2007 Airborne Time Domain Electromagnetics over north side of Roberts Lake

Open Report 2015

Detailed Analyses of a VTEM anomaly coinciding with a MaxMin anomaly

Survey Overview

In February, 2007, HBED contracted a VTEM airborne electromagnetic and magnetics survey to be flown over the north end o f Roberts Lake extending to the north of the lake (Figure 1).

The VTEM system consists of a transmitter loop approximately 26m in diameter towed behind a helicopter with a ground clearance on average of 35m. The VTEM system drives a current of approximately 190 Amps with a roughly trapezoid shape with a basefrequency of 30Hz. The instrument measures inside the loop the vertical component of the time varying magnetic field. 24 channels in the off-time were measured.

In addition, the system measures the DC magnetic field with a fluxgate sensor which is above the transmitter loop and approximately 15m below the helicopter.

Survey Overview
KUS14

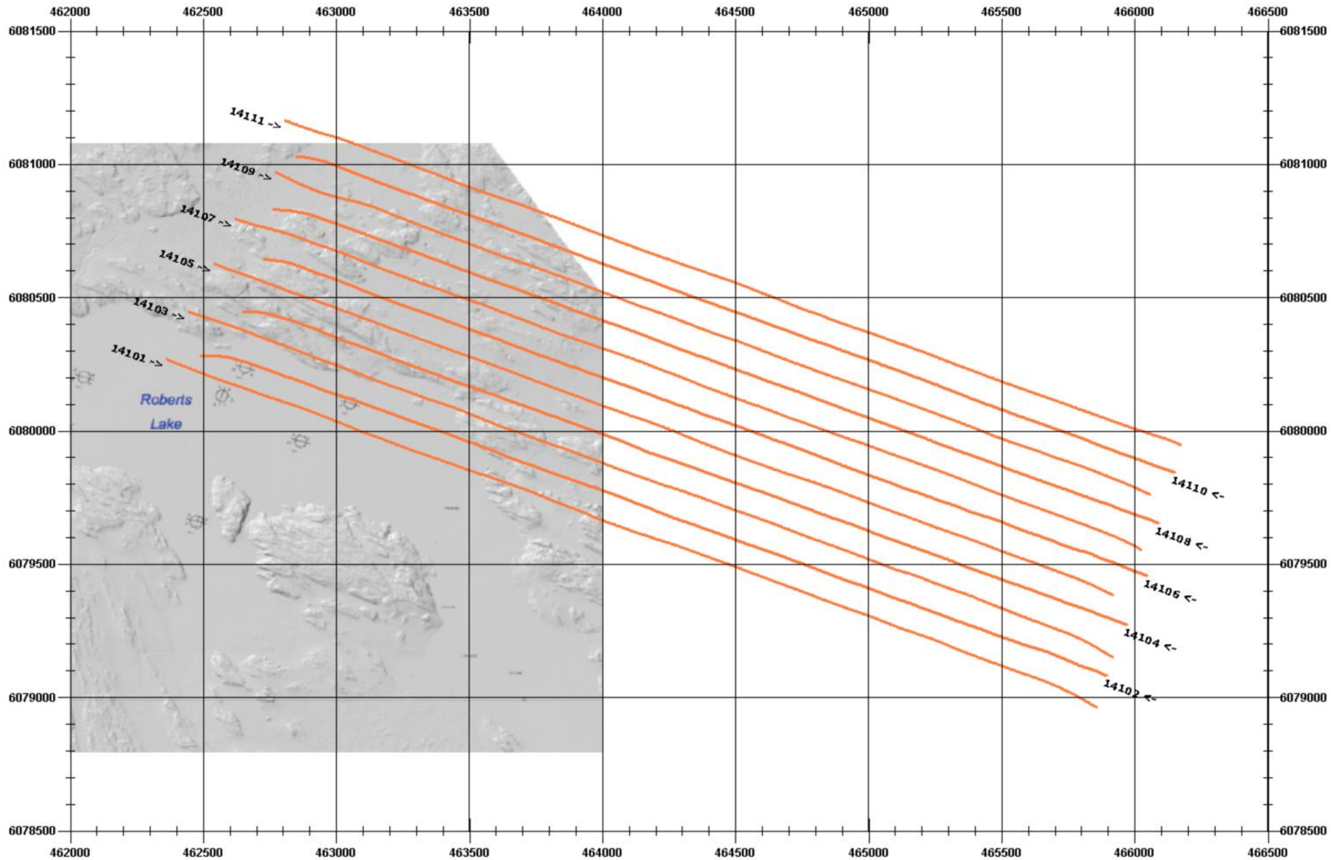


Figure 1: KUS14 survey lines with Lidar map underlay

Time Domain Response

The time domain response varies from early time to late time. Early time responses generally relate to shallow conductors while late time response relate to deeper or more conductive targets.

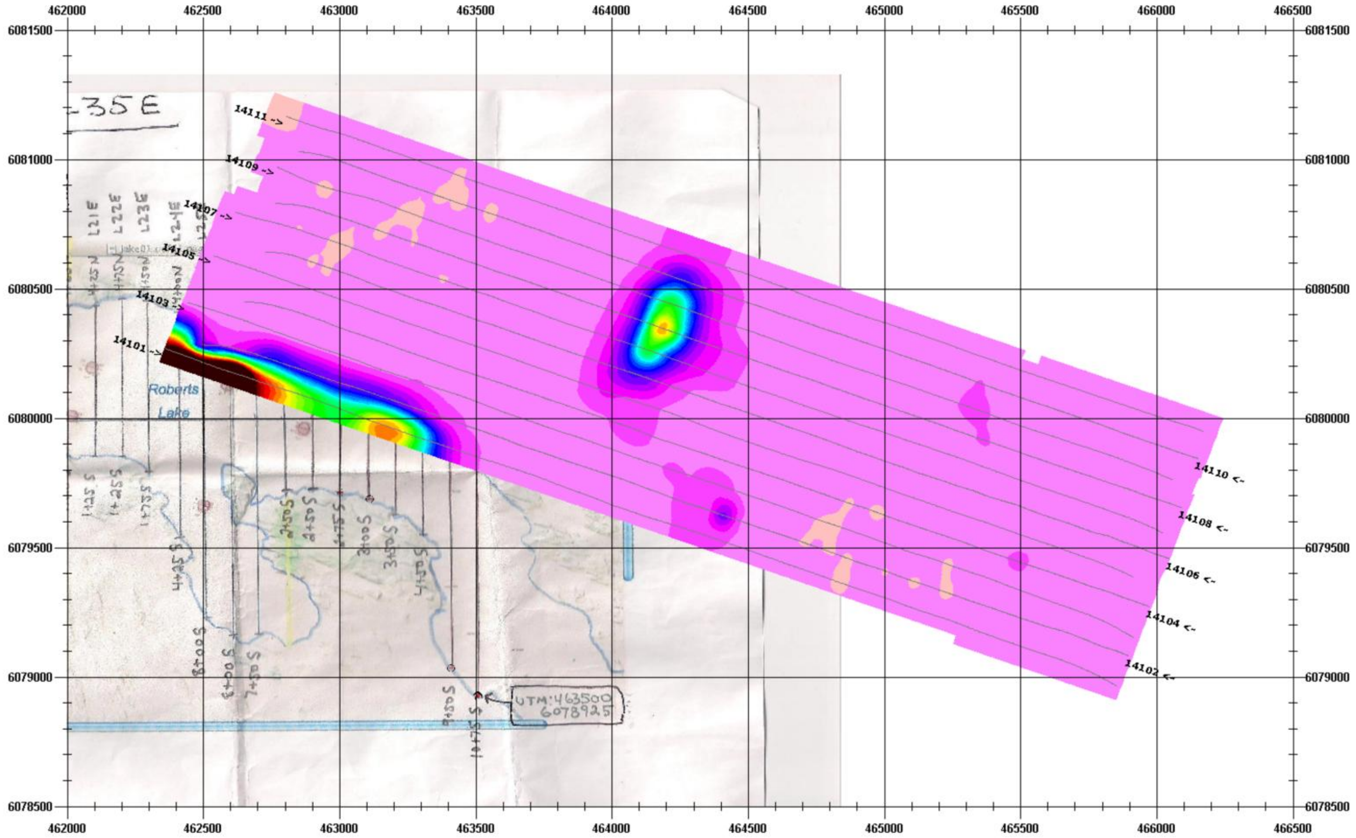


Figure 2: Early Time VTEM response – Channel 3.

At early time, two features are prominent. The target in the central north which is of interest to HBED and the targets under Roberts Lake. The Roberts Lake feature contains several aspects. First it is obvious that the lake sediments are mapped but there are two higher conductive features which are consistent with the MaxMin anomalies.

Time Domain Response

As the response varies into later time, we are seeing deeper as well as differentiating more conductive targets. The target to the central north which was likely the target for the survey is still prominent. The 2 targets inside Roberts lake are strong and well differentiated but the higher response is now seen now north of the lake. A new target to in the south central area is also now seen.

