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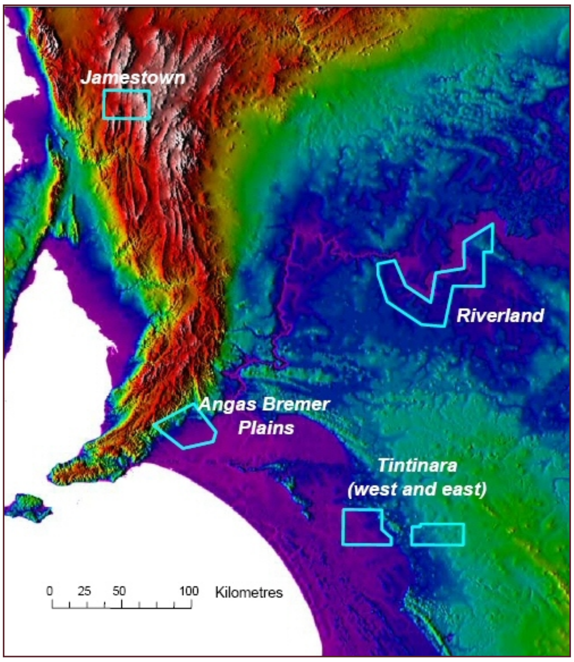
CALCULATION OF CONDUCTIVITY DEPTH IMAGES (CDI) FOR SA AEM DATA USING EMFLOW 5.30 (AMIRA-P407B): RESOLVE: RIVERLAND AND TINTINARA (EAST & WEST); TEMPEST: JAMESTOWN & ANGAS BREMER PLAINS



A. Fitzpatrick

CRC LEME OPEN FILE REPORT 176

September 2004

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Report prepared for the South Australia Salinity Mapping and Management Support Project.
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Headquarters: CRC LEME c/o CSIRO Exploration and Mining, PO Box 1130, Bentley WA 6102, Australia

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Address and Affiliation of Authors

Andrew Fitzpatrick
Cooperative Research Centre for Landscape
Environments and Mineral Exploration
Geoscience Australia
GPO Box 378,
Canberra, ACT 2601
Australia

1. INTRODUCTION

This report summarises the calculation of conductivity depth images (CDI) from airborne electromagnetic (AEM) surveys flown for the South Australian Salinity Mapping and Management Projects. Three areas, Riverland, Tintinara-east, and Tintinara-west were surveyed with the DIGHEM RESOLVE frequency domain helicopter electromagnetic system. Two areas, Jamestown and Angas Bremer Plains were surveyed with the TEMPEST fixed-wing, towed-bird time domain electromagnetic system. All surveys were conducted by Fugro Airborne Surveys (FAS). The location of the survey areas are shown in Figure 1.

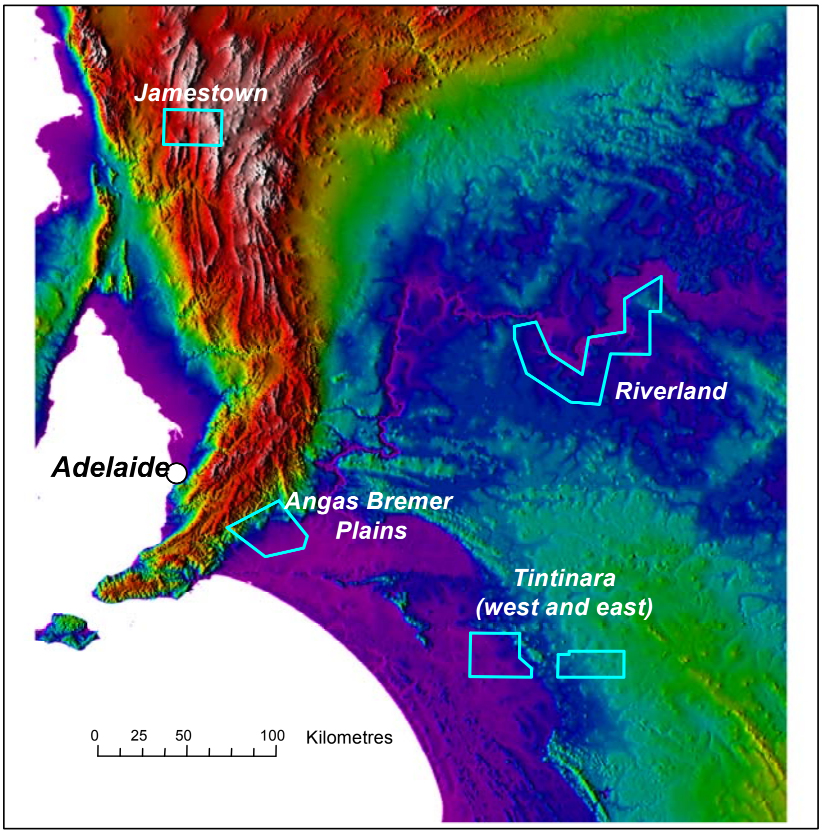


Figure 1. Location Map of South Australian Salinity investigation AEM surveys. Background image is a digital elevation model (DEM).

The survey acquisition and processing details for the RESOLVE Riverland and Tintinara surveys are reported by Cowey et al (2002). Survey details for the TEMPEST Angas Bremer Plains and Jamestown surveys are reported by Owers and Stenning (2002). Conductivity depth predictions were delivered as a product from the contractor produced using EMFlow version 4 for the TEMPEST surveys and version 5.10 for the RESOLVE surveys.

EMFlow was developed within the CRC AMET through several AMIRA research projects (Macnae et al, 1998, Macnae and Zonghou, 1998). The software has been commercialised by Encom Technology Pty Ltd. EMFlow is currently be upgraded through the AMIRA-P407B project, which CRCLEME sponsors.

The RESOLVE Riverland and Tintinara datasets were calibrated and subject to a constrained inversion to specifically map a near surface clay layer (Blanchetown Clay), reported by Brodie et al, (2003).

A new set of conductivity predictions for all the surveys have been produced using the proprietary research version of EMFlow (version 5.30) which CRCLEME has access to. This software has several features and improvements over the commercially available product (EMFlow 5.10).

The re-calculation of the conductivity depth images was considered necessary for several reasons;

- Independent borehole conductivity measurements were available, thereby allowing a direct comparison with conductivity predictions from the airborne data.
- Comparisons between forward models of borehole measurements and the real airborne response indicated calibration errors in the RESOLVE data. Subsequently the RESOLVE data was re-scaled using the appropriate factors. (Brodie et al, 2003).
- EMFlow v5.30 allows a greater number of discretised conductivity values to be used in calculating the CDI (upgraded from 20 to 250 values) than previous versions. This may increase resolution in conductivity models allowing more subtle conductivity features to be imaged.
- The original FAS derived CDI's utilised only the 5 coplanar frequencies of the RESOLVE system; EMFlow v5.30 allows all 6 frequencies of the RESOLVE system to be incorporated into the CDI calculation.

The discussion of the EMFLOW v5.30 processing will be subdivided into two sections based upon the type of system employed; RESOLVE and TEMPEST.

2. RESOLVE: Riverland and Tintinara

2.1. CDI generation with EMFlow v5.30

Brodie, et al (2003) produced scaling factors for the Riverland and Tintinara East RESOLVE HEM surveys. This was accomplished by comparing the forward models of the HEM response from borehole conductivity data with the RESOLVE survey data. The scaling factors for each frequency are listed in table 1.

Table 1. Calibration factors for the Riverland and Tintinara RESOLVE surveys (Brodie et al 2003)

Frequency (Hz)	385	1518	3323	6135	25380	106140
Calibration Factor	0.96	1.04	1.11	1.15	1.29	1.23

The scaling factors were applied to levelled data provided from FAS for input into EMFlow v5.30. The 3323Hz vertical coaxial coil was scaled by a further 2.76 in order to be treated as a horizontal coaxial planar coil (HCP@7.86m) for input into EMFlow. The system geometry for the EMFlow input is listed in Table 2.

Table 2. System geometry of RESOLVE for input into EMFlow v5.30

Variable	***Survey specification***	***Input for EMFLOW***
Transmitter loop pitch	0	0
Transmitter roll	0	0
Transmitter-receiver height	As measured by bird altimeter	As measured by bird altimeter
Transmitter loop- receiver coil spacing		
385 HCP	7.86m	7.86m
1518 HCP	7.86m	7.86m
3323 VCX (rescaled to HCP@7.86m)	8.99m	7.86m
6135 HCP	7.86m	7.86m
25380 HCP	7.86m	7.86m
106140 HCP	7.86m	7.86m

The EMFlow descriptor file used for processing the Riverland and Tintinara survey areas is included in Appendix 1. An exponential approximation was used to create the basis function. Twenty-two time constants (Taus) ranging from 1μs to 2ms were used in the decomposition, with normalisation completed using a global maximum and a smoothing factor of 0.4. The data weights were 1.0 for all frequencies.

Conductivity values were calculated down to 50 metres below the ground in 2 metre increments. The range of conductivity values were set to range between 1 and 2000 mS/m for Riverland and 1 to 1000 mS/m for the Tintinara areas. Conductivity predictions were output as ASCII files.

2.2. Gridding

Conductivity grids for each depth interval were created within INTREPID using a minimum curvature algorithm. The inputs to gridding were log10(conductivity) values. Grids were assigned an MGA54 projection and GDA94 datum. Grid settings are given in Table 3.

Table 3. Settings used for gridding the Riverland and Tintinara conductivity data

Gridding Parameters	***Riverland***	***Tintinara***
Grid Size	30 metres	60 metres
Line Orientation	0 degrees	90 degrees
Output Precision	IEEE4ByteReal	IEEE4ByteReal
Initial Method Mode	Nearest Neighbours	Nearest Neighbours
Spline Type Mode	Akima	Akima
Minimum Curvature	Yes	Yes
Honour Original	Yes	Yes
Honour 2Cells	No	No
Maximum Iterations	50	50
Maximum Residual	0.000001	0.000001
Minimum Curvature Tension	0.0	0.0
Relaxation Factor	1.375	1.375
Grid Conditioning		
Masking	Yes	Yes
Crew Cut	No	No
Clipping	Yes	Yes
Smoothing	No	No
Smoothing Iterations	6	6
Laplace Iterations	2	2
Cells2Extrapolate	200	200

Grids were masked back to the survey boundary to avoid misrepresentation through extrapolation beyond the limits of the data.

Analysis of preliminary grids showed line artefacts attributed to minor levelling differences. The data were micro-levelled using a decorrugation filter in the INTREPID software. A number of trials were carried out to determine suitable settings for the filtering. In each case, the results were examined using ERMapper. The final settings for the de-corrugation filter are given in Table 4.

Table 4. De-corrugation settings.

	Riverland		*Tintinara*	
Filter	High Pass	Naudy Filter	High Pass	Naudy Filter
	Low Pass	Smoothed Fuller	Low Pass	Smoothed Fuller
Extrapolator	High Pass	Mirror	High Pass	Mirror
	Low Pass	Flipped mirror	Low Pass	Flipped mirror
Minimum streak length	5000 m		2000m	
Streak width	300m		600m	
Minimum adjustment	-1		-1	
Maximum adjustment	1		1	

The de-corrugation corrections were applied to the point located data using the INTREPID micro-levelling tool. The micro-levelling settings are given in table 5.

Table 5. Micro-levelling settings.

AREA	***Secondary filter along along line correction***	***Nominal strike***	***Adjustments(LOG) Min/max***
Riverland (0-6m)	5000m	0/180	-1/+1
Riverland (6m-50	5000m	0/180	-1/+1
Tintinara W	2000m	90/270	-1/+1
Tintinara E	2000m	90/270	-1/+1

An example of a conductivity grid from the reprocessed Riverland RESOLVE data is shown in Figure 2. The FAS supplied conductivity grid is also shown for comparison. A logarithmic colour stretch has been applied to the gridded data to optimise the interpretation of spatial patterns in the conductivity data for each depth slice. Although the two grids are of the same interval, the scaling factors applied to the reprocessed product have resulted in some significant differences in the observed conductivity patterns.

