GO TO 400
570 IF(ANS.NE.'E') THEN
WRITE(5,415)
415 FORMAT(' ANSWER Q OR E')
GO TO 412
ENDIF
```

C
C EDITING OF DATA
C

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419 WRITE(5,420)
420 FORMAT(1X,'CHANGE, REPEAT, DISPLAY OR EXIT-EDIT?',
1/1X,'( C , R , D OR X )')
421 READ(5,422,ERR=419) ANS
422 FORMAT(A1)
IF(ANS.EQ.'D') THEN
EDIT='D'
GO TO 550
ENDIF
IF(ANS.EQ.'C') THEN
EDIT='C'
429 WRITE(5,430)
430 FORMAT(1X,'ENTER ',7X,'POTENTIAL PROBE POSITION FROM',
1' CENTRE, RESISTANCE',/, ' OF ENTRY TO BE CHANGED')
READ(5,*,ERR=429) SDIST,SRES
ISREC=IREC-1
442 READ(3,446,REC=ISREC,ERR=443) RDIST,RRES
GO TO 447
443 WRITE(5,444)
444 FORMAT(1X,'ILLEGAL CHARACTERS OR VALUES NOT FOUND')
GO TO 419
446 FORMAT(16X,F12.4,36X,F12.4)
C#447 IF((RDIST.EQ.SDIST).AND.(RRES.EQ.SRES)) THEN
447 IF((ABS(RDIST-SDIST).LT.1.0E-6).AND.(ABS(RRES-SRES).LT.1.0E-6))
1THEN
READ(3,450,REC=ISREC) ALINE
WRITE(5,452) ALINE
449 FORMAT(1X,'ATTEMPT TO READ PAST CURRENT END OF FILE')
450 FORMAT(A80)
452 FORMAT(1X,A80)
453 WRITE(5,454)
454 FORMAT(1X,'THIS IS LINE TO BE CHANGED.... ENTER',/,
1' CORRECT VALUES FOR POSITION AND RESISTANCE')
READ(5,*,ERR=453) XD,YR
A=CURSPH-POTSPH-ABS(XD)
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B=CURSPH+POTSPH+ABS(XD)
C=CURSPH+POTSPH-ABS(XD)
D=CURSPH-POTSPH+ABS(XD)
RHOAPP=2.0*PI*YR*1/(1/A-1/B-1/C+1/D)
WRITE(5,460) RHOAPP,XD,XD-POTSPH,XD+POTSPH,YR
WRITE(3,464,REC=ISREC) RHOAPP,XD,XD-POTSPH,XD+POTSPH,YR
460 FORMAT(1X,F5.0,5X,F10.4,5X,F4.0,'-',F4.0,5X,F10.4)
464 FORMAT(F12.4,4(4X,F12.4))
GO TO 419
ELSE
WRITE(5,*) ISREC,RDIST,RRES,SDIST,SRES
ISREC=ISREC-1
GO TO 442
ENDIF
ELSE
IF(ANS.EQ.'R') THEN
IF(EDIT.NE.'C') THEN
WRITE(5,470)
470 FORMAT(1X,'R MAY ONLY FOLLOW C OR R.')
GO TO 419
ENDIF
ISREC=ISREC+1
IF(ISREC.GE.IREC) THEN
WRITE(5,449)
GO TO 419
ENDIF
READ(3,475,REC=ISREC) ALINE
475 FORMAT(A80)
WRITE(5,477) ALINE
477 FORMAT(1X,A80)
478 WRITE(5,479)
479 FORMAT(1X,'THIS IS THE LINE TO BE CHANGED.....ENTER',/,
1' CORRECT VALUES FOR POSITION AND RESISTANCE')
READ(5,*,ERR=478) XD,YR
A=CURSPH-POTSPH-ABS(XD)
B=CURSPH+POTSPH+ABS(XD)
C=CURSPH+POTSPH-ABS(XD)
D=CURSPH-POTSPH+ABS(XD)
RHOAPP=2.0*PI*YR*1/(1/A-1/B-1/C+1/D)
WRITE(5,483) RHOAPP,XD,XD-POTSPH,XD+POTSPH,YR
WRITE(3,484,REC=ISREC) RHOAPP,XD,XD-POTSPH,XD+POTSPH,YR
483 FORMAT(1X,F5.0,5X,F10.4,5X,F4.0,'-',F4.0,5X,F10.4)
484 FORMAT(F12.4,4X,F12.4,3(4X,F12.4))
GO TO 419
ELSE
IF(ANS.NE.'X') THEN
WRITE(5,490)
490 FORMAT(1X,'ANSWER C (CHANGE) OR R (REPEAT) OR D (DISPLAY)',
1' OR X (EXIT-EDIT)')
EDIT='X'
GO TO 421
ELSE
EDIT='X'
IF(MODE.EQ.'M') GOTO 140
GO TO 126
ENDIF
ENDIF
ENDIF
C
C RETURN FROM EDITING PROCEDURE
C
C
C 900 CONTINUE
END
```

