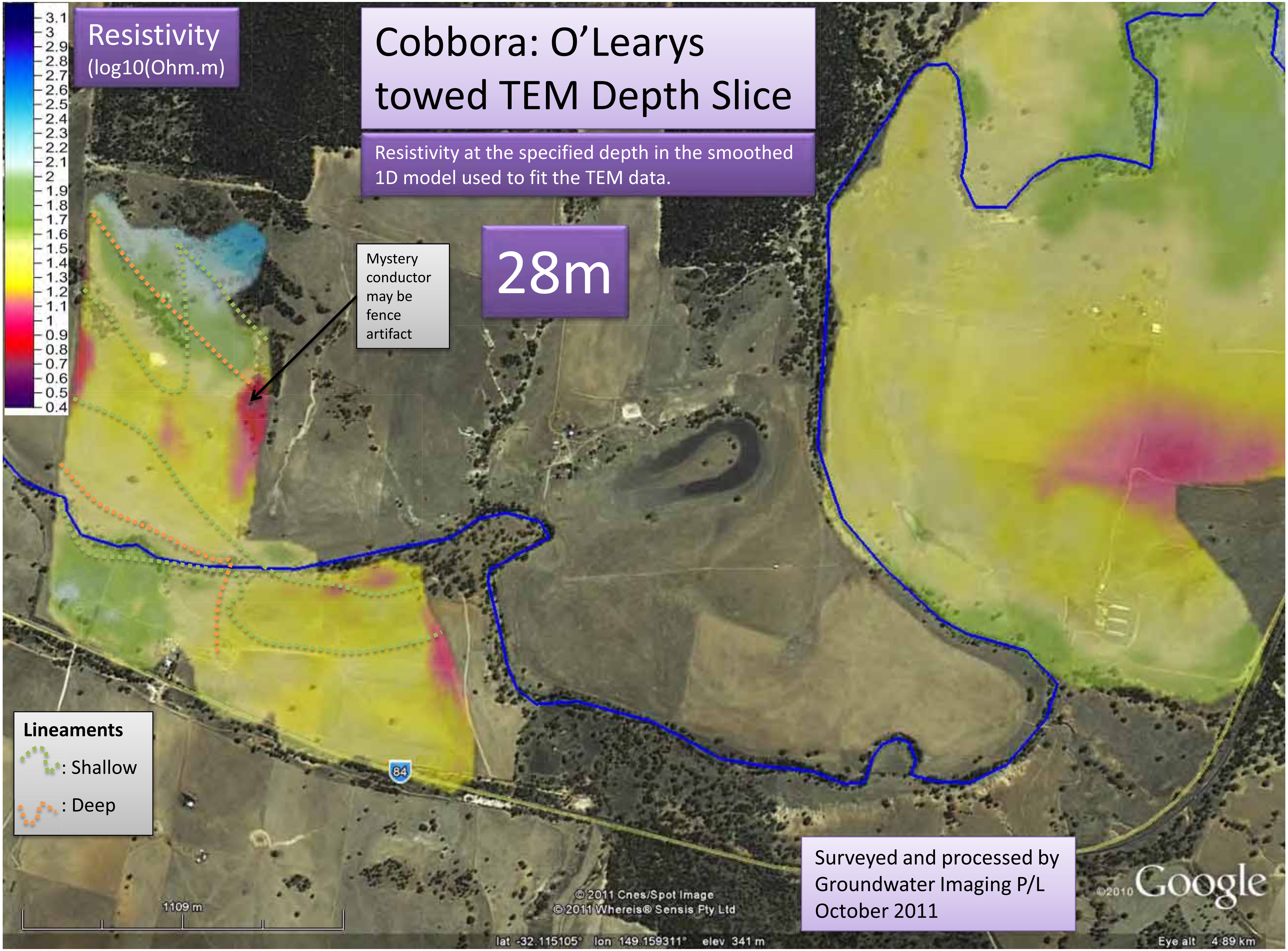
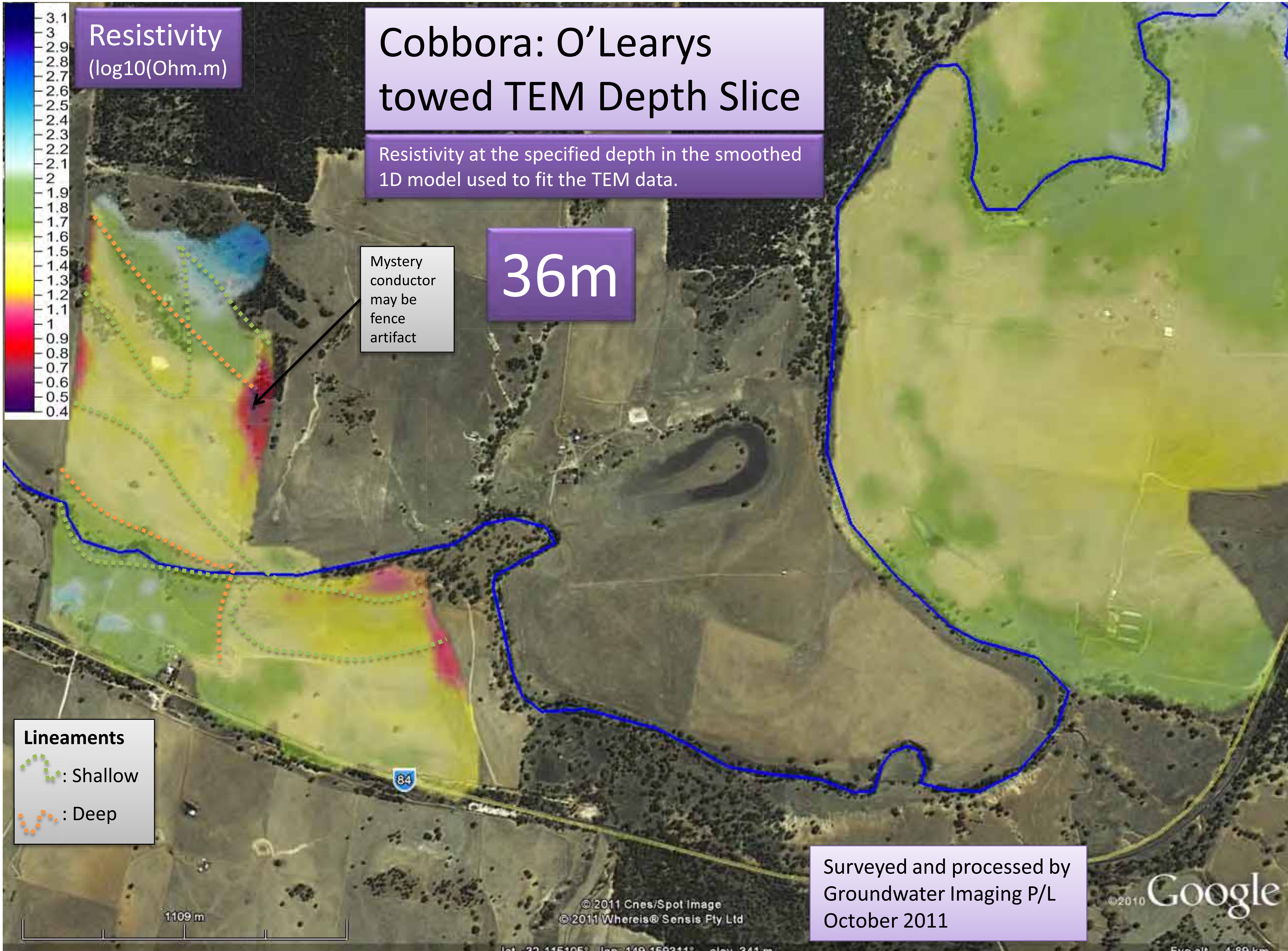
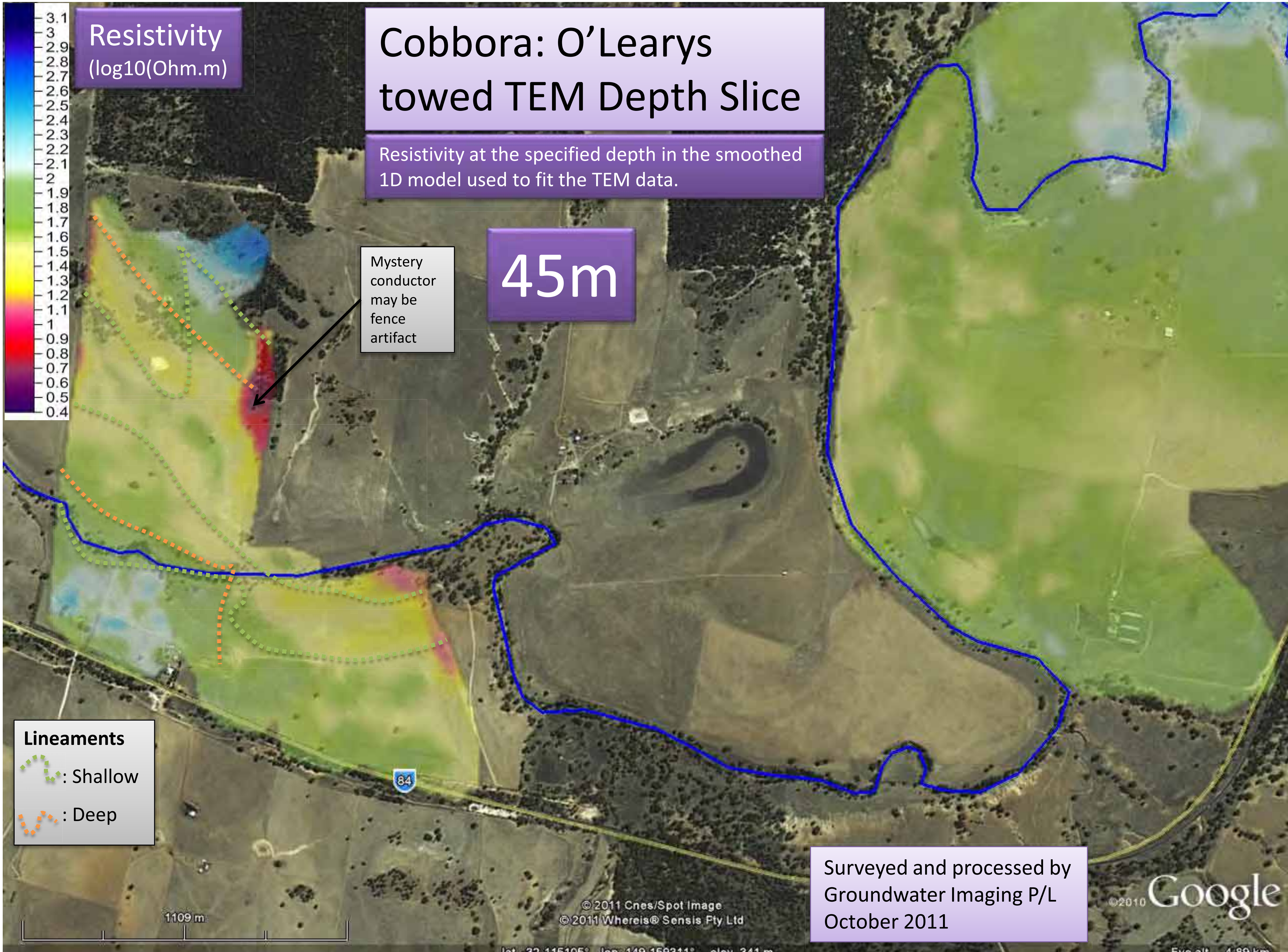
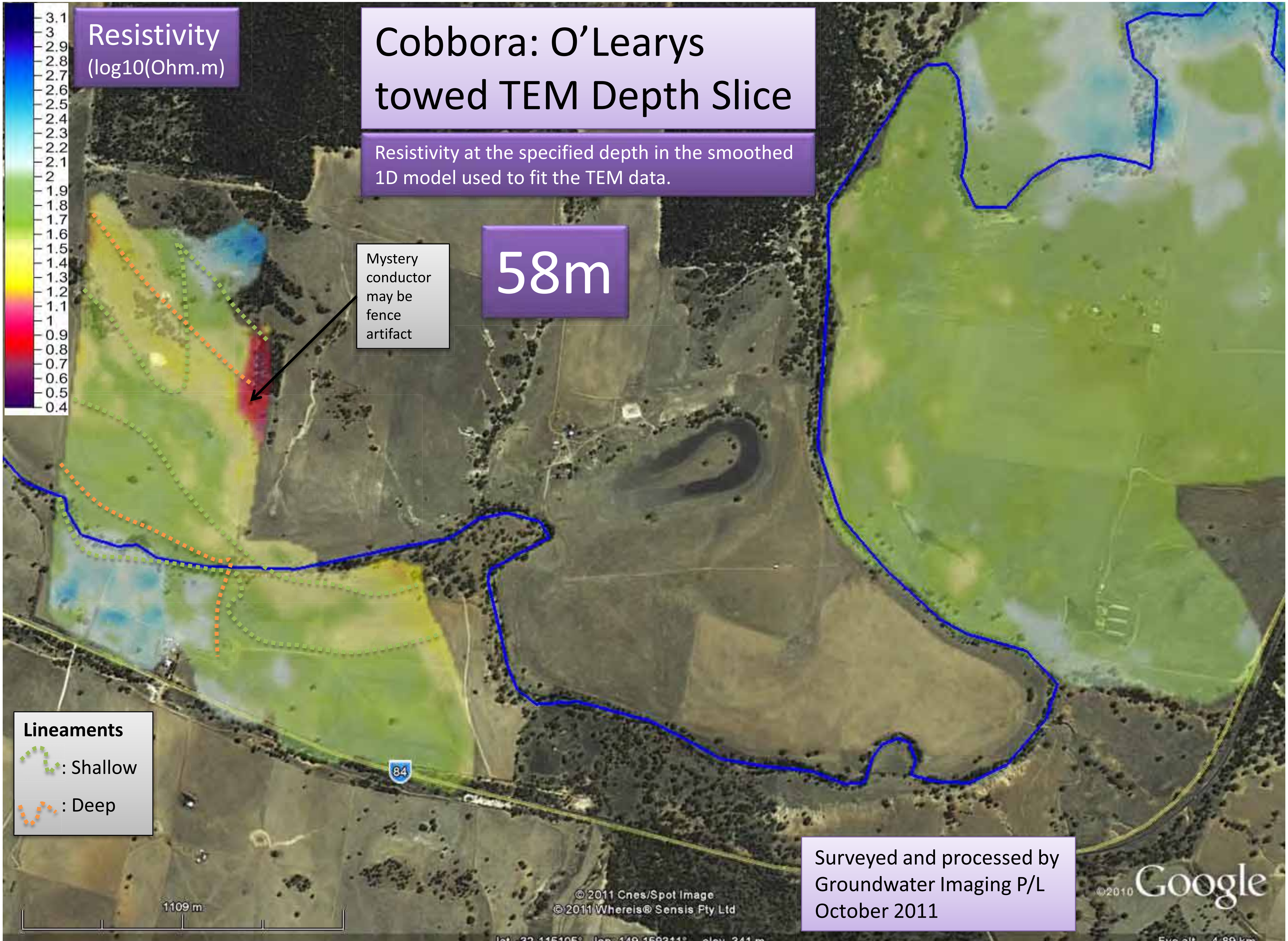


Resistivity
(log10(Ohm.m)
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Cobbora: O'Learys towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
28m
Mystery conductor may be fence artifact
Lineaments
: Shallow
: Deep
84
1109 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.115105° lon 149.159311° elev 341 m
Surveyed and processed by Groundwater Imaging P/L October 2011
©2010 Google
Eye alt 4.89 km



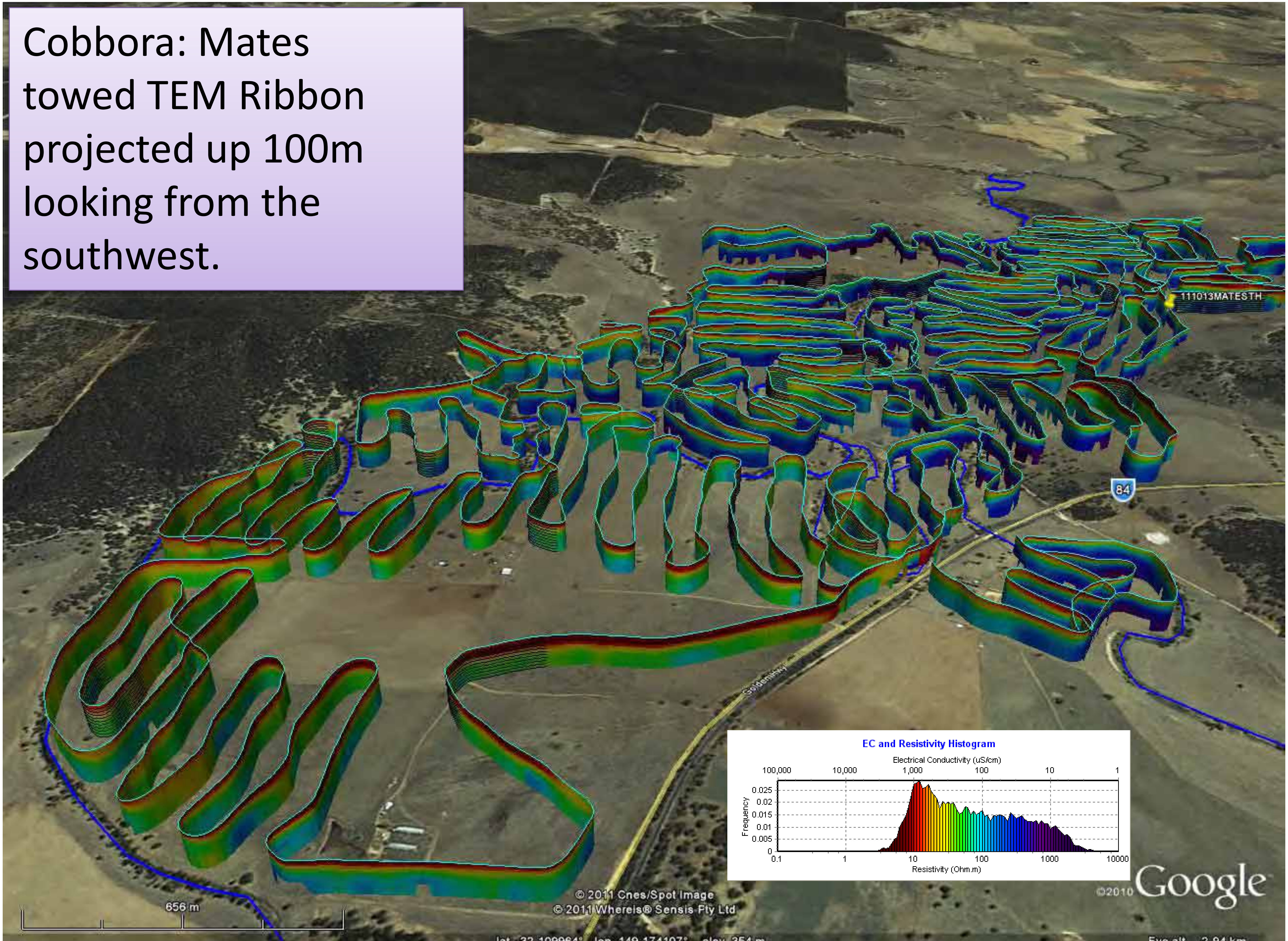
Cobbora: O'Learys towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Resistivity (log10(Ohm.m)
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
36m
Mystery conductor may be fence artifact
Lineaments
: Shallow
: Deep
Surveyed and processed by Groundwater Imaging P/L October 2011
1109 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.115105° lon 149.159311° elev 341 m
Eye alt 4.89 km
©2010 Google
84


Cobbora: O'Learys towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Resistivity (log10(Ohm.m)
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
45m
Mystery conductor may be fence artifact
Lineaments
: Shallow
: Deep
84
1109 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
Surveyed and processed by Groundwater Imaging P/L October 2011
©2010 Google
lat -32.115105° lon 149.159311° elev 341 m
Eye alt 4.89 km



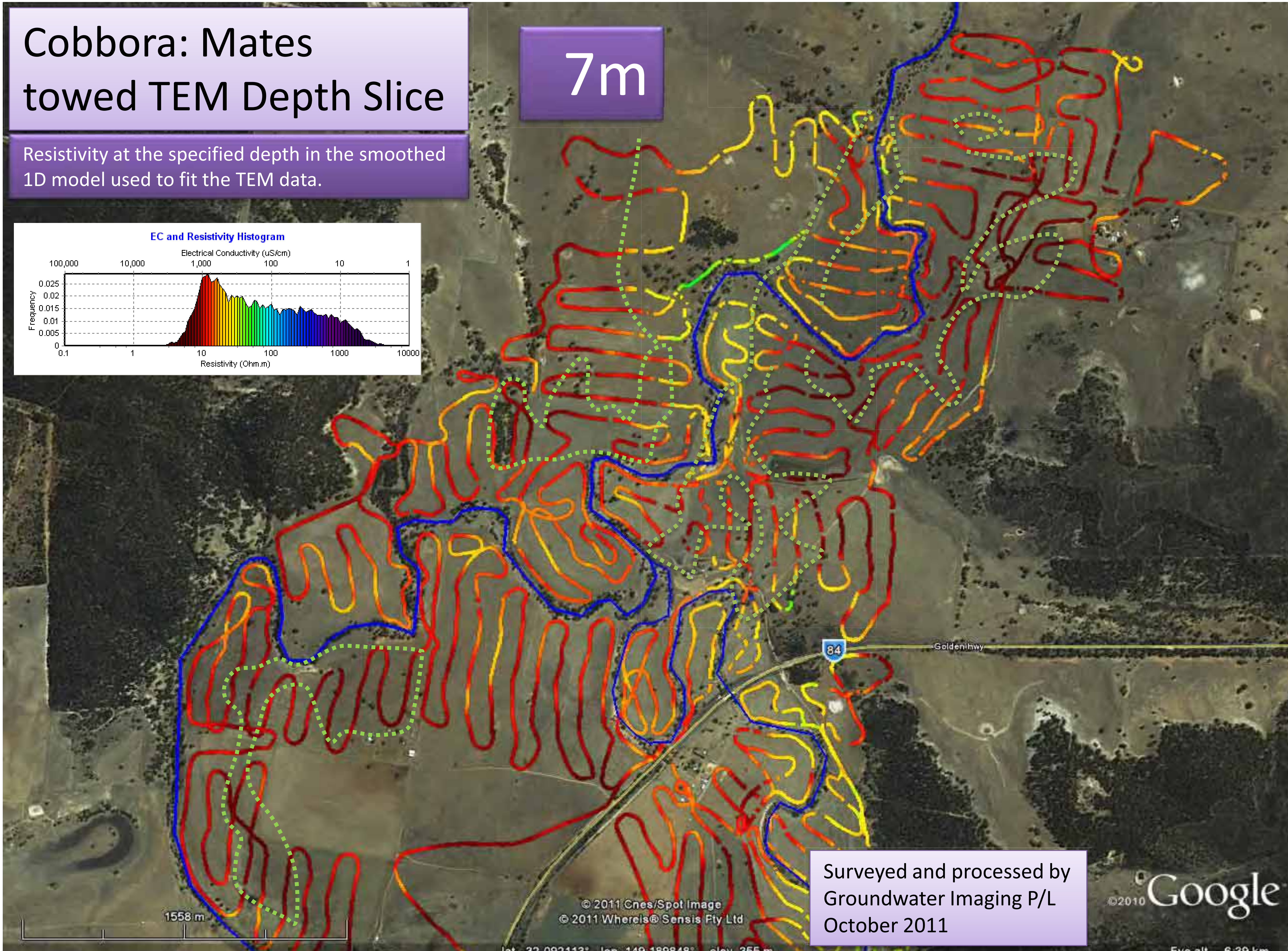
Cobbora: O'Learys towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
58m
Resistivity (log10(Ohm.m)
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Mystery conductor may be fence artifact
Lineaments
: Shallow
: Deep
84
1109 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.115105° lon 149.159311° elev 341 m
Eye alt 4.89 km
©2010 Google
Surveyed and processed by Groundwater Imaging P/L October 2011

