DEPARTMENT OF MINES AND ENERGY

SOUTH AUSTRALIA

REPORT BOOK 94/21

A TRANSIENT ELECTROMAGNETIC SURVEY AT TUMBY BAY, SOUTH AUSTRALIA

by

A R DODDS

GEOPHYSICIST

GROUNDWATER SECTION

AUGUST 1994

DME 255/91

G06520.SRD

CONTENTS **PAGE**

LIST OF FIGURES **PLAN NO.**

DEPARTMENT OF MINES AND ENERGY
GEOLOGICAL SURVEY
SOUTH AUSTRALIA

REPORT BOOK 94/21 DME NO. 255/91

A Transient Electromagnetic Survey at Tumby Bay, S.A.

A R Dodds

A Transient Electromagnetic survey was done over several locations at Tumby Bay to assist in dryland salinity problems. The surveys were useful in mapping subsurface saline groundwater and basement topography and indicated clear links between saline seeps and shallow basement.

INTRODUCTION

The area around Tumby Bay has a number of saline seeps, the largest of which, the Town Swamp, is located just outside Tumby Bay. The background is described fully in Pugh (1994). Goephysical methods were chosen to assist in analysing the subsurface geological environment of the seeps.

Transient Electromagnetic (TEM) measurements were taken along various traverses and at spot locations to map the subsurface resistivity and, indirectly, salinity distribution. The results are shown as resistivity sections which portray the ground resistivity variation with depth along each traverse. High resistivities (red) indicate basement or dry ground and low resistivities (blue) indicate high salinity. Low salinity groundwater is indicated by intermediate resistivity levels, but these can also be caused by lower porosity levels in, say, slightly weathered basement. There are no hard and fast rules relating resistivity to salinity, since there are too many other variables which can affect the relationship - porosity, saturation and clay content, for example.

RESULTS

In the discussion below the bold print picks out comments of general interest and can be read in isolation form the normal print, which covers more technical details.

Spot readings near the Town Swamp (Fig 2).

These readings were taken at various convenient locations around the Town Swamp area. Readings 1-3 were taken in a line between the swamp and the airstrip, and readings 4 and 5 to the west of these. Reading 6 was taken just north of the industrial estate and reading 7 further east towards the town. The last two readings were in an area showing surface salinity and little vegetation.

The results indicate that the worst of the salt is in the top 25 metres, and that it is present at all seven sites. At stations 3 and 5 there is more indication of less saline material in the top 10 metres, above the salt. As expected, the salt indicator (blue) comes closest to surface at stations 6 and 7, near the industrial estate.

Higher resistivities below 50 metres probably indicate lower porosities associated with weathered to fresh basement.

Conclusion

Salt water is present at all locations to a depth of 25 metres, but comes closest to surface at the Industrial Estate and near the swamp. Basement is 40-50 metres below surface.

Mine Creek. (Figure 3)

Conclusion

The apparent resistivities here are much higher, and have not been inverted. There is no sign of salt at any depth, and it is possible that there is little water. Certainly any water present must be of low salinity. Basement is not clearly identified.

Line B3 (Figure 4)

This line is located south of the swamp and the main access road to Tumby Bay. Readings were taken just far enough south of the road to avoid the effects of the houses, and extend from the main road 450 metres east.

The results show the saline groundwater at a depth of less than 10 metres on the east half of this line, dropping rather deeper at the west end, towards the main road. There is a layer of higher resistivity above the salt, particularly at the west end, indicating either unsaturated ground or fresher water. A large basement high extends to within 30 metres of surface over the eastern half of this line, and may be forcing the saline waters up to the shallower depths. A similar feature exists at 400m. It appears that basement topography is quite rugged.

Conclusion

Salt water is present all along the line, at depths from a metre or so to five metres. Vegetation probably reflects the closeness of salt to the surface. Basement is within 20 metres of surface under the shallow salt, and at least 100 metres down elsewhere. Shallow basement may be forcing the saline water closer to surface.

Line B4 (Figure 5)

This line is just north of the swamp, and extends from the swamp in the east to the highway in the west. The results are similar to B3, with basement extending to within 30 metres or less of surface in places and dropping out of sight at -300m. Saline waters appear to be continuous across most of the profile at a depth of 10 to 20 metres, generally with a lower salinity or less saturated zone nearer surface. Again the basement topography appears uneven, especially around -300m where it disappears below 100 metres depth. The break in the conductive saline layer at -200m is interesting and may indicate so me kind of blockage to the flow of saline groundwater. It does not appear resistive enough to be a basement high, unless it is weathered basement. The break in basement at -750m may be caused by deeper weathering, or perhaps a different rock type.

Conclusion

Saline groundwater is present at a depth of 5 metres all along this line, with a possible exception at -200m. It extends to 20 metres depth in most places, but to much greater depths at -250 to -350m. Basement is generally at a depth of 25 to 30 metres, but is over 100 metres deep in places.

Creek Salinity Assessment - Graham's Place. (Figures 6-8)

Three short traverses were done across a creek where there are spreading indications of salinity, one at the saline seep and two others upstream. These TEM data did not invert credibly, so the basic data is displayed. The east line over the seep clearly shows the low resistivities associated with salt at the north end of the line. It appears that basement shallows from north to south, but does not come close to surface. There is no indication of salinity at the south end of the line. To the west basement gets rather shallower on the centre line and much shallower on the west line, as indicated by the surface expression. There is some indication of salinity in shallow layers in both of these profiles, but the west line clearly indicates that this salinity does not come from the south, nor it is rising from depth. However, rising groundwater may cause it to move in from the north or west.

Conclusion

The seep area is closed off by shallowing basement to the south, but was not delimited to the north. The ground is nearly as conductive on the centre line, so saline water may be close to surface. On the west line basement is very shallow to the south of the creek and the only sign of salinity is at the extreme north end of the line. The saline

source would appear to be to the north and, possibly, east with a basement barrier to the south.

Traverse C0 - Figure 9

Conclusion

The traverse shows a simple picture of basement at a depth of 30-40 metres dropping off to the north. A continuous conductive layer at 15-30 metres probably indicates more saline water, with either unsaturated or less saline ground above. The 15 metre level could indicate the water table.

Traverse C3 (Figure 10)

This traverse runs around four sides of an open rectangle. 0 and -50m are over the saline seep, and show the shallow conductor. The 50 ohm-metre contour shows that probable weathered basement is within 20 metres of surface.

Stations -100m to -200 are on the south side of the creek, and show basement at a depth of some 50 metres, overlain by a conductor at a depth of 30 metres. The more resistive material above may be drier or less saline.

Stations -250m and -300m are over the creek and are subject to interference by fences. However, the indications of very shallow saline waters are clear and the shallow basement at 20-25 metres may be taken qualitatively at least.

Stations -350m to -550m extend along the north side of the creek, going east. Basement dips steadily to the east, with the saline waters sitting above it.

This picture indicates that the saline groundwaters are sitting on impervious basement and that the seep in controlled by basement topography. However, surface topography has not been taken into account here, and will probably affect the interpretation.

Conclusion

Basement is shallowest just north of the creek and west of the seep at 20 metres, dropping to 50 metres depth north and south of the seep. Under the seep it is also shallow at 20 metres or so, but perhaps weathered. Saline water is at a depth of 20 metres south and northeast of the seep, but close to surface northwest of the seep, where basement is shallow. Basement topography appears instrumental in pushing saline waters to surface.

