COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF SUPPLY AND SHIPPING.

MINERAL RESOURCES SURVEY.

REPORT No. 1944/18 .

- THE ELECTRICAL RESISTIVITIES OF WET SOILS -

By

C. H. ZELMAN

CANBERRA. 8th May, 1944.

1229. By Authority: L. F. JOHNSTON, Commonwealth Government Printer, Canberra.

DEPARTMENT OF SUPPLY AND SHIPPING

MINERAL RESOURCES SURVEY

(Report No.1944/18)

- THE ELECTRICAL RESISTIVITIES OF WET SOILS -

By

C. H. ZELMAN

CANBERRA. 8th May, 1944.

REPORT ON THE ELECTRICAL RESISTIVITIES OF WET SOILS.

Report No.1944/18.

INTRODUCTION.

This report deals with an investigation of the electrical resistivities of a variety of wet surface soils, gravels and sands. The work may be regarded as preliminary to an investigation by Mr. R.F.Thyer into the detection of electrically resistive bodies buried in wet soils at shallow depths.

It was required to determine the range over which the resistivities of surface soils vary, also the changes that may be expected in any one type of soil between measurements made within say 1 foot of each other.

Owing to the dry weather conditions, it was difficult to find suitable areas of thoroughly saturated ground in the vicinity of Canberra. Measurements were made in four localities, three being in the bed or on the banks of the Molonglo River, where the surface materials are sand, gravels, silts, and in some places, clay. The fourth locality was near the head of Sullivan's Creek, where the soil is a heavy black clay.

METHOD AND INSTRUMENTS USED.

The resistivity measurements were made with a "Megger" earth tester, and the four electrodes were supported in a wooden frame somewhat like a rake. In his report, Mr.Thyer describes the apparatus in detail.

The electrodes were arranged in the Wenner configuration with a constant separation of 12 inches.

When calibrating a "Megger" earth tester a value is assumed for the external resistance in the potential circuit. In practice, however, the external resistance which arises from the vicinity of the contacts between the potential electrodes and the ground, generally differs from the assumed value, and a correction has to be applied to the measurements. In attempting to detect buried mines, however, in connection with which these tests were carried out, it would be impracticable to interrupt the procedure in order to calculate and apply corrections. Consequently one of the principal objects of these tests was to determine under what conditions the corrections can be neglected. In the accompanying plates, curves corresponding to both uncorrected (Pm) and corrected (Pc) "Megger" readings are shown for comparison.

NOTES ON THE TESTS.

(a) Scotts Crossing:

The first tests were made in saturated river sands and gravels in the Molonglo River near Scott's Crossing. The resistivities determined from the actual "Megger" readings (Pm) ranged from 9,760 to 18,960 ohm. cm. When corrected for the rather high resistances of the potential electrodes, the values (Pc) ranged from 10,036 to 21,600 ohm. cm.

Additional readings were taken with the electrodes in sands and gravels beneath 2 inches of water, and also with the electrodes in water about 3 inches deep. The resistivities were within the range measured for the saturated sands and gravels.

The readings were taken at random close to the water's edge and often between tussocks of reeds.

Hereunder are shown the resistivities from the "Megger" readings (Rm), the correction factor (K), the resistance of the potential electrodes, and the corrected resistivities (Rc) for each station, and notes on the ground conditions there.

Reading R	Resistance of Potential Electrodes.	Correction Factor K	Rm	Rc	Remarks
56	15,000	1.280	10,710	13,710	Saturated river sands and gravels.
68	7,800	1.137	13,020	14,820	Do.
51	4,000	1.060	9,760	10,036	Do.
99	8,000	1.140	18,960	21,600	Do.
72	8,500	1.150	13,800	15,880	Wet river sands and gravel.
93	5,500	1.090	17,800	19,530	River sands and gravels beneath 2 inches of water
56	3,000	1.040	10,730	11,170	Electrodes in water 3 inches above bottom.
135	4,700	1.074	25,440	27,380	Damp river sands and gravel.

The average of these eight readings is 16,766 ohm. cm., and the largest changes are + 63 per cent. and - 40 per cent.

(b) Power House Weir:

The second set of tests was made in the sands, gravels and muds of the bed of the Molonglo River, downstream from the weir at the Canberra Power House. There was some mud or silt mixed with sands and gravels.

Readings were taken in the form of rough traverses and their positions and profiles are shown on Plate 1.

An inspection of the profiles shows that the range of resistivities in wet gravel, sand and mud is large. In wet mud the value is quite small, while in plastic mud, it is still small, but increases rapidly as the mud becomes drier. The correction for the resistance of potential electrodes was very small.

Stations, 1, 2 and 3 taken at random in wet muddy sand, gave readings of 4710, 9160 and 11,290 ohm cm., respectively.

The first traverse (stations 4 - 16) was read over wet gravel, sand and mud, close to the water's edge. The resistivities ranged between 5,400 and 10,300 ohm. cm. Their average was 7,980 ohm. cm., and the greatest changes + 29 per cent. and - 32 per cent.

Stations 17 - 20 were read at random positions under about 2 inches of water near station 4. Readings ranged between 6,900 and 8,860 ohm. cm.

