

I. I. Rust.

Research on Sedimentation in Estuaries

SEDIMENTATION  
IN THE KROMME ESTUARY

ROSIE REPORT No 6

By: JSV Reddering  
K Esterhuysen

Project leader: IC Rust



Department of Geology  
University of Port Elizabeth

May 1983

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## CONTENTS

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ABSTRACT	1
1. INTRODUCTION	2
2. BACKGROUND INFORMATION	4
2.1 Catchment area	4
2.1.1 Geology	4
2.1.2 Climate	8
2.1.3 Soil and veld types	8
2.1.4 Geomorphology	13
2.2 Estuary	13
3. SEDIMENT DISTRIBUTION	15
3.1 Sediment size distribution and composition	15
3.2 Aerial photograph interpretation	29
3.3 Sediment source	35
4. SECTIONS ACROSS THE ESTUARINE CHANNEL	37
4.1 General	37
4.2 Interpretation of results	39
5. SEDIMENT ACCUMULATION IN THE KROMME ESTUARY	40
5.1 General	40
5.2 The effect of previously existing coastal dunes	41
5.3 The effect of the bridge	41
5.4 The effect of the dams	43
5.5 The erosion base	44
6. DISCUSSION AND CONCLUSION	47

ACKNOWLEDGEMENTS	48
REFERENCES	48
APPENDIX 1	50
APPENDIX 2	69

Reddaring & Esterhuysen (1983). Sedimentation in the Kromme Estuary, ROSIE Report No 6, U.P.E. 92 pp.

#### ABSTRACT

The Kromme estuary on the Cape South-east coast has sandy lower reaches and mud coexists with sand in its higher reaches. The tide is flood-dominant so that sediment enters mainly from the sea and is accumulated in the estuary. Fluvial sediment input is minimal and consists of some mud and fine-grained sand. The cross-sectional area of the channel progressively increases up-estuary from the tidal inlet, confirming the relatively low fluvial sediment input.  $\text{CaCO}_3$  content of the sediment decreases up-estuary from the inlet whereas its organic content increases.

Although sedimentation is taking place in the estuary, the sediment volume in the estuary has decreased since 1942. Removal of sediment from the estuary by freshwater floods is being reduced as a result of damming in the catchment area; this may result in excessive sediment accumulation in the estuary in future.

The bridge across the lower estuary shows no evidence of having detrimental effects on the hydrodynamics of the estuary.

## THE SEDIMENTARY STATE OF THE KROMME ESTUARY

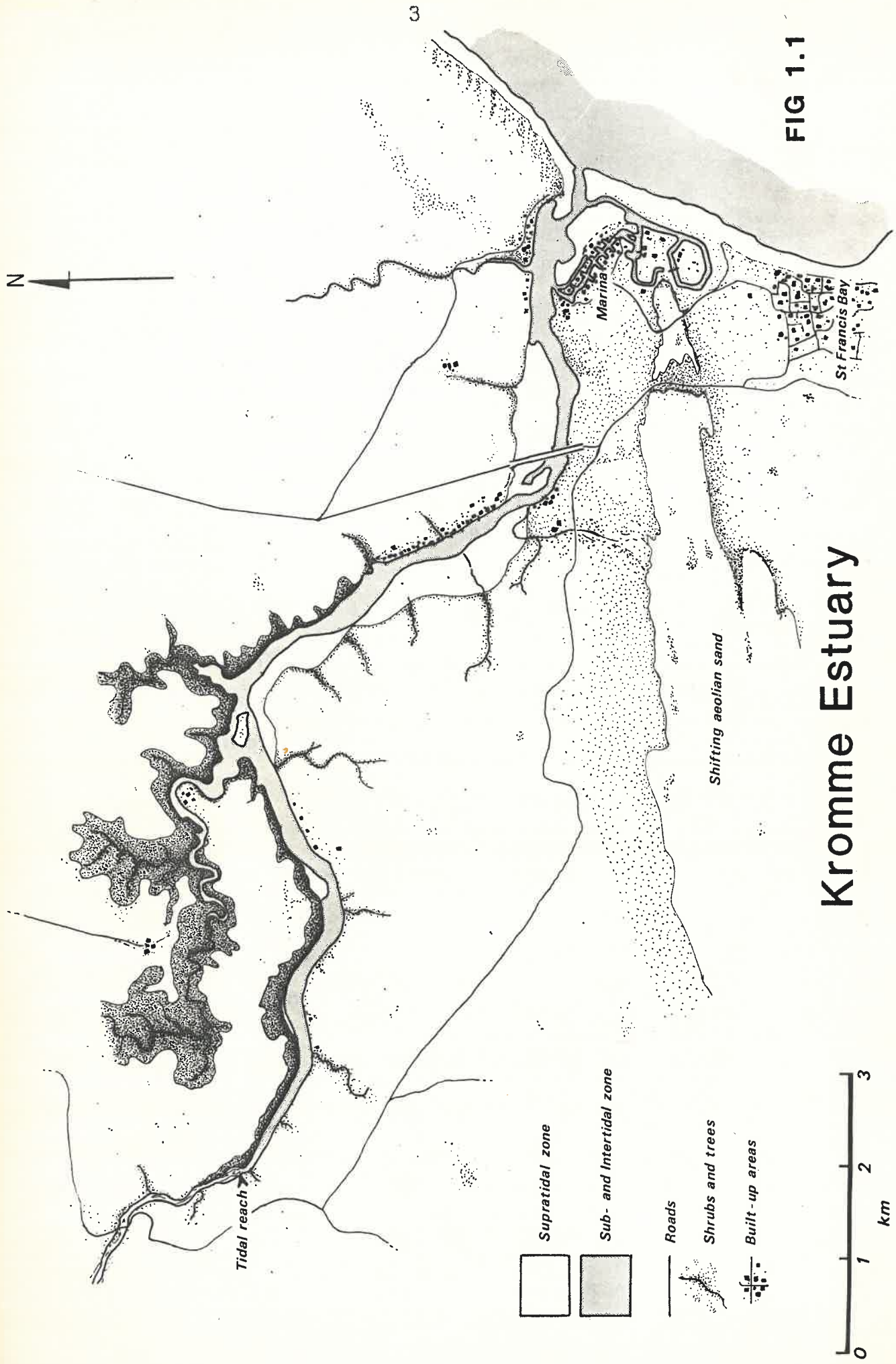
### 1. INTRODUCTION

The estuary of the Kromme River has a permanent tidal inlet on St Francis Bay (34° 87' S, 24° 50' E). Its catchment area drains a large part of the Langkloof. The Geelhoutboom River drains an area around Humansdorp and joins the estuary about 5,5 km from its tidal head.

St Francis Bay is also the name of a small holiday resort which lies on the estuary banks near the inlet. A marina canal system (fig. 1.1) was dredged (started in 1967) into older estuarine deposits and is fed by tidal water from the adjacent estuary. The Kromme is a popular recreational area and concern has been expressed that excessive sediment build-up is taking place.

The aims of this study are:

1. To establish whether net sedimentation in the estuary is taking place;
2. To determine the source of the sediment in the estuary;
3. To establish baseline information regarding the sedimentation in the estuary for future reference.



- Supratidal zone
- Sub- and Intertidal zone
- Roads
- Shrubs and trees
- Built-up areas



# Kromme Estuary

FIG 1.1

## 2. BACKGROUND INFORMATION

### 2.1 Catchment area

The Kromme River drains part of the Langkloof. This valley lies between the coastal Tsitsikamma Mountains and the landward Kouga Range. Apple and wheat farming are the main economic activities of the area. The Churchill Dam (completed in 1947, capacity  $33,3 \times 10^6 \text{ m}^3$ , fig. 2.2) is one of the major water supplies for the city of Port Elizabeth. Another dam for the same purpose, the Elandsjagd Dam, is under construction 4 km upstream from the tidal head of the estuary. It is ready to impound water.

#### 2.1.1 Geology (fig. 2.3)

The Langkloof is a 75 km long east-west trending Bokkeveld slate syncline which stretches from 20 km east of Joubertina to near the tidal head of the estuary. Resistant quartzite of the Table Mountain Group forms the adjacent anticlinal ridges (section 2.1). These deformed rock suites form part of the Cape Fold Belt which extends across the entire southern Cape coastal area.

# LOCATION OF KROMME RIVER

34°08'S, 24°50'E

• Johannesburg



• Bloemfontein

Durban

5

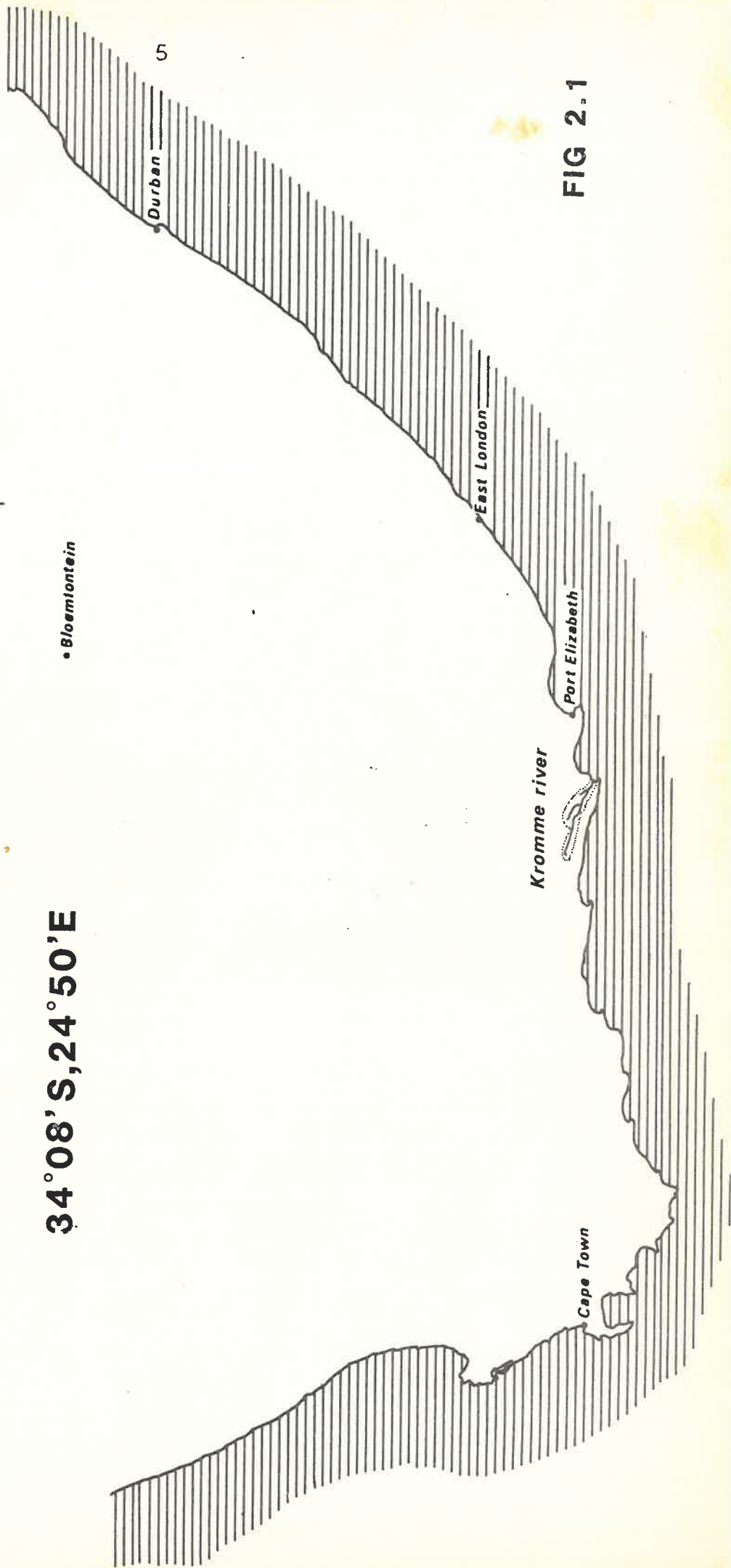
East London

Port Elizabeth

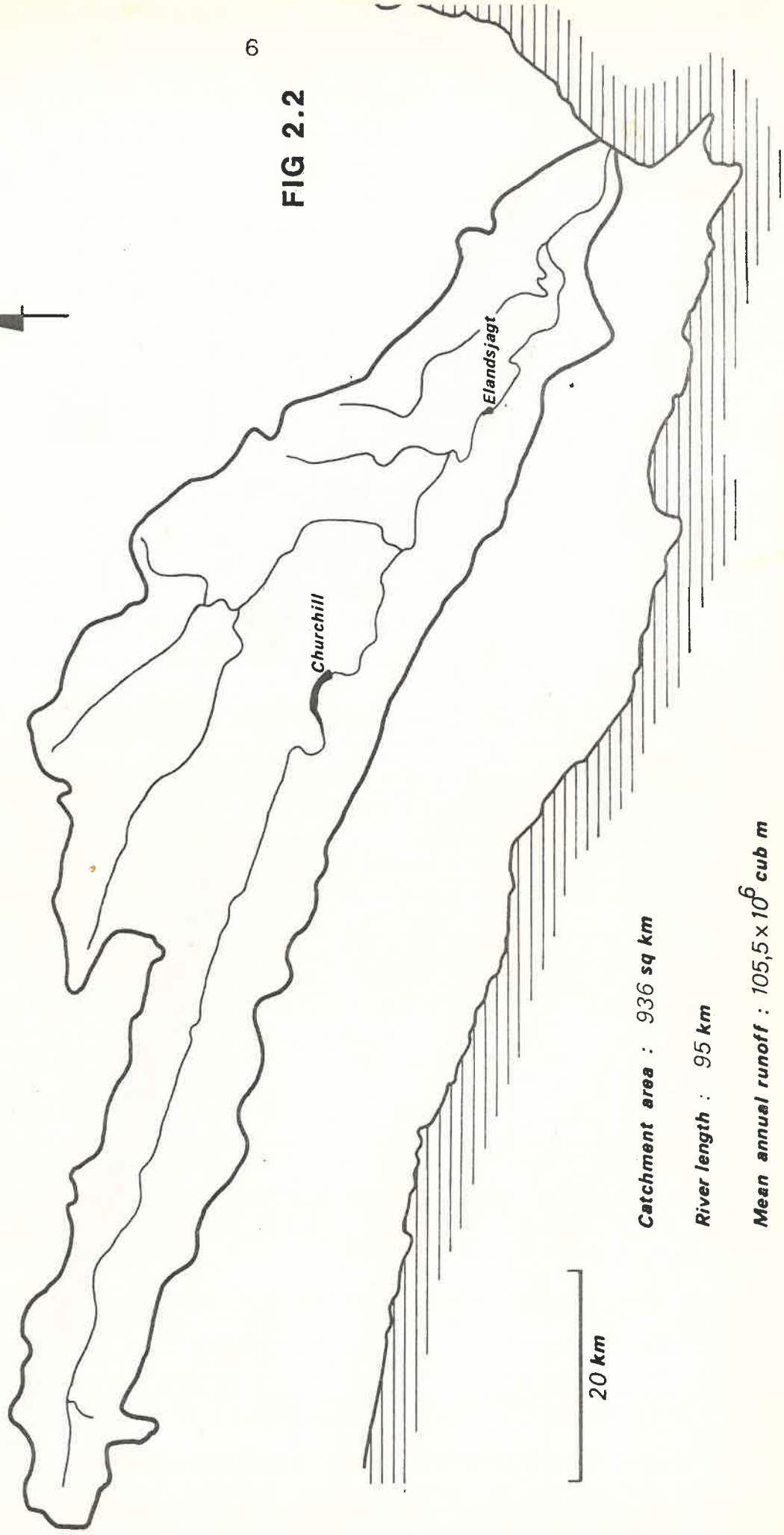
Kromme river

Cape Town

FIG 2.1



# KROMME RIVER CATCHMENT AREA



Catchment area : 936 sq km

River length : 95 km

Mean annual runoff :  $105,5 \times 10^6$  cub m

FIG 2.2

# KROMME RIVER CATCHMENT AREA

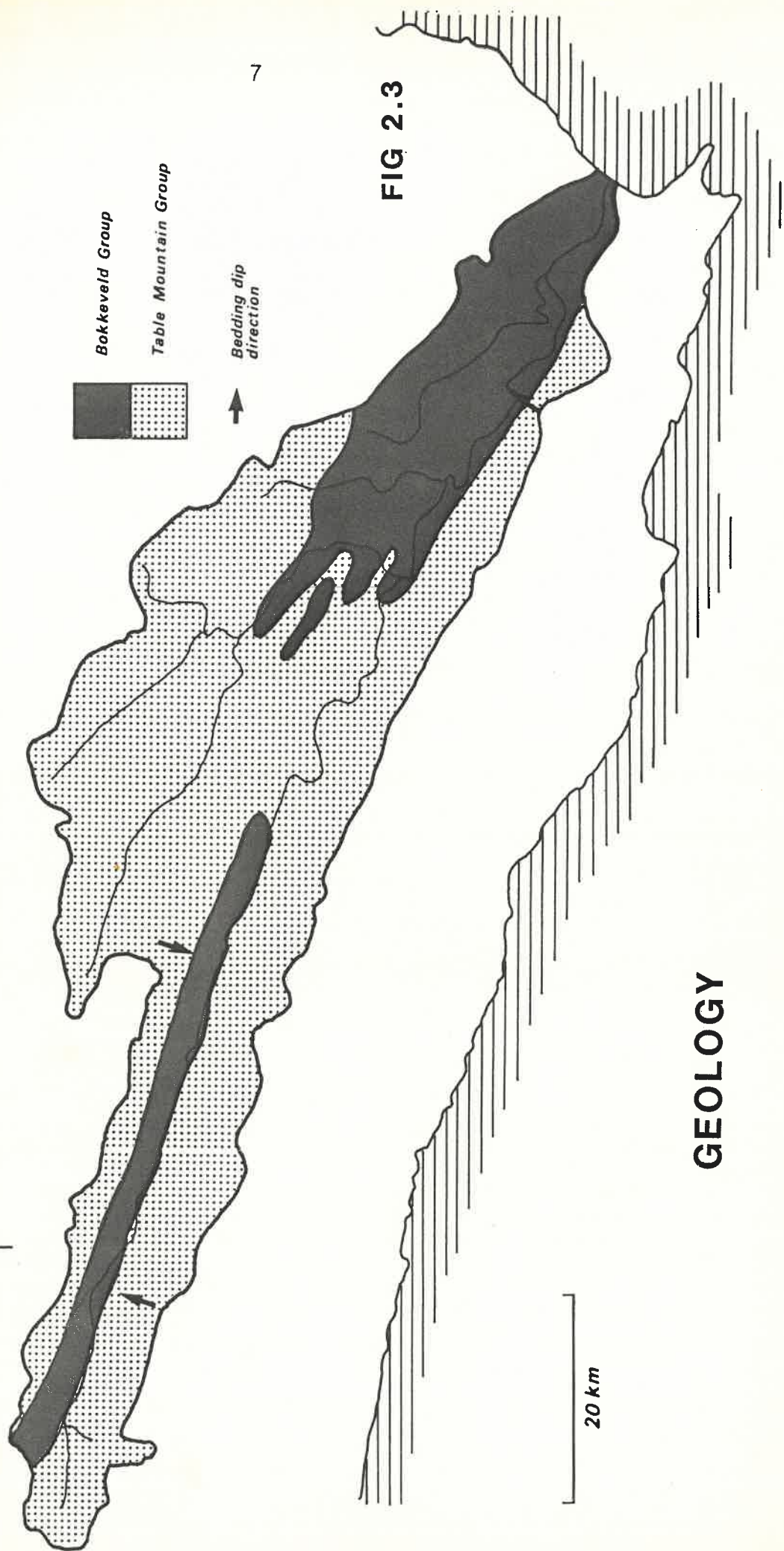


FIG 2.3

# GEOLOGY

### 2.1.2 Climate (fig. 2.4)

The Kromme River basin lies in the southern Cape climatic zone. Rainfall is distributed throughout the year with slight spring and autumn peaks. Mean annual precipitation varies from 700 to 1200 mm. Mean annual runoff is about  $105,5 \times 10^6 \text{ m}^3$ . With the Elandsjagd Dam practically completed little of this will probably pass through the estuary. Prevailing winds are south-westerly and have 18% frequency.

### 2.1.3 Soil and veld types (figs. 2.5 & 2.6)

The geologic substrate in the largest part of the catchment basin consists of quartzite. These rocks weather to acid and well drained soils. Owing to effective leaching by meteoric water the soil has a low plant nutrient content and the vegetation is characterized by hardy false scherophyllous bush.

The fluvial sediment yield is small and consists mainly of mud weathered from the Bokkeveld slates. The sand input is also small because its quartzitic source resists weathering and erosion. It is likely that the Churchill Dam retains some sediment that would otherwise have been transported to the estuary. Completion of the Elandsjagd Dam will effectively stop fluvial sediment input from the Kromme River into the estuary.

The small catchment of the Geelhoutboom River drains the Humansdorp area and is underlain by readily eroded Bokkeveld slate. The sediment input is consequently muddy with a subordinate sand input. This sand consists of rock fragments.