# Cobbora: Mates towed TEM Ribbon projected up 100m looking from the southwest.

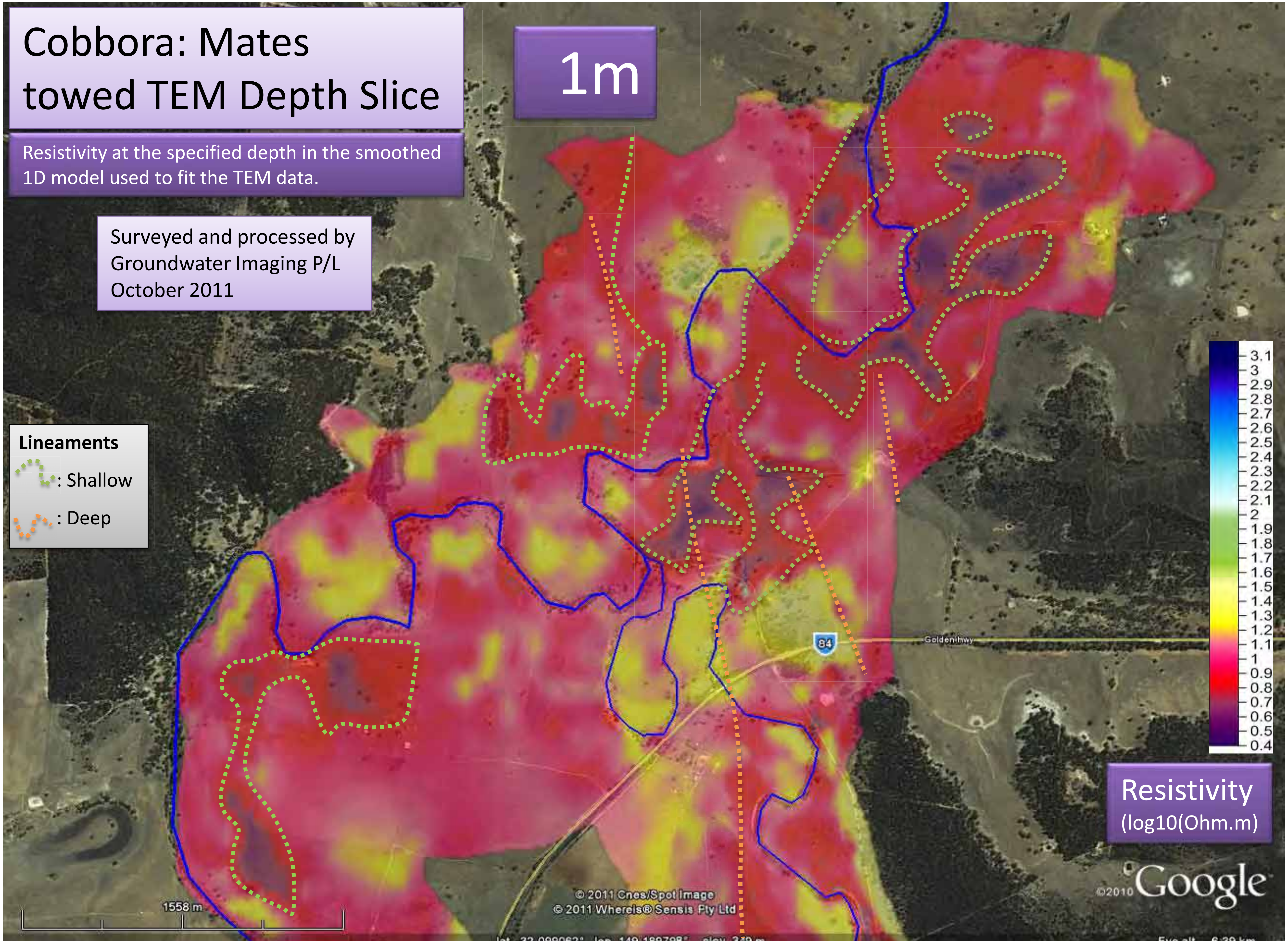


# Cobbora: Mates towed TEM Depth Slice

Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.

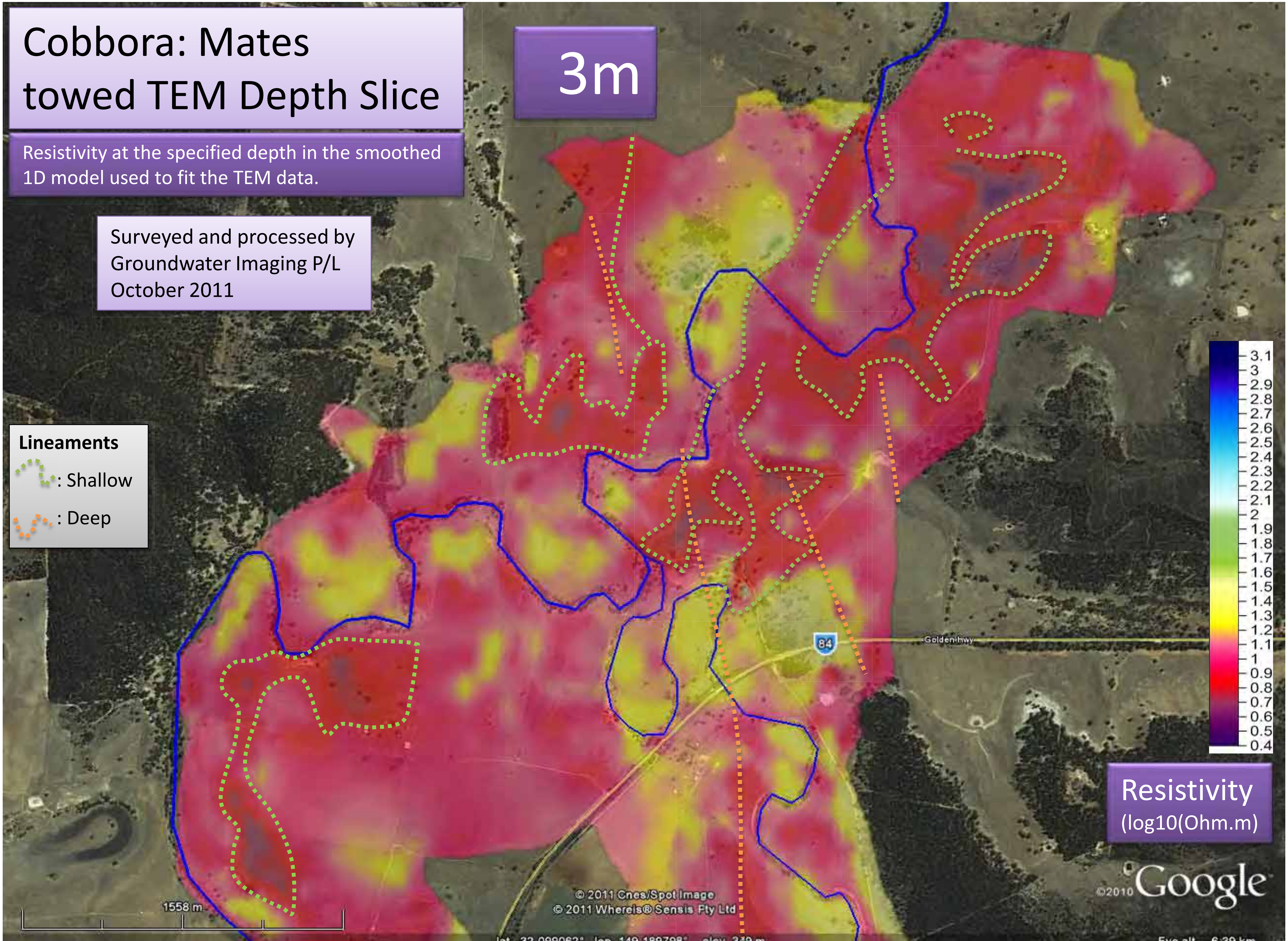


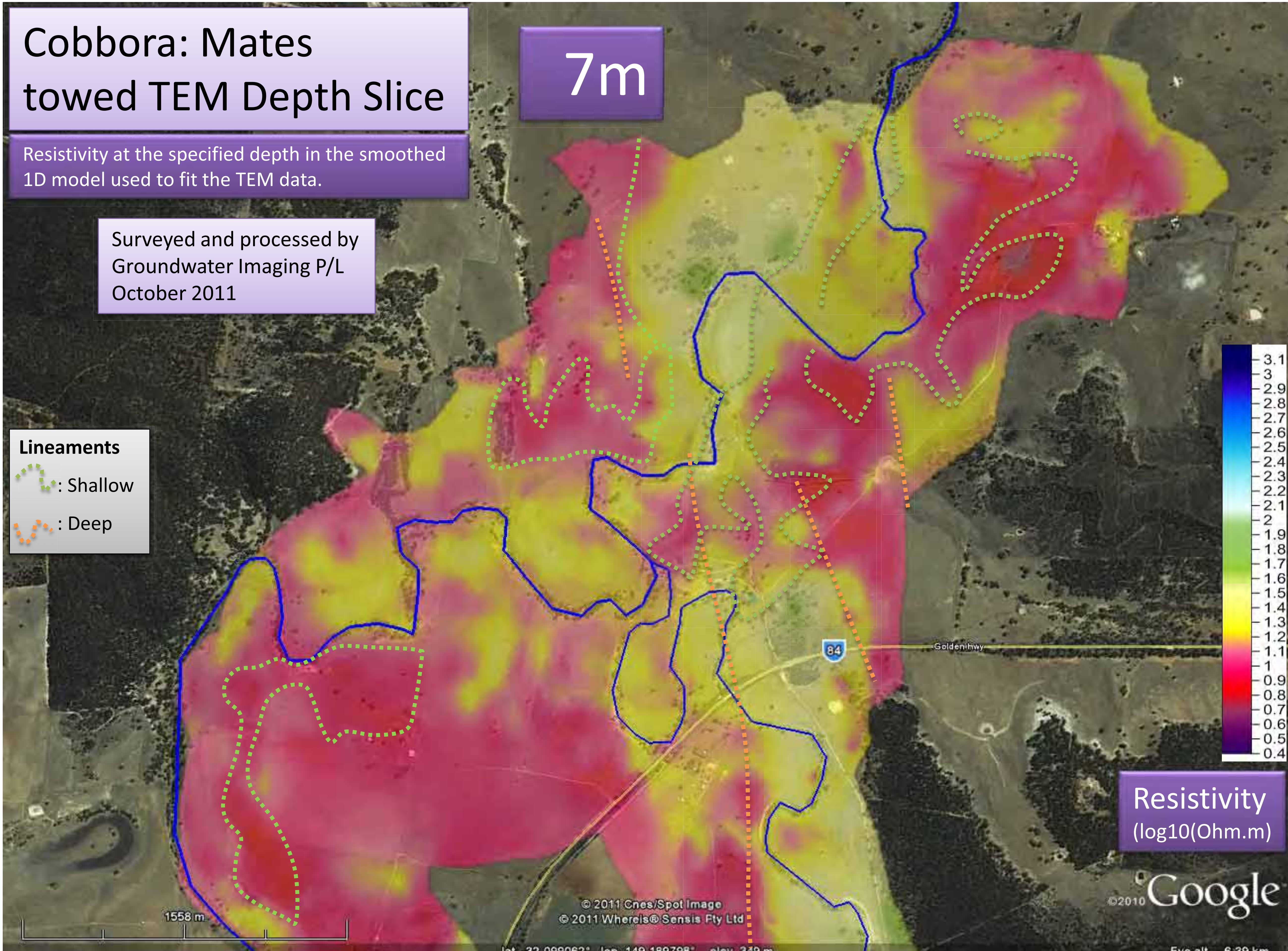

Surveyed and processed by Groundwater Imaging P/L October 2011


Cobbora: Mates towed TEM Depth Slice
1m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by Groundwater Imaging P/L October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden Hwy
1558 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.099062° lon 149.189798° elev 349 m
Eye alt 6.39 km
©2010 Google

# Cobbora: Mates towed TEM Depth Slice

Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.



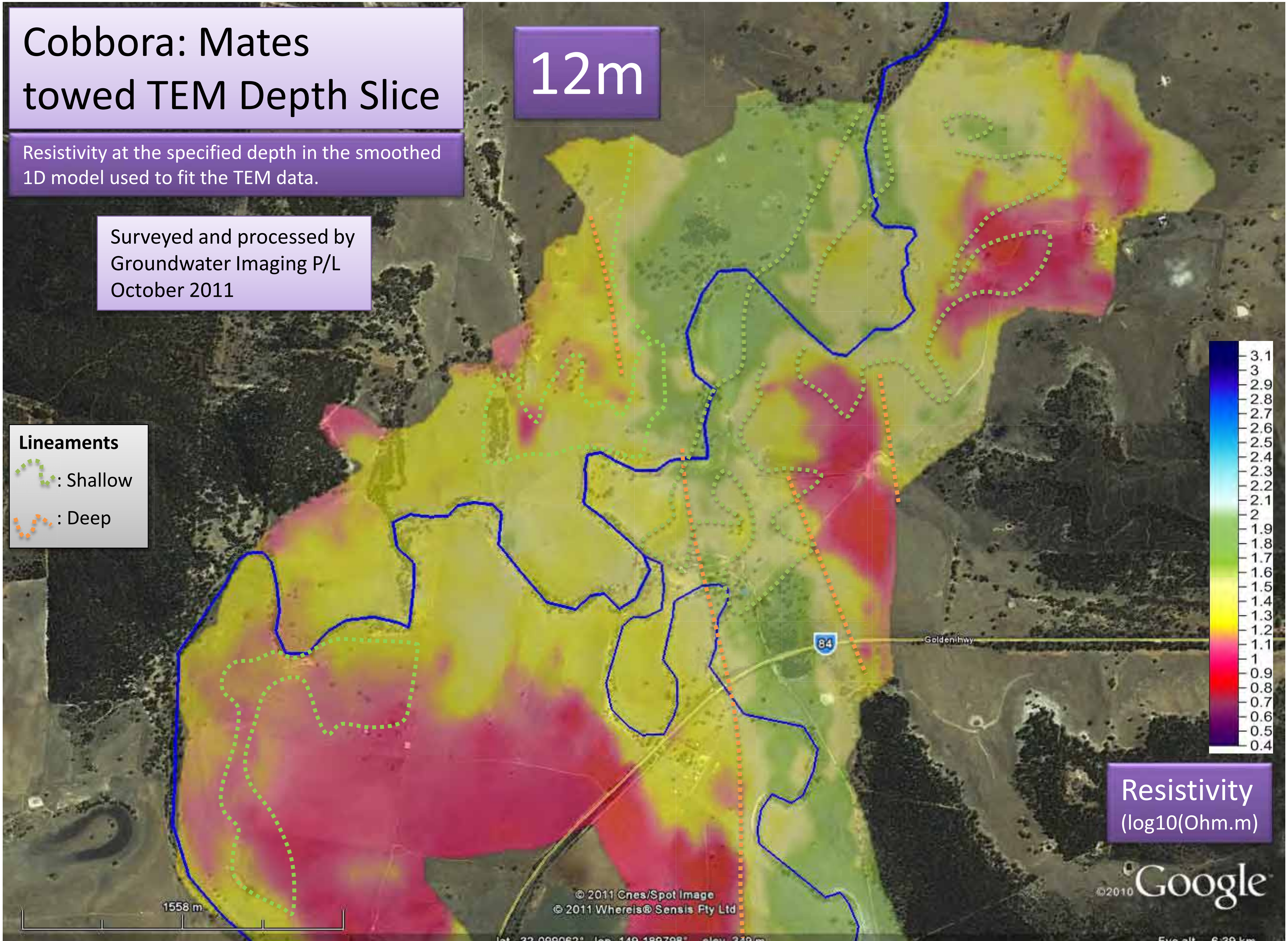


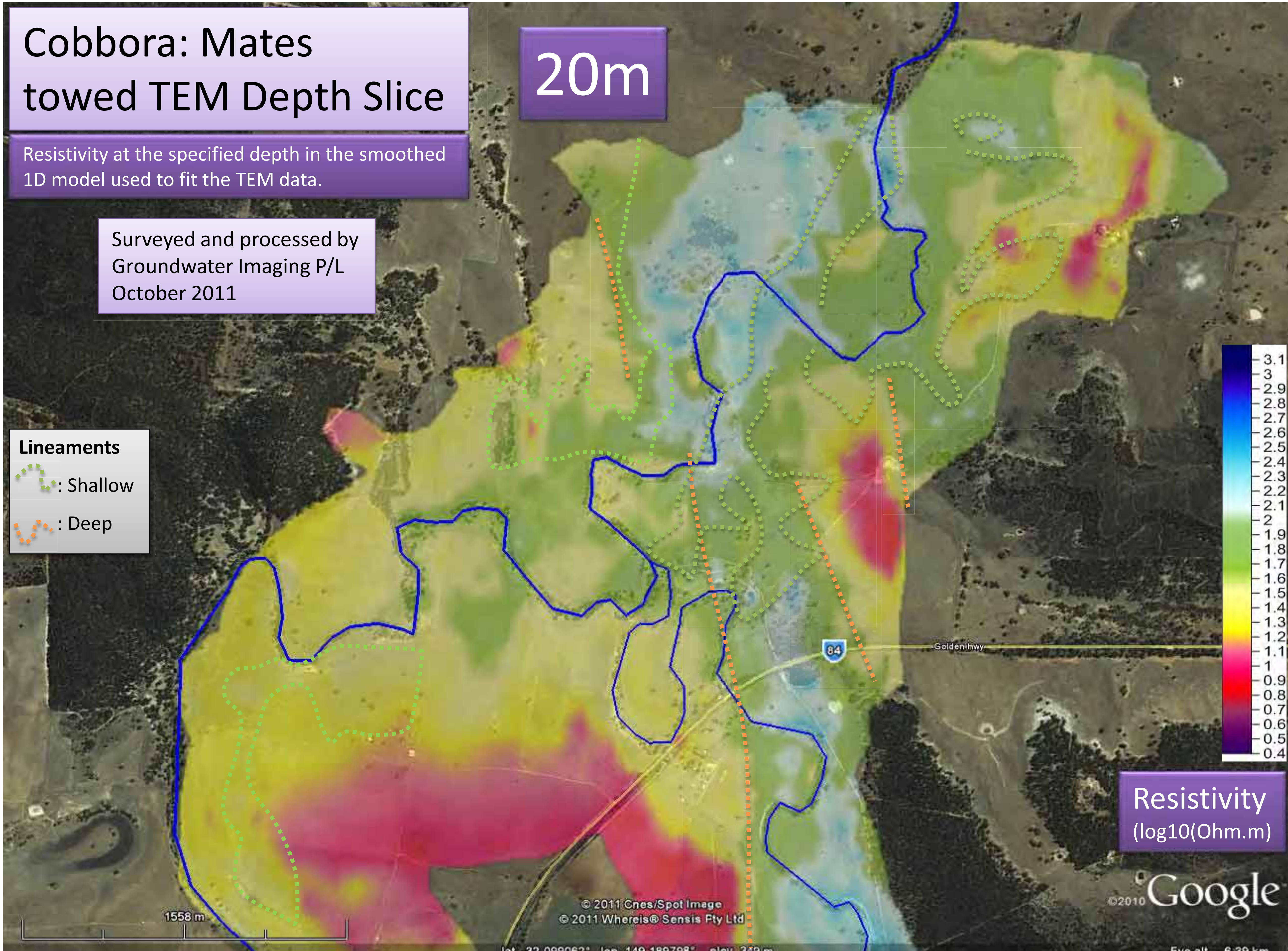
Cobbora: Mates towed TEM Depth Slice
7m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by Groundwater Imaging P/L October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity (log10(Ohm.m))
84
Golden Hwy
1558 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.099062° lon 149.189798° elev 349 m
Eye alt 6.39 km
©2010 Google

# Cobbora: Mates towed TEM Depth Slice

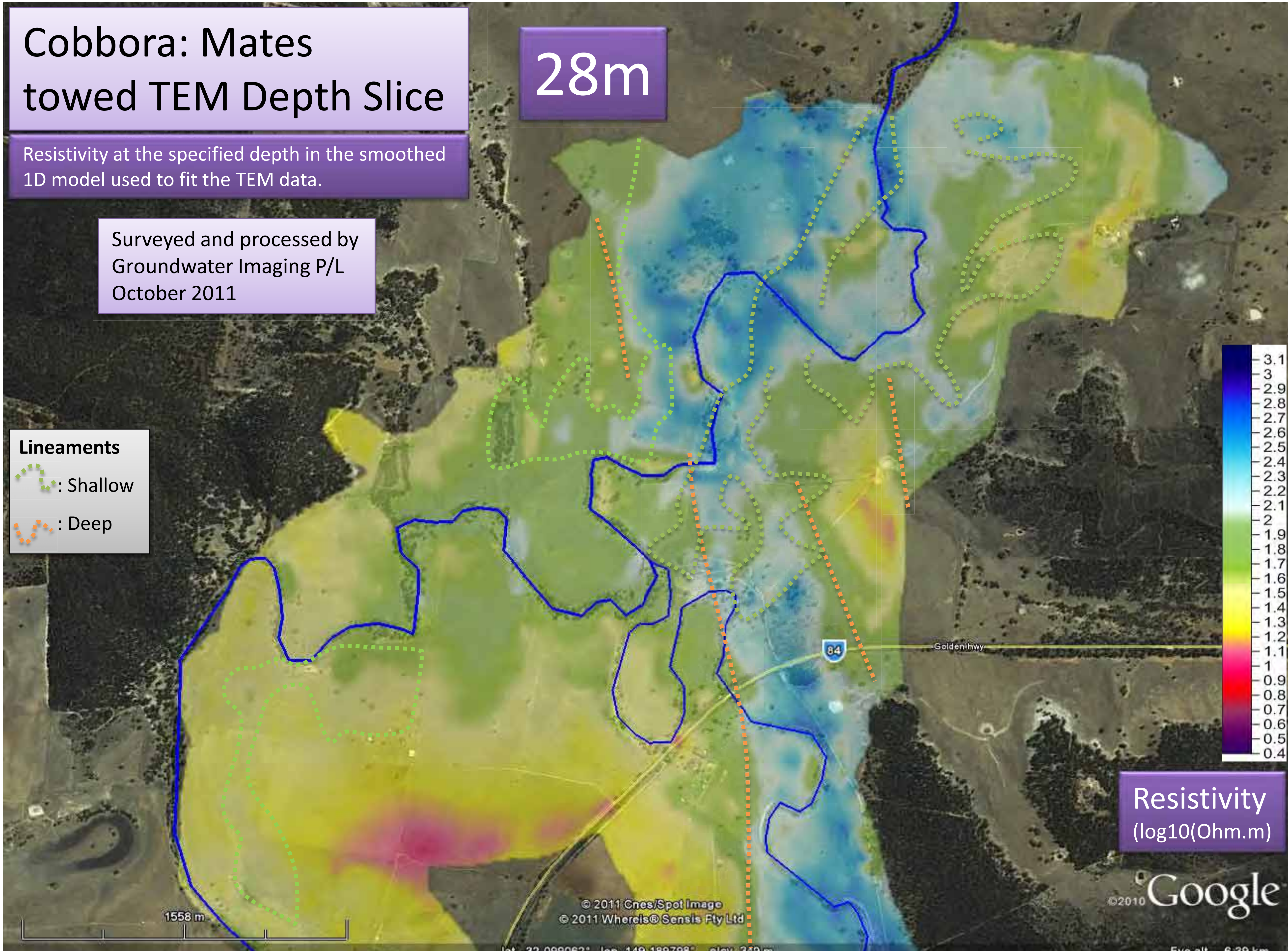
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.

