EM SURVEY
SOUTH BAY RECLAMATION PROJECT
SOUTH BAY, ONTARIO

PREPARED FOR:
BOOJUM RESEARCH LIMITED

PREPARED BY
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MISSISSAUGA
ONTARIO

APRIL, 1992

1.0 INTRODUCTION

A geophysical survey was carried out in March, 1992 in the vicinity of Town of South Bay, Ontario. The purpose of the survey was to detect the presence of contaminants and abandoned structures at the South Bay mine site. The work was authorized by M. Kahn of Boojum Research Limited.

2.0 SURVEY DESCRIPTION

2.1 General

In its natural (uncontaminated) state, ground water acts as a relatively poor electrical conductor. However, the presence of inorganic contaminants in the ground water can increase the ground water electrical conductivity and thus the electrical conductivity of the saturated soil.

Generally, ground conductivity depends principally on (McNeill, 1987):

- soil structure (coarser structure and smaller porosity producing lower conductivity)
- clay content (increasing clay fraction) producing higher conductivity
- soil moisture content (increasing moisture producing higher conductivity)
- conductivity of included pore water.

The conductivity of a water (electrolyte) is proportional both to the total number of ions in the solution and their mobility. The mobility is different for different ions since it depends on their diameter. Values for some common ions are given in table 1.

Table 1. Mobility of common ions at 25°C (after Keller and Frischknecht, 1966)

Ion	Mobility (m^2/sec V)
H^+	36.2 x 10”
OH^-	20.5 x 10”
SO,	8.3 x 10^{-8}
Na’	5.2 x 10”
Cl^-	7.9 x 10”
K^+	7.6 x 10”
NO,	7.4 x 10^{-8}
Li^+	4.0 x 10”
HCO,	4.6 x 10”

It has been shown that for average unconsolidated soil, an increase of approximately 25 ppm of total dissolved solids (TDS) of sodium chloride (NaCl) to soil water will increase the saturated bulk soil conductivity by 1 mS/m (McNeill, 1987).

In order to best delineate the extent of contamination, a method that can resolve relative changes in the subsoil conductivity caused by increases/decreases in the concentration of contaminant in terms of total dissolved solids can be employed. For this reason a Fixed Frequency Electromagnetic (EM) Profiling technique were employed for this survey. The basic principles of the technique are briefly outlined below.

2.2 Fixed Freauencv EM Profiling

In the EM method, eddy current flow is induced in the ground by a time varying magnetic field of a vertical or horizontal magnetic transmitter dipole operating at a fixed frequency. This eddy current flow induces a secondary magnetic field which, together with the primary field, is sensed by a similar receiver dipole. The ratio of the primary field and secondary fields is related to the conductivity of the subsurface.

The instrument configuration, frequency and coil separation, are selected so that operation can be described by the low induction number approximation (range in which the true conductivity is linearly proportional to the apparent conductivity indicated by the instrument, McNeill, 1980) over a relatively large range of terrain conductivities. In this sense, each induced eddy current loop is independent of the others and the measured signal can be thought of as a linear superposition of the responses of strata within the exploration range of the array used. The effective exploration depth of the EM equipment can be varied by changing one or more of loop spacing, loop orientation (vertical or horizontal), or height above the ground. Figure 3.1 shows relative responses for vertical and horizontal dipoles (where z is the depth normalized by intercoil spacing s).

Frequency domain EM profiling can also be used for down-hole geophysical investigations. In this case the tool is lowered down a drill hole. Then, with properly selected parameters of the arrangement (such as, the tool length, frequency, etc.), the measurements will be referred to the conductivity of the subsurface in the vicinity of the plastic-cased (or open) borehole. The instrument is essentially insensitive to borehole fluid conductivity. This technique is used in the case when the detailed monitoring of the vertical distribution of the formation conductivity is required.

2.3 Instrumentation

The Fixed Frequency EM measurements were carried out using Geonics EM31-DL and EM34-3 terrain conductivity meters.

