



Geological investigation of a proposed water supply pipeline route: Tea Tree—Richmond—Campania

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INTRODUCTION

A geological investigation of the route of the proposed new water supply pipeline from Tea Tree to Richmond, and the investigation for the proposed replacement line between Tea Tree, Campania, and Richmond, has been completed.

These proposed works will ultimately involve the laying of some 25 km of pipe at an average depth of 2.0–2.5 metres. Information was sought regarding the nature of the materials likely to be encountered, with specific reference to rippability and soil corrosiveness.

As the works are to be carried out in three phases, namely Tea Tree to Richmond, Richmond to Campania, and Campania to Tea Tree (fig. 1), this report will discuss each section separately. The investigation procedure was similar for each section and involved detailed geological mapping, followed by seismic refraction and resistivity surveys.

SURVEY DETAILS

Seismic Refraction

Twenty-three spreads were fired at locations selected on the results of the geological mapping and resistivity survey. The spreads were designed to determine a typical range of excavation conditions likely to be expected from the major rock types. Traverses were carried out both in areas of outcrop or sub-outcrop and soil cover only.

A Nimbus 12-channel seismograph was used; spread lengths of 24.0 m were employed with 2.0 m geophone spacings. Shots were fired from both ends. The only exceptions were spreads 8 and 9 on the Tea Tree—Richmond route, where geophone spacings of 3.0 m (with a spread length of 36.0 m) were used. Calculations were by the critical distance, intercept time, and where appropriate, the reciprocal time methods.

Resistivity

Continuous resistivity traversing was carried out along the entire route in order that a guide to the soil corrosivity could be determined. Sections of the existing Tea Tree to Campania pipeline have had to be prematurely replaced because of the corrosive nature of some of the soils. The traversing was done using the

constant electrode spacing Wenner configuration, with electrode spacings of 4.0 metres.

RESULTS

Every effort has been made to indicate, with some degree of confidence, the likely nature and range of materials to be encountered along the proposed routes. However, it is stressed that in any investigation employing geophysical methods, the results are an interpretation (based largely on experience) of the physical properties measured. No amount of investigative work at this preliminary survey level can accurately predict the extremes or rapid variability of materials (both laterally and vertically) that may exist over short distances.

Contractors should view the results only as a guide to the conditions likely to be encountered and judgements made accordingly following a field inspection.

TEA TREE—RICHMOND LINE

The geological route map of this proposed new 12 km (approx.) pipeline (fig. 2) shows that the 2.0–2.5 m deep trench will involve excavation of a number of rock types of different geological ages, origins and physical characteristics.

At bedrock level, the route is underlain by Jurassic dolerite (approximately 38% of the route), Triassic sandstone with minor mudstone (30%), Tertiary sand and clay deposits (20%), and Quaternary alluvial river deposits (12%). The degree and depth of weathering of these rocks can be expected to be variable.

The mapping and seismic refraction results (Table 1) suggests that the excavation of the large majority of the route will involve the removal of the weathered materials overlying 'bedrock'. These materials will range from soil through to highly to slightly weathered jointed rock.

In general terms, irregular weathering is characteristic of the dolerite, both in depth and lateral extent; these rocks tend to produce brown and black high plasticity clay soils. The Triassic rocks are more likely to exhibit a gradational weathering profile that usually produces sandy soils with clay sub-soils. Both the Tertiary and Quaternary deposits will be composed largely of sand and clay, grading into low strength mudstone and sandstone in the case of the Tertiary materials.

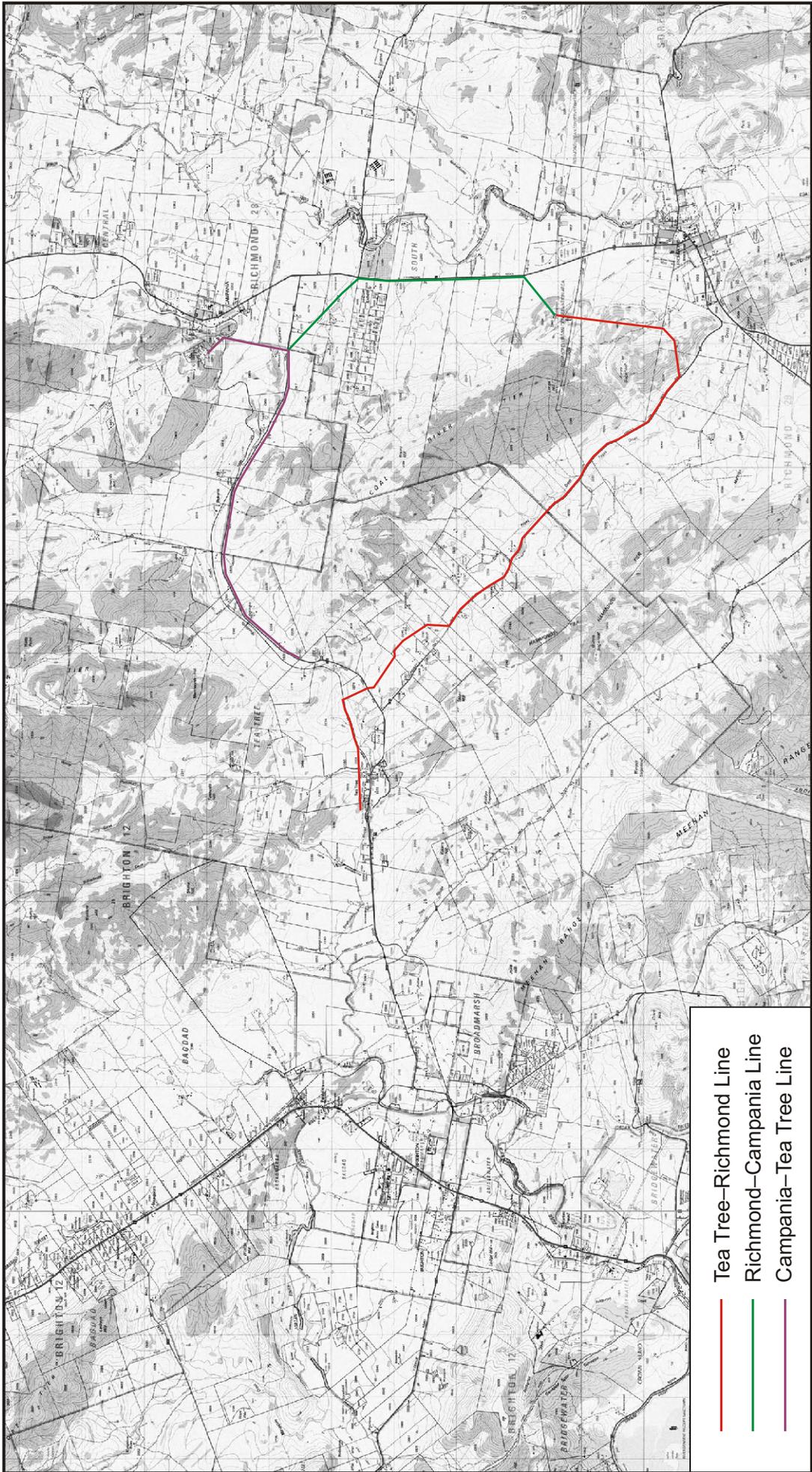


Figure 1

Location of proposed pipeline routes

The majority of the rock, where encountered, should be sufficiently well jointed at the 2.0–2.5 m excavation depth to either be worked with a bucket of a large traxcavator or require the use of a hydraulic impact rock breaker to loosen the material.

Velocities in excess of about 2500 m/s (dolerite) and 3000 m/s (sandstone) are considered to represent material that would probably require blasting. Whilst these velocities were seen, they were, with the exception of steps in spreads 2 and 3, well below the excavation limit (Table 1).

The amount of material that may conceivably require blasting prior to removal is minimal, possibly no more than a few hundred metres. This opinion is reinforced by qualitatively assessing the results of the continuous resistivity traverse (fig. 5–11). The anomalously high zones tend to correspond with either outcrop or rock close to surface. Ultimately, it is the attitude and fracture spacing that will determine the rippability.

Based on a set of figures supplied by the Board relating soil corrosivity to resistivity, the resultant series of graphs suggest that moderately corrosive (1000–2000 Ωcm) to corrosive (500–1000 Ωcm) soils are present over much of the route. The graphs are basically self-explanatory and require no further comment. The degree of protection required to ensure the longevity of the 600 mm diameter steel pipes is a matter for the Board to determine.

TEA TREE–CAMPANIA LINE

Only two rock types are represented along this 7.5 km section. The geological strip map (fig. 3) shows that approximately 50% of the route is underlain by Jurassic dolerite and the remainder by Triassic sandstone. The near-surface materials in the section between Alma Lodge and Windarra, whilst derived from dolerite, may in fact be alluvial in origin.

Basic comments made in the previous section relating to the general characteristics and physical properties of the dolerite, sandstone and their weathering products also apply here.

The mapping and seismic refraction survey results indicate that the vast majority of materials in the 0–2.5 m depth range are likely to be soils and the weathered materials of the parent bedrock. Outcrops observed along the route, including the nearby roadside cuttings, showed the sandstone bedrock to be highly to slightly weathered and of low to medium strength. This rock varied from being bedded to massive. Where exposed, the dolerite bedrock tended to be slightly weathered and of high strength but well jointed.

The only high velocity materials encountered were in spreads 2 and 3 (Table 2) where values of around 3000 m/s were recorded at a calculated depth of 2.5 m or more. Whilst this represents the approximate excavation limit for the proposed pipeline, materials with such velocities would probably require blasting. Given the highly variable nature of the dolerite in

particular, isolated sections requiring blasting must be expected.

The resistivity plots (fig. 12–15) show that about 40% of the route has mildly corrosive soils (2000–10 000 Ωcm) the remainder being either moderately corrosive (1000–2000 Ωcm) or corrosive (500–1000 Ωcm). The degree of soil corrosivity appears to be independent of rock type. For example, the Triassic sandstone section between Old Oakington and Rekuna has three distinct changes. The reason for this is not immediately clear. In broad terms, the high resistivity section appears to be more closely related to the grey silty sand surface soils with the associated sandstone float or sub-outcrop. The low resistivity sections tend to have soils with a higher clay content. However, it does not follow that the high resistivity areas necessarily indicate hard rock conditions close to the surface. A comparison of spreads 1, 5 and 6 confirms this.

The resistivity values in the vicinity of the replaced sections of pipe to the east of Alma Lodge fall within the moderately corrosive to corrosive range. With some 60% of this 7.5 km pipeline in the same corrosivity category, the question arises as to why more of the pipe has not required replacement. Is it just a matter of time or are there other factors involved?

According to the owner of Alma Lodge, an acid train derailed many years ago and reportedly spilt its contents in the immediate vicinity of the replaced sections of pipe. The validity of this story has not been checked.

RICHMOND–CAMPANIA LINE

The geological route map (fig. 4) for this 5.0 km pipeline section should be regarded as approximate only. There is minimal outcrop along the route and soil boundaries are indistinct. As a result, this map differs slightly to the published 1:50 000 scale geological map (Leaman, 1975).

The route is underlain by three distinct rock types; Tertiary basalt (60–70%), Tertiary sediments (20–30%) and Jurassic dolerite (10%).

In line with the previous two pipeline routes, the survey results indicate a similar trend with respect to rock weathering characteristics. Basalts are notoriously variable in the depth and degree of weathering over short distances. The seismic results indicate that the materials encountered during excavation to approximately 2.0 m depth will range from clay soils through to highly to slightly weathered open-jointed rock. These latter materials may require the use of a hydraulic impact rock breaker where the jointing is no longer open. It is unlikely that hard rock conditions requiring blasting will be encountered at more than a few isolated locations.

The Tertiary sediments are not expected to cause any difficulty with respect to ease of excavation. The only hard rock conditions likely to be encountered along this route is at the Richmond Reservoir site. Much of the initial 300 m of this route is either dolerite outcrop or

sub-outcrop. The rock is slightly weathered, has high strength and is generally tightly jointed. Seismic spread 6 (Table 3) gives an indication of the hard fresh nature of the rock below about one metre depth. Blasting must be expected along a portion of this 300 m section.

The resistivity traverse results (fig. 16–18) tend to show a broad correlation between high resistivity values and either outcrop or surface float. However, one should not draw the conclusion that areas of low resistivity preclude hard rock conditions. The results do indicate that most of the near-surface materials along the route are either corrosive or mildly corrosive.

SUMMARY

A variety of rock types with different weathering characteristics and physical properties will be encountered during the excavation for the proposed pipelines.

The most variable and therefore unpredictable conditions will be associated with the dolerite and basalt; the depth and degree of weathering both laterally and in profile, can change rapidly. This makes any reliable estimate of excavation conditions most difficult. The results suggest that most of the hard rock conditions encountered should be sufficiently well

jointed and weathered to allow the material to be loosened using a hydraulic impact rock breaker. It is inevitable that minor blasting will be required over short sections.

The Triassic sandstones are considered to have a sufficiently thick weathering profile such that it is unlikely that explosives will be required, except perhaps in isolated occurrences.

The Tertiary sediments and Quaternary deposits are not expected to present any hard rock conditions requiring explosives.

The resistivity traverse results indicate that a high percentage of the near-surface materials along the 25 km of pipeline route investigated are either mildly corrosive or corrosive.

Contractors should view the results of the investigation as a guide to the conditions likely to be encountered and a judgement made accordingly following an on-site visit.

REFERENCE

LEAMAN, D. E. 1975. *Geological Atlas 1:50 000 series. Sheet 75 (8312N). Brighton.* Department of Mines, Tasmania.