Stations 21-38 read along the clay bank of a nearby small stream gave very regular readings. The range was from 3,680 - 4,675 ohm. cm., with one reading in drying clay of 6,245 ohm. cm. Ignoring this last reading, the average was 4,140 ohm. cm., and the largest changes were + 13 per cent. and - 11 per cent.

For all stations in this area the range was from 3,600 ohm cm., to 11,300 ohm. cm., and the average of the thirty-eight readings was 6,100 ohm. cm. Thus the largest changes were + 69 per cent. and - 41 per cent.

(c) Acton Bridge:

The third set of tests was conducted in the sands and gravels in the bed of the Molonglo River, downstream from the Acton low-level bridge. Readings were taken at the places shown in the sketch plan on Plate 2. Profiles for stations 1 - 16, 17 - 37 and 39 - 44 are also shown on Plate 2. Readings 45 - 56 were taken at random amongst the tussocks of reeds on a wet silty sand flat.

Readings along the two lines on the sand bank, (stations 1 - 37), ranged between about 30,000 ohm. cm., and 54,000 ohm cm. Potential electrode resistances were high and, therefore, the correction factor was also large. Curves for both "Megger" resistivity (Pm) and corrected resistivity (Pc) are shown. Readings along a short traverse, going from the sandbank into shallow water, showed a range 20,000 - 35,000 ohm. cm. One isolated reading in damp clayey loam was 22,800 ohm. cm., and another nearby with 2 inches of damp sand over clay loam was 17,400 ohm. cm.

Random readings on the wet mud and sand flat ranged from 16,500 - 21,500 ohm. cm., while the range for the same materials under 2 - 3 inches of water was 13,500 - 15,000 ohm. cm.

The average of the readings on stations 1 - 16 (along the water's edge) was 33,400 ohm. cm., the range was 30,400 - 45,000 ohm. cm., so that the largest changes were + 35 per cent. and - 9 per cent.

For stations 17 - 38, the average was 39,150 ohm. cm., the range 17,000 - 53,800 ohm. cm., and the largest changes + 37 per cent. and - 56 per cent. These stations were in a line about 1 foot from the line of stations 1 - 16.

For stations 39 - 43, the average was 23,700 ohm. cm., the range 21,400 - 25,900 ohm. cm., and the largest changes + 41 per cent. and - 17 per cent. These stations form a line starting in the water and finishing 1 foot from the water. The large positive change was for this last station.

For stations 45 - 54, the average was 18,930 ohm. cm., the range 16,500 - 21,500 ohm. cm., and the largest changes + 18 per cent. and - 25 per cent.

For all readings in this area, the average was 31,600 ohm. cm., the range 13,600 - 53,800 ohm. cm., and the largest changes + 70 per cent. and - 57 per cent.

The resistivities of this area were generally about double those in area (a) and five times those in area (b).

(d) Sullivan's Creek:

The fourth set of tests was conducted on heavy black clay near the head of Sullivan's Creek, on the east side of the Yass Road, about four miles north of Canberra City. The tests were made in four short parallel traverses at right angles to the creek. The bed of the creek was covered with reeds and grass. A sketch

plan on Plate 3 shows the positions of the readings. Profiles and sketched sections are also shown on Plate 3.

The resistivities ranged from 1,060 ohm.cm., to 5,450 ohm.cm. (corrected readings). It will be seen from the curves that the largest and most irregular readings were observed where the grass was long and thick. Readings on the bare clay banks of the creek were lower than those in the wet bed. Clay beneath 2 feet of water in a hole in the creek bed showed the lowest values.

Readings on traverses 1, 2 and 3 (stations 1 - 94) ranged between 1,020 and 2,180 ohm.cm. The average value was 1,575 ohm.cm., and the greatest changes + 38 per cent. and - 35 per cent.

Traverse 4 started on drier ground about 20 feet from a water hole, the last reading being on its bank. The resistivities were generally much higher than those observed in the first three traverses. Potential electrode resistances were higher and the curve is more irregular than for the previous traverses. The range was 2,000 - 5,450 ohm.cm., and the average was 3,850 ohm.cm. The largest changes were + 42 per cent. and - 48 per cent.

The resistivity of the water in the pond was found to be 1,075 ohm.cm., and that of the clay beneath it was 735 ohm.cm. As might be expected, the readings taken in clay beneath the water were very steady.

For this area, the average of all readings was 1,730 ohm.cm., the range was 720 - 5,450 ohm.cm., and the largest changes were + 212 per cent. and - 59 per cent.

The resistivities in this area were generally much lower than in the other three areas investigated. The average resistivity for area (d) was:-

0.1 of that for area (a)
0.35 " " " " (b)
0.18 " " " " (c)

SUMMARY

The results are summarised in the table given overleaf.

From the accompanying plates and the table, it is possible to see how the resistivity of the ground changes between nearby points under different sets of conditions.

Comparison may also be made between the corrected and uncorrected "Megger" readings.

The significance of these results is developed further in Mr. Thyer's report which has been referred to above.