Surveyed and processed by Groundwater Imaging P/L October 2011

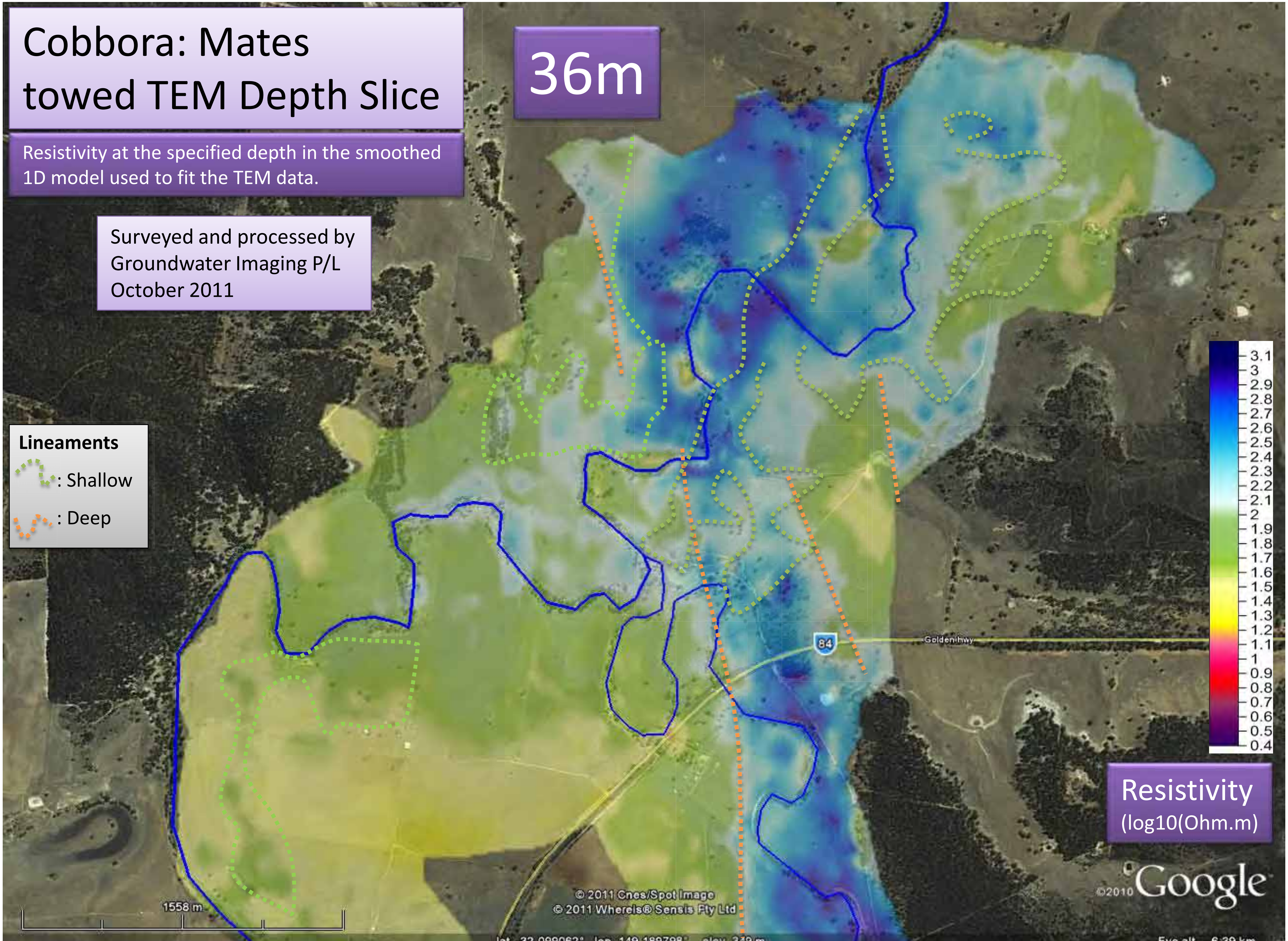




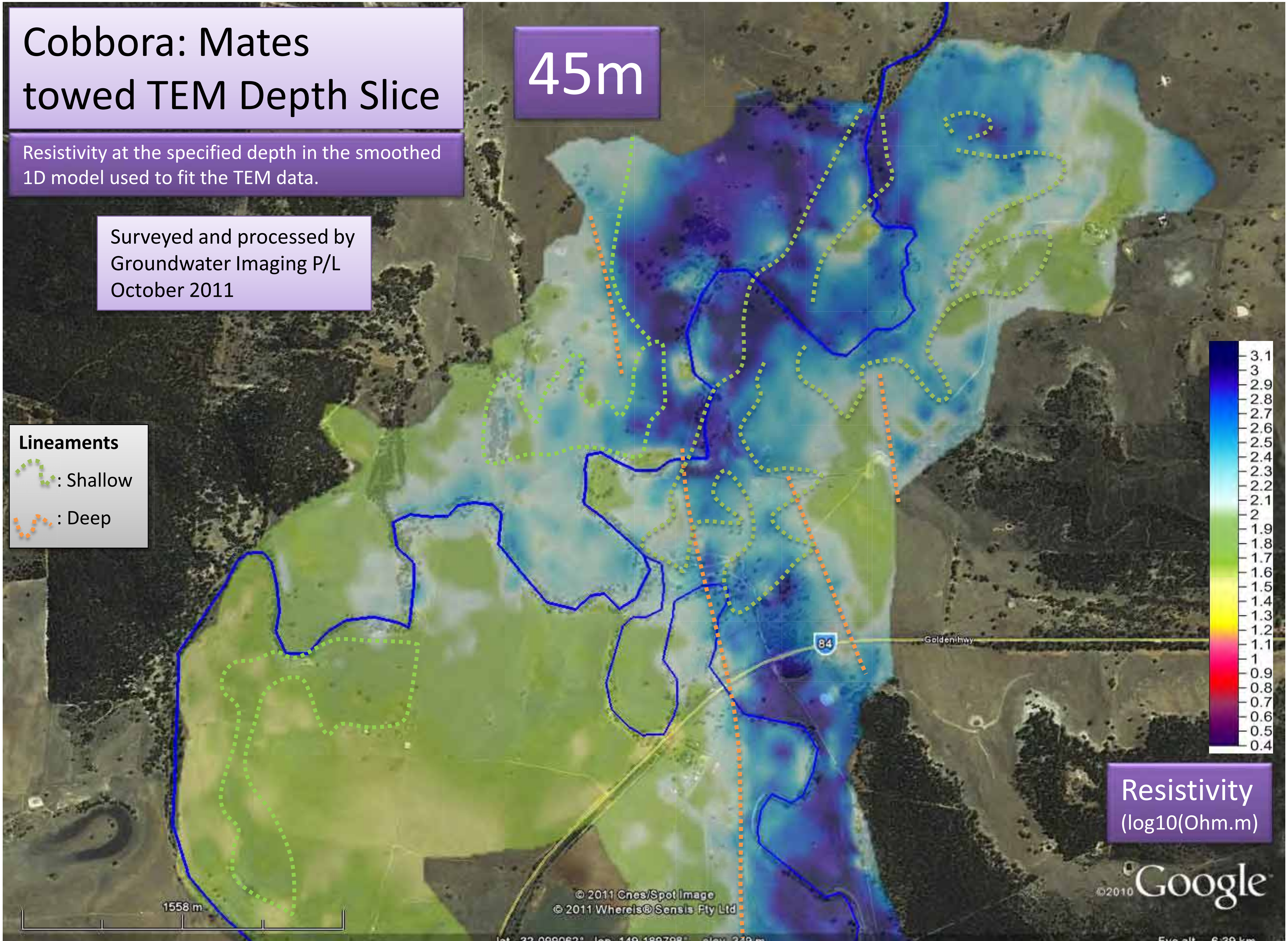
Cobbora: Mates towed TEM Depth Slice
20m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by Groundwater Imaging P/L October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m))
84
Golden Hwy
1558 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.099062° lon 149.189798° elev 349 m
Eye alt 6.39 km
©2010 Google



Cobbora: Mates towed TEM Depth Slice
28m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by Groundwater Imaging P/L October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden hwy
1558 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
©2010 Google
lat -32.099062° lon 149.189798° elev 349 m
Eye alt 6.39 km



Cobbora: Mates towed TEM Depth Slice
36m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by Groundwater Imaging P/L October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
Golden Hwy
84
1558 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
©2010 Google
lat -32.099062° lon 149.189798° elev 349 m
Eye alt 6.39 km



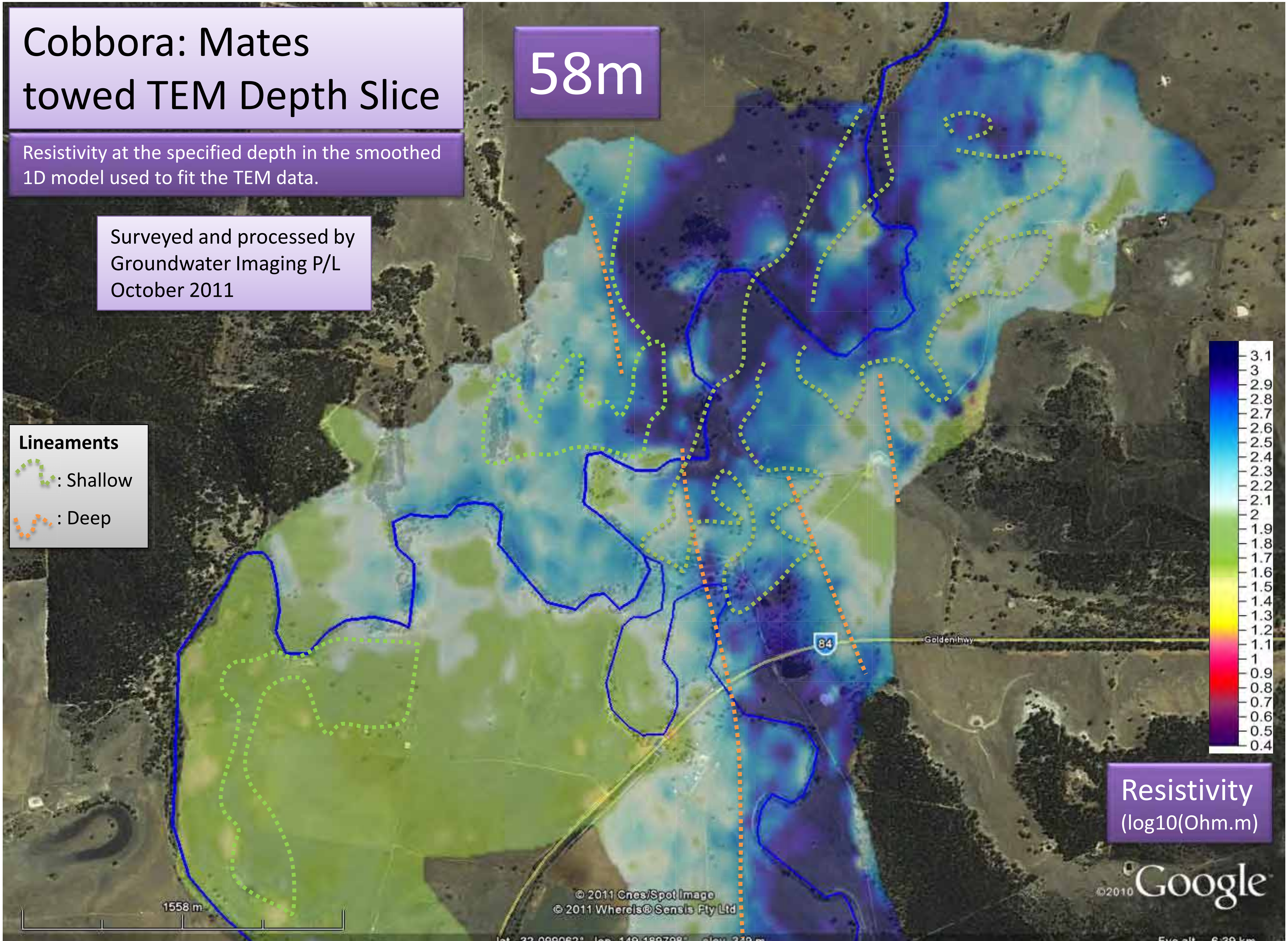
Cobbora: Mates towed TEM Depth Slice
45m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by Groundwater Imaging P/L October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity (log10(Ohm.m))
Golden Hwy
84
1558 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
©2010 Google
lat -32.099062° lon 149.189798° elev 349 m
Eye alt 6.39 km

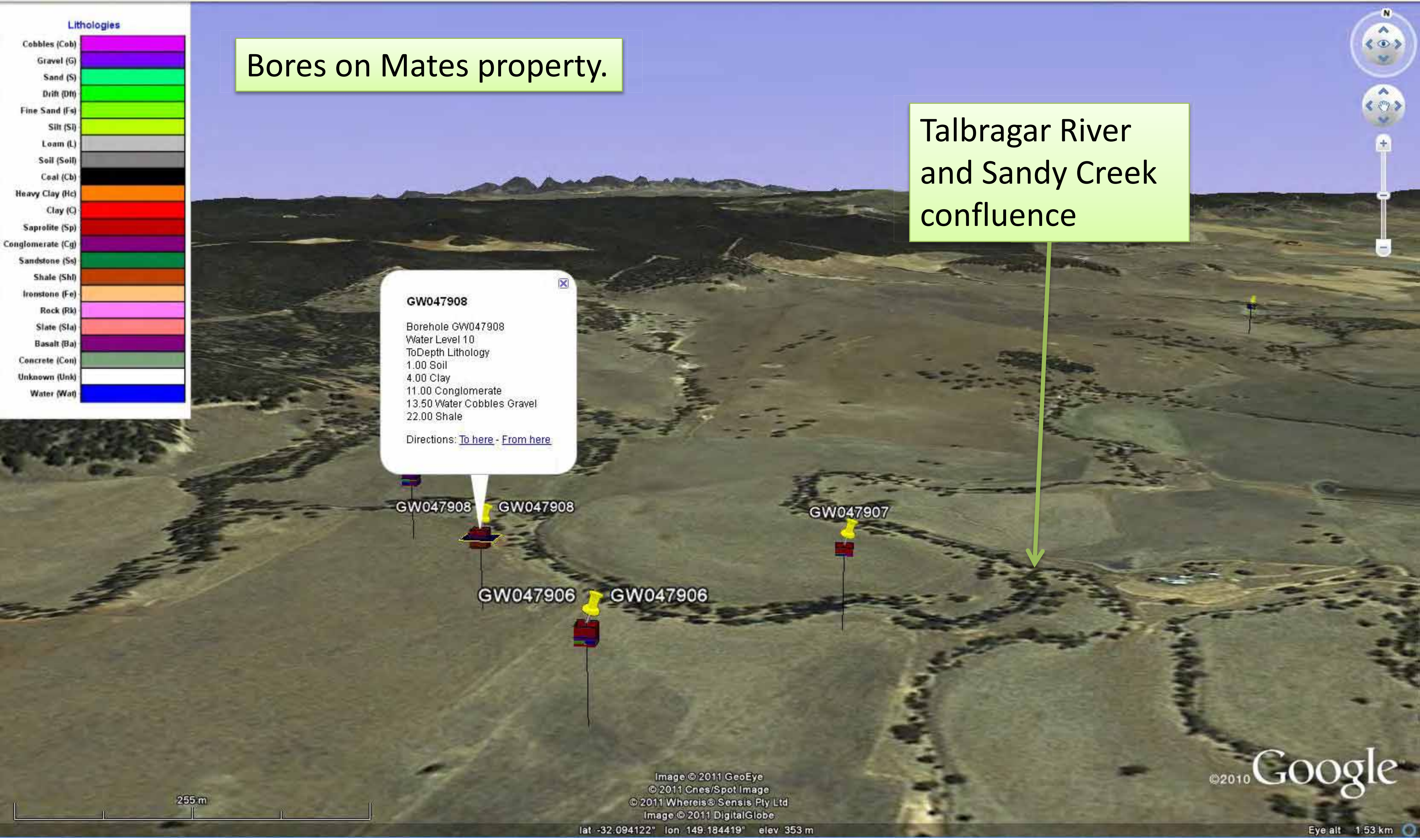
# Cobbora: Mates towed TEM Depth Slice

## 58m

Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.

Surveyed and processed by Groundwater Imaging P/L October 2011



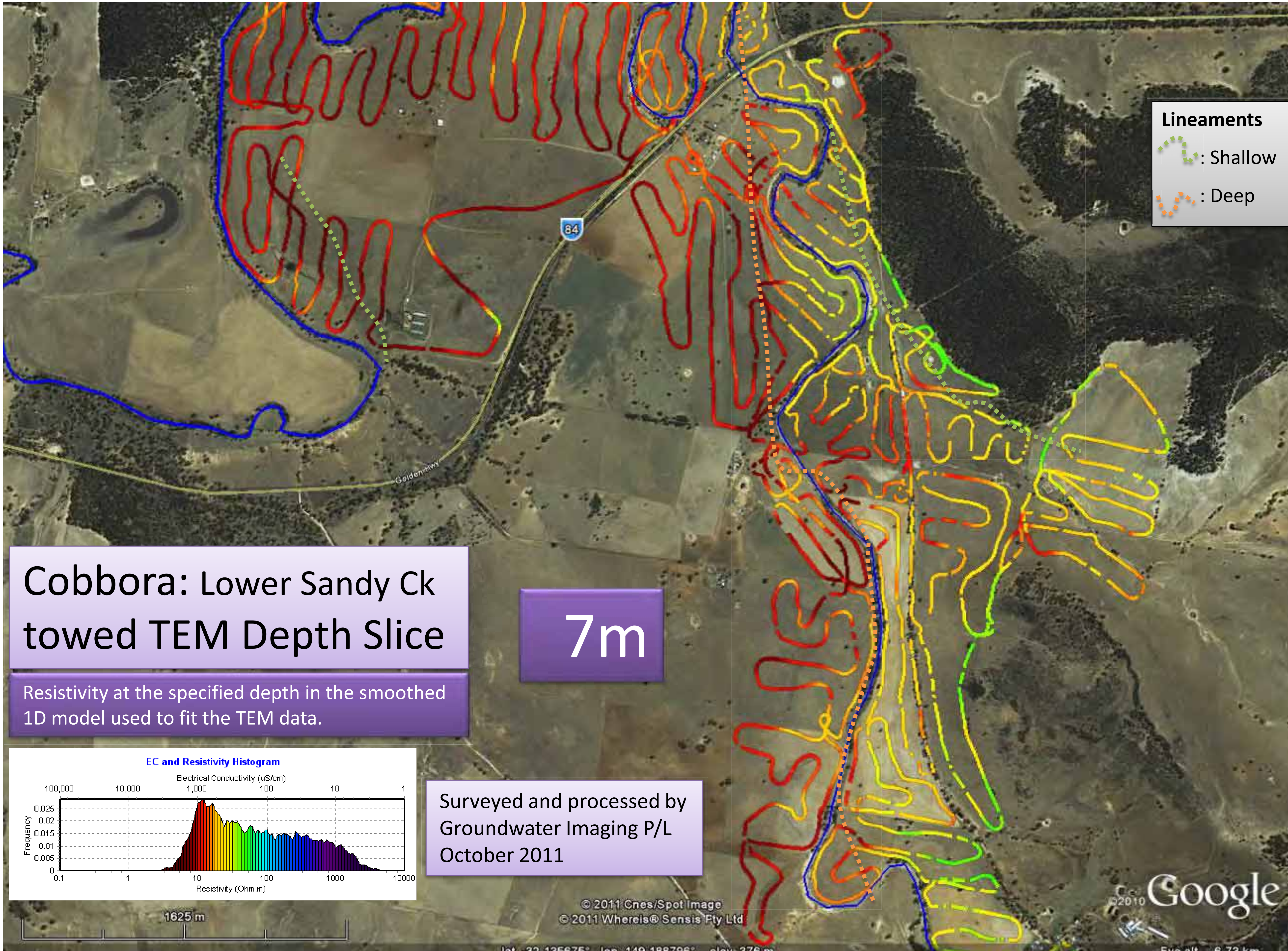



These bores indicate about 4m of clay over course and/or consolidated sediment thought to be weathered pre-quaternary sediment due to its similarity to the coal seam bearing strata.

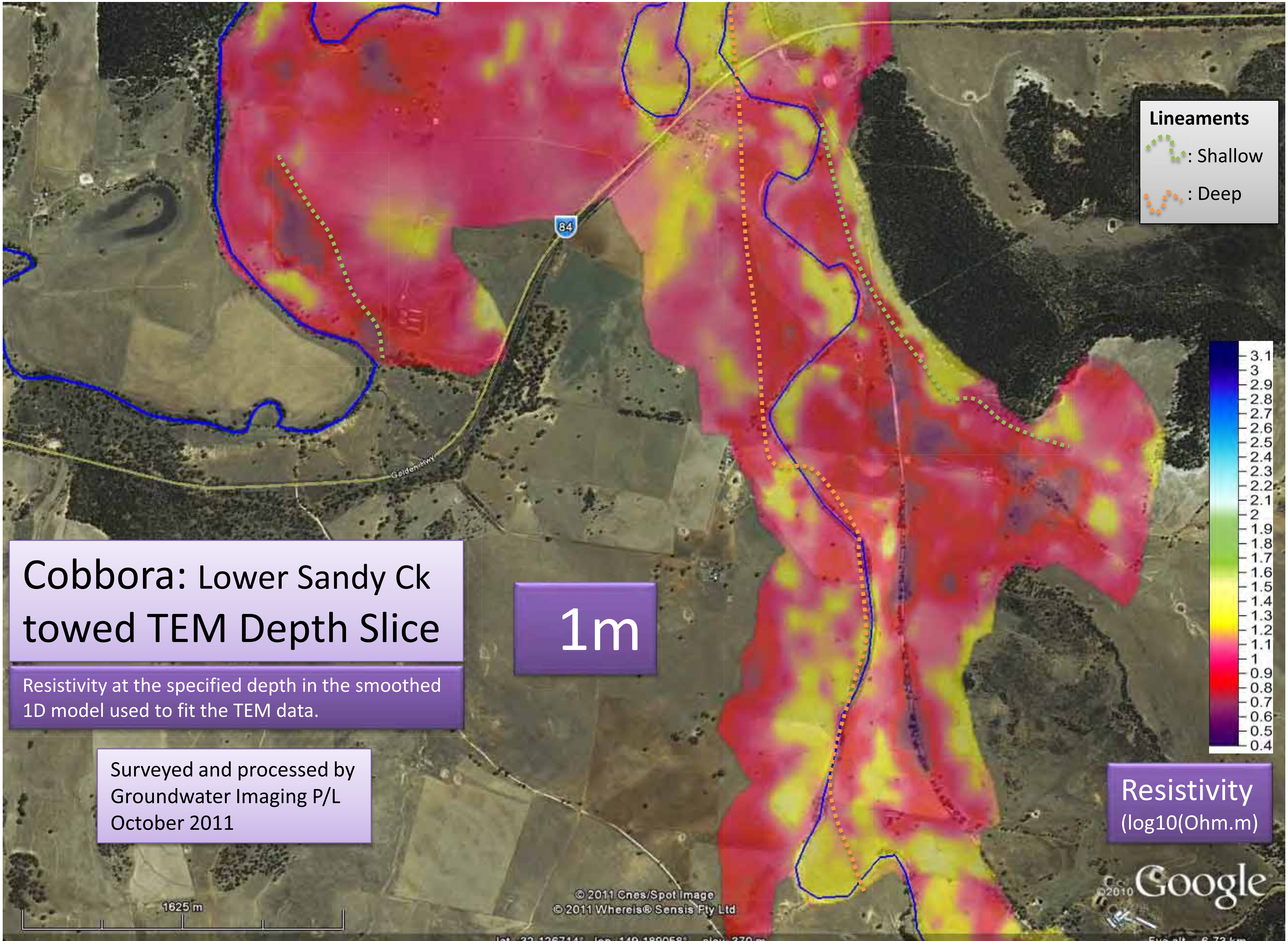
# Cobbora: Lower Sandy Ck towed TEM Depth Slice

Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.