[20 May 1987]

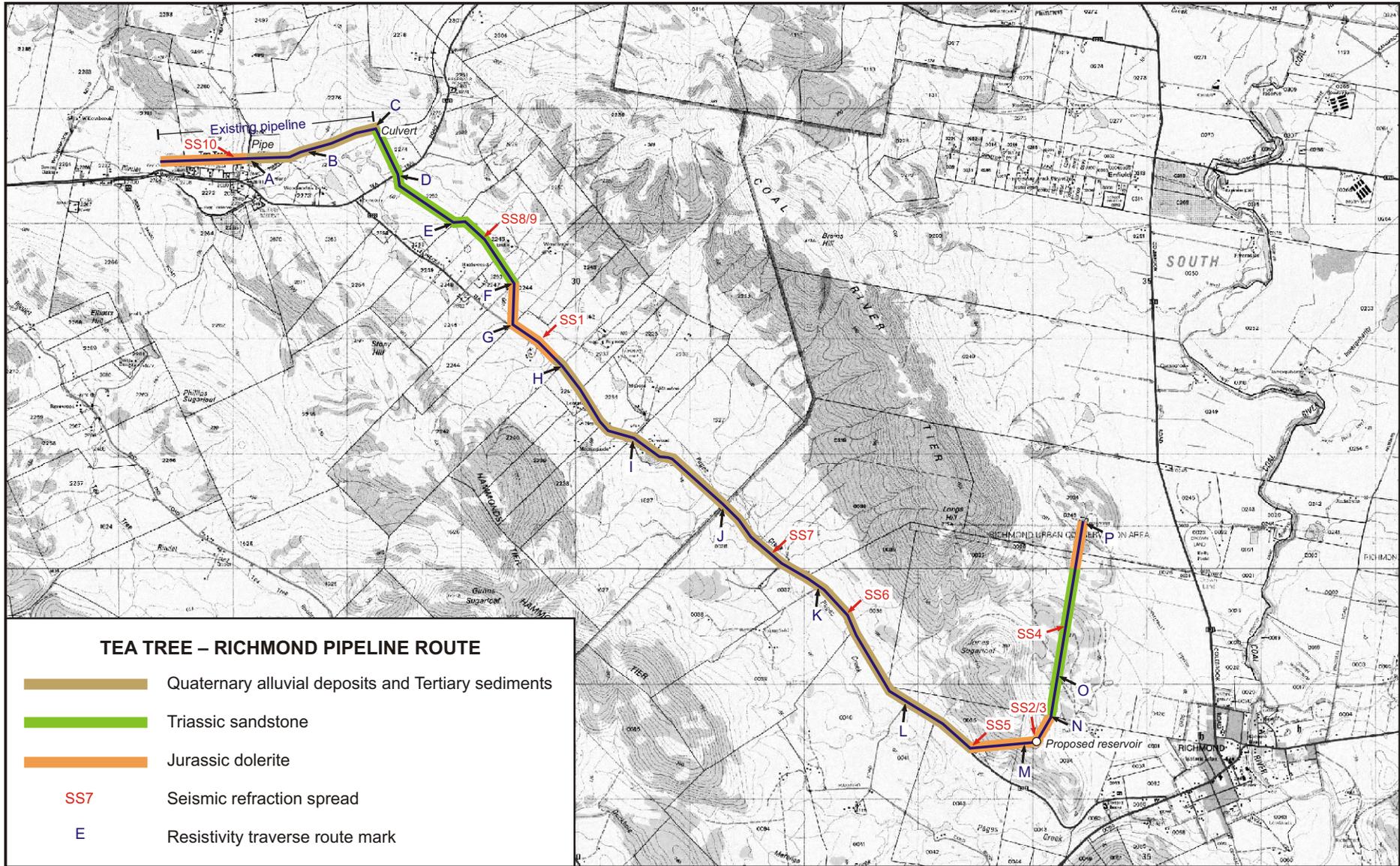


Figure 2

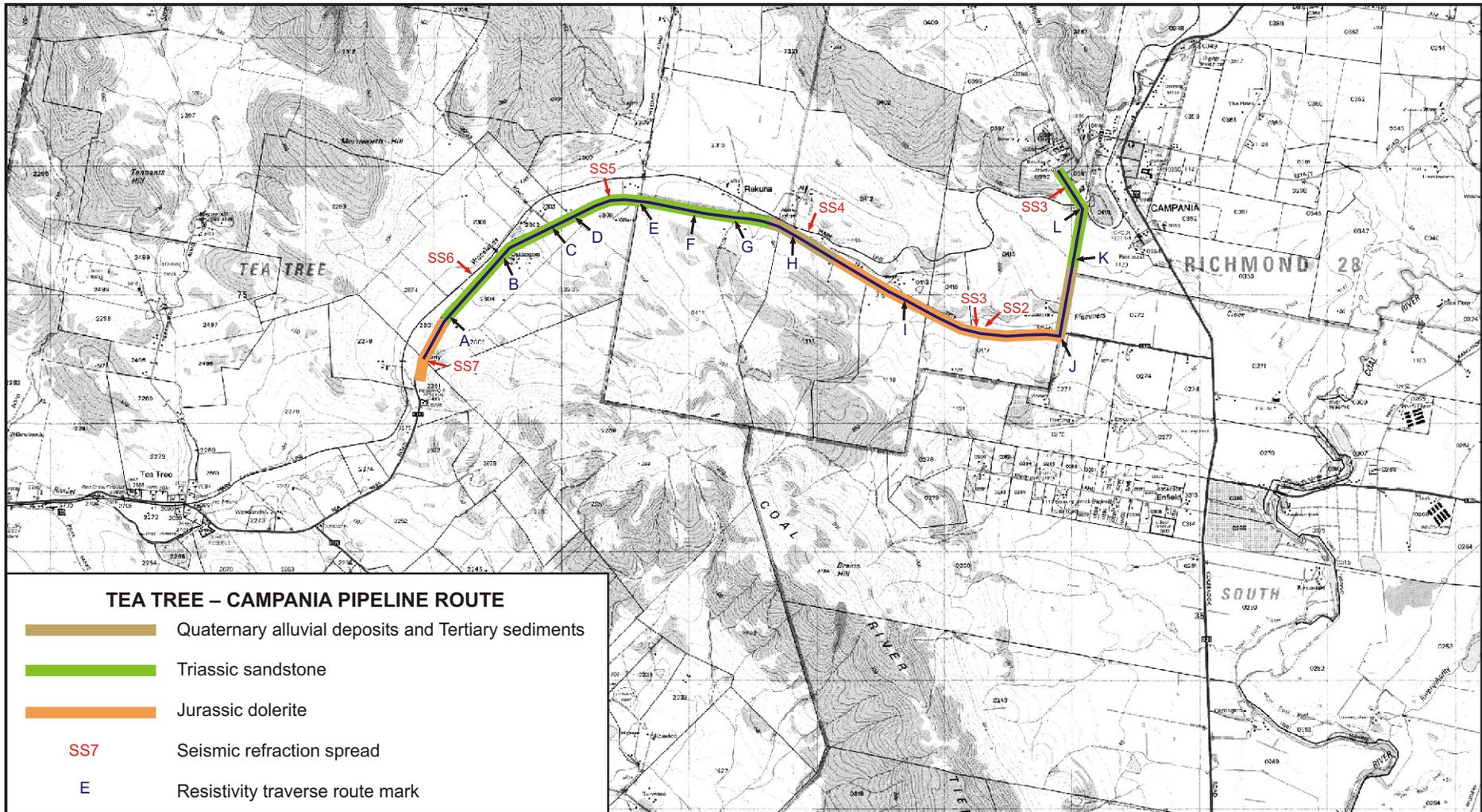


Figure 3

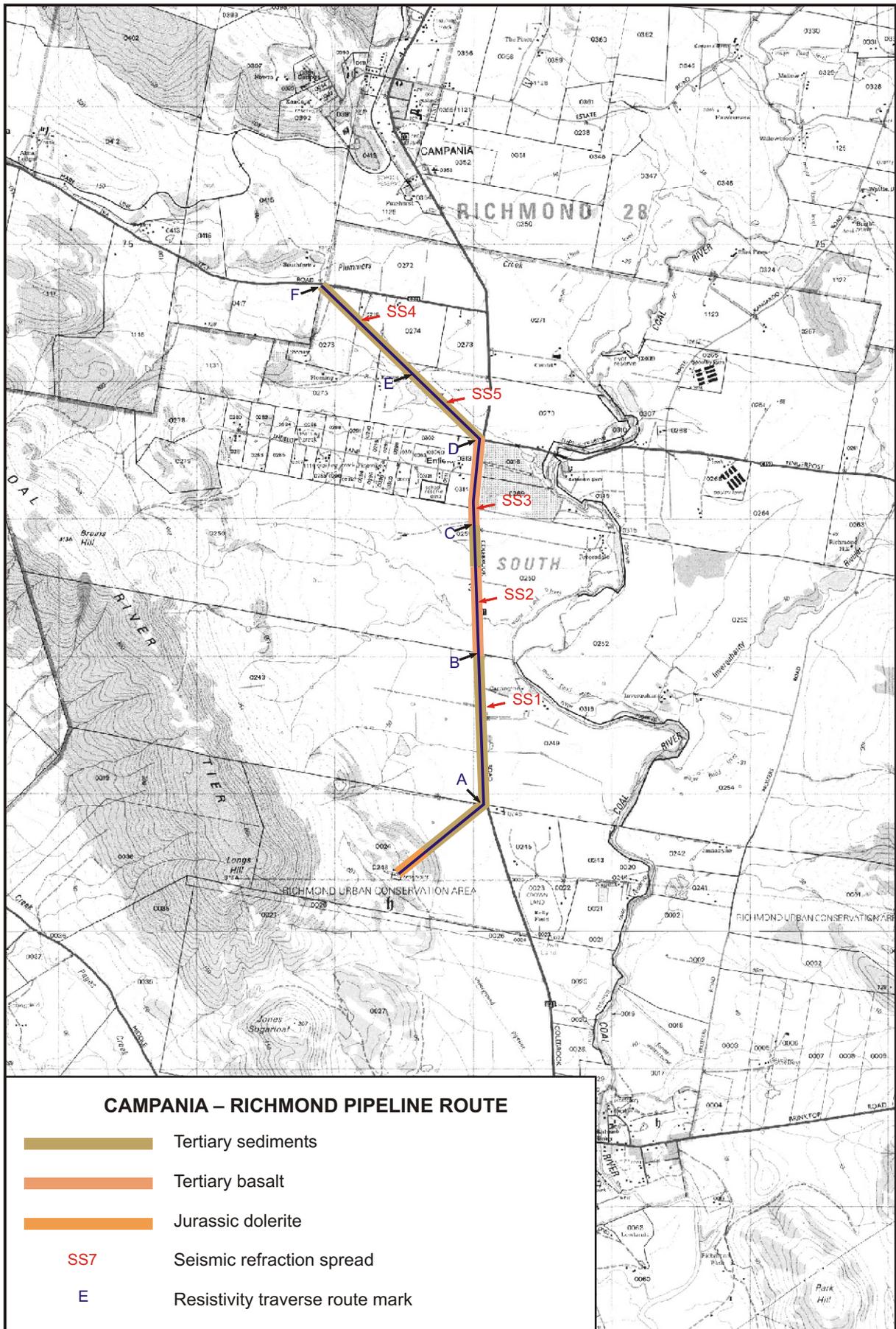


Figure 4

TABLE 1
Seismic refraction survey — Tea Tree to Richmond pipeline

Spread	Soil/Rock Type	Layer			Velocity Plot Characteristics	Geological Interpretation
		Velocity (m/s)	Depth (m)	Thickness (m)		
1	DOLERITE (Jurassic) Black clay (CH)	300–330	0.4–0.5	0.4–0.5	Symmetrical	Topsoil CH clay
		470–500	2.6–3.4	2.2–2.9		Residual clay, unsaturated
		670–740	9.4– 9.6	6.2– 6.8		
		1400–1500	–	–		Clay – EW weak rock
2	DOLERITE Sub-outcrop, brown clay (CH)	400–570	0.7–0.8	0.7–0.8	Stepped: Inverted segments	Topsoil: CH clay
		1770–2000 (with steps to 4000)	–	–		HW-SW rock; joints open, some clay filled High velocity segments (4000) represent FR rock – tight joints
3	DOLERITE Sub-outcrop, brown clay (CH)	650–1150	0.7–1.4	0.7–1.4	Stepped, inverted segments	Similar to above
		1700–2000 (with steps to 4000)	–	–		
4.	SANDSTONE Sandy clay (SC), 5% float	450	0.9–1.0	0.9–1.0	Asymmetrical, stepped	Topsoil–Sandy clay (SC)
		1350–1670	3.6–5.4	2.6–4.5		EW–MW rock, joints open, some clay filled
		2650–3500 [†]				SW–FR rock – massive to tightly jointed
5	DOLERITE Clay (CH), 20% float	500	0.7–0.9	0.8–0.9	Symmetrical, minor stepping	Topsoil – CH Clay
		1500–2000	2.8–3.5	1.9–2.7		HW–SW rock – close,open jointing
		3000–3500 [†]				SW–FR rock – massive–tightly jointed
6	TERTIARY SEDIMENTS Sandy clay (SC)	380–450	2.7–3.2	2.7– 3.2	Symmetrical	Topsoil – Sandy Clay (SC)
		1140–1600	5.4	2.3		Clay – consolidated to EW rock
		2000*				
7	TERTIARY SEDIMENTS Sandy clay (SC)	500	0.6–0.7	0.6–0.7	Symmetrical	Topsoil – Sandy Clay (SC)
		1670–1800	4.7 [#]	4.0 [#]		(i) Saturated sand/clay deposits
		2500 [†]				(ii) EW–HW rock; clay filled and open joints
8	SANDSTONE	375–550	0.9–1.2	0.9–1.2	Symmetrical	Topsoil
		1500–1750	10.2–10.8 [#]	9.2 [#]		EW–HW rock – joints open, some clay filled
		3000 [†]				