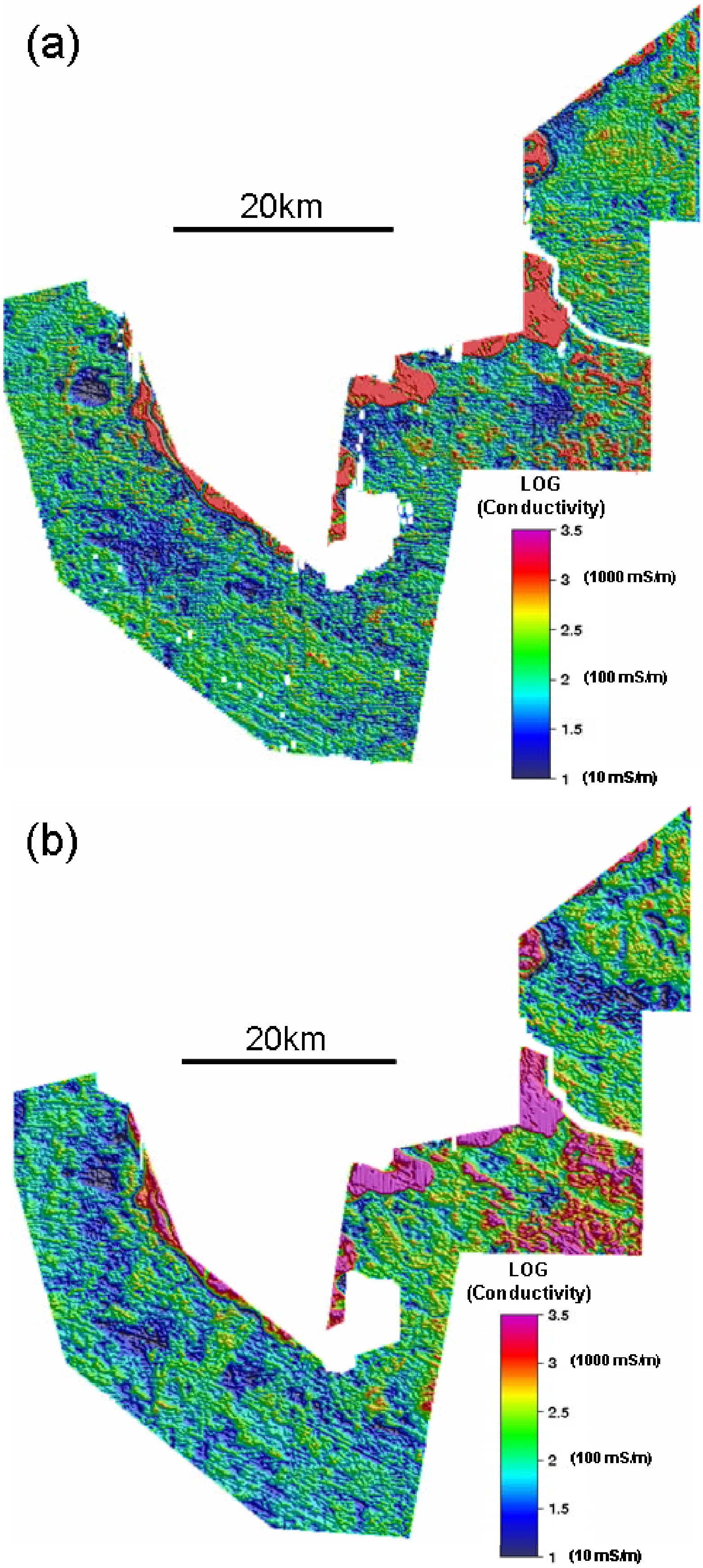


Figure 2. Conductivity grid (6-8 metres) of Riverland, (a) as supplied by FAS (b) reprocessed by CRC LEME.

3. TEMPEST AEM Angas Bremer Plains and Jamestown

A number of boreholes were geophysical logged within the Angas Bremer Plains and Jamestown survey areas following the TEMEPEST AEM surveys. As a larger number of boreholes were provided for the Angas Bremer Plains area, this survey was chosen to approximately calibrate the airborne data. It was assumed the same calibration scaling could be applied to the Jamestown survey as it was flown immediately after the Angas Bremer Plains survey.

Simple calibration of TEMPEST AEM data is often achieved by adjusting the geometry of the system, until a suitable match is made between borehole measurements and the AEM conductivity model (in particular the transmitter loop height) (Brodie et al, 2002, Christensen, 2002, Lane et al, 2003).

Analysis of the borehole conductivity data revealed a shallow conductive "bulge" common across most of the survey area. This bulge was imaged by the contractor supplied AEM conductivity data; however it was offset from the borehole anomaly by approximately 5 metres (Figure 3).

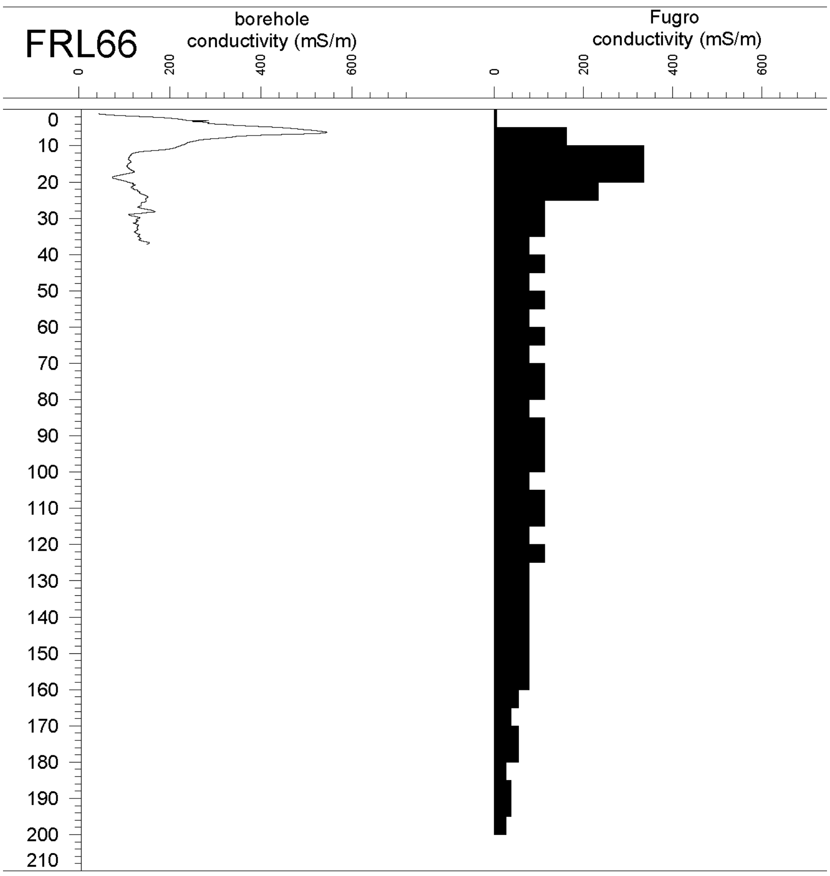


Figure 3. Borehole conductivity log for FRL66 and measured AEM conductivity response over borehole. The shallow conductive bulge is displaced 5 metres deeper in the AEM data.

3.1. CDI generation with EMFlow v5.30

The final height-geometry corrected X component data as supplied by the contractor (FAS) was used as input for the EMFlow v5.30 processing. A number of trials were carried out to determine suitable settings for the system geometry, until the AEM conductivity model matched the borehole conductivity measurements. This required a 5 metre offset to be added to the transmitter-loop height. The final system geometry for the EMFlow input is listed in Table 6. An example of the new AEM conductivity model as compared to the contractor supplied data and borehole is shown in Figure 4. Appendix 2 contains the comparison of AEM conductivity model derived by FAS and the reprocessed AEM data for all borehole measurements within the Angas Bremer Plains Area.

Table 6. System geometry of TEMPEST for input into EMFlow v5.30

Variable	***Survey specification***	***Input for EMFLOW***
Transmitter loop pitch	0	0
Transmitter roll	0	0
Transmitter loop height	120	125m
Trasnsmitter loop-receiver coil horizontal spacing	128m behind aircraft	128m behind aircraft
Transmitter loop- receiver coil vertical spacing	35m behind aircraft	35m behind aircraft

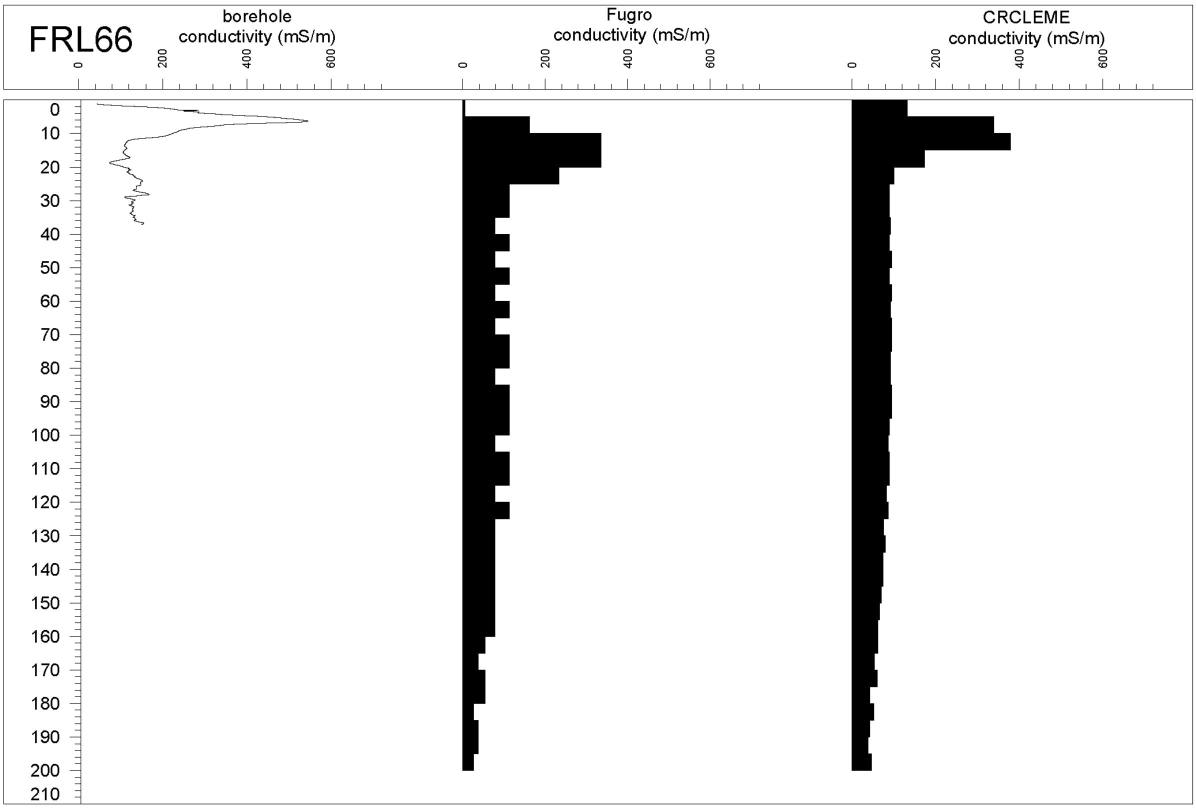


Figure 4. Borehole measurements and conductivity predictions from TEMPEST data (Angas Bremer Plains) derived by FAS and reprocessed by CRC LEME. The new conductivity model displaces the conductive bulge to shallower depth coinciding with the borehole measurements.

The EMFlow descriptor file used for processing the Jamestown and Angas Bremer Plain is included in Appendix 3. An exponential approximation was used to create the basis function. Forty-two time constants (Taus) ranging from 5µs to 50ms were used in the decomposition with normalisation completed by applying a global maximum and a smoothing factor of 0.4. The data weights were 1.0 for all windows.

Conductivity values were calculated down to 200 metres below the ground in 5 metre increments for Angas Bremer Plains and down to 100 metres for Jamestown. The range of conductivity values were set to range between 1 and 1000 mS/m. Conductivity predictions were output as ASCII files.

2.2. Gridding

Conductivity grids for each depth interval were created within INTREPID using a minimum curvature algorithm. The inputs to gridding were log10(conductivity) values. Grids were assigned an MGA54 projection and GDA94 datum. Grid settings are given in Table 7.

Table 7. Settings used for gridding the Riverland and Tintinara conductivity data

Gridding Parameters	*Angas Bremer Plains*	*Jamestown*
Grid Size	80 metres	60
Line Orientation	57 degrees	90 degrees
Output Precision	IEEE4ByteReal	IEEE4ByteReal
Initial Method Mode	Nearest Neighbours	Nearest Neighbours
Spline Type Mode	Akima	Akima
Minimum Curvature	Yes	Yes
Honour Original	Yes	Yes
Honour 2Cells	No	No
Maximum Iterations	50	50
Maximum Residual	0.000001	0.000001
Minimum Curvature Tension	0.0	0.0
Relaxation Factor	1.375	1.375
Grid Conditioning		
Masking	Yes	Yes
Crew Cut	No	No
Clipping	Yes	Yes
Smoothing	No	No
Smoothing Iterations	6	6
Laplace Iterations	2	2
Cells2Extrapolate	200	200

Grids were masked back to the survey boundary to avoid misrepresentation through extrapolation beyond the limits of the data.

Analysis of preliminary grids showed line artefacts attributed to minor levelling differences for Jamestown survey. No levelling problems were observed in the Angas Bremer Plains dataset. The Jamestown data were micro-levelled using a decorrugation filter using INTREPID software. A number of trials were carried out to determine suitable settings for the filtering. In each case, the results were visualised using ERMapper. The final settings for the de-corrugation filter are given in Table 8.

Table 8. De-corrugation settings.

<table>
<tr><th></th><th colspan="2">Jamestown</th></tr>
<tr><td rowspan="2">Filter</td><td>High Pass</td><td>Naudy Filter</td></tr>
<tr><td>Low Pass</td><td>Smoothed Fuller</td></tr>
<tr><td rowspan="2">Extrapolator</td><td>High Pass</td><td>Mirror</td></tr>
<tr><td>Low Pass</td><td>Flipped mirror</td></tr>
<tr><td>Minimum streak length</td><td colspan="2">5000 m</td></tr>
<tr><td>Streak width</td><td colspan="2">800 m</td></tr>
<tr><td>Minimum adjustment</td><td colspan="2">-1</td></tr>
<tr><td>Maximum adjustment</td><td colspan="2">1</td></tr>
</table>

The de-corrugation corrections were applied to the point located data using the INTREPID micro-levelling tool. The micro-levelling settings are given in table 9.