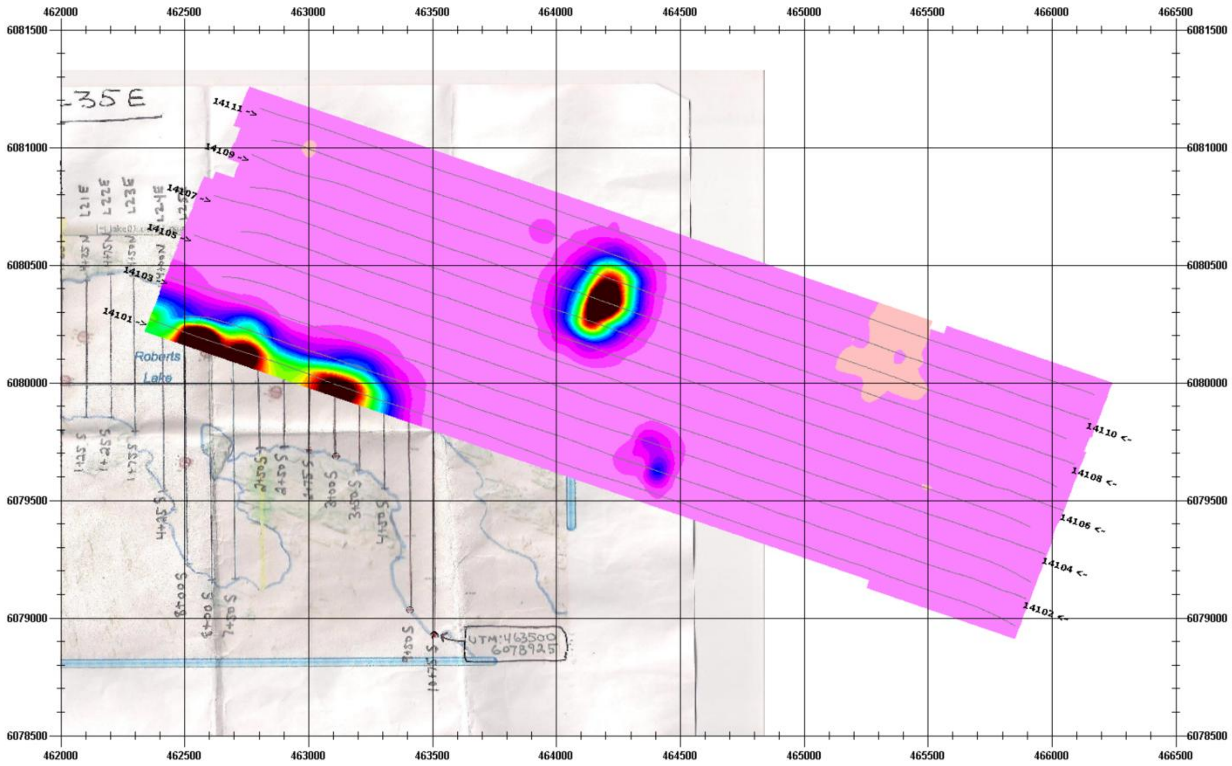


Figure 3 Early Mid-time VTEM response- Channel 13.

Time Domain Response

By early late-time, the Robert's Lake anomaly has split into 3 stronger sections.

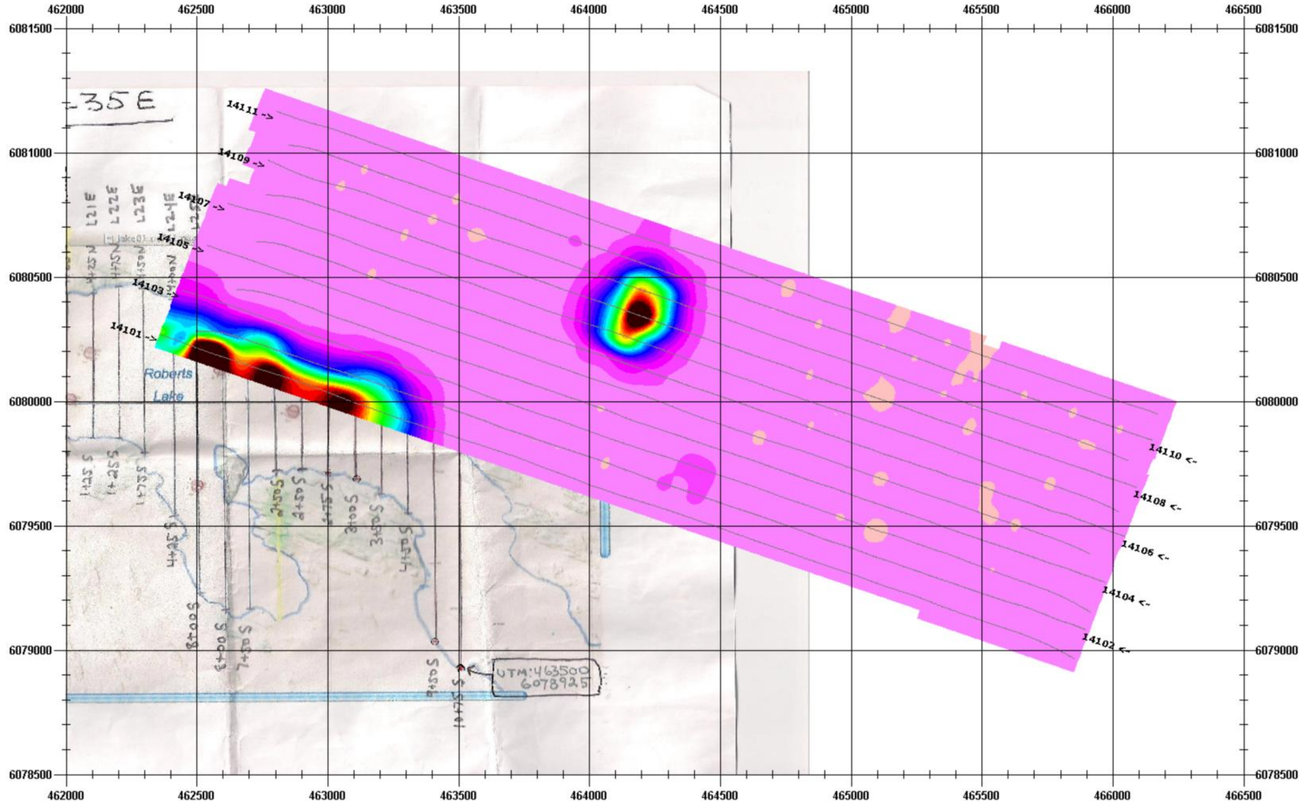


Figure 4 Early Late-time VTEM response- Channel 21.

Time Domain Response

By last time channel, Channel 24, the Robert's Lake anomaly differentiates into a strongest west anomaly, an almost as strong central anomaly and the weaker eastern anomaly. From this figures, apparently the western and central anomaly are stronger than the NE anomaly which is likely the reason for this survey.

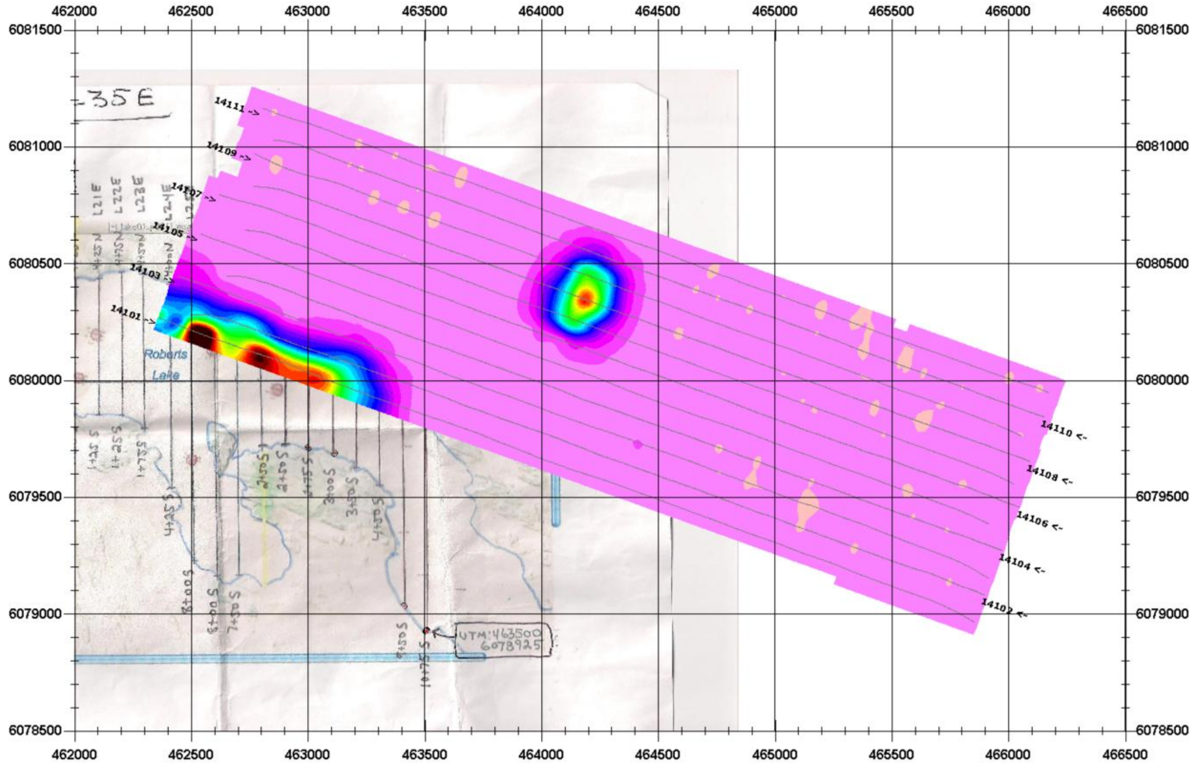


Figure 5 Late-time VTEM response- Channel 24.