Traverse C4, (Figure 11)

Stations 0m to -600m extend south over two saline seeps. 50m to 150m extend to the east.

The results are similar to C3, indicating saline waters at a depth of 5-30 metres generally controlled by basement topography. Saline seeps occur where impervious basement is closer to surface, at -50m to -100m and -500m to -600m.

Conclusion

Saline groundwater is present everywhere at a depth of 5-10 metres. Basement highs are evident on the south side of each seep, pushing the saline water up to surface, and also to the northeast of the north seep, indicating a northeast strike for this basement high. It is probable that basement is rarely more than 30 metres deep at this location, the exception being 250 metres south of the north seep.

Traverse C5, (Figure 12)

Conclusion

Basement is shallow on all of this line, varying from 20 to 50 metres. The salt scald at -300m and -350m is marked by very shallow conductive material. A similar shallow conductor at -100m and -150m, where no indications of salinity were seen, indicates a danger area for future scalds, if the groundwater continues to rise. These are again coincident with basement highs or, perhaps, topographic lows.

SUMMARY

The surveys indicate general conclusions about salinity problems in this area. Saline groundwater appears to be widespread in the areas where seeps occur, but is currently too deep to be a problem to vegetation. The locations of seeps coincide with areas of shallow impermeable basement, and it seems clear that there is an association between the two, probably the shallow basement forcing saline groundwater to the surface in topographically low areas.

A full regional understanding of the salinity problem would be achieved by:

comprehensively mapping saline areas to depths of 50 metres or so. This could be done by airborne or ground EM techniques.

mapping basement topography. This would also be shown by airborne or ground EM surveys, but a study of existing airborne magnetic surveys could help.

combining the above with surface topographic information to outline areas where surface topographic lows coincide with basement topographic highs and a saline source.

Such a program would be very expensive (perhaps $50,000), but appears the best way to tackle the total problem. However, airborne EM and magnetics were flown over this area in 1973, and these data are now available to the public at MESA. While not as good as could be achieved today, these data should, with analysis and in combination with other data, give a good indication of the distribution of basement highs and accumulations of saline groundwater over most of the area. Such an analysis would not cost more than $2,000 at most. It could be followed by ground TEM aimed at specific targets selected during the analysis as critical points. Such ground follow-up work could be done when people and equipment are available, at modest cost.

REFERENCE

Pugh S. Report Book 94/20.

APPENDIX A

Transient Electromagnetic (TEM) Survey Specifications.

The TEM method causes eddy currents to flow in the ground by passing a current through a transmitter loop and terminating it abruptly. The distribution and strength of the eddy currents is monitored by a receiver loop.

Loop configuration

Transmitter loop size:	50 metres
Transmitter loop orientation:	Horizontal
Receiver loop size:	50 metres
Receiver loop orientation:	Horizontal
Configuration:	Single Loop
Station Interval:	50 metres