# KROMME RIVER CATCHMENT AREA

N

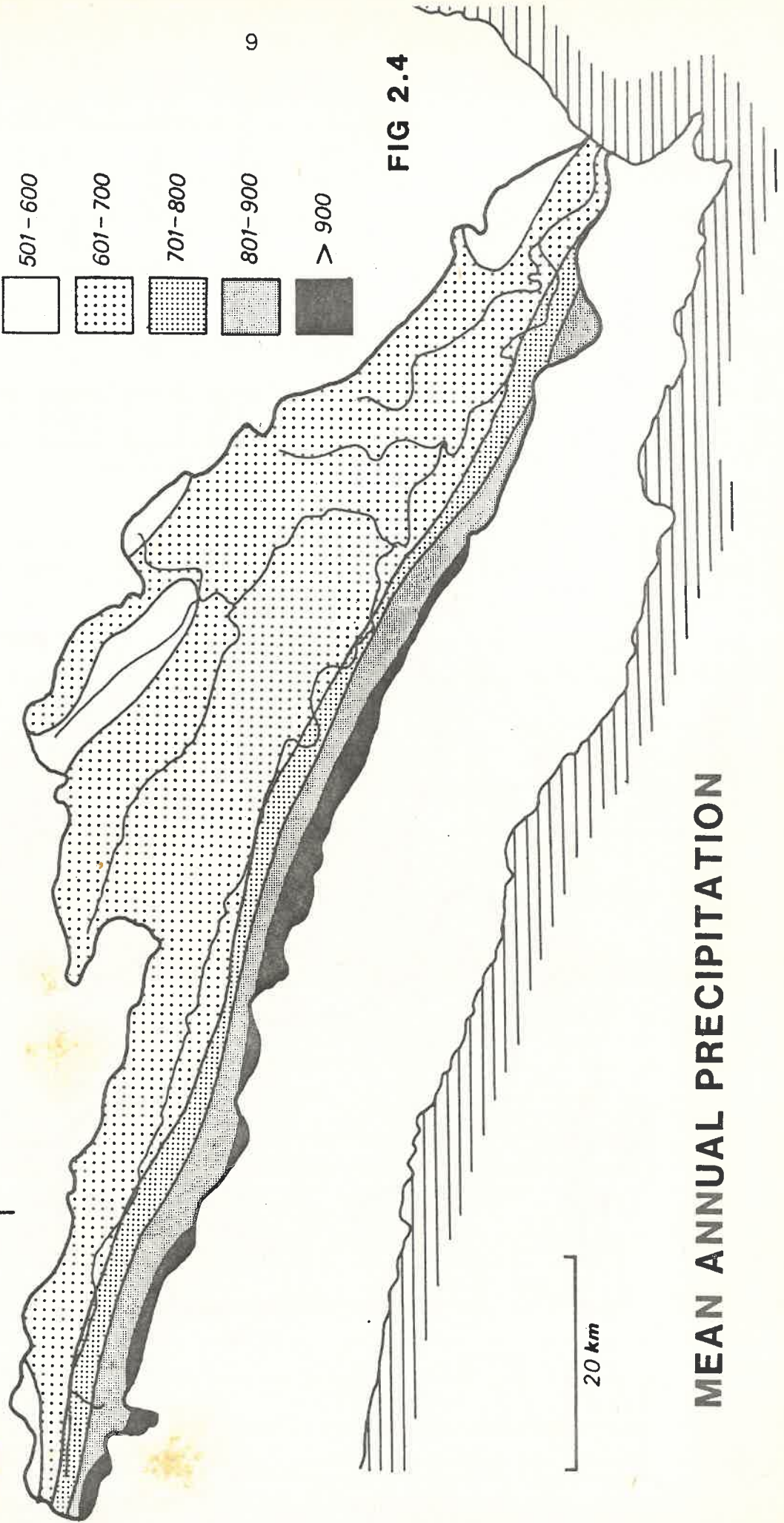
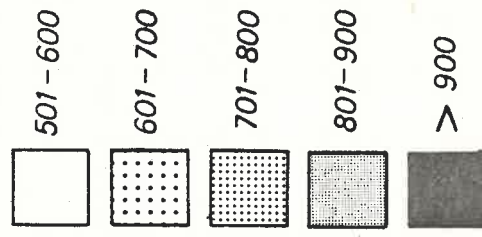
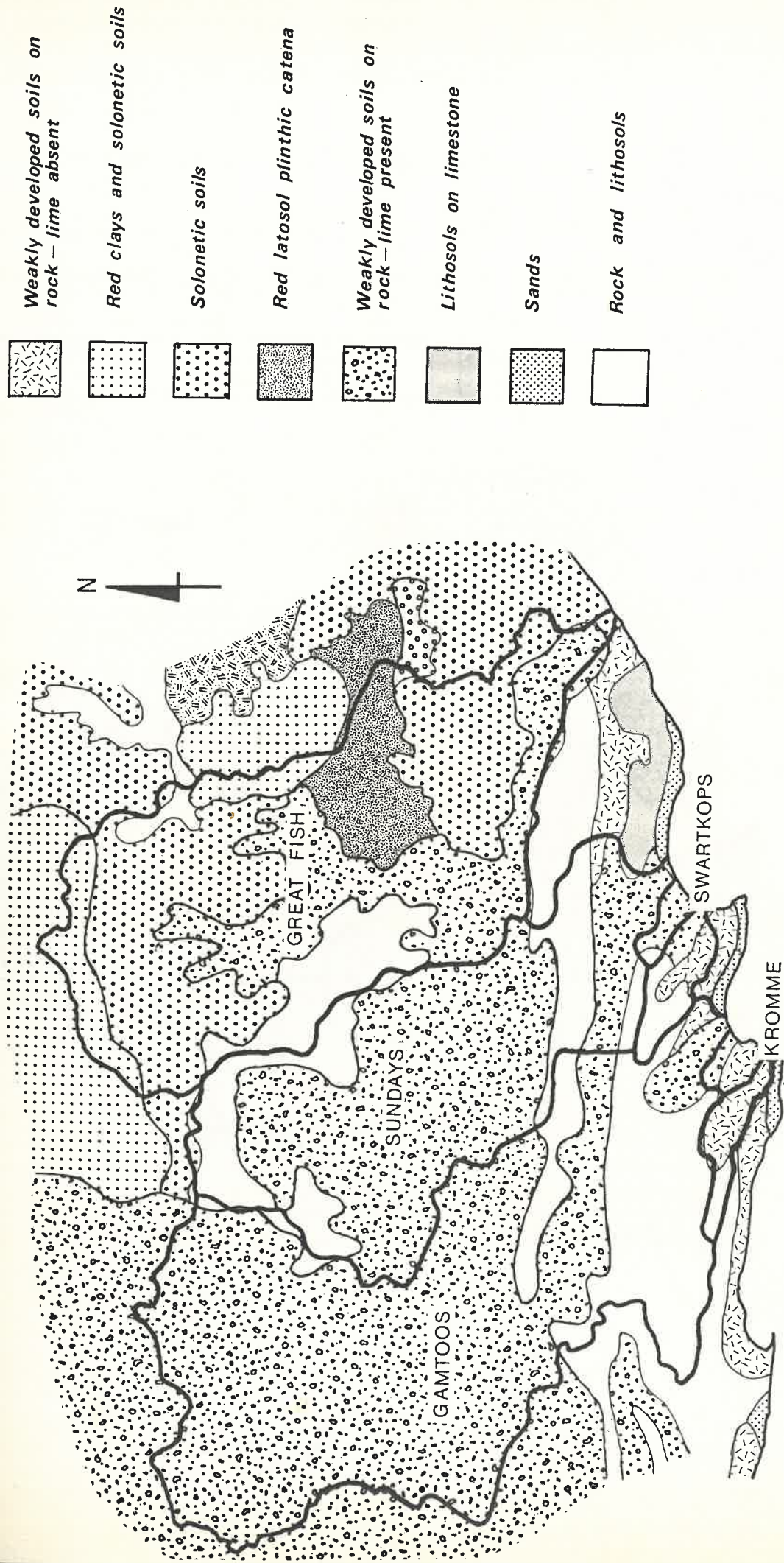


FIG 2.4

MEAN ANNUAL PRECIPITATION

20 km



Soil Types

100 km

FIG 2.5

After Macvicar et al

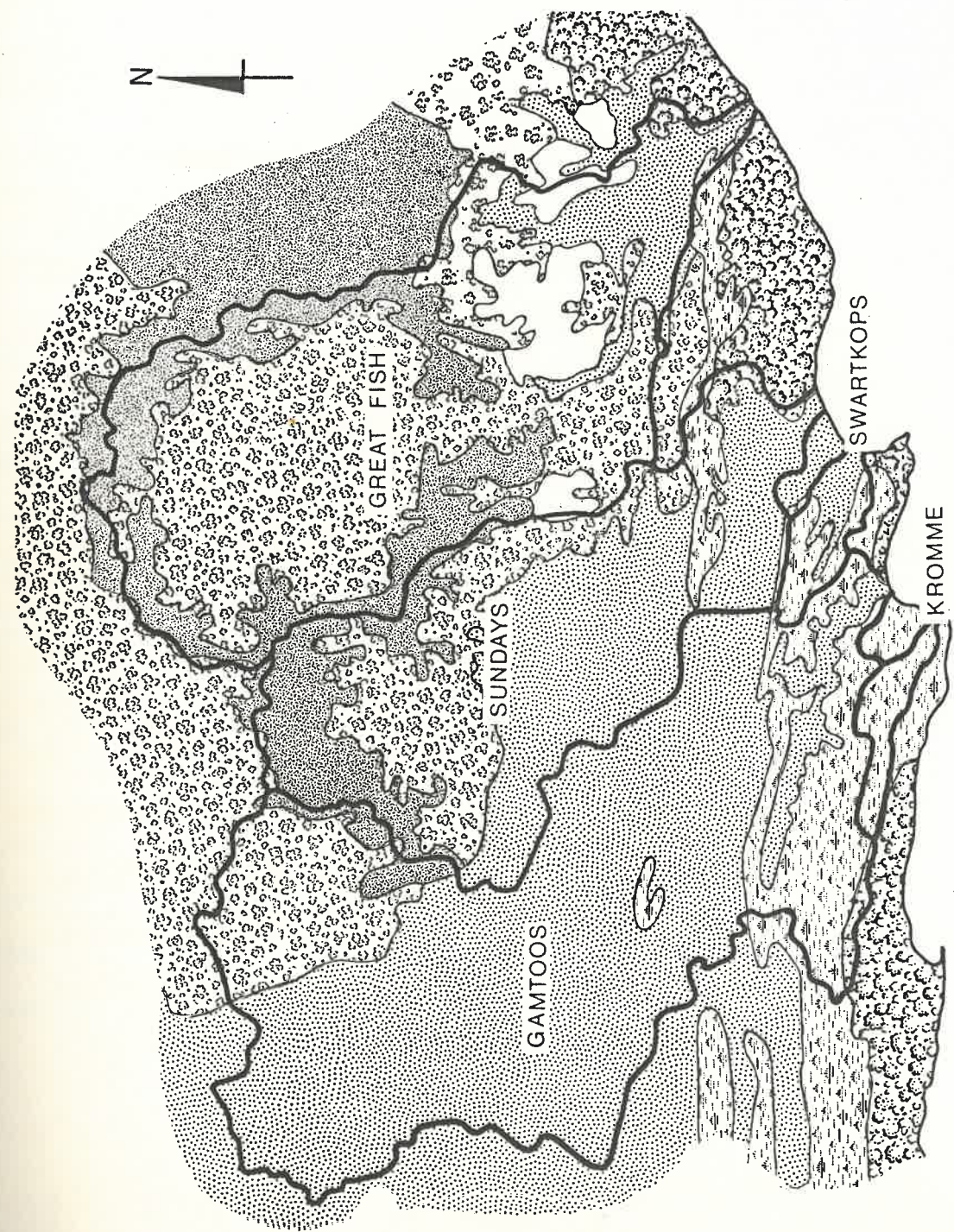
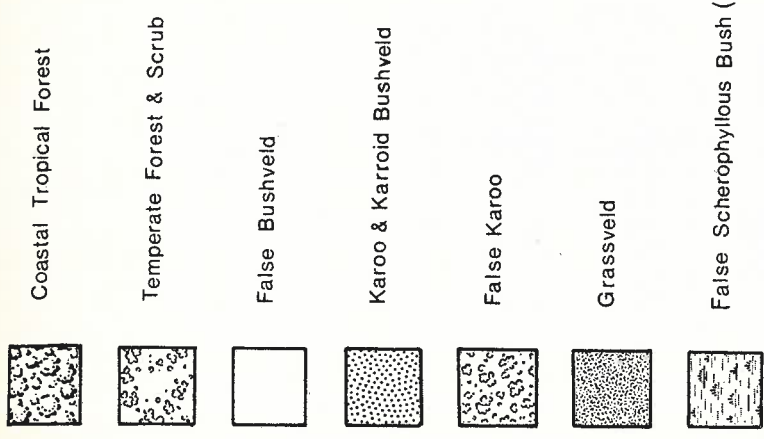


FIG 2.6

Veld Types

After Acocks

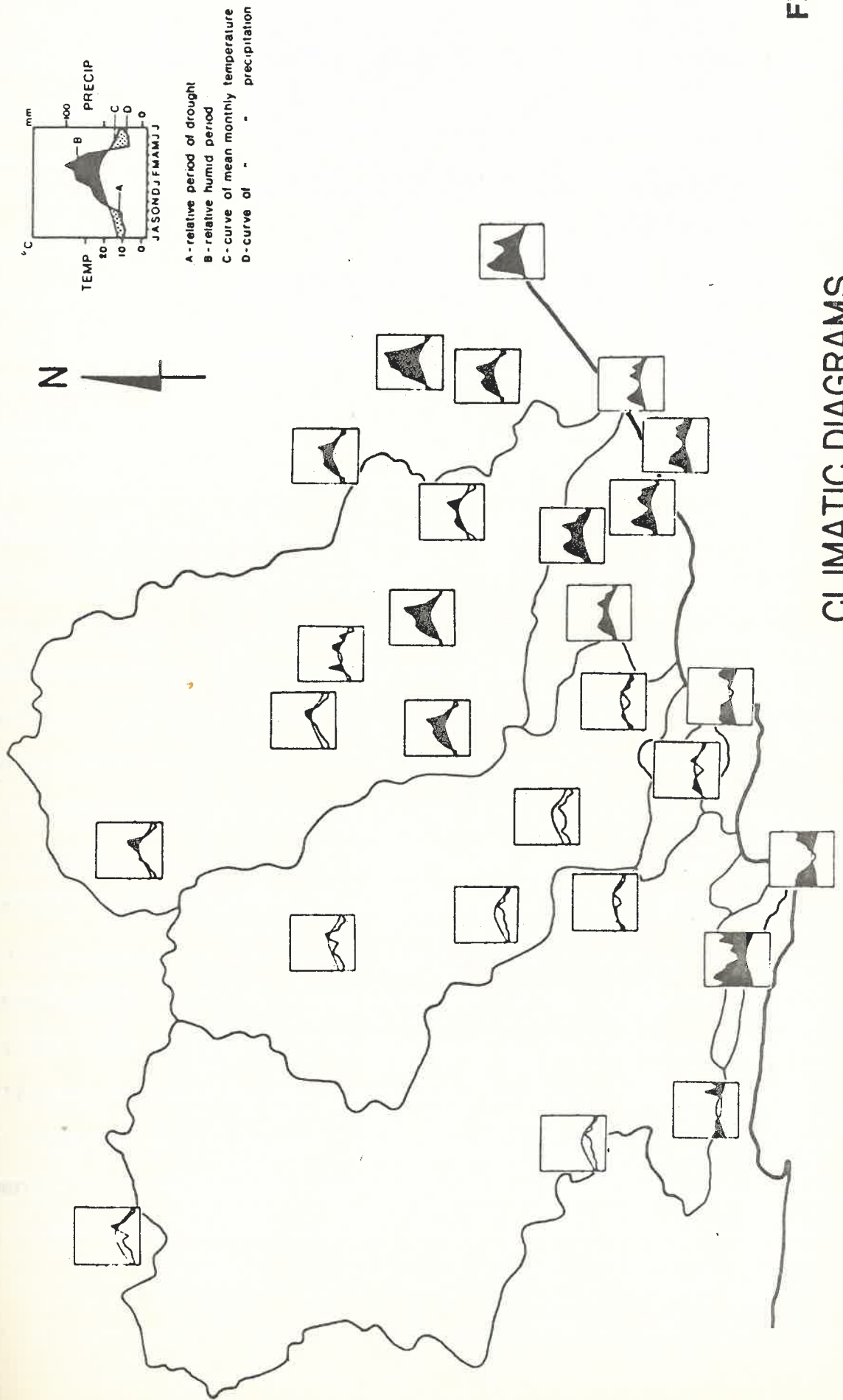


FIG 2.7

CLIMATIC DIAGRAMS

100 KM

#### 2.1.4 Geomorphology

The main water course follows the Langkloof as a subsequent stream, where the river follows the readily eroded Bokkeveld slate. With mountain ranges on both sides of the valley, the relief is high, and because the slopes are rocky and sparsely vegetated, the runoff is high. The regional gradient of the river is  $8,5 \times 10^{-3}$ .

#### 2.2 Estuary

The estuary is about 13 km long and its tidal head is a rapid across lower Bokkeveld sandstone. In its upper reaches the estuary is incised into bedrock (see APPENDIX 2) but the relief flattens down-estuary. The straight upper section of the channel near the tidal head (fig. 1.1) flows along a vertically folded contact between the Table Mountain and the Bokkeveld Groups. The latter is readily eroded whereas the quartzite resists weathering. The geological substrate of the estuary consists of Bokkeveld slate. Weathered outcrops are common the entire length of the estuary, particularly along its northern bank. These outcrops are usually weathered to form intertidal rock platforms. This probably results from seawater cementation in the cleavage cracks of the slate (Reddering, 1980). Weathered slate supplies a small volume of in situ sediment. It consists of blue-grey mud with slate chips.

The lower reaches of the estuary near the inlet are sandy and intertidal flats are well developed (200 m wide). In the muddier upper estuary the intertidal areas are much narrower (20 m).

The shallower waters in the lower estuary are well mixed whereas the deeper upper section of the estuarine channels is stratified. In the upper estuary muddy, fresh water can at times be seen floating on the underlying denser, saline water. The estuary has normal salinity gradient during the rainy season but an inverted gradient may be found in mid-summer when rainfall is low and evaporation is high (Hanekom, 1982; Hecht, 1973).

The Geelhoutboom River joins the main water course about 8 km up-estuary from the inlet. This tributary originates in the Humansdorp area and its bed is predominantly muddy owing to the slaty source rock.

Development along the estuary includes the marina near the inlet (fig. 1.1), a bridge, and holiday shacks with jetties farther up-estuary. Farming is practised on a limited scale on some parts of the estuary bank.

### 3. SEDIMENT DISTRIBUTION

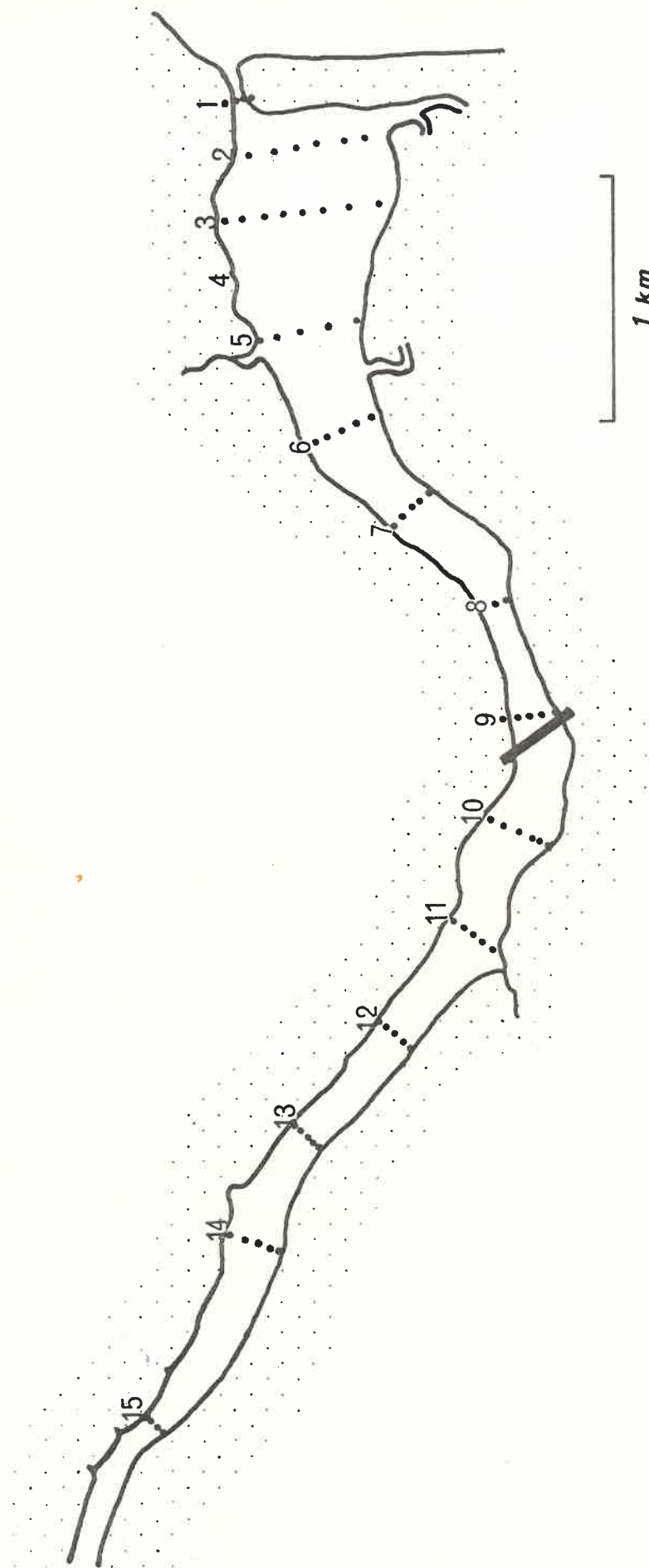
#### 3.1 Sediment size distribution and composition

Field work in the Kromme estuary consisted of intertidal and subtidal sampling, and observations. Subtidal work was carried out with the aid of SCUBA. Samples were collected on a pre-determined sampling grid (fig. 3.1). Sediment was sampled at the bed and also 0,5 m into the substrate. The latter was achieved by coring, using a 0,55 m long PVC pipe (50 mm diameter).

Sediment size proportions were determined by wet sieving through a 0,063 mm sieve and dry sieving the coarser material. Statistical parameters were obtained from the size distributions (Buller and McManus, 1979). The carbonate content of the samples was determined using a "carbonate bomb" (Schink et al., 1979). The organic content was established by peroxide digestion (McCave, 1979). This method does not measure all the organic material present in the sediment but indicates the amount of organic material which will influence the redox potential (i.e. the oxygen affinity) of the sediment. All data were processed on a micro-computer.

Results of these determinations are presented in APPENDIX 1. The more important parameters are contoured on figures 3.2 and 3.3.

# KROMME ESTUARY



SEDIMENT DISTRIBUTION SAMPLE SITES

FIG 3.1

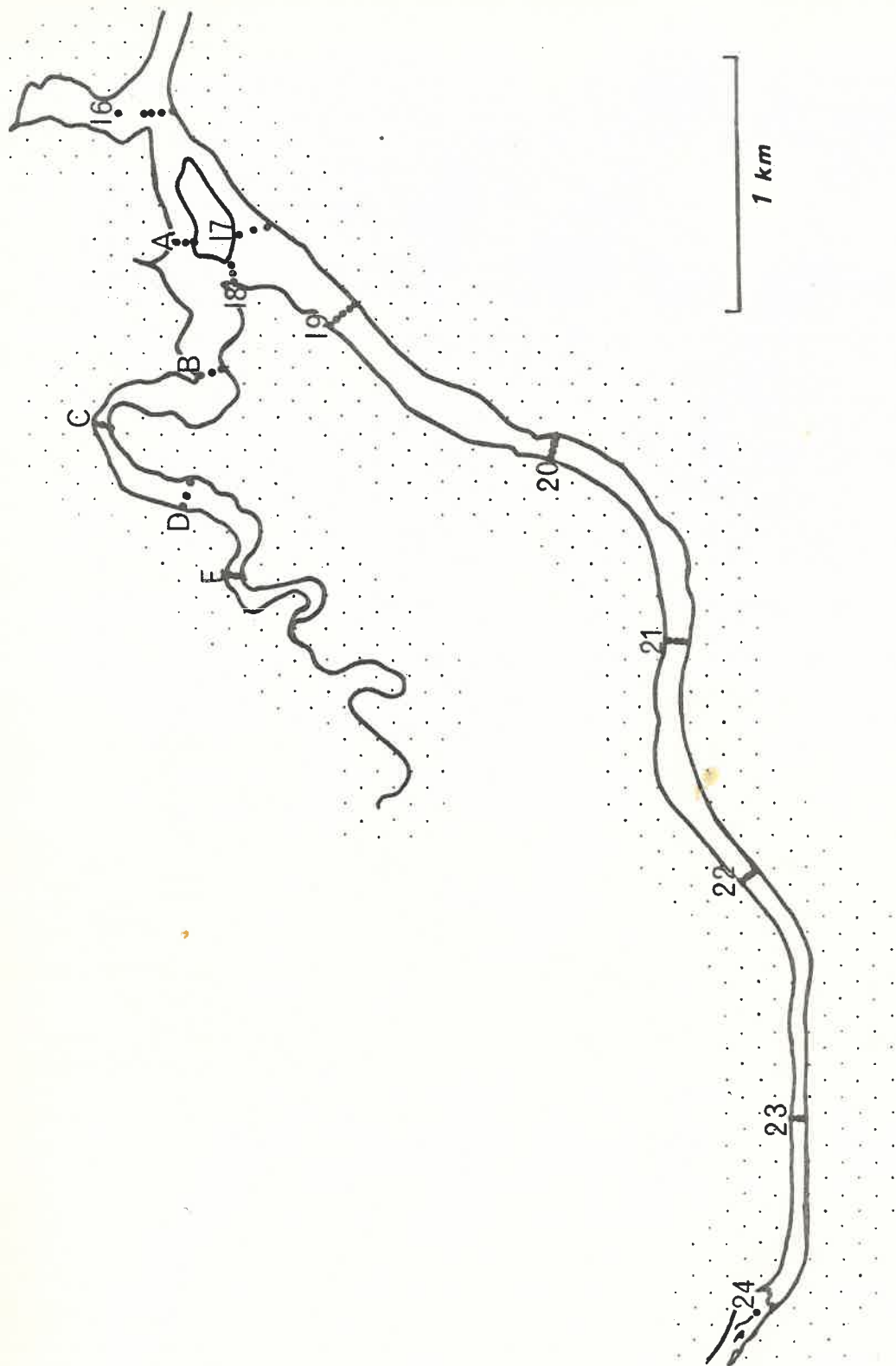


FIG 3.1(CONT)