Time Domain Response – Roberts Lake anomaly focus

Now, we will focus on the 3 flight lines over Roberts and the 2 flight lines immediately north of Roberts. The figure below is for Channel 5, in the late early time. This display is equal weight rather than equal range as before. The purpose of this is not too weigh the larger responses too high in order to see that the anomaly extends to the northern shore. As well, the 3 sections are evident and apparently dipping to the NE. The possible extension to the north beyond the lake centers on the green halo around the principle Roberts Lake anomalies. This halo extends over the north shore and is not coincident with the lake shore boundary.

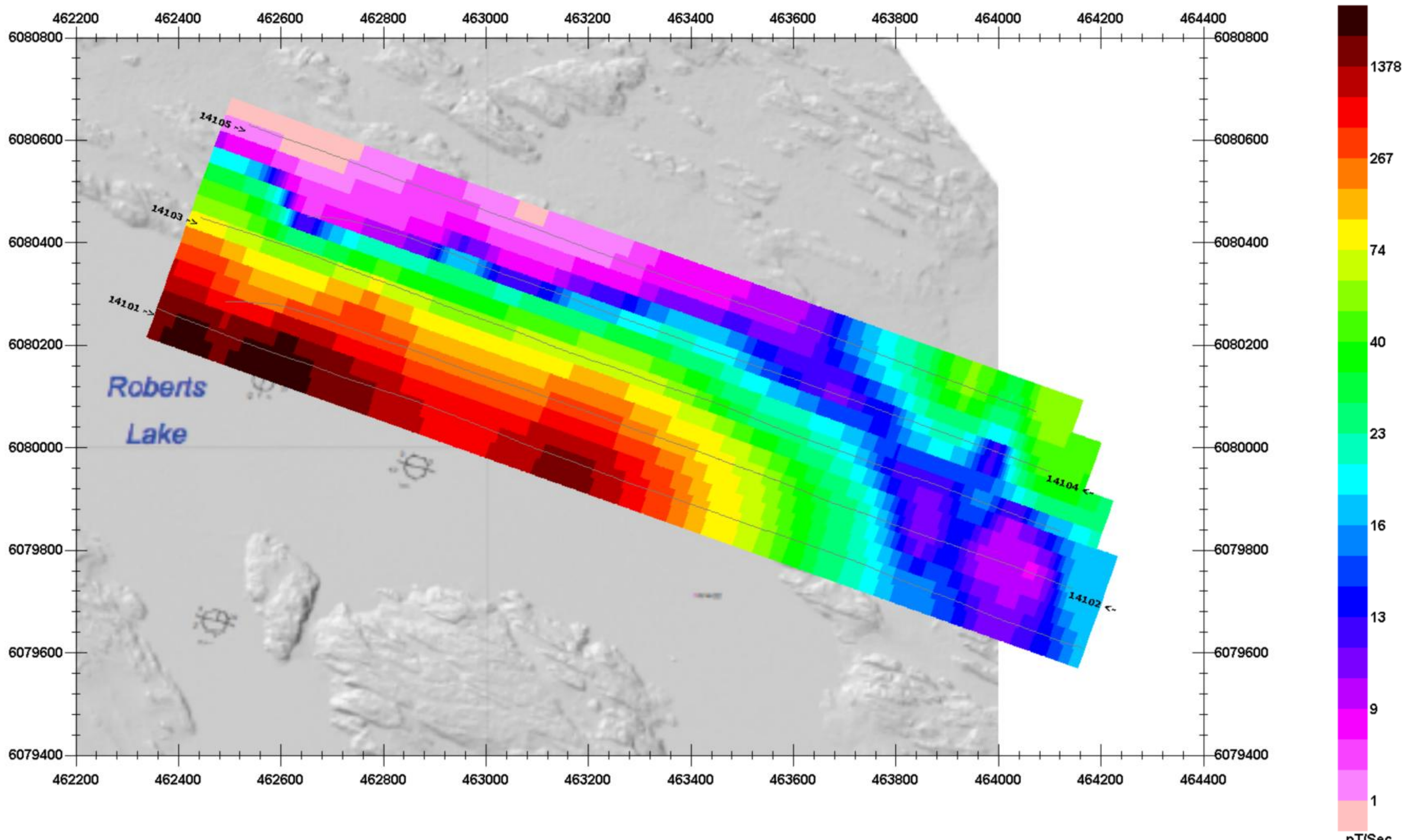


Figure 6: Late early-time VTEM response- Channel 5 – Equal weight display.

Time Domain Response – Roberts Lake anomaly focus

This extension to the north as well as the striking border to the east is even more evident at late mid-time – Channel 15 shown below. The geophysical anomaly is outlined. A geophysical anomaly is an anomaly in the data as opposed to an anomaly in the geology.

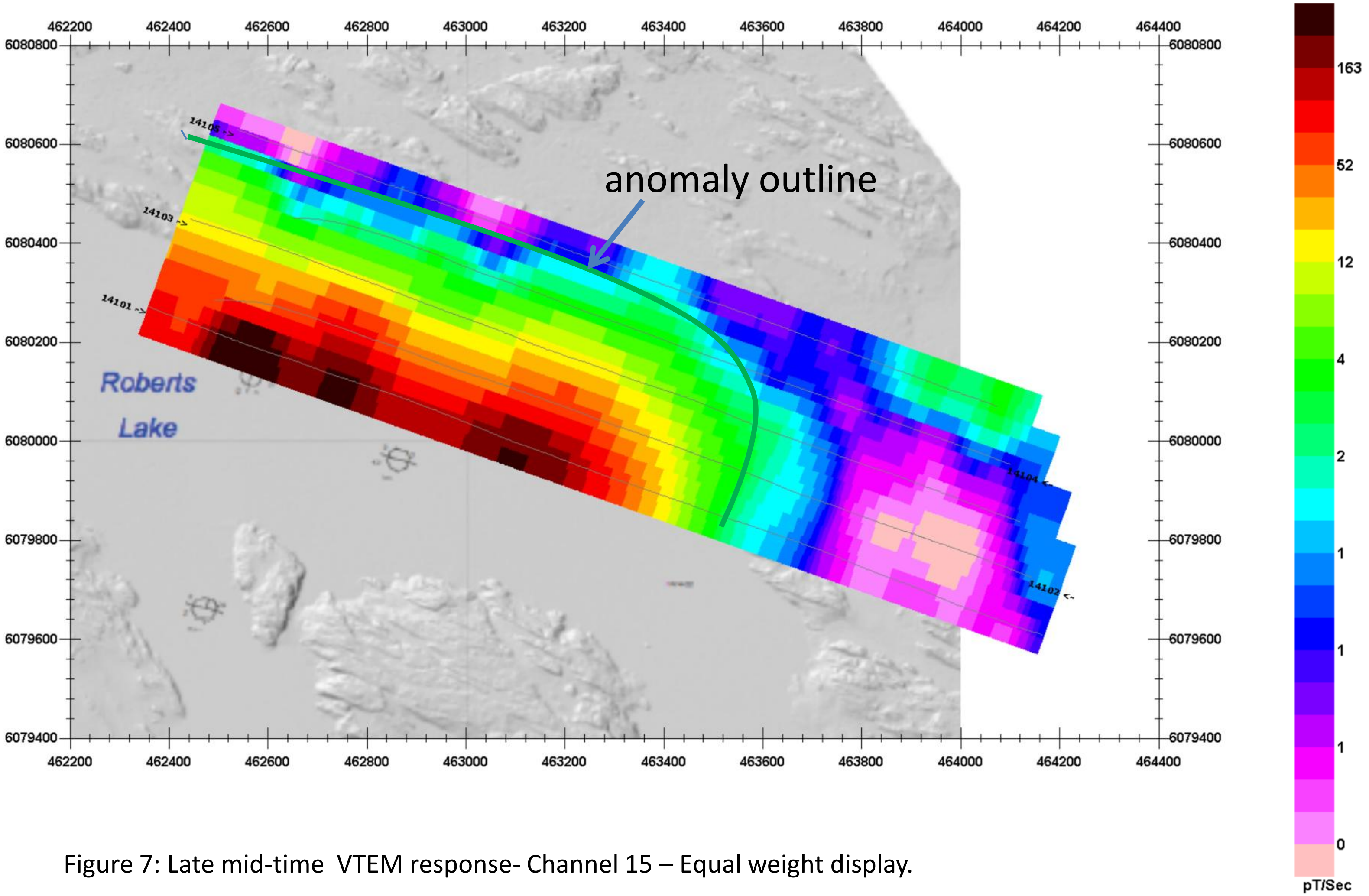


Figure 7: Late mid-time VTEM response- Channel 15 – Equal weight display.