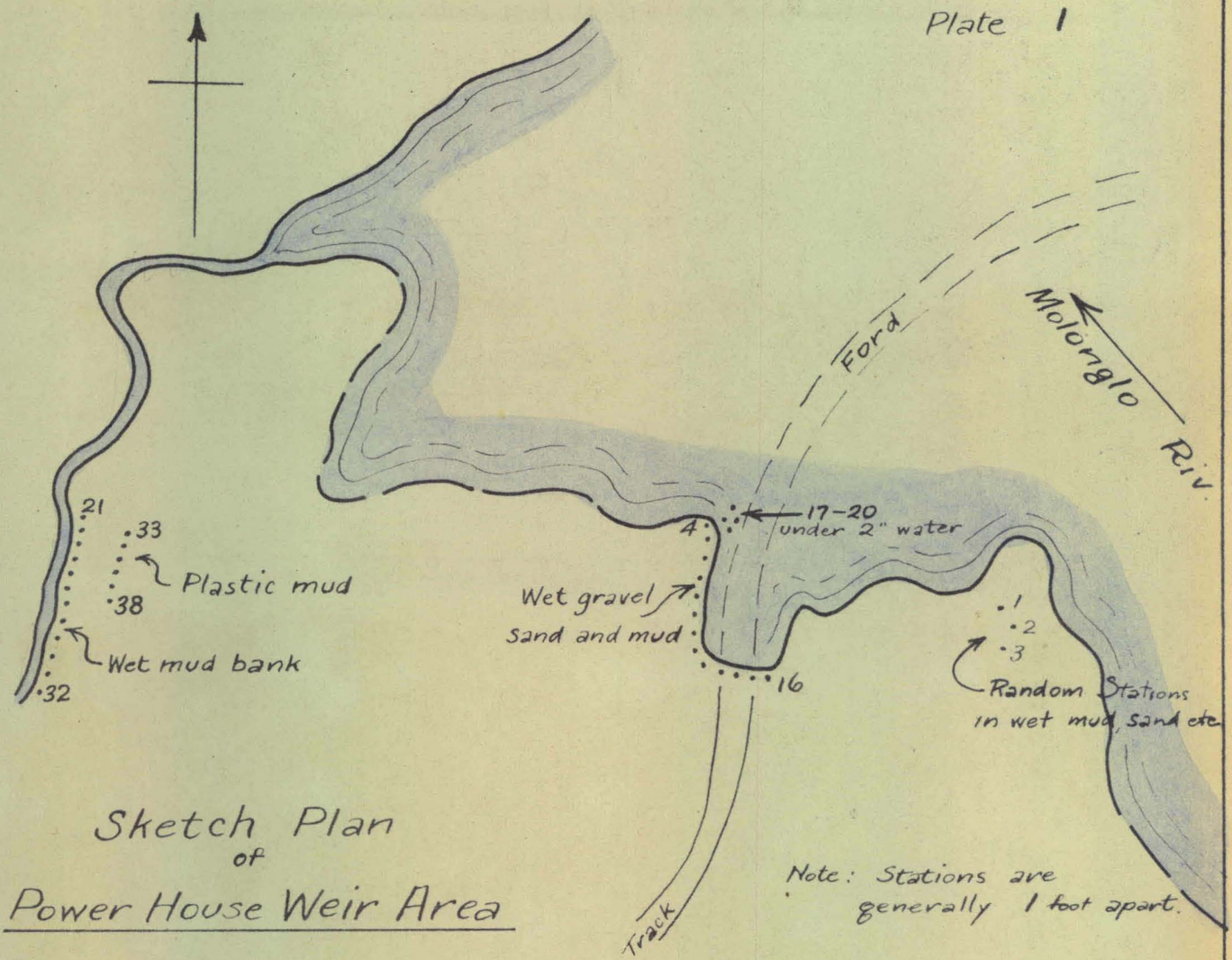
(C. H. Zelman)
ASSISTANT GEOPHYSICIST.

8th May, 1944.

- SUMMARY OF CONCLUSIONS FROM MEGGER TESTS ON WET GROUND. -

LOCALITY	RANGE OF CORRECTION FACTOR K	RANGE OF CORRECTED RESISTIVITY Pc	AVERAGE Pc	LARGEST VARIATION FROM AVERAGE	GROUP AVERAGE OF Pc	LARGEST VARIATION FROM AVERAGE FOR GROUP.
(a) Scotts Crossing:						
Saturated river sands and gravels ..	1.060 - 1.280	10,036 - 21,600	15,210	+ 42% - 34%		
Above, under water ..	1.090	19,530	-	- -	16,766	+ 63% - 40%
Water ..	1.040	11,170	-	- -		
(b) Power House Weirs. ..						
Saturated mud, sand and gravel ..	1.026 - 1.120	4,710 - 11,290	7,980	+ 29% - 32%		
Above, under water ..	1.038 - 1.050	6,900 - 88,860	7,650	+ 16% - 10%	6,100	+ 69% - 41%
Very wet mud or clay bank ..	1.055 - 1.090	3,679 - 4,310	4,140	+ 13% - 11%		
Plastic clay ..	1.045 - 1.125	3,558 - 6,245				
(c) Acton Bridge:						
Saturated sand	1.010 - 1.780	30,400 - 45,000	33,400	+ 35% - 9%		
Wet sand	1.10 - 2.380	17,000 - 53,000	39,150	+ 37% - 56%		
Sand under water	1.066 - 1.080	21,340 - 25,890	23,700	+ 9% - 10%	31,600	+ 70% - 57%
Wet mud, sand and weeds ..	1.024 - 1.060	16,495 - 21,530	18,930	+ 13% - 13%		
Above, under water	1.016	13,680	-	+ -		
(d) Sullivan's Creek:						
Wet clay near water	1.004 - 1.025	1,049 - 1,905	1,575	+ 30% - 35%		
Wet clay on higher ground ..	1.005 - 1.380	1,018 - 2,180				
Damp loam (long grass) ..	1.045 - 1.350	1,992 - 5,452	3,850	+ 42% - 48%	1,750	+212% - 59%
Water only	1.004	1,075	-	+ -		
Clay under water	0.989 - 0.990	717 - 740	735	+ 1% - 2%		