Spread	Soil/Rock Type	Layer			Velocity Plot Characteristics	Geological Interpretation
		Velocity (m/s)	Depth (m)	Thickness (m)		
9	SANDSTONE	350–375	1.1–2.1	1.1–2.1	Symmetrical	Topsoil Consolidated clay to EW rock
		1100–1465	9.8 [#]	7.7 [#]		
		3000 [†]				
10	DOLERITE Sub-outcrop, black clay (CH)	890*	1.2	1.2	Asymmetrical	Topsoil – CH Clay EW–HW rock, joints open, some clay filled FR rock – massive, tightly jointed
		1600–1850	3.6–4.9	3.6–3.7		
		4000–4400				

* Recorded from one end only

† Assumed velocity

Minimum calculated layer depth

FR Fresh

SW Slightly weathered

HW Highly weathered

EW Extremely weathered (soil properties)

TABLE 2
Seismic refraction survey — Tea Tree to Campania pipeline

Spread	Soil/Rock Type	Layer			Velocity Plot Characteristics	Geological Interpretation
		Velocity (m/s)	Depth (m)	Thickness (m)		
1.	SANDSTONE (Triassic) grey silty sand, some quartz sandstone float	360–400	0.7–1.2	0.7–1.2	Symmetrical	Topsoil (silty sand) Residual clay – EW rock HW rock – open joints
		1300–1450	2.3–3.1	1.6–2.1		
		1780–1840				
2.	DOLERITE (Jurassic) Brown/black CH Clay, 30% dolerite float	360–450	0.6–0.7	0.6–0.7	Asymmetrical, stepped	Topsoil (CH Clay) Residual clay (unsaturated) SW–FR rock – open to closed joints
		890–1230	2.5–3.9	1.9–3.2		
		2230–3100				
3.	DOLERITE Brown/black CH Clay, no float	360–450	0.8–1.0	0.8–1.0	Symmetrical	Topsoil (CH Clay) EW–SW rock – open joints SW–FR rock – joints open to tight
		1330–2000	2.1–2.8	1.3–1.8		
		2250–3200				
4.	DOLERITE Brown/black CH Clay	300–320	0.9–1.2	0.9–1.2	Asymmetrical	Topsoil (CH Clay) Residual clay (unconsolidated)
		670*	2.9	2.0		
5.	SANDSTONE Grey/brown silty sand(SM)	300–430	1.1–3.2	1.1–3.2	Asymmetrical	Topsoil (silty sand/clay) Residual clays (unsaturated) EW–HW rock – open & clay filled joints
		800*	2.7	1.6		
		1330–1850				
6.	SANDSTONE Brown sandy clay (CH)	310–460	1.5–2.0	1.5–2.0	Asymmetrical	Topsoil (CH Clay) Clay–EW rock HW–SW rock
		1180–1330	4.6–5.0	3.0–3.1		
		2000				
7.	DOLERITE Brown CH clay some dolerite float	400–450 2110–2500	1.1–1.2	1.1–1.2	Asymmetrical	Topsoil (CH Clay) SW–FR rock – tightly jointed

* Recorded from one end only

† Assumed velocity

Minimum calculated layer depth

FR Fresh

SW Slightly weathered

HW Highly weathered

EW Extremely weathered (soil properties)

TABLE 3

Seismic refraction survey — Richmond to Campania pipeline

Spread	Soil/Rock Type	Layer			Velocity Plot Characteristics	Geological Interpretation
		Velocity (m/s)	Depth (m)	Thickness (m)		
1	TERTIARY SEDIMENTS	500–615	1.1–1.2	1.1–1.2	Symmetrical	Topsoil (CH clay)
	Grey-brown CH Clay	1230–1250	4.8–5.1	3.7–3.9		Residual clay deposits (unsaturated)
		3000–3330				SW–FR rock
2	BASALT (TERTIARY)	310–500	0.9–1.1	0.9–1.1	Symmetrical, minor stepping	Topsoil (CH Clay)
	Grey-brown CH Clay	1330–2000	2.7–4.3	1.6–3.4		EW–SW rock – joints open, some clay filled
	up to 20% basalt float	2000–3430				SW–FR rock – joints open to tight
3	BASALT	285–315	0.9–1.1	0.9–1.1	Symmetrical	Topsoil (CH clay)
	Grey-brown CH Clay	1230–1250	4.7–4.9	3.8		Residual clay (unsaturated)
		4000				FR rock – massive, tightly jointed
4	TERTIARY SEDIMENTS?	440–480	1.8–2.1	1.8–2.1	Asymmetrical, minor stepping	Topsoil (CH clay)
	Grey-brown sandy clay (CH)	1330–1390	4.9–?	2.8–?		Residual clay – EW bedrock
		2000*				SW rock – open joints
5	BASALT	330–350	0.8–1.1	0.8–1.1	Symmetrical	Topsoil (CH clay)
	Black CH clay	1000–1200	2.7–3.5	1.9–2.4		Residual clay (unsaturated)
		1260–1330				Residual clay (unsaturated)
6	DOLERITE (Jurassic)	570–650 5000 [†]	0.9–1.2	0.9–1.2	Stepped, inverted segments	Topsoil (CH clay and boulders) FR rock – massive, tightly jointed

* Recorded from one end only

† Assumed velocity

Minimum calculated layer depth

FR Fresh

SW Slightly weathered

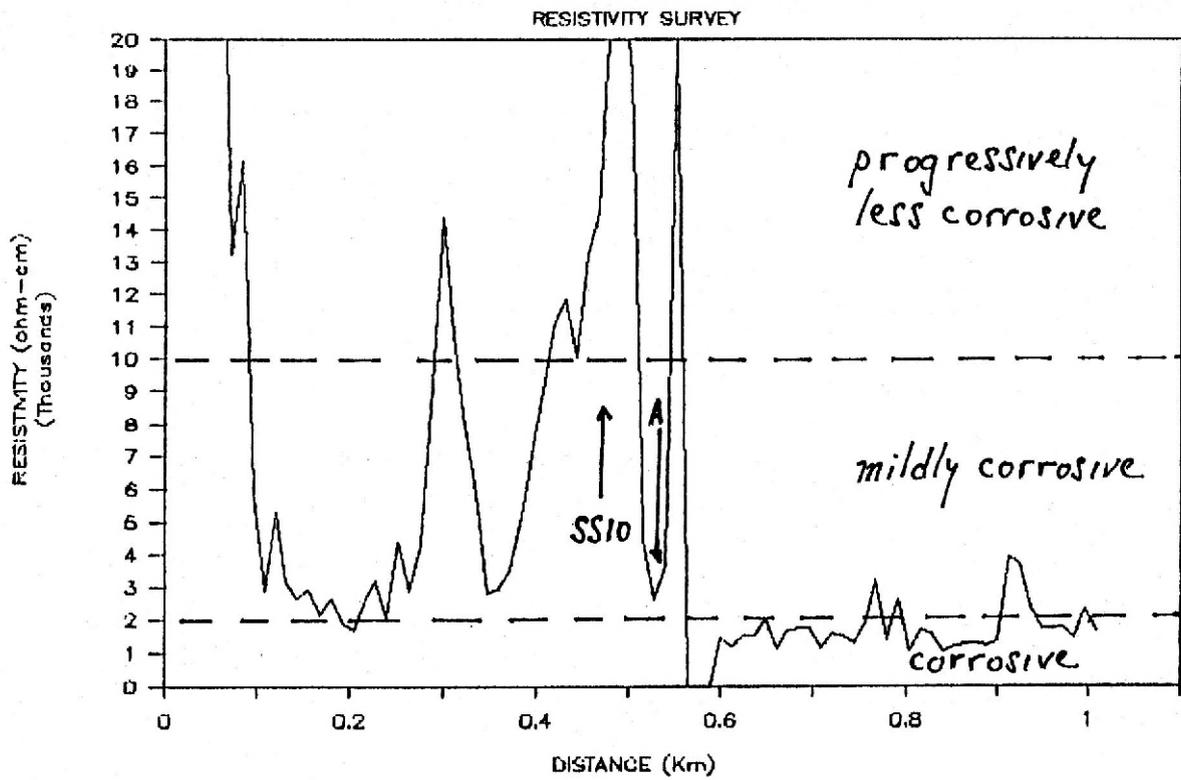
HW Highly weathered

EW Extremely weathered (soil properties)

APPENDIX 1

Resistivity survey plots

TEA TREE — RICHMOND PIPELINE



TEA TREE — RICHMOND PIPELINE

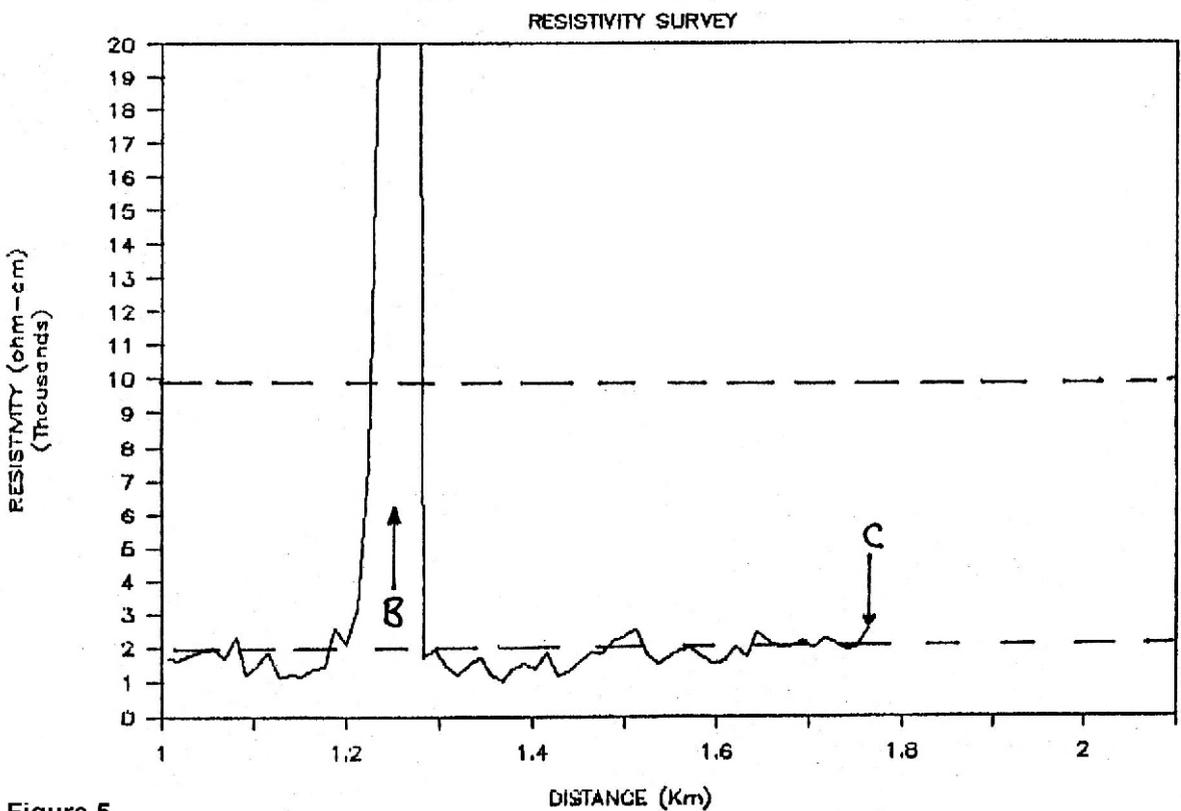
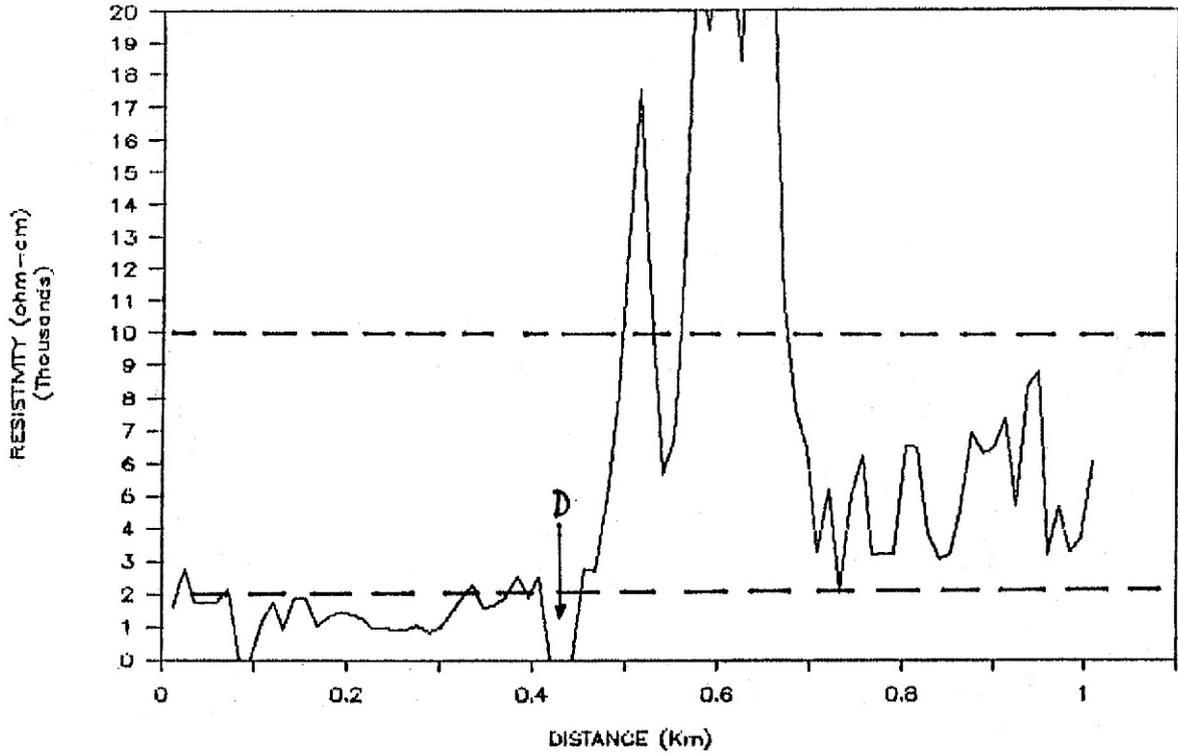