Time Domain Response – Roberts Lake anomaly focus

Finally, the latest time response is shown – Channel 24.

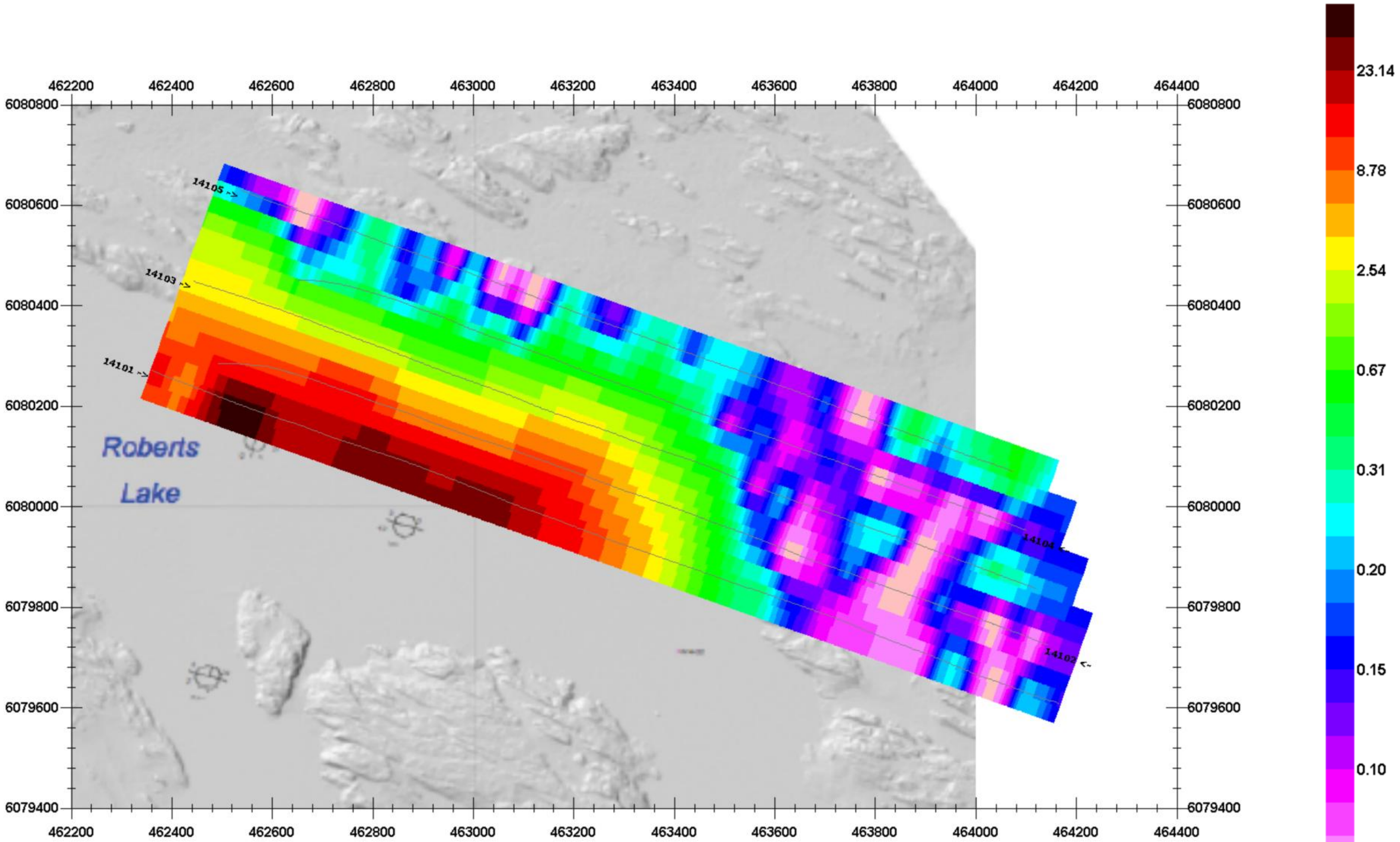


Figure 8: Late time VTEM response- Channel 24 – Equal weight display.

Time Domain Response – Roberts Lake anomaly focus

There are ways to examine this type of data other than through making maps of different channels. Here, we will look at plots of the response along flight lines at different channels and at the response as a function of time at specific locations along a flight line. Below, on the left in figure 9, is the response at Channel 5 on the southerly most flight line – L14101 and on the right is the response as a function of time at 3 locations along that flight line – Easting – 462605 (red), 463202 (blue) and 463554 (green).

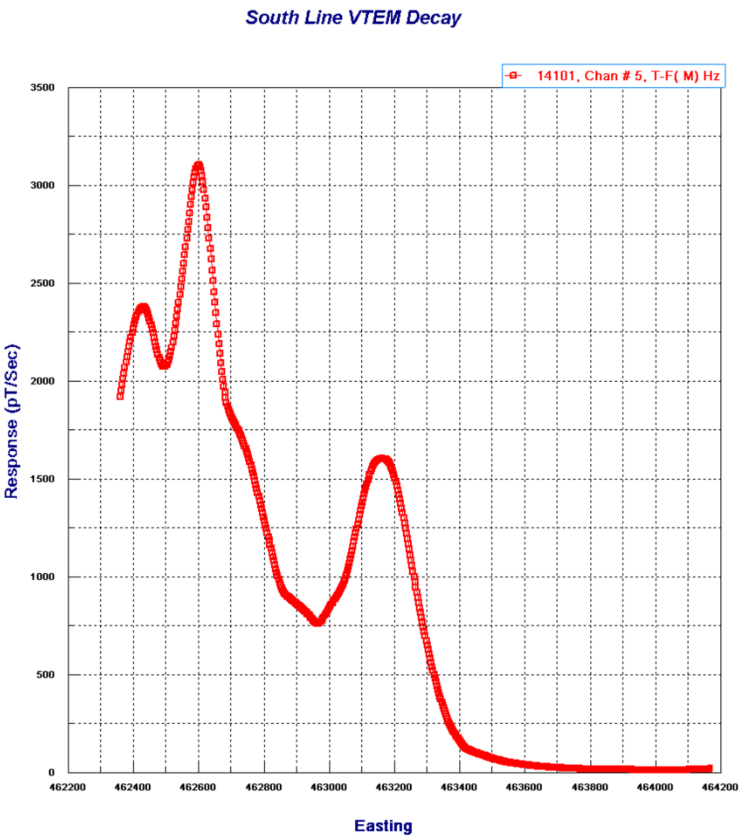


Figure 9: Channel 5 (mid-early time), along L14101.
Note: 3 peaks, 2 in the west and one central, east has very low response. Large early-time anomalies are not necessarily good conductive targets.

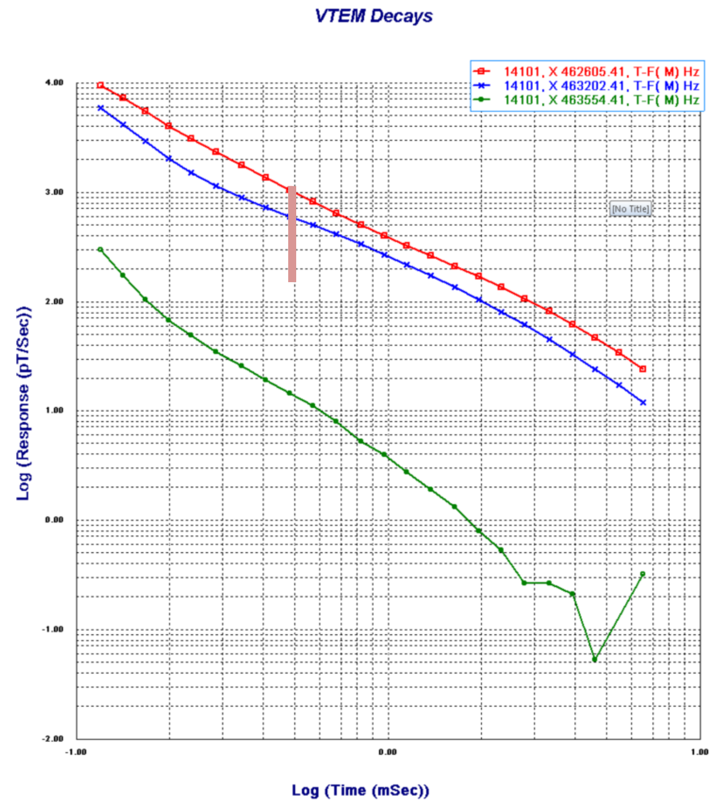


Figure 10: Response as function of time, at 3 locations.
Note: First, the 3rd station (green) while still over the lake has a much lower response and a faster rate of decay in early time than the other 2 stations. The two easterly stations have very slow rates of decays starting in late early time.