Table 9. Micro-levelling settings.

AREA	***Secondary filter along along line correction***	***Nominal strike***	***Adjustments(LOG) Min/max***
Jamestown	5000 m	90/270	-1/+1

An example of a conductivity grid from the reprocessed Angas Bremer Plains TEMPEST data is shown in Figure 5. The FAS supplied conductivity grid is shown for comparison. A linear colour stretch has been applied to the gridded data to optimise the interpretation of spatial patterns in the conductivity data for each depth slice. Although the two grids are of the same interval, the scaling factors applied to the reprocessed product have resulted in subtle differences in the observed conductivity patterns.

3. SUMMARY

The reprocessing of the South Australian Salinity Mapping and Management Support Project airborne electromagnetic datasets have resulted in new datasets which accord better with conductivity structure as determined from electrical borehole logs. In addition, EMFlow v5.30 provides higher resolution conductivity models than current commercial versions of the software as used by the contractor (250 conductivity values vs 20 conductivity values).

4. REFERENCES

Brodie. R.C. Green, A.A. and Munday, T.J., 2003, Constrained inversion of RESOLVE airborne electromagnetic data, Riverland and Tintinara East. CRC LEME Restricted Report 152.

Brodie, R., Lane, R. and Gibson, D., 2002, Gilmore Project, Comparison of AEM and Borehole conductivity data: Report prepared for CRCLEME, June 2002.

Christensen, A., 2003, Calibration of Honeysuckle Creek Conductivity Depth Imaging, Preview, Australian Society of Exploration Geophysicists, 27-30.

Cowey, D., Garrie, D. and Tovey, A., 2002, Acquisition and processing reports, Riverland and Tintinara SA, RESOLVE Survey; Fugro Airborne Survey report to the Bureau of Rural Sciences for Job 912.

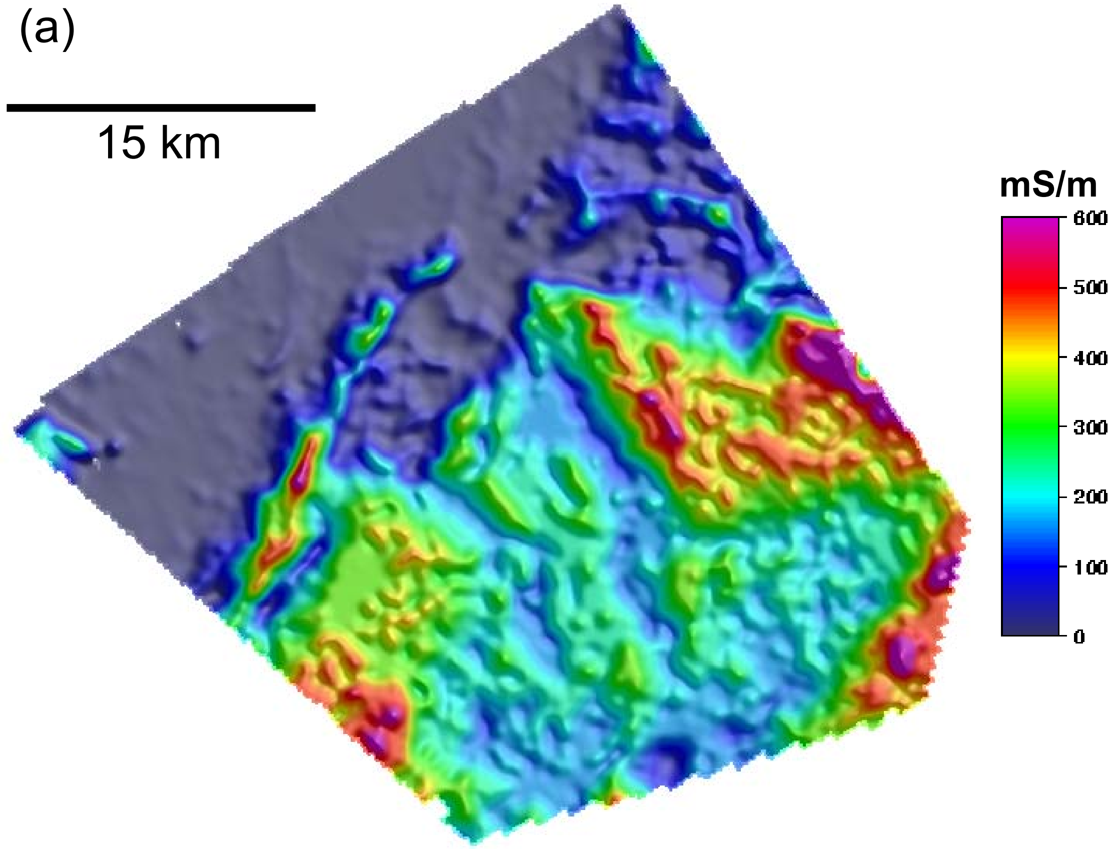
Lane R., Brodie R., & Fitzpatrick A. 2003, Constrained inversion of AEM data from St George, Queensland, Australia, unpublished report, CRC LEME, Geoscience Australia.

Macnae, J., King, A., Stolz, N., Osmakoff, A. and Blaha, A., 1998, Fast AEM data processing and inversion: Exploration Geophysics 29, 163-169.

Macnae, J. and Xiong, Z., 1998, Block modelling as a check on the interpretation of stitched CDI sections from AEM data: Exploration Geophysics 29, 191-194.

Owers, M. and Stenning, L., 2002, Acquisition and processing reports, Jamestown and Angas Bremer Plains, TEMPEST Survey; Fugro Airborne Survey report to the Bureau of Rural Sciences for Job 900 & 901.

(a)


15 km
mS/m
600
500
400
300
200
100
0

(b)

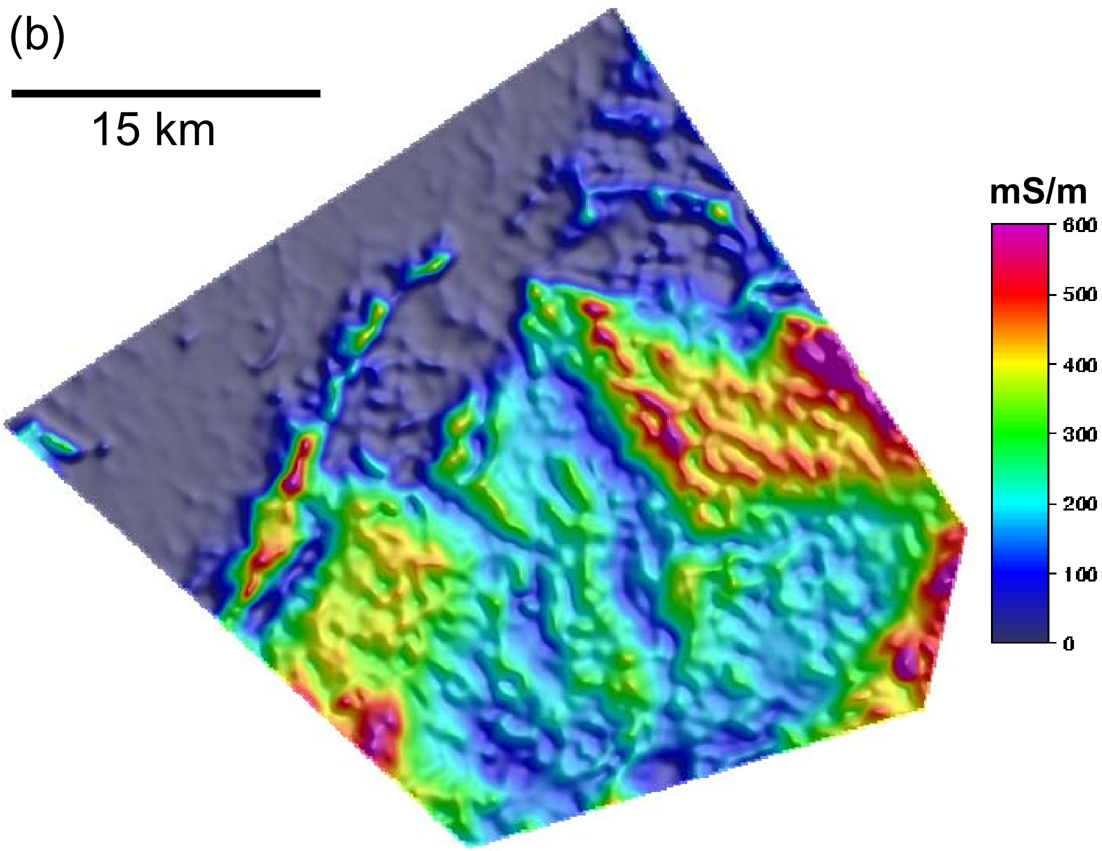

15 km
mS/m
600
500
400
300
200
100
0

Figure 5. Conductivity grid (15-20 metre interval) of Angas Bremer Plains, (a) as supplied by FAS (b) reprocessed by CRC LEME.

APPENDIX I: EMFlow descriptor files: Riverland and Tintinara

```
Riverland

FILE FORMAT VERSION
9
SYSTEM NAME
Dighem Resolve 2002
VERSION
1
DEFINED BY
Andrew Fitzpatrick
DATE DEFINED
10/04/03
TIME SCALING
1  1   [sec]
WAVEFORM TYPE
frequency domain
WAVEFORM NORMALIZED BY
component
--------------------------------------------------------
  TxRx  TxRy  TxRz  TyRx  TyRy  TyRz  TzRx  TzRy  TzRz
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--------------------------------------------------------
                         ++++++++
                         + TzRz +
                         ++++++++
--------------------------------------------------------
FREQUENCIES
5
--------------------------------------------------------
         385          1
        1518          1
        6135          1
       25380          1
      106140          1
AMPLITUDE SCALING
1e+006 1
--------------------------------------------------------
TRANSMITTER GEOMETRY
moving dipole
z
      0       0       1
XYZ POSITION:
      0       0       0
--------------------------------------------------------
RECEIVER GEOMETRY
moving dipole
z
      0       0       1
XYZ POSITION:
   -7.9       0       0
--------------------------------------------------------
DATA FORMAT
Geosoft format (1 yes, 0 no)
     0
Sample file name (if available)
```

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Number of comment lines at the beginning of each data file
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Number of items in each data record
    19
POSITION (INDEX) OF IN PHASE IN EACH DATA RECORD
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     2     0     0     0     0     0     0     0     0     0    10
     3     0     0     0     0     0     0     0     0     0    14
     4     0     0     0     0     0     0     0     0     0    16
     5     0     0     0     0     0     0     0     0     0    18
POSITION (INDEX) OF QUADRATURE IN EACH DATA RECORD
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     2     0     0     0     0     0     0     0     0     0    11
     3     0     0     0     0     0     0     0     0     0    15
     4     0     0     0     0     0     0     0     0     0    17
     5     0     0     0     0     0     0     0     0     0    19
----------------------
line          1   1
FID           3   1
east          4   1
north         5   1
z_topo        7   1
altitude      6   1
Rx_pitch      0   0
Rx_roll       0   0
Rx_yaw        0   0
Tx_pitch      0   0
Tx_roll       0   0
Tx_yaw        0   0
z(ASL)        0   2
```

```
Tintinara East and Tintinara West

FILE FORMAT VERSION
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SYSTEM NAME
Dighem Resolve 2002
VERSION
1
DEFINED BY
Andrew Fitzpatrick
DATE DEFINED
10/04/03
TIME SCALING
1  1   [sec]
WAVEFORM TYPE
frequency domain
WAVEFORM NORMALIZED BY
component
---------------------------------------------------------
  TxRx  TxRy  TxRz  TyRx  TyRy  TyRz  TzRx  TzRy  TzRz
     0     0     0     0     0     0     0     0     6