Instrument settings

Ramp Time	100 usecs
Delay Times	SIROTEM Early Times
Stacking	512
Gain	1

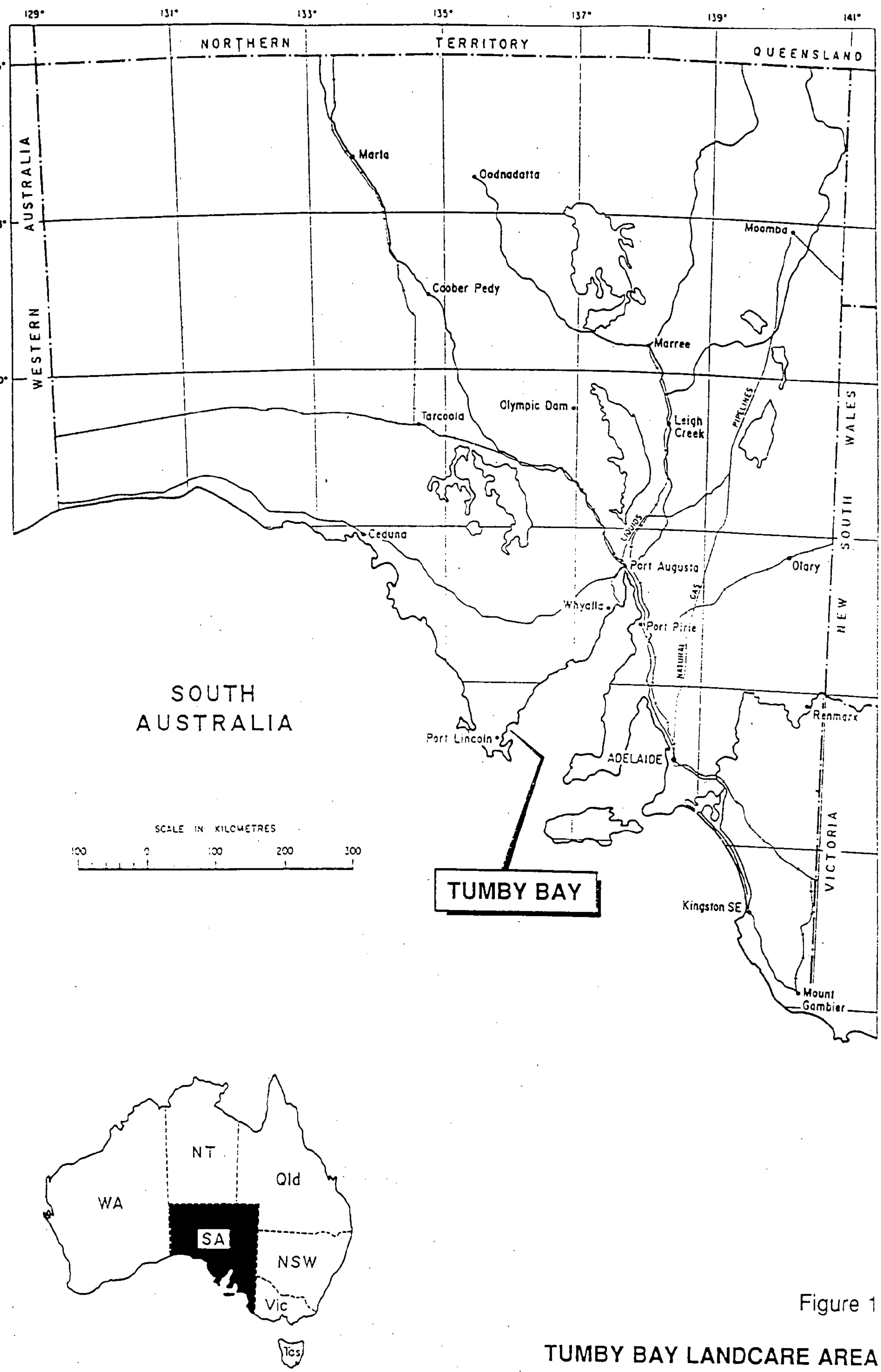


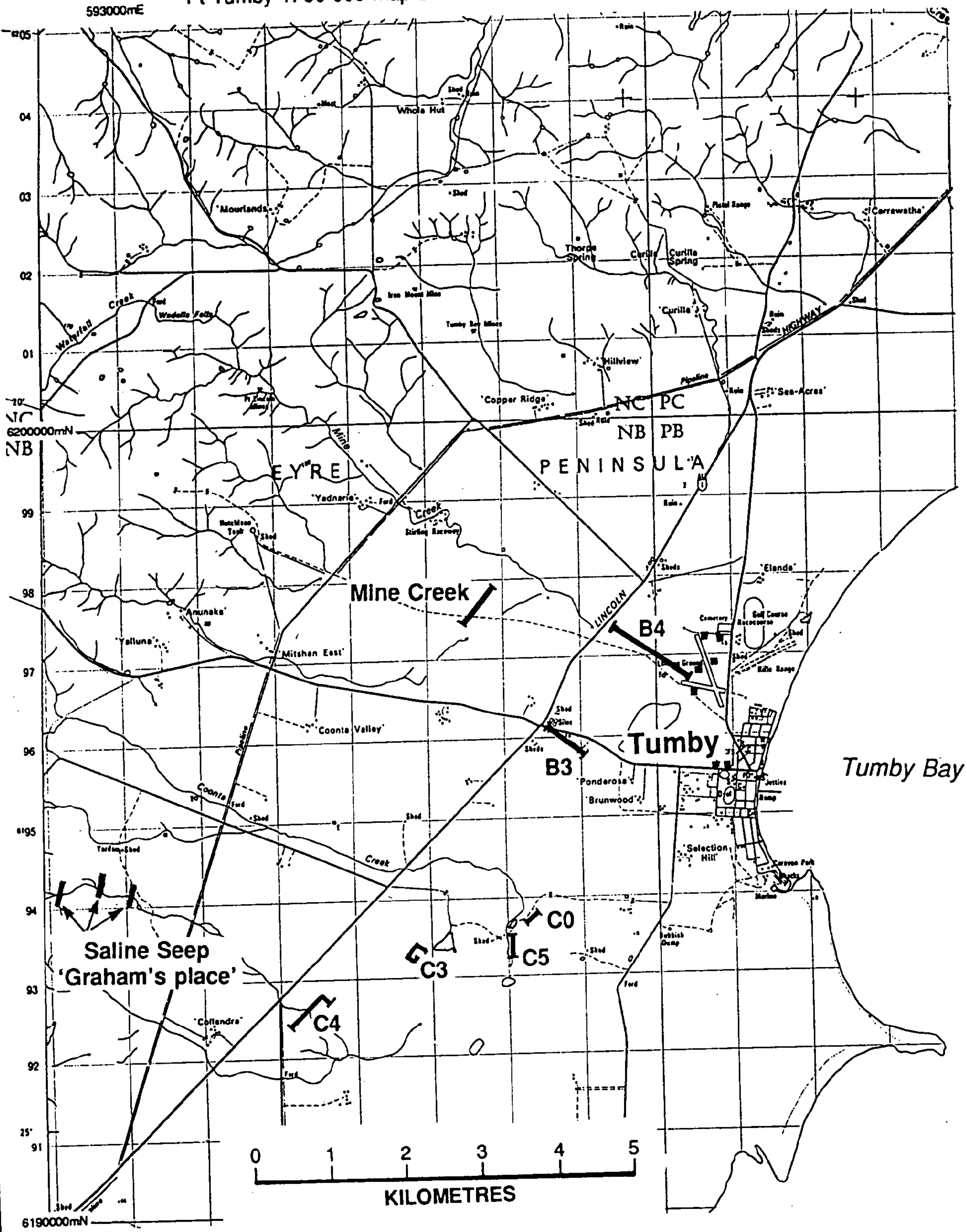
Figure 1 A

TUMBY BAY LANDCARE AREA LOCALITY PLAN

MINES AND ENERGY SOUTH AUSTRALIA

94-600

Pt Tumby 1: 50 000 map sheet 6129-III