Time Domain Response – Roberts Lake anomaly focus

Preliminary Inference:

My preliminary interpretation of the data at this stage is that there are 2 conductors, one shallow and weakly conducting and another sequence of conductors significantly deeper but also significantly more conductive. The amps indicate on initial examination that the deeper conductors are dipping to the NE. The shallow conductor may also be dipping in this direction.

Also, the deeper conductor has a significant depth extent as its response extends to the NE more than 400m and thus beyond the northern shore of the lake.

However, we will continue to examine this data in order to try to unravel more about the conductors.

Time Domain Response – Roberts Lake anomaly focus

On the left, we see the response at Ch15 (late mid-time) again along Line L14101 which is the flight line furthest south. A central anomaly now appears as a peak centered about 462745E. In the figure on the right (Fig 12), the data at this station is also plotted (brown). We see that while the decay in early time is close to the middle anomaly (blue), the late time matches the western anomaly (red). The inference being that all 3 anomalies result from a single contiguous conductor which may be plunging to the east. Note: decay rate is indicative of conductance – conductivity times thickness.

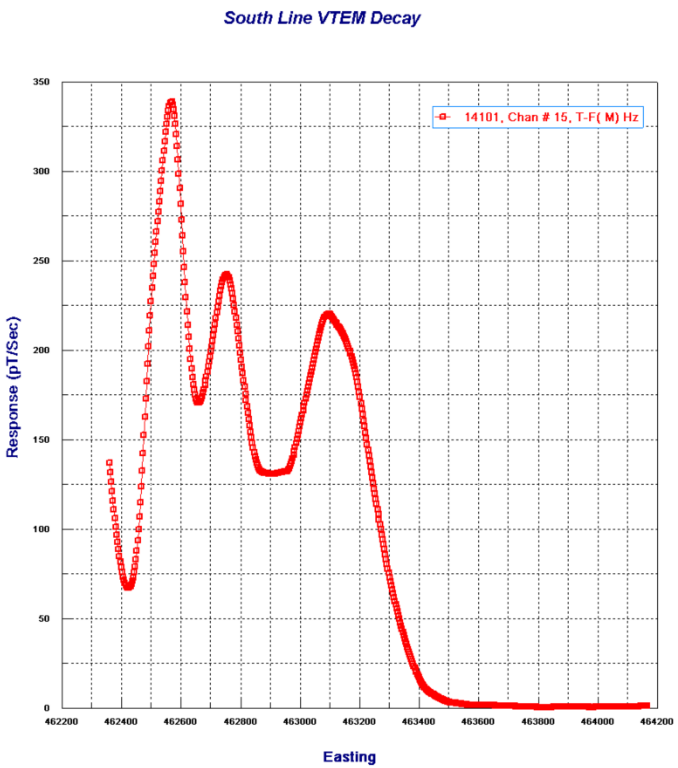


Figure 11: Channel 15 late mid-time), along L14101. Note: Most westerly peak no longer appears but the central anomaly is now evident.

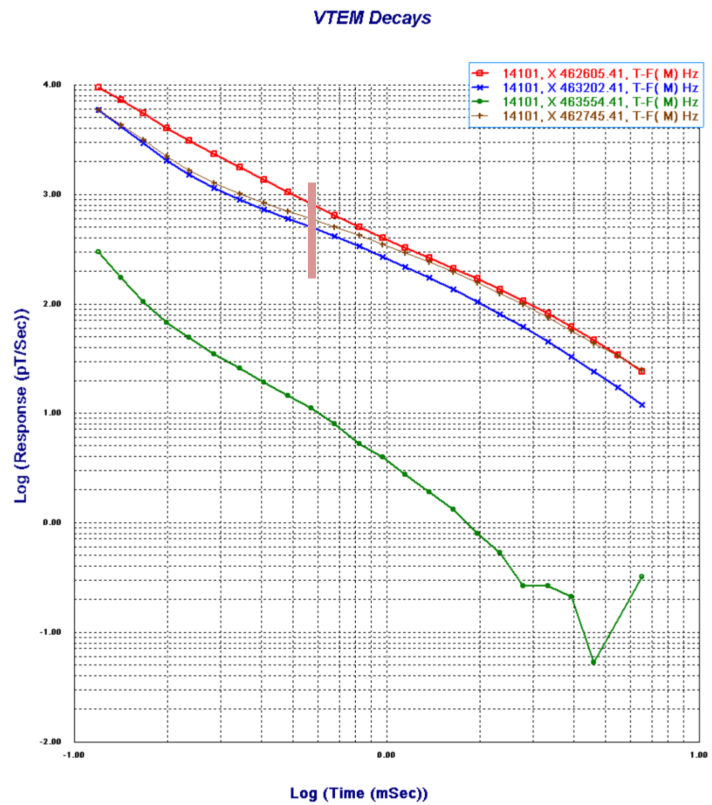


Figure 12: Response as function of time, at 4 locations.
Stations red and brown have very close amplitudes and decay rates at late time. Blue, while a little smaller in amplitude at late time has a very similar decay rate.

petroseikon

Time Domain Response – Roberts Lake anomaly focus

Finally, the very latest time response along this line. Apparently, the strongest conductances are in the central area. The westerly anomaly migrates slightly westward with time as does the eastern anomaly. The central anomaly is quite stationary until very late time when it migrates slightly to the east.

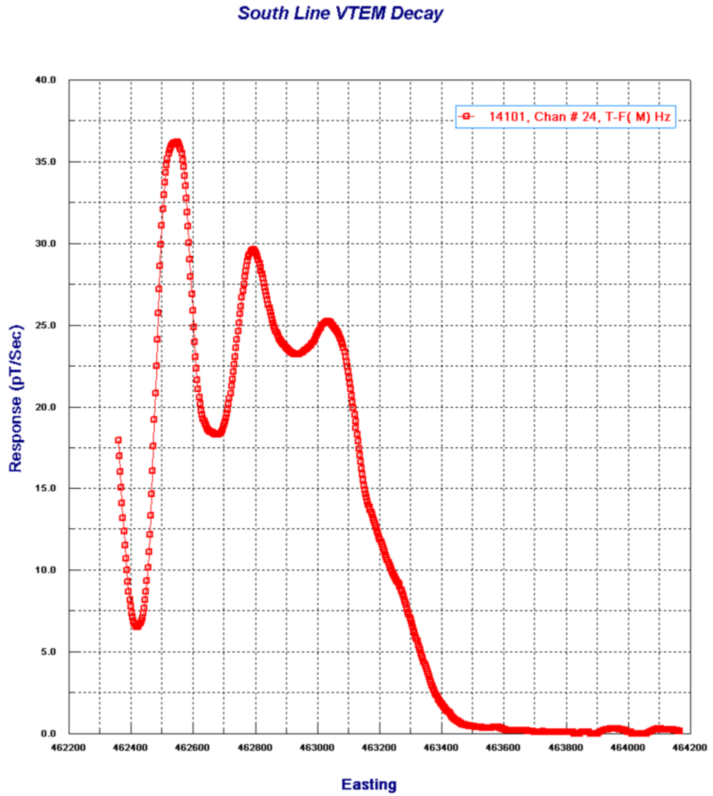


Figure 15: Channel 24 late time resposne L14101.
3 peaks all of very comparable amplitude.