---------------------------------------------------------
                         ++++++++
                         + TzRz +
                         ++++++++
---------------------------------------------------------
FREQUENCIES
6
---------------------------------------------------------
         385           1
        1518           1
        3323           1
        6135           1
       25380           1
      106140           1
AMPLITUDE SCALING
1e+006 1
---------------------------------------------------------
TRANSMITTER GEOMETRY
moving dipole
z
      0       0       1
XYZ POSITION:
      0       0       0
---------------------------------------------------------
RECEIVER GEOMETRY
moving dipole
z
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     3     0     0     0     0     0     0     0     0     0    24
     4     0     0     0     0     0     0     0     0     0    26
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     3     0     0     0     0     0     0     0     0     0    25
     4     0     0     0     0     0     0     0     0     0    27
     5     0     0     0     0     0     0     0     0     0    29
     6     0     0     0     0     0     0     0     0     0    31
----------------------
line          2   1
FID           3   1
east          4   1
north         5   1
z_topo        7   1
altitude      6   1
Rx_pitch      0   0
Rx_roll       0   0
Rx_yaw        0   0
Tx_pitch      0   0
Tx_roll       0   0
Tx_yaw        0   0
z(ASL)        0   2
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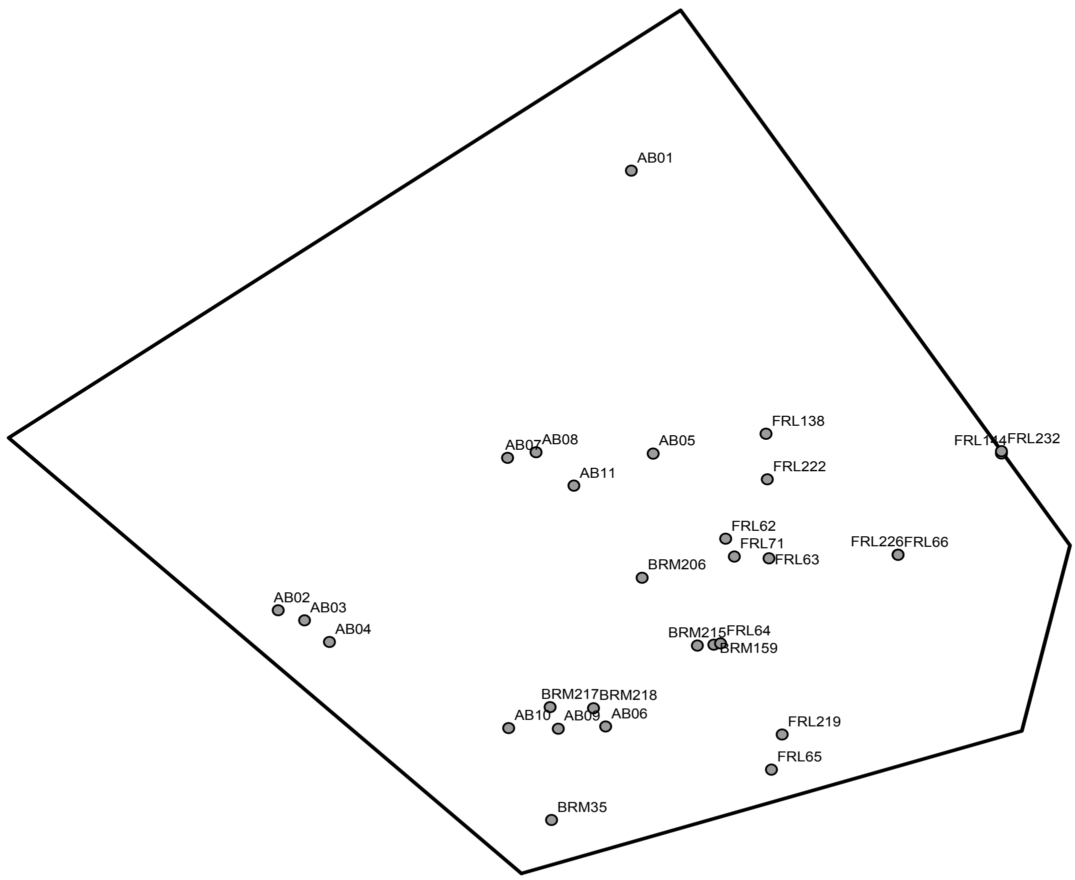
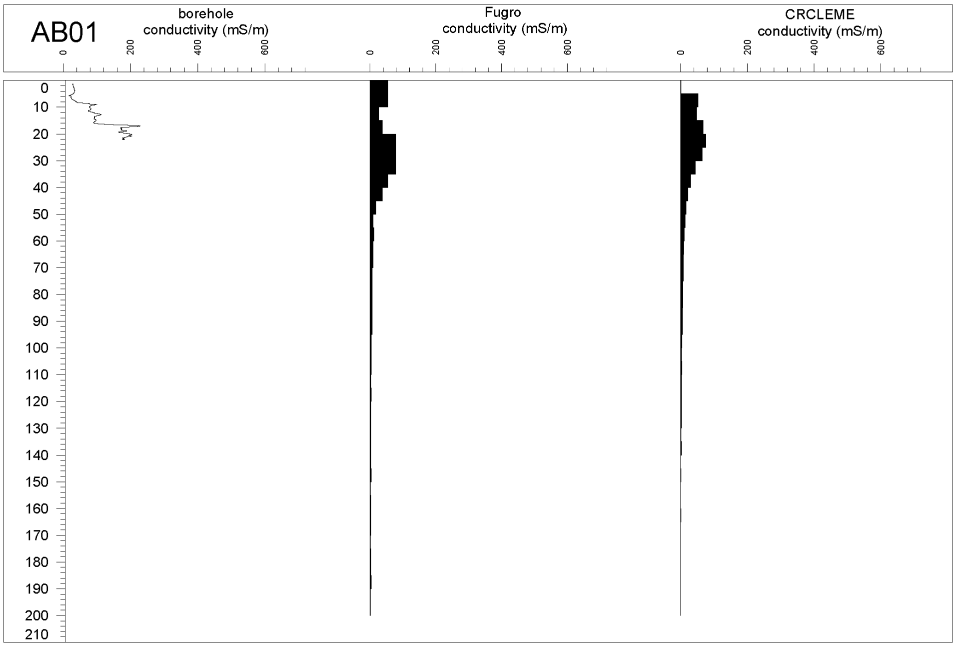
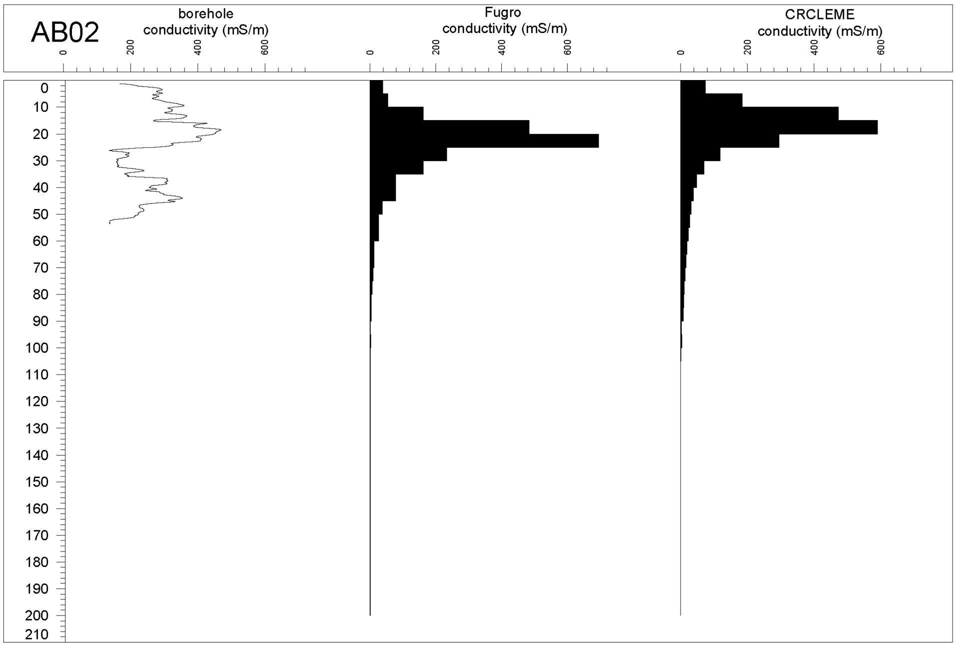
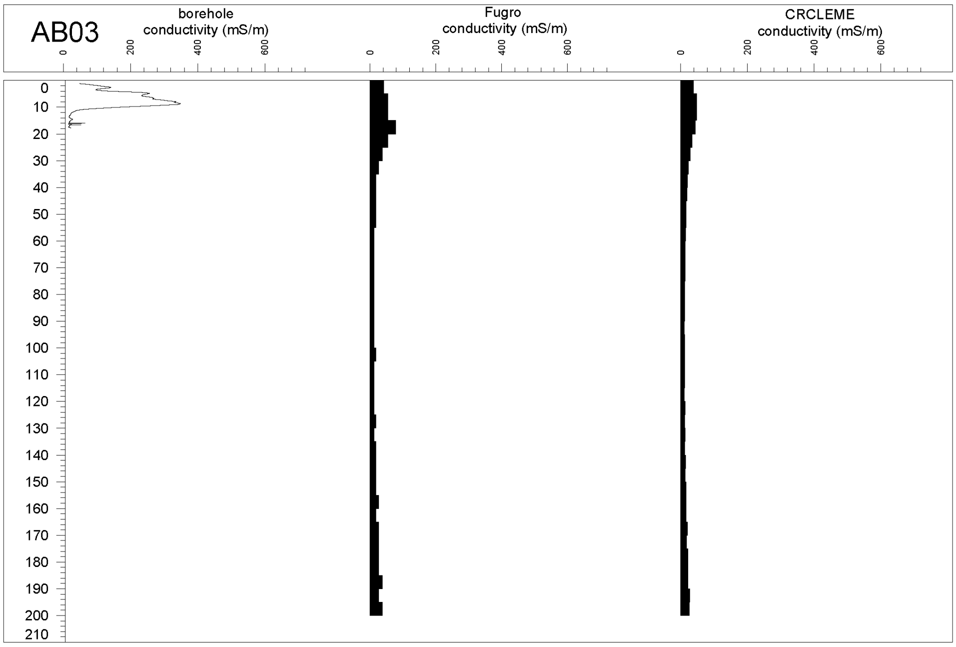
Appendix II: Borehole and AEM conductivity models for Angas Bremer Plains

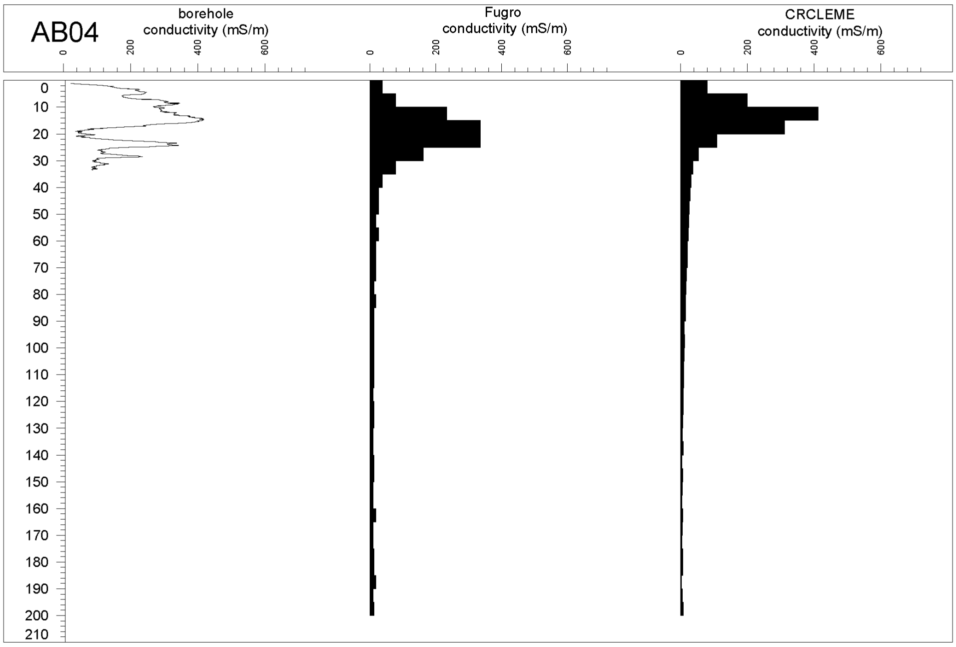


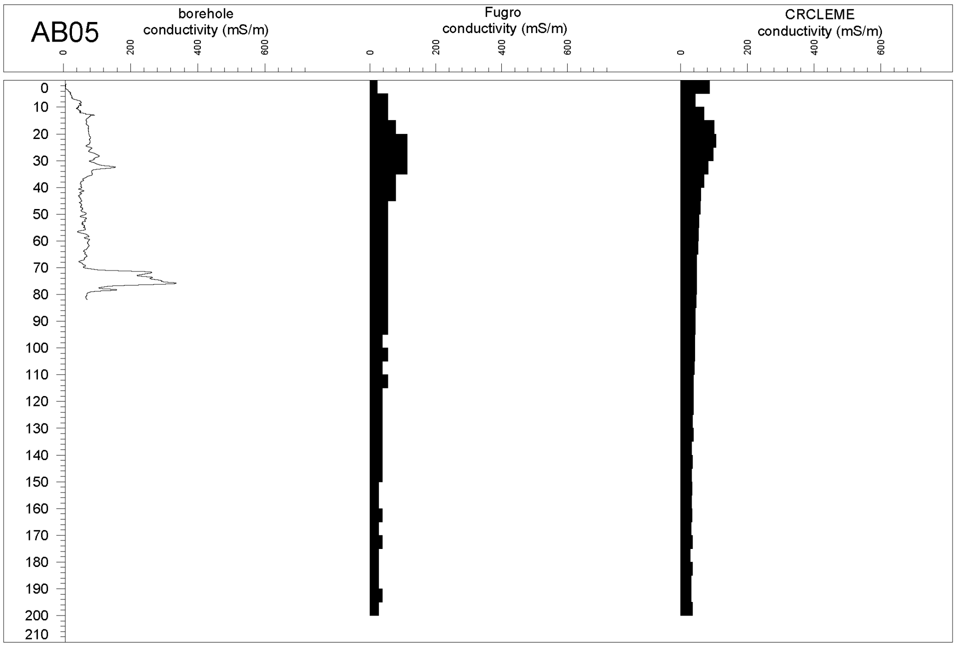
Borehole locations within Angas Bremer Plains AEM survey area.