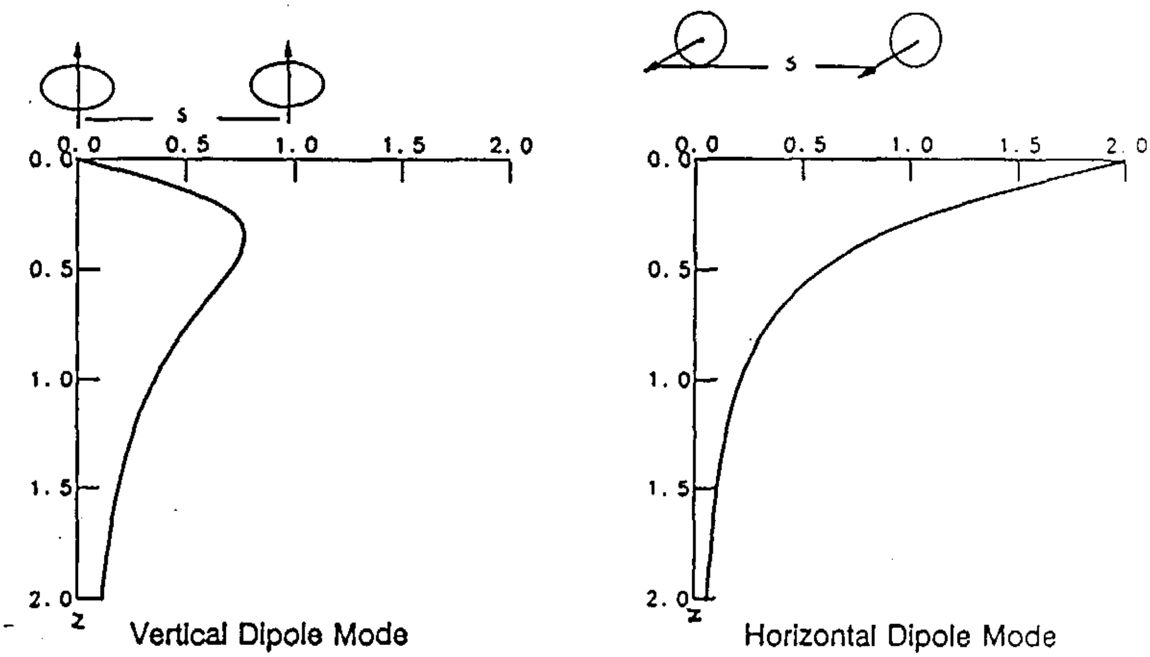

Figure 3.1 Relative responses for vertical and horizontal dipoles.

The measurements with EM31-DL were taken with vertically oriented magnetic dipoles at hip level. The instrument in this configuration has a depth of penetration up to 6 m. The distance between the measurement points along the survey lines varied from 1 to 2 m.

The approximate exploration depths for EM34-3 instrument at various intercoil spacing are given in Table 2. The relative contribution from material at different depths to the conductivity indicated by the instrument meter is discussed in detail in literature (McNeill, 1980).

Table 2. Approximate Exploration Depths for EM34-3 at various intercoil spacings.

Intercoil Spacing (meters)	Exploration Depth (meters)	
	Horizontal Dipoles	Vertical Dipoles
10	7.5	15
20	15	30

The measurements with EM34-3 were taken at a distance of 10 m along survey lines. The intercoil spacing for the horizontal dipole mode was 10 and 20 m, while for the vertical mode it was 20 m.

It should be understood that there are other factors, besides the presence of contaminants, which can affect conductivity of the subsurface. The major ones are lithology and water content. Factors affecting the soil conductivity were discussed above, and they are described in detail in literature (McNeill 1980, and 1987). Those factors were taken into account in the description of the survey results.

3.0 LOGISTICS

The survey was carried out by a two man crew. Both the crew and equipment were mobilized from Mississauga to Town of Ear Falls by air. Local commercial facilities were used to accommodate the crew. The crew travelled daily to the mine site by truck.

Three grids were surveyed in six days. Out of those, two days were spent for laying out the grids, one day for EM31 measurements, and three days for EM34 measurements. The presence of strong atmospheric noise and the weather conditions precluded the acquisition of EM34 data for all grids.

4.0 RESULTS

The results of the survey are present in the form of coloured maps for each reading and each grid. A number of areas of anomalous conductivity can be clearly seen on each grid. The analysis of readings to different exploration depth shows that the anomalous objects occur as a rule at shallow depths. The linear anomaly detected near Confederation Lake at the mine site presents an exception. The amplitude of the anomaly is the greatest in EM34 10H reading.

5.0. CONCLUSIONS AND RECOMMENDATIONS

A number of anomalies of increased conductivity were detected at all grids. The anomalies appear to be in agreement with available information regarding the distribution of contaminants and location of abandoned structures.

Regarding future studies, the following recommendations can be made:

Since many of the anomalies are produced by targets of small lateral extent, tighter survey grid can be strongly recommended. This would help to outline the extent of anomalies more accurately and clarify their nature.

The technique used is very efficient in mapping lateral variations in the subsurface conductivity. The use of a sounding technique can be recommended for delineating these variations in section view.

Many drill holes are available at the site. It will be beneficial to perform downhole geophysical measurements. This would allow for accurate determinations of lithology and ground water properties and provide valuable information for the analysis of surface data.

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Respectfully submitted
per
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Maps: 1A to 1C; 2A to 2C and 3A have no PDF formats in PDF report database. They are paper copy only, which is in Laurentian Library in Sudbury.