Plate 1



Sketch Plan of Power House Weir Area

Note: Stations are generally 1 foot apart.

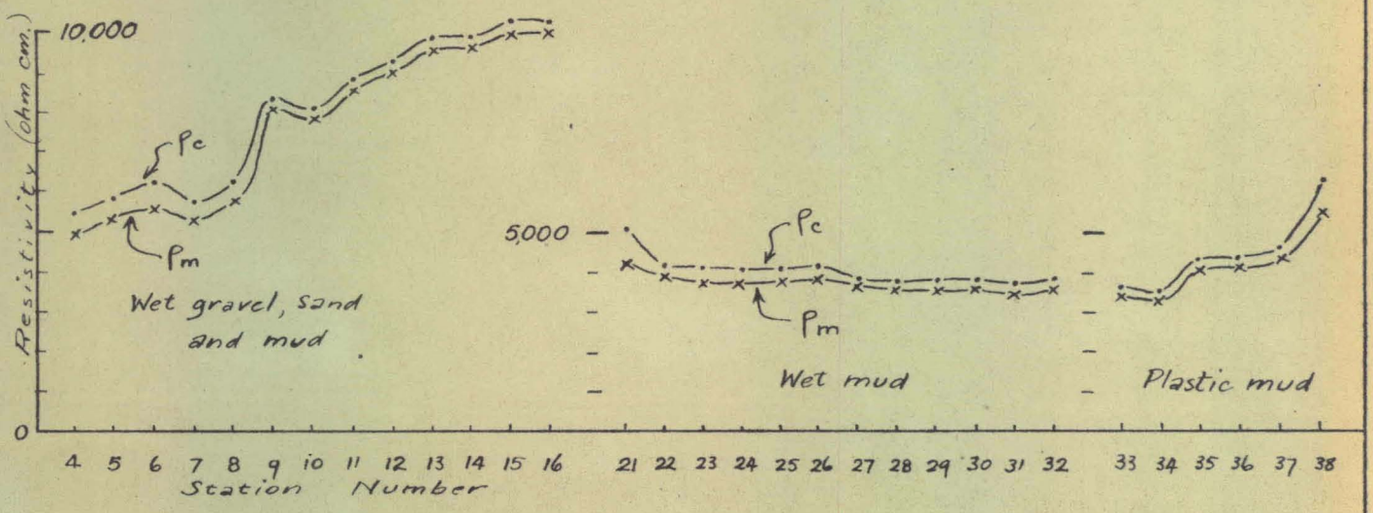
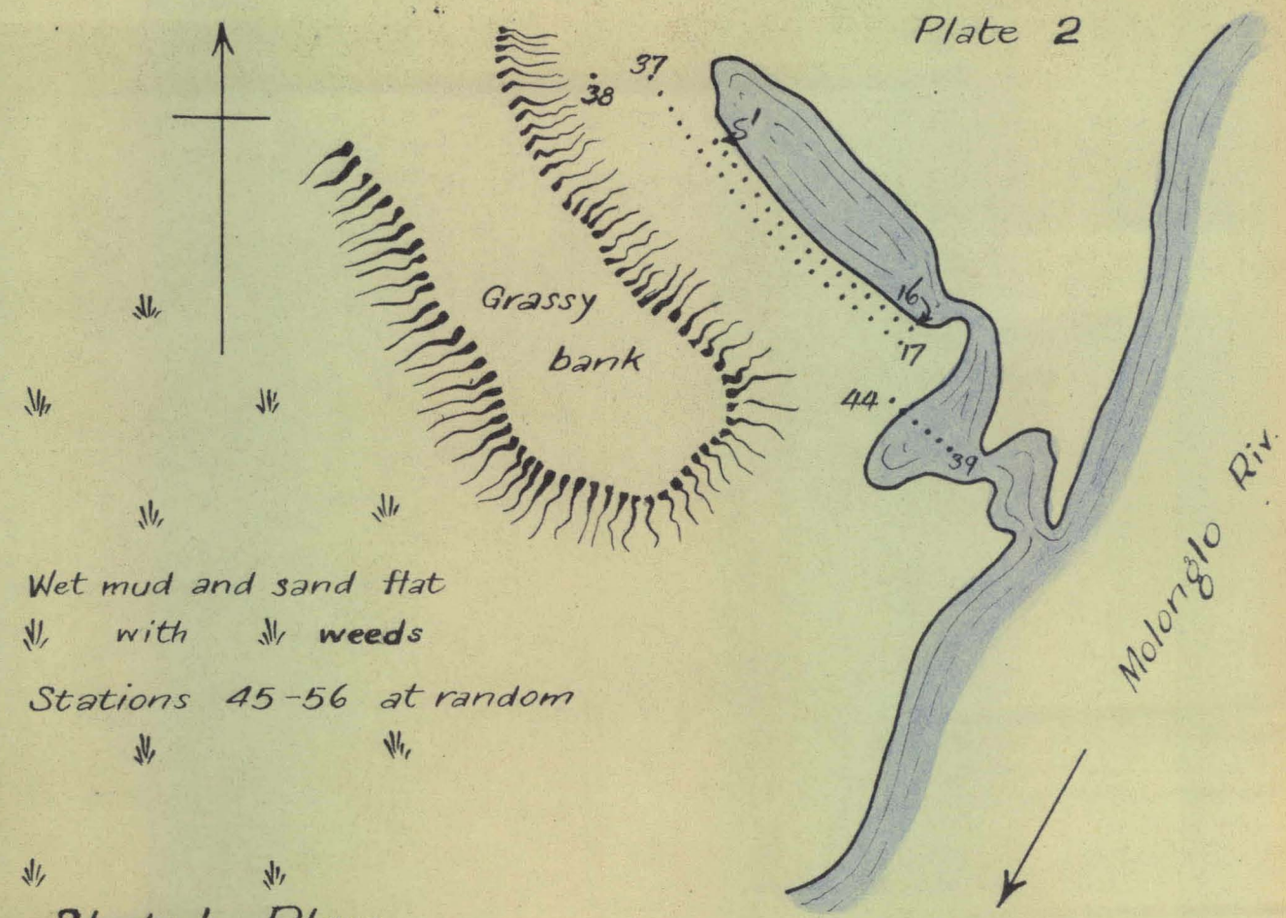
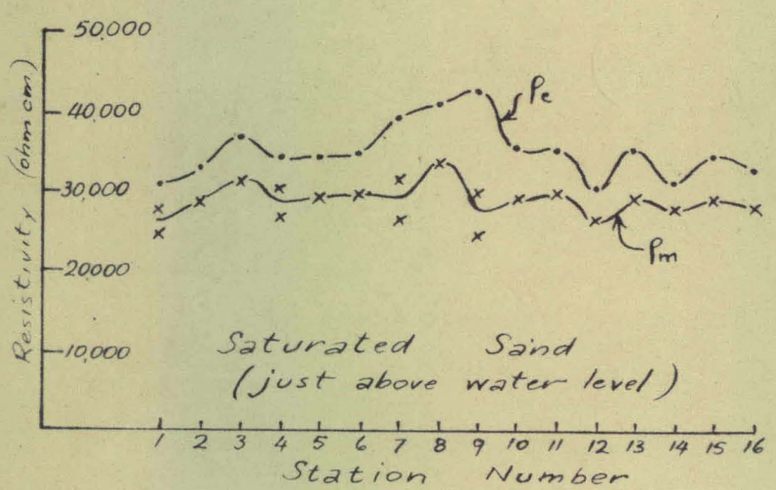