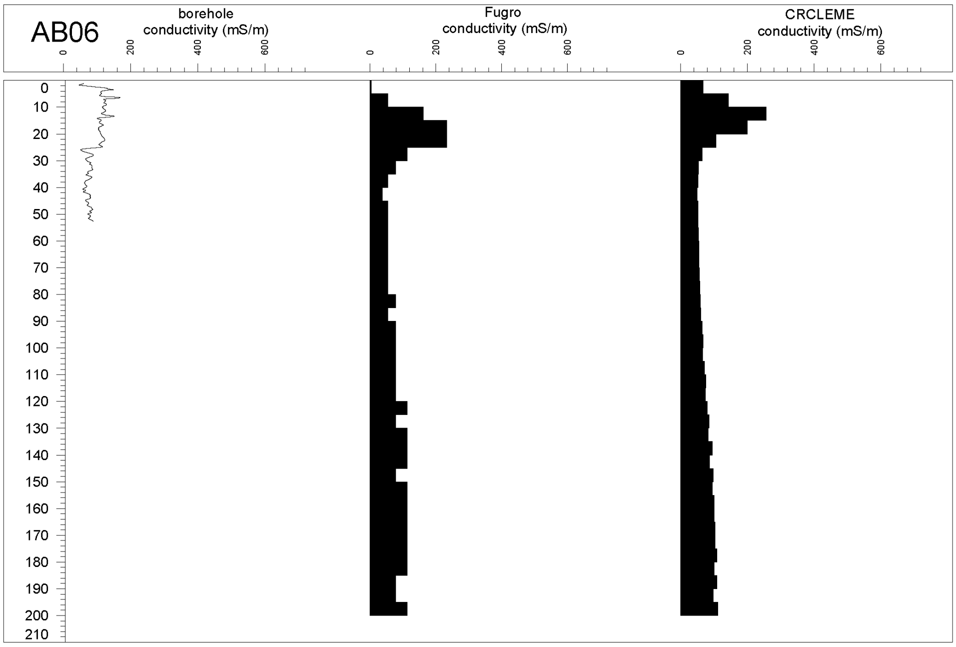

AB01
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

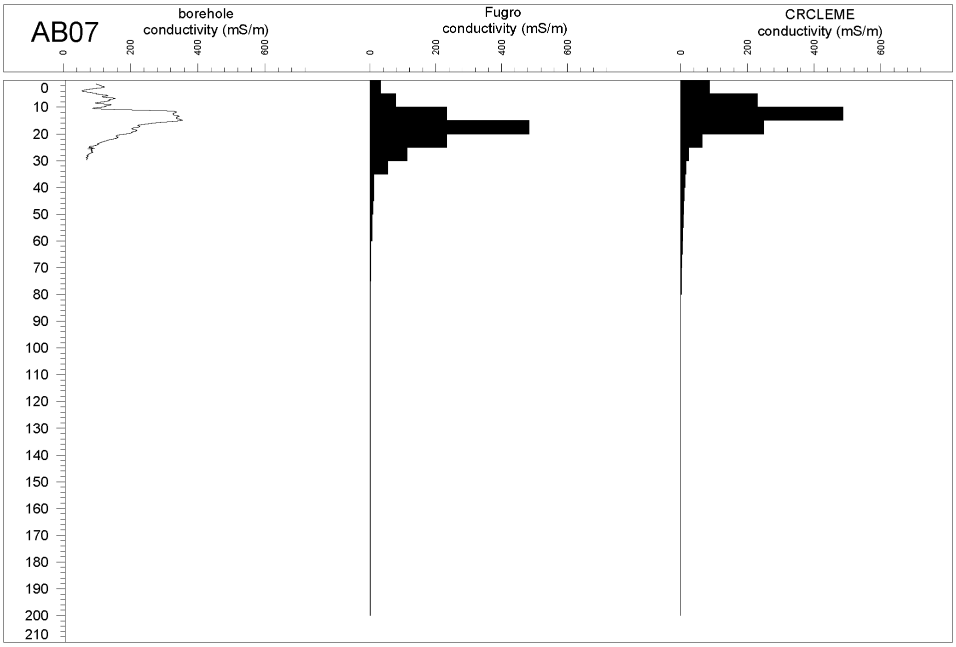

AB02
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

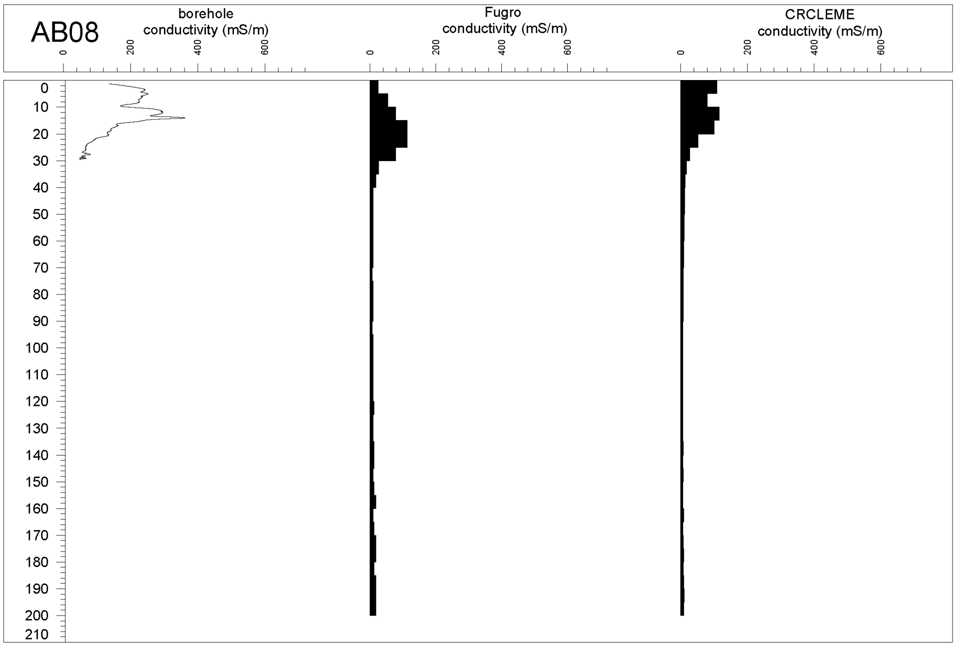

AB03
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

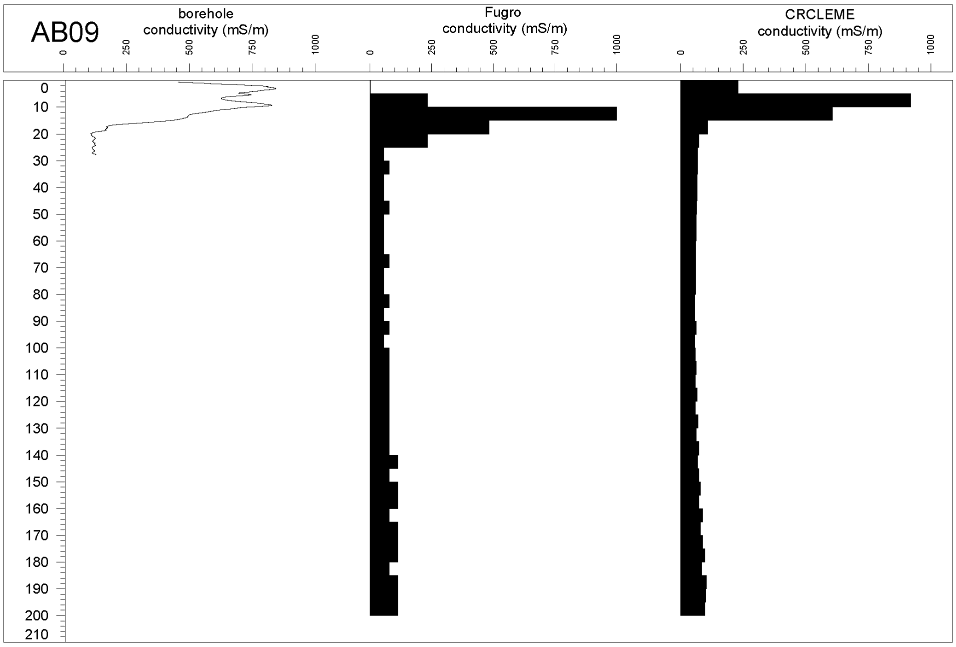

AB04
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

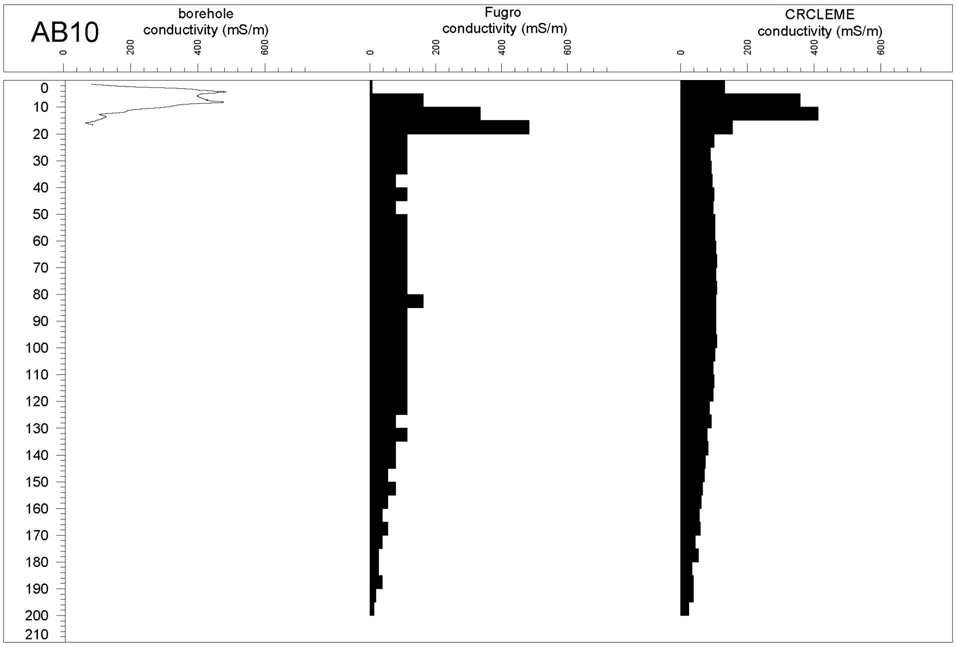

AB05
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

