

ANNEX B - Soil Measurements

Two environmental parameters have been identified having particular relevance to metal detector performance; electrical conductivity and magnetic susceptibility of soil. It is also known that magnetic susceptibility of a soil affects metal detector performance more than its electrical conductivity. Ideally, one would want to measure these soil properties over the frequency range of operation of metal detectors. However, such instruments are not readily available for field use at this time. For this project an approximate but achievable readily approach was adopted, and the relevant parameters were measured using the readily available survey instruments listed the table.

Ground conductivity: Geonics EM38, a well-known instrument in geophysical applications.

Magnetic susceptibility: Bartington MS2 - a susceptibility meter routinely used to measure magnetic susceptibility in fields such as environmental magnetism, soil science and geophysics. An MS2 with a D-coil sensor, designed for in-situ measurements, was used to measure volume susceptibility of the test lanes.

LOCATION	Conductivity EM38 (horizontal) mS/m			Conductivity EM38 (vertical) mS/m			Susceptibility MS2 ($\times 10^{-5}$)		
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
TNO-FEL Test lanes									
Lane 1 – Sand	5.6 -10.4	3	4	10.7 6.9	8	1	9 1	3	2
Lane 2 – Clay	25.6 14.6	22	3	27.5 10.6	20	5	11 7	9	1
Lane 3 – Peat	28.4 17.9	23	3	26.5 10.5	18	6	24 11	16	3
Lane 4 – Ferruginous	3.3 -2.1	2	1	6.4 3.6	4	1	48 13	27	9
CROATIA									
Lane 1	18.9 0.4	12	4	12.5 -18.4	-7	5	264 3	140	63
Lane 2	25.3 -6.9	15	5	8.5 -19.8	-7	5	224 31	99	51
CAMBODIA									
Clay Lane	8.4 3.4	5	1	11.7 5	8	2	15 5	11	2
Laterite Lane	15.6 8	12	2	15.7 5.6	12	3	133 62	90	15

Soil conductivity and susceptibility measured on the IPPTC test locations.

For details of the measurement steps using these instruments, the approximations and errors involved, the reader should consult the relevant operational manuals [8, 9, 10].

At the Cambodia Field Test site, conductivity (mS/m) and susceptibility (MKS units) were measured every 1 meter along a straight line over the center of each of the two test lanes. Similar measurements were carried out over the soil lanes at TNO-FEL and over the Croatian test lanes. The mean values and their standard deviations are summarized in the table.

As seen from the table, the EM38 electrical conductivity is measured in two modes (vertical and horizontal). The horizontal mode is most sensitive at the surface and decreases with depth. The vertical mode is less sensitive to surface material (zero at the surface) and more sensitive at depth. The results for all the lanes are quite small (less than 24 mS/m) and are thought to have had no influence on detector performance.

Magnetic susceptibility varied significantly among the lanes – from a small value of 3 for the TNO-FEL sand lane to a value of 140 in the Croatian Lane 1. A value of the order of 140 will have an effect on metal detectors. The soils, listed in order of difficulty of detection of the targets for metal detectors, with most difficult soil first, are:

1. Croatia Lane 1
2. Croatia Lane 2
3. Cambodia Laterite Lane
4. TNO-FEL Lane 4 – Ferruginous
5. TNO-FEL Lane 3 – Peat
6. Cambodia Clay Lane
7. TNO-FEL Lane 2 – Clay
8. TNO-FEL Lane 1 – Sand