Mean Grain Size on Surface

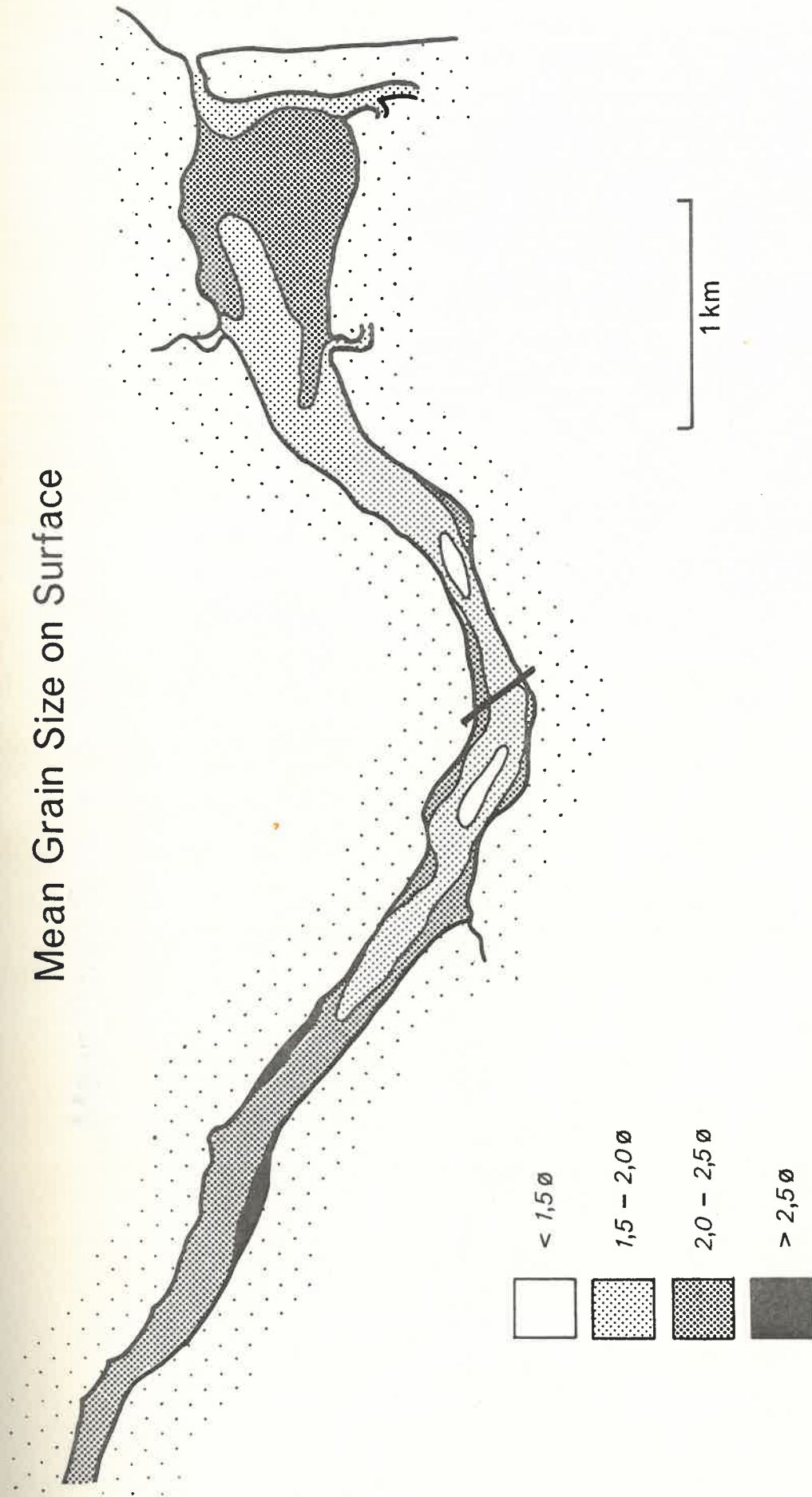


FIG 3.2A

Mean Grain Size at -0.5m  
Mean Grain Size on Surface

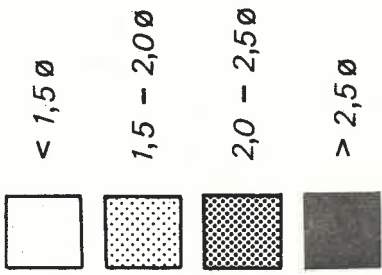
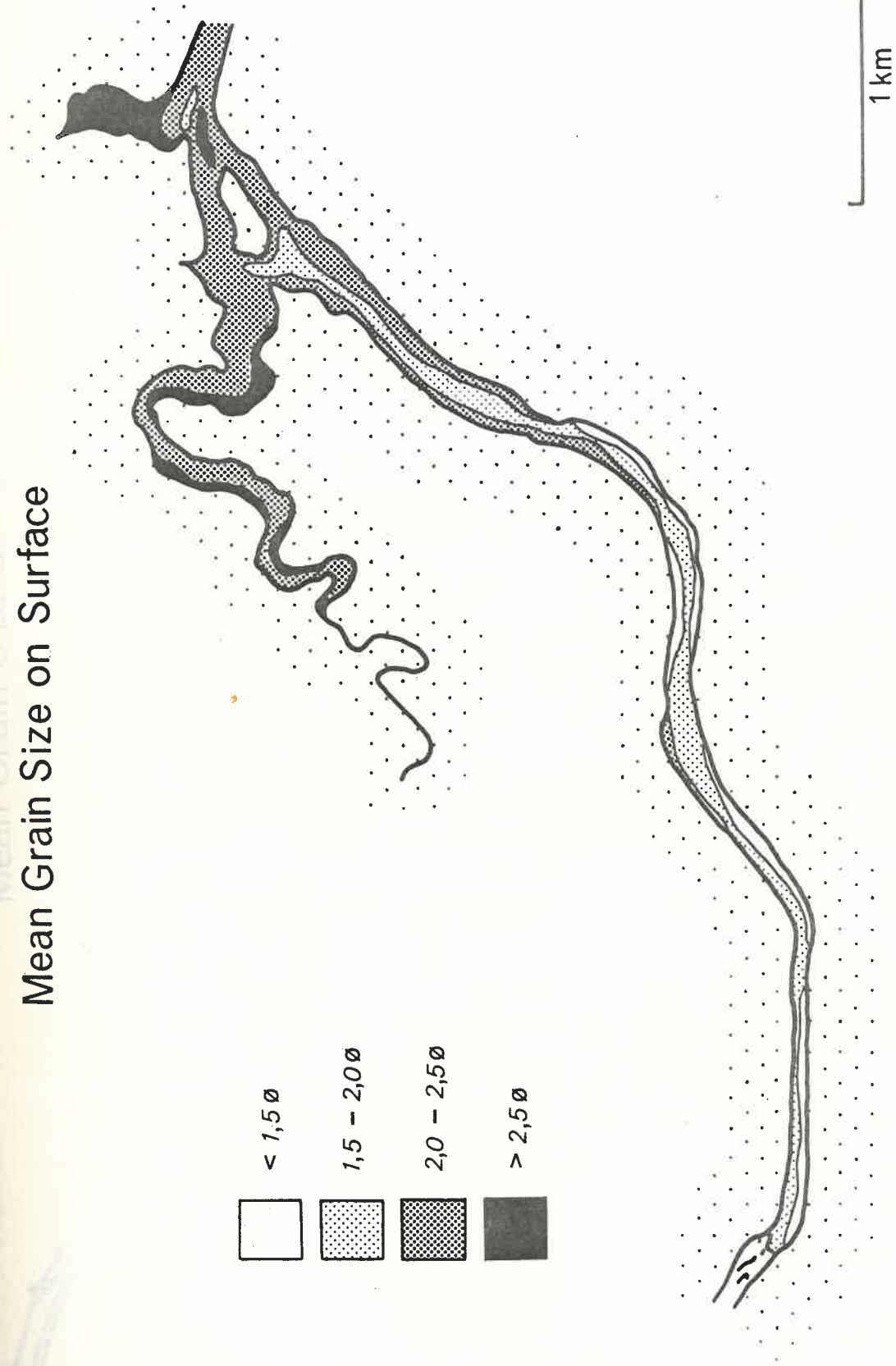


FIG 3.2A(CONT)

Mean Grain Size at -0,5m

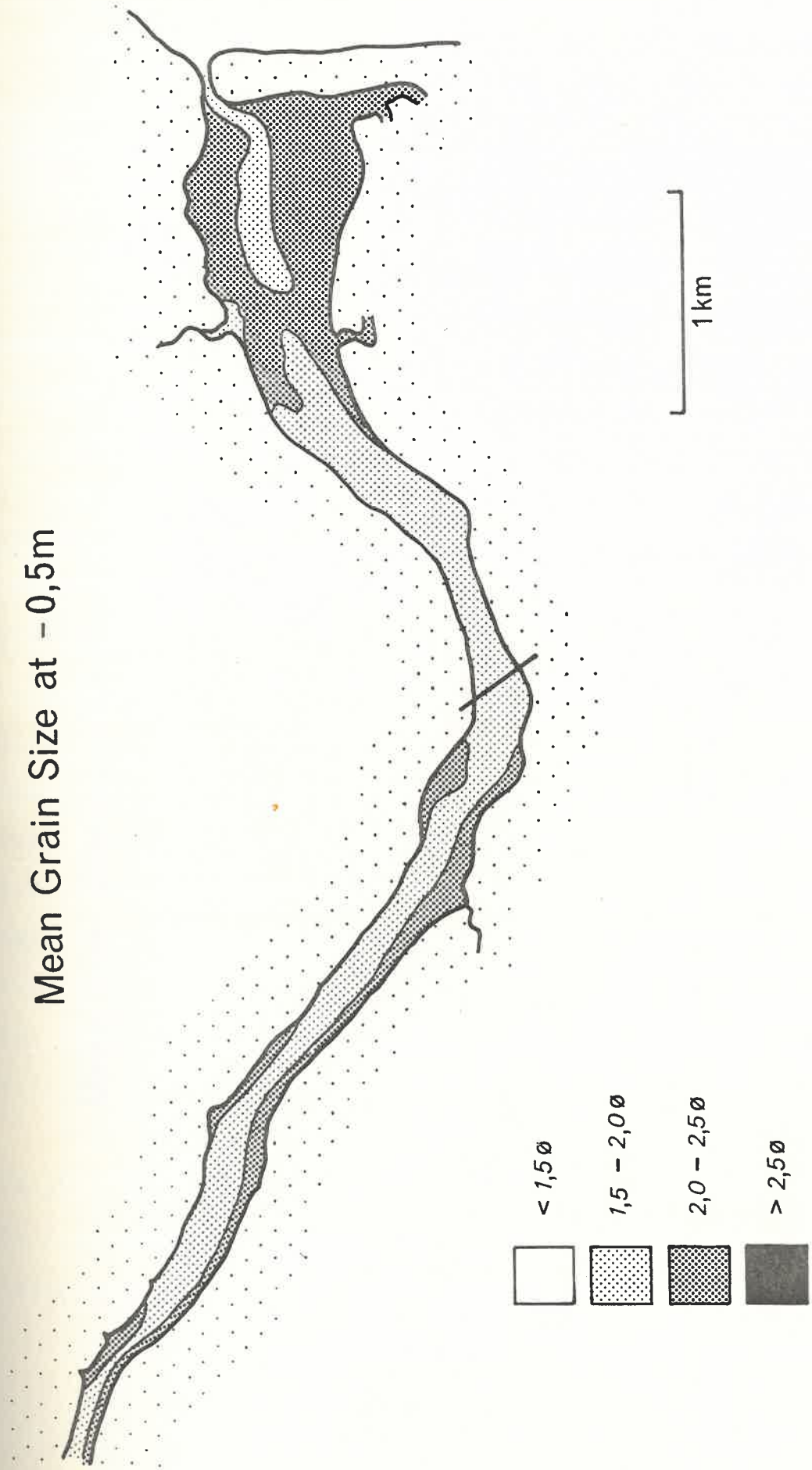


FIG 3.2B

Mean Grain Size at -0,5m

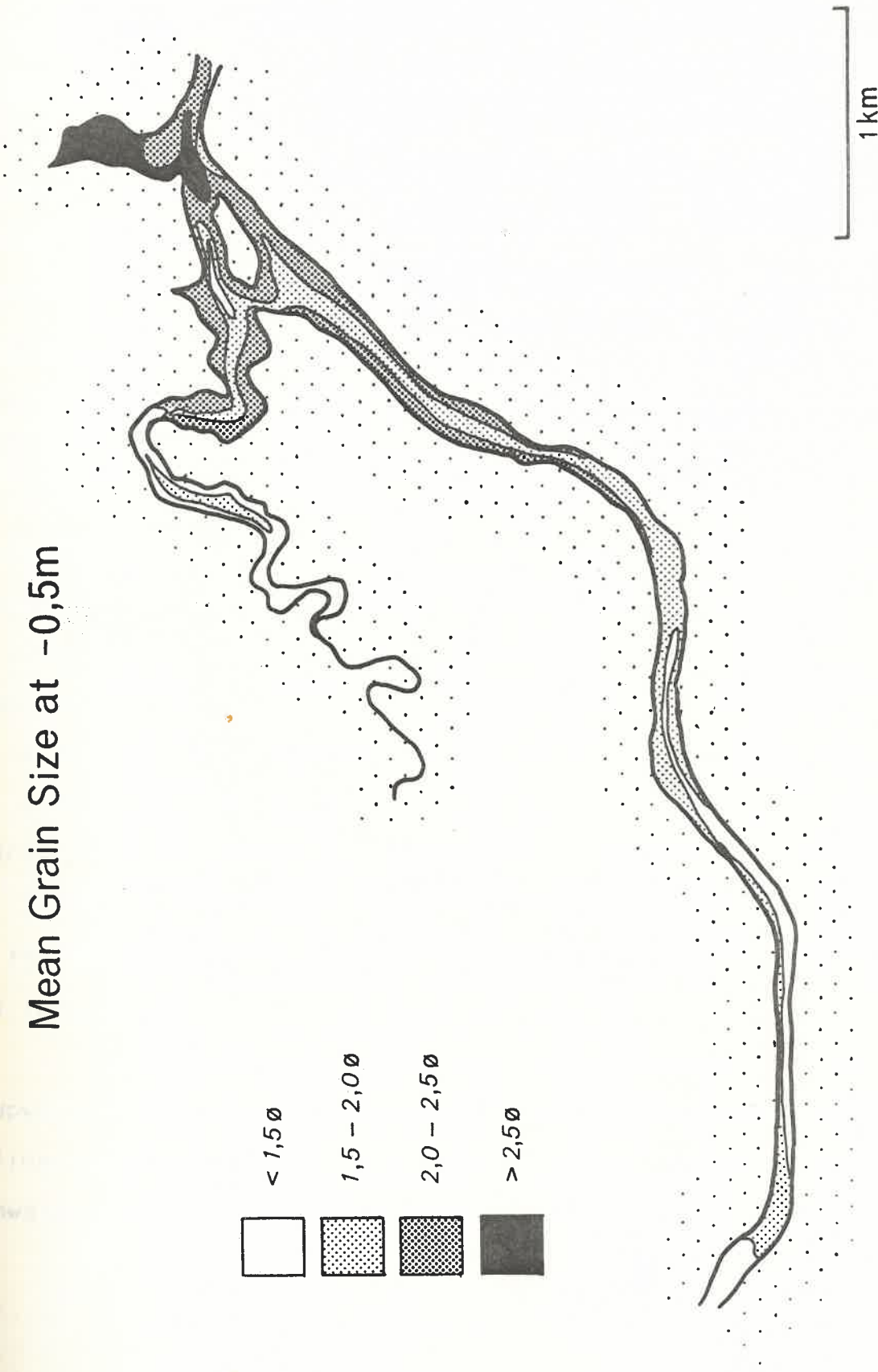


FIG 3.2B(CONT)

Sediments become progressively finer grained from the inlet towards the tidal head. Sand grain size decreases (fig. 3.2) and mud content increases (fig. 3.3). The Geelhoutboom tributary is muddier than the main estuary (figs. 3.3, APPENDIX 1). These trends result from the normal up-estuary decrease in tidal current velocity and from sediment availability. The fluviially derived sediment which enters at the head of the estuary is finer grained than the marine sediment entering at the inlet. Under conditions of low tidal current velocity in the upper estuary, the clastic mud settles from suspension, probably aided by saltwater induced flocculation.

Comparison of the grain size distribution at the bed (fig. 3.2a) with that at 0,5 m into the sediment substrate (fig. 3.2b) indicates that the sand generally fines upward. Comparison between mud distribution at the sediment surface (fig. 3.3a) with that at a depth of 0,5 m (fig. 3.3b) shows that the surface mud is proportionately more abundant and that it is laterally distributed farther down the estuary.

The upward fining of sand presumably results from winnowing of the finer grained populations from the sand at depth during freshwater floods.

Surface Distribution of Mud

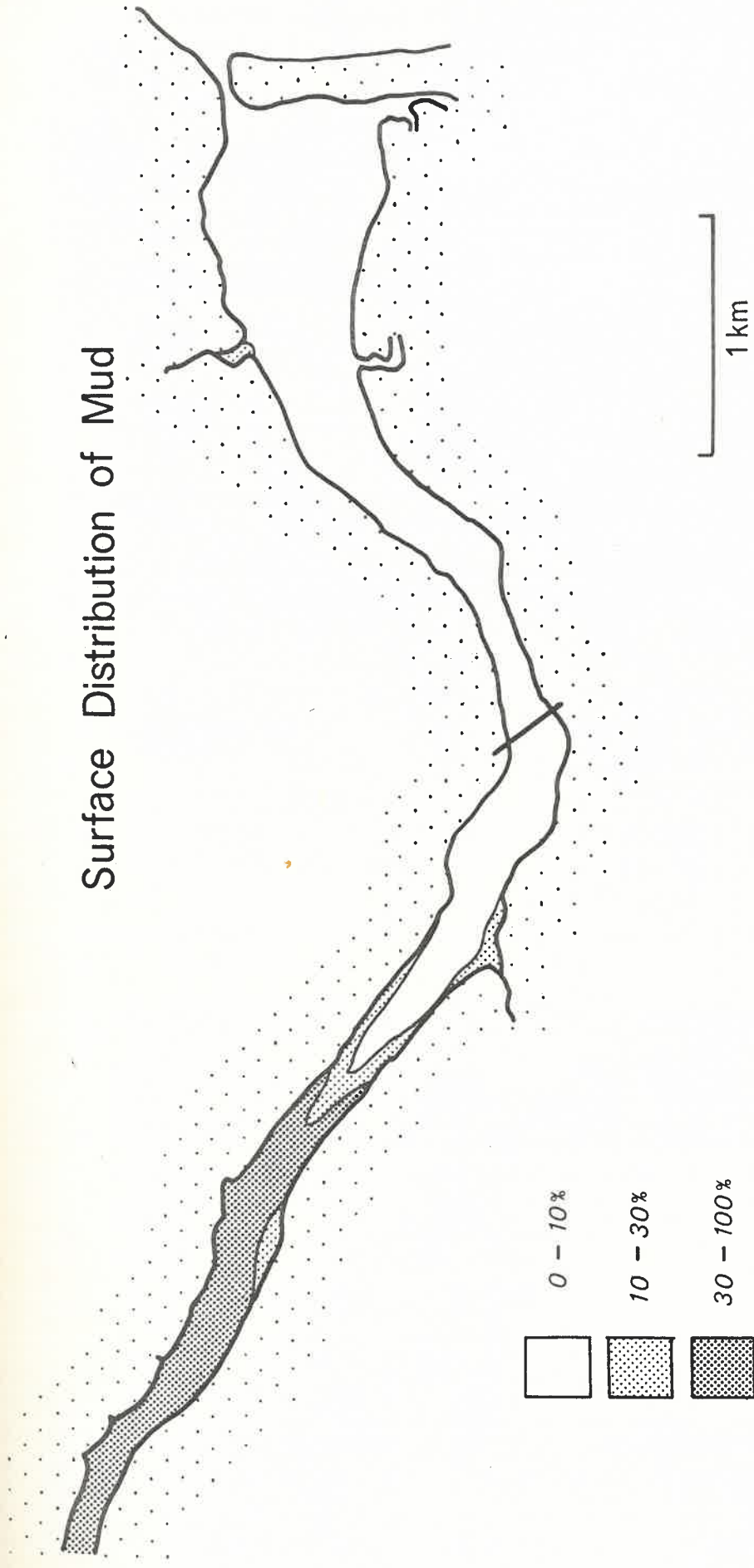


FIG 3.3A

# Surface Distribution of Mud

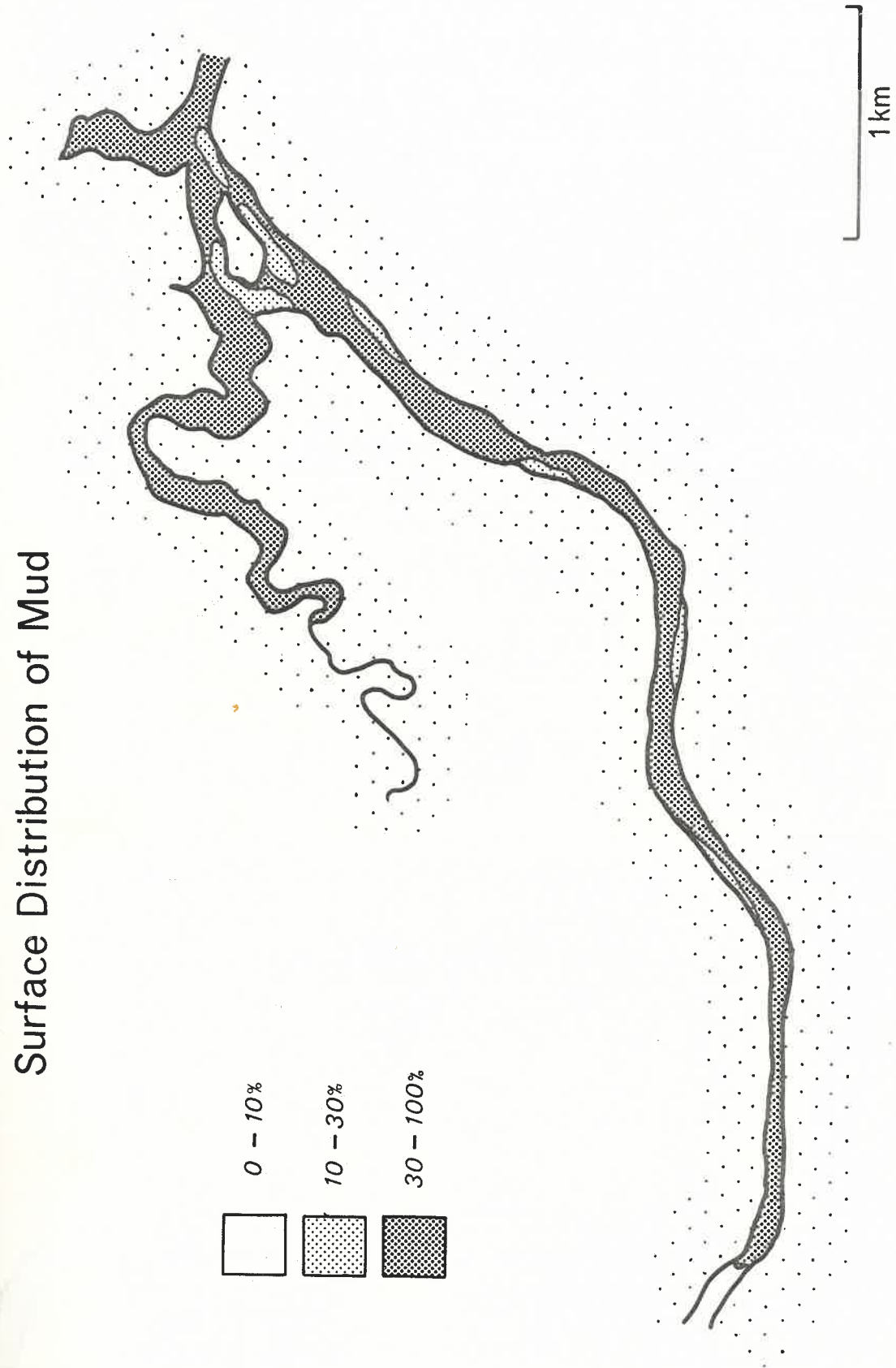


FIG 3.3A(CONT)