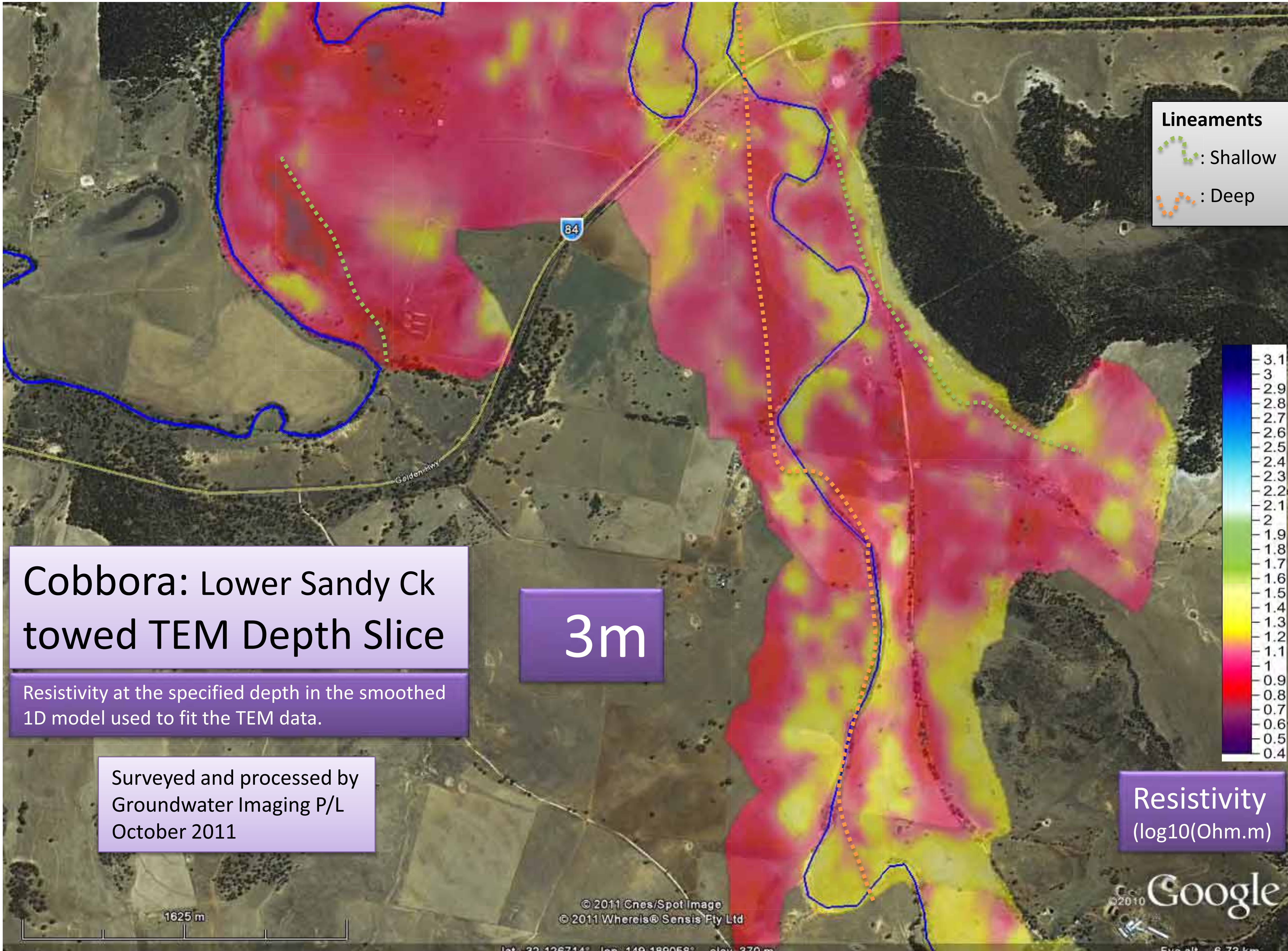
## 7m

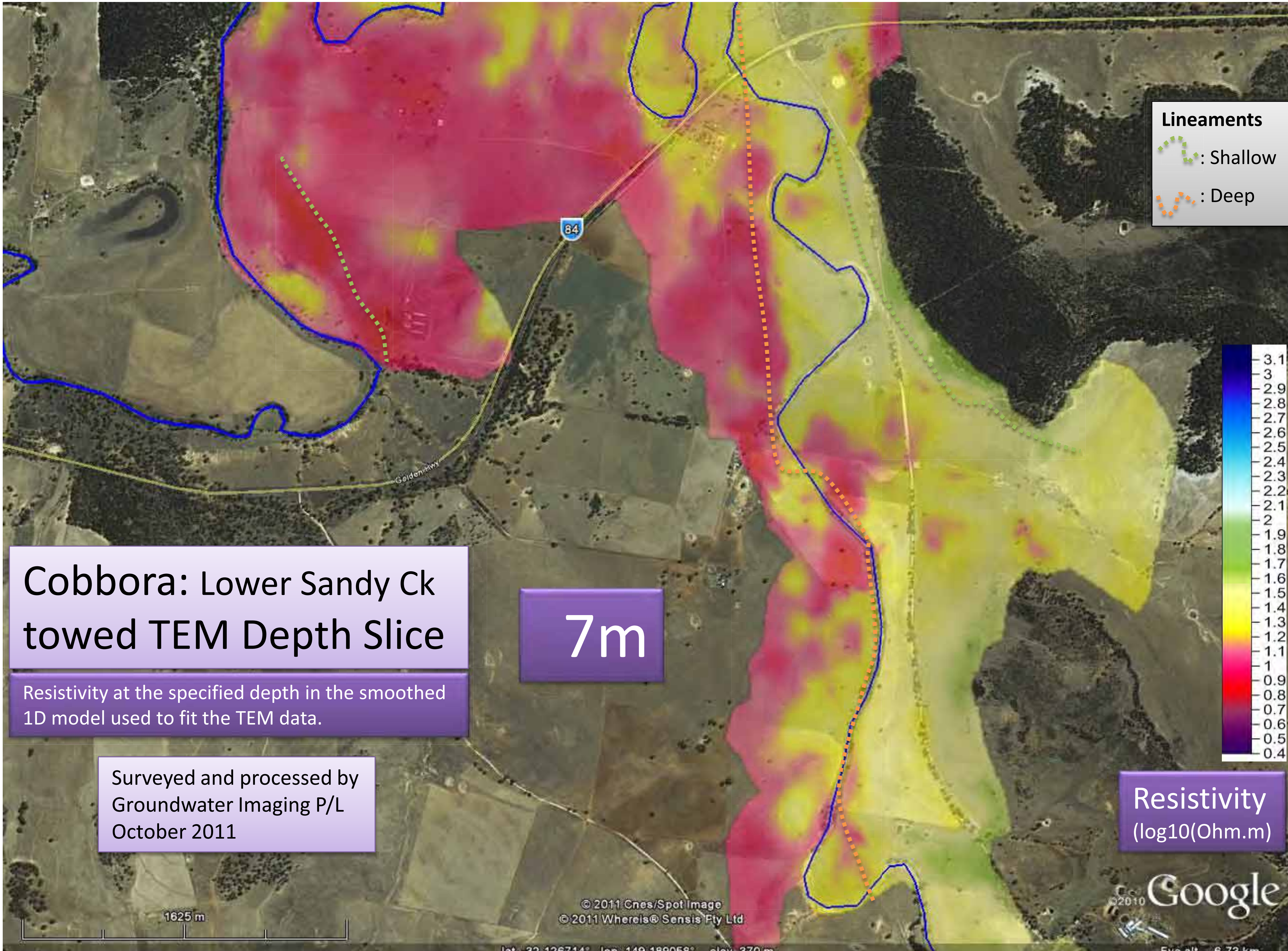


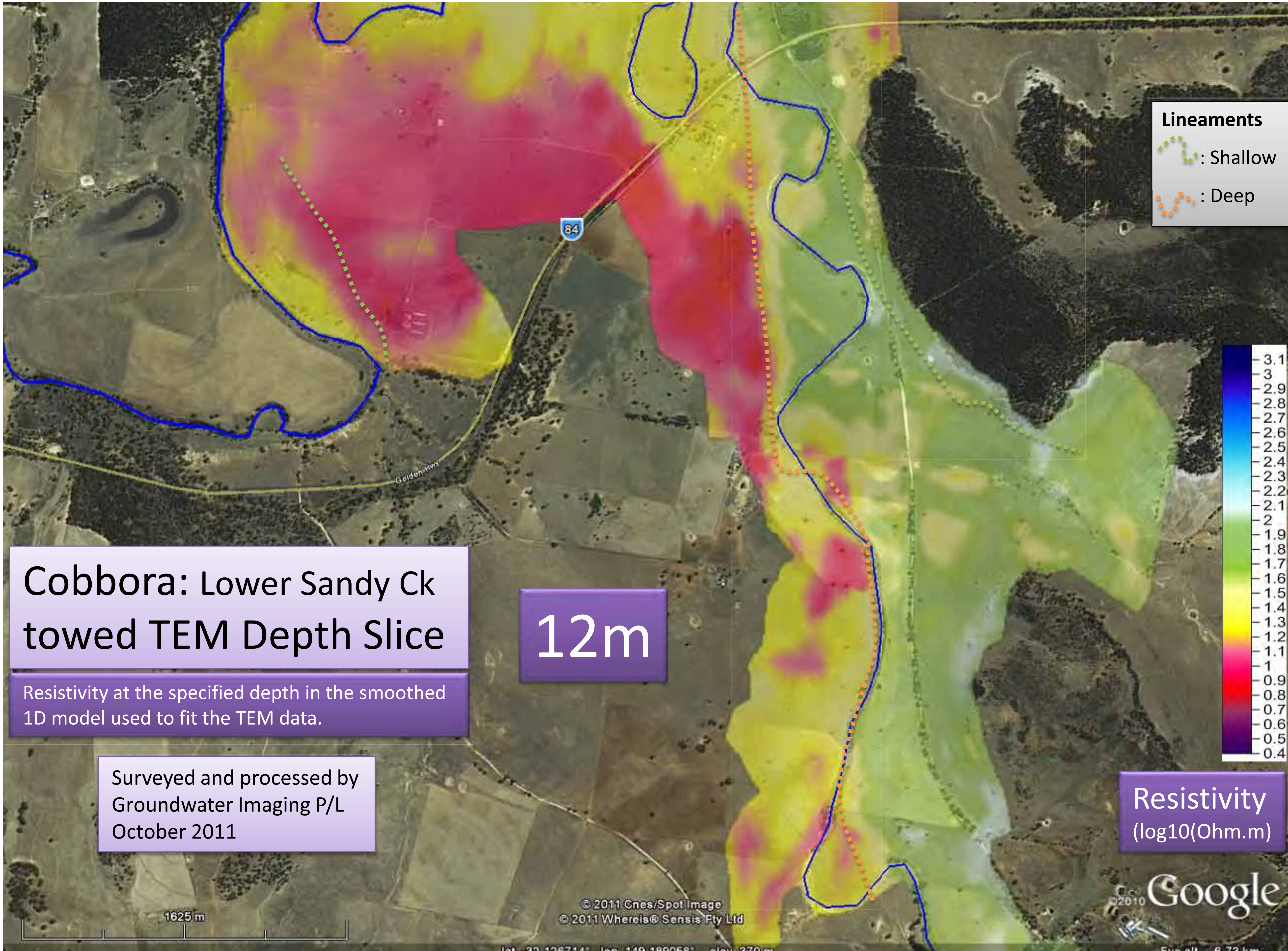

Surveyed and processed by Groundwater Imaging P/L October 2011



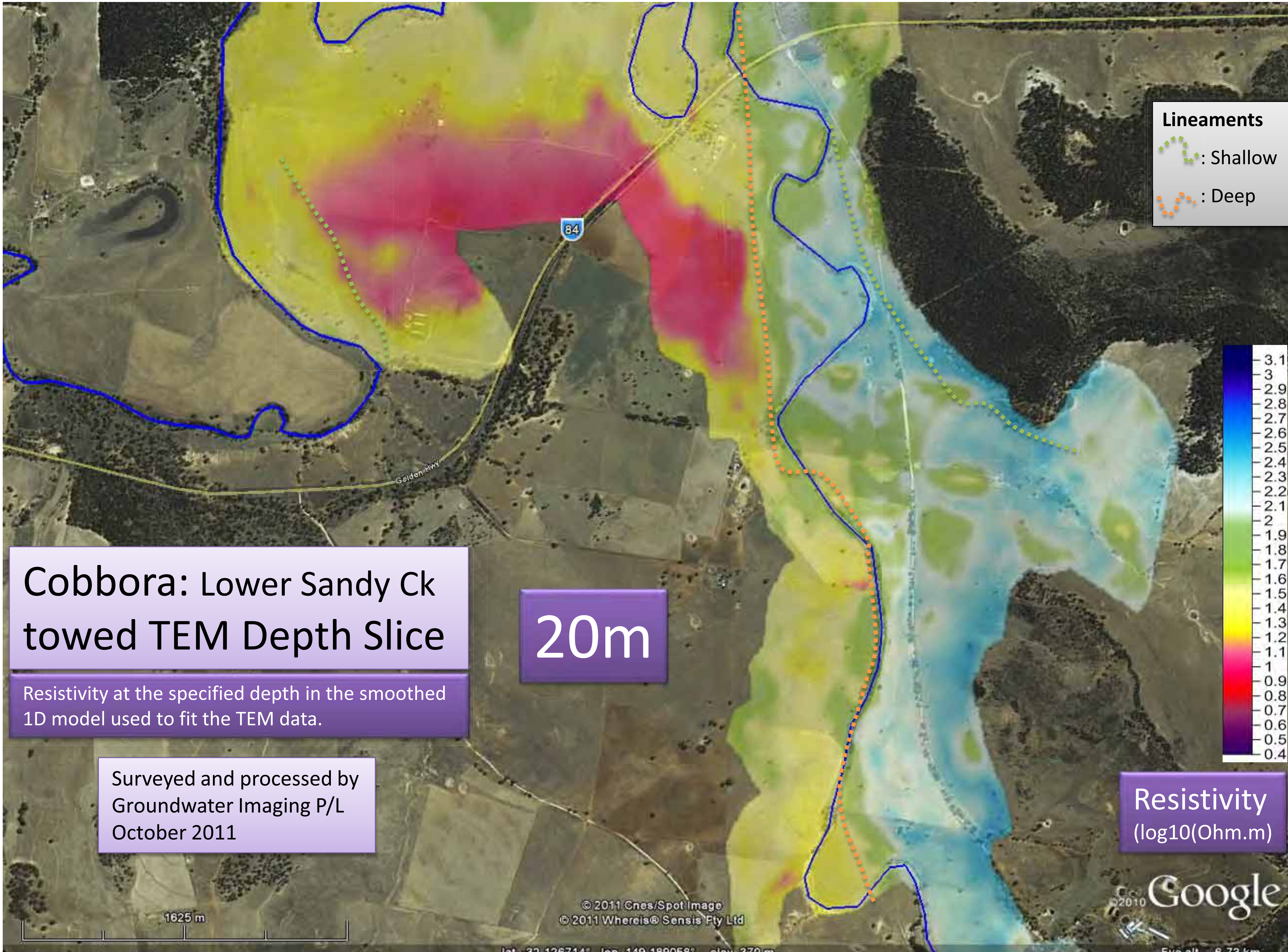
Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
1m
Surveyed and processed by
Groundwater Imaging P/L
October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden Hwy
1625 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
©2010 Google

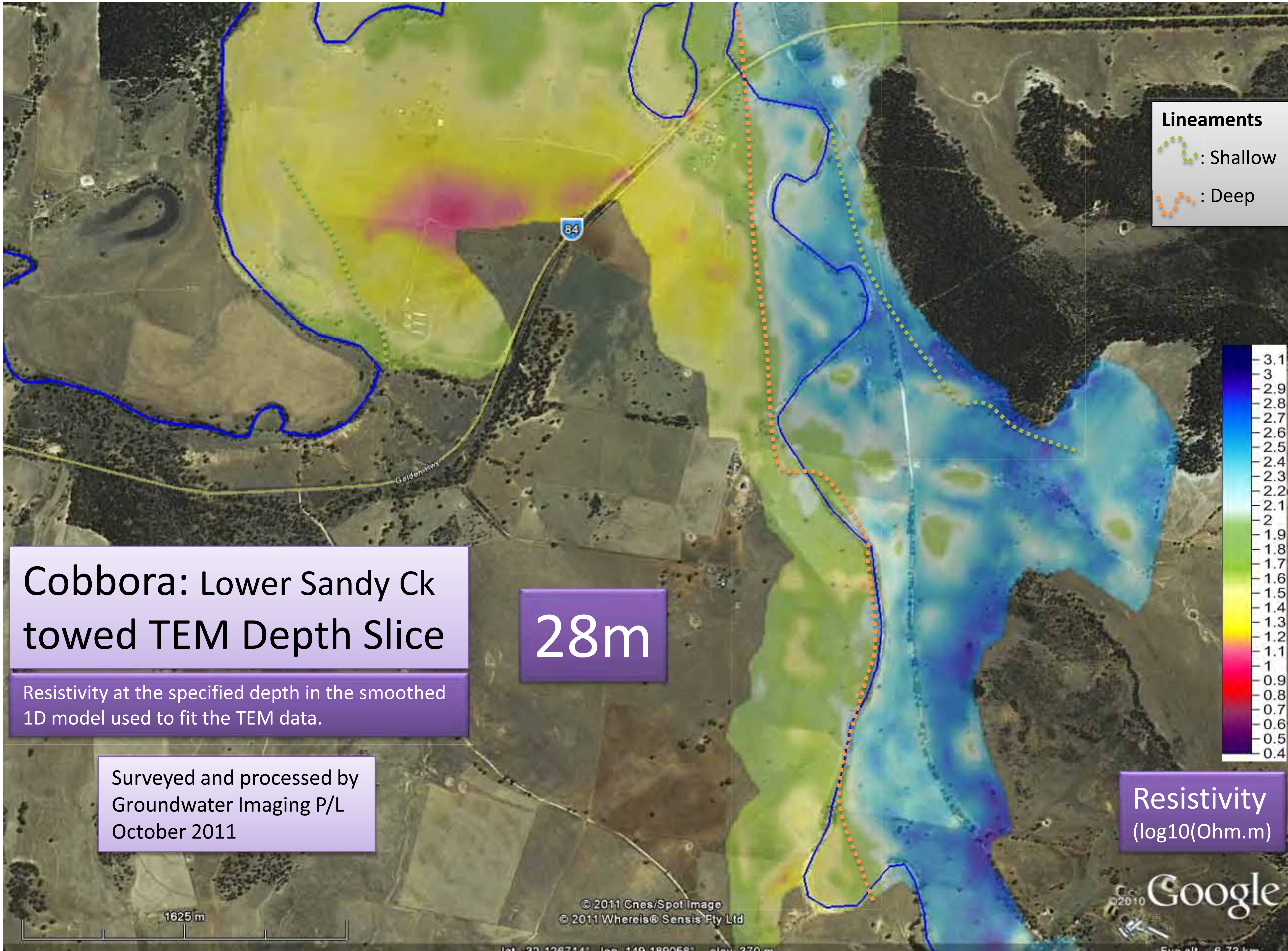

Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
3m
Surveyed and processed by
Groundwater Imaging P/L
October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden Hwy
1625 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
©2010 Google


Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
7m
Surveyed and processed by
Groundwater Imaging P/L
October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden Hwy
1625 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
Google

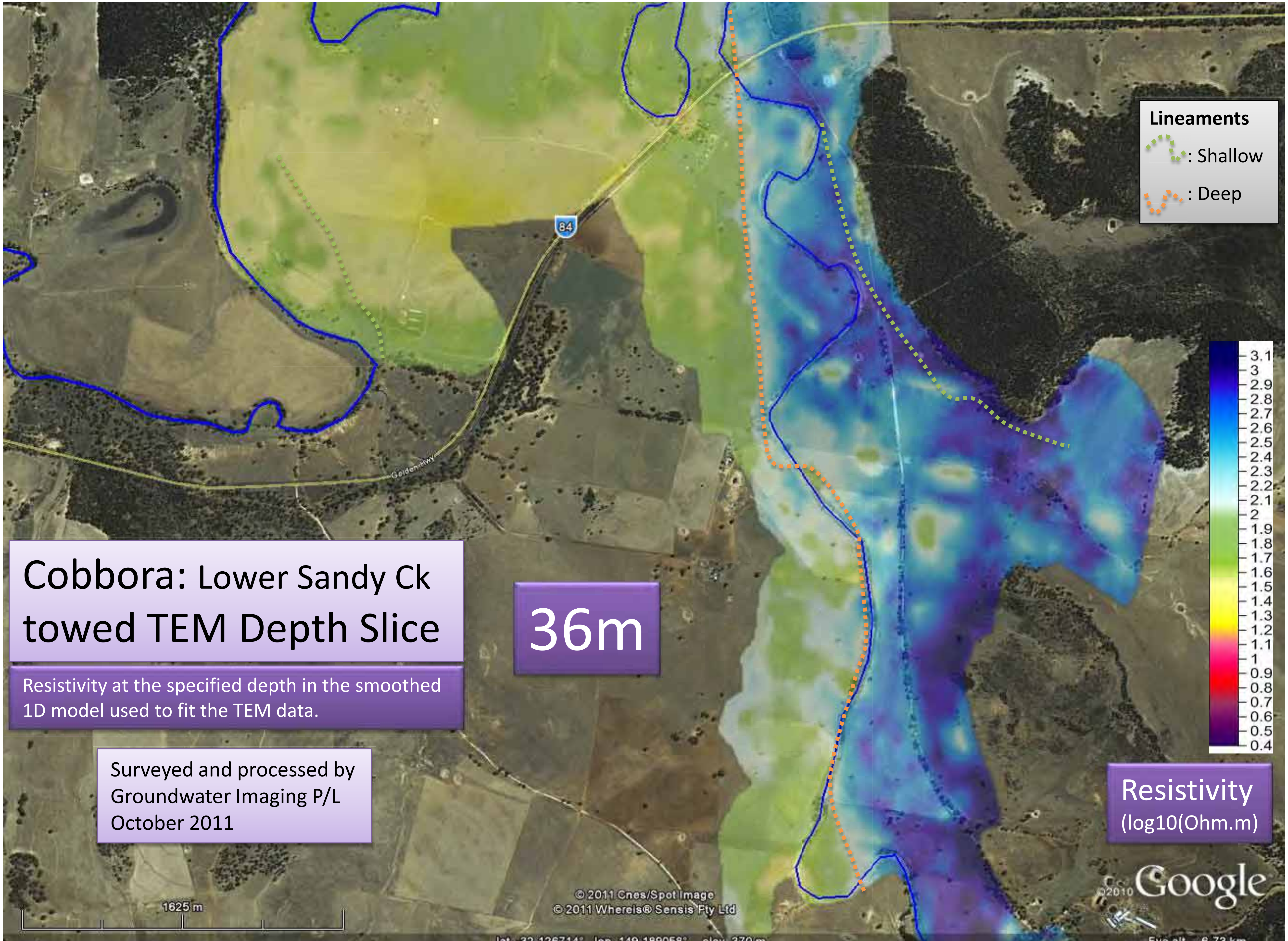


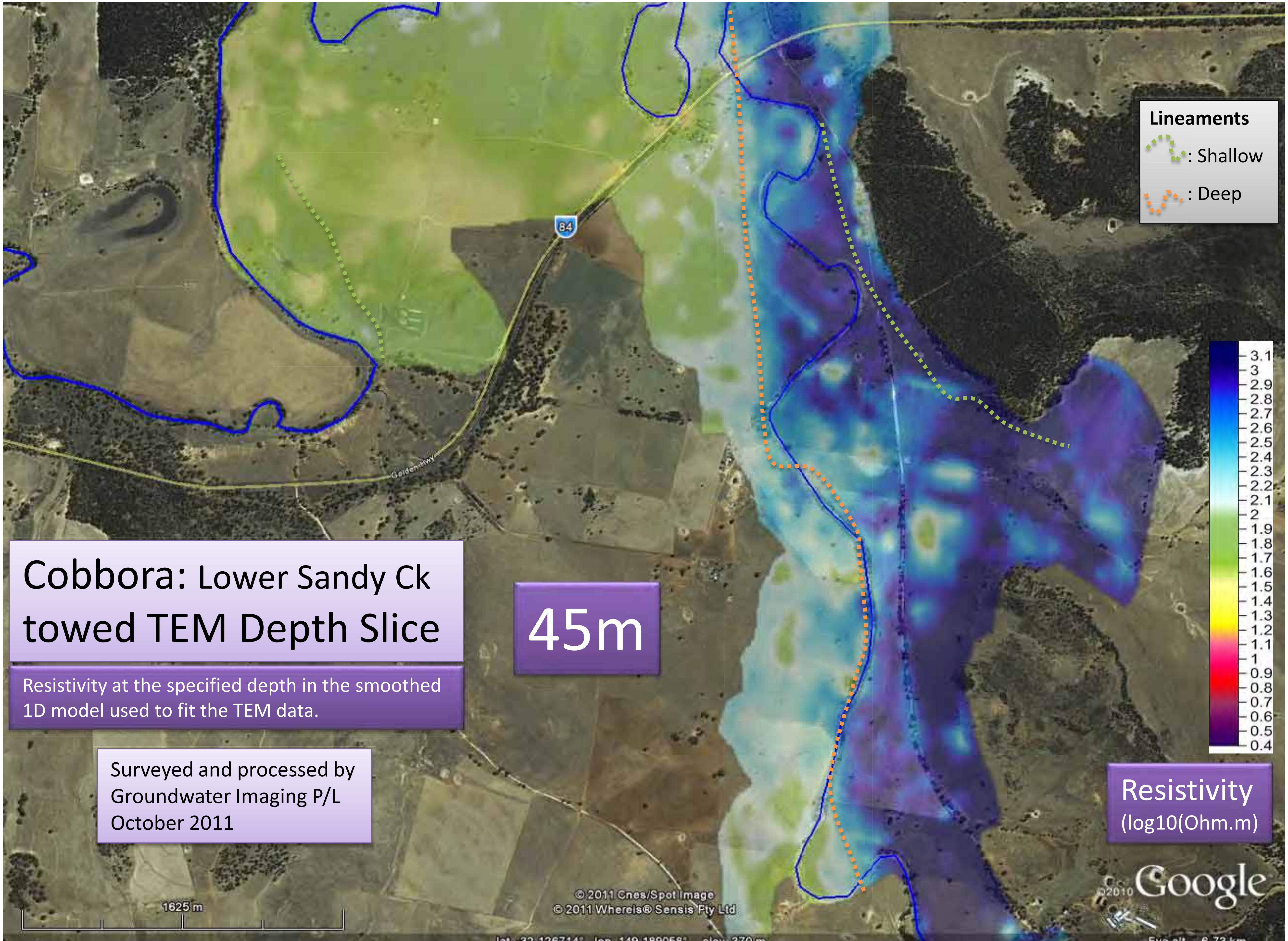
Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by
Groundwater Imaging P/L
October 2011
12m
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden Hwy
1625 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
©2010 Google


Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by
Groundwater Imaging P/L
October 2011
20m
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden Hwy
1625 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
©2010 Google

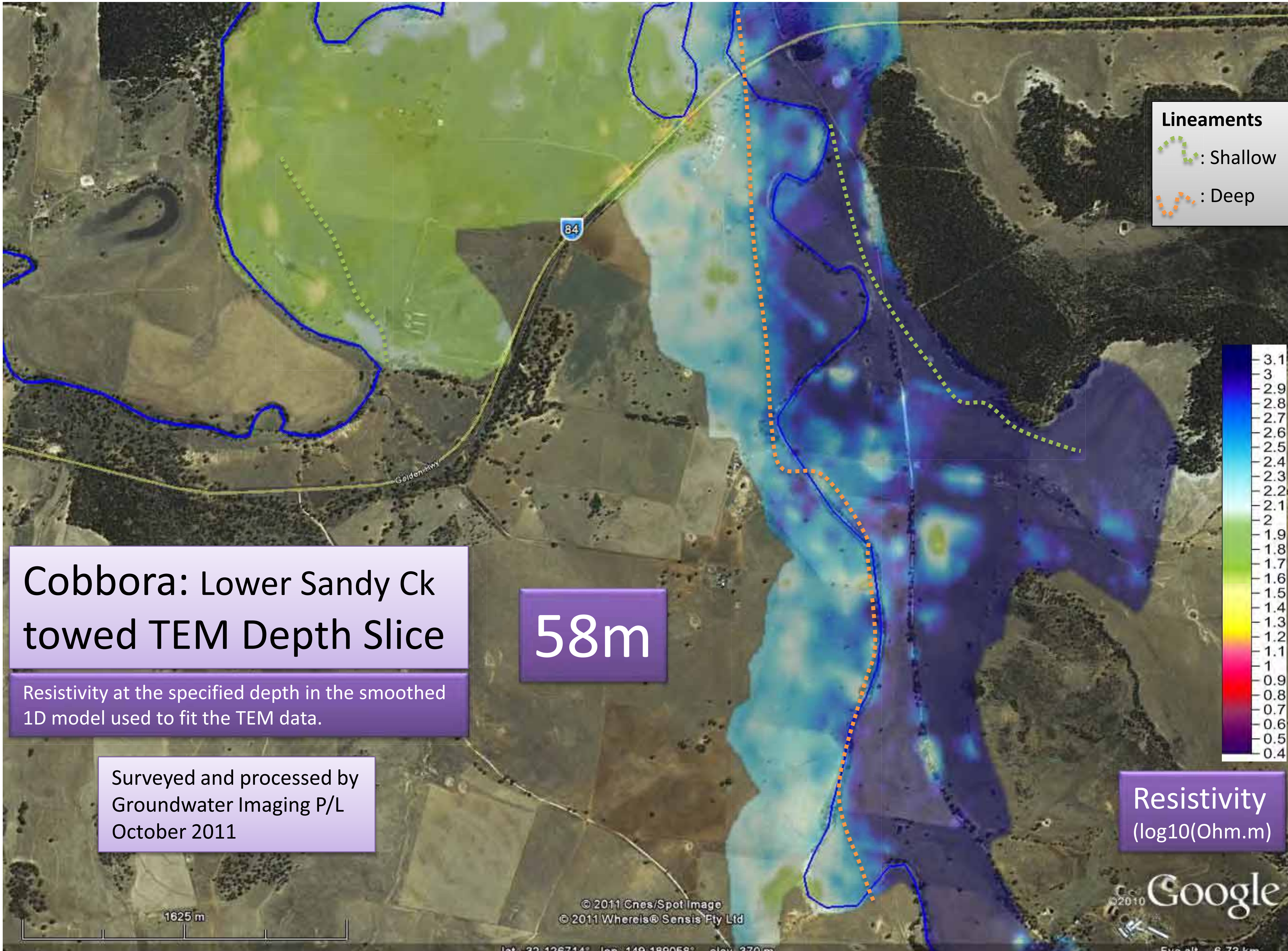


Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
28m
Surveyed and processed by
Groundwater Imaging P/L
October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden Hwy
1625 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
©2010
Google

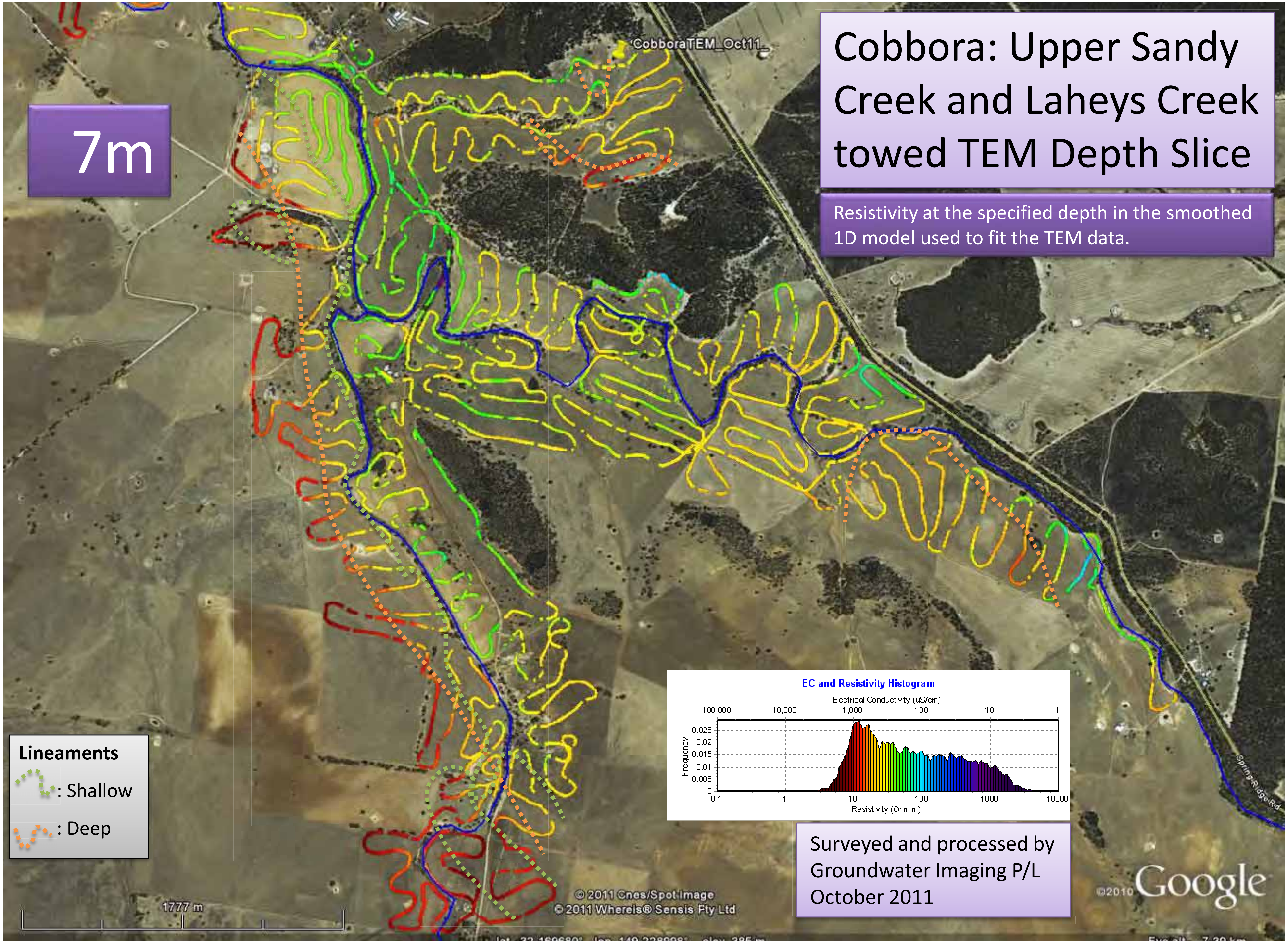

Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
36m
Surveyed and processed by
Groundwater Imaging P/L
October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
Golden Hwy
1625 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
©2010 Google

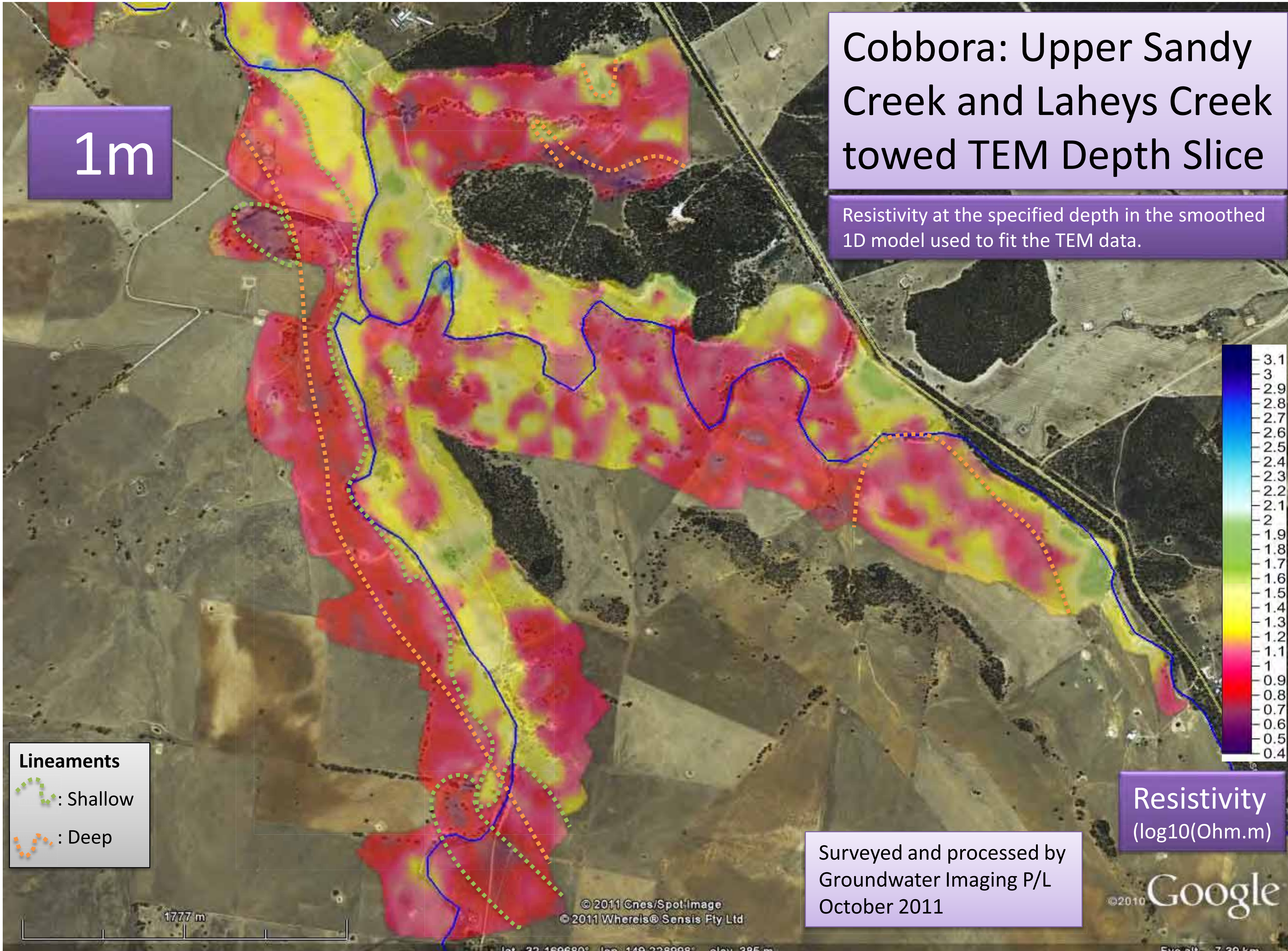


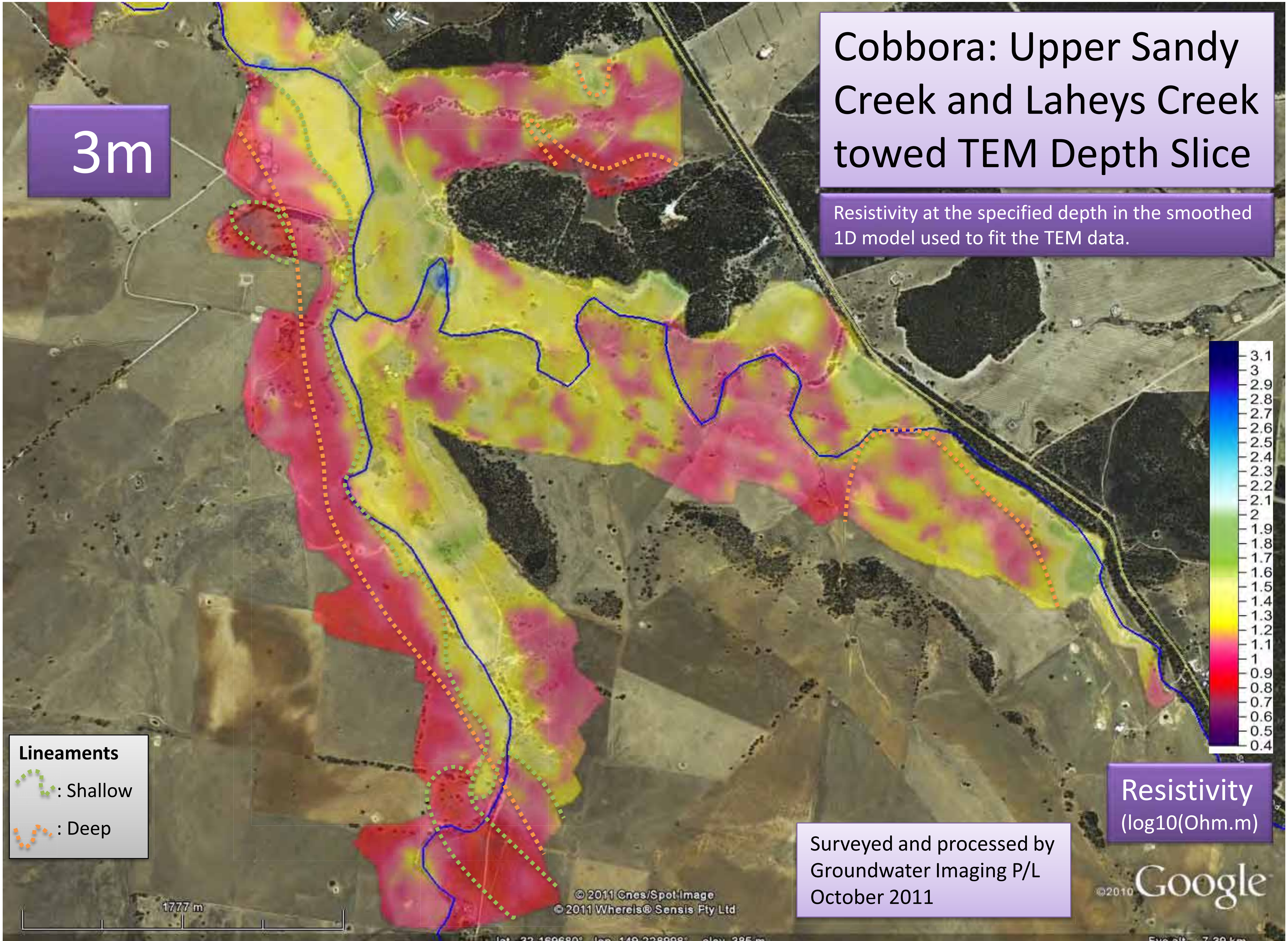
Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
45m
Surveyed and processed by
Groundwater Imaging P/L
October 2011
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
84
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
1625 m
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
Google

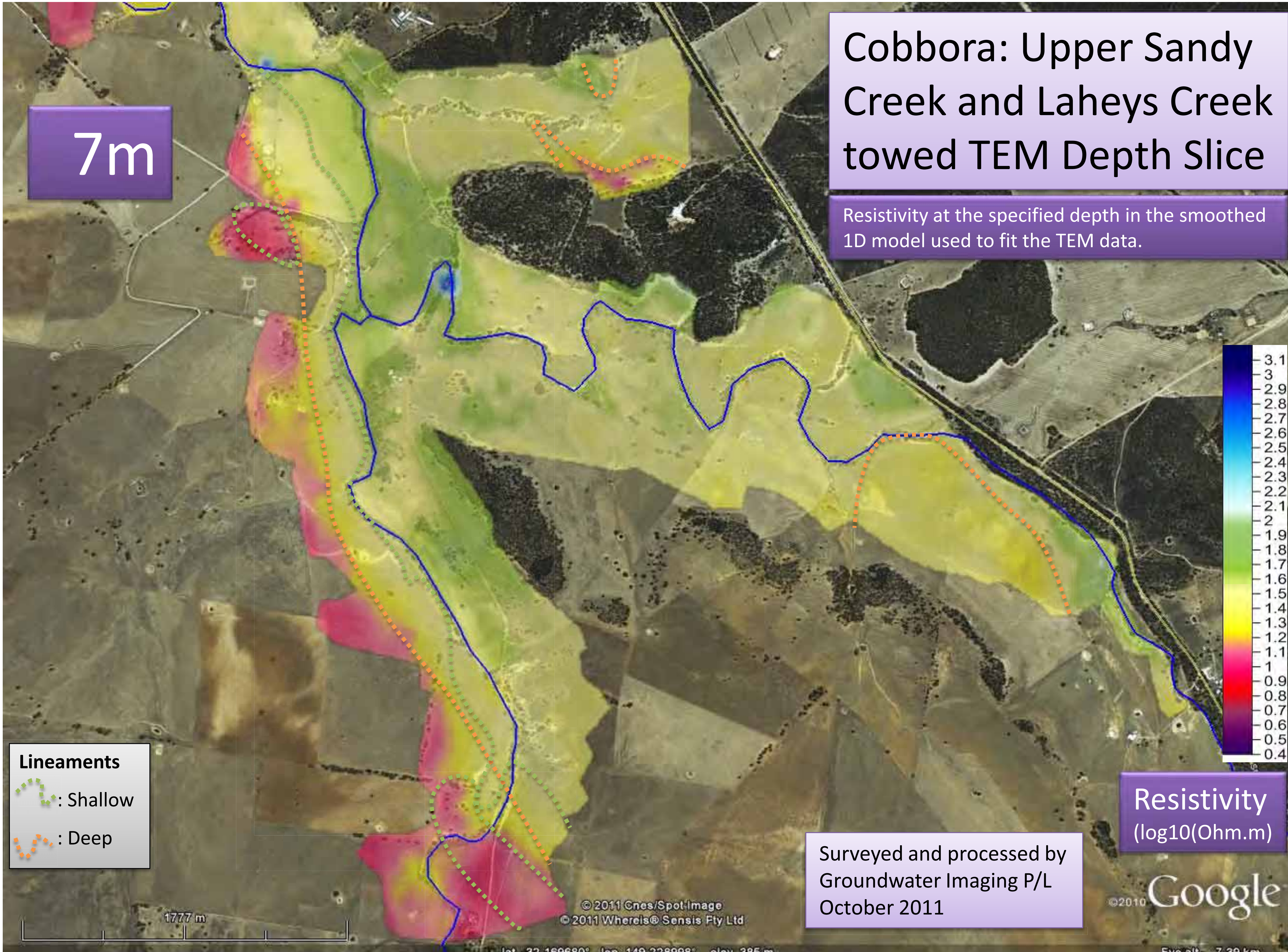


Cobbora: Lower Sandy Ck
towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Surveyed and processed by
Groundwater Imaging P/L
October 2011
58m
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m))
84
Golden Hwy
1625 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.126714° lon 149.189058° elev 370 m
Eye alt 6.73 km
©2010
Google


Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
7m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
CobboraTEM_Oct11
Lineaments
: Shallow
: Deep
EC and Resistivity Histogram
Electrical Conductivity (uS/cm)
100,000
10,000
1,000
100
10
1
Frequency
0.025
0.02
0.015
0.01
0.005
0
0.1
1
10
100
1000
10000
Resistivity (Ohm.m)
Surveyed and processed by Groundwater Imaging P/L October 2011
Spring Ridge Rd
1777 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
©2010 Google
lat -32.169680° lon 149.228998° elev 385 m
Eye alt 7.39 km


Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
1m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Lineaments
: Shallow
: Deep
Resistivity
(log10(Ohm.m)
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Surveyed and processed by Groundwater Imaging P/L October 2011
1777 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.169680° lon 149.228998° elev 385 m
Eye alt 7.39 km
©2010 Google