Figure 5

TEA TREE — RICHMOND PIPELINE

RESISTIVITY SURVEY



TEA TREE — RICHMOND PIPELINE

RESISTIVITY SURVEY

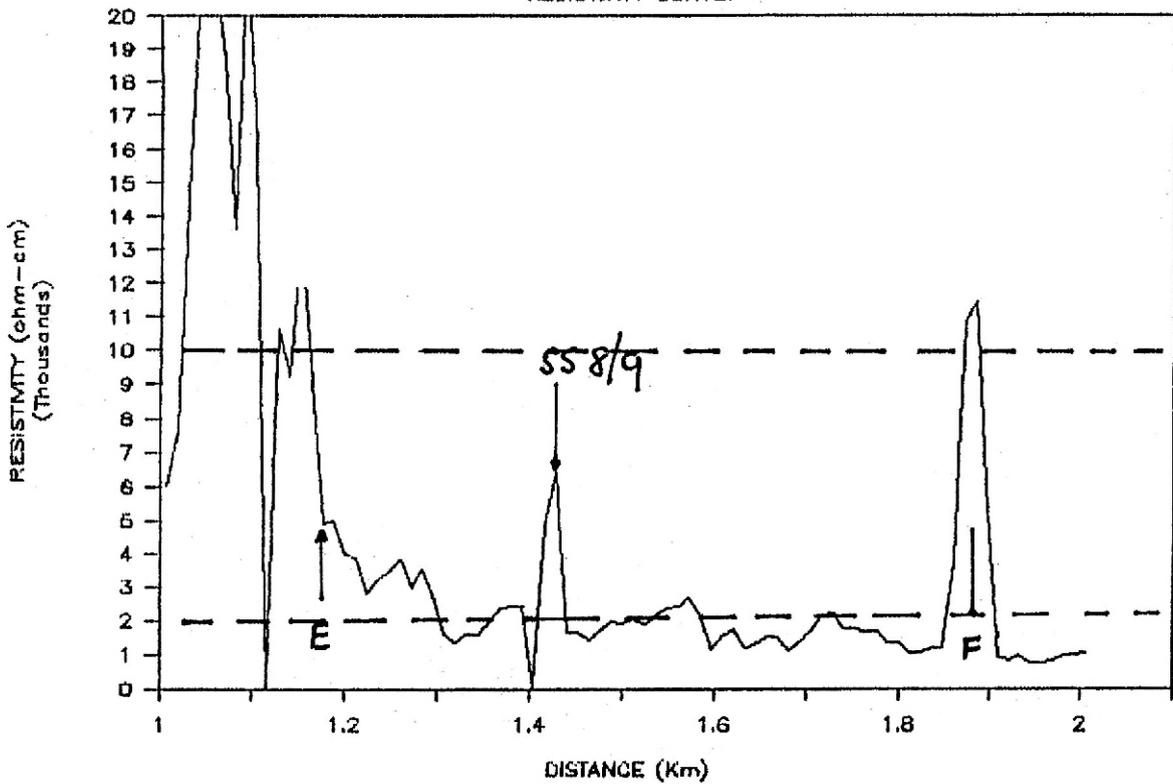
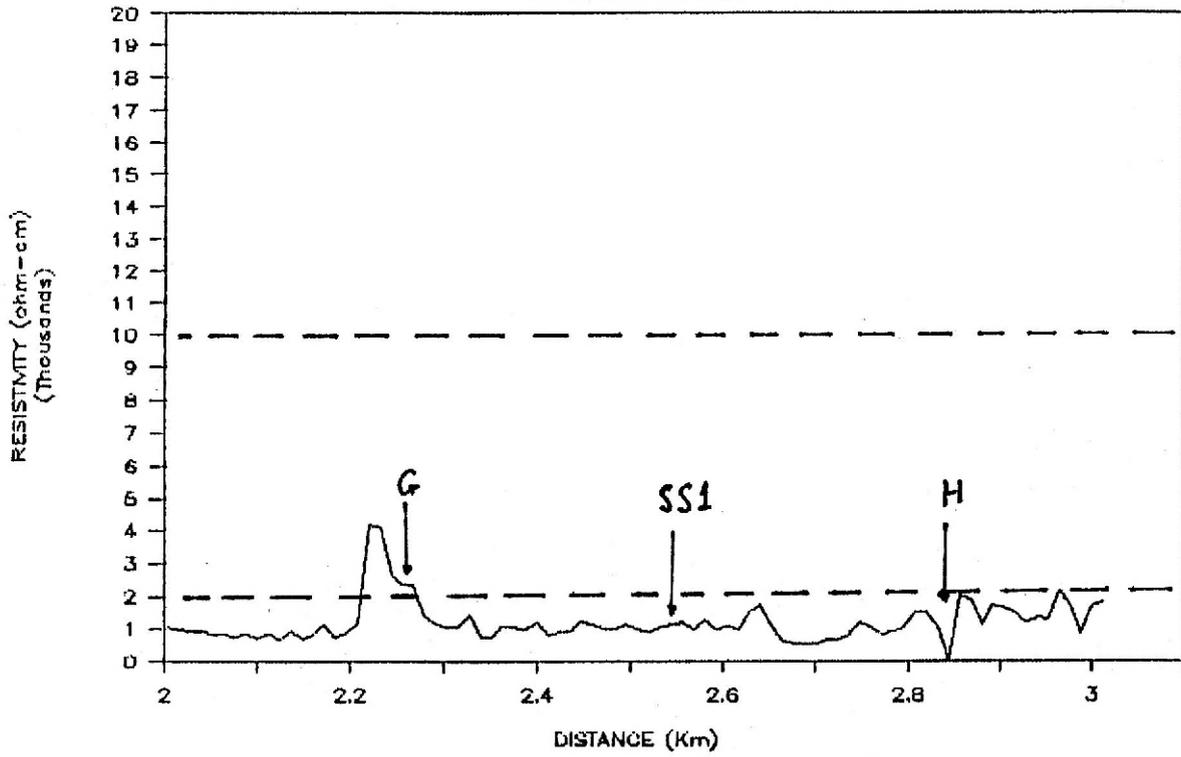


Figure 6

TEA TREE — RICHMOND PIPELINE

RESISTIVITY SURVEY



TEA TREE — RICHMOND PIPELINE

RESISTIVITY SURVEY

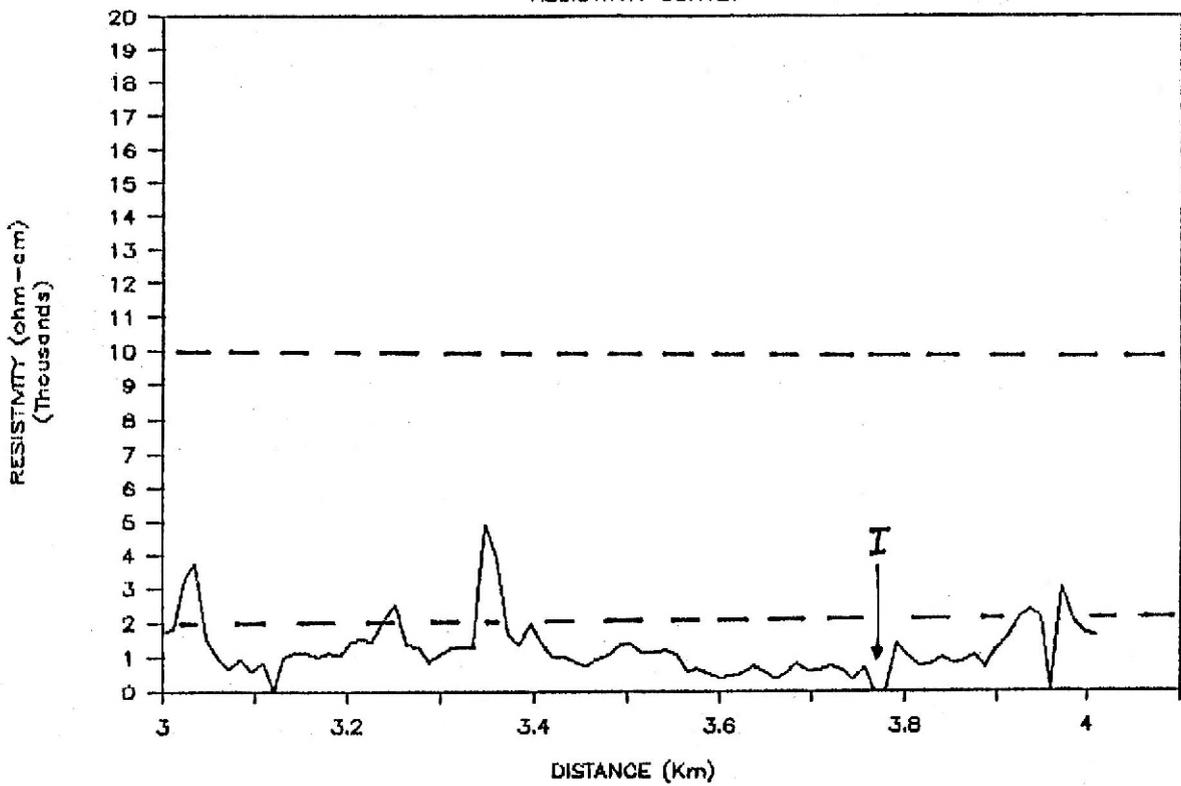
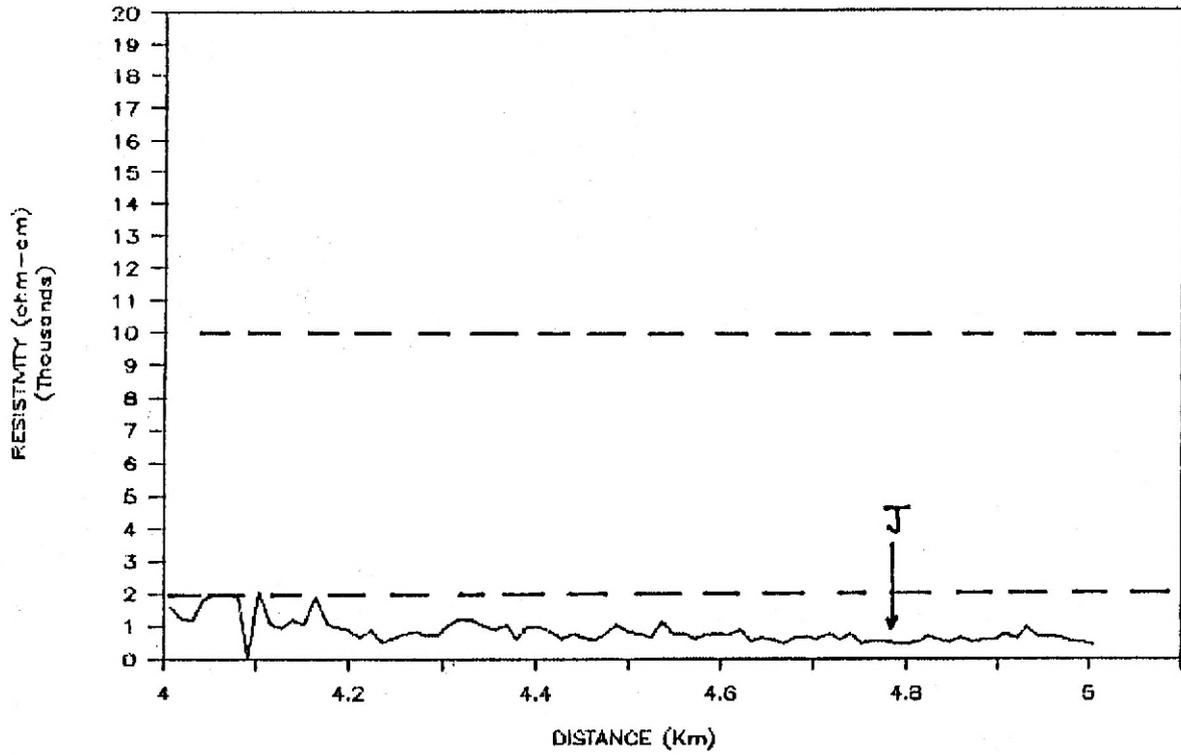