Sirotem survey line . . . . ⊢——⊣

Spot readings . . . . ▪

Figure 1B

TUMBY BAY LANDCARE AREA
LOCATION OF SIROTEM SURVEY

MINES AND ENERGY
SOUTH AUSTRALIA

94-799

TUMBY BAY SALINITY STUDY - SPOT READINGS NEAR TOWN SWAMP
Resistivity Sections from Inversion

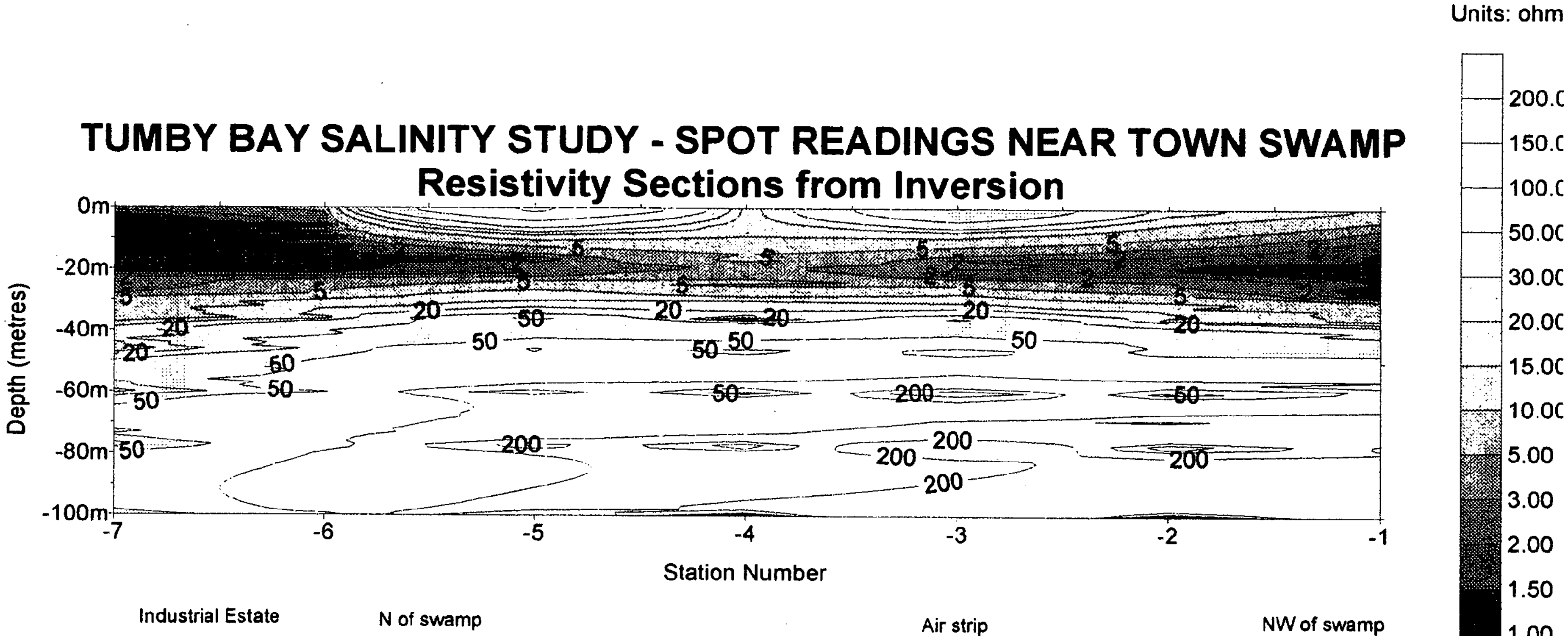
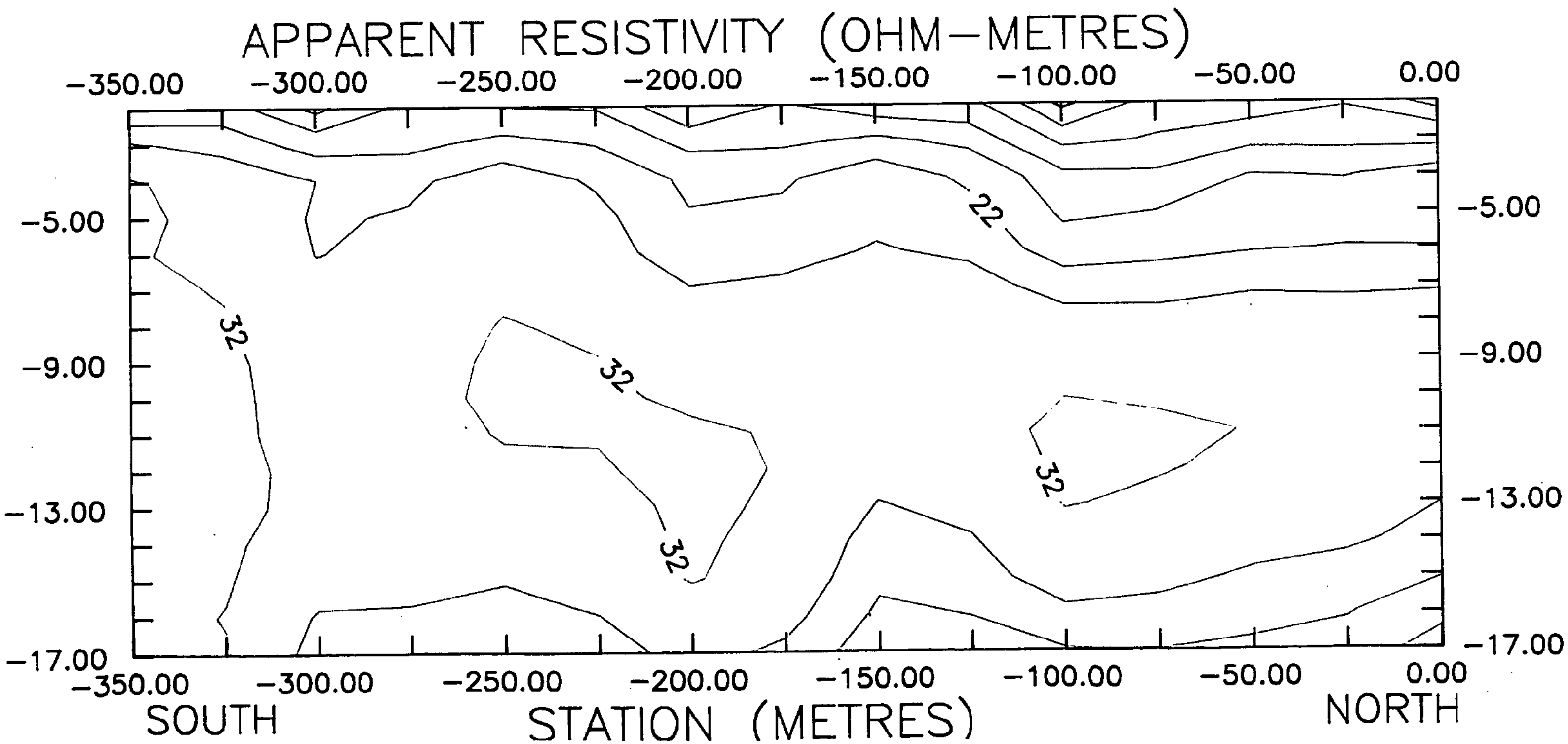