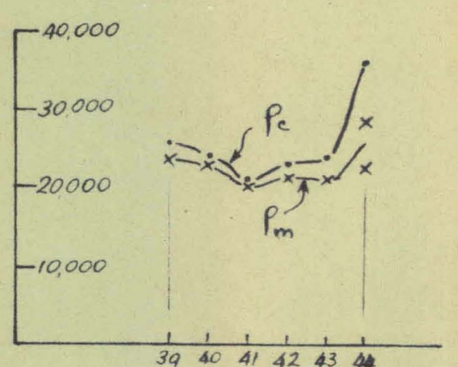
Plate 2

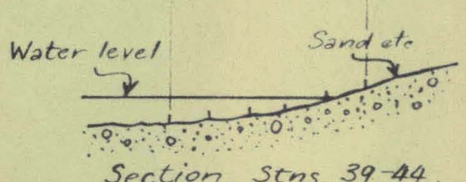


Sketch Plan of ACTON BRIDGE AREA

Note: Stations are generally about 1 foot apart.







Section, Stns. 39-44.

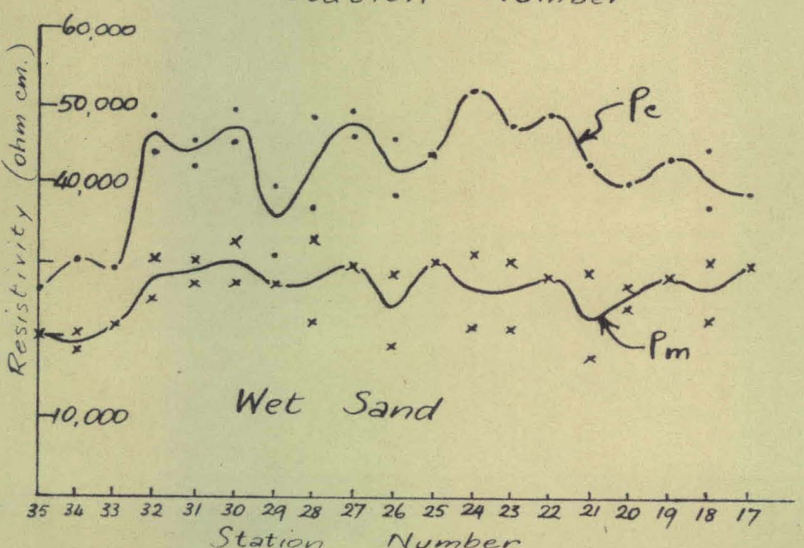
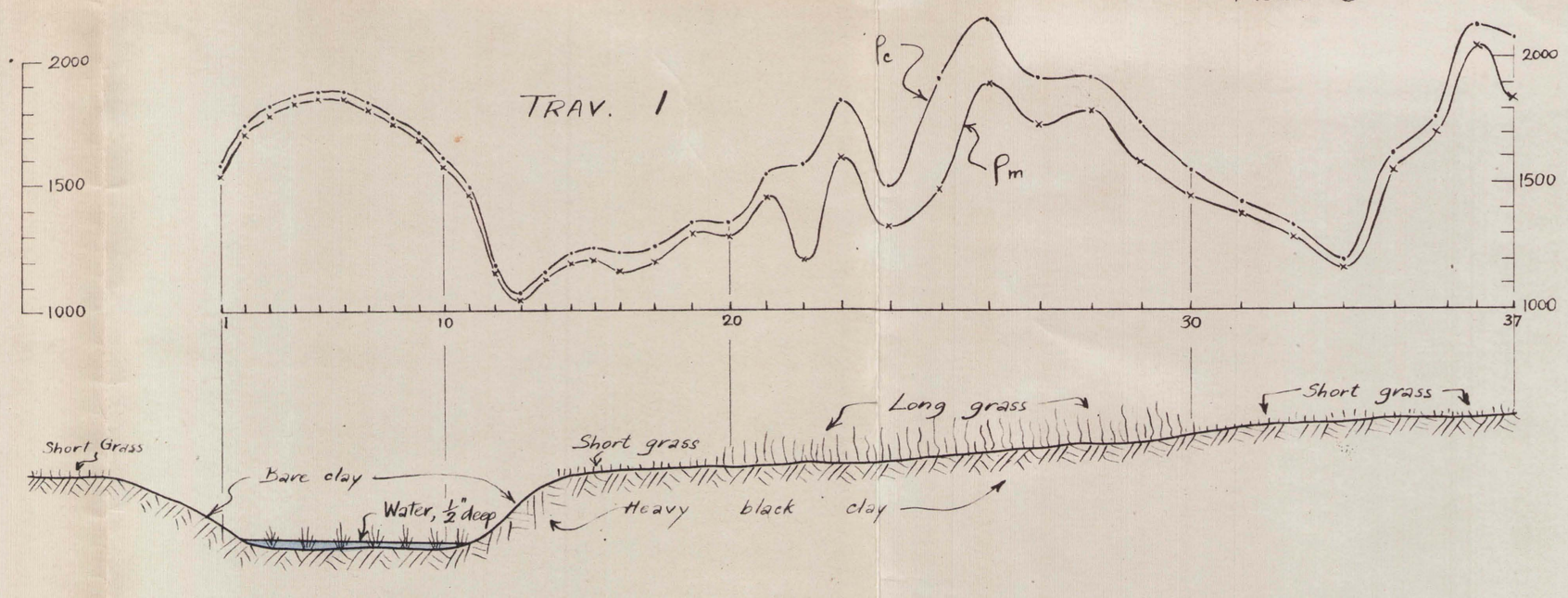
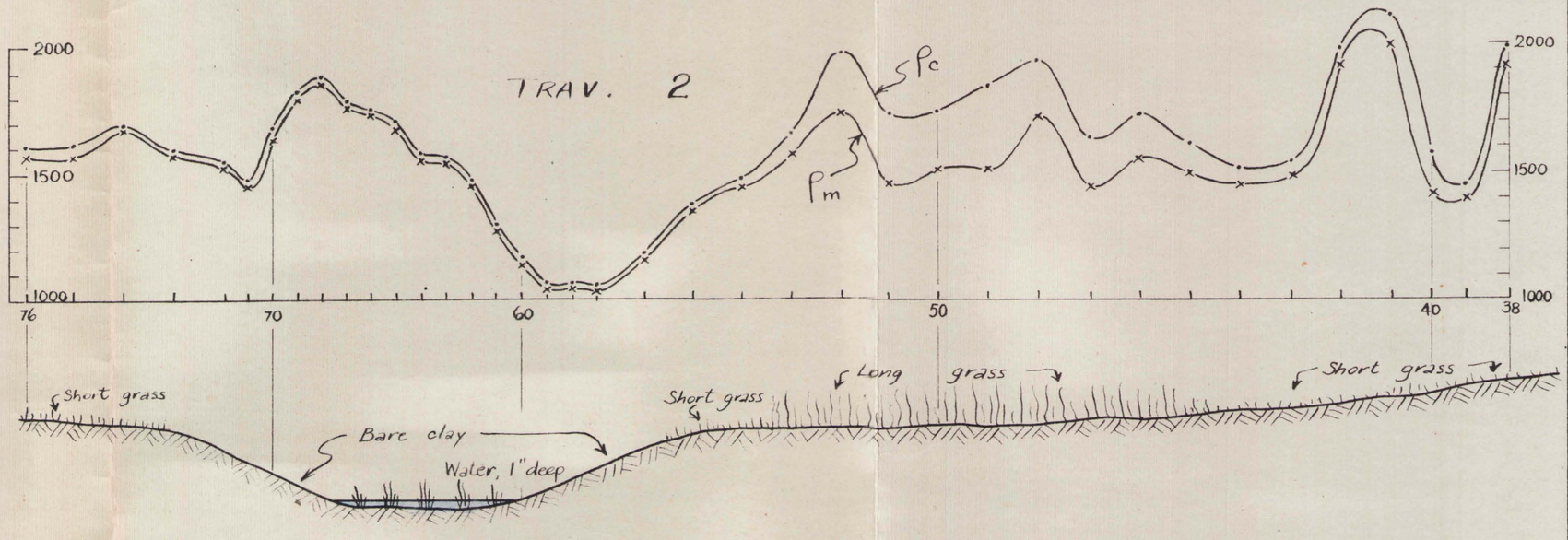


