TDEM – Delineation of groundwater salinity

TDEM is a high precision method for mapping the interface or the transition zones in between fresh and saline groundwater

Saltwater intrusion deteriorating our water resources is a global problem and lack of sub-surface information often the critical aspect finding a sustainable solution forward.

Time Domain ElectroMagnetic method (TDEM) is the most effective and efficient tool to map the interaction in between fresh and saline groundwater.

The method benefits from the fact that saline sediments are very conductive and create a distinct contrast to the more resistive geological layers containing fresh water.

Since the early 90's, where Ramboll acquired the first TDEM instrument, we have been among the global pioneers when it comes to applying ground based TDEM soundings for large scale subsurface mapping.

During the last 20 years the accuracy of the instruments has improved significantly and the ability to obtain information on aquifers and hydrogeological properties is now the most efficient technology on the market.

The last 10 years airborne TDEM systems have been introduced. With the airborne systems the ability to survey large areas and coastal zones has been significantly improved. Using modern technology the depth to the saline water can often be detected with less than 5% uncertainty.

Ground based TDEM systems can be configured to achieve a depth of investigation to more than 1 km, and can be used to ensure the validity of the TDEM in an area before a large scale airborne survey.

Time laps

All water utilities takes samples and monitor the changes in chlorine content as it is a vital water quality parameter. However, the information is only a snapshot captured when the water sample was taken at the location of filter intake. In contrary, a TDEM survey will provide a 3D picture of the equilibrium in between the fresh and the saline water.

In addition, revisiting specific areas of interest with TDEM changes of the interface between fresh and saline water can be determined which enable the utility and water authorities to forecast and plan the water abstraction strategy in a sustainable way.

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Strength:

- **Depth of investigation: Up to 1km depending on geology, background noise and system setup**
- **Approximate resolution: A conductive layer like saline water can typically be mapped within a 5% of accuracy**
- **Field production per day: A ground based field crew of two experienced persons can do up to 3 to 4 km of profile per day. Though the productivity will be very depended on the terrain conditions and the configuration of the system. Airborne systems can collect 200 line km or more on a single day.**

Weaknesses:

- **Man-made installations will add noise to the TDEM measurements. Typically a minimum distance of 100-200 m to an installation is required to achieve reliable measurements.**

Salt-Fresh Water Transition Zones

The division in between fresh and saline water is characterized as the transition zone where the salinity gradually increases with depth. The TDEM method is also able to discriminate between levels of different salt content as seen in a transition zone.

Groundwater modelling

As the TDEM method produces very accurate estimations of the depth to the saline water the results are often being used as fundamental information to establish and calibrate numerical ground water models.

Contamination plumes

Landfills or other point sources often produce a contaminated plume in the aquifer. In many cases the pollution has an increased content of chloride components which makes the plume conductive. Hence the TDEM method can be applied to delineate such a plume, providing valuable information to the authorities and decision makers.

TDEM key benefits

Fresh groundwater is a scarce resource - especially in the often very developed areas along the coast lines. Monitoring and management strategies to limit or prevent saltwater intrusion as a result of increasing demands on coastal groundwater resources requires reliable information about the geologic structure and hydrologic state of an aquifer system.

TDEM provide such an efficient and quantitative tool for

evaluating ground water resources:

- at fairly high vertical resolution
- to a depth down to several hundred meters
- on both local and regional scales.

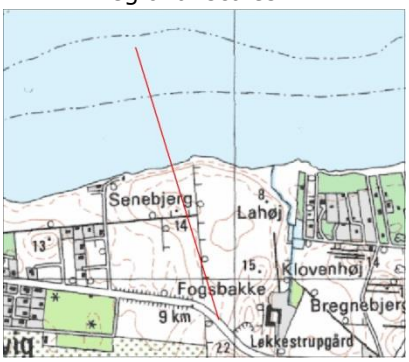

Figure 2 Profile shown from North to South on Figure 2.

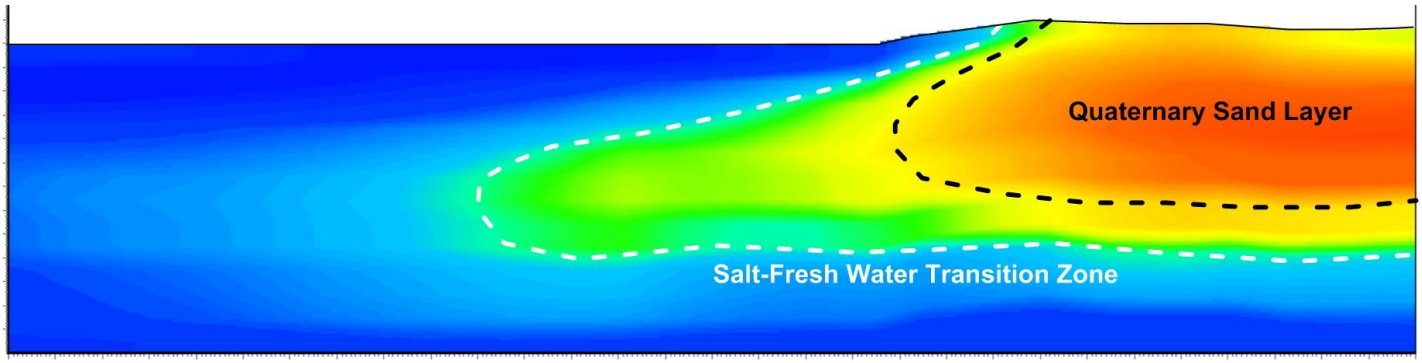

Figure 1 Conductivity profile along the profile shown on figure 1. Saline water/groundwater is characterized with high conductivity (blue colors) and quaternary sand layer with low conductivity (red colors). 2D profile extracted from 3D simulation model based on TDEM data.