Distribution of Mud at -0,5m

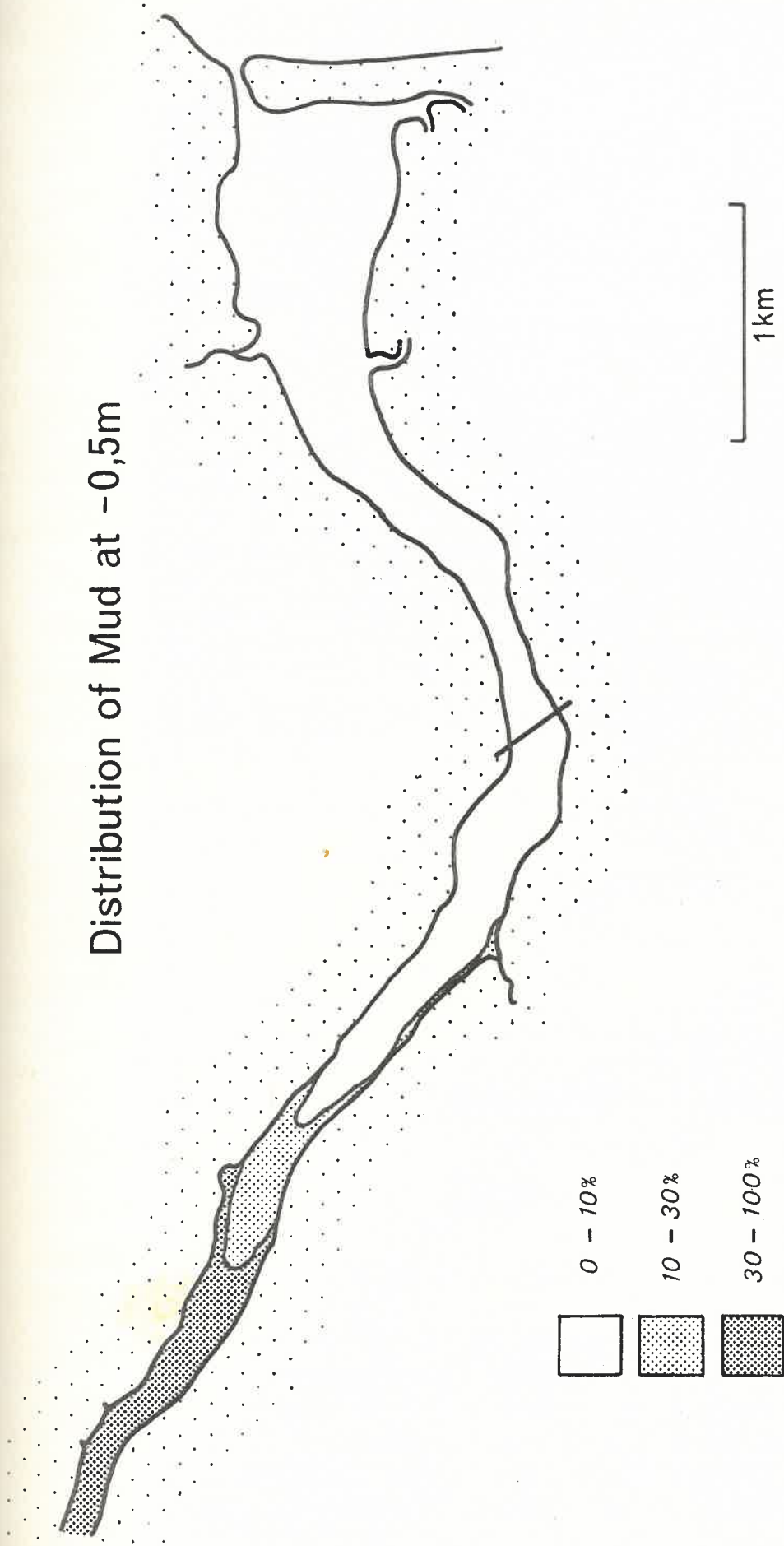


FIG 3.3B

Distribution of Mud at -0,5m

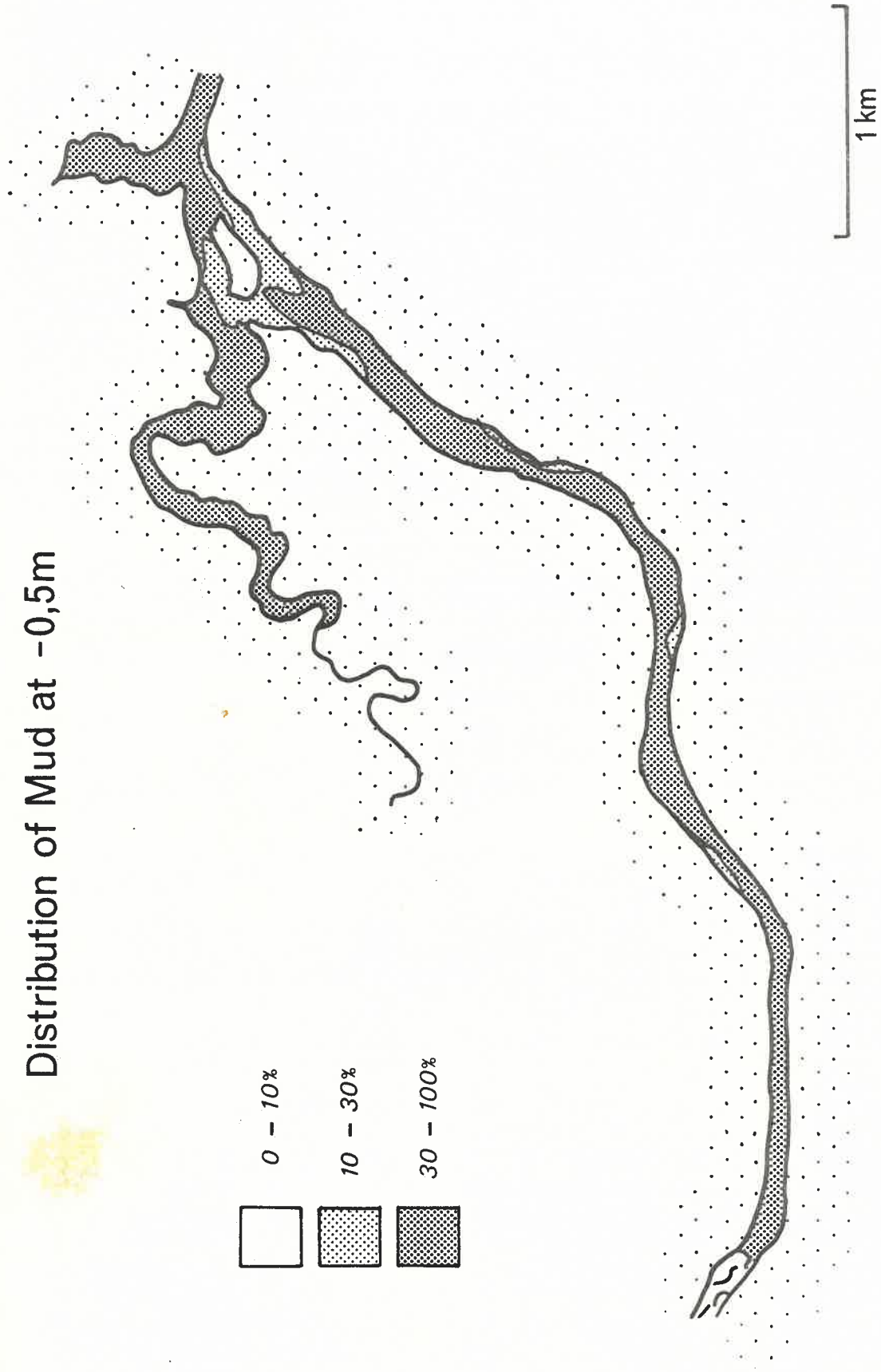


FIG 3.3B(CONT)

The distribution of mud is more complex. The obvious answer that increased down-estuary mud deposition with time is the result of generally decreasing current velocity is not necessarily correct. Mud deposition is intimately related to the salt content of the estuarine water. Clay particles tend to flocculate when they mix into an electrolytic solution. In this way, clay particles entering the estuary in freshwater suspension form floccules soon after mixing with the salty estuarine water. These floccules settle faster than the individual particles and are consequently deposited more rapidly. Deposition from suspension therefore commonly takes place in the area where fresh water and salt water mixes.

The Kromme estuary has a tendency of becoming hypersaline in its upper reaches during the drier summer months (section 2.2). Under such conditions mud entering the estuary at the head would probably be deposited soon after entering the estuary. If the zone where salt water and fresh water mixes, is moved down-estuary by increased freshwater discharge, the area where mud is deposited also migrates seaward. The conditions influencing mud flocculation are changed by very subtle variations in dissolved salt content and water turbulence. A large number of non-related climatic and tidal variables contribute towards these two factors and control the deposition of mud in the estuary.

Carbonate in the Kromme estuary consists of marine-derived shell fragments and moves up-estuary by tidal action. The  $\text{CaCO}_3$  content in the sediment decreases up-estuary from the inlet (APPENDIX 1). This primarily results from up-estuary fining of marine sediment. Carbonate is concentrated in the coarse sediment which is deposited near the inlet whereas the finer sediment which penetrates farther up-estuary has a relatively low  $\text{CaCO}_3$  content.  $\text{CaCO}_3$  is also produced metabolically by organisms (mainly molluscs) in the estuary.  $\text{Ca}^{++}$  ions present in the water column (Erasmus et al., 1980) are used in the process. As the river water contains little  $\text{Ca}^{++}$  (Erasmus et al., 1980), these ions are probably of marine origin.

Organic content of the sediment follows a reciprocal trend to that of carbonate (APPENDIX 1). The higher values are found in the upper estuary whereas the organic content of the sediment near the inlet is generally low. Organic material, usually being fine grained is often deposited in association with clastic mud.

### 3.2 Aerial photograph interpretation

Aerial photographs dating as far back as 1942 illustrate the sedimentary history of the estuary. Only the lower 4,5 km of the estuary has shown any significant alteration over the years. Aerial photographic maps (fig. 3.4 a to e) indicate little change in the period between 1942 and 1978. Channels generally seem to have deepened since 1942. This probably resulted from the stabilization of the aeolian dunes to the south-west of the inlet (section 5.2).

The sand bar configuration near the inlet is often complex but a navigable channel is always present. Flood-tidal deltas are deposited in the lower estuary by flood-tidal currents. These are common in inlets on wave-dominated microtidal coasts (Hubbard et al., 1979). The sediment on flood deltas is of marine origin.

Since 1942 shoaling has been prevalent in the channel bend about 4 km up-estuary from the inlet. It results from flow separation at the edges of flood-dominated and ebb-dominated channels where the channels cross. Sand is deposited in the flood-dominant channel during the ebbing tide and deposited in the ebb-dominant channel during the flooding tide. The sand body formed in this way is laterally connected and partially blocks both tidal channels. Such a shoal is not readily eroded by the comparatively weak tidal currents. Because channels frequently cross in the bends of estuaries, problems of this kind are often encountered there. Shoaling of this type is