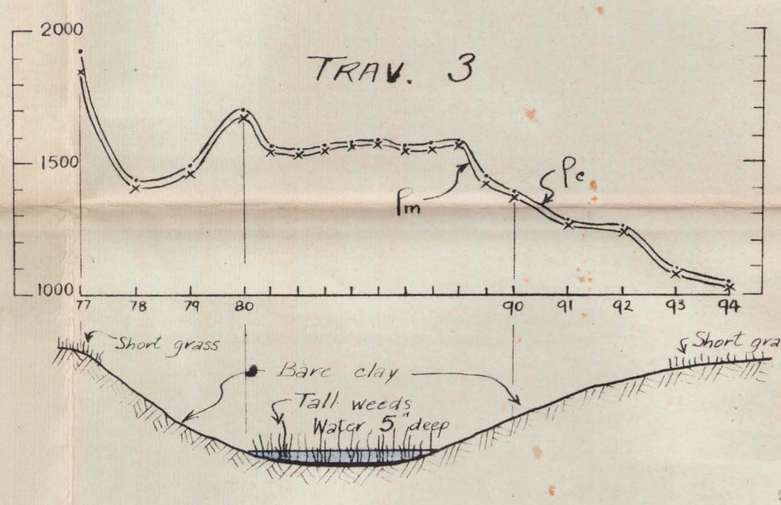
Plate 3

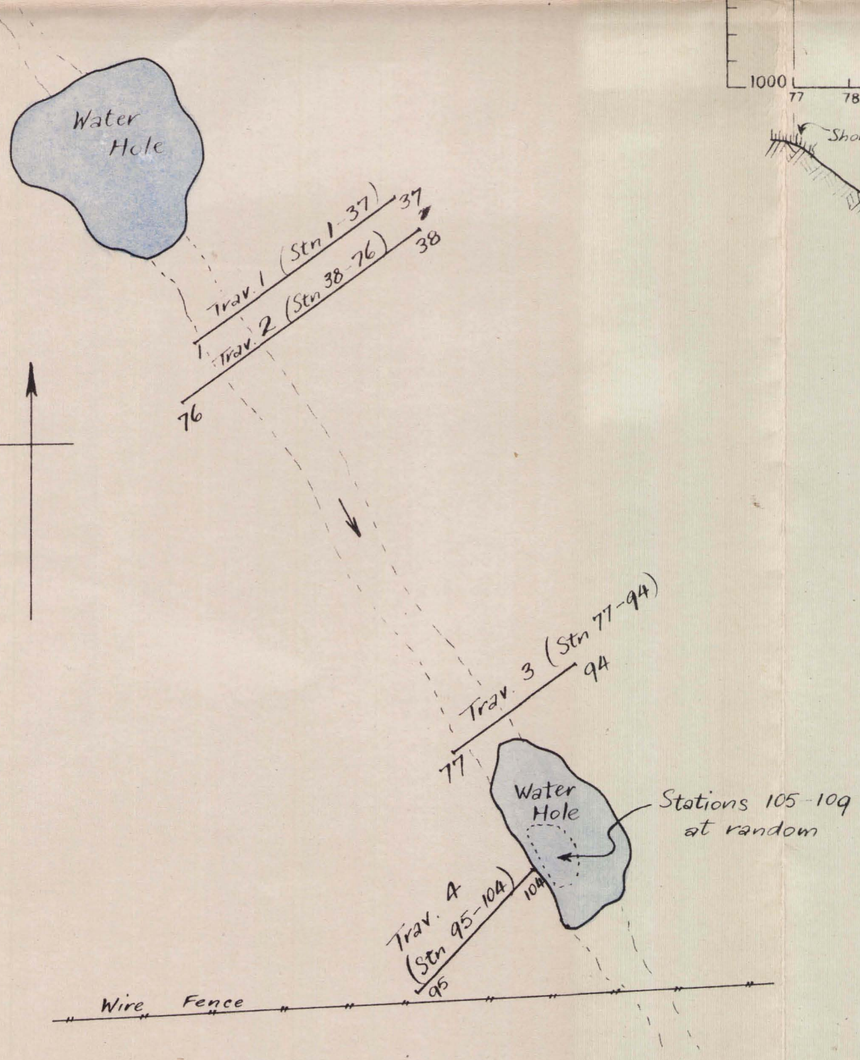
PROFILES AND SKETCHED SECTIONS

SULLIVAN'S CREEK AREA