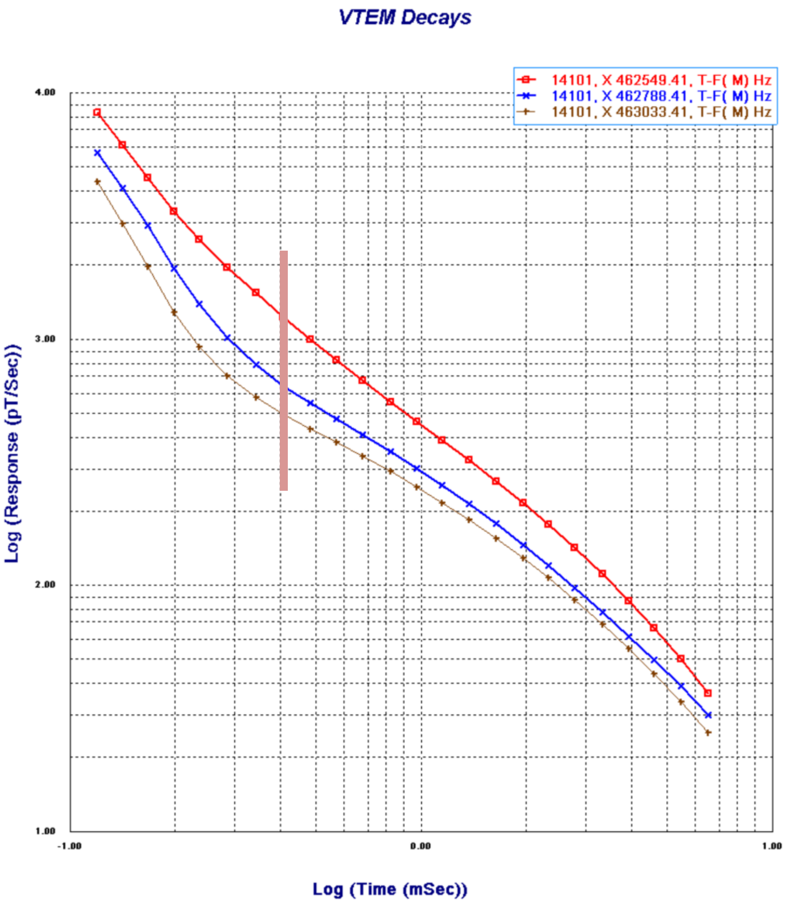
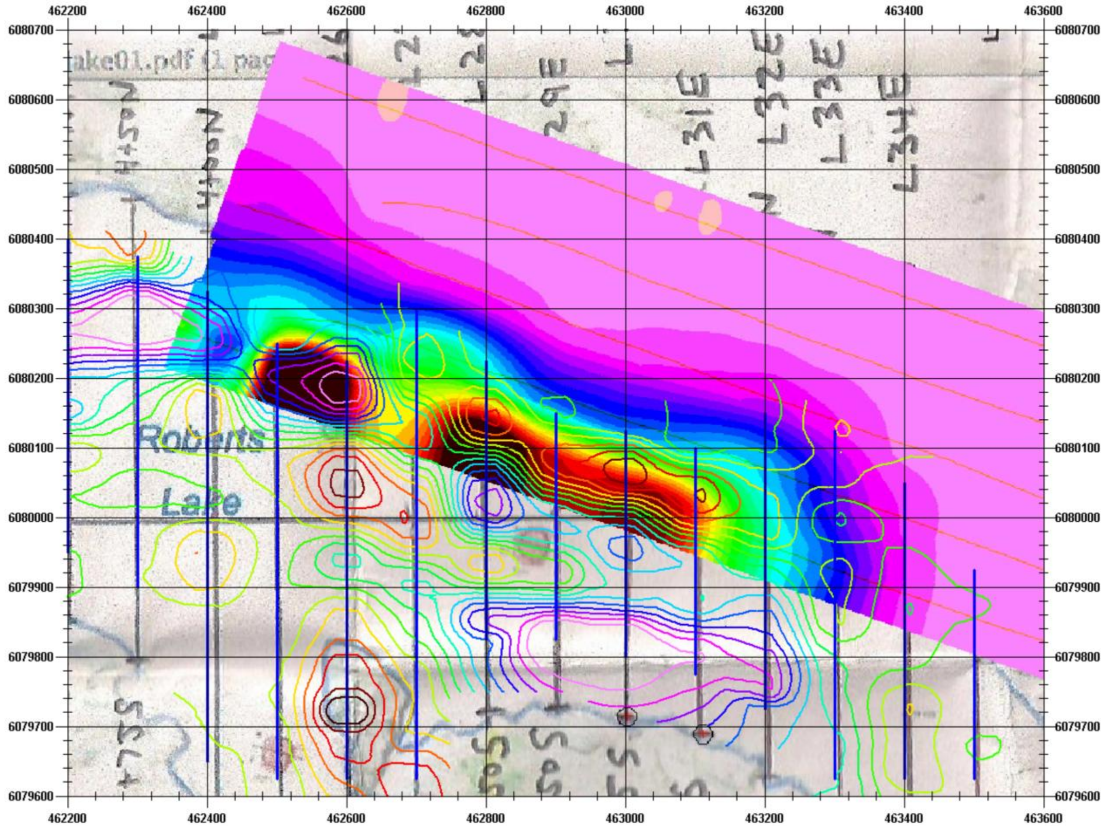


Figure 16: Decays at center of 3 peaks. Decay rates all very similar at late time. Western anomaly higher in amplitude probably due to enhanced early-time (shallow) response. While the western anomaly has the slowest decay at early time, the central and eastern anomalies have slow decays at late time.

Time Domain Response – Roberts Lake anomaly focus

Comparison to MaxMin anomalies:

The MaxMin data as collected would not be able to differentiate shallow and deep conductors. This would have required data to be collected at least at 2 separations. However, it may be instructive to compare the locations of the MaxMin anomalies with the VTEM anomalies.



MaxMin survey lines are shown in blue. VTEM flight lines are shown in orange.

The 3 main VTEM anomalies are indicated by the MaxMin. Positioning displacements are generally consistenet with the differences in survey lines and flight lines.

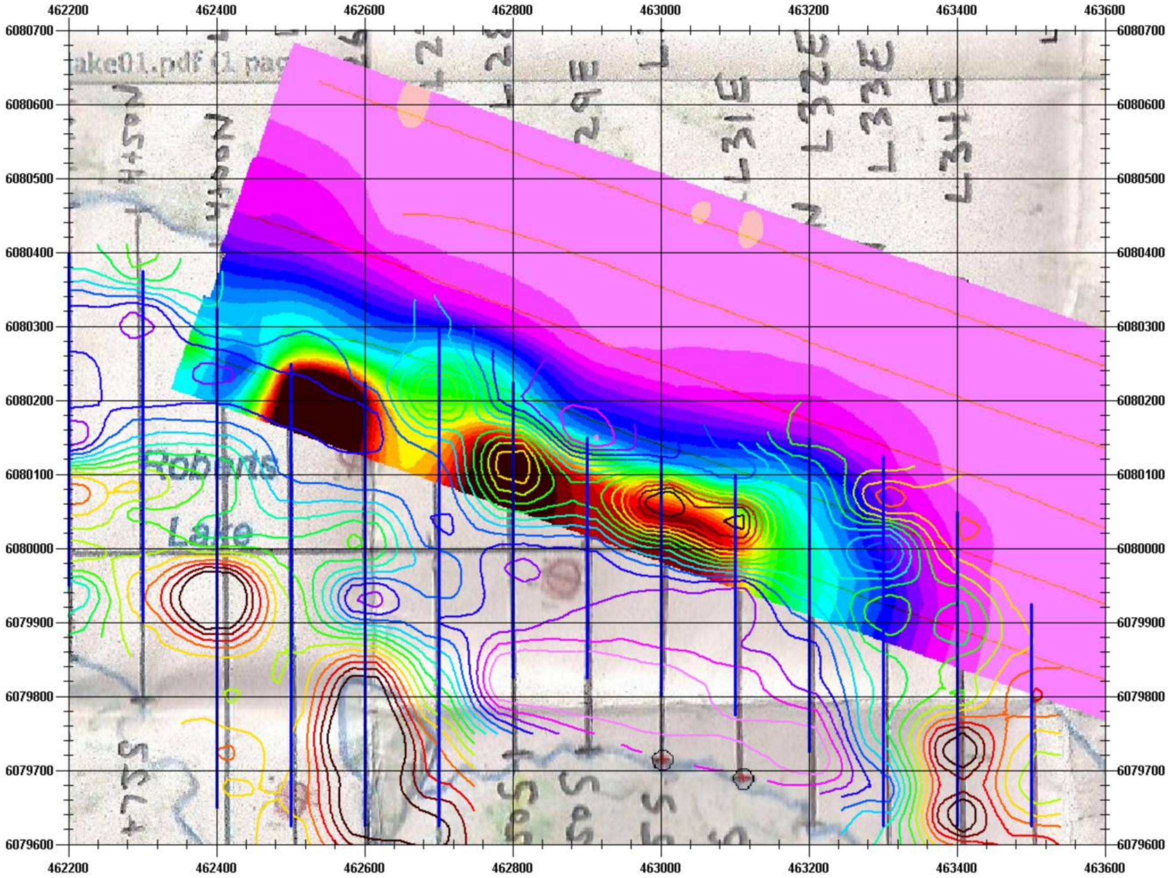
Resolution of the northern extensions of the targets are limited by the limitation of the northern extent of the MaxMin survey lines.

Figure 17: Comparison of VTEM to MaxMin: The late-time VTEM (Ch24) is underlain as filled contours with the InPhase 880Hz MaxMin overlain as unfilled contours.

Time Domain Response – Roberts Lake anomaly focus

Comparison to MaxMin anomalies:

The MaxMin identification of the targets is strongest in the lowest frequency (880Hz). However, the higher frequency reponse (3520Hz) is now more understandable. Below, we show the late time VTEM underlain against the InPhase 3520Hz MaxMin response.



MaxMin survey lines are shown in blue. VTEM flight lines are shown in orange.

The westerly anomaly is not strongly identified by this MaxMin response indicating likely a deeper target.

The central anomaly is now positioned slightly more south that in the low frequency response which may indicate the 2 targets – one shallow and one deep.

Similarly, the MaxMin anomaly at this frequency for the eastern target is also slightly further south than for the low frequency response.

Figure 18: Comparison of VTEM to MaxMin: The late-time VTEM (Ch24) is underlain as filled contours with the InPhase 2520Hz MaxMin overlain as unfilled contours.