Figure 2

6129-a010

SALINITY ASSESSMENT – MINE CREEK



TUMBY BAY SALINITY STUDY
RESISTIVITY SECTION - LINE B3

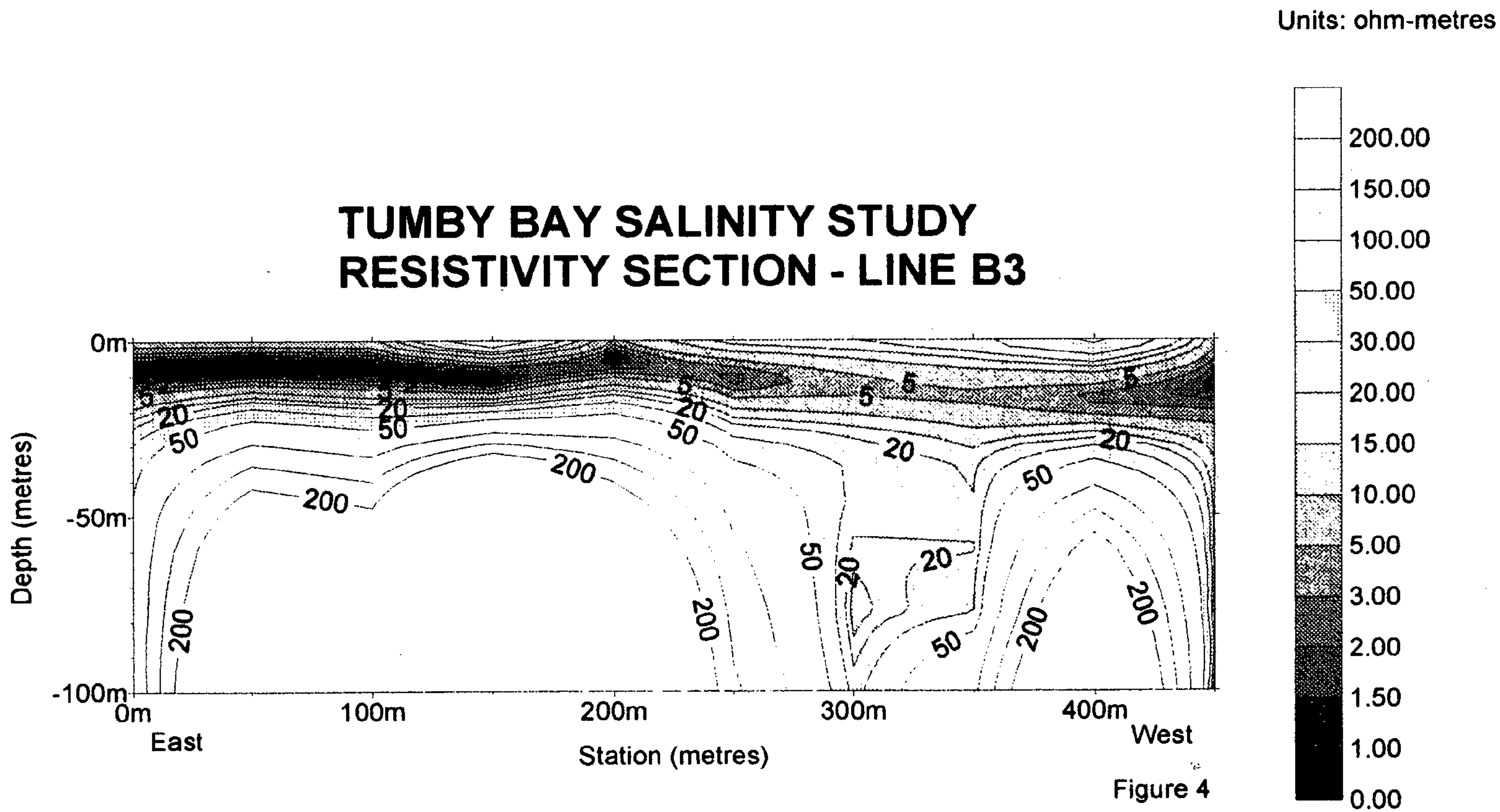


Figure 4

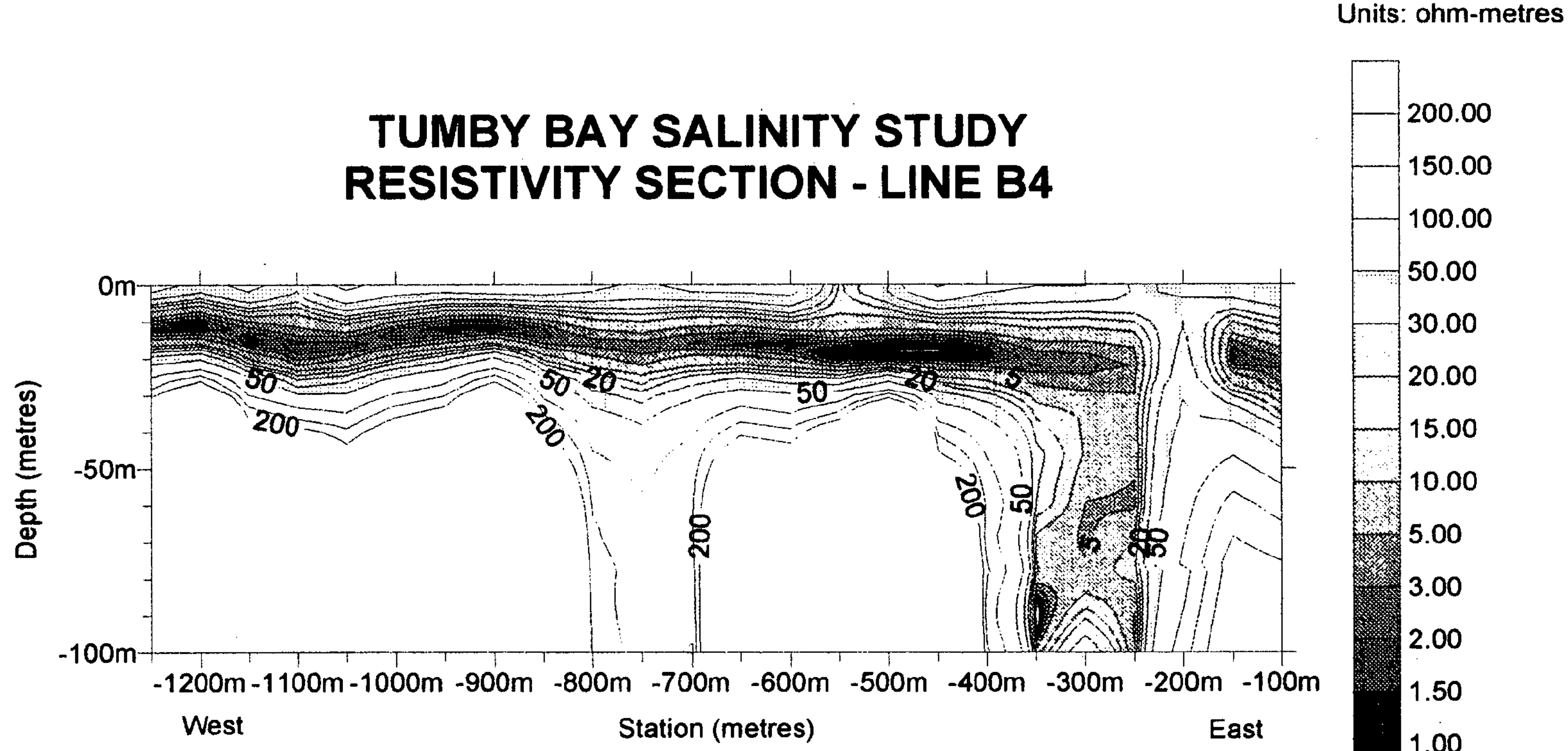
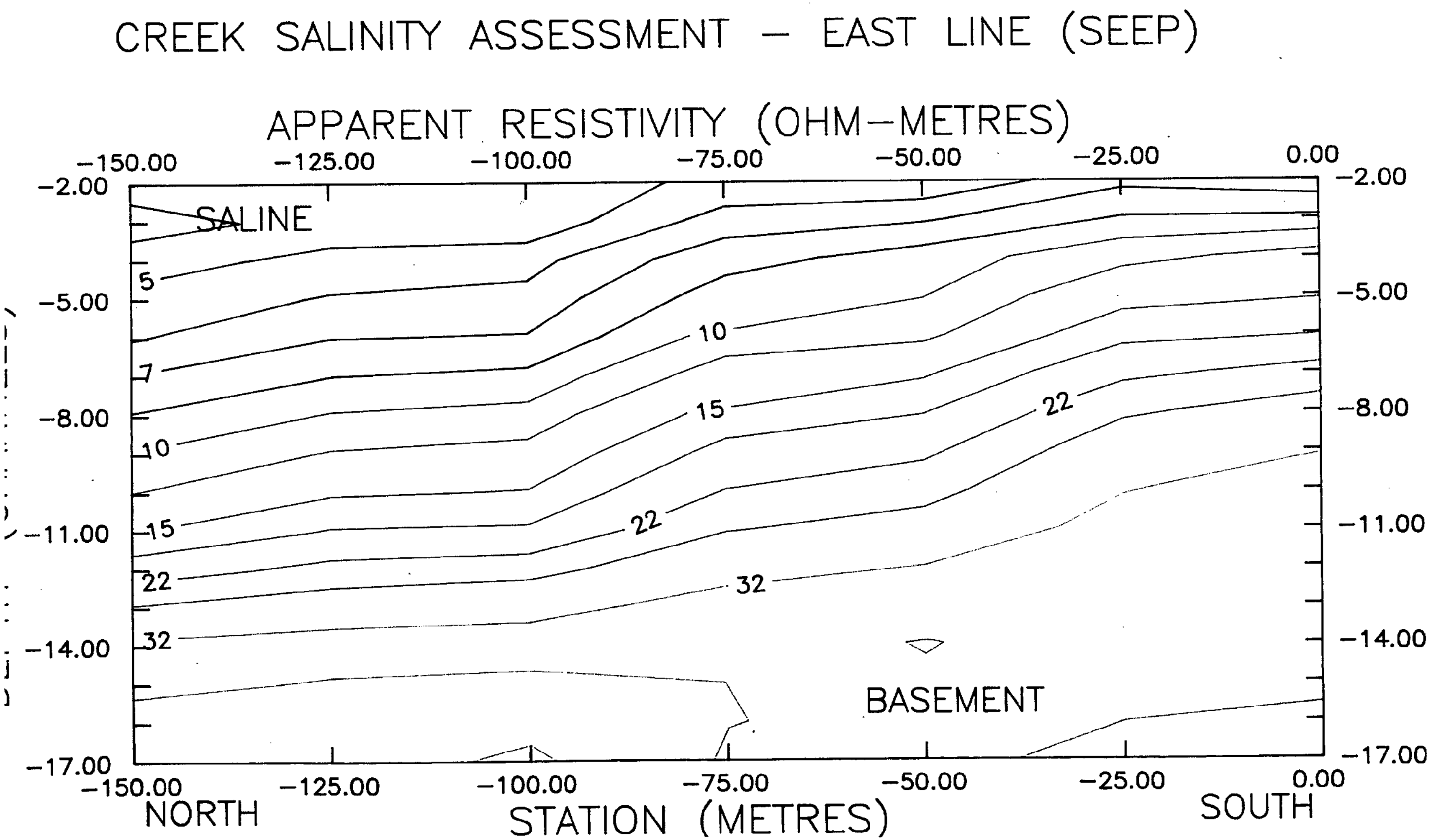