# Kromme Estuary 1942

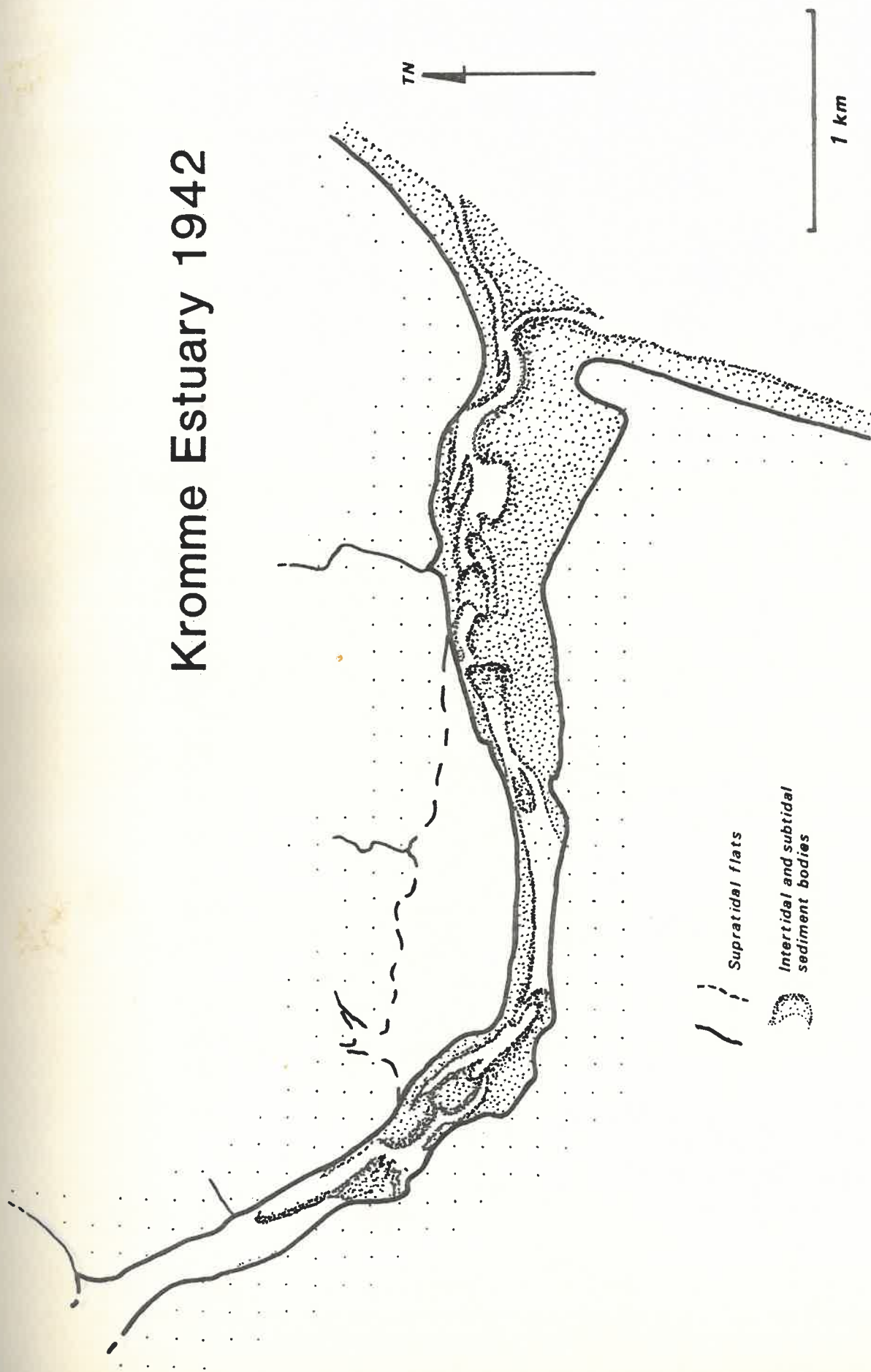


FIG 3.4A

# Kromme Estuary 1961

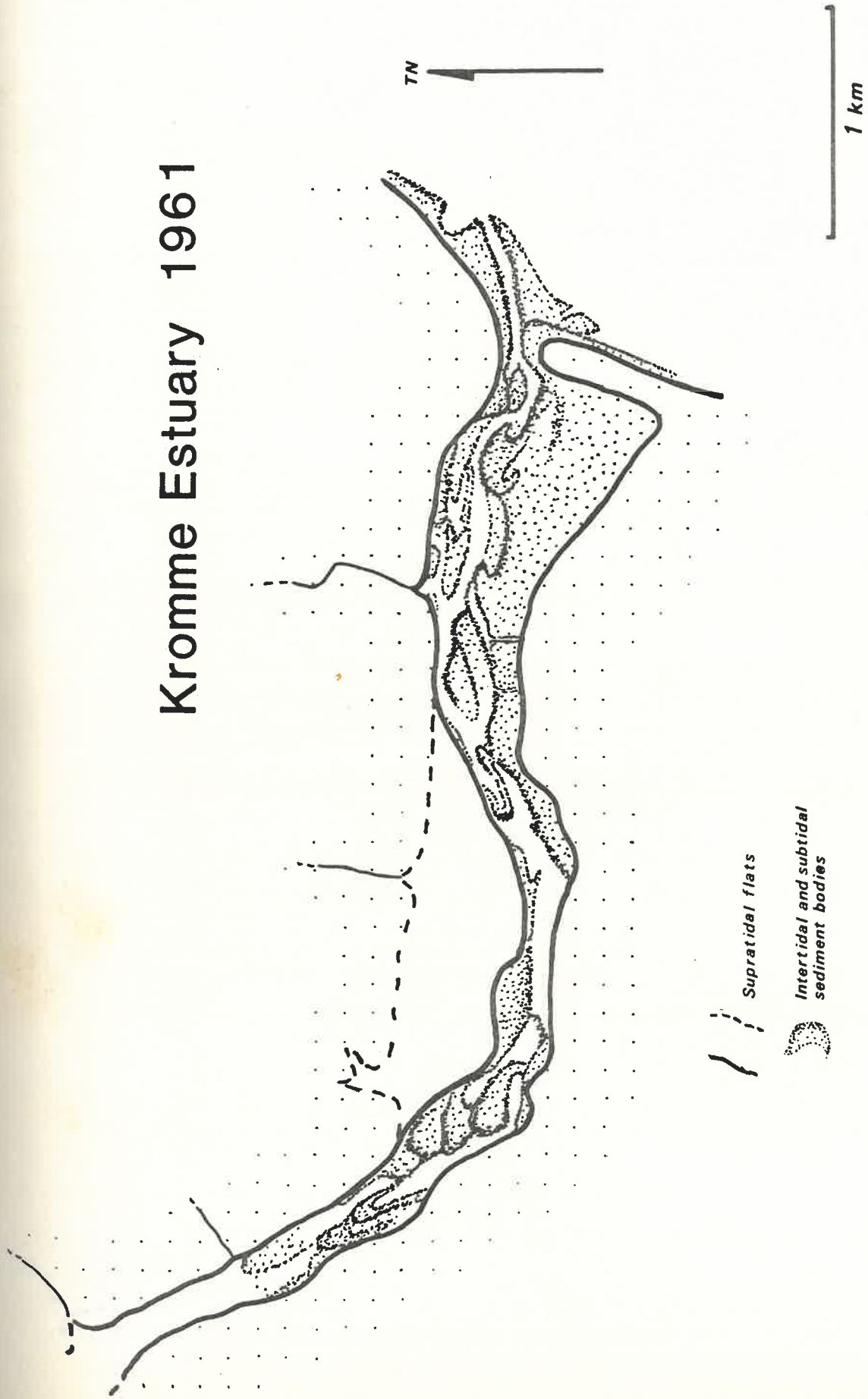


FIG 3.4B

# Kromme Estuary 1968

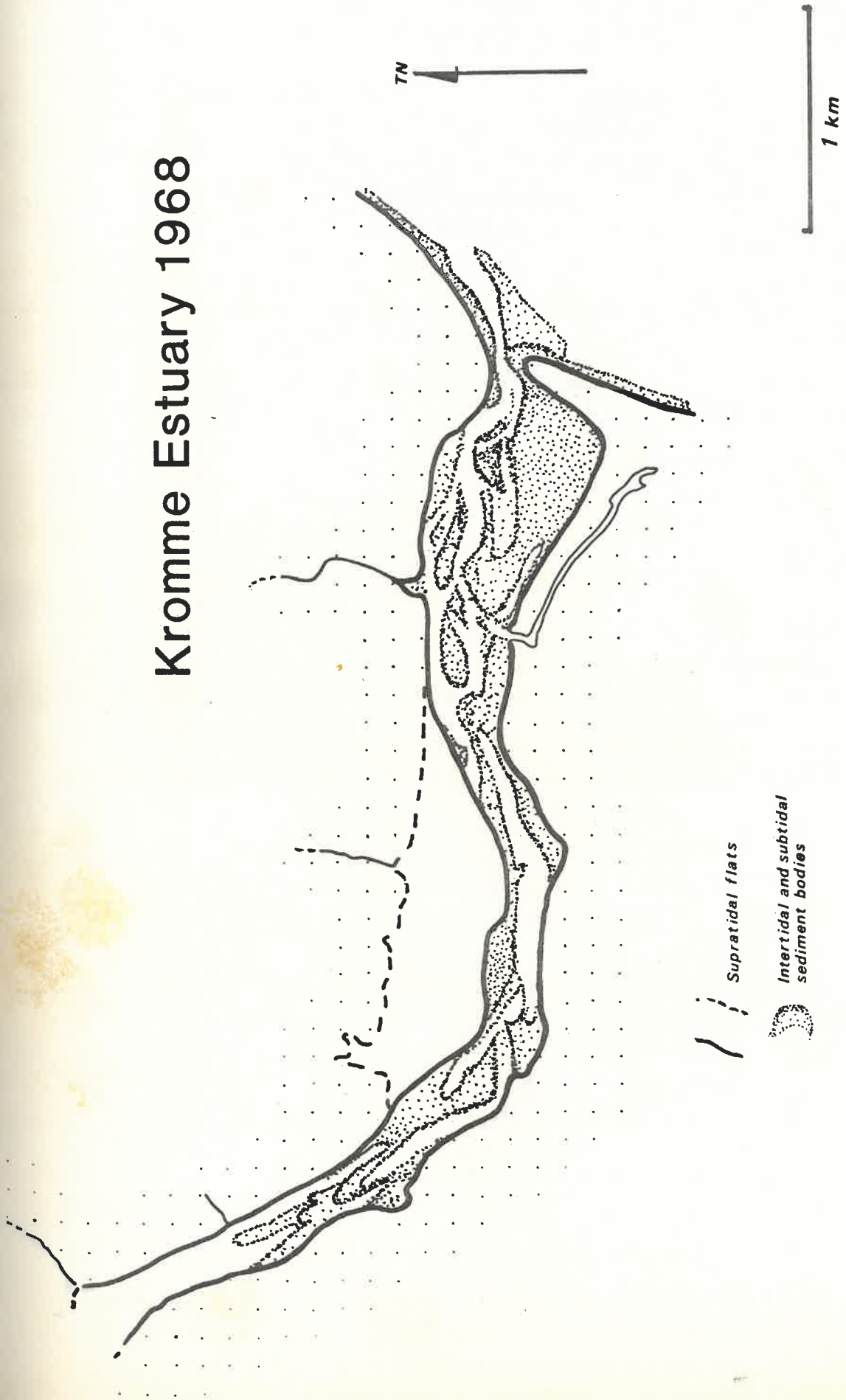


FIG 3.4C

# Kromme Estuary 1975

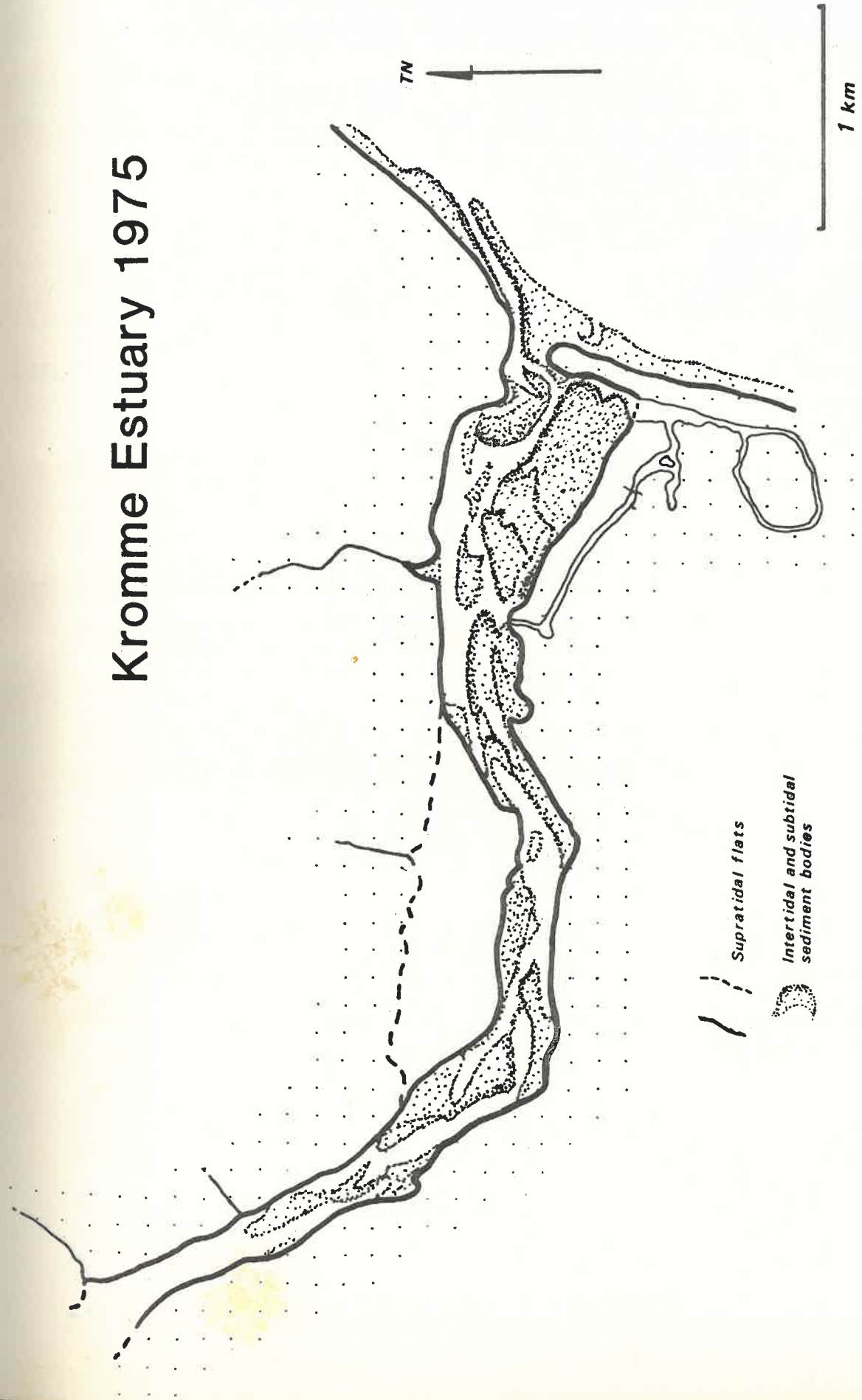


FIG 3.4D

# Kromme Estuary 1978

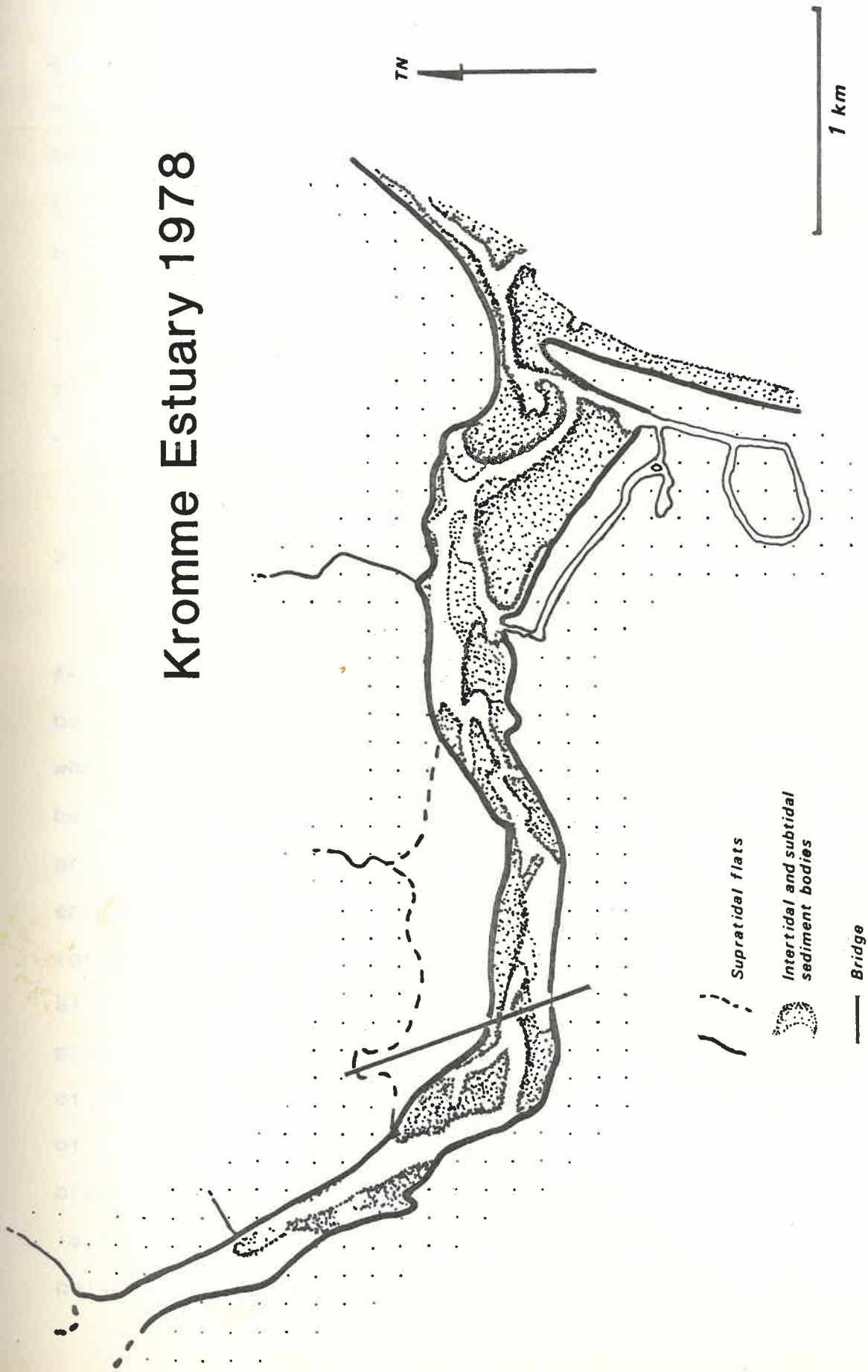


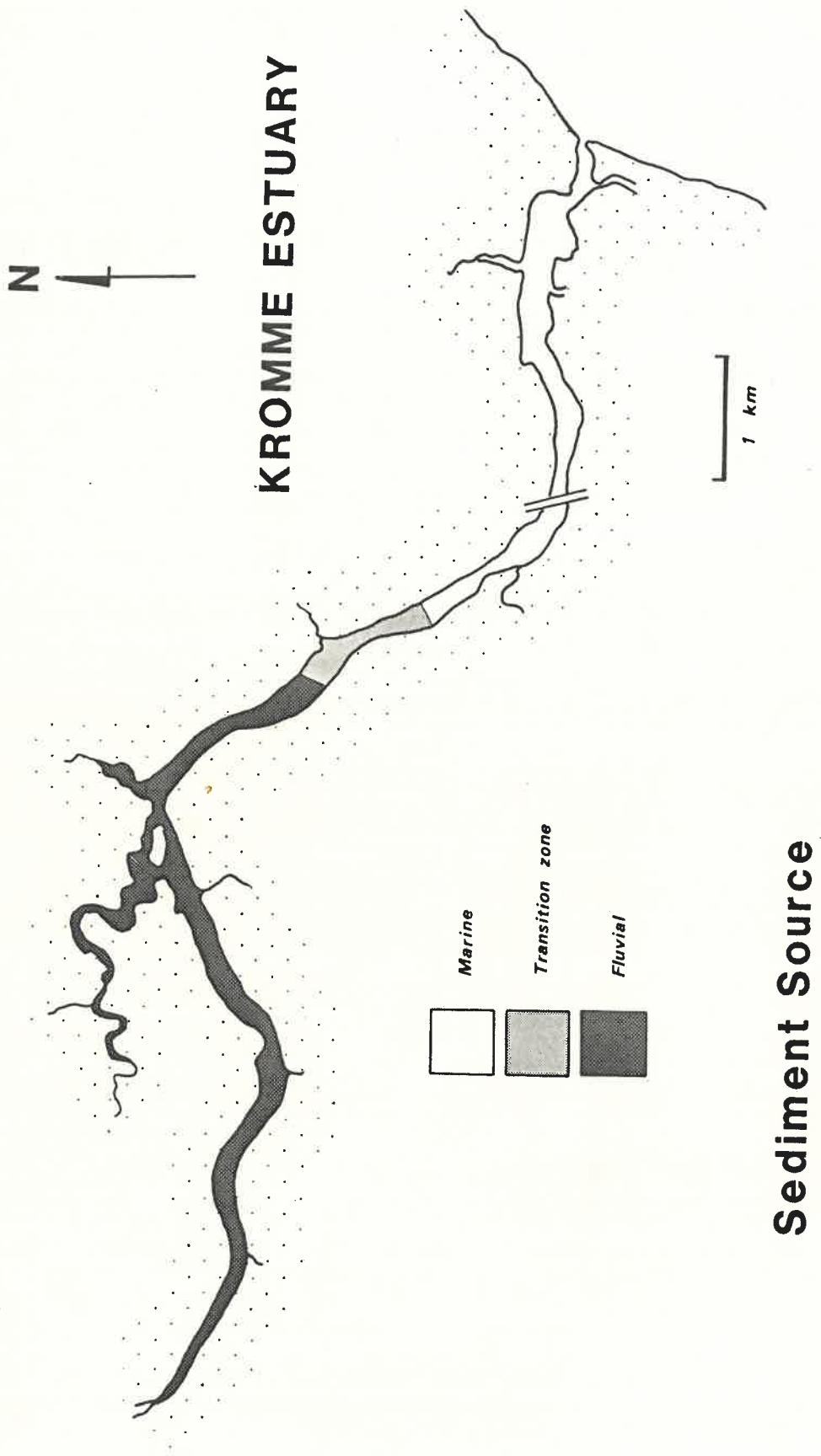
FIG 3.4E

common in the estuaries of the southern and eastern Cape coast (Reddering, 1981; Reddering & Esterhuysen, 1981a, 1981b). The bridge across the estuary (figs. 1.1 & 3.4) was constructed near the channel bend in 1976. This position is unfortunate because although the bridge will not influence shoaling (section 5.3) it may well be blamed for it by uninformed observers.

The marina which was constructed between 1968 and the early 70's (fig. 3.4c) has had no apparent effect on the sedimentary regime of the estuary.

### 3.3 Sediment source

Aerial photographs (section 3.2) show laterally connected sand bars extending from the inlet to 4,5 km farther up-estuary where they stop. This indicates that the sediment of these bars is marine-derived. Microscopic investigation of quartz grains show them to be well rounded between the inlet and the end of the prograding bars, also indicating their marine (or aeolian?) source (fig. 3.5). Fluvial grains that enter at the tidal head of the estuary are angular and have a high proportion of rock fragments. Sediment entering the main body of the estuary from the Geelhoutboom River consists chiefly of clastic mud and rock fragments. Little wind-blown sand presently enters the estuary. All clastic mud in the estuary is fluvio-gene. Some of this mud is reworked into faecal pellets by the sand prawn, Callianassa kraussi.



**FIG 3.5**

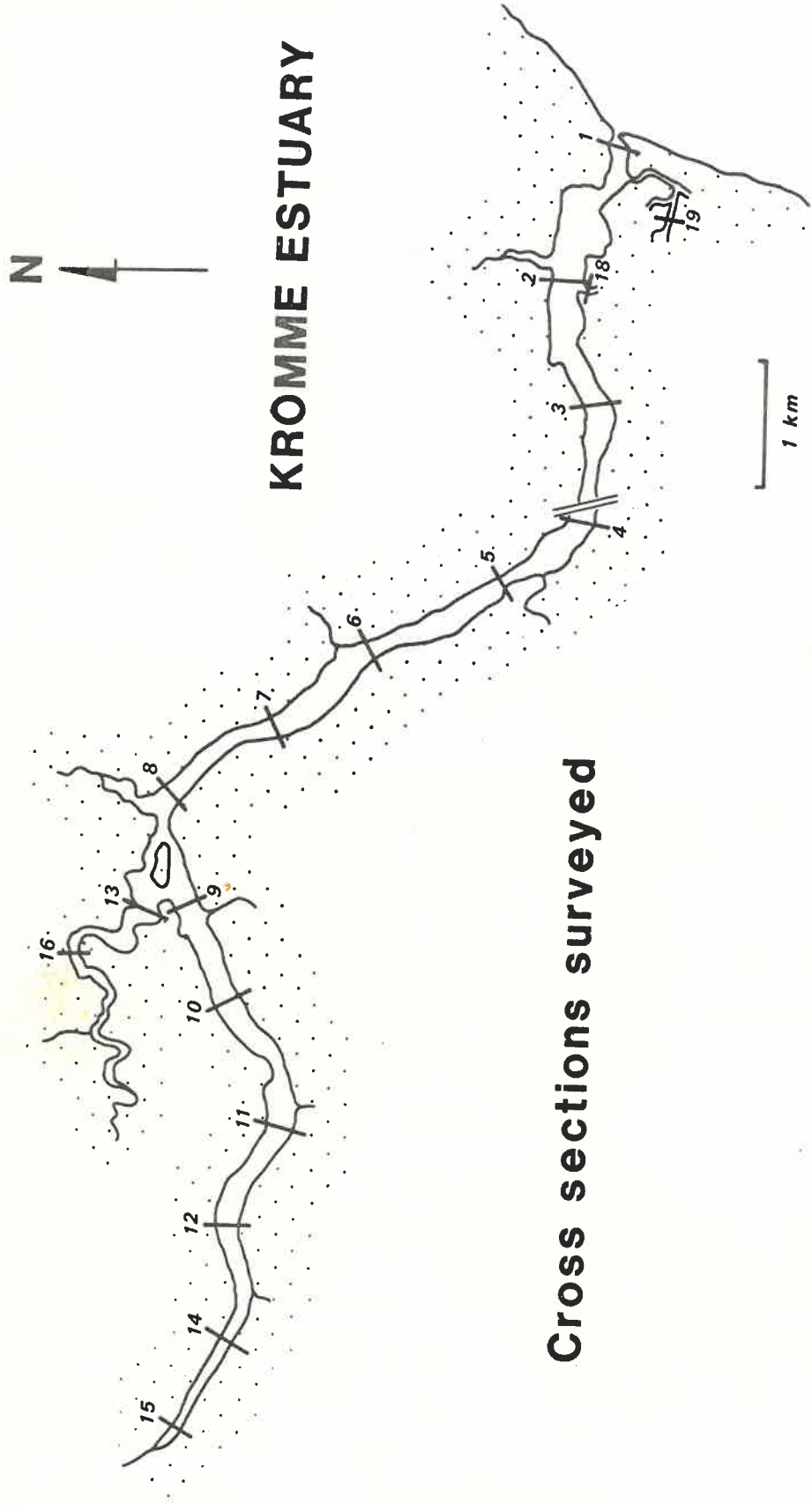
#### 4. SECTIONS ACROSS THE ESTUARINE CHANNELS.

##### 4.1 General

The purpose of the cross sections measured across the estuarine channel at 1 km intervals (fig. 4.1) is twofold. Firstly the cross-sectional areas can be monitored and used to establish whether sediment accumulation is taking place. The cross-sectional areas can further be used for a hydraulic one-dimensional computer simulation model. The purpose of such a model is to predict the hydraulic reaction of the estuary under changed environmental conditions owing to floods, reduced discharge, bridges, dams, and other factors.

The datum with respect to MSL was relayed up the estuary by a consultant (Mr Hemsley of Messrs Rollo, Hemsley and Myrdal). Benchmarks relative to this datum were established at the 1 km intervals from where the sections were surveyed. Measurements were taken by theodolite, while the stadia rod was positioned in the subtidal channel by a diver. The rod was placed at topographic inflections on the section line and at about 5 m intervals in the subtidal zone. Section 1 at the inlet could not be measured as wind erosion and deposition there destroyed the relevant benchmarks.

Cross section co-ordinates, cross-sectional areas, hydraulic radii, effective channel widths and cross section diagrams are presented in APPENDIX 2.



Cross sections surveyed

FIG 4.1

#### 4.2 Interpretation of results

The cross-sectional areas and the hydraulic radii increase up-estuary from the inlet. A sudden increase is found between section lines 5 and 6 (fig. 4.1), where the prograding marine sediment bars (section 3.3) end. This probably indicates that migration of these sand bars causes shoaling of an existing channel. A sudden decrease of hydraulic radius cannot simply be assumed to indicate shoaling of a channel. Sandy channels have a tendency to braid, whereas muddy channels will tend to be of the deeper, meandering type. These channel types have different hydraulic properties. A sand-bedded channel tends to be wider and shallower, giving it a relatively low hydraulic radius compared to that of a deeper muddy channel. However, in the Kromme estuary the cross-sectional area decreases simultaneously with hydraulic radius. From this it can be deduced that the channel is shoaled by the marine sand bars.

Comparison of channel widths indicate down-estuary widening of the channel (also see section 2.2). The cause for this is twofold. The upper estuary is confined by narrow, rocky banks and secondly, the lower estuary is predominantly sandy and the intertidal areas are readily reworked into wide sand flats that are not appreciably restricted by rocky banks.

## 5. SEDIMENT ACCUMULATION IN THE KROMME ESTUARY

### 5.1 General

Like most estuaries on the south-east Cape coast, the Kromme estuary is a natural sediment trap. Sediment enters from the tidal head and from the inlet but the net long term rate is relatively slow as much of the accumulated sediment is periodically removed by episodic freshwater floods. In this way estuaries maintain a system of channels and bars that effectively change very little.

The natural sediment balance of an estuary is likely to be changed by artificial modifications to the system. If sediment trapping in the estuary is made more efficient by poorly designed causeways or bridges, or if the discharge is reduced by dam construction in the catchment area, the sediment balance in the estuary is altered.

The assertion that excessive sedimentation is taking place in an estuary may also be biased by observational error by uninformed persons. Channel systems of an estuary are often in a state of dynamic change, particularly if these are in a sandy part of the estuary. These channels often change their positions. An original channel may be filled in while another is being established. If the original channel was used for pleasure boating for the past umpteen years the obvious deduction (to man's naturally conservative mind!) is that the

whole estuarine system is being filled in. This observation is often made by small craft operators at the critical point when the channel shoals to an outboard propellor's draught at low tide.

### 5.2 The effect of previously existing coastal dunes

Before being reclaimed, coastal dunes to the south-west of the Kromme inlet (fig. 1.1) supplied sand to the adjacent beach. This sand was transported north-eastward towards the inlet by the prevailing longshore current. From the inlet flood-tidal currents could move the wave-entrained sediment through the inlet into the estuary.

After the coastal dunes were stabilized during the 1960's the sediment load passing into the inlet was reduced and the rate of sand accumulation in the estuary was decreased. Removal of sand from the estuary by freshwater floods (and perhaps by the ebb tides) became more efficient and channels deepened as a natural result (section 3.2).

### 5.3 The effect of the bridge

A road bridge was constructed across the estuary in 1976, about 3 km from the inlet (fig. 1.1). It allows amply for tidal exchange and does not interfere with the tidal hydraulics of the system.

The northern approach road to the bridge was built on an embankment across a supratidal flat. Such embankments are generally environmentally undesirable as they can cause damming of water on the saltmarshes during freshwater floods. This may lead to sediment accumulation on these flats which increases their elevation. Halophytic vegetation on the flats depend on tidal water for sustenance, and if the flats are elevated above the spring high tide level, they cease to be inundated by estuarine water. Under such conditions the halophytes are eventually replaced by terrestrial vegetation. This is of considerable environmental concern as supratidal saltmarshes are an integral, and a very important part of the estuarine bio-ecology (P.E.D. Winter, pers. comm.).

The embankment across the Kromme estuary has three large culverts at the high tide level, allowing water to pass. To an extent this should decrease the damming effect of the embankment. The contribution of the culverts towards conservation of the supratidal flats is uncertain.

#### 5.4 The effect of the dams

Two dams in the catchment area influence the estuary (section 2.1). The effect of these dams on the estuary is twofold. Firstly, the dams retain a certain volume of sediment that would otherwise have passed into the estuary. The second influence is less desirable. Damming necessarily reduces the discharge passing through an estuary. Both the frequency and eroding power of freshwater floods in the estuary are reduced. Sediment accumulations can consequently not be scoured from the estuary effectively.

The dams may in future have a profound influence on the sediment balance of the Kromme estuary. Sand body morphology in the estuary clearly shows that the estuary is flood dominant and that marine sediment moves up into the estuary under tidal action (section 3.3). This is inherently the case in estuaries with constricted inlets (Uncles et al., in prep.). Sediment consequently accumulates in the estuary under tidal influence whereas the effect of fluvial sediment input is very much subordinate (section 3.3). Marine sediment entering the estuary without effective periodic scouring will continuously accumulate to the eventual detriment of the tidal circulation in the estuary. Shoaling associated with such sedimentation will also cause navigational obstacles for pleasure craft operating on the estuary.

Further influences of damming are:

1. Sediment input from the Geelhoutboom tributary of the estuary will not be influenced by the dams and it will continue to deposit mud in the estuary. When mud and marine sand are deposited together the mud occupies the sand grain interstices as a matrix. This sediment will compact to a cohesive mass if it is not disturbed by a freshwater flood for an extended period. When a flood of sufficient discharge subsequently passes through the estuary, it will not be able to erode the compacted sediment from the estuary to maximum potential effect as the bed will erosion-resistant.
2. Should shoaling increase to the extent that it causes flow restrictions, the hydraulic regime of the estuary could be influenced. This could have compounding negative effects on the estuary (e.g. nutrient and pollutant transfer problems, increased salt balance problems etc.).

#### 5.5 The erosion base

When a channel bottom is eroded, it is paved with an armour of non-erodable material. This generally consists of pebbles, shell gravel, bedrock, or at times highly highly compacted clay. This layer of material represents the lower level of erosion and is called the erosion base. Any sediment accumulated subsequently to a significant erosional event is deposited on top of this erosion surface.

The position of the erosion base with respect to the bed surface can thus be used to determine whether sediment is being accumulated or not. Should evidence of an erosion base be absent at the bed surface over the whole estuary it must have been covered by sediment. If alternatively the erosion base outcrops over large areas of the bed, sediment is not accumulating.

In the Kromme estuary the erosion base is not commonly encountered and its extent is usually limited to rocky outcrops at the channel margins. Lags of weathered slate chips (section 2.2) are commonly found there. The erosion base was also also encountered in the deeper channel (section 4) of the upper estuary. In the Geelhoutboom tributary of the estuary the erosion base is limited to the bank where slate chips are locally deposited. The channel bed is covered by a layer of unconsolidated mud (section 3.1). From the Geelhoutboom confluence with the main channel to the prograding marine sand bars lower down in the estuary (fig. 3.5) the erosion base was sporadically encountered. Between the bridge and 1,5 km farther up-estuary the erosion base is absent. Between the bridge and the inlet the erosion base is confined to bedform troughs and to the banks of the estuary. In the inlet itself a lag of coarse shell material and outcrops of Bokkeveld slate form the erosion base.

Extensive deposition onto the erosion base indicates that sediments are at present accumulating in the Kromme estuary. The largest volumes occur in the area between the bridge and 1,5 km farther up-estuary (also see section 3.2), the Geelhoutboom estuary and to a lesser extent in the lower estuary between the bridge and the inlet.

## 6. DISCUSSION AND CONCLUSION

Sedimentation is taking place in the Kromme estuary and as a result of reduced freshwater discharge passing through the estuary sedimentation can be expected to increase.

The sediment that causes shoaling is primarily of marine origin and its influx cannot readily be controlled by artificial means.

Sedimentation problems of the type that are becoming evident in the Kromme estuary will generally become more serious as increased demand for fresh water increases water retention in the catchment areas of South African estuaries. If the preservation of these areas as a natural resource is desired, it is essential that management of estuaries is properly planned in the long term.

In the specific case of the Kromme estuary, sedimentation is taking place but its extent and significance are not known. Research should be directed towards predictive simulation modelling (section 4.1) to find some quantitative answers on the behaviour of the system under changed environmental conditions. Management proposals, if required, can then be made with some degree of confidence.

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## REFERENCES

- Buller, A.T. and McManus, J. (1979) Sediment sampling and analysis. In Dyer, K.R., Ed., Estuarine hydrography and sedimentation. Cambridge University Press. 230 pp.
- Erasmus, T., Watling, R.J., Emmerson, W.D. and Reddering, J.S.V. (1980) South Eastern Cape Monitoring Programme Report for the period April 1979 - August 1980. Univ. of Port Elizabeth, Zoology Dept., Report no. 1, 68pp.
- Hanekom (1982) An ecological study of the *Zostera* beds in the Kromme Estuary. Univ. of Port Elizabeth, Zoology Dept., Report no. 18.
- Hecht, T. (1973) The ecology of the Kromme estuary with special reference to *Sesarma catenata* (Ortm.)., M.Sc. dissert., Univ. of Port Elizabeth.

- Hubbard, D.K., Oertel, G.F. and Nummedal, (1979) The role of waves and tidal currents in the development of tidal-inlet sedimentary structures and sand body geometry: examples from North Carolina, South Carolina and Georgia. J. sedim. Petrol., 49, 1073-1092.
- McCave, I.N. (1979) Suspended sediment. In Dyer, K.R., Ed., Estuarine hydrography and sedimentation. Cambridge University Press. 230 pp.
- Reddering, J.S.V. (1978) The geology of some southern Cape coastal aeolianites. B.Sc. Hons. project, Univ. of Port Elizabeth, 47pp.
- Reddering, J.S.V. (1981) The sedimentology of the Keurbooms estuary. Unpubl. M.Sc. dissert., Univ. of Port Elizabeth. 131pp.
- Schink, J.C., Stockwell, J.H. and Ellis, R.A. (1979) An improved device for gasometric determination of carbonate in sediments. J. sedim. Petrol., 49, 651-653.
- Uncles, R.J., Baird, D. and Reddering, J.S.V. (in prep.) Tidal dynamics of an estuary with a restricted inlet, and application to the Bushmans Estuary, South Africa. Oceanologica Acta.