Figure 7

TEA TREE — RICHMOND PIPELINE

RESISTIVITY SURVEY



TEA TREE — RICHMOND PIPELINE

RESISTIVITY SURVEY

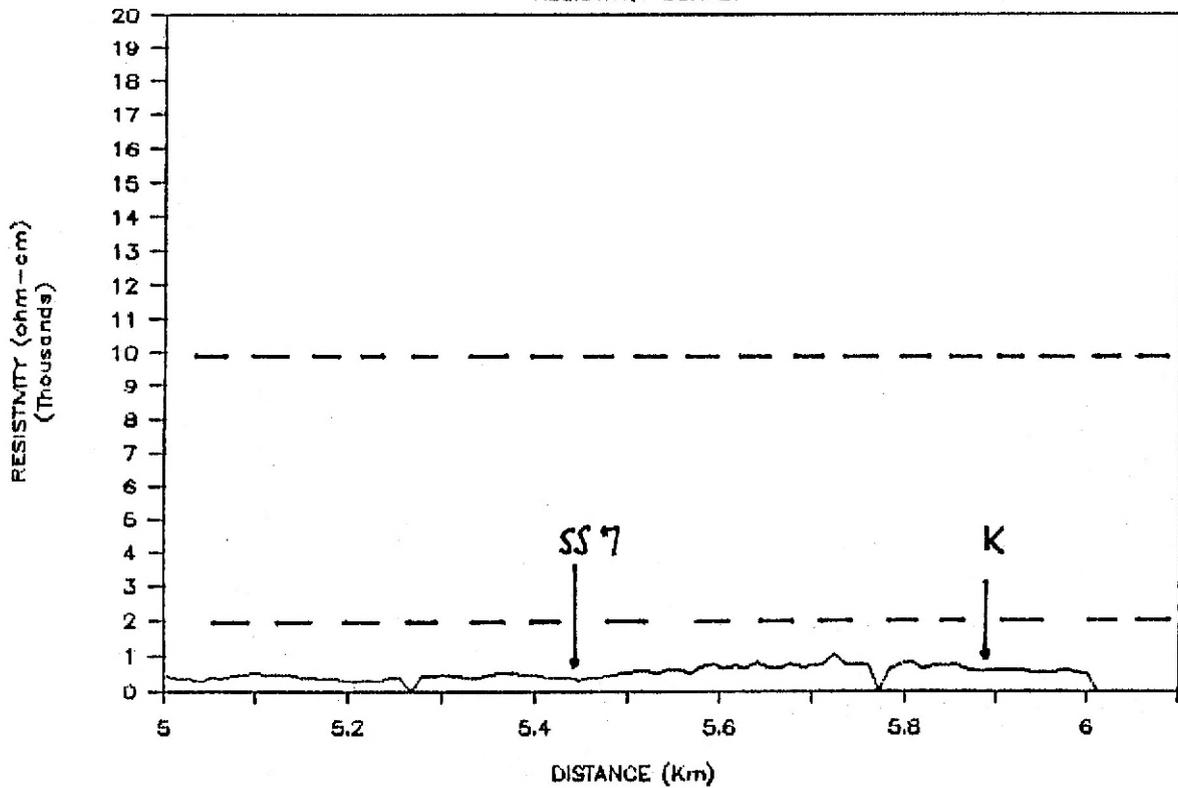
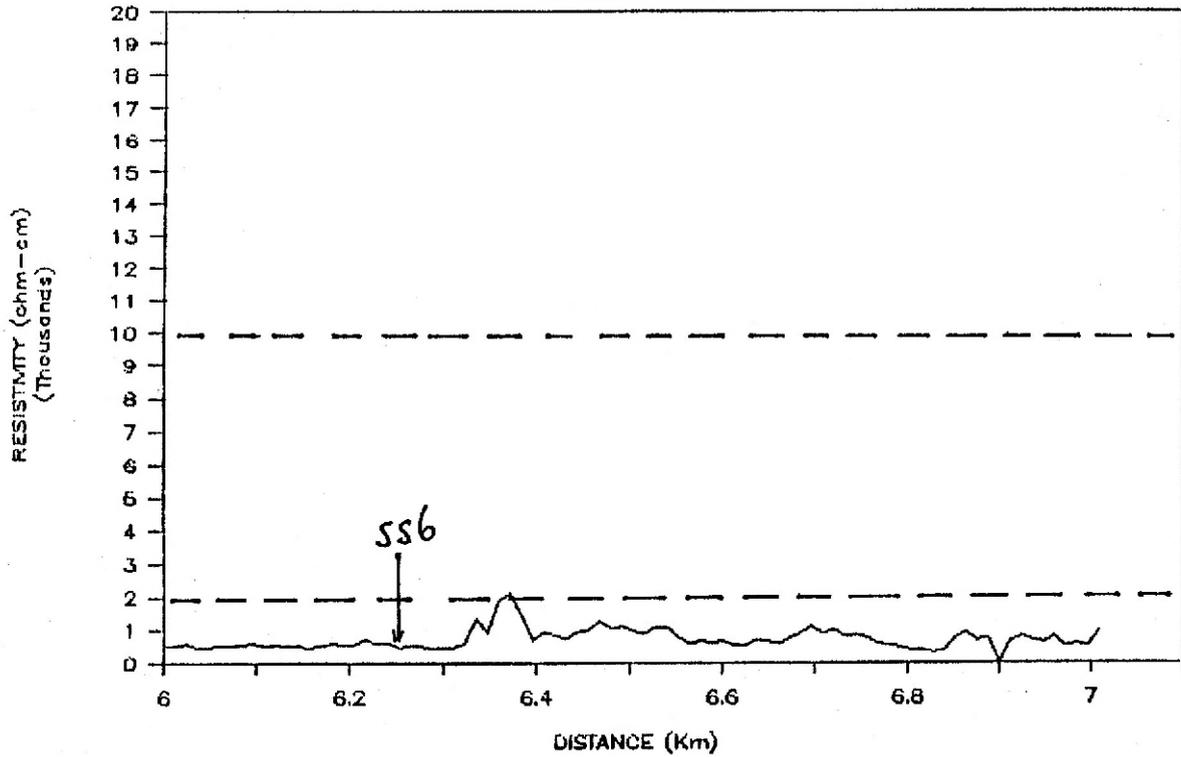


Figure 8

TEA TREE - RICHMOND PIPELINE

RESISTIVITY SURVEY



TEA TREE - RICHMOND PIPELINE

RESISTIVITY SURVEY

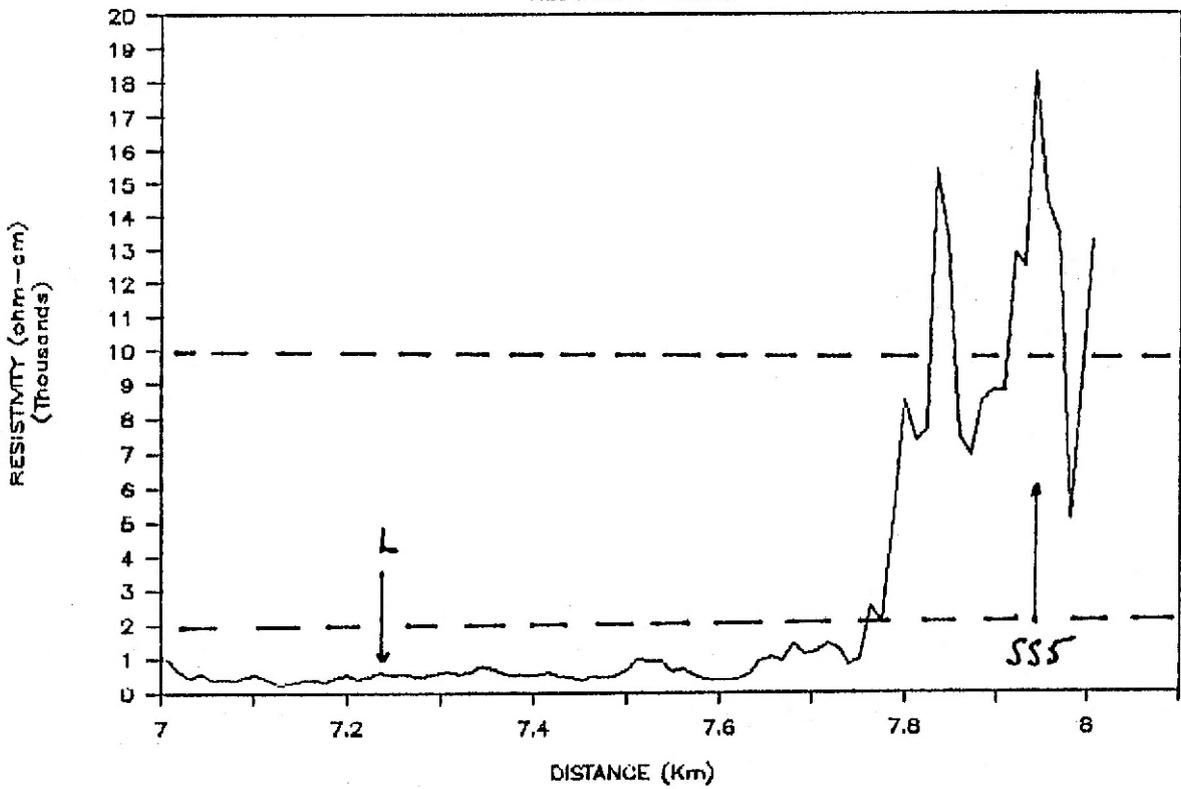
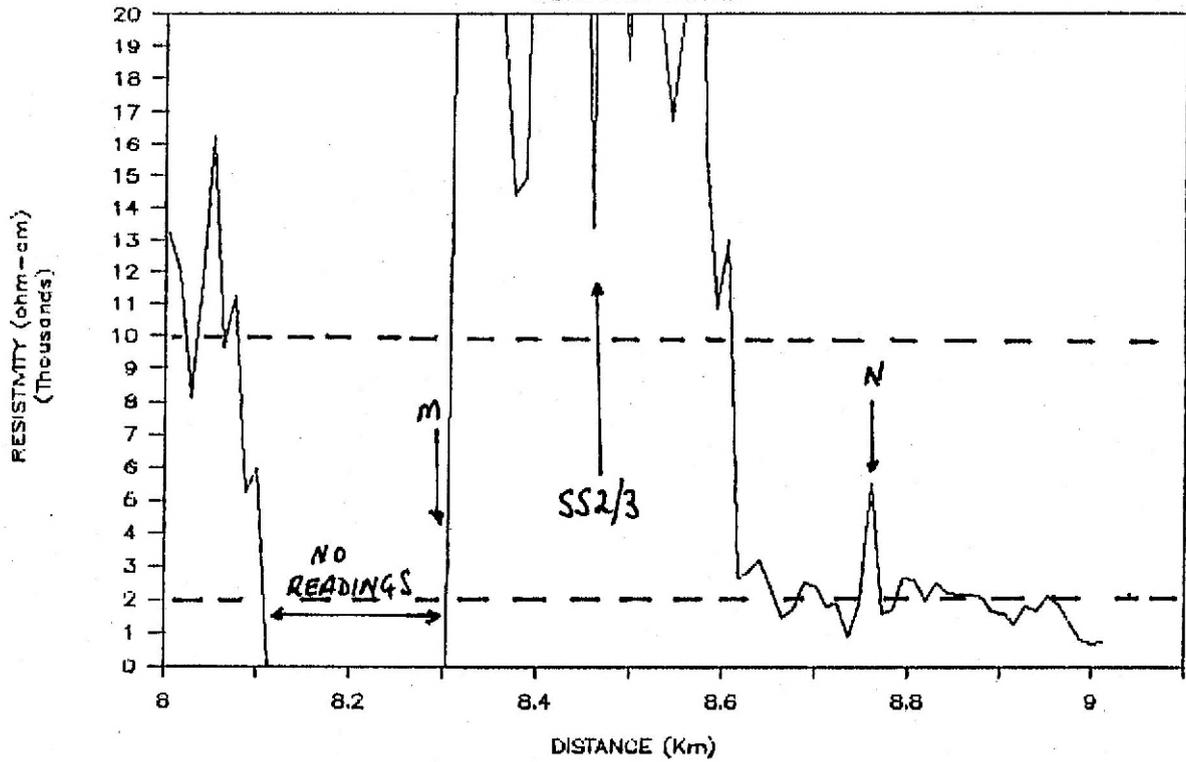