Units: ohm-metres
TUMBY BAY SALINITY STUDY
RESISTIVITY SECTION - LINE B4
0m
-50m
-100m
Depth (metres)
-1200m
-1100m
-1000m
-900m
-800m
-700m
-600m
-500m
-400m
-300m
-200m
-100m
West
Station (metres)
East
50
200
50
20
200
50
20
5
200
200
50
5
20
50
200.00
150.00
100.00
50.00
30.00
20.00
15.00
10.00
5.00
3.00
2.00
1.50
1.00
0.00

Figure 5

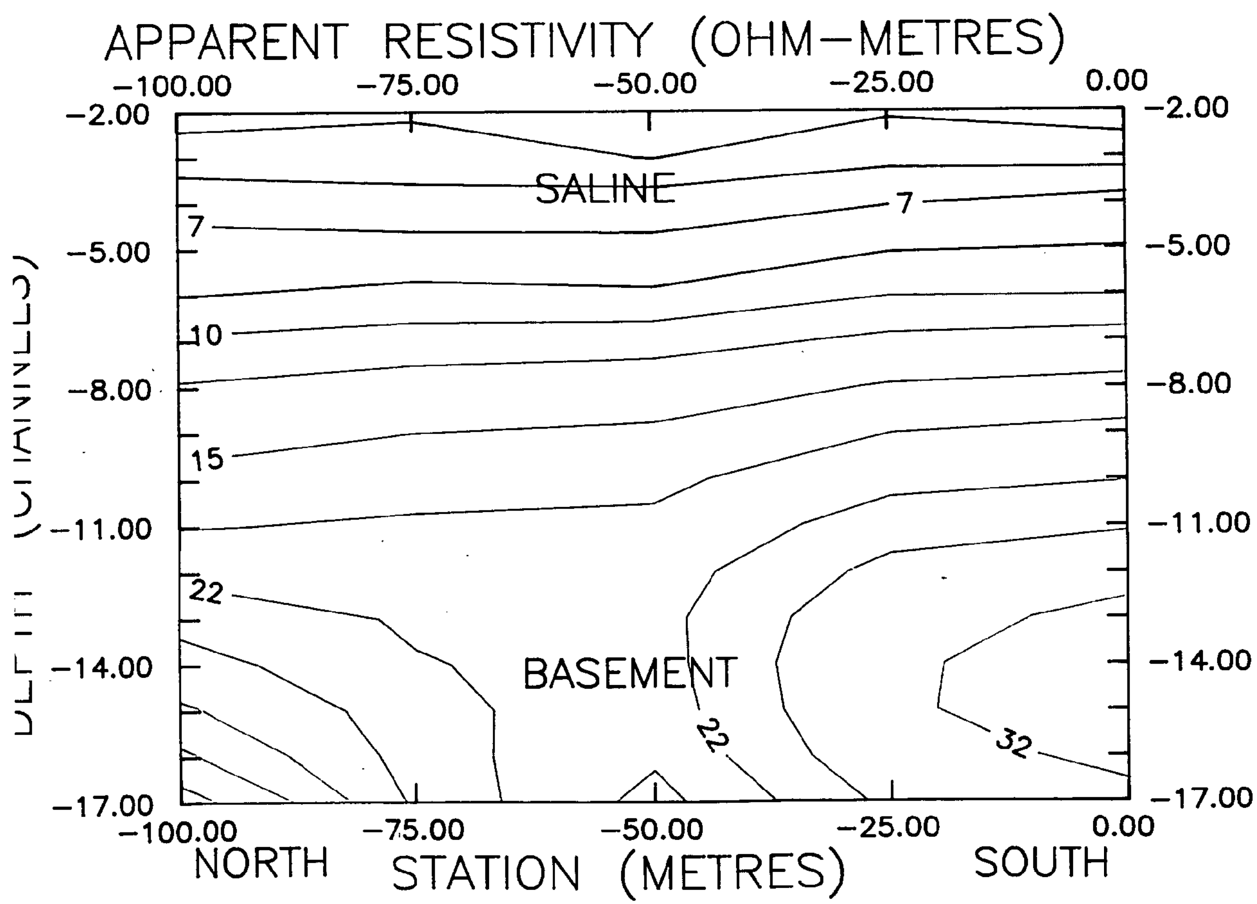
6129-a003.



CREEK SALINITY ASSESSMENT – EAST LINE (SEEP)
APPARENT RESISTIVITY (OHM–METRES)
–150.00
–125.00
–100.00
–75.00
–50.00
–25.00
0.00
–2.00
–5.00
–8.00
–11.00
–14.00
–17.00
SALINE
5
7
10
15
22
32
BASEMENT
NORTH
STATION (METRES)
SOUTH