## APPENDIX 1

This section lists all the sediment data collected in the Kromme estuary. The sample lines are marked on fig. 3.1. The position of the the sample stations can be found from the coded station numbers. For example K 3;2T originates from the Kromme ("K" in the code) and was collected on line number 3 ("3", see fig. 3.1). It was taken at the bed surface ("T" denotes TOP) at position 2 on that line. This sampling spot (indicated as a dot, fig. 3.1) is the second from the LEFT, looking up-estuary. Samples were also collected 0,5 m below the surface by coring. These samples are indicated by a "B" (for BOTTOM) in the code.

All grain sizes listed below are in PHI-units and NOT in mm.  
( $\text{PHI} = -\log_2 (\text{grain size in mm} / 1 \text{ mm})$  )

This appendix has three sections: A, B and C. Section A lists the grain size class distributions of the samples. Section B gives the statistical parameters and section C lists the respective contents of bioclastic carbonate and of organic material.

## APPENDIX 1 A

This section lists the grain size class distributions.

The parameters listed below are as follows:

- VCS - Very coarse sand (grain diameters 1 mm to 2 mm)
- CS - Coarse sand (grain diameters 0,5 mm to 1 mm)
- MS - Medium sand (grain diameters 0,25 mm to 0,5 mm)
- FS - Fine sand (grain diameters 0,125 mm to 0,25 mm)
- VFS - Very fine sand (grain diameters 0,063 mm to 0,125 mm)
- Mud - Silt and clay (grain diameters less than 0,063 mm)

Sample no -----	%VCS -----	%CS -----	%MS -----	%FS -----	%VFS -----	%Mud -----
K 1; 1T	0.41	1.63	37.80	58.54	0.81	0.81
1B	0.32	0.96	26.20	69.01	1.28	2.24
2T	1.89	5.68	59.94	29.34	0.00	3.15
2B	0.00	1.88	45.11	51.13	0.38	1.50
3T		Solid substrate				
3B		Solid substrate				
4T	0.00	0.00	53.87	45.56	0.00	0.57
4B		Solid substrate				
K 2; 1T	0.00	0.83	26.86	69.42	0.83	2.07
1B	0.00	1.64	25.14	68.85	2.19	2.19
2T	0.00	2.35	25.87	60.84	1.75	11.19
2B	0.00	0.28	30.47	66.76	0.55	1.94
3T	0.00	0.00	22.54	73.77	2.46	1.23
3B	0.00	0.00	13.62	83.06	1.66	1.66
4T	0.00	0.00	20.00	77.58	1.82	0.61
4B	0.37	0.37	37.31	60.45	0.37	1.12
5T	0.00	0.48	38.94	59.62	0.00	0.96
5B	0.00	0.35	17.54	81.40	0.00	0.70
6T	0.00	1.27	34.32	63.98	0.00	0.42
6B	0.00	0.00	15.27	84.00	0.36	0.36
K 3; 1T	0.00	0.51	14.14	81.82	2.53	1.01
1B	0.00	0.37	24.44	69.26	1.85	4.07
2T	0.00	0.37	27.41	69.63	1.11	1.48
2B	0.00	0.72	32.26	58.42	2.87	5.73
3T	0.00	0.46	14.29	79.26	4.15	1.84
3B	0.35	1.40	18.88	73.43	3.15	2.80
4T	0.00	0.00	7.89	89.10	1.88	1.13
4B	0.00	0.00	11.38	86.90	1.03	0.69
5T	1.28	0.43	25.96	68.09	2.13	2.13
5B	1.23	3.70	53.40	38.89	0.62	2.16
6T	0.00	0.00	22.65	76.80	0.00	0.55
6B	0.00	0.36	30.22	68.35	0.36	0.72
7T	0.00	0.00	17.05	81.06	0.76	1.14
7B	0.00	0.00	13.90	83.05	1.02	2.03
8T	0.00	0.00	14.34	79.25	1.13	5.28
8B	0.00	0.33	24.10	72.64	1.30	1.63
K 5; 1T	0.00	0.28	29.75	65.56	2.20	2.20
1B	0.00	0.33	17.73	72.58	4.68	4.68
2T	0.00	0.32	45.69	51.12	1.60	1.28
2B	0.00	0.42	48.33	46.25	2.92	2.08
3T	0.00	0.42	56.30	39.92	1.26	2.10
3B	0.33	0.33	45.90	51.48	0.33	1.64
4T	0.00	0.27	41.62	54.86	1.62	1.62
4B	0.45	0.90	38.57	57.85	0.45	1.79
5T	0.32	0.32	59.35	38.39	0.32	1.29
5B	1.20	2.40	61.20	33.20	0.80	1.20
6T	9.69	4.26	29.07	38.37	4.65	13.95
6B	57.43	3.50	15.45	18.66	1.17	3.79

Sample no -----	%VCS -----	%CS -----	%MS -----	%FS -----	%VFS -----	%Mud -----
K 6; 1T	0.00	0.75	54.89	42.86	0.38	1.13
1B	0.00	0.30	39.22	56.59	2.40	1.50
2T	0.00	0.29	60.52	37.75	0.29	1.15
2B	0.00	0.29	52.03	45.06	0.29	2.33
3T	0.67	0.67	48.49	47.16	1.67	1.34
3B	1.06	2.11	55.63	40.14	0.35	0.70
4T	0.00	0.00	52.34	47.23	0.00	0.43
4B	1.16	2.70	35.91	57.53	0.77	1.93
5T	0.00	0.88	58.77	39.91	0.00	0.44
5B	0.36	1.09	50.73	45.26	1.09	1.46
K 7; 1T	0.43	0.43	55.60	42.24	0.43	0.86
1B	0.00	0.32	55.38	43.67	0.00	0.63
2T	0.00	0.60	65.17	33.63	0.00	0.60
2B	0.00	0.28	48.04	49.16	0.56	1.96
3T	1.22	2.43	77.81	17.93	0.00	0.61
3B	1.64	3.29	61.84	30.26	0.66	2.30
4T	0.00	0.29	47.06	51.76	0.00	0.88
4B	1.48	1.48	52.82	43.03	0.30	0.89
5T	2.38	2.04	45.24	40.82	2.04	7.48
5B	0.31	0.62	60.06	34.98	1.55	2.48
K 8; 1T	13.41	1.81	25.72	47.83	3.26	7.97
1B		Solid substrate				
2T	79.69	0.62	12.00	7.38	0.00	0.31
2B		Solid substrate				
3T	12.11	0.53	40.53	46.32	0.26	0.26
3B	4.66	6.21	52.80	35.40	0.00	0.93
4T	0.65	1.31	66.99	30.39	0.00	0.65
4B	1.08	2.69	31.18	63.17	0.54	1.34
5T	0.24	0.48	48.22	48.69	0.95	1.43
5B	1.32	1.99	53.64	40.07	0.66	2.32
K 9; 1T	1.17	2.35	80.35	14.96	0.29	0.88
1B	1.46	2.33	73.76	21.57	0.00	0.87
2T	0.34	0.68	73.63	25.00	0.00	0.34
2B	2.90	4.15	53.11	35.27	0.41	4.15
3T	0.72	1.44	57.40	38.63	0.36	1.44
3B	0.00	0.97	55.34	42.72	0.32	0.65
4T	0.00	0.00	12.28	83.16	3.51	1.05
4B	2.38	5.44	53.74	36.39	0.34	1.70
5T	0.00	0.30	32.12	63.03	0.91	3.64
5B	0.29	0.88	51.76	37.06	1.76	8.24
K 10; 1T	0.00	0.29	30.88	65.88	1.76	1.18
1B	0.66	0.00	1.32	17.11	27.63	53.29
2T	0.00	0.64	56.87	42.17	0.00	0.32
2B	0.90	1.51	43.98	51.20	1.20	1.20
3T	0.00	0.39	75.39	23.83	0.00	0.39
3B	1.36	1.02	57.48	38.78	0.34	1.02
4T	0.35	0.70	45.96	48.07	1.40	3.51
4B	0.00	0.36	59.35	39.57	0.00	0.72
5T	0.43	1.30	64.78	32.61	0.00	0.87
5B	0.31	0.93	47.06	50.46	0.31	0.93
6T	0.00	0.89	48.44	48.44	0.44	1.78
6B	0.33	0.66	38.87	56.48	1.66	1.99

Sample no	%VCS	%CS	%MS	%FS	%VFS	%Mud
K 11; 1T	0.49	0.49	21.95	52.20	9.27	15.61
1B	0.47	0.00	21.70	47.64	7.08	23.11
2T	0.00	0.00	54.85	43.69	0.49	0.97
2B	0.35	0.35	44.60	52.61	0.35	1.74
3T	0.46	0.92	58.53	39.63	0.00	0.46
3B	2.80	2.80	59.09	34.27	0.35	0.70
4T	2.24	1.79	73.99	21.52	0.00	0.45
4B	8.39	4.03	56.38	29.53	0.00	1.68
5T	45.08	5.08	42.03	7.46	0.00	0.34
5B	15.97	6.08	64.26	12.17	0.00	1.52
K 12; 1T	0.46	0.46	18.81	51.38	8.26	20.64
1B	0.00	0.41	20.99	65.02	5.76	7.82
2T	1.30	1.30	57.58	38.96	0.43	0.43
2B	1.04	2.42	46.02	43.60	2.77	4.15
3T	0.78	2.71	74.42	21.71	0.00	0.39
3B	0.47	3.79	68.72	24.64	0.95	1.42
4T	5.41	0.90	63.96	28.83	0.45	0.45
4B	7.08	10.00	57.92	22.50	0.00	2.50
5T	1.14	1.90	77.57	18.63	0.00	0.76
5B	5.77	4.33	76.44	12.98	0.00	0.48
K 13; 1T	1.35	0.45	6.76	30.63	15.77	45.05
1B	2.17	1.08	11.91	45.49	15.52	23.83
2T	0.49	2.46	34.48	19.70	10.84	32.02
2B	2.45	15.29	71.25	9.48	0.61	0.92
3T	0.48	0.96	22.97	26.79	7.18	41.63
3B	0.78	4.26	38.37	26.74	3.88	25.97
4T	1.14	1.71	9.14	20.00	21.14	46.86
4B		Solid substrate				
5T	1.67	0.56	5.56	11.11	18.89	62.22
5B		Solid substrate				
K 14; 1T	0.68	0.34	6.12	49.66	24.83	18.37
1B	0.84	0.84	21.43	53.36	5.46	18.07
2T	0.00	0.00	4.37	13.59	7.28	74.76
2B	0.35	0.35	21.83	53.52	5.99	17.96
3T	0.49	2.45	12.25	7.84	5.88	71.08
3B	3.38	13.51	47.30	17.57	2.03	16.22
4T	0.73	1.83	26.37	26.37	13.19	31.50
4B	1.98	3.16	47.04	28.46	5.53	13.83
5T	3.77	1.42	8.96	20.75	20.28	44.81
5B	10.81	3.15	13.96	23.42	11.71	36.94
K 15; 1T	0.00	0.42	8.33	34.58	19.17	37.50
1B	0.00	0.37	10.66	53.31	15.81	19.85
2T	0.45	1.34	25.00	24.11	8.48	40.62
2B	3.23	1.79	36.56	22.58	6.45	29.39
3T	0.00	0.00	0.00	0.93	0.93	98.15
3B	0.00	0.00	0.00	0.78	0.00	99.22
4T	0.00	0.00	0.00	0.92	1.83	97.25
4B	1.50	0.00	0.75	0.75	3.01	93.98

Sample no -----	%VCS ----	%CS ----	%MS ----	%FS ----	%VFS ----	%Mud ----
K 16; 1T	2.20	6.59	42.86	21.61	3.66	23.08
1B	0.35	7.75	48.24	26.41	2.82	14.44
2T	0.00	0.00	0.66	1.99	1.99	95.36
2B	0.00	0.65	1.31	1.96	0.65	95.42
3T	0.00	0.00	0.00	1.42	4.26	94.33
3B	0.00	0.00	0.00	0.72	2.16	97.12
4T	6.80	0.49	1.46	8.25	12.62	70.39
4B	9.40	2.35	10.74	27.52	17.11	32.89
5T	1.22	0.41	1.63	8.54	18.29	69.92
5B	4.64	4.97	12.58	26.82	20.53	30.46
K 17; 1T	2.84	3.41	21.02	23.86	9.66	39.20
1B	1.39	4.63	27.78	21.30	16.67	28.24
2T	0.41	5.31	24.90	27.76	15.10	26.53
2B	1.15	8.05	37.55	24.90	5.75	22.61
3T	2.42	6.85	31.45	34.68	7.26	17.34
3B	1.08	9.39	42.96	28.88	6.14	11.55
K 18; 1T	9.55	1.27	5.73	21.02	17.83	44.59
1B		Solid substrate				
2T	0.74	2.60	41.26	34.94	3.35	17.10
2B	2.29	2.86	13.71	27.43	22.29	31.43
3T	0.37	1.49	30.97	44.40	5.22	17.54
3B	2.03	6.50	47.15	32.11	3.66	8.54
K 19; 1T	0.71	8.21	31.79	31.43	9.64	18.21
1B	1.24	5.37	22.31	21.49	9.92	39.67
2T	1.60	3.19	13.30	10.11	7.98	63.83
2B	5.03	15.72	41.51	20.13	2.20	15.41
3T	1.46	3.40	27.67	13.59	1.46	52.43
3B	4.13	6.61	52.89	21.07	1.24	14.05
4T	0.88	1.77	8.85	5.31	2.65	80.53
4B	3.35	4.18	42.26	24.69	6.69	18.83
5T	0.00	0.59	2.94	20.59	20.59	55.29
5B	0.99	0.66	5.61	28.05	15.18	49.50
K 20; 1T	44.44	4.09	4.09	4.09	2.34	40.94
1B		Solid substrate				
2T	0.56	0.56	2.81	1.12	0.56	94.38
2B	0.47	5.14	60.28	14.49	0.47	19.16
3T	0.71	5.67	25.53	40.78	6.74	20.57
3B	1.94	16.13	58.39	13.23	1.94	8.39
4T	1.35	7.74	34.01	25.25	10.44	21.21
4B	0.37	2.99	20.52	19.03	24.25	32.84
K 21; 1T	2.87	17.53	33.05	29.60	5.46	11.49
1B	7.40	13.27	31.38	25.77	9.18	13.01
2T	2.30	37.93	52.30	4.60	0.00	2.87
2B	6.23	37.39	47.03	4.82	0.00	4.53
3T	0.00	7.48	61.06	20.87	0.93	9.66
3B	0.00	2.23	36.31	34.08	8.10	19.27
4T	1.89	0.63	0.63	1.26	0.63	94.97
4B	0.72	0.72	1.44	2.16	1.44	93.53

Sample no	%VCS	%CS	%MS	%FS	%VFS	%Mud
-----	-----	---	---	---	-----	-----
K 22; 1T	13.33	1.85	8.15	21.11	10.00	45.56
1B		Solid substrate				
2T	5.42	24.10	10.84	1.81	0.60	57.23
2B	16.29	32.13	15.38	1.36	0.45	34.39
3T	2.01	31.54	56.71	5.03	0.34	4.36
3B	5.29	36.27	48.87	5.54	0.25	3.78
4T	0.00	1.23	31.48	38.89	11.73	16.67
4B	0.00	1.08	26.52	42.65	11.47	18.28
K 23; 1T	10.81	2.70	8.11	10.81	4.05	63.51
1B		Solid substrate				
2T	2.40	58.13	32.53	3.20	0.27	3.47
2B	1.81	47.93	43.01	2.33	0.26	4.66
3T	0.97	1.94	9.71	7.77	0.97	78.64
3B	0.00	1.47	9.56	8.82	1.47	78.68
K 24; 1T	11.26	46.42	32.08	4.44	1.02	4.78
Geelhoutboom tributary						
K A; 1T	1.63	1.22	13.41	47.56	11.79	24.39
1B	0.95	2.61	22.99	44.55	11.14	17.77
2T	56.18	4.12	4.41	5.29	0.88	29.12
2B	62.88	6.44	6.06	9.09	1.52	14.02
3T	12.44	2.39	5.74	18.18	11.48	49.76
3B		Solid substrate				
K B; 1T	30.66	5.84	6.20	4.01	3.28	50.00
1B		Solid substrate				
2T	0.00	0.00	0.00	0.00	1.20	98.80
2B	1.64	1.23	2.05	6.56	12.70	75.82
3T	0.61	0.61	0.61	2.42	4.24	91.52
3B	7.88	5.42	7.39	17.24	11.82	50.25
K C; 1T	0.55	0.00	0.55	4.37	7.65	86.89
1B	0.49	0.00	1.48	6.40	8.87	82.76
2T	0.00	0.00	0.58	1.16	1.16	97.09
2B	1.10	2.20	3.30	4.95	4.95	83.52
3T	0.91	0.91	0.91	0.91	0.00	96.36
3B	35.14	12.68	11.59	8.70	3.26	28.62
K D; 1T	46.55	3.02	2.59	3.45	1.29	43.10
1B		Solid substrate				
2T	0.65	0.65	2.61	3.27	2.61	90.20
2B	1.51	2.51	5.53	6.53	4.52	79.40
3T	0.00	1.30	3.90	7.79	5.84	81.17
3B	3.40	1.70	7.23	13.19	5.53	68.94
K E; 1T	6.25	2.68	11.61	16.96	1.79	60.71
1B	82.02	6.74	2.53	1.12	0.28	7.30
2T	0.68	0.68	1.35	2.03	0.68	94.59
2B	4.17	1.56	1.56	1.04	0.52	91.15
3T	2.84	0.71	2.84	5.67	4.26	83.69
3B	9.09	3.25	4.55	9.09	3.25	70.78

## APPENDIX 1 B

This section lists the statistical parameters of the Kromme estuary sediments. NOTE that the statistical parameters only apply to the sand size classes. Silt and clay are EXCLUDED from these parameters.

The parameters listed below are as follows:

- Med. - The distribution median in PHI-units ( $Md = P_{50}$ ) \*
- Mean - The mean grain size in PHI-units ( $M = (P_{16} + P_{84})/2$ )
- Sort - Grain sorting in PHI-units ( $So = (P_{84} - P_{16})/2$ )
- Ske. - Distribution skewness in PHI-units ( $Sk = (M - Md)/S$ )
- Kurt - Distribution kurtosis in PHI-units

$$(Ku = (((P_{95} - P_5)/2) - S)/S)$$

\*  $P_x$  is the xth percentile of the relevant distribution.

Sample no -----	Med. ----	Mean ----	Sort ----	Ske. ----	Kurt ----
K 1; 1T	2.17	2.05	0.69	-0.16	0.35
1B	2.31	2.17	0.62	-0.23	0.46
2T	1.68	1.80	0.67	0.18	0.73
2B	2.04	2.00	0.70	-0.06	0.32
3T		Solid substrate			
3B		Solid substrate			
4T	1.92	1.97	0.68	0.07	0.33
4B		Solid substrate			
K 2; 1T	2.31	2.17	0.62	-0.22	0.45
1B	2.32	2.18	0.62	-0.23	0.47
2T	2.30	2.17	0.63	-0.21	0.43
2B	2.27	2.14	0.63	-0.21	0.41
3T	2.36	2.26	0.56	-0.19	0.56
3B	2.43	2.43	0.40	0.00	0.99
4T	2.38	2.31	0.51	-0.15	0.67
4B	2.19	2.07	0.67	-0.17	0.35
5T	2.17	2.06	0.67	-0.16	0.35
5B	2.39	2.35	0.46	-0.10	0.82
6T	2.22	2.09	0.66	-0.20	0.37
6B	2.41	2.41	0.40	0.00	1.01
K 3; 1T	2.43	2.43	0.41	0.00	1.01
1B	2.33	2.21	0.60	-0.21	0.49
2T	2.31	2.18	0.61	-0.22	0.45
2B	2.24	2.12	0.67	-0.18	0.37
3T	2.43	2.43	0.42	0.00	0.99
3B	2.38	2.28	0.55	-0.18	0.65
4T	2.47	2.47	0.38	0.00	0.78
4B	2.44	2.44	0.39	0.00	0.95
5T	2.31	2.17	0.63	-0.23	0.45
5B	1.82	1.91	0.71	0.12	0.35
6T	2.35	2.25	0.55	-0.19	0.57
6B	2.28	2.14	0.63	-0.22	0.41
7T	2.40	2.37	0.44	-0.06	0.87
7B	2.42	2.42	0.40	0.00	1.00
8T	2.42	2.42	0.41	0.00	1.00
8B	2.34	2.22	0.58	-0.21	0.51
K 5; 1T	2.29	2.16	0.64	-0.21	0.41
1B	2.41	2.35	0.51	-0.12	0.73
2T	2.07	2.03	0.69	-0.05	0.33
2B	2.00	2.02	0.70	0.02	0.32
3T	1.86	1.95	0.68	0.14	0.34
3B	2.05	2.01	0.69	-0.05	0.32
4T	2.13	2.06	0.69	-0.11	0.33
4B	2.16	2.05	0.68	-0.15	0.34
5T	1.82	1.93	0.67	0.16	0.35
5B	1.75	1.87	0.67	0.19	0.37
6T	2.00	1.86	0.90	-0.16	1.01
6B	-0.16	0.75	1.48	0.62	0.25

Sample no -----	Med. -----	Mean -----	Sort -----	Ske. -----	Kurt -----
K 6; 1T	1.89	1.96	0.68	0.10	0.33
1B	2.17	2.08	0.68	-0.14	0.34
2T	1.81	1.92	0.67	0.17	0.35
2B	1.93	1.98	0.68	0.06	0.33
3T	1.99	2.00	0.70	0.01	0.32
3B	1.84	1.92	0.69	0.12	0.34
4T	1.95	1.98	0.68	0.05	0.32
4B	2.16	2.04	0.71	-0.18	0.35
5T	1.83	1.93	0.67	0.14	0.34
5B	1.94	1.98	0.70	0.05	0.33
K 7; 1T	1.88	1.95	0.68	0.11	0.33
1B	1.89	1.96	0.68	0.10	0.33
2T	1.75	1.88	0.65	0.20	0.38
2B	2.01	2.01	0.69	-0.01	0.32
3T	1.59	1.64	0.48	0.09	0.78
3B	1.71	1.84	0.67	0.19	0.41
4T	2.04	2.01	0.68	-0.04	0.32
4B	1.88	1.94	0.70	0.08	0.33
5T	1.92	1.96	0.73	0.05	0.33
5B	1.80	1.92	0.68	0.18	0.36
K 8; 1T	2.11	1.74	1.02	-0.36	0.79
1B		Solid substrate			
2T	-0.37	0.24	1.04	0.59	0.56
2B		Solid substrate			
3T	1.92	1.87	0.79	-0.06	1.21
3B	1.73	1.82	0.73	0.12	0.93
4T	1.71	1.84	0.63	0.21	0.41
4B	2.23	2.07	0.69	-0.23	0.38
5T	2.01	2.00	0.69	0.00	0.32
5B	1.85	1.93	0.70	0.11	0.34
K 9; 1T	1.57	1.57	0.42	0.01	0.99
1B	1.62	1.71	0.55	0.17	0.59
2T	1.66	1.78	0.58	0.21	0.51
2B	1.77	1.87	0.71	0.14	0.70
3T	1.82	1.92	0.68	0.14	0.34
3B	1.88	1.95	0.68	0.11	0.33
4T	2.45	2.45	0.40	0.00	0.95
4B	1.77	1.86	0.72	0.13	0.68
5T	2.25	2.12	0.65	-0.20	0.38
5B	1.86	1.96	0.70	0.13	0.34
K 10; 1T	1.50	1.50	1.70	-0.00	0.32
1B	3.15	3.03	0.70	-0.18	0.35
2T	1.87	1.95	0.68	0.12	0.33
2B	2.06	2.01	0.71	-0.07	0.33
3T	1.66	1.77	0.56	0.20	0.54
3B	1.82	1.92	0.68	0.14	0.34
4T	2.03	2.01	0.70	-0.02	0.32
4B	1.83	1.93	0.67	0.15	0.34
5T	1.74	1.87	0.65	0.20	0.39
5B	2.02	2.00	0.69	-0.03	0.32
6T	2.00	2.00	0.69	-0.00	0.32
6B	2.16	2.06	0.69	-0.14	0.34