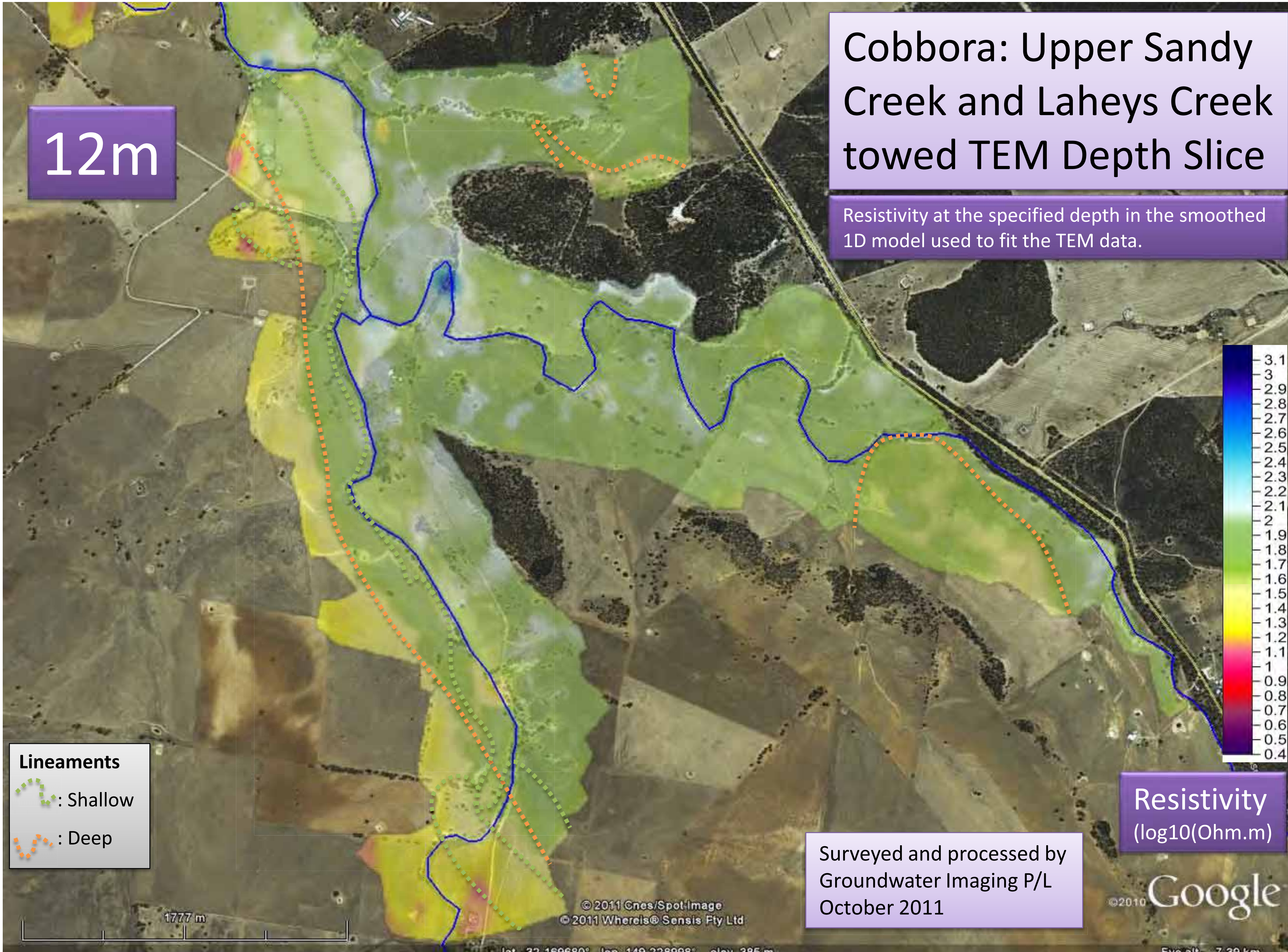

Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
3m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
Lineaments
: Shallow
: Deep
3.1 3 2.9 2.8 2.7 2.6 2.5 2.4 2.3 2.2 2.1 2 1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2 1.1 1 0.9 0.8 0.7 0.6 0.5 0.4
Resistivity (log10(Ohm.m))
Surveyed and processed by Groundwater Imaging P/L October 2011
1777 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
©2010 Google
lat -32.169680° lon 149.228998° elev 385 m
Eye alt 7.39 km



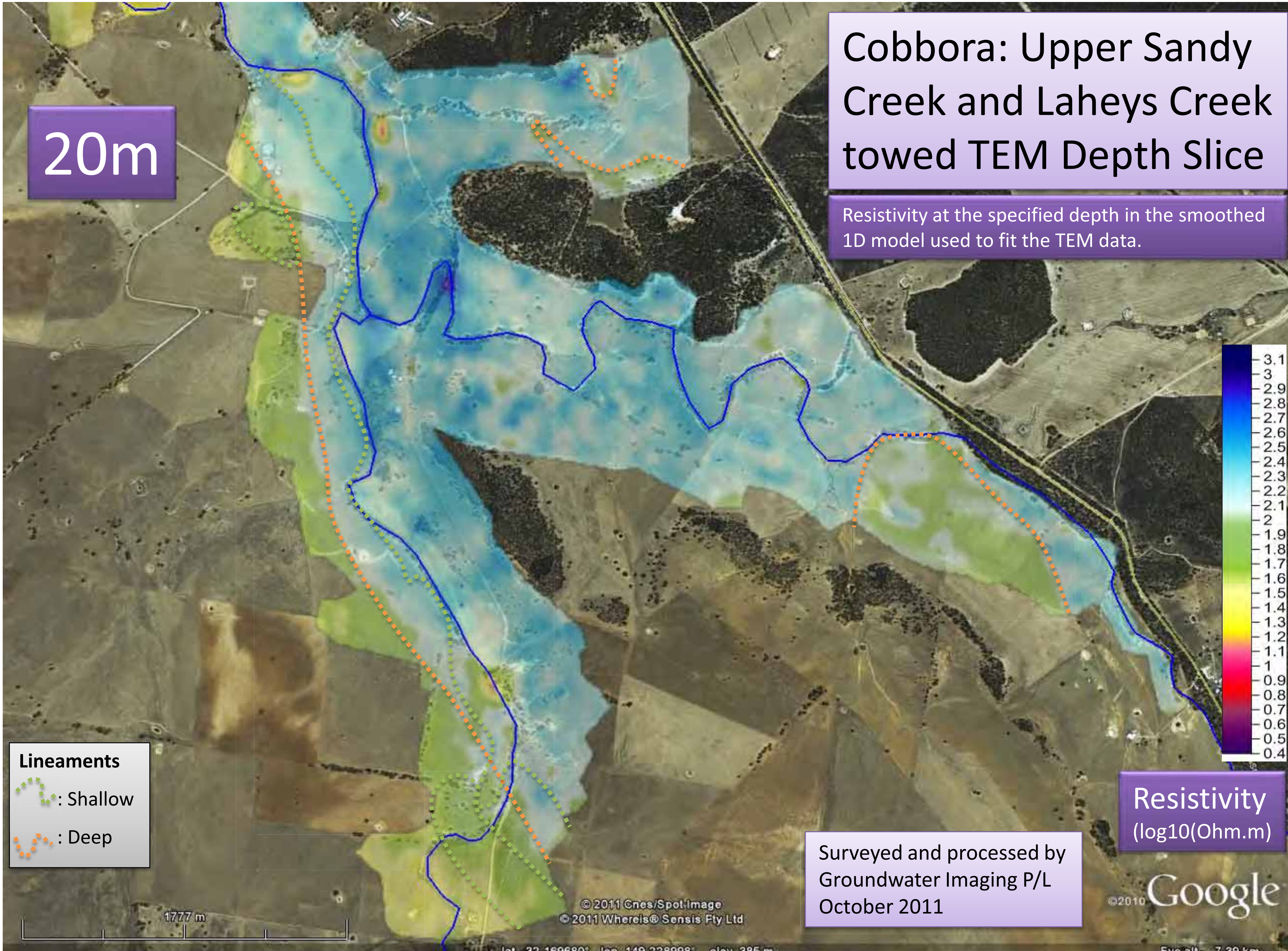
Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
7m
Lineaments
: Shallow
: Deep
Resistivity (log10(Ohm.m))
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Surveyed and processed by Groundwater Imaging P/L October 2011
1777 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
lat -32.169680° lon 149.228998° elev 385 m
©2010 Google
Eye alt 7.39 km

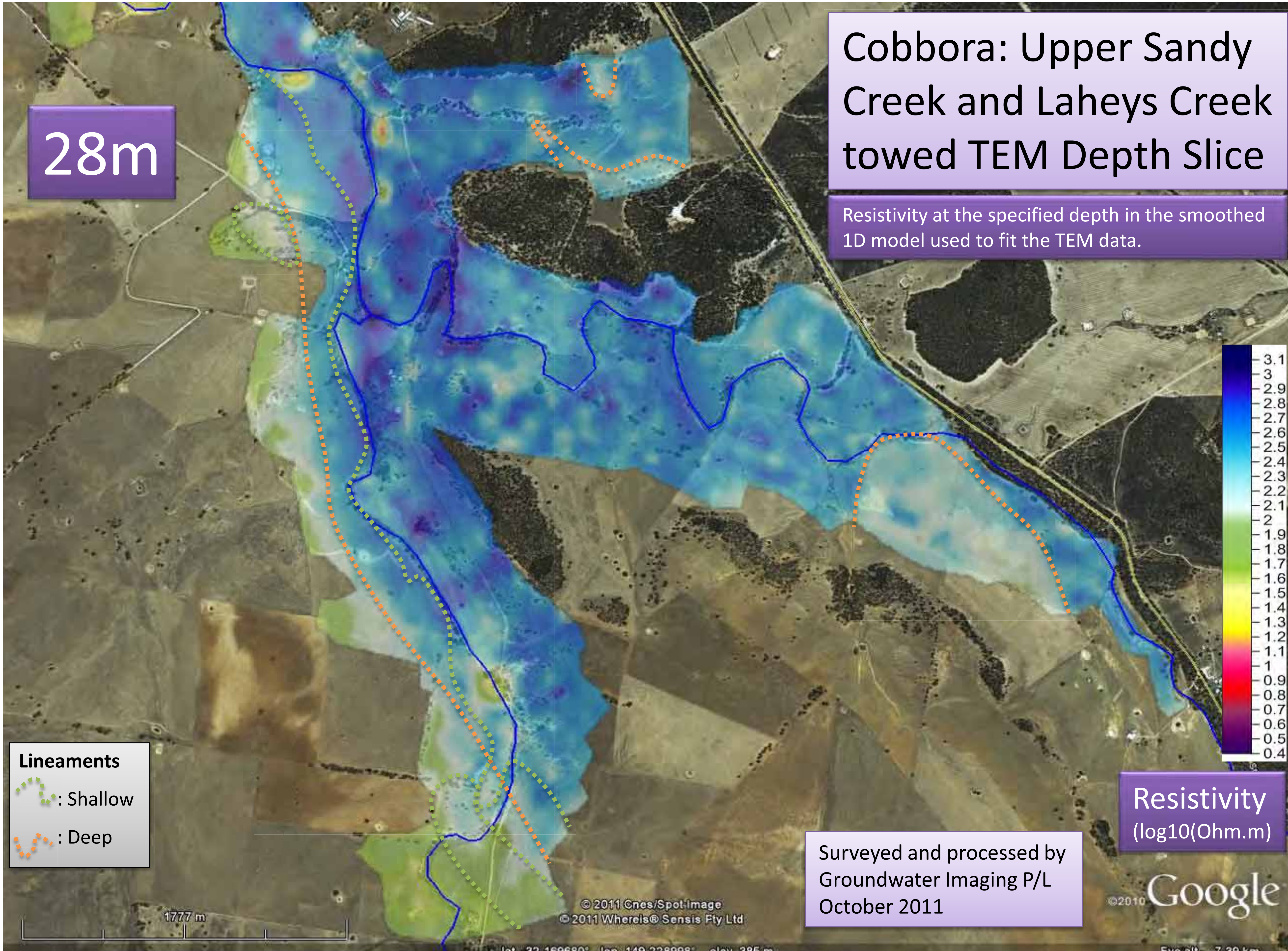
# Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice

Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.

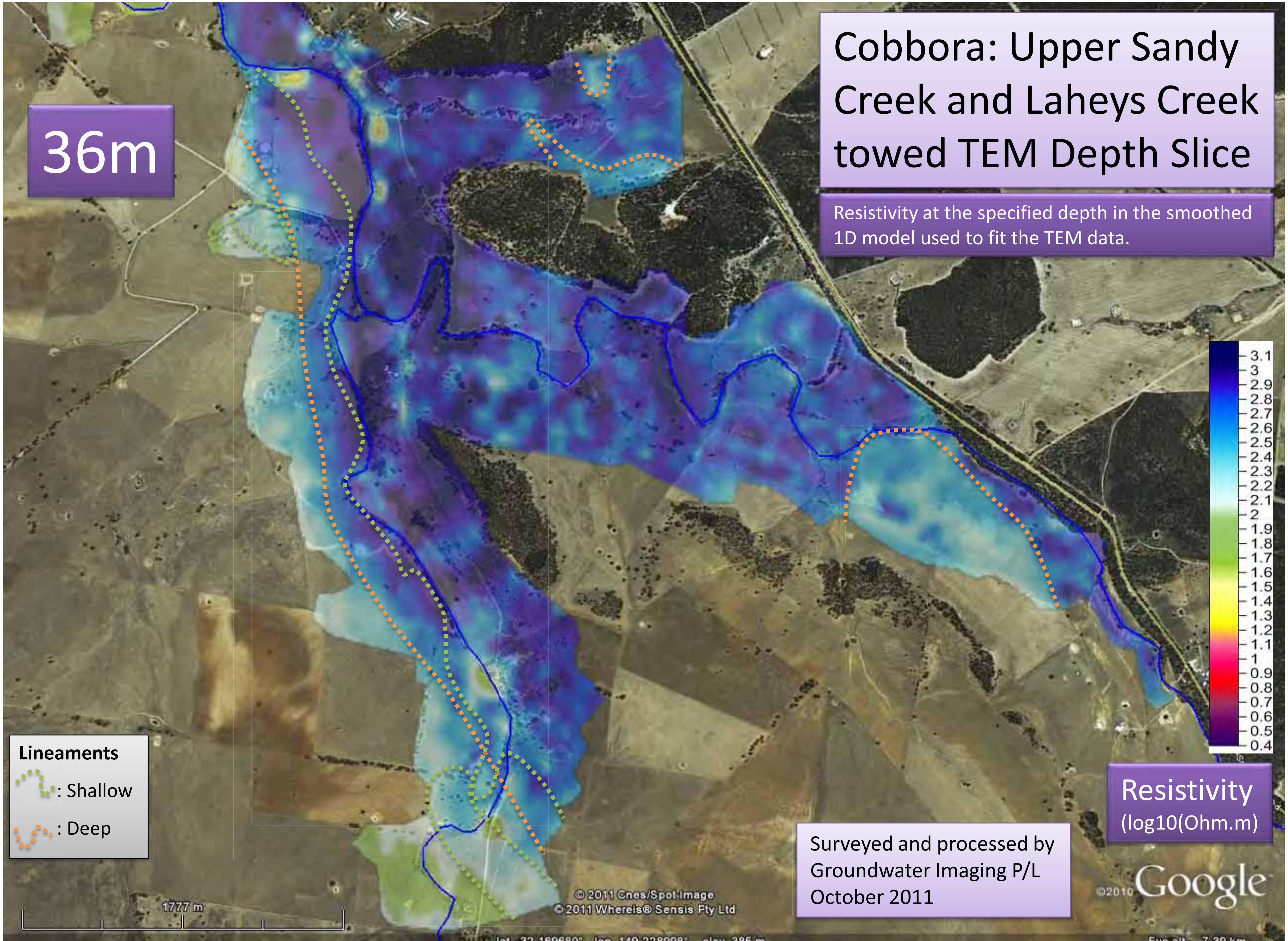



Surveyed and processed by
Groundwater Imaging P/L
October 2011

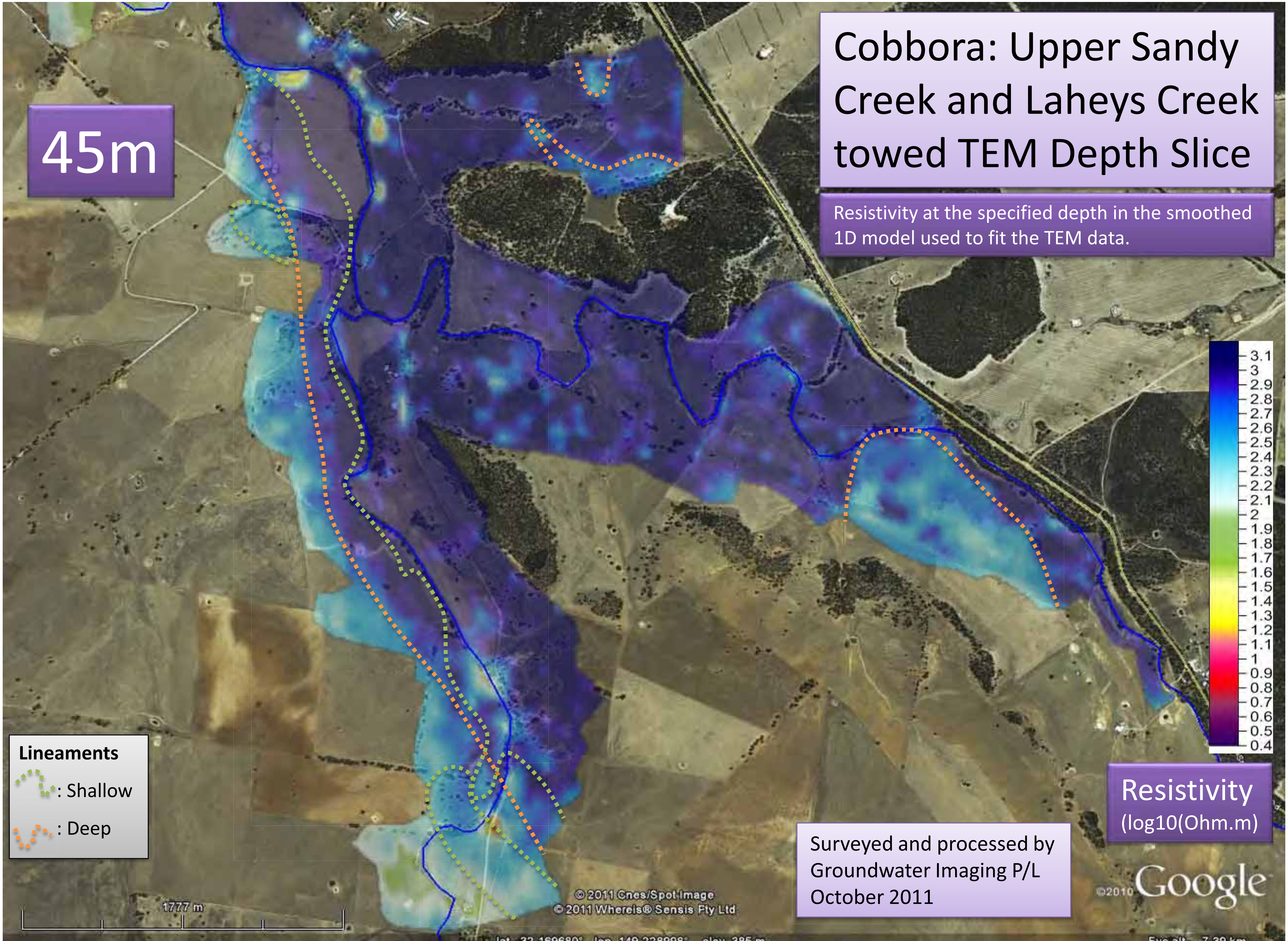

Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
20m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
Lineaments
: Shallow
: Deep
Surveyed and processed by
Groundwater Imaging P/L
October 2011
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
1777 m
©2010 Google
lat -32.169680° lon 149.228998° elev 385 m
Eye alt 7.39 km

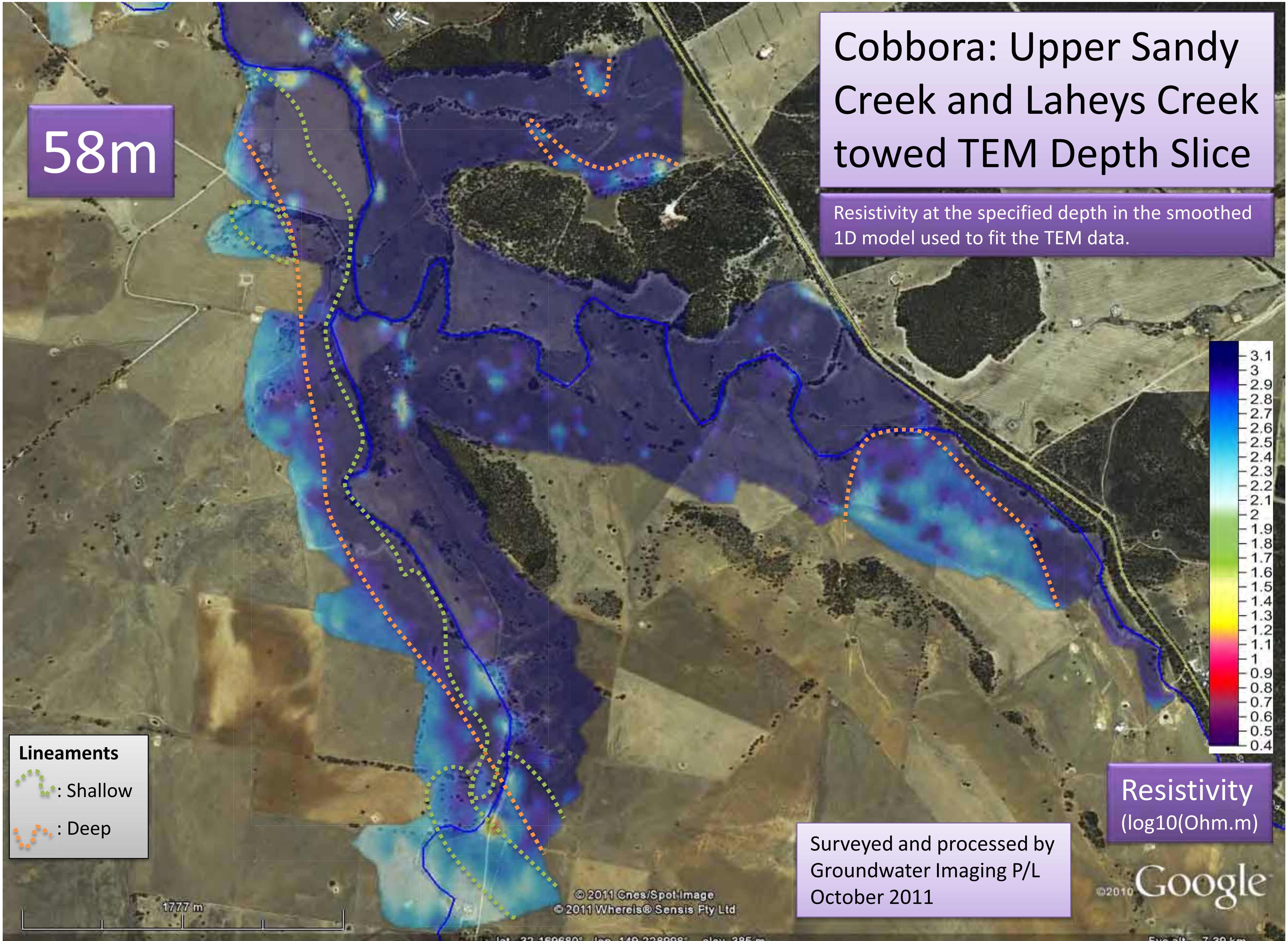


Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
28m
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
Lineaments
: Shallow
: Deep
Surveyed and processed by
Groundwater Imaging P/L
October 2011
1777 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
©2010 Google
lat -32.169680° lon 149.228998° elev 385 m
Eye alt 7.39 km



Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
36m
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m)
Surveyed and processed by
Groundwater Imaging P/L
October 2011
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
©2010 Google
1777 m
lat -32.169680° lon 149.228998° elev 385 m
Eye alt 7.39 km


Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
45m
Lineaments
: Shallow
: Deep
3.1 3 2.9 2.8 2.7 2.6 2.5 2.4 2.3 2.2 2.1 2 1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2 1.1 1 0.9 0.8 0.7 0.6 0.5 0.4
Resistivity
(log10(Ohm.m)
Surveyed and processed by
Groundwater Imaging P/L
October 2011
1777 m
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
©2010 Google
lat -32.169680° lon 149.228998° elev 385 m
Eye alt 7.39 km



Cobbora: Upper Sandy Creek and Laheys Creek towed TEM Depth Slice
Resistivity at the specified depth in the smoothed 1D model used to fit the TEM data.
58m
Lineaments
: Shallow
: Deep
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
Resistivity
(log10(Ohm.m))
Surveyed and processed by Groundwater Imaging P/L October 2011
© 2011 Cnes/Spot Image
© 2011 Whereis® Sensis Pty Ltd
1777 m
lat -32.169680° lon 149.228998° elev 385 m
Eye alt 7.39 km
©2010 Google

# Conclusions

• East of a straight line approximating the route of Sandy Creek the substrate is typically resistive inferring that it is composed of relatively impervious unweathered rock. There is not clear evidence that westerly dipping resistive strata, exposed east of the creek, extend west of the creek under more conductive cover – rather the resistivity contrast occurs at all depths at approximately the same lineament. A steep fault is thus inferred.