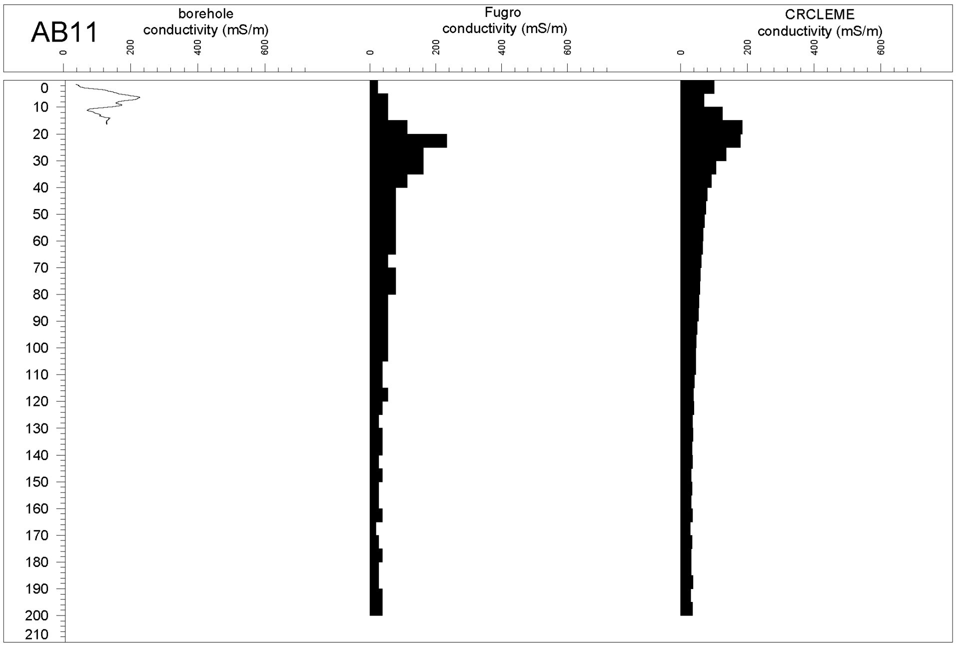

AB06
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

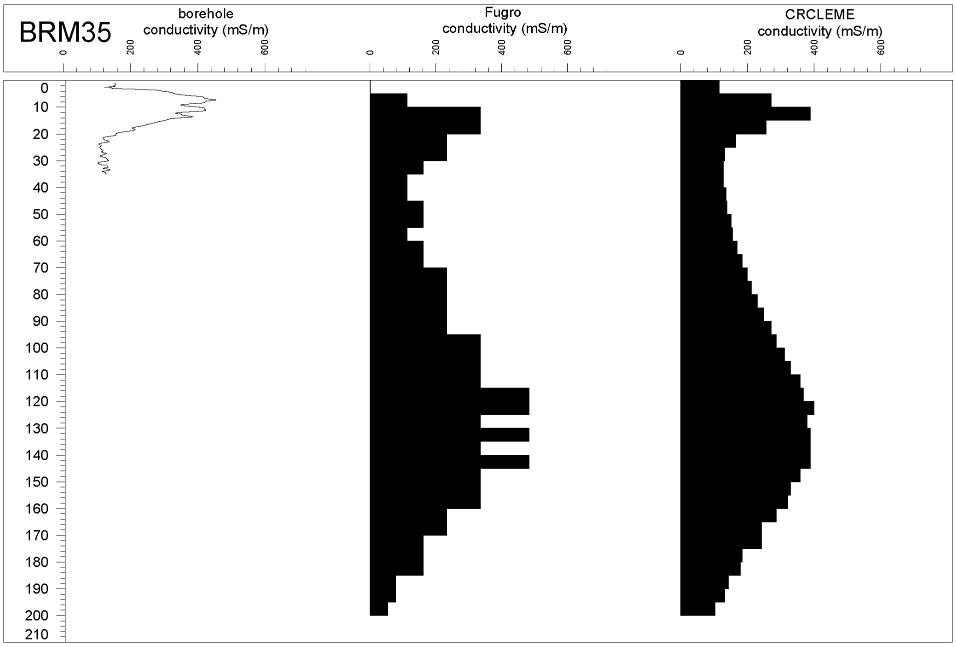

AB07
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

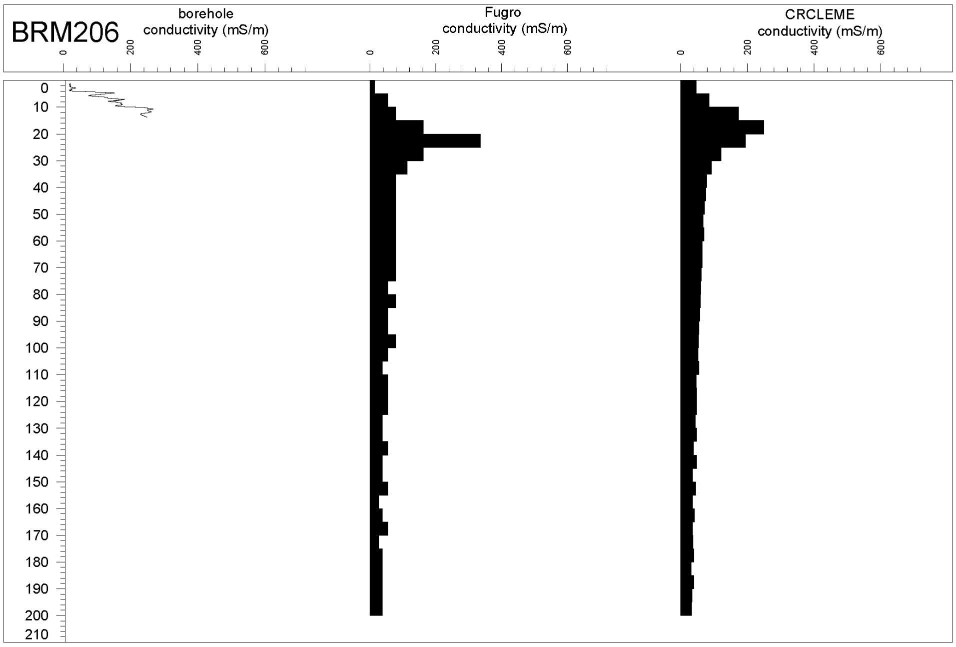

AB08
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

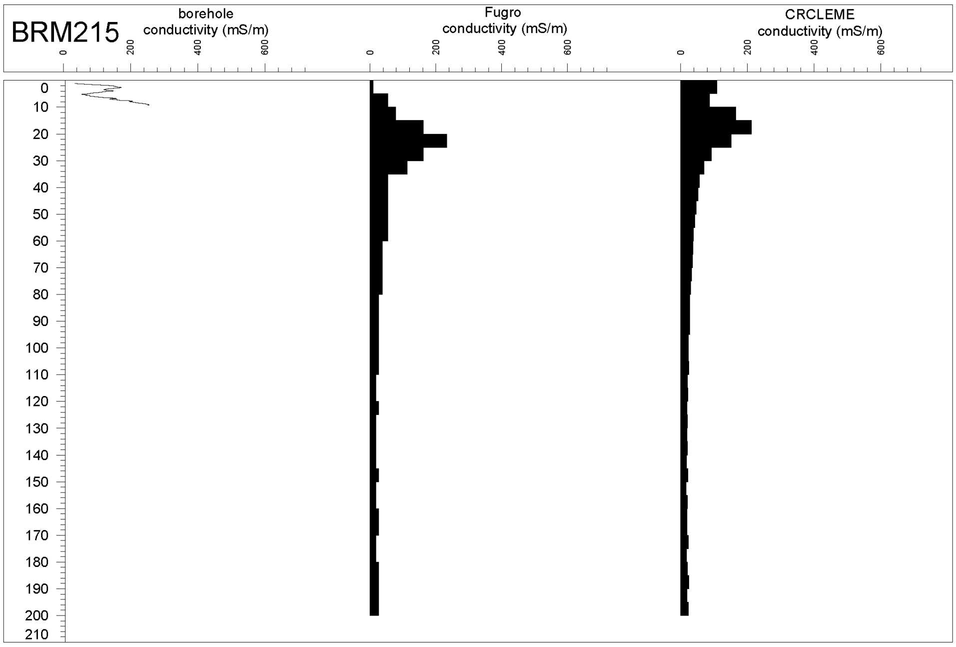

AB09
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)

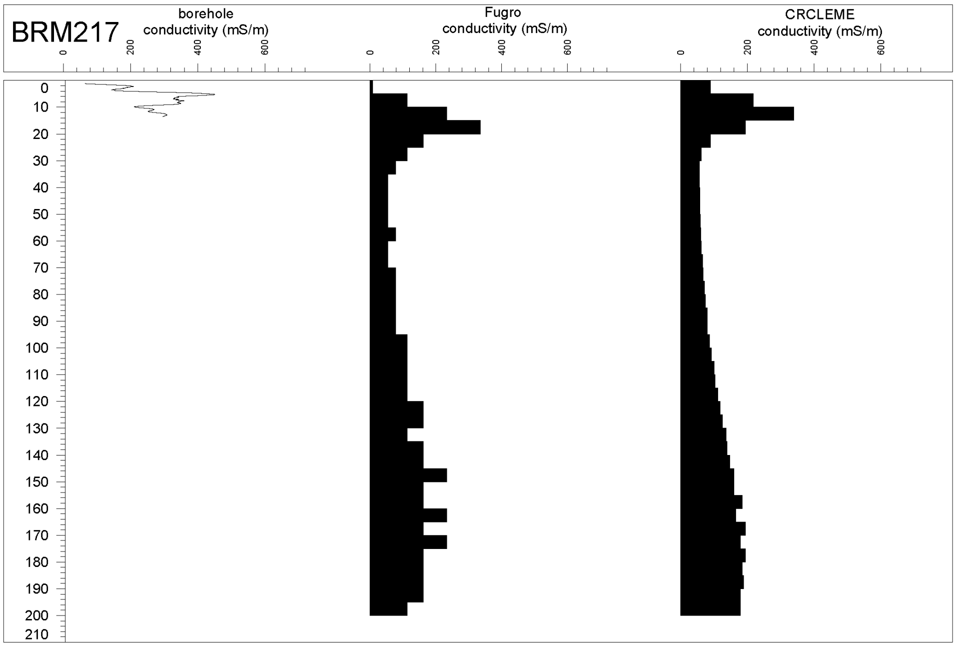

AB10
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)