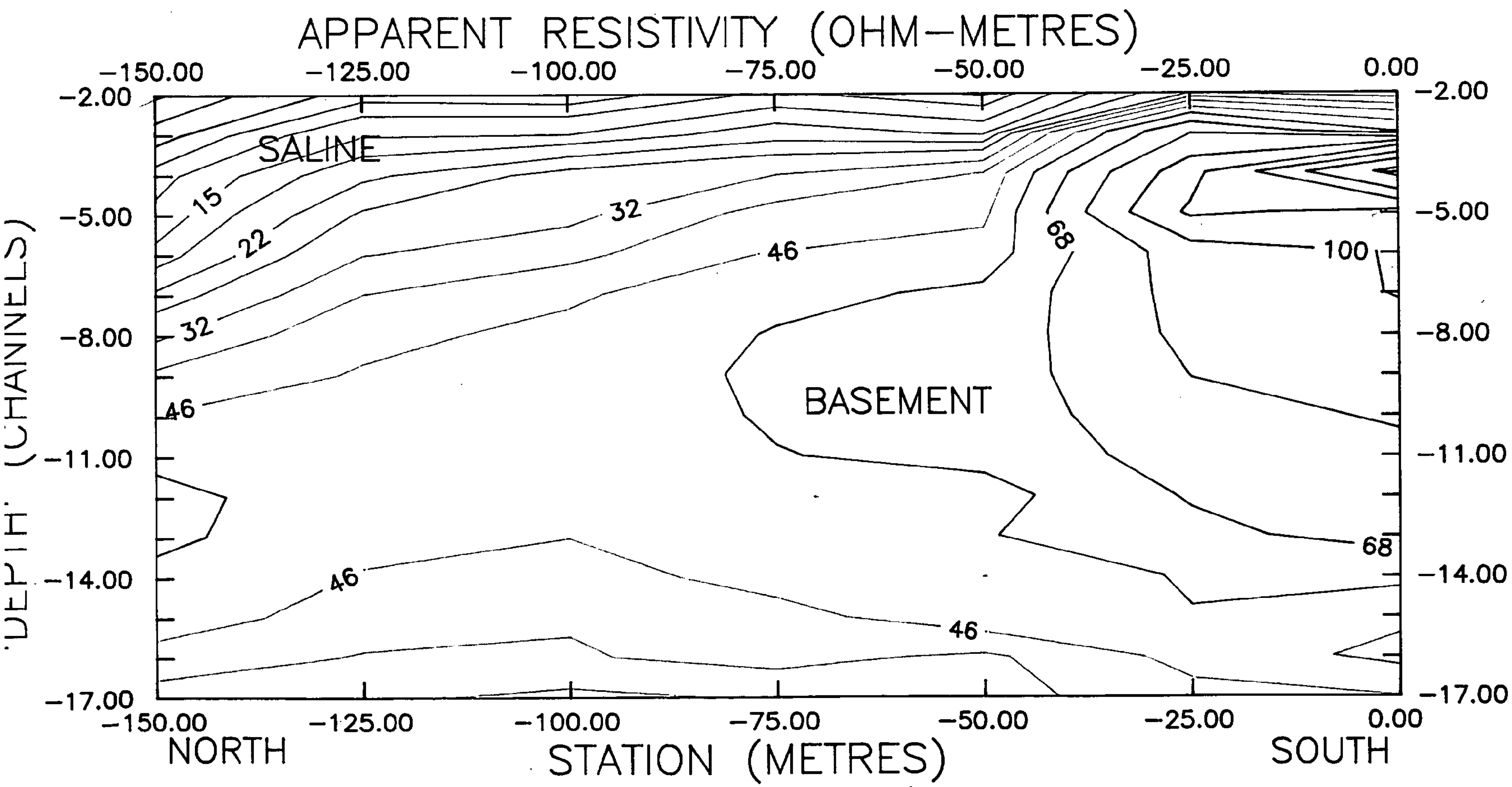
6129-a002

CREEK SALINITY ASSESSMENT – CENTRE LINE



6129 - a 001

CREEK SALINITY ASSESSMENT — WEST LINE



TUMBY BAY SALINITY STUDY - C0
RESISTIVITY SECTION FROM INVERSION

Units: ohm-metres

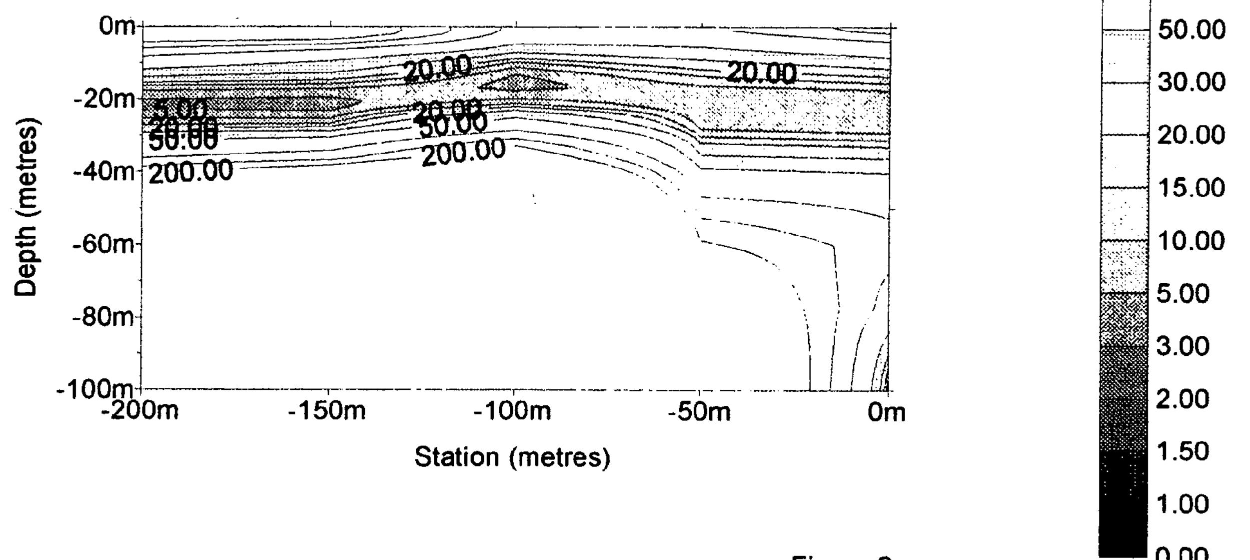


Figure 9

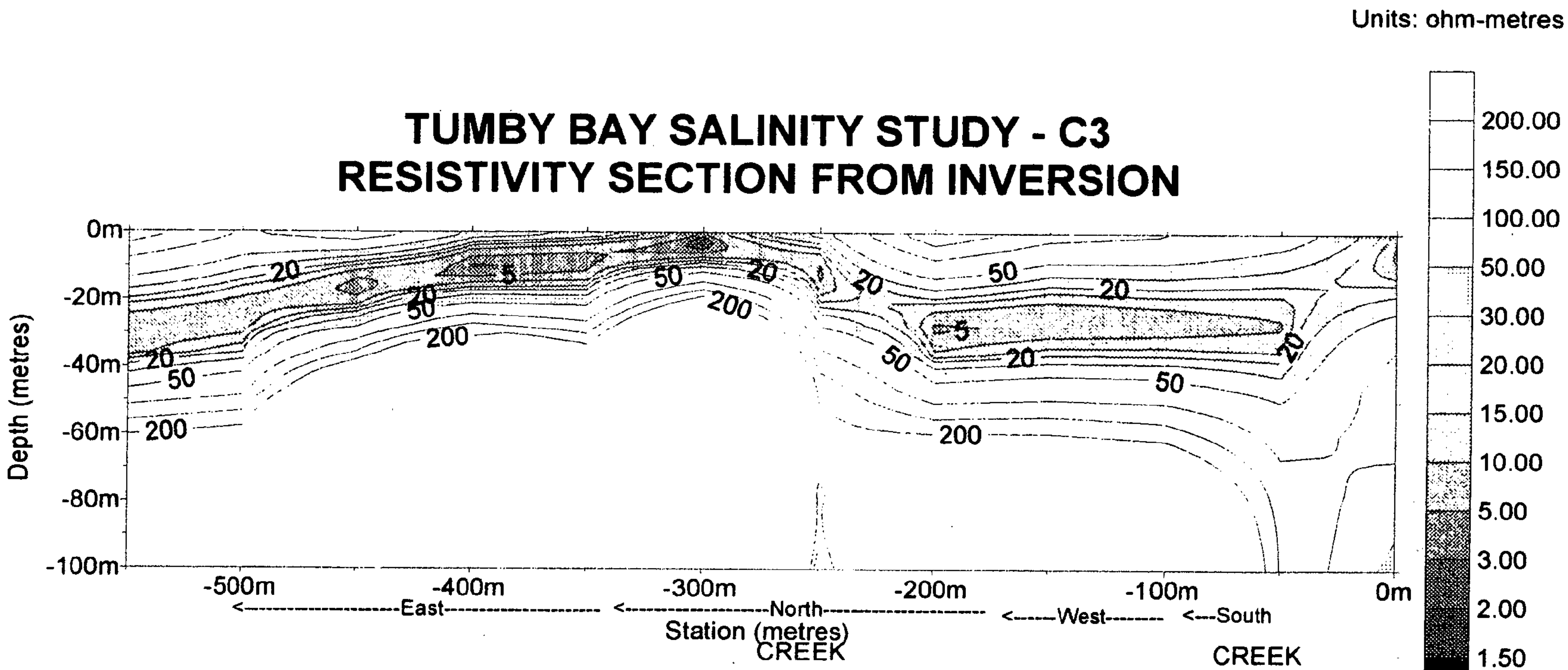

Units: ohm-metres
TUMBY BAY SALINITY STUDY - C3
RESISTIVITY SECTION FROM INVERSION
Depth (metres)
0m
-20m
-40m
-60m
-80m
-100m
-500m
-400m
-300m
-200m
-100m
0m
<-------------------East--------------------
<-------------------North----------------------
<------West--------
<---South
Station (metres)
CREEK
CREEK
200.00
150.00
100.00
50.00
30.00
20.00
15.00
10.00
5.00
3.00
2.00
1.50
1.00
0.00