• West of the same line, the substrate near the surface is much more conductive inferring relatively clayey and/or saline weathered sediment.

• There are some conductive features trending in other directions that in no way relate to present day watercourses. At O'Leary's, to the northwest, the main resistivity contrasts are more north-south and again do not exactly relate to the position of the river and are thought to be unrelated to alluvium.

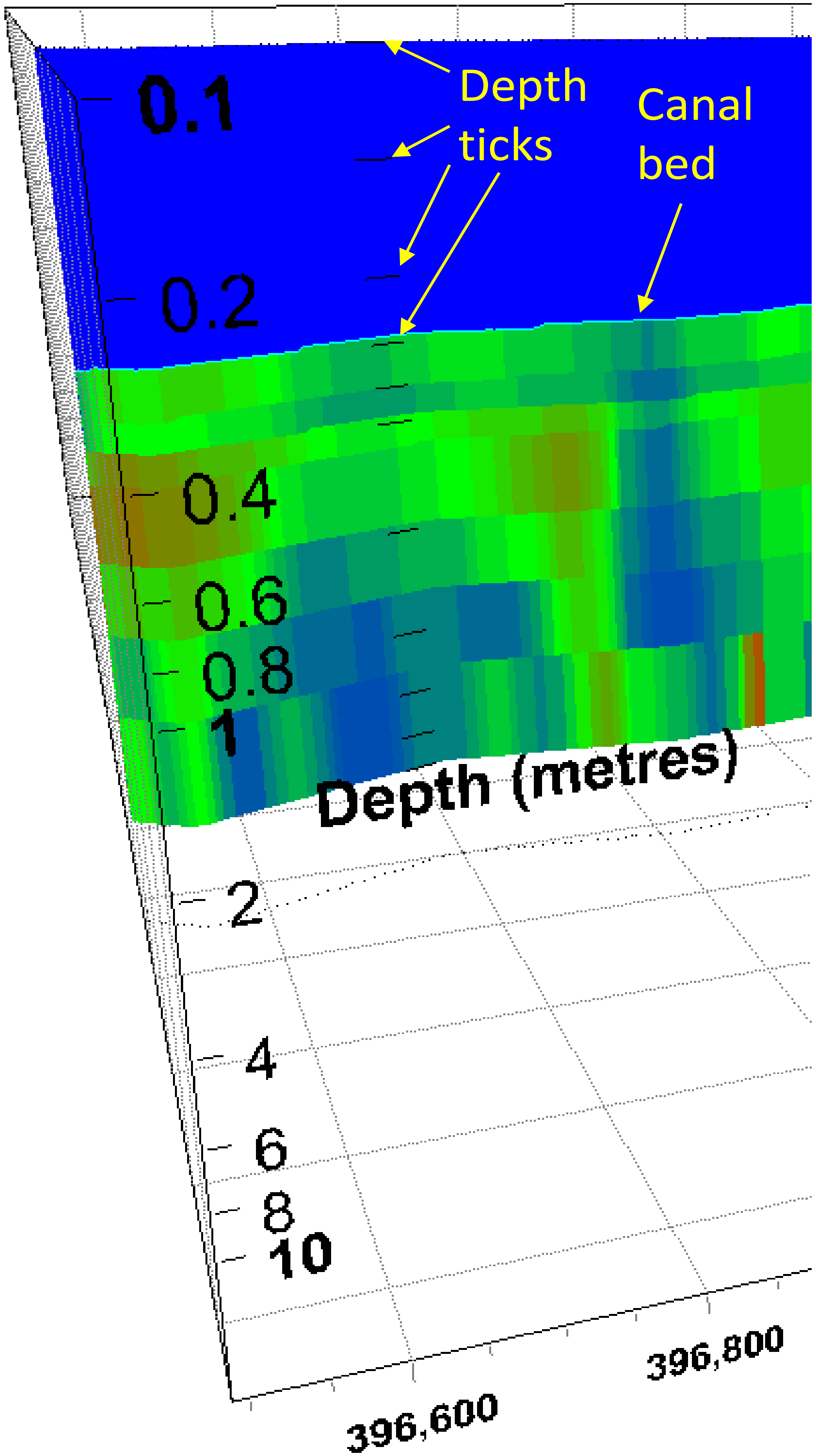
• Apart from some very shallow TEM features along the Talbragar River that are shaped like river meanders, there appears to be little correlation between the TEM data and alluvial thickness and this strongly suggests that alluvium related to the present day watercourses apart from the Talbragar River is close to absent from the site. There is potentially little difference between the composition and salinity of the alluvium that is present and underlying eluvium. Possibly even some of the types of consolidated rock beneath have similar salinity and permeability to this eluvium and alluvium. It is suspected that it is not possible or at least not easy to distinguish eluvium from alluvium in bore logs.

•Meander shaped TEM anomalies around the Talbragar River are most prominent at 1m and have almost disappeared by 12m deep. They are very conductive and do not extend to the river itself suggesting that they are charged with saline baseflow while sediment closer to the river has been recharged with fresh river sourced water from recent floods. They may also be clay filled billabongs.

# Appendices

- Identifying depths on ribbon images
- Towed Transient Electromagnetic schematic
- TEM platform configuration schematics
- TerraTEM specifications
- Processing sequence

# Identifying depths on ribbons

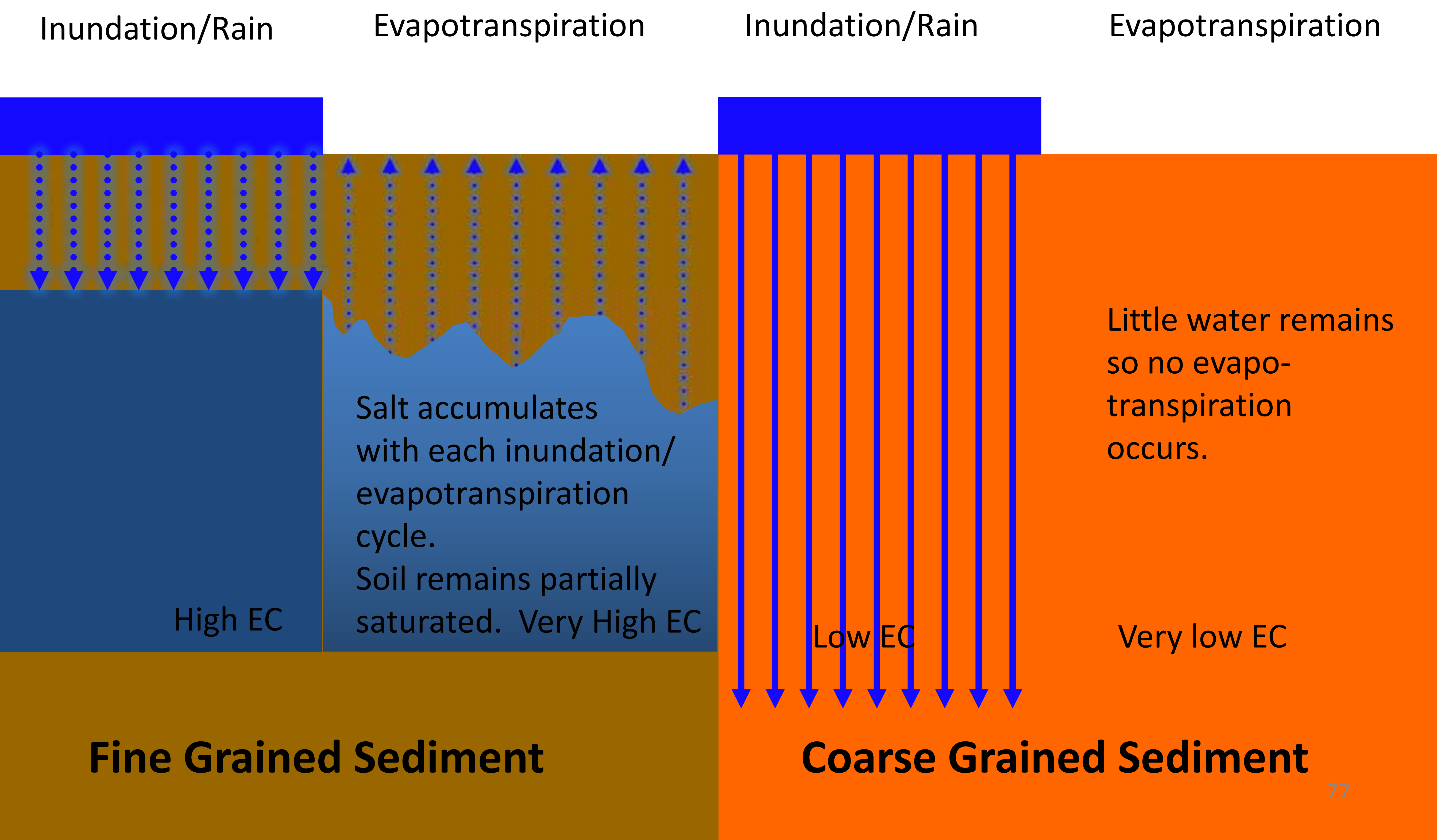



All the 3D imagery has the log or linear depth scales. It is labelled on the south-west corner of the 3D viewing space (as shown). Notice the increments are logarithmic. Logarithmic depth plotting is used so that deep data can be examined at the same time as detailed shallow (near canal bed) data. The geophysical data loses resolution with increasing depth and so this type of depth scale presents all the data in a way that is easy to see.

Look on the ribbon behind the depth scale and you will see a column of black ticks. These correspond to the ticks on the annotated depth scale. Notice that they bunch up at 1m. Black dots mark the projection of the ribbon onto the base plane of the viewing space which is 20 m below the surface.

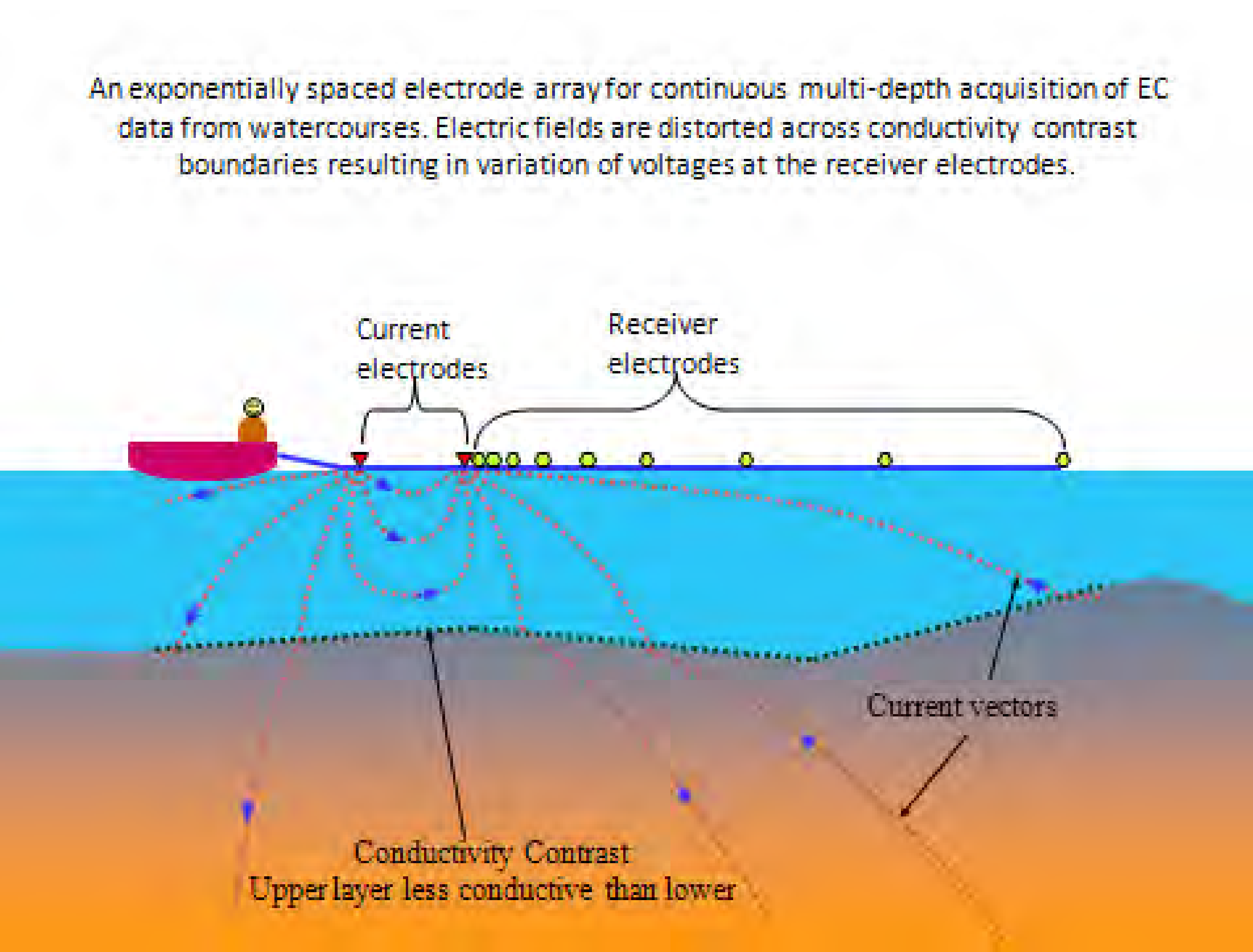
The canal bed is marked with an aqua line.

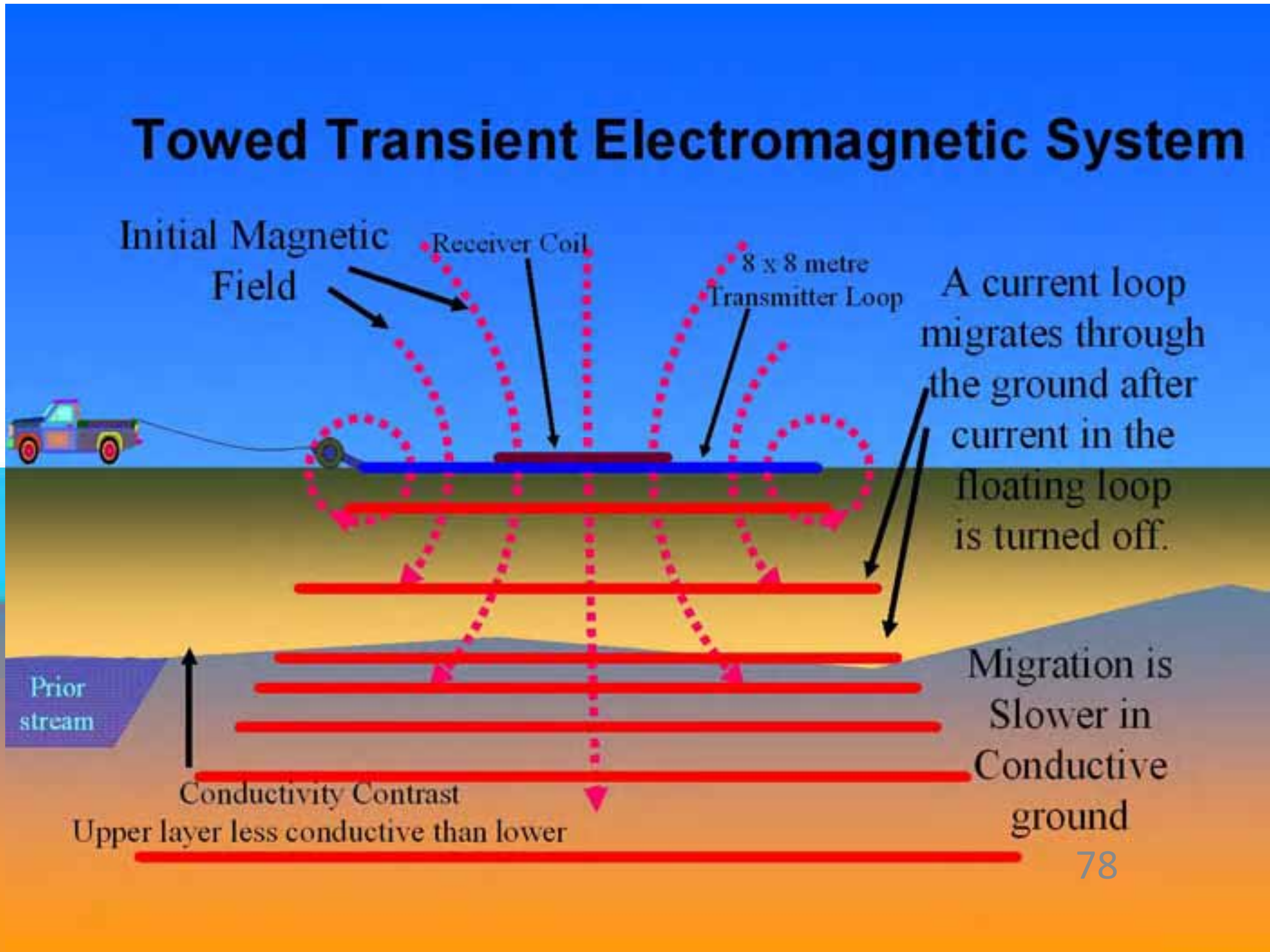
# Seepage, EC and soil texture in a recharge dominated environment.



# At depths significant to groundwater investigation, EC imaging may be conducted

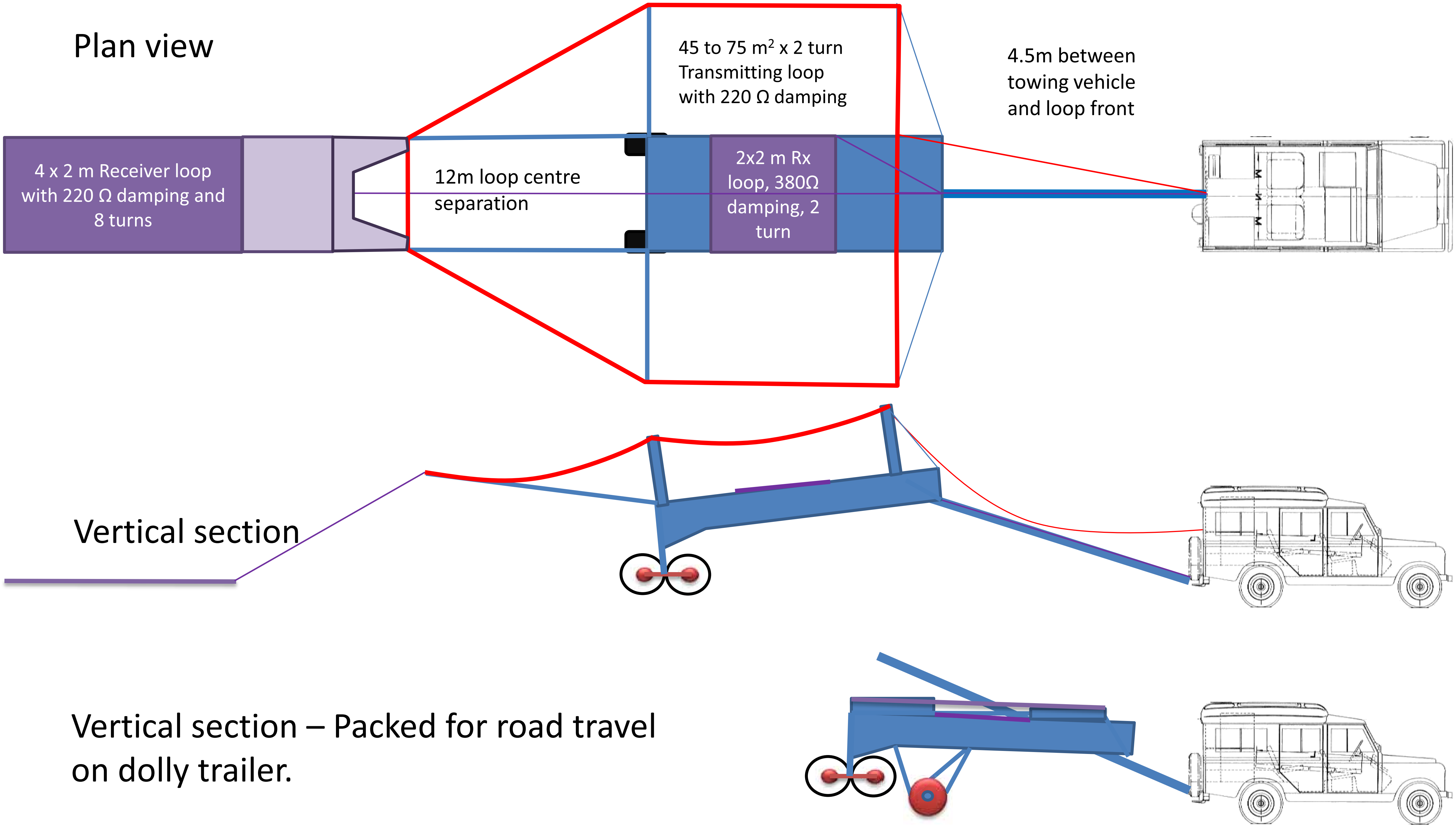
- on water, using geo-electric streamers
- on land, using Transient Electromagnetics (TEM)



