Mapping lake sediments and objects

Description of problem

Prior to the construction of bridges, pipes etc. in lake environments it is important to have some knowledge of the lake geology. This is also true concerning environmental investigations, where the amount of bottom sediments can be most critical. In this specific case the customer wanted to know the extent of sediments, together with information of dumped objects in parts of the lake. The measurements are done in a lake with fresh water and low conductivity.

Equipment used

The radar equipment comprised a RAMAC X3M control unit with a shielded 250 MHz antenna and the RAMAC Monitor XV11 for data collection. The 250 MHz antenna was used as the depth penetration needed to be at least
10 m. The radar system was complemented with a GPS with differential correction; 10 Hz update rate and NMEA communication protocol.

Investigation method

The complete lake was to be covered, to enable an estimation of the amount of sediments and to map the different objects. Distance between measurement lines was kept around 10 to 15 m.

To keep track of where the measurements had been done the GPR system was connected to a GPS and the whole setup was placed in a plastic boat, with the GPR antenna on the bottom. This set up gave a position (x- and y-coordinate) for each trace measured.

Of course the measurements can also be done during the winter season, from the lake ice.

During measurement a simple handheld GPS was used in order to give an immediate map of the boat track.

Measurement settings

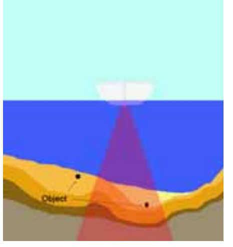
As the purpose of the investigation was to map the extent of sediments, and the depth was unknown, the system settings are aiming at deep penetration. The following settings were used:

Time window: Long, to reach as deep as possible, 1024 samples
Stacks: Auto
Sampling frequency: 2200 MHz
Velocity: 33 m/µs for water, 33 m/µs for sediments (very loose) and 90 m/µs for firm bottom.
Trigger: Time, 0.1 or 0.2 seconds between measurements.

Critical elements

The boat needs to have a single hull, as double layers can create a ringing and disturb the depth penetration. This is also valid for measurements on lake ice, where a layered ice-water structure can create problems. The quality of the lake water has to be satisfying concerning the amount of dissolved solids and conductivity.

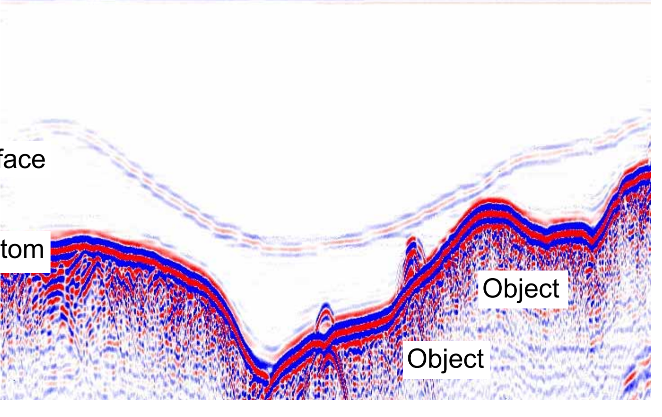
The distance between the measurement lines has to be set according to the purpose of the investigation. If, as in this case, objects are to be mapped, the distance between the measurement lines are correlated to the depth of the lake. As seen in the picture at right, the line spacing has to be decreased if the lake is shallow, and can be increased if the lake is deep.



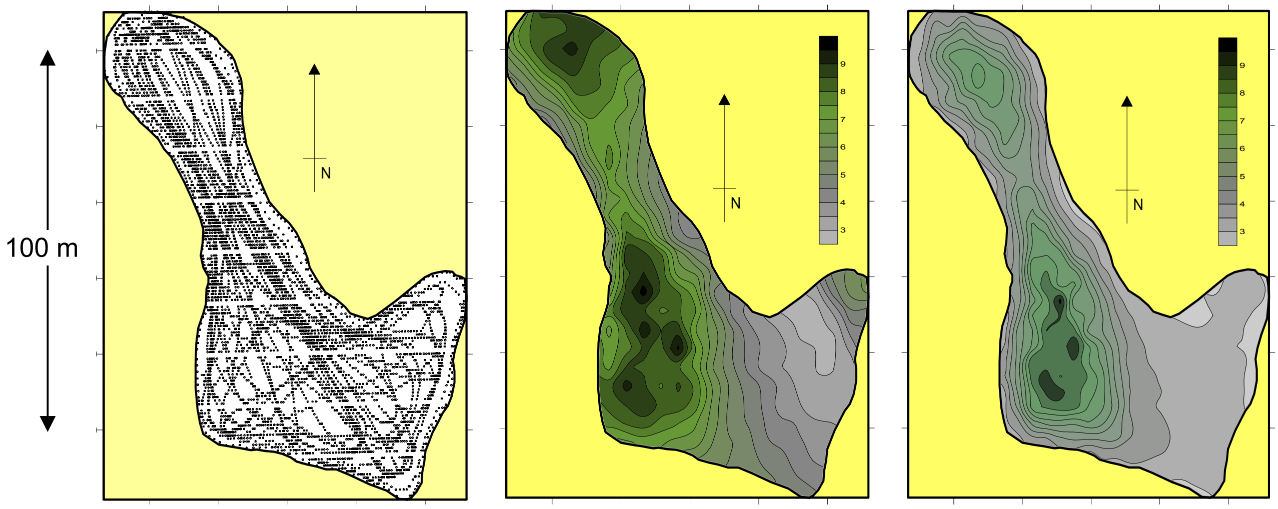
It should also be noticed that the antenna footprint in water is smaller than in other geological medias.

Results

The achieved radar data was processed and interpreted in ReflexWin, where also the coordinate data can be linked to the trace number. Processing comprised DC-shift, gain and bandpass filtering. The two different layers, sediment surface and firm lake bottom, were identified. From this interpretation the two thicknesses together with the position were saved in ASCII-files. The information was then used to create surface maps of the lake configuration. Observe that the coordinates delivered from the GPS equipment and stored in the RAMAC *.cor file is given in latitude and longitude. Therefore the coordinates need to be transformed to a rectangular grid like e.g. UTM. In the actual case we used the Swedish Grid RT90. The radargram below shows one example of the data achieved, with two clear objects together with the sediment surface and the firm till bottom.



The following pictures, created with Surfer, represent the track measured together with two maps of the different identified depths. In the middle the depth to the firm bottom is shown (in m) and to the right the depth from lake surface to sediment surface. The colour scale represents a depth range from 2 m (gray) to 11 m (black). These two can then be used to calculate the thickness and amount of the sediment.



Measured GPR profile | Depth to firm bottom | Depth to sediment surface

Conclusions

In a quite fast manner the lake could be covered with GPR measurements, freely measured as position was logged with a DGPS system. The information of the different layers could be transformed to easily understandable surface maps of the different thickness. The objects looked for could also in a similar way be placed on a map.

The chosen equipment, together with the investigation method used did solve the customer’s problem. The presented lake was approximately 100 times 120 metres and it took ca 8 hours (including mobilisation, set up and demobilisation) to measure the whole lake. The maximum speed of investigation was kept around 2-3 knots. So depending on the purpose of the work approximately 2 to 20 ha / day can be covered.

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