Sample no -----	Med. -----	Mean -----	Sort -----	Ske. -----	Kurt -----
K 11; 1T	2.37	2.24	0.67	-0.18	0.78
1B	2.34	2.22	0.67	-0.18	0.71
2T	1.90	1.97	0.68	0.10	0.33
2B	2.07	2.02	0.69	-0.07	0.33
3T	1.83	1.92	0.67	0.14	0.34
3B	1.75	1.86	0.69	0.17	0.52
4T	1.62	1.71	0.55	0.17	0.60
4B	1.65	1.76	0.70	0.16	1.31
5T	0.93	0.58	1.22	-0.29	0.32
5B	1.42	0.97	0.98	-0.47	0.68
K 12; 1T	2.39	2.27	0.64	-0.18	0.83
1B	2.38	2.27	0.59	-0.18	0.70
2T	1.82	1.92	0.69	0.14	0.34
2B	1.97	1.98	0.73	0.03	0.32
3T	1.62	1.72	0.55	0.17	0.59
3B	1.66	1.78	0.62	0.21	0.49
4T	1.68	1.81	0.66	0.19	1.23
4B	1.55	1.58	0.73	0.04	1.13
5T	1.60	1.66	0.49	0.11	0.74
5B	1.52	1.52	0.44	0.01	2.11
K 13; 1T	2.62	2.72	0.72	0.15	0.87
1B	2.50	2.48	0.73	-0.03	0.85
2T	1.90	2.11	0.88	0.24	0.51
2B	1.45	1.40	0.52	-0.09	1.28
3T	2.18	2.13	0.79	-0.06	0.61
3B	1.83	1.94	0.76	0.14	0.55
4T	2.73	2.61	0.99	-0.12	0.51
4B		Solid substrate			
5T	3.00	2.68	1.00	-0.32	0.76
5B		Solid substrate			
K 14; 1T	2.68	2.80	0.68	0.17	0.72
1B	2.33	2.20	0.66	-0.21	0.62
2T	2.61	2.68	0.76	0.10	0.67
2B	2.35	2.22	0.65	-0.20	0.66
3T	1.94	2.18	1.04	0.23	0.62
3B	1.53	1.55	0.81	0.02	0.75
4T	2.20	2.24	0.93	0.05	0.46
4B	1.81	1.95	0.76	0.18	0.63
5T	2.65	2.49	1.08	-0.15	0.91
5B	2.15	1.54	1.60	-0.39	0.39
K 15; 1T	2.65	2.76	0.72	0.15	0.74
1B	2.54	2.61	0.58	0.11	1.08
2T	2.12	2.13	0.82	0.02	0.58
2B	1.83	1.98	0.81	0.19	1.03
3T	3.00	3.00	0.68	0.00	0.32
3B	2.50	2.50	0.34	0.00	0.32
4T	3.25	3.12	0.64	-0.20	0.39
4B	3.00	1.66	2.02	-0.66	0.16

Sample no -----	Med. ----	Mean ----	Sort ----	Ske. ----	Kurt ----
K 16; 1T	1.69	1.84	0.76	0.20	0.81
1B	1.72	1.85	0.74	0.18	0.66
2T	2.83	2.83	0.79	0.01	0.60
2B	2.17	2.01	0.95	-0.16	0.74
3T	3.33	3.21	0.57	-0.21	0.51
3B	3.33	3.21	0.57	-0.21	0.51
4T	2.74	1.66	1.96	-0.55	0.19
4B	2.40	1.97	1.40	-0.31	0.59
5T	3.18	2.96	0.78	-0.28	1.07
5B	2.47	2.29	1.17	-0.15	0.75
K 17; 1T	2.13	2.08	0.92	-0.05	0.98
1B	2.10	2.25	1.06	0.15	0.57
2T	2.22	2.23	0.99	0.01	0.59
2B	1.79	1.91	0.82	0.15	0.81
3T	2.02	1.98	0.85	-0.05	0.87
3B	1.79	1.90	0.82	0.14	0.79
K 18; 1T	2.53	1.72	1.79	-0.46	0.27
1B		Solid substrate			
2T	1.92	1.98	0.74	0.07	0.33
2B	2.56	2.47	1.04	-0.09	0.65
3T	2.19	2.09	0.73	-0.13	0.47
3B	1.79	1.89	0.76	0.14	0.69
K 19; 1T	2.01	2.01	0.88	0.01	0.80
1B	2.06	2.08	0.95	0.03	0.78
2T	2.00	2.17	1.10	0.16	0.69
2B	1.52	1.49	0.95	-0.03	0.61
3T	1.68	1.82	0.72	0.19	0.84
3B	1.61	1.73	0.67	0.18	1.10
4T	1.80	1.98	0.93	0.20	0.93
4B	1.78	1.94	0.81	0.19	0.99
5T	2.91	2.91	0.74	0.00	0.58
5B	2.64	2.75	0.72	0.15	0.86
K 20; 1T	-0.34	0.24	1.03	0.56	0.85
1B		Solid substrate			
2T	1.60	1.65	1.05	0.05	0.90
2B	1.58	1.63	0.51	0.10	1.02
3T	2.19	2.05	0.80	-0.18	0.77
3B	1.48	1.41	0.62	-0.10	1.11
4T	1.89	2.01	0.91	0.13	0.82
4B	2.51	2.46	1.10	-0.05	0.30
K 21; 1T	1.72	1.67	1.03	-0.05	0.50
1B	1.73	1.65	1.16	-0.06	0.69
2T	1.16	1.07	0.72	-0.12	0.34
2B	1.09	1.01	0.77	-0.10	0.46
3T	1.62	1.73	0.62	0.19	0.80
3B	2.05	2.08	0.78	0.03	0.57
4T	1.00	1.14	1.72	0.08	0.30
4B	2.17	1.86	1.42	-0.22	0.52

Sample no	Med.	Mean	Sort	Ske.	Kurt
K 22; 1T	2.18	1.39	1.74	-0.46	0.30
1B		Solid substrate			
2T	0.66	0.83	0.77	0.21	0.80
2B	0.51	0.54	0.90	0.03	0.51
3T	1.25	1.12	0.70	-0.18	0.45
3B	1.13	1.04	0.76	-0.12	0.49
4T	2.23	2.17	0.79	-0.07	0.62
4B	2.31	2.21	0.75	-0.14	0.68
K 23; 1T	1.58	1.19	1.65	-0.24	0.33
1B		Solid substrate			
2T	0.79	0.93	0.70	0.20	0.36
2B	0.96	0.99	0.71	0.05	0.32
3T	1.80	1.87	0.82	0.08	0.80
3B	1.96	1.99	0.79	0.04	0.62
K 24; 1T	0.78	0.89	0.80	0.13	0.70
Geelhoutboom tributary					
K A; 1T	2.45	2.34	0.65	-0.17	1.00
1B	2.33	2.19	0.77	-0.18	0.70
2T	-0.37	0.01	0.81	0.47	1.13
2B	-0.32	0.35	1.13	0.59	0.60
3T	2.25	1.47	1.83	-0.43	0.25
3B		Solid substrate			
K B; 1T	-0.18	0.57	1.31	0.58	0.58
1B		Solid substrate			
2T	3.50	3.50	0.34	0.00	0.32
2B	3.05	2.59	1.10	-0.41	0.89
3T	3.00	2.46	1.22	-0.44	0.72
3B	2.24	1.67	1.66	-0.35	0.35
K C; 1T	3.14	2.98	0.75	-0.22	0.81
1B	3.03	2.91	0.78	-0.16	0.69
2T	2.75	2.70	0.90	-0.06	0.46
2B	2.33	2.08	1.38	-0.18	0.48
3T	1.00	1.00	1.36	-0.01	0.32
3B	0.04	0.69	1.37	0.48	0.41
K D; 1T	-0.39	-0.20	0.61	0.32	1.87
1B		Solid substrate			
2T	2.30	2.25	1.15	-0.04	0.77
2B	2.12	1.99	1.28	-0.10	0.60
3T	2.54	2.46	1.02	-0.08	0.52
3B	2.24	2.01	1.09	-0.21	0.95
K E; 1T	1.92	1.37	1.36	-0.40	0.35
1B	-0.43	-0.43	0.38	0.00	1.39
2T	2.00	1.59	1.31	-0.31	0.60
2B	0.17	0.74	1.40	0.41	0.44
3T	2.31	1.65	1.73	-0.38	0.30
3B	1.50	1.18	1.66	-0.19	0.32

## APPENDIX 1 C

This section lists the respective contents of  $\text{CaCO}_3$  and of  $\text{H}_2\text{O}_2$ -leachable organic material.

The parameters listed below are as follows:

- %Carb. - The percentage (m/m) of carbonate in the sediment samples expressed as  $\text{CaCO}_3$ .
- %Org C - The percentage organic material in the samples.

The "tr." occurring in some columns denotes trace amounts of carbonate. The sample effervesced when the acid was added but the carbonate content was too low to register a reading.

Sample no	%Carb.	%Org C
-----	-----	-----
K 1;1T	41.40	0.70
K 1;1B	37.20	1.00
K 1;2T	40.30	1.20
K 1;2B	41.30	0.90
K 1;3T	Solid substrate	
K 1;3B	Solid substrate	
K 1;4T	28.20	1.00
K 1;4B	Solid substrate	
K 2;1T	38.50	1.10
K 2;1B	43.90	2.20
K 2;2T	34.10	1.80
K 2;2B	32.70	1.00
K 2;3T	40.90	1.20
K 2;3B	41.20	0.90
K 2;4T	35.80	0.80
K 2;4B	30.70	0.90
K 2;5T	33.60	0.00
K 2;5B	35.80	1.00
K 2;6T	38.70	0.00
K 2;6B	35.20	0.70
K 3;1T	39.40	0.00
K 3;1B	37.70	0.90
K 3;2T	34.30	0.00
K 3;2B	39.00	0.80
K 3;3T	42.10	1.30
K 3;3B	46.20	0.90
K 3;4T	43.00	0.00
K 3;4B	42.00	0.00
K 3;5T	43.30	0.80
K 3;5B	40.80	0.00
K 3;6T	34.00	0.00
K 3;6B	31.40	0.00
K 3;7T	36.10	0.80
K 3;7B	38.40	1.00
K 3;8T	33.00	0.00
K 3;8B	37.60	0.80
K 5;1T	31.80	1.20
K 5;1B	32.60	1.60
K 5;2T	27.40	1.40
K 5;2B	26.30	1.60
K 5;3T	23.00	1.30
K 5;3B	22.90	1.20
K 5;4T	26.60	1.70
K 5;4B	26.80	0.70
K 5;5T	23.40	0.80
K 5;5B	33.40	1.30
K 5;6T	32.70	1.50
K 5;6B	41.10	1.10

Sample no	%Carb.	%Org C
K 6; 1T	22.70	1.10
K 6; 1B	25.80	0.80
K 6; 2T	23.80	1.60
K 6; 2B	23.30	1.40
K 6; 3T	25.80	1.00
K 6; 3B	21.60	0.80
K 6; 4T	25.00	0.70
K 6; 4B	33.10	0.80
K 6; 5T	25.50	0.60
K 6; 5B	29.10	1.60
K 7; 1T	23.60	1.00
K 7; 1B	23.70	0.70
K 7; 2T	19.30	0.00
K 7; 2B	25.60	1.10
K 7; 3T	19.40	1.10
K 7; 3B	23.60	1.10
K 7; 4T	19.90	0.00
K 7; 4B	21.60	0.00
K 7; 5T	20.10	1.90
K 7; 5B	23.00	1.00
K 8; 1T	17.00	0.70
K 8; 1B	Solid substrate	
K 8; 2T	7.30	0.80
K 8; 2B	Solid substrate	
K 8; 3T	19.00	1.00
K 8; 3B	25.30	0.90
K 8; 4T	15.30	0.90
K 8; 4B	26.80	0.00
K 8; 5T	13.90	1.10
K 8; 5B	21.10	0.00
K 9; 1T	14.80	0.70
K 9; 1B	17.60	0.90
K 9; 2T	12.60	0.70
K 9; 2B	24.50	1.00
K 9; 3T	19.30	0.90
K 9; 3B	17.30	0.80
K 9; 4T	22.20	0.90
K 9; 4B	25.30	1.70
K 9; 5T	18.70	1.80
K 9; 5B	16.80	0.80
K 10; 1T	20.60	0.70
K 10; 1B	31.30	1.00
K 10; 2T	15.40	0.00
K 10; 2B	20.00	0.70
K 10; 3T	15.90	0.00
K 10; 3B	23.40	1.40
K 10; 4T	20.10	0.90
K 10; 4B	18.10	0.70
K 10; 5T	15.60	0.60
K 10; 5B	18.40	0.90
K 10; 6T	15.60	0.80
K 10; 6B	16.80	0.80

Sample no	%Carb.	%Org C
-----	-----	-----
K 11; 1T	22.70	0.90
K 11; 1B	26.90	1.60
K 11; 2T	15.40	7.90
K 11; 2B	12.60	0.70
K 11; 3T	20.90	0.80
K 11; 3B	18.60	0.70
K 11; 4T	14.60	0.00
K 11; 4B	27.80	0.60
K 11; 5T	40.80	0.70
K 11; 5B	21.60	0.70
K 12; 1T	11.40	2.30
K 12; 1B	10.90	2.20
K 12; 2T	12.80	1.00
K 12; 2B	7.60	0.90
K 12; 3T	11.80	0.70
K 12; 3B	13.90	1.00
K 12; 4T	17.40	1.50
K 12; 4B	21.90	1.40
K 12; 5T	13.80	1.80
K 12; 5B	10.00	1.50
K 13; 1T	13.70	3.00
K 13; 1B	15.60	3.40
K 13; 2T	19.20	3.90
K 13; 2B	6.50	2.40
K 13; 3T	14.10	4.50
K 13; 3B	12.70	3.40
K 13; 4T	30.00	5.60
K 13; 4B	Solid substrate	
K 13; 5T	11.50	5.30
K 13; 5B	Solid substrate	
K 14; 1T	tr.	2.00
K 14; 1B	16.50	4.50
K 14; 2T	12.50	4.50
K 14; 2B	10.80	1.60
K 14; 3T	8.50	5.10
K 14; 3B	12.80	2.40
K 14; 4T	5.60	1.40
K 14; 4B	8.00	2.40
K 14; 5T	10.90	2.60
K 14; 5B	tr.	3.30
K 15; 1T	tr.	2.50
K 15; 1B	tr.	2.30
K 15; 2T	tr.	5.70
K 15; 2B	7.60	2.70
K 15; 3T	tr.	10.00
K 15; 3B	tr.	11.30
K 15; 4T	8.00	5.40
K 15; 4B	6.40	7.90

Sample no	%Carb.	%Org C
-----	-----	-----
K 16; 1T	tr.	3.10
K 16; 1B	0.00	1.50
K 16; 2T	tr.	8.20
K 16; 2B	tr.	6.30
K 16; 3T	tr.	7.40
K 16; 3B	tr.	7.10
K 16; 4T	tr.	3.30
K 16; 4B	12.80	2.70
K 16; 5T	tr.	1.90
K 16; 5B	16.00	1.60
K 17; 1T	tr.	2.90
K 17; 1B	0.00	3.70
K 17; 2T	tr.	1.80
K 17; 2B	0.00	4.00
K 17; 3T	tr.	1.30
K 17; 3B	tr.	2.50
K 18; 1T	tr.	2.10
K 18; 1B	Solid substrate	
K 18; 2T	tr.	3.40
K 18; 2B	tr.	9.80
K 18; 3T	tr.	2.70
K 18; 3B	tr.	2.30
K 19; 1T	0.00	2.40
K 19; 1B	0.00	9.50
K 19; 2T	0.00	3.80
K 19; 2B	tr.	2.40
K 19; 3T	tr.	3.80
K 19; 3B	tr.	2.30
K 19; 4T	0.00	6.80
K 19; 4B	7.70	7.00
K 19; 5T	tr.	3.90
K 19; 5B	tr.	8.70
K 20; 1T	tr.	3.80
K 20; 1B	Solid substrate	
K 20; 2T	0.00	6.80
K 20; 2B	0.00	3.40
K 20; 3T	0.00	1.70
K 20; 3B	0.00	0.80
K 20; 4T	0.00	1.90
K 20; 4B	tr.	1.70
K 21; 1T	0.00	2.00
K 21; 1B	0.00	2.20
K 21; 2T	0.00	1.40
K 21; 2B	tr.	1.00
K 21; 3T	0.00	1.60
K 21; 3B	tr.	1.70
K 21; 4T	tr.	9.40
K 21; 4B	tr.	11.80

Sample no	%Carb.	%Org C
-----	-----	-----
K 22;1T	tr.	4.30
K 22;1B	Solid substrate	
K 22;2T	tr.	9.40
K 22;2B	tr.	3.70
K 22;3T	tr.	2.50
K 22;3B	tr.	0.80
K 22;4T	tr.	1.60
K 22;4B	tr.	2.00
K 23;1T	tr.	9.10
K 23;1B	Solid substrate	
K 23;2T	0.00	1.80
K 23;2B	0.00	1.50
K 23;3T	0.00	9.30
K 23;3B	0.00	7.90
K 24;1T	0.00	0.80
Geelhoutboom tributary		
K A;1T	0.00	1.00
K A;1B	0.00	1.50
K A;2T	tr.	2.40
K A;2B	41.00	1.40
K A;3T	40.30	1.80
K A;3B	Solid substrate	
K B;1T	0.00	1.20
K B;1B	Solid substrate	
K B;2T	0.00	2.80
K B;2B	0.00	3.80
K B;3T	0.00	1.70
K B;3B	12.00	2.20
K C;1T	0.00	2.00
K C;1B	0.00	10.30
K C;2T	0.00	1.40
K C;2B	0.00	2.60
K C;3T	0.00	4.70
K C;3B	0.00	1.30
K D;1T	0.00	0.90
K D;1B	Solid substrate	
K D;2T	0.00	2.70
K D;2B	0.00	3.30
K D;3T	0.00	1.10
K D;3B	0.00	6.20
K E;1T	0.00	5.20
K E;1B	0.00	0.60
K E;2T	0.00	1.40
K E;2B	0.00	3.40
K E;3T	0.00	3.30
K E;3B	0.00	4.10

## APPENDIX 2

This section lists the cross section information of the Kromme estuary study. The section positions are given on fig. 4.1. Part A lists the vertical section co-ordinates with respect to mean sea level. Part B gives the cross section diagrams and part C shows the respective cross-sectional areas, channel widths at MSL, and hydraulic radii of the channel sections.

XRC

H

D

1L

2L

3L

4L

5L

6L

7L

8L

## APPENDIX 2 A

This section gives benchmark heights and section co-ordinates for channel profiles measured in the Kromme estuary at 1 km intervals extending from the tidal inlet to the head of the estuary. It also includes two sections each for the Geelhoutboom tributary of the estuary and the marina system near the inlet.

10L

11L

1R

2R

3R

4R

5R

6R

7R

8R

9R

10R

11R

12R

13R

14R

15R

16R

17R

## KROMME RIVER PROFILE SURVEY

## HEIGHTS (M.S.L.)

Note: C = Checked.  
 NC = Not Checked.

1L	6,73	C
2L	1,77	C
3L	1,76	C
4L	7,25	C
5L	1,17	C
6L	1,44	C
7L	1,40	NC
8L	1,71	NC
9L	1,45	C
10L	0,86	NC
11L	1,78	C
12L	0,64	C
13L	1,36	C
14L	3,07	NC
15L	1,34	NC
16L	0,71	C
18L	3,27	C
19L	3,17	C
1R	0,69	C
2R	3,31	C
3R	1,00	C
4R	1,92	C
5R	1,13	C
6R	2,51	C
7R	1,12	C
8R	0,78	C
9R	0,84	C
10R	1,52	C
11R	0,93	NC
12R	2,11	NC
13R	0,96	NC
14R	1,61	NC
15R	-	-
16R	0,94	C
18R	1,63	C

## Cross-section co-ordinates for the KROMME ESTUARY

## Co-ordinates for SECTION 2

Distance	Height (MSL)
-----	-----
0.0	1.46
41.0	-0.09
50.0	-1.01
63.0	-1.43
78.0	-1.61
86.0	-1.90
98.0	-1.74
121.0	-1.28
143.0	-0.87
159.0	-0.71
178.0	-0.18
230.0	0.01
267.0	0.19
295.0	-0.20
306.0	-1.54
311.0	-2.06
322.0	-1.42
346.0	-0.18
349.5	0.46

This line has 19 stations.

## SECTION 3

Distance	Height (MSL)
-----	-----
0.0	0.64
25.0	-0.59
68.0	-0.70
107.0	-0.66
128.0	-0.87
139.0	-1.18
156.0	-1.54
174.0	-1.37
181.0	-0.28
198.0	0.18
206.0	0.14
225.0	0.38
262.0	0.87
272.0	1.00

This line has 14 stations.

## SECTION 4

Distance	Height (MSL)
-----	-----
0.0	0.96
13.8	0.66
24.8	0.05
43.8	-0.55
58.8	-1.11
83.8	-1.13
98.8	-0.79
121.8	-1.22
144.8	-1.34
168.3	-1.04
188.8	-1.01
214.8	-0.60
225.8	-0.18
260.8	-0.52
276.8	-0.46
282.8	-0.30
290.8	0.60

This line has 17 stations.

## SECTION 5

Distance	Height (MSL)
-----	-----
0.0	1.17
8.8	0.60
18.8	-0.01
32.3	-0.67
53.8	-1.48
71.8	-1.26
90.8	-1.12
97.3	-0.35
120.8	-0.46
144.8	-0.88
164.8	-1.39
181.8	-1.72
186.8	-0.19
191.8	0.28
193.8	1.09

This line has 15 stations.

## SECTION 6

Distance	Height (MSL)
-----	-----
0.0	1.44
3.2	0.60
18.0	0.27
24.5	-0.33
31.0	-0.94
44.0	-2.02
64.0	-3.11
82.0	-3.13
98.0	-3.13
118.0	-3.00
144.0	-2.86
168.0	-1.74
182.0	-0.43
196.0	0.77

This line has 14 stations.

## SECTION 7

Distance	Height (MSL)
-----	-----
0.0	1.40
10.5	0.25
12.5	-0.08
21.5	-0.90
33.5	-2.19
44.5	-2.82
65.5	-3.82
85.5	-3.92
104.5	-3.33
118.5	-2.70
135.5	-1.13
151.5	-0.02
163.5	1.03

This line has 13 stations.

## SECTION 8

Distance -----	Height (MSL) -----
0.0	1.71
0.0	0.83
15.5	1.18
27.0	0.65
49.5	0.13
67.5	-0.63
95.5	-2.15
116.5	-2.87
149.5	-2.07
166.5	-1.00
180.5	0.11
190.5	0.83
201.5	1.18
256.5	1.31

This line has 14 stations.

## SECTION 9

Distance -----	Height (MSL) -----
0.0	1.45
4.3	0.39
11.3	-0.53
31.3	-1.38
60.3	-1.90
80.3	-2.11
109.3	-2.29
134.3	-1.72
147.3	-0.74
176.3	0.19
185.3	-0.06
199.3	0.52

This line has 12 stations.

## SECTION 10

Distance	Height (MSL)
-----	-----
0.0	0.86
6.9	0.50
17.9	0.10
29.9	-0.52
43.9	-2.86
59.9	-3.09
83.9	-4.65
96.9	-2.91
112.9	-1.20
120.9	0.92

This line has 10 stations.

## SECTION 11

Distance	Height (MSL)
-----	-----
0.0	1.78
36.0	0.61
37.0	-0.43
44.0	-2.00
55.0	-2.51
71.0	-2.86
86.0	-2.49
113.0	-2.01
125.0	-1.48
146.0	-0.78
167.0	-0.14
173.0	0.38

This line has 12 stations.

## SECTION 12

Distance	Height (MSL)
-----	-----
0.0	0.33
7.0	-0.15
16.0	-0.27
33.0	0.05
53.8	0.64
58.0	0.34
67.0	-0.18
87.0	-0.49
104.0	-1.25
120.0	-1.92
138.0	-2.63
158.0	-3.31
177.0	-3.61
195.0	-0.42
195.0	0.58

This line has 15 stations.

## SECTION 14

Distance	Height (MSL)
-----	-----
0.0	1.57
2.0	1.25
10.0	-2.69
28.0	-4.67
42.0	-4.80
61.0	-5.01
75.0	-4.44
84.0	-2.27
89.0	1.61

This line has 9 stations.

## SECTION 15

Distance -----	Height (MSL) -----
0.0	1.34
1.0	-1.78
8.0	-5.69
13.0	-5.46
24.0	-5.34
34.0	-0.63
41.0	-2.40
47.0	0.92
53.0	-2.04
57.0	-0.74
62.0	-0.40
66.0	-1.99
70.0	0.21

This line has 13 stations.

Geelhoutboom River:

## SECTION 13

Distance -----	Height (MSL) -----
0.0	1.36
4.2	0.50
13.6	-0.37
30.0	-1.04
46.7	-1.27
76.2	-1.25
105.2	-1.21
130.2	-1.39
156.2	-1.03
168.2	-0.50
180.7	0.80

This line has 11 stations.