# Transient EM equipment configuration

## (6 to 10 adjustable width) x 10 (length) metre transmitter loop platform

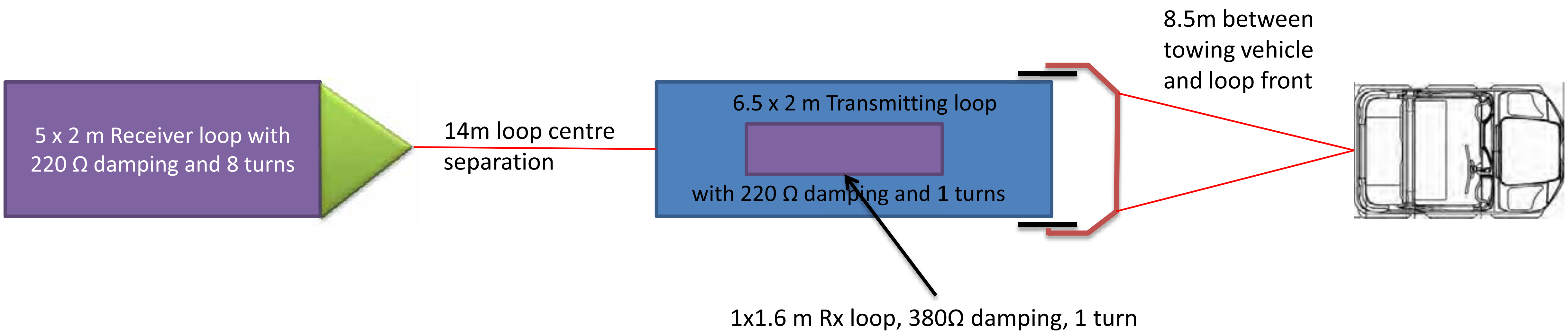



This schematic is not to scale

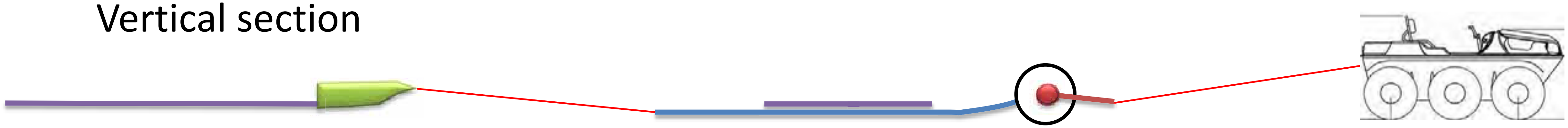
# Transient EM equipment configuration

## 6.5 x 2 m transmitting loop towed mats system

Plan view

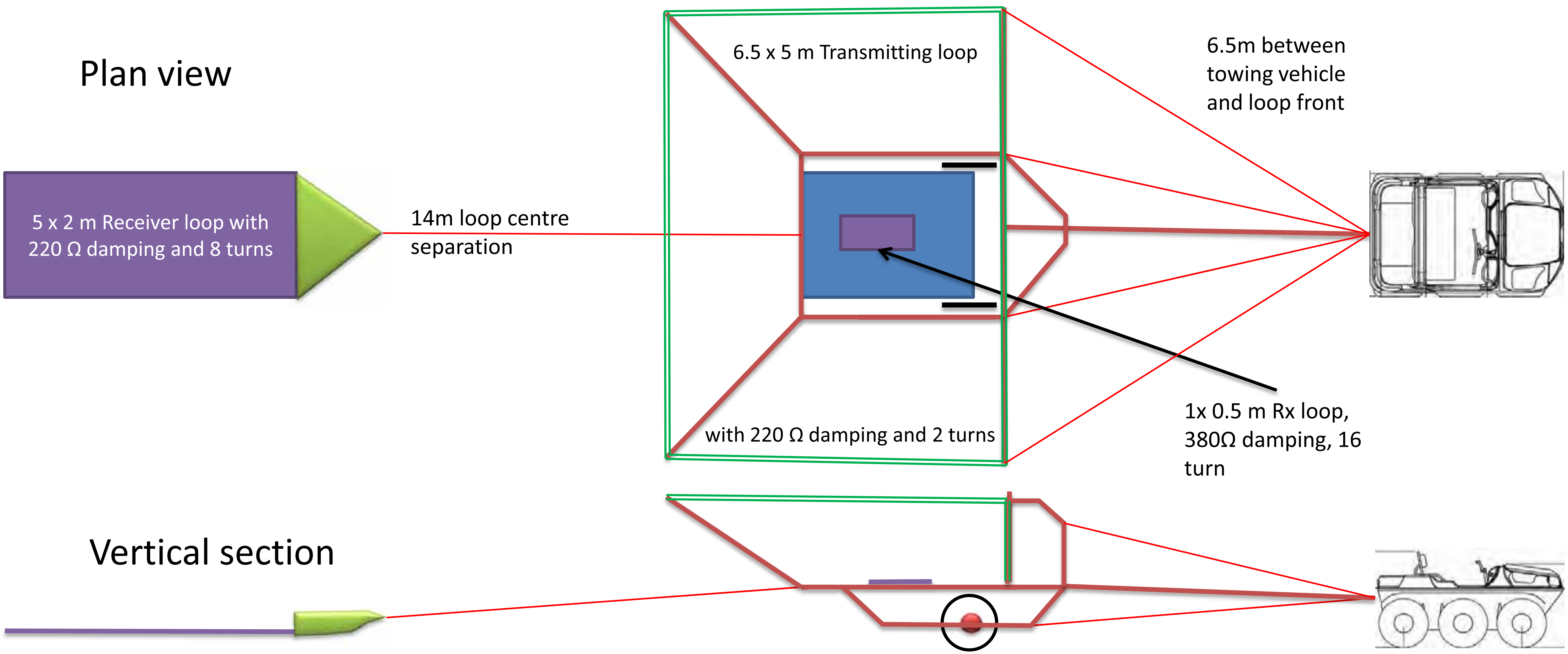



Vertical section



# Transient EM equipment configuration

## 6.5 x 5 m transmitting loop towed TEM system




Transmitter loop suspension arms are attached elastically to prevent attrition upon impact with trees. Arms may be raised from the towing vehicle and fold inwards for obstacle avoidance and for compact transport when not surveying. The trailer draw-bar is detached for between-job transport. The trailer is lightweight and can be lifted by one person. Attrition is also avoided by addition of a breakaway pin.

# The 6.5 x 5m transmitter loop towed electromagnetic system

# Transient EM equipment specifications

Alpha GeoInstruments

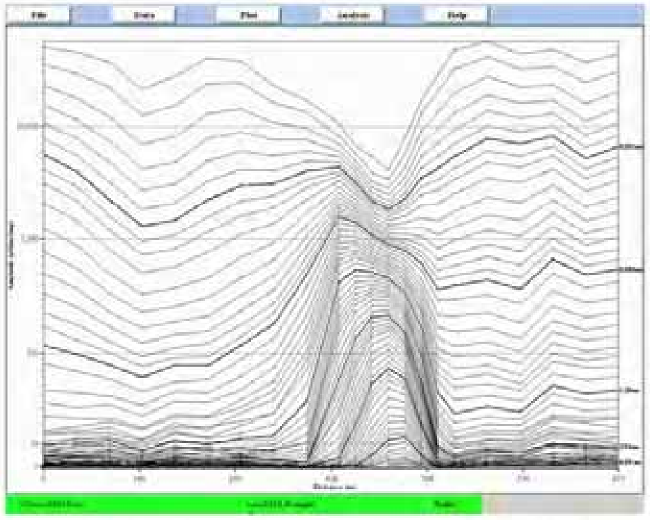
## terraTEM
Time-Domain EM Surveying System

### terraTEM Features

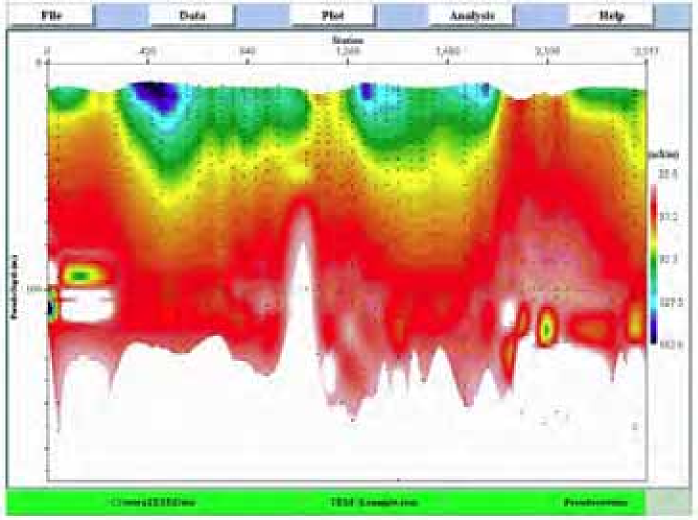
- Transmitter and receiver in one unit
- Single or 3 channel receiver with 10 amp. transmitter
- High speed sampling at 500 kHz for superior near surface resolution
- Easy to use touch screen with auto set-up and smart menus
- Large 15" LCD display for data visualisation
- Fast and easy data transfer via USB port
- Integrated 12 channel GPS system for seamless station positioning (option)
- Integrated PC for data visualisation, data processing, and interpretation in field using built-in software
- Rugged construction with external 24 V battery power pack and charger
- Several optional extras to broaden capability
- Designed and built in Australia

### Screen Dumps

The following are a number of screen views from the **terraTEM** system.




*Full control of all aspects of data display, post-survey filtering, and decay curve analysis*




*Multiple display formats, including gridding and raster images (options)*

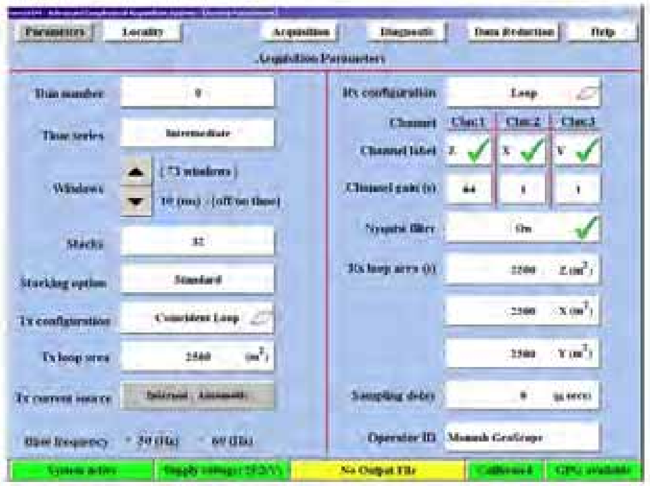
The **terraTEM** is designed, developed and manufactured by **Monash GeoScope**

Monash GeoScope

## Applications

The **terraTEM** can be used for various applications including the following:

- Mineral exploration
- Near surface including geo-technical and engineering investigations
- Groundwater and salinity studies
- Environmental surveys



*Easy access to all parameters, multiple binning and stacking options; smart menu system.*

*Internal GPS, for positional accuracy (option)*

## General Specifications

| | terraTEM | Options |
|---|---|---|
| Transmitter Output | 10 Amps. (max.) | **Enhanced Transmitter** |
| Receivers | 1 Channel | **3 Channels (simultaneous)** |
| High Resolution Sampling Rates | 500 kHz | - |
| User Selectable Multiple Time Gates | - | **Option** |
| Data Visualisation and Processing in field | Standard Software | **Enhanced Software** |
| Storage Device – 1 GB Flash Disk | Standard | - |
| GPS Receiver – 12 channel | - | **Option** |
| Communications – Port for Data Transfer | USB and RS-232 Standard | - |
| External Synchronisation | - | **Option** |
| Continuous Recording (with external GPS Interface) | - | **Option** |
| Extra Stacking Options and Gain Functions | **10 Selectable Gain Settings from 1 to 8,000** | **Auto Gain** |
| Vectem 3 Interface Module (for down-hole surveying) | - | **Option** |
| Interface Options (third party devices) | - | **Option** |
| Dimensions: Console: 530 x 350 x 160 mm. 13 kg.<br>Battery Box: 280 x 250 x 180 mm. 12 kg. | | |
| Operating Temperature: -10 to 40 degrees C. | | |

## Further Information

For further information regarding this product, either technical or sales, please contact:


**Alpha GeoInstruments**

Unit 1, 43 Stanley Street, Peakhurst. N.S.W. 2210. Australia
**Phone** +61 (0) 2 9584 7555 **Fax** +61 (0) 2 9584 7599
**e-mail** info@alpha-geo.com **website** www.alpha-geo.com


Your Distributor:



# terraTEM
## Technical Specifications

### Transmitter

| | |
|---|---|
| Output | 10 Amp. (max.) |
| On/Off Period | Adjustable 10 ms (50 Hz) or 8.33 ms (60 Hz) increments |

### Receiver

| | |
|---|---|
| Sampling | 500 kHz per channel, fixed |
| Inputs | +/- 40 V maximum continuous voltage |
| Gain | User selectable fixed gains<br>Other Gains Optional |
| Resolution | Maximum 28 bits, effective |
| Functions Measured | Tx/Rx loop resistance, Tx current, Tx turn-off time, battery voltage, automatic gain/offset calibration, transient response |

### Console

| | |
|---|---|
| Display | LCD TFT, 15 inch |
| Touch Screen | Splashproof |
| Storage | 1 GB flash RAM |

### External Interfaces

| | |
|---|---|
| Communications | USB and Serial port for data transfer |

### Equipment Supplied

- Console
- Loop connectors
- Battery Pack (24 volts), complete with connector cable (overseas batteries not included)
- Battery charger
- USB flash disk (for data transfer)
- Operations manual

### Sensor Attachments Available

| | |
|---|---|
| Surface Receiver | RVR-1 or cable loop |
| Downhole | Vectem 3 or equivalent |

### Physical

| | |
|---|---|
| Housing | Aluminium "Zero" case |
| Console: Weight | 13 kgs. |
| Dimensions | 530 x 350 x 160 mm. |
| Battery Pack: Weight | 12 kgs. |
| Dimensions | 280 x 250 x 180 mm. |
| Operating Temperature | -10 to 40 degrees C. |

### Options

| | |
|---|---|
| GPS Receiver | 12 channel receiver |
| Multi-channel Receiver | 3 channel simultaneous A/D |
| External Transmitter Interface | External synchronisation option (for use with TEMTX-32, Zonge high powered transmitters) |
| Vectem 3 Interface | Internal interface module |
| Continuous Recording | Continuous recording of unit with external GPS interface using NMEA standard |
| Software Packages | Extra Stacking Options, Sferics Rejection and Gains, Spectral Analysis and Digital Signal Processing<br>User-defined time series |


## Further Information

For further information regarding this product, either technical or sales, please contact:

**Alpha GeoInstruments**

Unit 1, 43 Stanley Street, Peakhurst. N.S.W. 2210. Australia
**Phone** +61 (0) 2 9584 7555 **Fax** +61 (0) 2 9584 7599
**e-mail** info@alpha-geo.com **website** www.alpha-geo.com

Your Distributor:

Alpha Geoinstruments is a division of Alpha Geoscience Pty. Ltd. (ABN 14 080 819 209)
The above Technical Specifications could change without notice.

# Towed platform TEM Method Description

- ***Towed platform TEM Method Description***
- Towed platform specifications are given on prior slides.
- Towed transient electromagnetic arrays have been applied by Sørensen, et. al.(2000), and the author (Allen, 2007) however the full potential of the technique is far from being realised. Other options for fast TEM data acquisition have been described by Harris et. al. (2006) and Hatch et. al. (2007).
-
- Key features of practical towed TEM devices are:
- They must facilitate towing of sufficiently large area transmitter loops and one or more receiver loops upon largely non-metallic structure;
- They must be robust enough to withstand field use;
- They must be capable of passing through farm gates and between other common obstructions without undue delay;
- They should be designed in such a way that they can isolate and minimise effects of incomplete transmitter turn off, loop self and mutual inductance, super-paramagnetic near-surface minerals and chargeable near-surface minerals;
- The transmitters need to be able to cleanly transmit high currents. Dual moment operation is beneficial;
- They must be readily road transportable and GPS equipped.
-
- Figure 4 presents a platform with the transmitter and receiver loops placed on dragged sheets, the sides of which can be raised when passing through gates. The main sheet is 2mm thick polyethylene which is heavy enough to prevent lifting by all but strong wind and rigid enough not to catch on stumps, barbed wire, and other obstacles. Practical size of the sheet is limited by the combination of the necessity of weight per unit area needed to prevent lifting by wind, and total weight which needs to be low enough to permit man-handling. The sheet is very useful for permitting precise layout of primary field nulling coils when using central loop receiver loops, and for spacing multi-turn transmitter loops so as to reduce self-capacitance and, to a lesser extent, self-inductance. It is difficult to increase the number of transmitter loop turns without compromising turn-off ramp integrity. This is a problem well understood by designers of airborne TEM systems.
-
- Receiver coil movement through the earth's magnetic field produces noise. When the coil is on a mat, it generally does not suffer from movement at frequencies above the sampling frequency as there are no taut elastic components that can resonate. Noise lower than the sampling frequency can be removed in post-processing of appropriately stacked data using techniques common to airborne TEM survey (eg. Noteboom, 2007).

# Processing – introductory notes

One of the big advantages of a towed system is that it has a small near surface footprint that can isolate and avoid most problematic cultural effects. Further, it can be manoeuvred in order to test the effect of culture. In this way, processing, in effect, really starts during acquisition. Cultural effects need to be identified and this is done by repeatedly driving close to them and noting their response. Once problematic culture is identified, it is either avoided or its location is noted for later removal of affected data. The TerraTEM continuously displays decays of incoming data, and for quality control and verification of system response, these are continuously monitored while driving.

Data from all the relevant devices was merged together using interpolation and extrapolation where necessary. Position data was written in WGS84 UTM(MGA94 equivalent at the accuracy of the DGPS that will be used). Data is in tabular format in dBase files suitable for importing into ArcGIS and Google Earth products as specified in *Allen, D.A., 2005, Towards creation of a national multi-depth electrical conductivity database. Australian Society of Exploration Geophysicists, Preview, August, Issue No. 117.*

The Gridding was conducted as follows:

- Depth slice data was all log transformed;
- A proximity filter averaged points closer than 20m apart;
- An exclusion filter removed null records caused by depth slicing beneath cutoff depths;
- Natural neighbour gridding was performed with a cell size of 20m;
- The grid was blanked to remove most overshoots occurring around grid extremities in the absence of data;
- Gridding was imaged with valid and non-valid colour coded points registering data locations posted on the image so that viewers can determine what are real geological features and what are simply gridding artefacts. Non-valid points are important for showing where data cutoff above slicing depth as soundings penetrate much deeper depth when modelling resistive features – the result being that gridded data will be excessively resistive at depths below conductive feature cut out depths.

Data was then interpreted.

# Processing Sequence

Define System Geometry

–

1. Quality control and data parsing during acquisition
   1. At the beginning of each day, select a reference sounding and plot it along with all incoming data.
   2. Watch all incoming data constantly making comparison with the reference sounding.
   3. Cancel acquisition or note problems as noise sources, metal artefacts, or equipment malfunctions are encountered. Alter course across ground to both more clearly define noise and artefacts and to subsequently avoid them.
   4. Each night, convert BIN file into TEM and TXT files and back them up.
   5. Each night, display selected channels of the data in plan view to appraise layout of geological features and any present geophysical artefacts.
2. Acquire system response from data obtained (stacked then averaged) in a very resistive area.
3. Determine EM1DInv inversion software initial model, constrains and control parameters.
4. –
5. Operations performed on TEM files
   1. Basetrend removal (optional – only possible on moderately to highly resistive areas). This removes movement noise from the receiver coil moving through the magnetic field of the earth slowly. Large mat receiver loops do not create much movement noise.
   2. Adjust magnitude according to primary field response (optional).
   3. Reject records with low primary field response as they are clearly suffering from equipment malfunction (eg. Receiver loop blown over by wind) (optional).
6. Convert TEM file into a relational voltage database (*Volt.DBF, *XVolt.DBF,*YVolt.DBF)
7. Normalize data using average magnitude of log10(data) from a small receiver placed directly on the transmitter loop wires (*YVolt.DBF) (This is optional as the data is already normalized according to current monitored (every 100 soundings in 2010)).
8. Remove system response, taking magnitude of transmitted data (proportional to *YVolts.DBF) into account for every sounding.
9. –
10. Display voltage data, in map view, coloured to represent magnitude of a particular channel. Simultaneously view decay plots of picked soundings, along with a reference sounding.
    1. Interactively remove geophysical artefacts by clicking on points or data segments.
    2. Alter the channel and repeat a.
    3. Repeat b. until satisfied that data is suitably cleaned.
    4. Interactively clip channel count on soundings with procedure as for a., b. and c. (optional).
11. Smooth voltage data horizontally. Trapezoidal filtering is ideal (optional). Note well that this step is conducted after removal of artefacts which would have spread their mess throughout the data if smoothed.
12. Calculate noise levels from sounding tails and specify ready for inversion. Should telecom cable or powerline noise be encountered, then this step will lead to recovery of shallow information without unduly corrupting deeper information!
13. Determine valid time range for inversion input from each sounding using noise levels specified in step 14.
14. Create EM1DInv inversion input files.
15. Run EM1DInv on each sounding, conjunctively inverting both in-loop and out-of-loop data. This scheduled using batch files and runs overnight, or even over several days or weeks.
16. Run EM1DInv again with lateral constraint (optional – also time consuming).
17. Read inversion output files to create relational *Ohmm.dbf files.
18. View *Ohmm.dbf files in plan view.
    1. Colour proportional to curve fitting RMS error and view to determine an appropriate cut-off RMS threshold. Exercise caution in determining the threshold as data in resistive areas will still be valid at much higher threshold than in conductive areas.
    2. Reject soundings with RMS error greater than the threshold level determined in a..
    3. Colour proportional to resistivity of successively deeper layers. Interactively remove or depth-limit soundings containing artefacts by clicking on points or data segments.
19. View *Ohmm.dbf in 3D – check data more, switching back and forth to 2D view to remove further artefacts.
20. Horizontally smooth the *Ohmm.dbf file to clean up erratic variation in inverted data.
21. Horizontally shift *Ohmm.dbf files to account for antenna offset.
22. –
23. Divide day *Ohmm.dbf files into logical segments (where appropriate) and recombine into *Ohmm.dbf files covering logical geographic extents.
24. Calculate resistivity distribution histograms and combine to make a master histogram for the area.
25. –
26. Re-load regional *Ohmm.dbf files and colour with master histogram equalization (quantization).
27. Query state bore databases and generate a subset of bore data for the area.
28. Interpret the drillers logs into lithological categories.
29. View bore log graphics with the resistivity data for each region.
30. Create graphics of histograms and lithological keys for posting externally.
31. Pack regional *ohm.dbf files and augment with shapefile indexes, projection files etc.
32. Create 3D polygon KML and shapefiles for each region (both resistivity and lithological files).
33. Slice each regional resistivity file into depths and output as *.csv with columns of logarithmically transformed resistivity for external gridding in packages such as Golden Software Surfer 9.
34. Create any other appropriate theme datasets (eg. Depth to maximum resistivity) and 3D graphics (eg. Voxler).
35. Grid and display depth slices, stacked if required in 3D space (Surfer).
36. Organize and refine KML files in Google Earth and select enhanced snapshot views. Combine into a folder and collectively output as a new KMZ file. The KMZ files are compact - Email to interested parties.
37. Collect all graphics in MS Powerpoint (A3 resolution!) and create a report. Make a summary report in MS Word (optional). Generate PDF report.
38. Package job DVD and printing, mailing etc.

# Results – digital products

- EC datafiles in resistivity units - Ohm.metres accompany this presentation. There is one column for each layer sampled and one column for the depth to the bottom of each layer sampled. The datafiles are in dBase format and may be read using MS Excel, MS Access or ESRI software. ArcView contains a routine for expanding the dBase files into ESRI shapefiles but in most cases this is already done. Co-ordinates are all WGS84 (equivalent to MGA94 to the degree of accuracy of the survey) and are given as both UTM projection and latitude and longitude decimal degrees. Google Earth KML (or zipped = KMZ) format files are also provided for various 2D themes and in 3D. CSV ASCII files of depth slices also provided for generic loading into any spreadsheet or GIS software.
- **Results – Accompanying CD contents**
- The accompanying CD contains this document, digital data, the power point presentation, the A3Earth Plus. Further explanation is as follows:
- This report is stored as a *.doc (MS Word 2003 format) and *.pdf
- The powerpoint presentation is stored as *.ppt and *.pdf
- The Google Earth datasets are stored as *.KML and/or *.KMZ and are opened using File:Open in Google Earth.
- The A3 maps are stored, ready for viewing as *.pdf or *.jpg files
- Data files *Volt.dbf
- Transformed Data files *Ohmm.dbf.
- Depth slice files *DepthSlice.csv
- ESRI ArcMap file *.Mxd demonstrates access to transformed data files and can be used to locate them all.
- Golden Software Surfer *.srf displays and provides locations of all the gridded data files.
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- All data is stored in GDA94/MGA94 UTM Zone 55 coordinates (Lat Long, E N, or both).

# Production Report

Total production distance
excluding gaps >60m
= 286.46km Averaging 35.8km/day

| Date | Charge | Details |
|---|---|---|
| 7th October 2011 | Reconnaissance | Drive Dubbo-Cobbora-Dubbo<br>Conduct reconnaissance and discuss access with farmers and Cobbora Holdings Ltd. Staff.<br>Arrange accommodation.<br>Assess ground conditions after recent heavy rain. |
| 8/10/11 | Nil | Delay start due to wet ground |
| 9/10/11 | Nil | Delay start due to wet ground |
| 10/10/11 | Nil | Delay start due to wet ground |
| 11/10/11 | Production | Drive Dubbo to Cobbora<br>100m spaced survey of O'Leary's Farm.<br>Float equipment to Mates and reassemble ready for survey again. |
| 12/10/11 | Production | Survey Mates Farms north-west of the River then east of the river. |
| 13/10/11 | Production | Survey Mates Farms north of the Highway and south of the river and then start south of the highway. |
| 14/10/11 | Production | Survey south of the Highway down the west side of Sandy creek.<br>Return to Dubbo |
| 17/10/11 | Production | Drive Dubbo to Cobbora<br>Survey northern Sandy creek. |
| 18/10/11 | Production | Survey southern Sandy Creek.<br>Timing belt failed returning to Woolandra Cottage at end of day. |
| 19/10/11 | Nil | Towed back to Dubbo. |
| 25/10/11 | Production | Drive Dubbo to Cobbora.<br>Survey Laheys Creek. Return to Dubbo. |

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