Figure 10

TUMBY BAY SALINITY STUDY - C4
Resistivity Section from Inversion

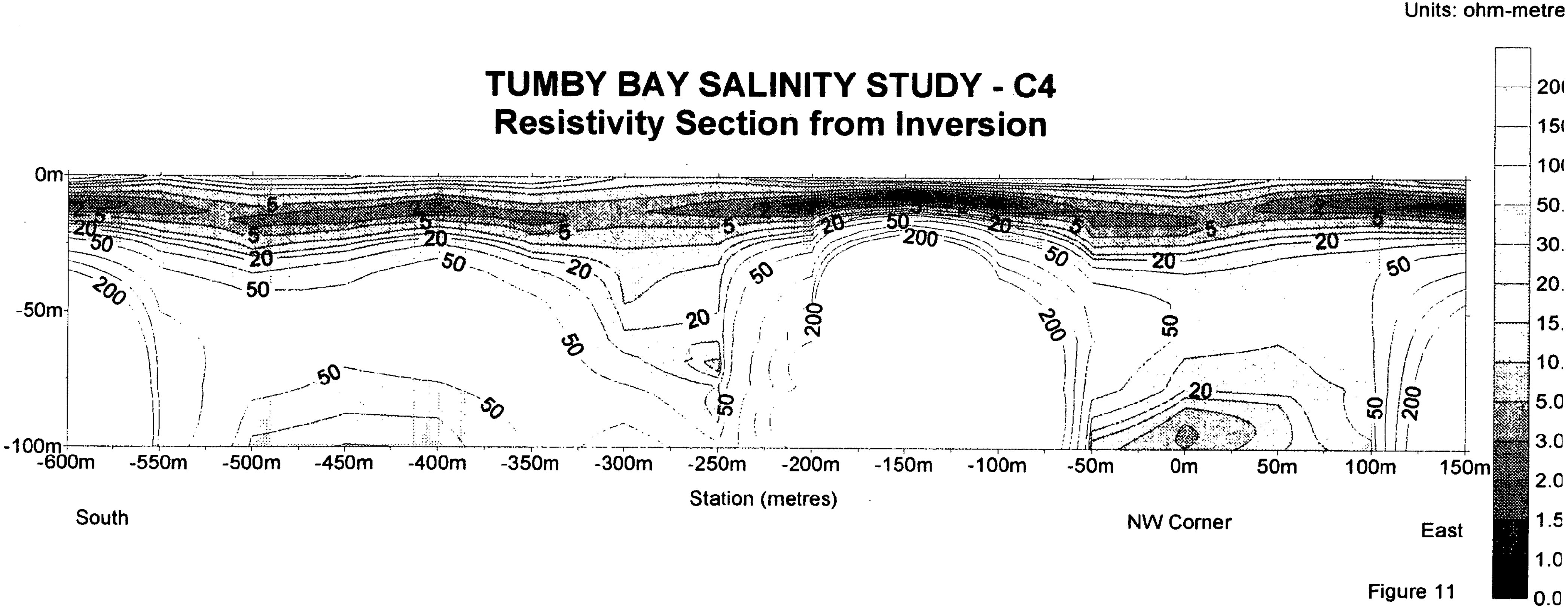


Figure 11

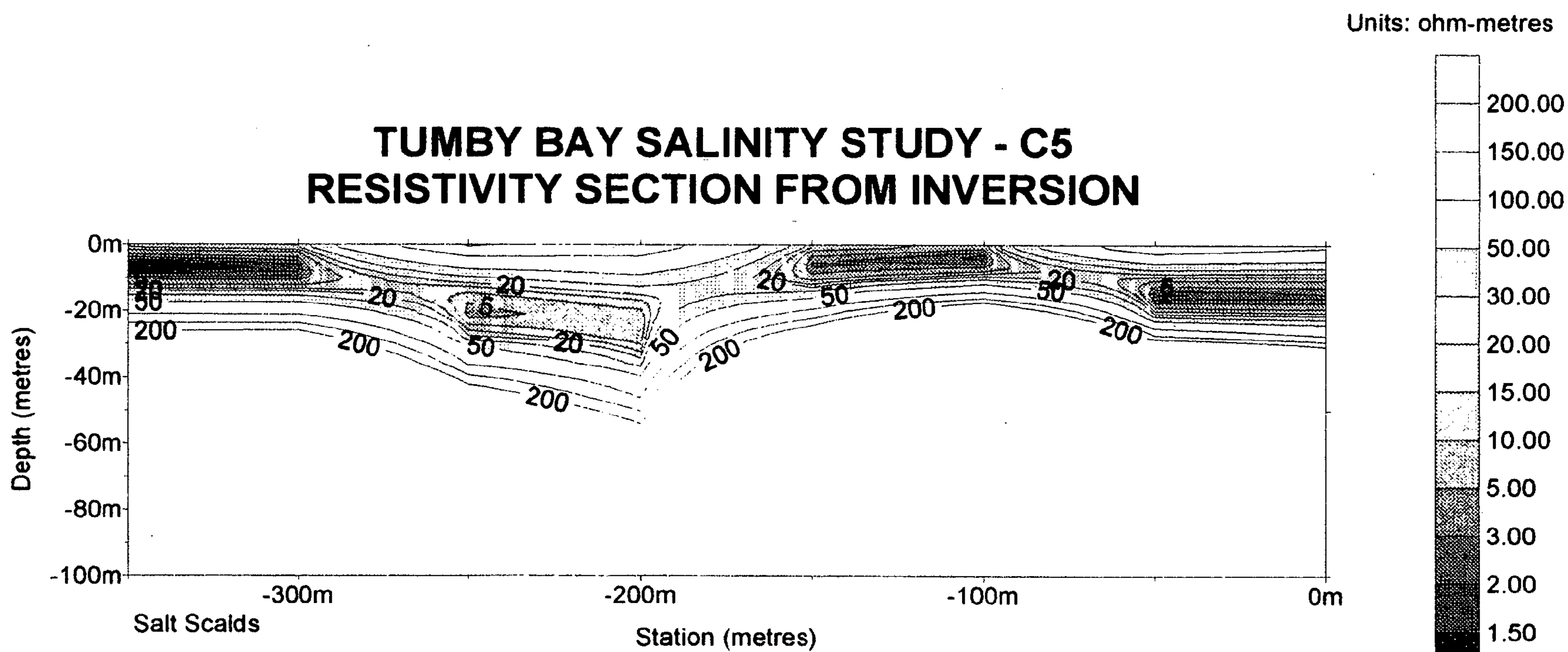

TUMBY BAY SALINITY STUDY - C5
RESISTIVITY SECTION FROM INVERSION
Units: ohm-metres
200.00
150.00
100.00
50.00
30.00
20.00
15.00
10.00
5.00
3.00
2.00
1.50
1.00
0.00
0m
-20m
-40m
-60m
-80m
-100m
Depth (metres)
-300m
-200m
-100m
0m
Salt Scalds
Station (metres)
20
50
200
5

Figure 12