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APPENDIX 2

Sample SCHTRAV output

RAILTON, ANR SINKHOLES, ASYMMETRICAL SCHLUMBERGER TRAVERSE NO.4
 ASYMMETRICAL SCHLUMBERGER ARRAY
 N CURRENT ELECTRODE ABOUT 5 METRES SOUTH OF LOADING RAMP
 TRAVERSE N TO S
 TRAVERSE LINE EAST OF TRACKS, ABOUT 5 METRES EAST OF EASTERNMOST TRACK
 WEDNESDAY 24TH. AUGUST 1983

APPARENT RESISTIVITY	POSITION	POTENTIAL POSITIONS	YEW READINGS	
183.1872	92.5000	90.0000	95.0000	2.9200
148.2506	87.5000	85.0000	90.0000	0.7900
164.3641	82.5000	80.0000	85.0000	0.4400
222.6183	77.5000	75.0000	80.0000	0.3600
229.7823	72.5000	70.0000	75.0000	0.2500
302.6450	67.5000	65.0000	70.0000	0.2380
339.0869	62.5000	60.0000	65.0000	0.2030
453.3242	57.5000	55.0000	60.0000	0.2150
474.2542	52.5000	50.0000	55.0000	0.1840
567.4478	47.5000	45.0000	50.0000	0.1850
531.3879	42.5000	40.0000	45.0000	0.1490
458.9839	37.5000	35.0000	40.0000	0.1130
576.5383	32.5000	30.0000	35.0000	0.1270
543.4099	27.5000	25.0000	30.0000	0.1090
608.4578	22.5000	20.0000	25.0000	0.1130
612.3967	17.5000	15.0000	20.0000	0.1070
1173.9240	12.5000	10.0000	15.0000	0.1960
790.1130	7.5000	5.0000	10.0000	0.1280
921.1458	2.5000	0.0000	5.0000	0.1470
1021.4070	-2.5000	-5.0000	0.0000	0.1630
950.6047	-7.5000	-10.0000	-5.0000	0.1540
850.4956	-12.5000	-15.0000	-10.0000	0.1420
915.7327	-17.5000	-20.0000	-15.0000	0.1600
608.4578	-22.5000	-25.0000	-20.0000	0.1130
593.2642	-27.5000	-30.0000	-25.0000	0.1190
985.1086	-32.5000	-35.0000	-30.0000	0.2170
438.6750	-37.5000	-40.0000	-35.0000	0.1080
781.0334	-42.5000	-45.0000	-40.0000	0.2190
417.1509	-47.5000	-50.0000	-45.0000	0.1360
600.5503	-52.5000	-55.0000	-50.0000	0.2330
461.7583	-57.5000	-60.0000	-55.0000	0.2190
534.5212	-62.5000	-65.0000	-60.0000	0.3200
445.0662	-67.5000	-70.0000	-65.0000	0.3500
473.3513	-72.5000	-75.0000	-70.0000	0.5150
556.5457	-77.5000	-80.0000	-75.0000	0.9000
508.0342	-82.5000	-85.0000	-80.0000	1.3600
480.4067	-87.5000	-90.0000	-85.0000	2.5600
432.8740	-92.5000	-95.0000	-90.0000	6.9000