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# GEOPHYSICAL INVESTIGATION AND WELL LOGGING AT MSW LANDFILL

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## Background and introduction

Ordinary groundwater monitoring at the closed Stavröd landfill near Hörby in central Scania, Southern Sweden, revealed elevated values of electrical conductivity (EC), TOC (total organic carbon) and other parameters in two wells at the end of year 2009 and in 2010. With 12 measurements a year, during 2000-2008, EC values ranged from 20-100 mS/m, but during October 2009 and February 2010 values of 400-500 mS/m were detected. The wells were drilled more than 20 years ago and, through subsequent expansion of the landfill, are situated close to the southern flank of the landfill body, presumably downstream. In order to investigate potential spatial impact of leachate emissions on groundwater downstream the wells and to investigate the depth of potential leachate leakage, the operator (Merab) commissioned a geophysical survey in connection with logging of the potentially affected wells.

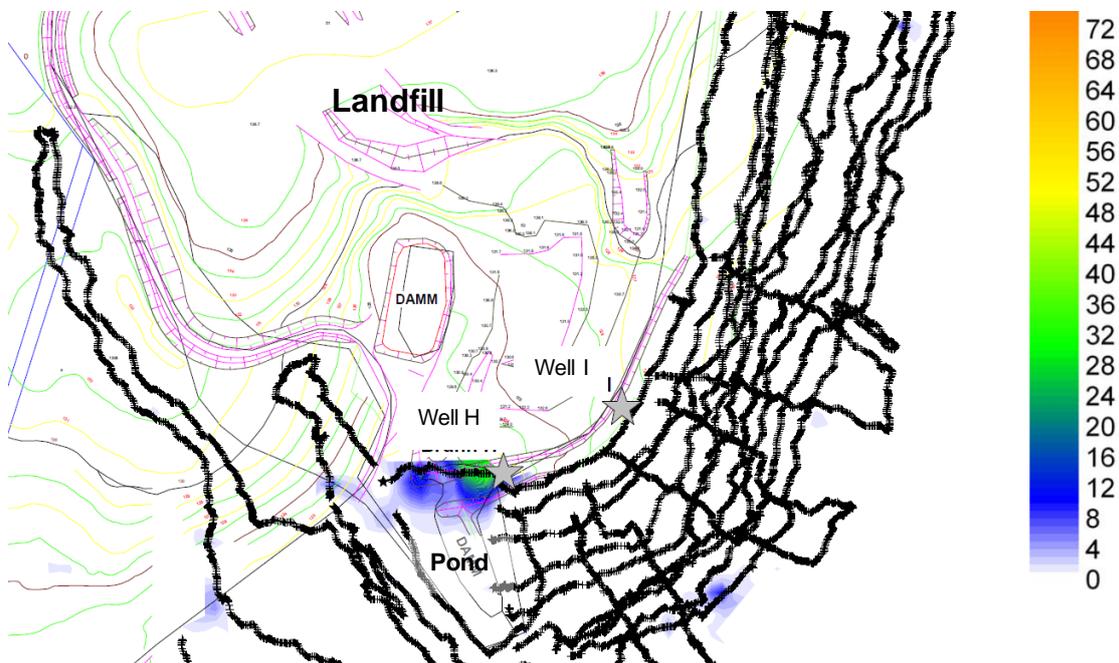
## Methods and Material

The area south and southeast of the landfill was surveyed with a multi-frequency electromagnetic sensor (GEM 162 instrument by *Geophex*, so called "stångslingram" or FDEM) at 1025, 5025, 10025, 35075 and 47975 Hz. The instrument is carried and moved by foot along the vectors to be investigated. No installation of electrodes is required. A primary wave is emitted and a secondary wave collected by GEM 162. The real and imaginary part of the magnetic wave is compiled via inversion (*EM Invertor!*). New data was produced at less than every 1 meter of distance covered. A total of 22 100 measurements was conducted per frequency through 21 transects of varying length (see figure 1). Values of apparent conductivity at data points were interpolated through kriging (*Surfer 8* software) and plotted for each frequency separately (see figure 1). The vertical resolution and possibility of depth determination of detected anomalies is less potent with the GEM 162 compared to, for example, Continuous Vertical Electrical Sounding (CVES), but was considered sufficient for this initial investigation.

The observation wells in question (denoted H and I, figure 1) are lined with an iron casting from the surface through a ca 6 and ca 8 m thick layer of moraine down to the solid, fractured rock at a further ca 14 and ca 18 meter, respectively. EC and temperature were measured and logged continuously while lowering the multi-probe of an *AquaRead* instrument into the wells down to a depth of ca 10 m from the edge of the liner (maximum cable length). Afterwards, the wells were purged (ca 320 and 300 l corresponding to 2 well volumes, respectively) and allowed to refill. The wells were subsequently sampled slowly (0.2 l min<sup>-1</sup> with a peristaltic pump) at different depth intervals of 1-2 m, starting at the bottom of the wells. The parameters EC, temperature, oxygen (O<sub>2</sub>), pH and turbidity were analysed at each depth interval with the same instrument as above with the aid of a flow cell at the surface.

## Results and Discussion

Results from well logging revealed anomalies at 6-8 m depth for temperature, oxygen and (partly) EC for well H and, to a lesser extent, for well I. This indicates that leachate or leachate affected groundwater might intrude at this level, which corresponds to the level at which the iron liner is inserted into the rock. Relatively higher EC values were calculated for all frequencies in the vicinity and southwest of well H. This area is, however, closely situated to the lower leachate pond, as well. Thus, with the technique applied here, the results do indicate a potential, albeit presumably horizontally and vertically restricted impact of leachate emissions on groundwater. In order to verify the results and to reveal the possible source of the suspected leachate leakage, a geophysical survey with better depth resolution, for example, CVES, is recommended.



**Figure 1.** Kriging results from geophysical survey at 5025 Hz (approx. measuring depth 0-10 m determined by skin depth, see Reynolds 1997 and Huang 2005), legend shows EC equivalents (mS/m) relative to background value of zero; black stars indicate sample locations determined by GPS.

## References

- Reynolds, J.M., 1997: An Introduction to Applied and Environmental Geophysics. John Wiley & Sons Ltd., 796 pp.
- Huang, H., 2005. Depth of investigation for small broadband electromagnetic sensors. *Geophysics*, 70, 6, 135–142.