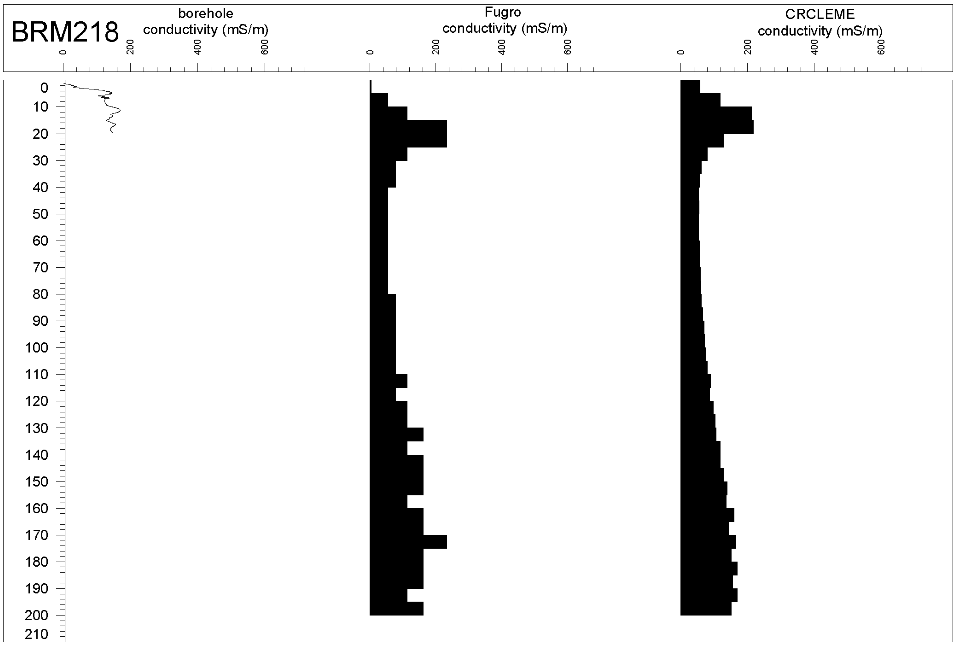

AB11
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

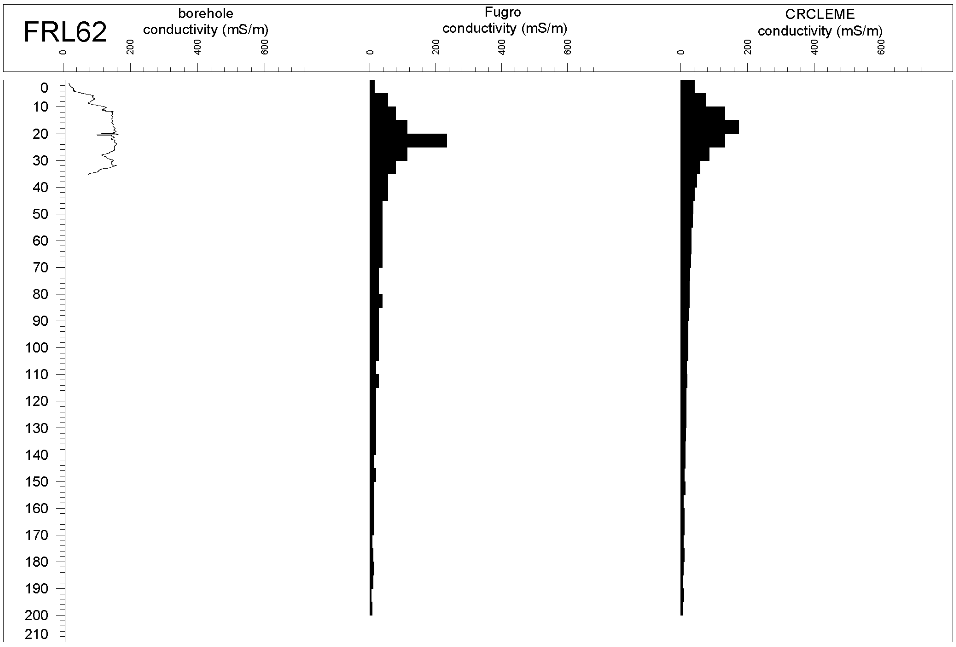

BRM35
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

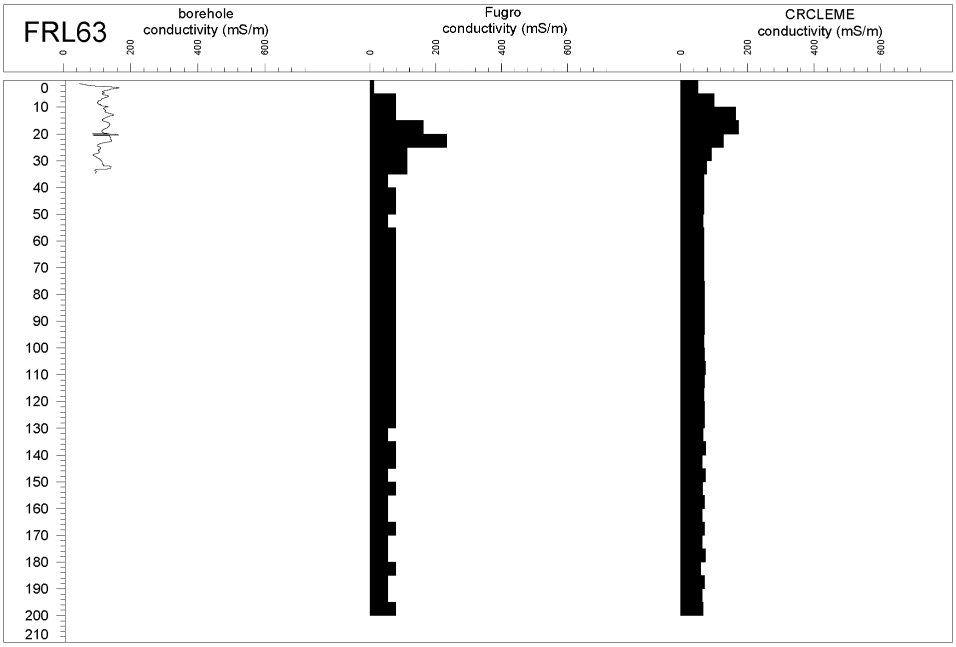

BRM206
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

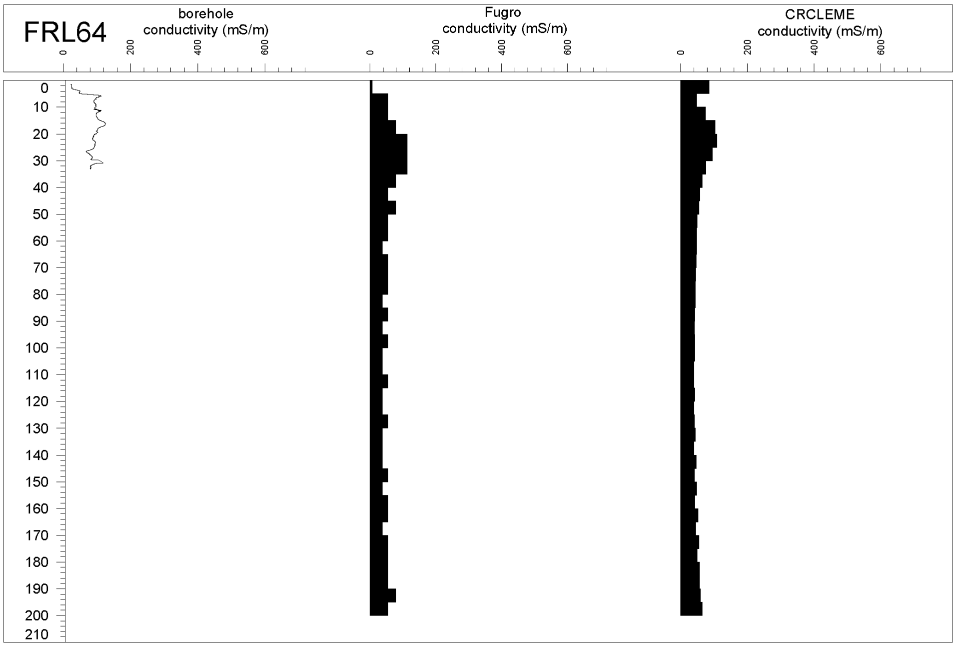

BRM215
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

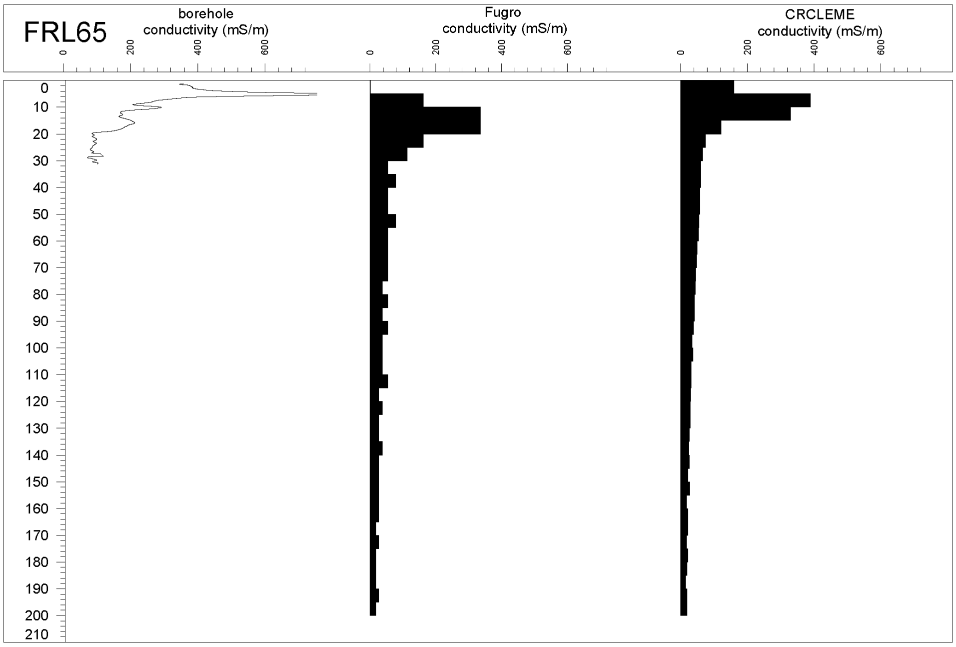

BRM217
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

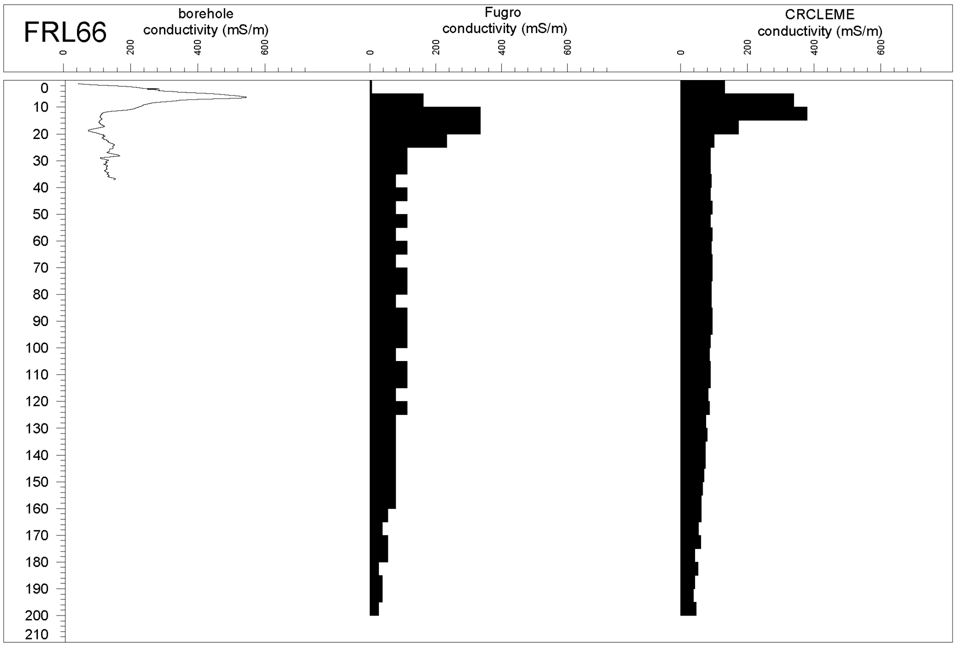

BRM218
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

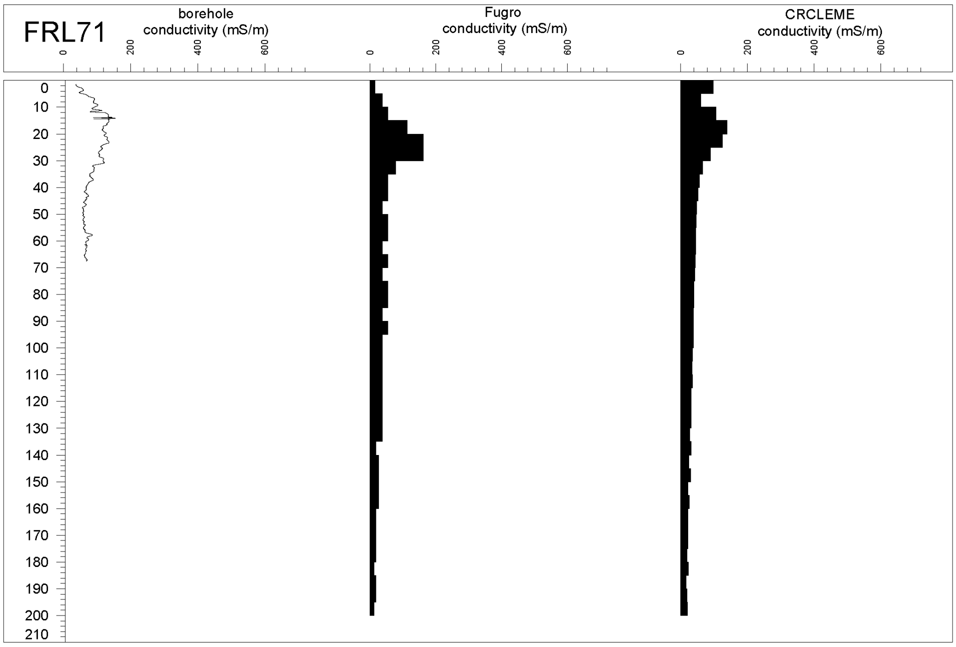

FRL62
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

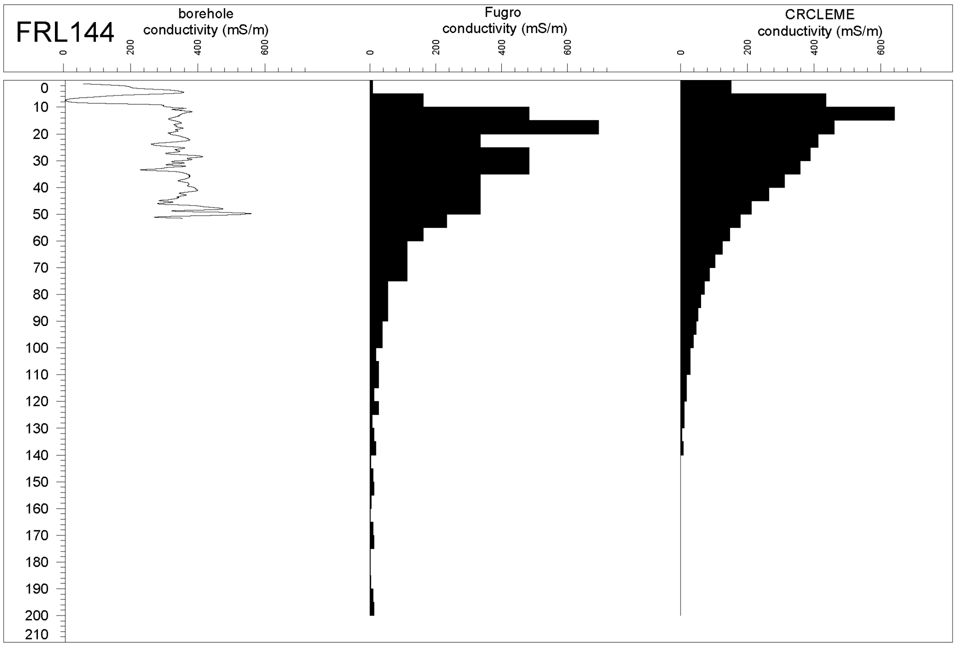

FRL63
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

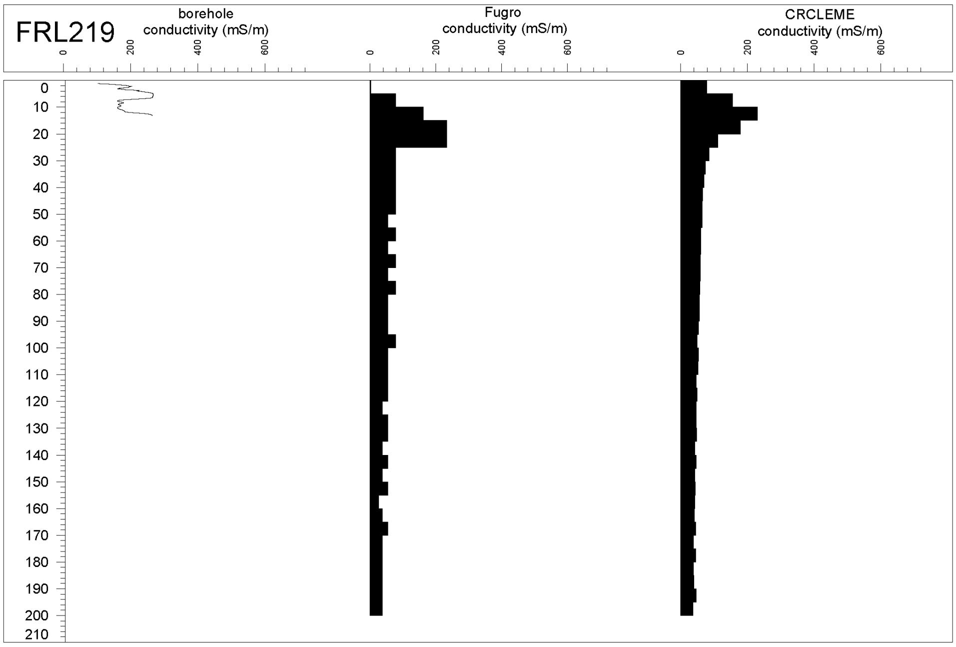

FRL64
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)