Figure 9

TEA TREE - RICHMOND PIPELINE

RESISTIVITY SURVEY



TEA TREE - RICHMOND PIPELINE

RESISTIVITY SURVEY

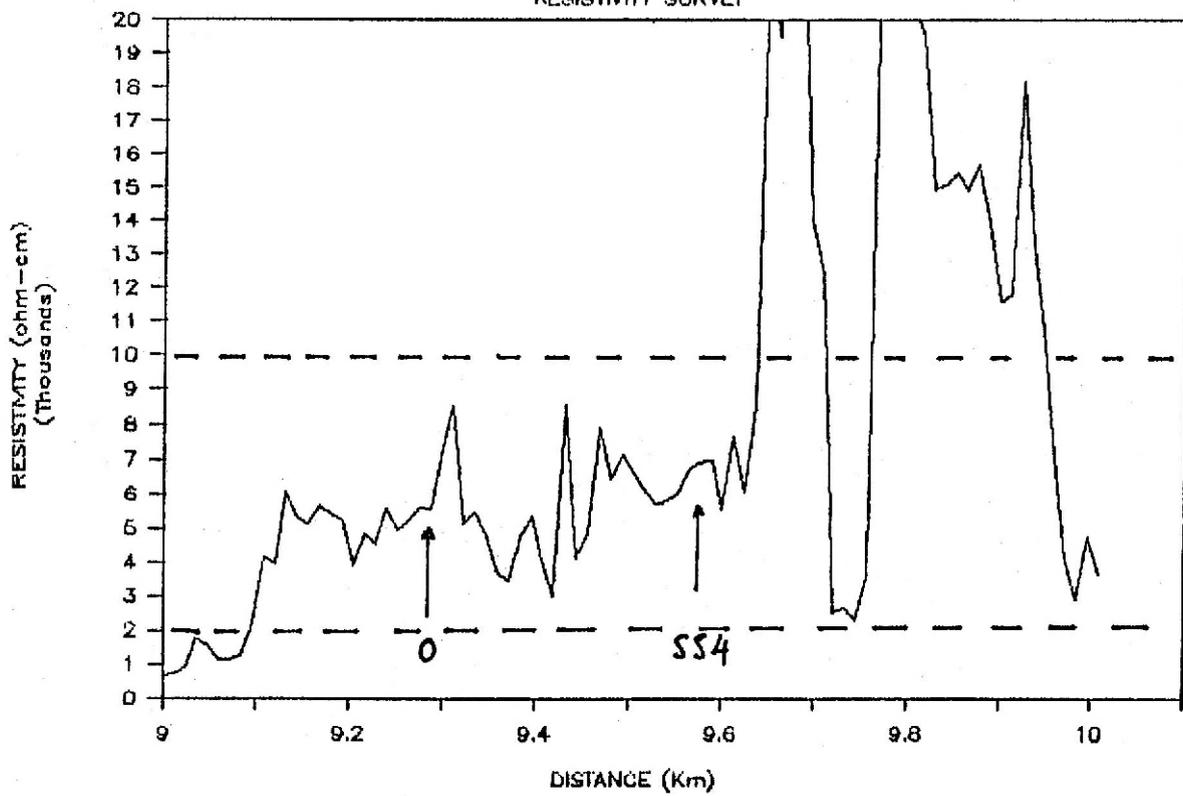


Figure 10

TEA TREE - RICHMOND PIPELINE

RESISTIVITY SURVEY

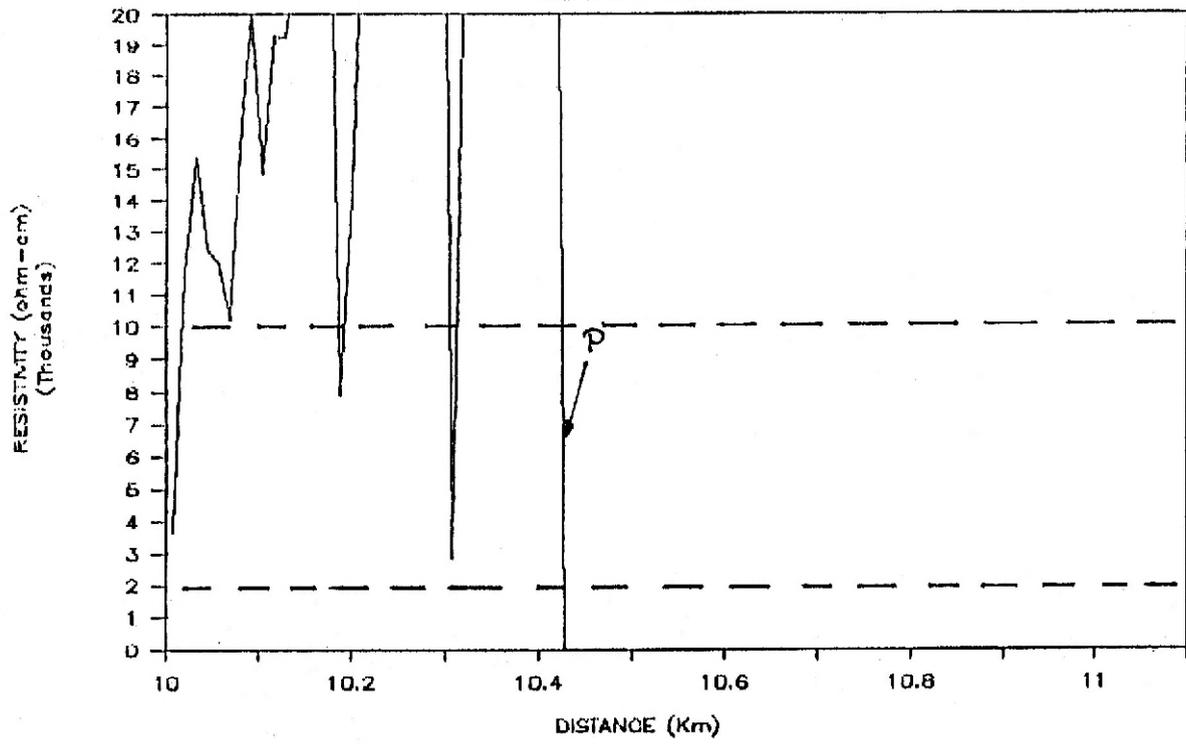
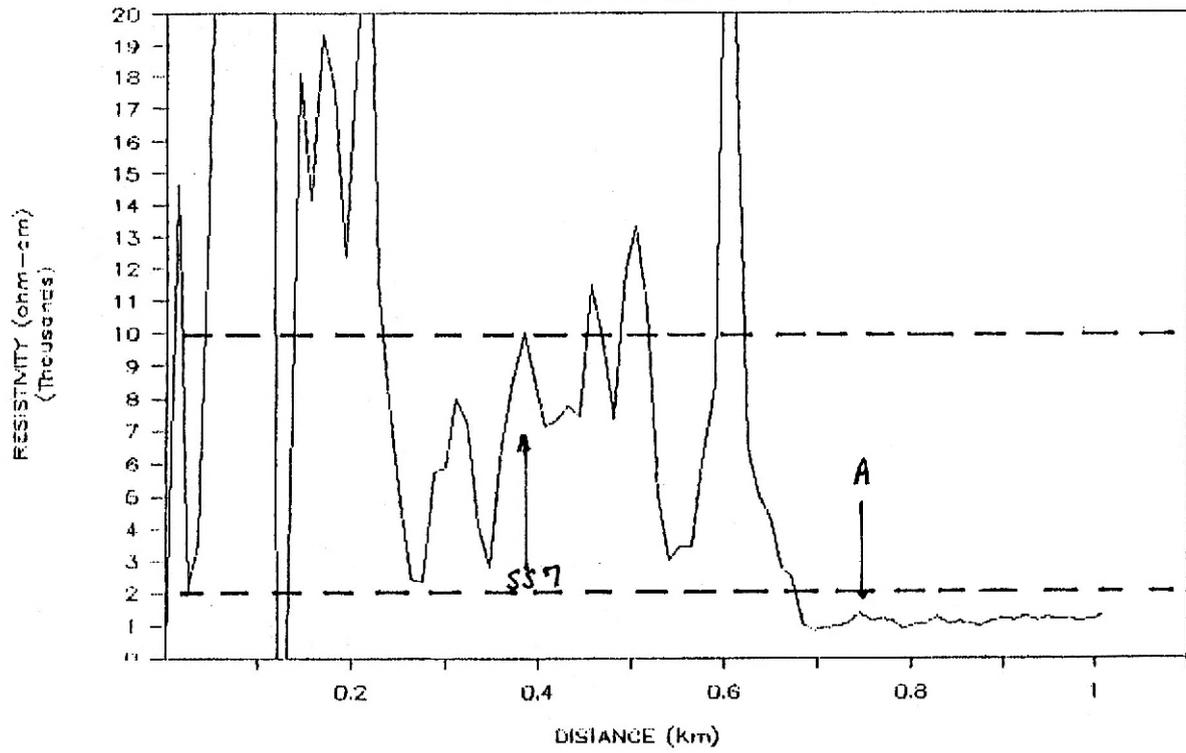


Figure 11

TEA TREE — CAMPANIA PIPELINE

RESISTIVITY SURVEY



TEA TREE — CAMPANIA PIPELINE

RESISTIVITY SURVEY

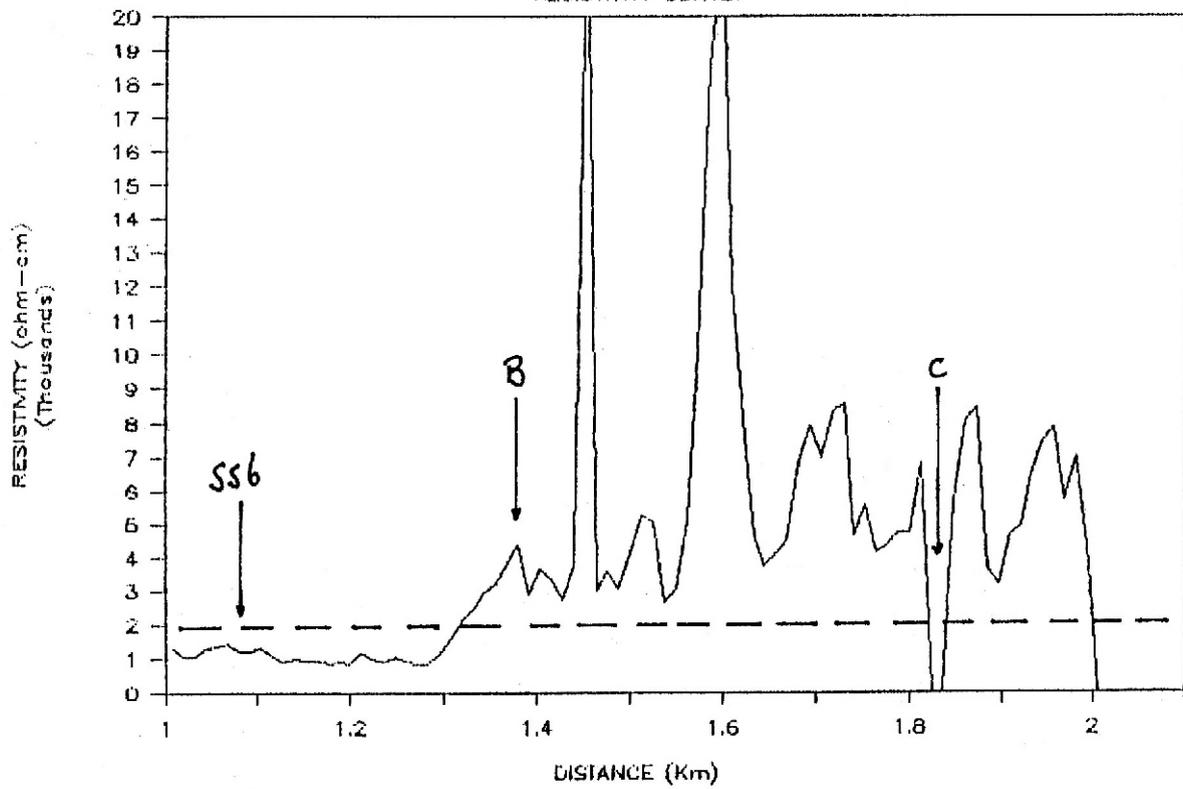
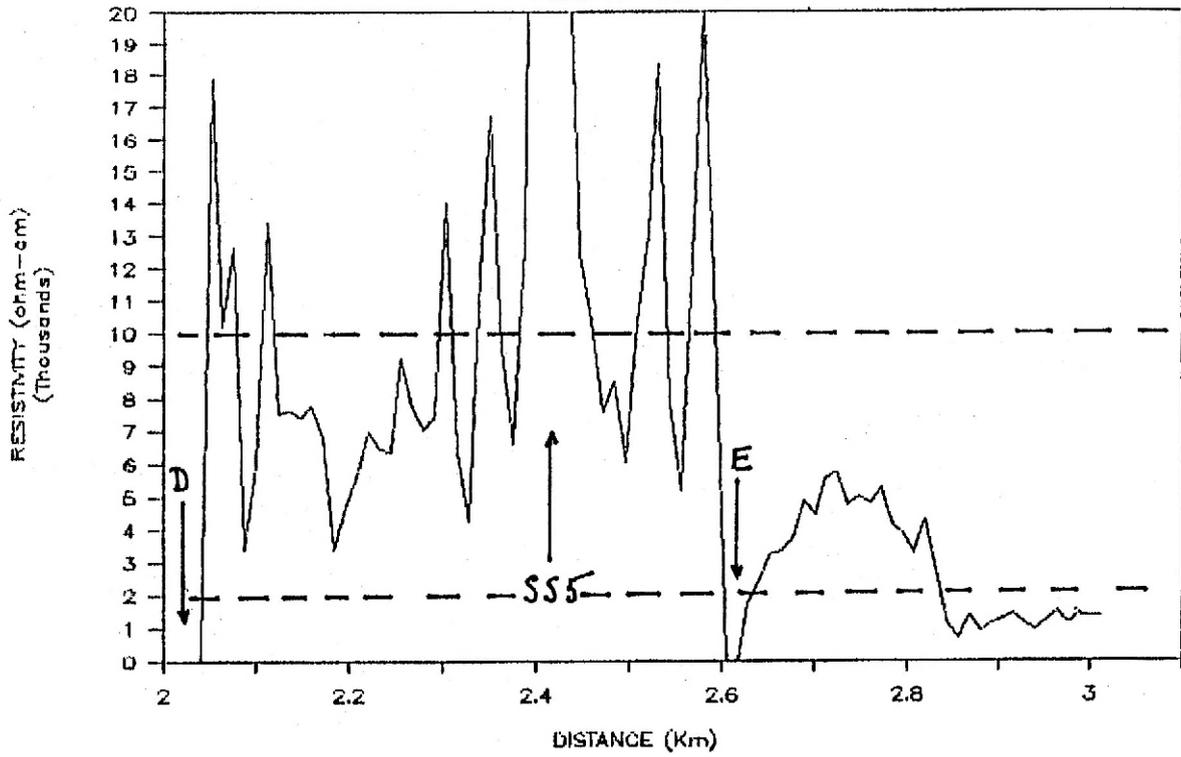