## SECTION 16

Distance	Height (MSL)
-----	-----
0.0	0.71
1.3	0.15
19.3	0.02
30.8	-0.79
34.3	-0.74
46.8	-0.58
58.8	-0.36
67.3	0.13
73.8	0.52

This line has 9 stations.

Marina canals:

## SECTION 18

Distance	Height (MSL)
-----	-----
0.0	0.82
4.0	0.15
12.0	-0.36
18.0	-2.11
26.0	-2.41
53.0	-0.55
55.0	0.47
70.0	0.68

This line has 8 stations.

## SECTION 19

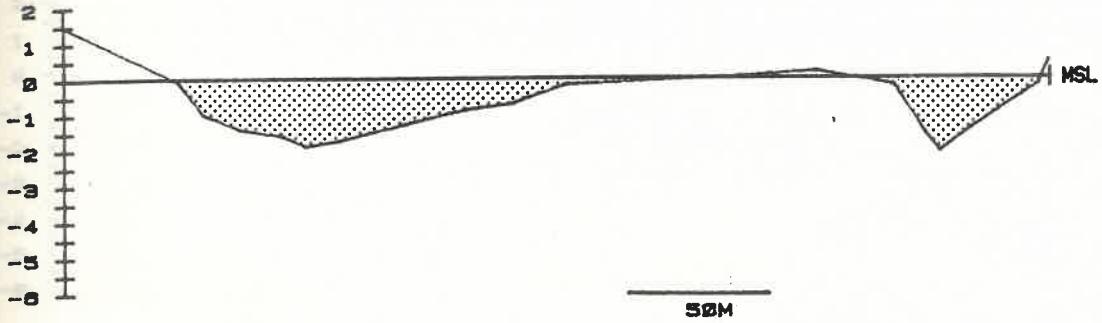
Distance	Height (MSL)
-----	-----
0.0	1.69
2.0	0.64
7.5	-0.52
11.0	-1.64
15.0	-1.95
18.0	-1.81
23.5	-0.55
30.5	1.00
32.0	1.96

This line has 9 stations.

## APPENDIX 2B

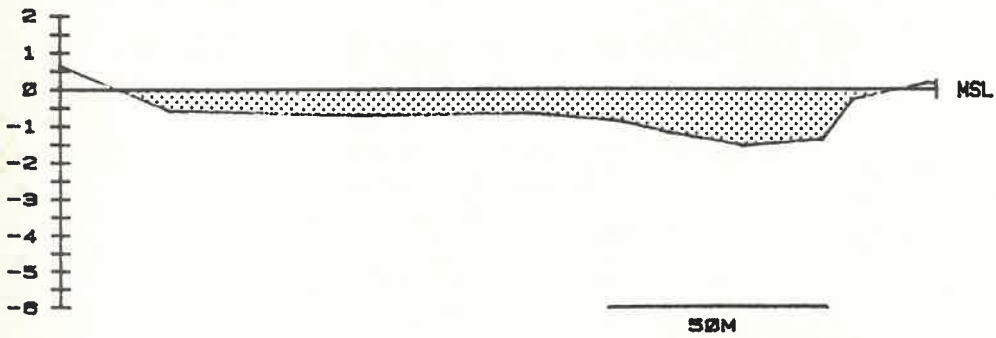
The following diagrams illustrate the sections across the Kromme estuary channel. All sections are viewed down-estuary and are shaded below MSL.

SECTION 2 KROMME ESTUARY



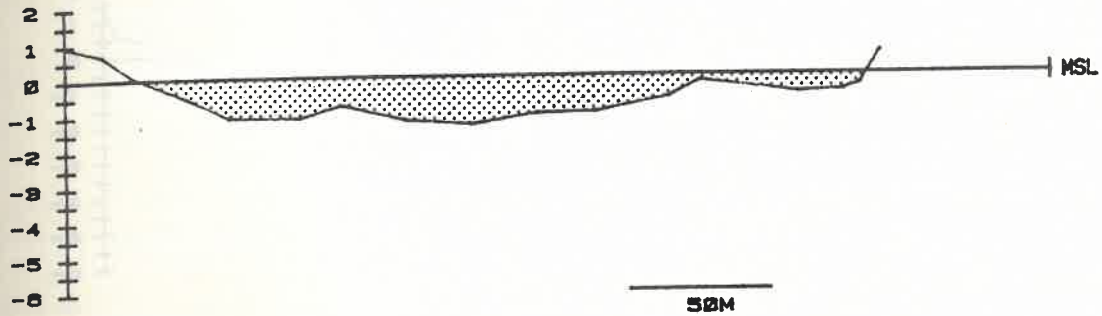
SECTION VIEWED DOWNSTREAM

SECTION 3 KROMME ESTUARY



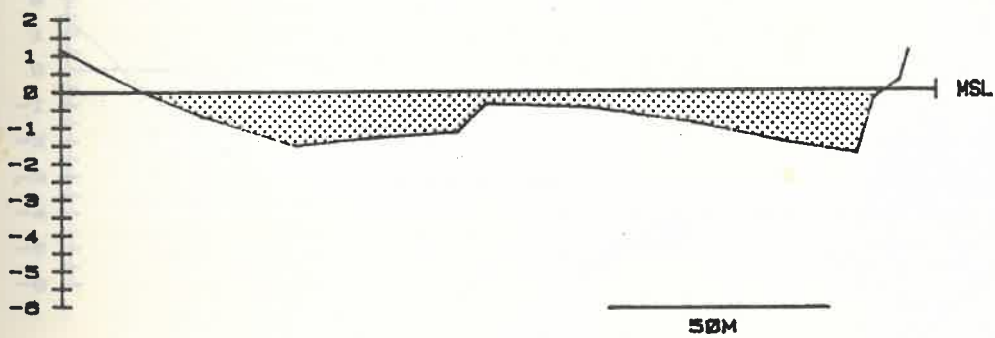
SECTION VIEWED DOWNSTREAM

## SECTION 4 KROMME ESTUARY



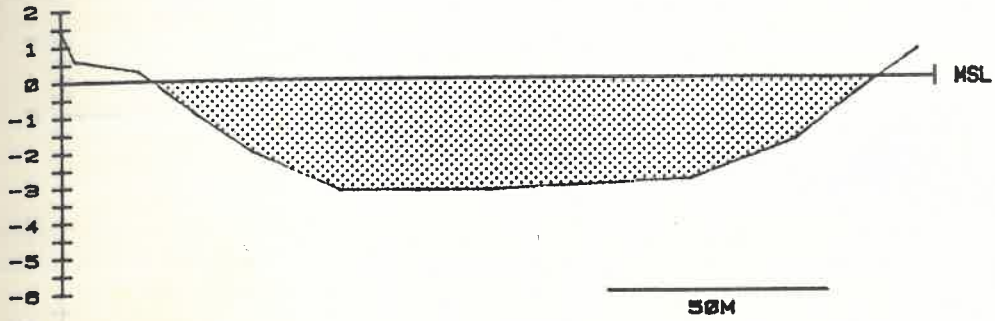
SECTION VIEWED DOWNSTREAM

## SECTION 5 KROMME ESTUARY



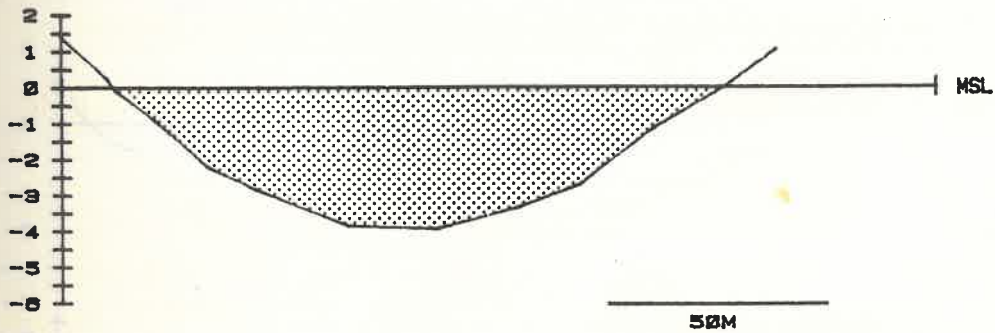
SECTION VIEWED DOWNSTREAM

SECTION 6 KROMME ESTUARY



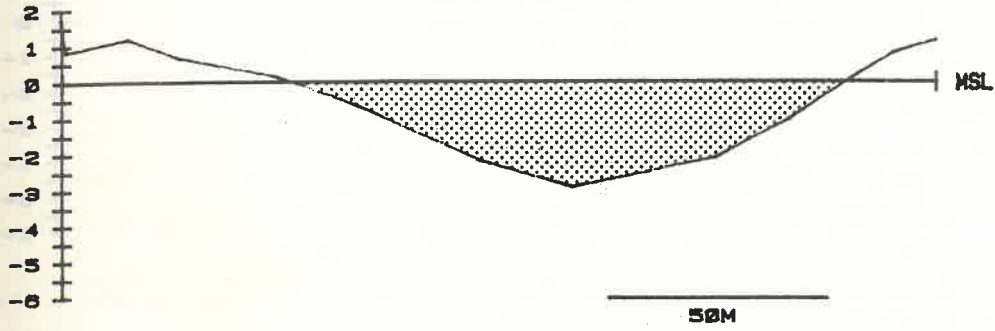
SECTION VIEWED DOWNSTREAM

SECTION 7 KROMME ESTUARY



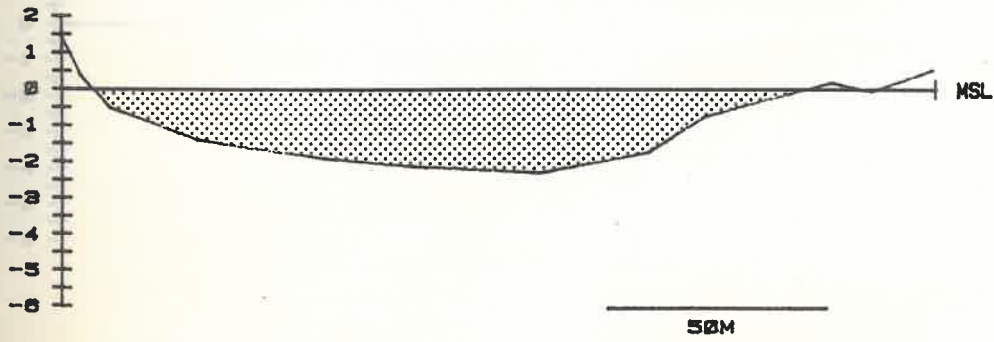
SECTION VIEWED DOWNSTREAM

SECTION 8 KROMME ESTUARY



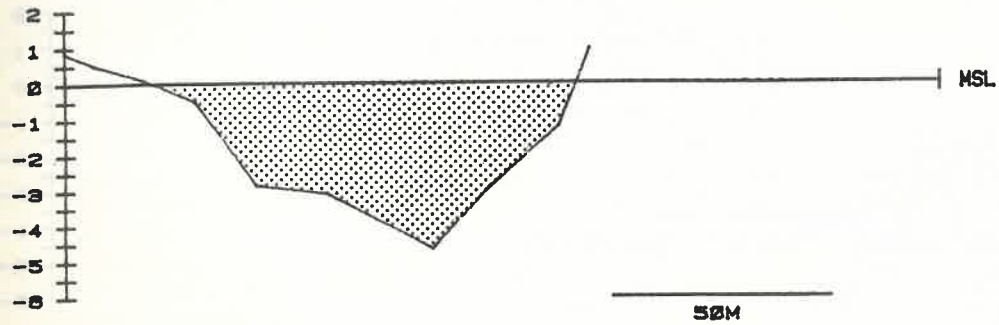
SECTION VIEWED DOWNSTREAM

SECTION 9 KROMME ESTUARY



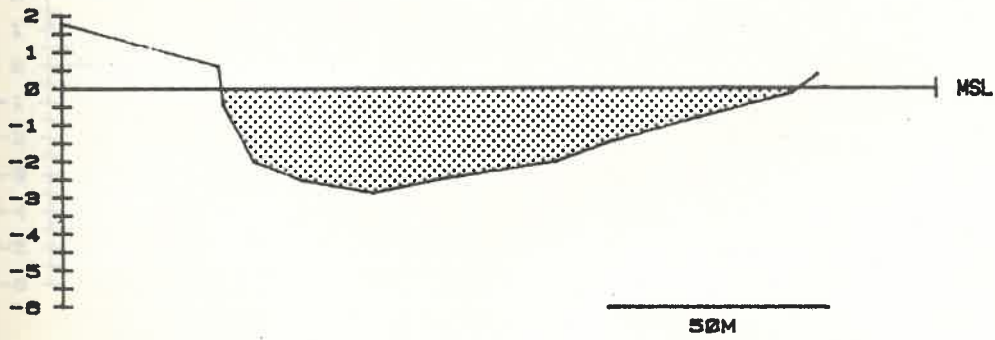
SECTION VIEWED DOWNSTREAM

SECTION 10 KROMME ESTUARY



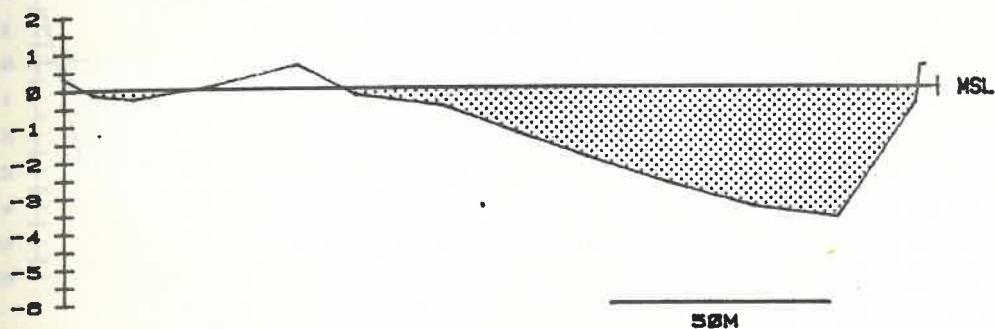
SECTION VIEWED DOWNSTREAM

SECTION 11 KROMME ESTUARY



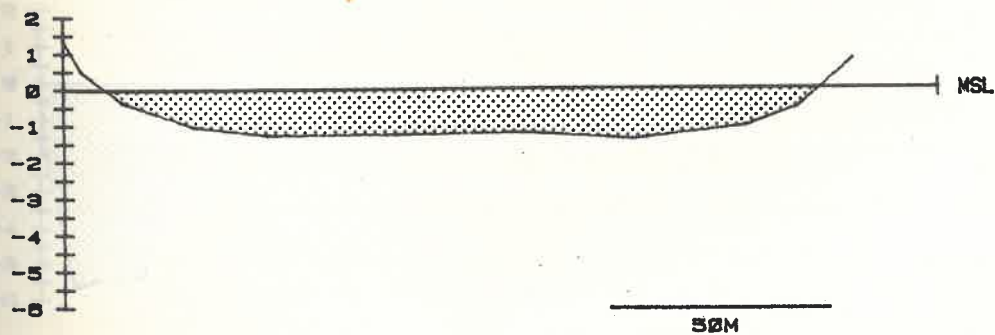
SECTION VIEWED DOWNSTREAM

## SECTION 12 KROMME ESTUARY



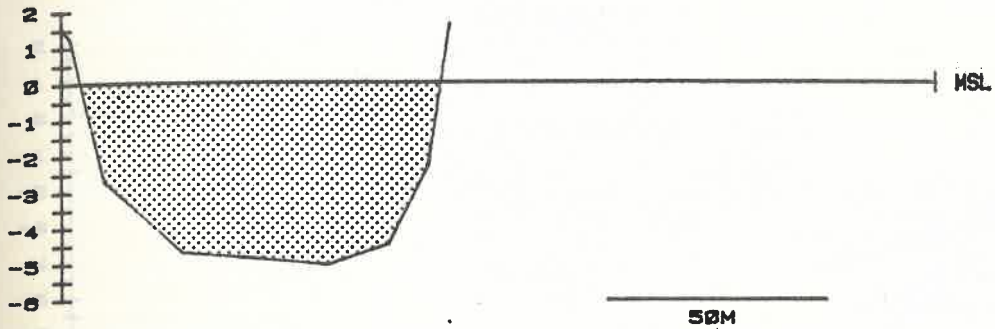
SECTION VIEWED DOWNSTREAM

## SECTION 13 KROMME ESTUARY



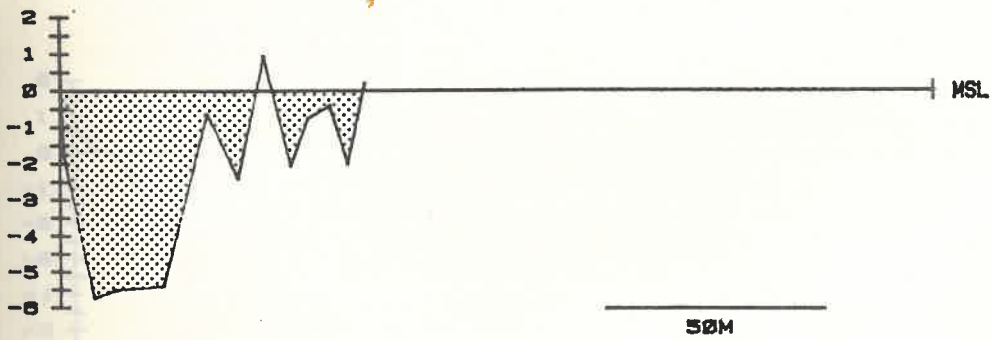
SECTION VIEWED DOWNSTREAM

SECTION 14 KROMME ESTUARY



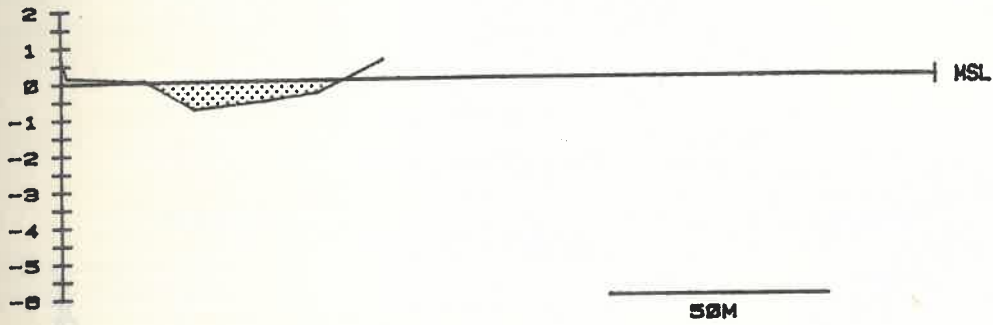
SECTION VIEWED DOWNSTREAM

SECTION 15 KROMME ESTUARY



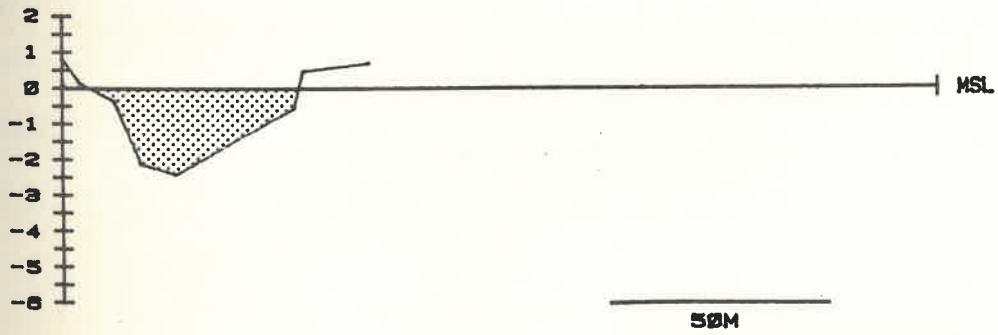
SECTION VIEWED DOWNSTREAM

SECTION 16 KROMME ESTUARY



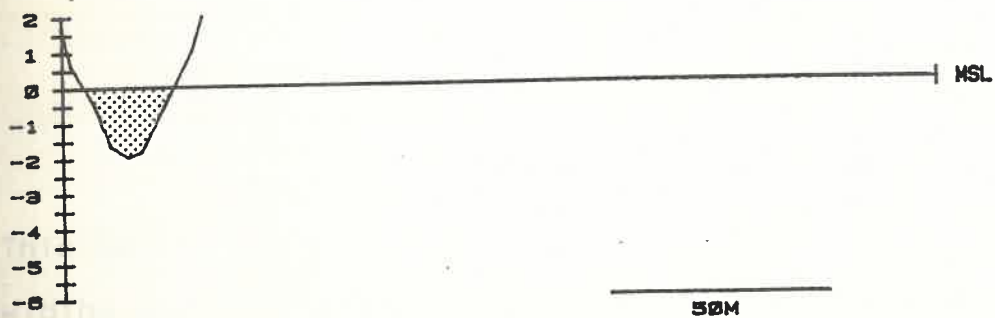
SECTION VIEWED DOWNSTREAM

SECTION 18 KROMME ESTUARY



SECTION VIEWED DOWNSTREAM

SECTION 19 KROMME ESTUARY



SECTION VIEWED DOWNSTREAM

level  
rough  
along  
The l  
the e  
dredged  
section

## APPENDIX 2 C

This section lists the cross-sectional areas, effective channel widths and hydraulic radii of the Kromme channels at three elevations with respect to MSL. These levels correspond very roughly to high, low and mid tides. (The actual levels change along the estuary channel and can only be approximated.)

The line labelled 2 ADD is line 2 which was modified to remove the effect of the entrance channel to the marina which was dredged into the intertidal sand flat. Data for the unmodified section is given under line 2.

No. 3,  
0  
-0.50

No. 10,  
0.50  
0.00  
-0.50

No. 11,  
0.50  
0.00  
-0.50

No. 12,  
0.50  
0.00  
-0.50

## CROSS SECTION INFORMATION FOR THE KROMME ESTUARY

Elevations in the left hand column (ELEV.) are with respect to MSL

LINE	ELEV. (m)	X-AREA (m <sup>2</sup> )	HYDR R (m)	WIDTH (m)
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2 ADD	0.50	291.80	0.89	327.8
	0.00	163.51	0.87	188.6
	-0.50	93.12	0.77	121.5
No. 2;	0.50	375.10	1.16	324.1
	0.00	221.94	0.87	255.0
	-0.50	125.89	0.77	163.9
No. 3;	0.50	243.93	1.05	231.2
	0.00	141.67	0.79	178.3
	-0.50	58.92	0.38	156.4
No. 4;	0.50	342.39	1.25	273.2
	0.00	209.16	0.81	259.1
	-0.50	92.06	0.50	182.6
No. 5;	0.50	247.72	1.36	181.9
	0.00	159.45	0.94	170.2
	-0.50	80.24	0.62	129.9
No. 6;	0.50	477.20	2.57	185.2
	0.00	390.45	2.35	166.1
	-0.50	310.21	2.00	154.9
No. 7;	0.50	433.38	2.78	155.3
	0.00	356.78	2.35	151.5
	-0.50	285.26	2.13	133.8
No. 9;	0.50	338.86	1.74	195.0
	0.00	246.39	1.48	166.7
	-0.50	169.58	1.18	143.7
No. 10;	0.50	310.86	2.72	114.0
	0.00	257.26	2.53	101.1
	-0.50	209.14	2.28	91.4
No. 11;	0.50	299.17	2.18	136.9
	0.00	231.68	1.75	132.0
	-0.50	168.61	1.43	117.9
No. 12;	0.50	340.37	1.80	188.1
	0.00	253.48	1.61	156.6
	-0.50	188.53	1.75	107.3

LINE	ELEV. (m)	X-AREA (m <sup>2</sup> )	HYDR R (m)	WIDTH (m)
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No. 14;	0.50	374.34	4.35	84.0
	0.00	332.74	3.95	82.4
	-0.50	291.96	3.55	80.7
No. 15;	0.50	214.10	2.87	68.1
	0.00	180.60	2.53	65.7
	-0.50	148.60	2.25	61.0

## Geelhoutboom River;

No. 13;	0.50	263.03	1.51	173.6
	0.00	178.77	1.09	163.4
	-0.50	99.74	0.66	151.4
No. 16;	0.50	54.73	0.75	73.0
	0.00	22.12	0.49	45.5
	-0.50	3.70	0.15	24.5

## Marina canals;

No. 18;	0.50	99.31	1.50	65.7
	0.00	68.93	1.25	54.8
	-0.50	45.01	1.07	41.8
No. 19;	0.50	36.05	1.38	25.6
	0.00	24.41	1.14	20.9
	-0.50	15.10	0.91	16.3