Time Domain Response – Roberts Lake anomaly focus

Northern VTEM Flight Lines:

We will now examine the VTEM data along the flight lines north of the lake – L14103, 14104 and 14105

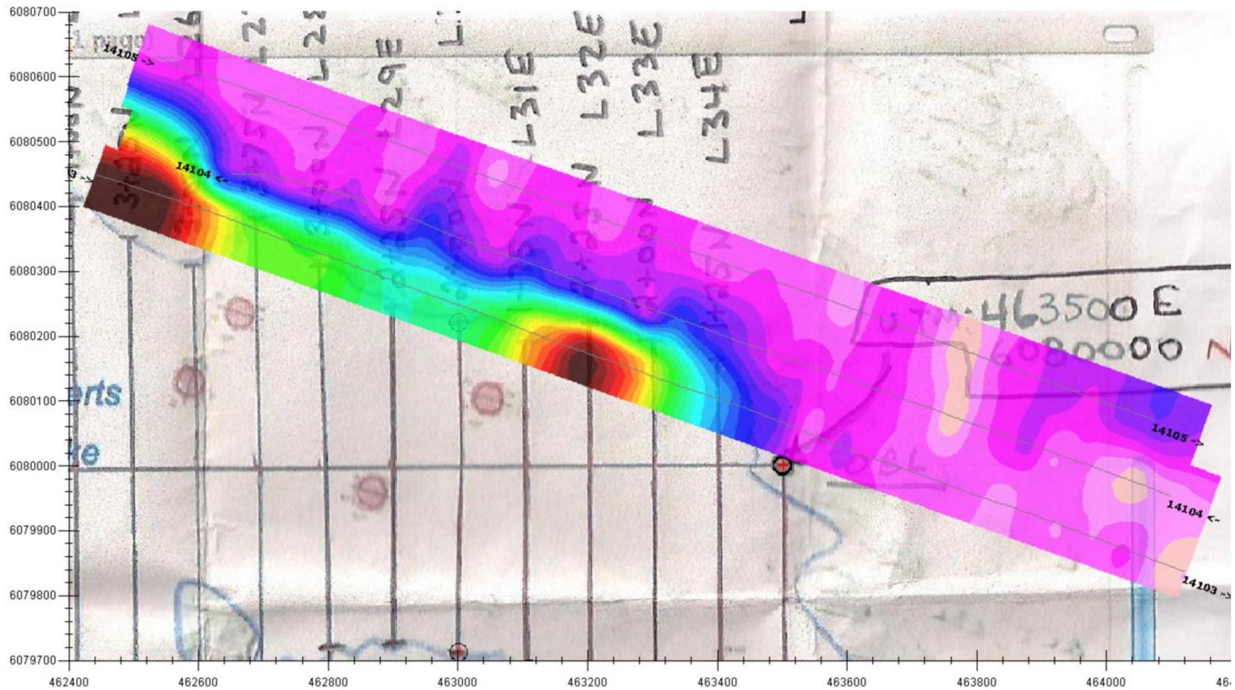


Figure 19: Late-time VTEM (Ch22) is underlain with lake boundaries. L14103 clips the lake in places but the other lines are entirely north of the large. The westerly anomaly is clearly seen north of the lake and the eastern anomaly hugs the lake shore. However, the green high extends across the lake shore in most of its extent.

Time Domain Response – Roberts Lake anomaly focus

Northern VTEM Flight Lines:

Finally, we will look for the characteristics late time decay of the deeper anomaly along the northern lines.

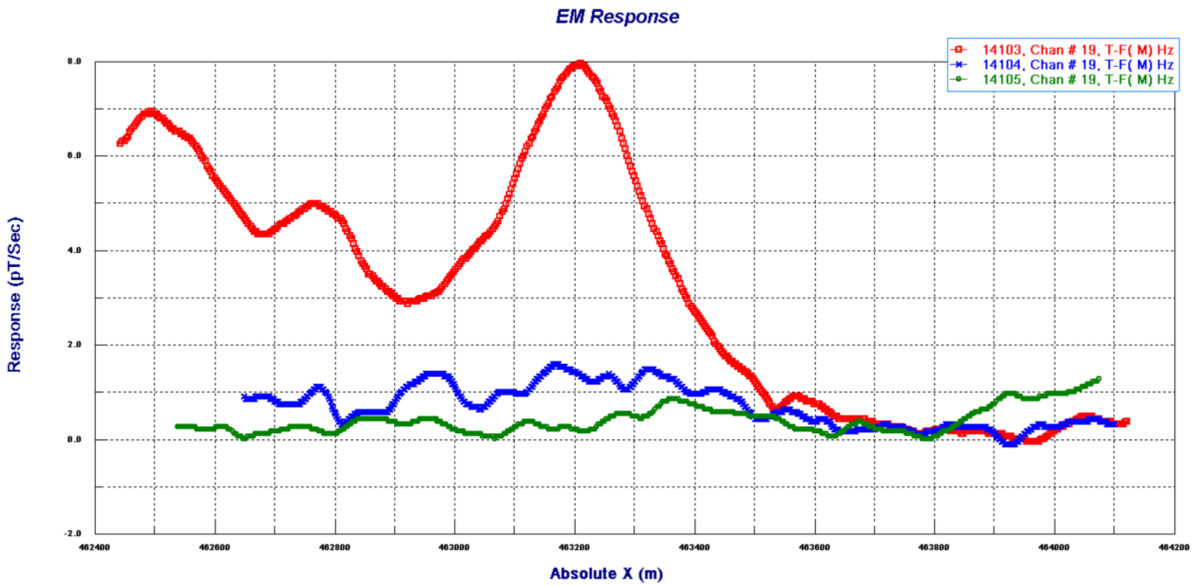


Figure 20: Late-time VTEM (Ch19) response plots along L14103, 14104 and 14105. The western, central and eastern anomalies can be seen clearly on L14103 which is partly over the lake and partly north of the lake. There is some indication of a high over the central and eastern anomalies on the next line north – L14104 but it is not clear.

Time Domain Response – Roberts Lake anomaly focus

Northern VTEM Flight Lines:

Finally, we will look for the characteristics late time decay of the deeper anomaly along the northern lines. The characteristic decay of the deeper targets can be seen in all 3 northern lines. The figure below shows examples on each of the 3 lines.

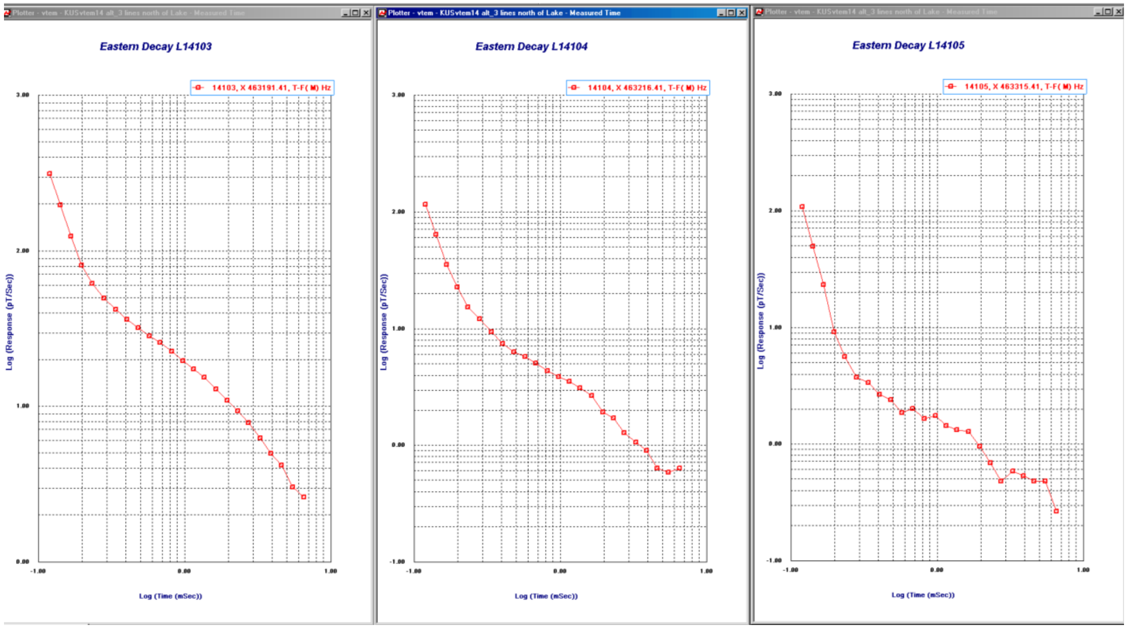


Figure 21: VTEM decays related to the eastern anomaly along Lines 14103, 14104 and 14105. The left figure is at X=463191 in the center of the eastern anomaly along L14103. The rapid early time decay is that of the host rock off the lake and then the very slow decay of a significant conductor can be seen. The middle figure is at 463216 on L14104. Again the strong conductor can be seen but the last 6-8 channels are very noisy. Finally, for L14105, the decay at X=463315 is shown. The conductor is not seen until later in time (deeper) and now the last 10-14 channels are noisy but it seems clear the conductor can still be observerd.