Figure 12

TEA TREE — CAMPANIA PIPELINE

RESISTIVITY SURVEY



TEA TREE — CAMPANIA

RESISTIVITY SURVEY

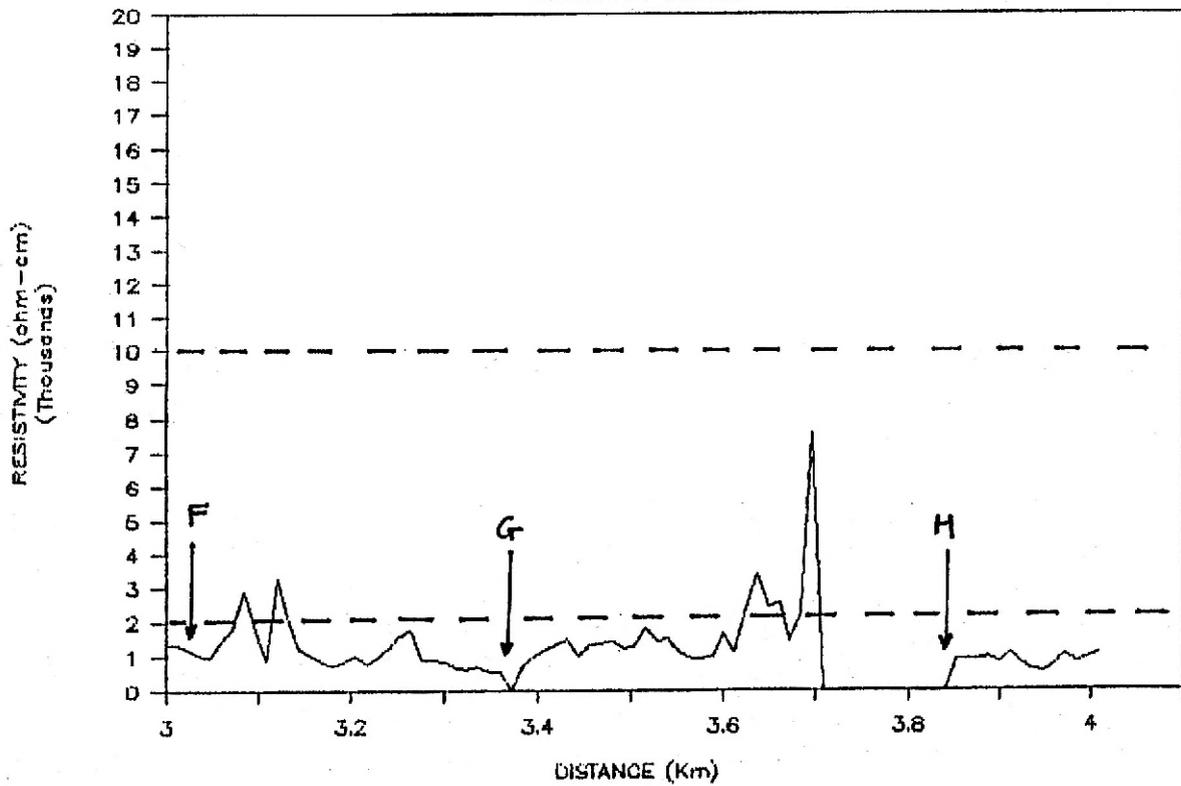
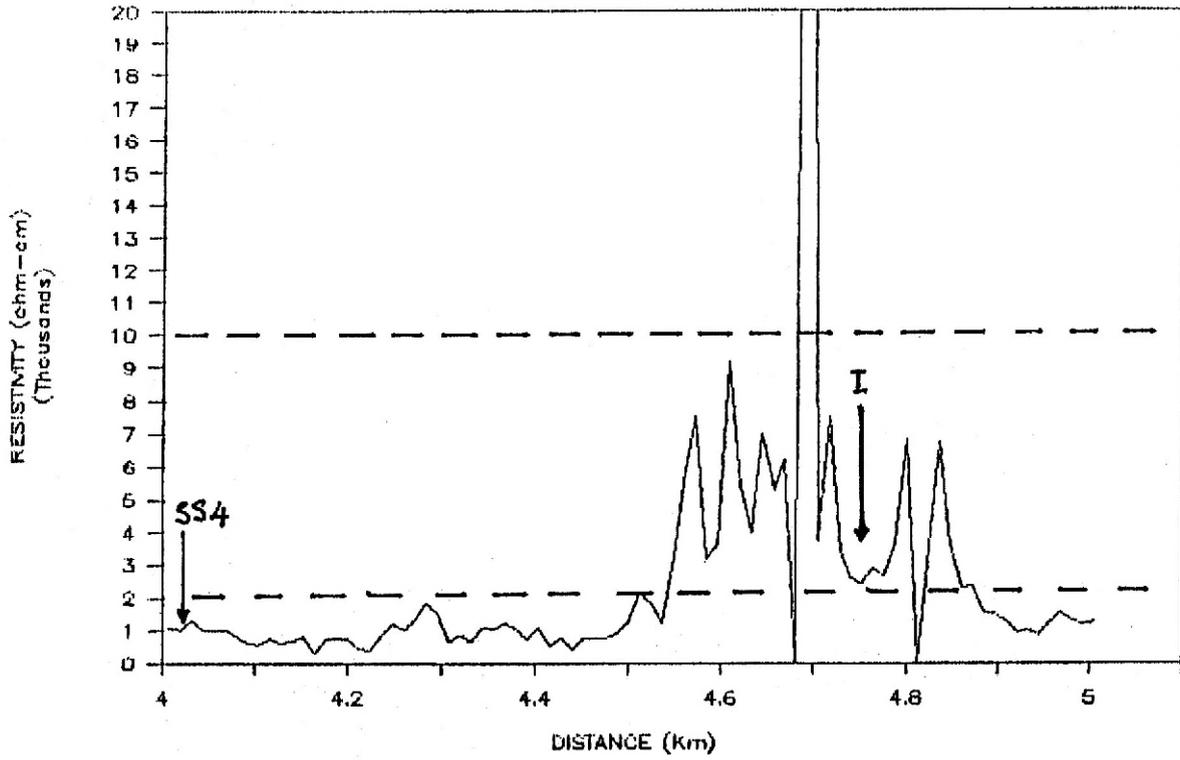


Figure 13

TEA TREE — CAMPANIA

RESISTIVITY SURVEY



TEA TREE — CAMPANIA

RESISTIVITY SURVEY

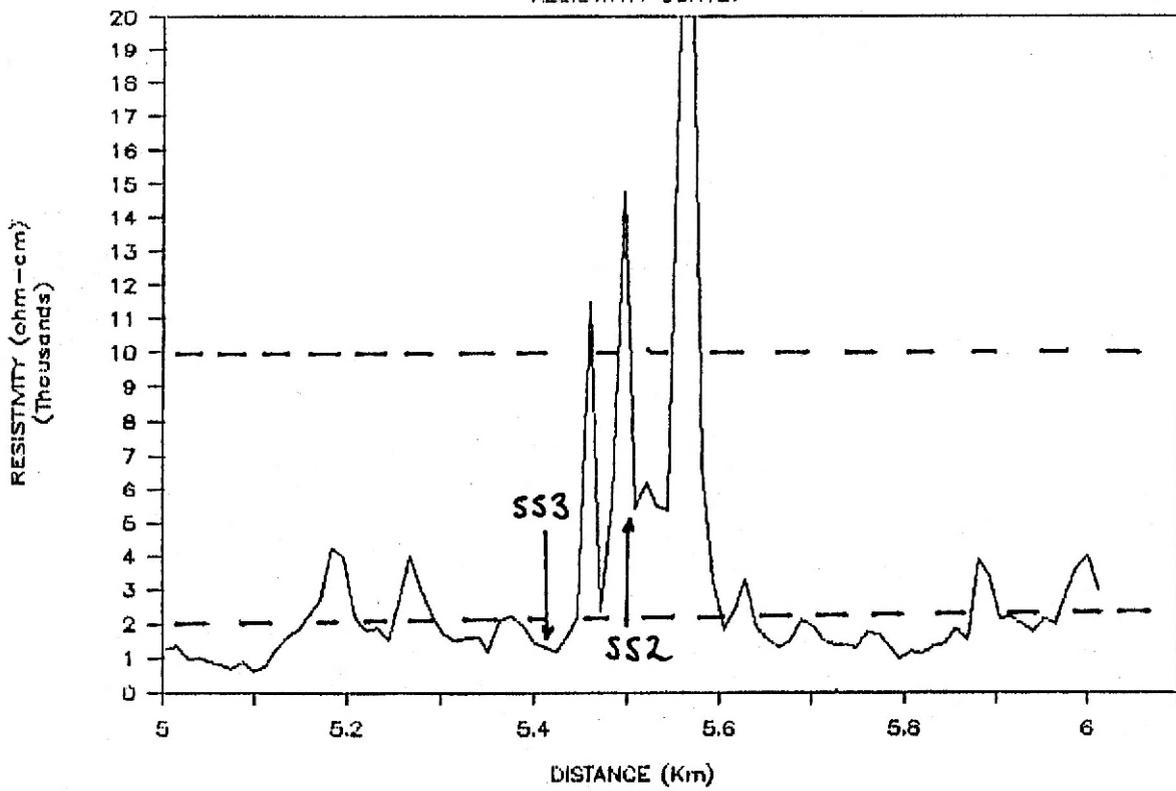
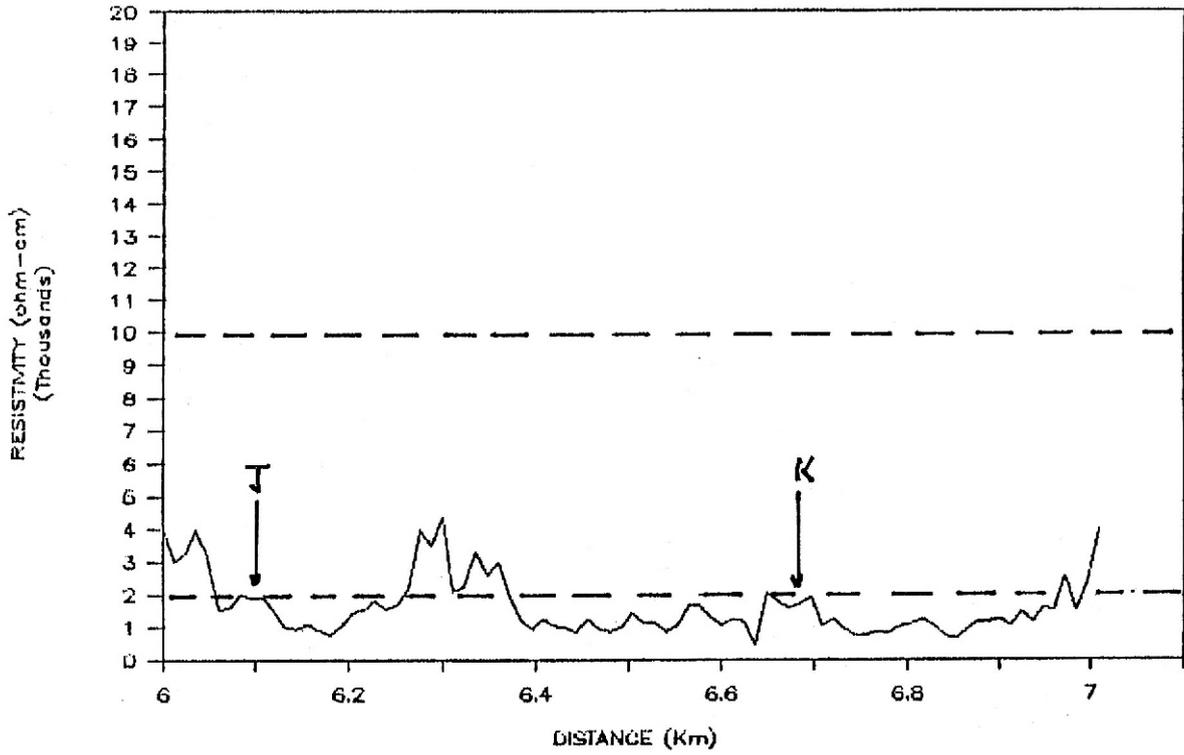


Figure 14

TEA TREE - CAMPANIA

RESISTIVITY SURVEY



TEA TREE - CAMPANIA

RESISTIVITY SURVEY

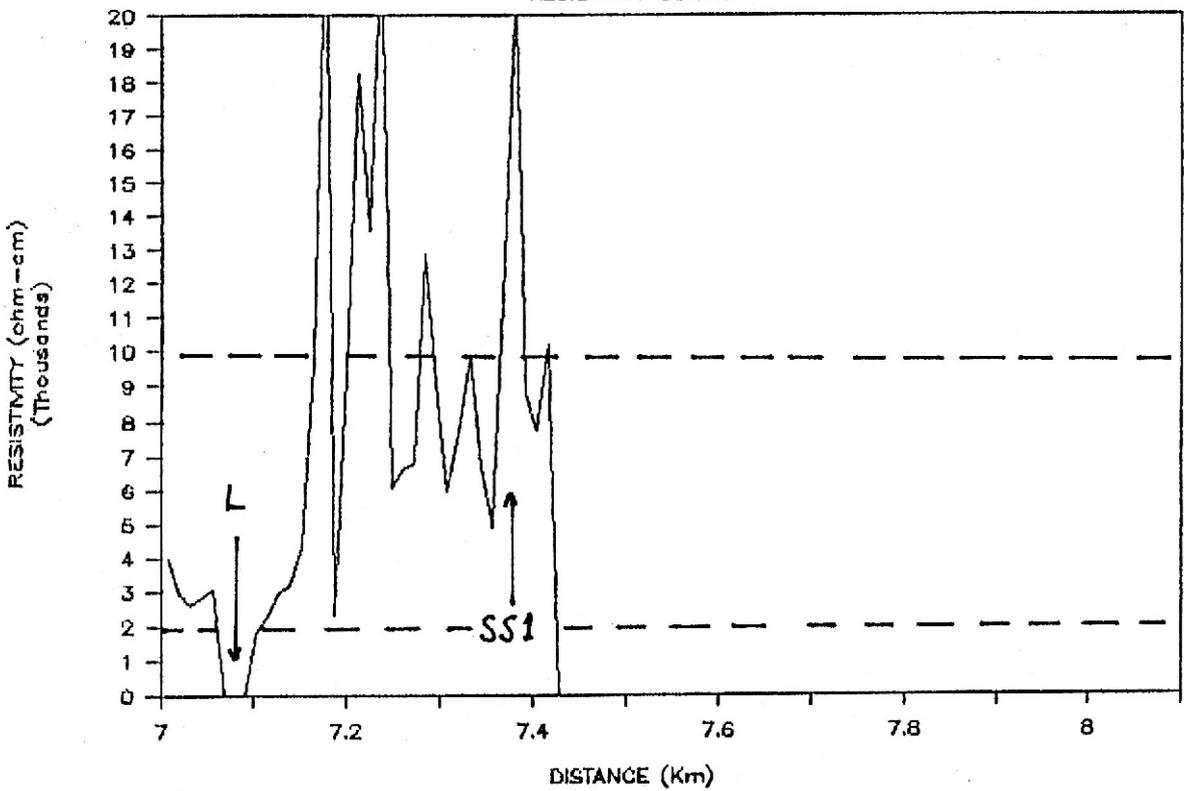
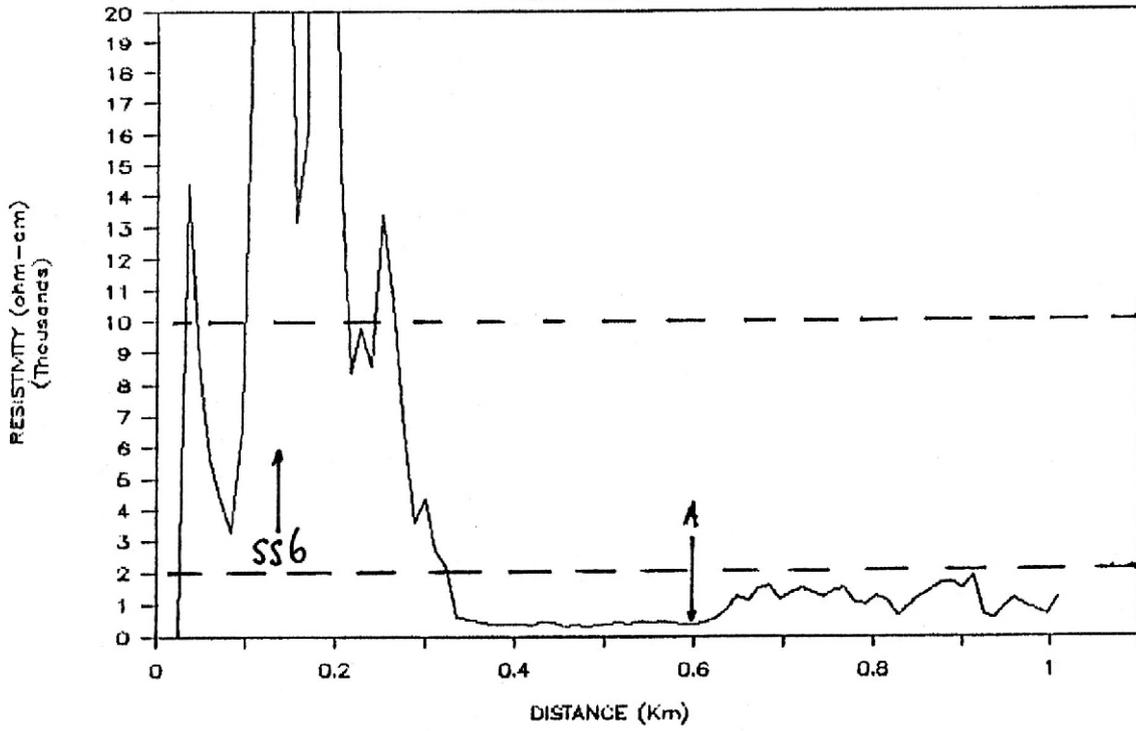