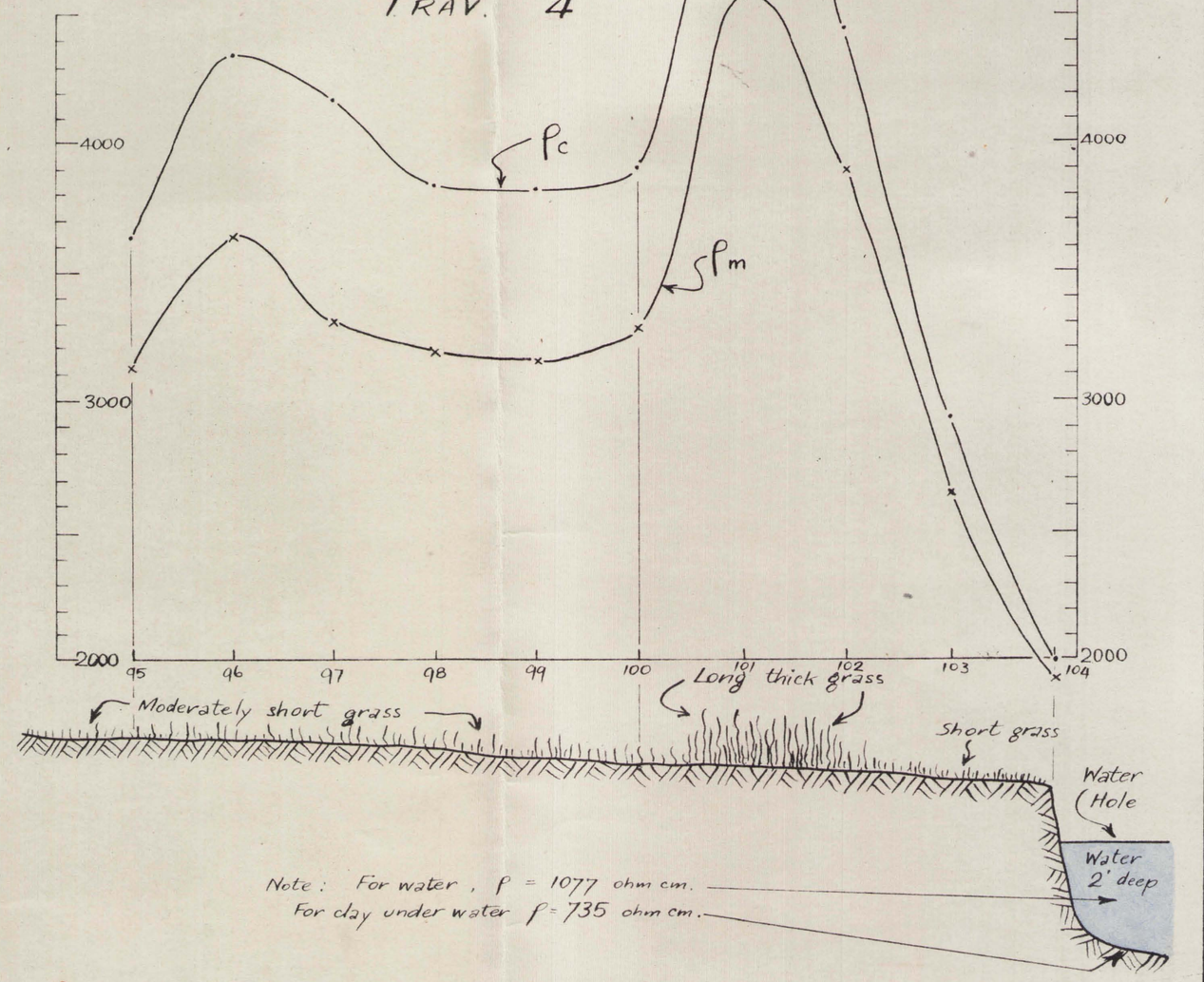








Sketch Plan of SULLIVAN'S CREEK AREA



Note: For water, ρ = 1077 ohm cm.
For clay under water ρ = 735 ohm cm.

1064