Examination of VTEM Responses through Geophysical Modeling

While it is evident that there is 2 conductors over the north end of Roberts and likely underneath the north side of the lake, the question that first needs to be determined is whether the shallow conductor is mineralization in the underlying rocks or is due to sediments on the bottom of the lake. It is common for lake bottoms to have a weak conductive response and as I am not familiar with the nature of the lakes in northern Manitoba, I wanted to examine the possibility of the conductivity of the lakes sediments as well as the cover material outside the lake. This is helped somewhat by having the MaxMin data. In the case of the MaxMin data, the best estimator of the conductance of cover or lake sediments comes from the higher frequency (3.5Khz) quadrature (out-of-phase) data. Our previous work on the MaxMin data estimated the conductance of the lake bottom to be no more than 0.3 Siemens or in other terms 3 metres of 10 ohm-m material.

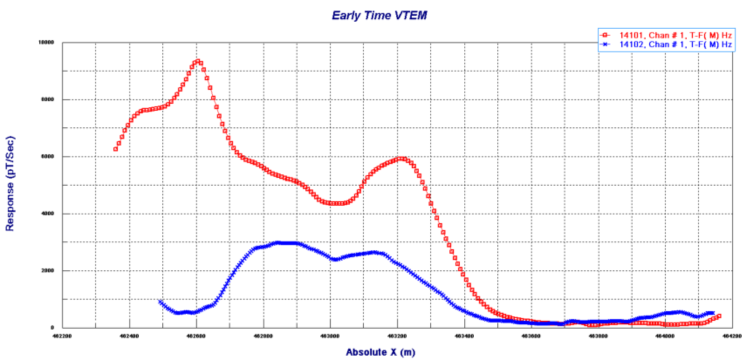


Figure 23: VTEM early time response on the 2 southern lines.

In figure 23, we see that the anomalous high response is not limited by the smaller (west,central,east) anomalies but there is an overall high which is somewhat bounded by the lake edges.

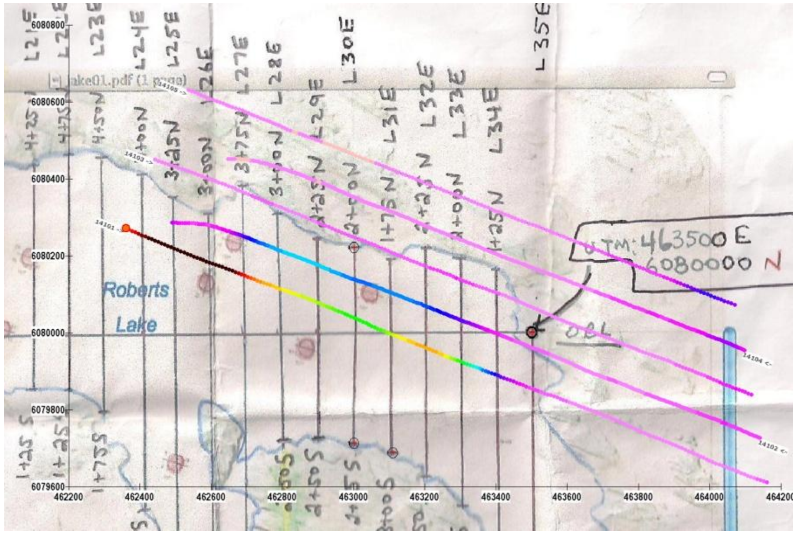


Figure 24: VTEM flight lines.

The early timer responses at for example 463000 east could be explained by conducting sediments. However, the conductance would have to about 1.2 Siemans. This conductance when applied to the MaxMin data produces a quadrature response at 3.5Khz which is on average 4 times too large. Utilizing the model for the lake bottom effect on the east end of the lines where the amplitude drops produces a simulated response very comparable to the data. Preliminary analyses would conclude that the cover material outside the lake was slightly less conductive than the lake bottom materials.

Examination of VTEM Responses through Geophysical Modeling

The early time response along the west side of the 2 southern flight lines agrees with the MaxMin model for this area. This is both in strike length, depth extent and conductance. This does not include in increased responses around what we have called the west, central and eastern anomalies.   Importantly, our analyses would include there is mineralization along a significant strike length with portions of somewhat higher conductances.

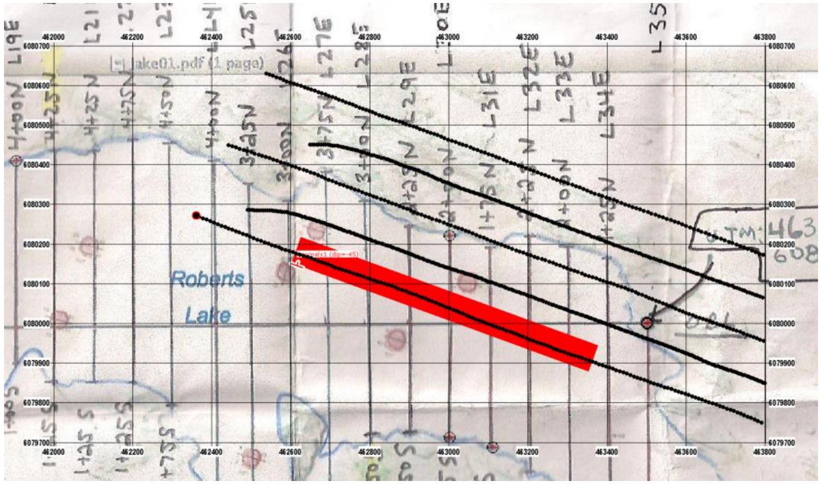


Figure 25: Shallow conductor

Shallow conductor: Strike length: 800m, Dip extent: 100m, Dip: 45 degrees, Strike : 20 degrees – SE, Conductance: 6 S, depth to top: 4m

The strike angle is approximate and agrees with the MaxMin. The other MaxMin anomaly was more EW and was off to the west of the VTEM survey with some overlap. Both dip angle and dip extent are approximate as the VTEM equipment does not provide high resolution of these factors. The conductance is quite weak but real.

Examination of VTEM Responses through Geophysical Modeling

An approximate model of the deeper conductor is shown below. From geophysical simulation modeling, this anomaly would not be detected by the MaxMin survey that was performed. A larger separation would have had to be used in order to detect this target. This is much more steeply dipping and much, much more conductive than the shallow target. Again, it is not uniform in conductance and the east, west and central anomalies are increased material within this approximate structure.

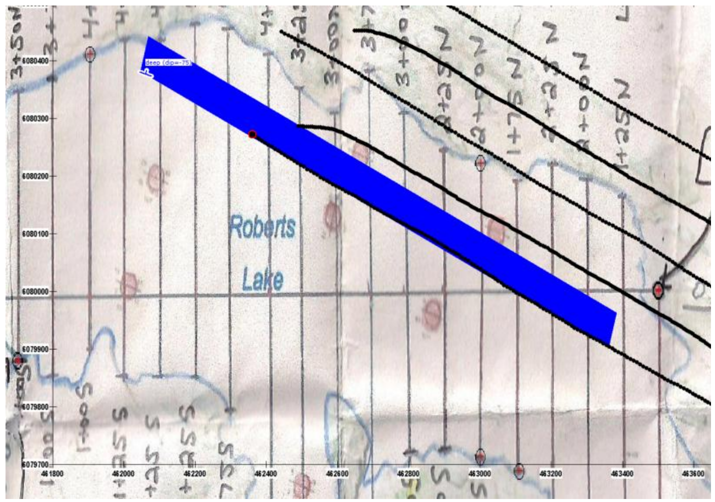


Figure 26: Deep, strong conductor

Deep conductor: Strike length: 1400m, Dip extent: 250m, Dip: 75 degrees, Strike : 20 degrees – SE, Conductance: 100S
Depth to Top: 120m

The VTEM system is such that it has limited resolution regarding dip extent. With this model, at its furthest depth extent it is about 350m below surface which is stretching the depth resolution of this system.

Summary, Conclusions and Recommendations

The 2007 time domain, electromagnetic, VTEM data detects 2 large conductors consistent with the MaxMin conductor in the NE of the MaxMin survey. There are local increased highs in these conductors and these highs are somewhat consistent with the Spectrem EM picks of the 1990's. These VTEM conductors are also consistent with the ground and airborne magnetics.

However, there are definitely 2 different conductors, one shallow and weak and other much stronger and deeper. The MaxMin data likely only detects the shallow target and the magnetics may well only respond to the shallow material.

Generally, the strike is known and we have some estimate of the dip of the deeper structure.

With the possibility of drilling the deeper target, we would recommend a ground TEM survey. We would recommend what is called a fixed loop TEM survey with a survey transmitter loop of approx. 600m x 600m centred in the middle of the lake and angled slightly to the NE. The survey lines would then be carried out along a heading of 20 degrees east of north. The survey lines would be approximately 600m in length with approximately 12 lines at a station spacing of 50m. In addition, we would recommend 3 much smaller higher resolution surveys over at least 1 of the high concentration west, central and east anomalies. This survey would have to be accomplished in winter.

However, a smaller survey could be done in non-winter conditions which should resolve better the deeper conductor. This survey would be carried out entirely on the north shore of the lake within the Strider claim.