Figure 15

RICHMOND TO CAMPANIA

RESISTIVITY SURVEY



RICHMOND TO CAMPANIA

RESISTIVITY SURVEY

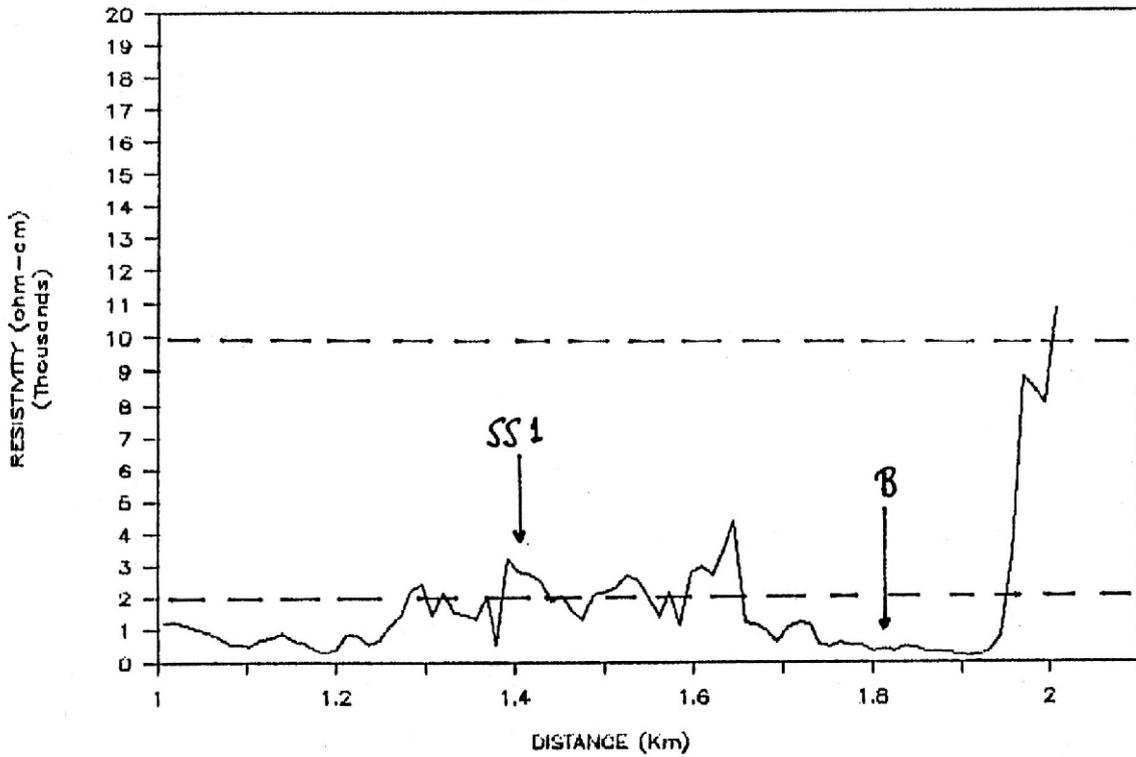
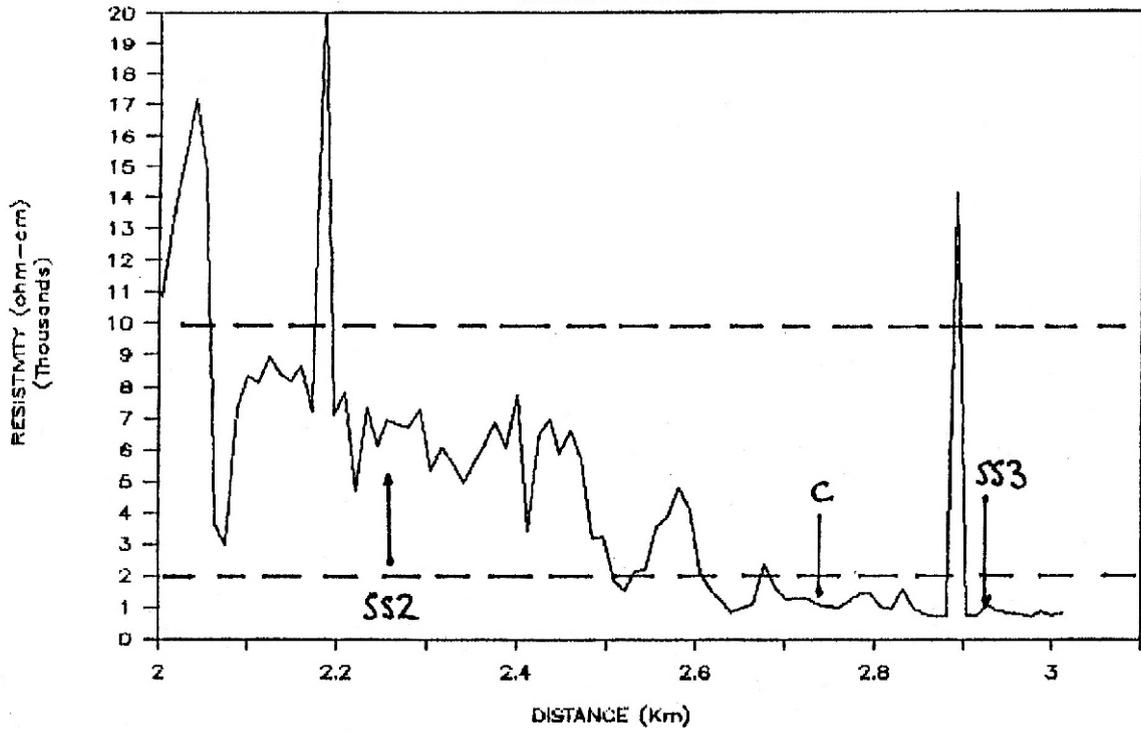


Figure 16

RICHMOND TO CAMPANIA

RESISTIVITY SURVEY



RICHMOND TO CAMPANIA

RESISTIVITY SURVEY

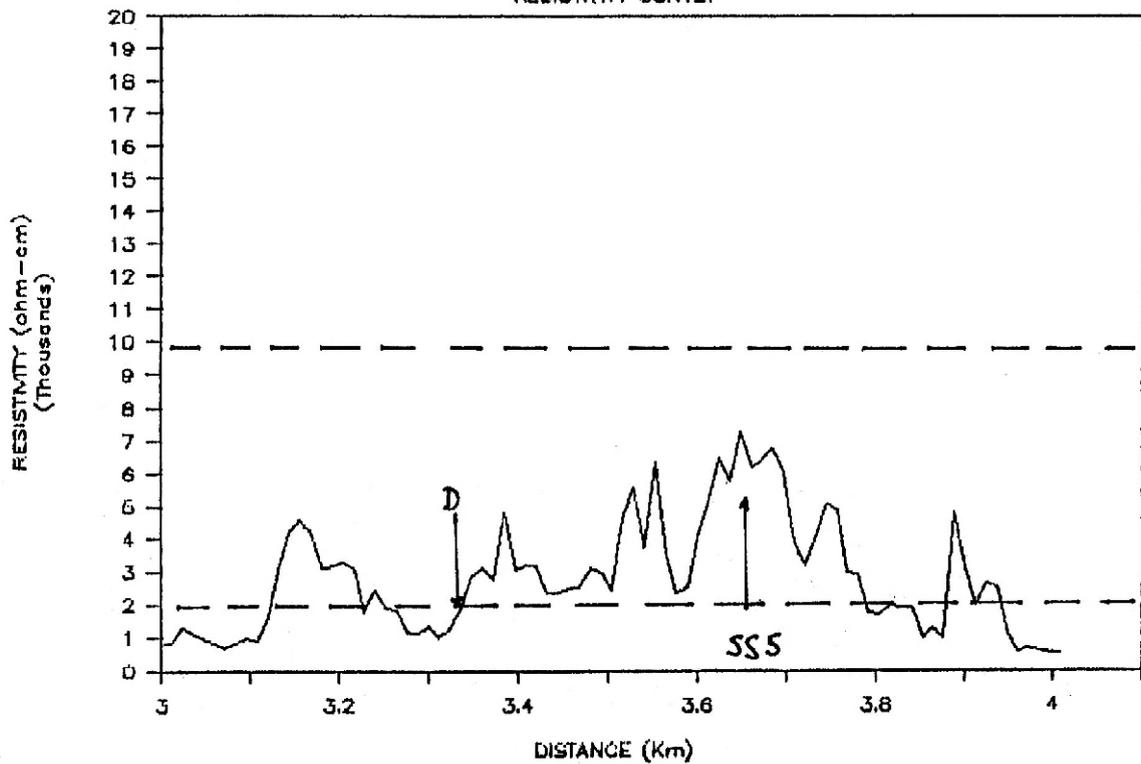


Figure 17

RICHMOND TO CAMPANIA

RESISTIVITY SURVEY

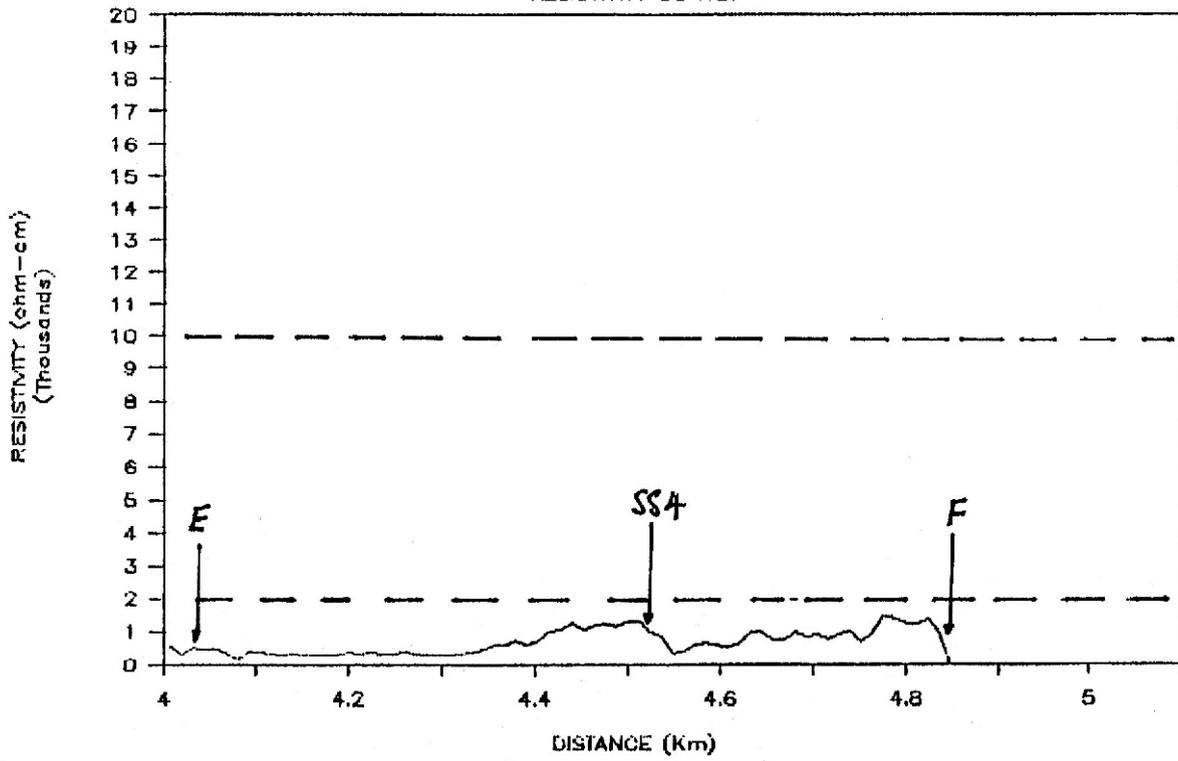


Figure 18