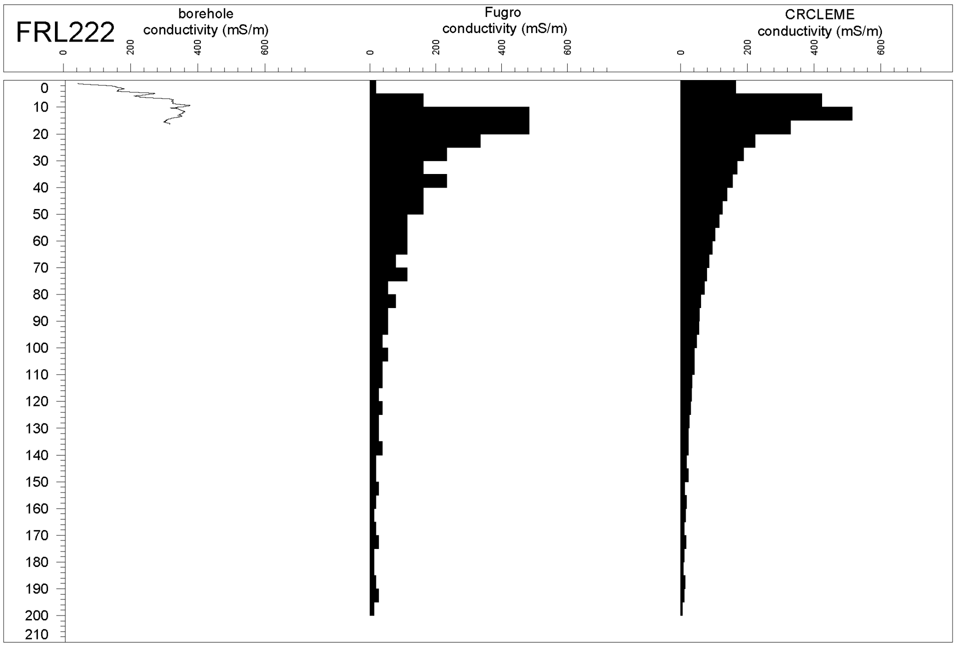

FRL65
borehole
conductivity (mS/m)
Fugro
conductivity (mS/m)
CRCLEME
conductivity (mS/m)

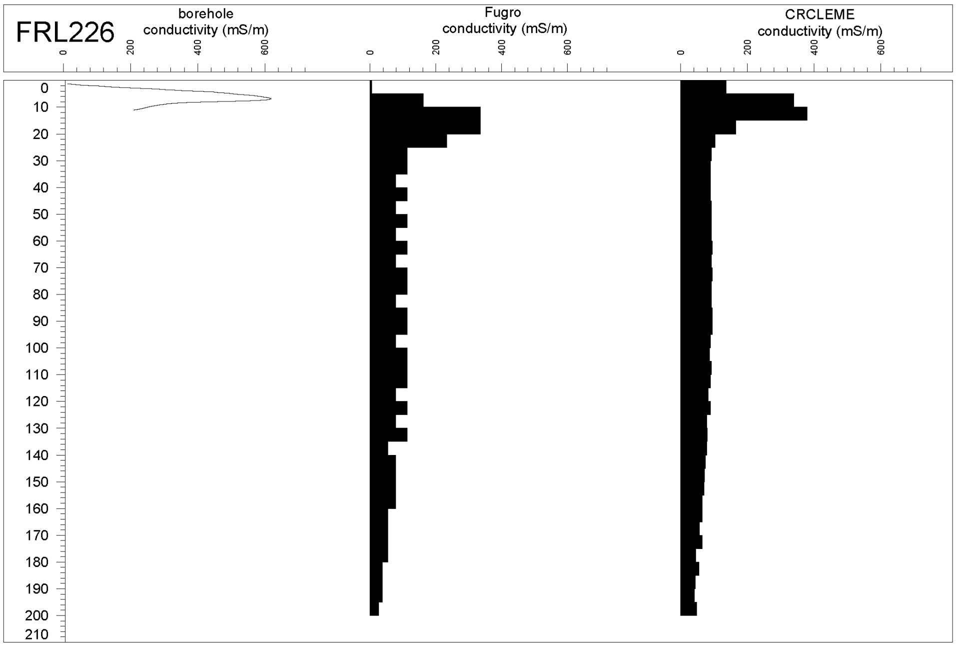

FRL66
borehole
conductivity (mS/m)
0
200
400
600
Fugro
conductivity (mS/m)
0
200
400
600
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

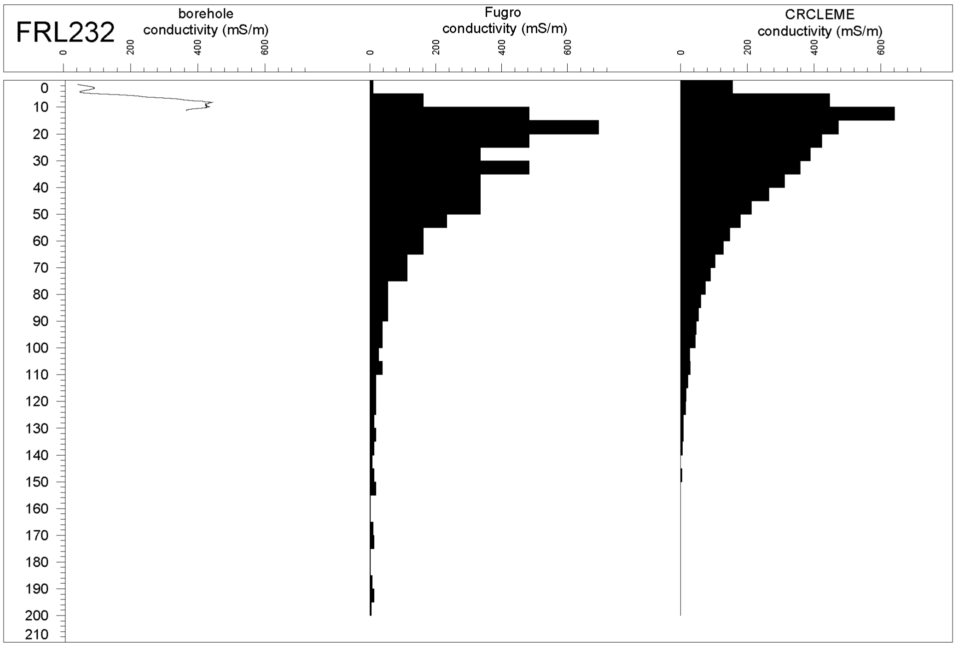

FRL71
borehole
conductivity (mS/m)
0
200
400
600
Fugro
conductivity (mS/m)
0
200
400
600
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


FRL144
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210


FRL219
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210


FRL222
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


FRL226
borehole conductivity (mS/m)
Fugro conductivity (mS/m)
CRCLEME conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210


FRL232
borehole
conductivity (mS/m)
0
200
400
600
Fugro
conductivity (mS/m)
0
200
400
600
CRCLEME
conductivity (mS/m)
0
200
400
600
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210

Appendix III- EMFlow descriptor files: Angas Bremer Plains and Jamestown

```
FILE FORMAT VERSION ANGAS BREMER PLAINS
SYSTEM NAME
TEMPEST 25 Hz X component
VERSION
1.0
DEFINED BY
Andrew Fitzpatrick
DATE DEFINED
24032003
TIME SCALING
1500  0.02   [sec]
WAVEFORM TYPE
halfperiod
0.02   [sec]
WAVEFORM NORMALIZED BY
total field
_________________________________________________________
  TxRx  TxRy  TxRz  TyRx  TyRy  TyRz  TzRx  TzRy  TzRz
     0     0     0     0     0     0    15     0     0
_________________________________________________________
                         ++++++++
                         + TzRx +
                         ++++++++
_________________________________________________________
TRANSMITTER CURRENT WAVEFORM
undefined
_________________________________________________________
RECEIVER PRIMARY FIELD
calibrated
AMPLITUDE SCALING
1  1   []
4
        TIME       CURRENT         ERROR  [ppm]
           0             0             0
           1         26.79             0
        1499         26.79             0
        1500             0             0
_________________________________________________________
RECEIVER SAMPLING
15
       START           END        WEIGHT
         0.5           1.5             1
         2.5           3.5             1
         4.5           5.5             1
         6.5           9.5             1
        10.5          15.5             1
        16.5          25.5             1
        26.5          41.5             1
        42.5          65.5             1
        66.5         101.5             1
       102.5         157.5             1
       158.5         245.5             1
       246.5         383.5             1
       384.5         599.5             1
       600.5         929.5             1
       930.5        1499.5             1
_________________________________________________________
```

```
TRANSMITTER GEOMETRY
moving dipole
z
      0       0       1
XYZ POSITION:
      0       0       5
```

```
RECEIVER GEOMETRY
moving dipole
x
      1       0       0
XYZ POSITION:
   -128       0     -30
```

```
DATA FORMAT
Geosoft format (1 yes, 0 no)
     0
Sample file name (if available)
C:\ab_plains\angasbremerplains_hprg_emflow.dat
Number of comment lines at the beginning of each data file
     0
Number of items in each data record
    40
POSITION (INDEX) OF CHANNELS IN EACH DATA RECORD
```

channel	????	TxRx	TxRy	TxRz	TyRx	TyRy	TyRz	TzRx	TzRy	TzRz
1	0	0	0	0	0	0	0	11	0	0
2	0	0	0	0	0	0	0	12	0	0
3	0	0	0	0	0	0	0	13	0	0
4	0	0	0	0	0	0	0	14	0	0
5	0	0	0	0	0	0	0	15	0	0
6	0	0	0	0	0	0	0	16	0	0
7	0	0	0	0	0	0	0	17	0	0
8	0	0	0	0	0	0	0	18	0	0
9	0	0	0	0	0	0	0	19	0	0
10	0	0	0	0	0	0	0	20	0	0
11	0	0	0	0	0	0	0	21	0	0
12	0	0	0	0	0	0	0	22	0	0
13	0	0	0	0	0	0	0	23	0	0
14	0	0	0	0	0	0	0	24	0	0
15	0	0	0	0	0	0	0	25	0	0

```
----------------------
line          2   1
FID           3   1
east          4   1
north         5   1
z_topo        6   1
altitude      8   1
Rx_pitch      0   0
Rx_roll       10  0
Rx_yaw        0   0
Tx_pitch      9   0
Tx_roll       0   0
Tx_yaw        0   0
z(ASL)        0   2
----------------------
```

FILE FORMAT VERSION
9
SYSTEM NAME
TEMPEST 25 Hz X component
VERSION
1.0
DEFINED BY
Andrew Fitzpatrick
DATE DEFINED
24032003
TIME SCALING
1500 0.02 [sec]
WAVEFORM TYPE
halfperiod
0.02 [sec]
WAVEFORM NORMALIZED BY
total field

TxRx	TxRy	TxRz	TyRx	TyRy	TyRz	TzRx	TzRy	TzRz
0	0	0	0	0	0	15	0	0

++++++++
+ TzRx +
++++++++

TRANSMITTER CURRENT WAVEFORM
undefined

RECEIVER PRIMARY FIELD
calibrated
AMPLITUDE SCALING
1 1 []
4

TIME	CURRENT	ERROR	[ppm]
0	0	0	
1	23.5	0	
1499	23.529	0	
1500	0	0	

RECEIVER SAMPLING
15

START	END	WEIGHT
0.5	1.5	1
2.5	3.5	1
4.5	5.5	1
6.5	9.5	1
10.5	15.5	1
16.5	25.5	1
26.5	41.5	1
42.5	65.5	1
66.5	101.5	1
102.5	157.5	1
158.5	245.5	1
246.5	383.5	1
384.5	599.5	1
600.5	929.5	1
930.5	1499.5	1

TRANSMITTER GEOMETRY
moving dipole
z

```
      0       0       1
```

XYZ POSITION:

```
      0       0       5
```

RECEIVER GEOMETRY
moving dipole
x

```
      1       0       0
```

XYZ POSITION:

```
   -128       0     -30
```

DATA FORMAT
Geosoft format (1 yes, 0 no)
0
Sample file name (if available)
C:\jamestown\jamestown_hprg_emflow.dat
Number of comment lines at the beginning of each data file
0
Number of items in each data record
40
POSITION (INDEX) OF CHANNELS IN EACH DATA RECORD

channel	????	TxRx	TxRy	TxRz	TyRx	TyRy	TyRz	TzRx	TzRy	TzRz
1	0	0	0	0	0	0	0	11	0	0
2	0	0	0	0	0	0	0	12	0	0
3	0	0	0	0	0	0	0	13	0	0
4	0	0	0	0	0	0	0	14	0	0
5	0	0	0	0	0	0	0	15	0	0
6	0	0	0	0	0	0	0	16	0	0
7	0	0	0	0	0	0	0	17	0	0
8	0	0	0	0	0	0	0	18	0	0
9	0	0	0	0	0	0	0	19	0	0
10	0	0	0	0	0	0	0	20	0	0
11	0	0	0	0	0	0	0	21	0	0
12	0	0	0	0	0	0	0	22	0	0
13	0	0	0	0	0	0	0	23	0	0
14	0	0	0	0	0	0	0	24	0	0
15	0	0	0	0	0	0	0	25	0	0

----

line	2	1
FID	3	1
east	4	1
north	5	1
z_topo	6	1
altitude	8	1
Rx_pitch	0	0
Rx_roll	10	0
Rx_yaw	0	0
Tx_pitch	9	0
Tx_roll	0	0
Tx_yaw	0	0
z(ASL)	0	2
