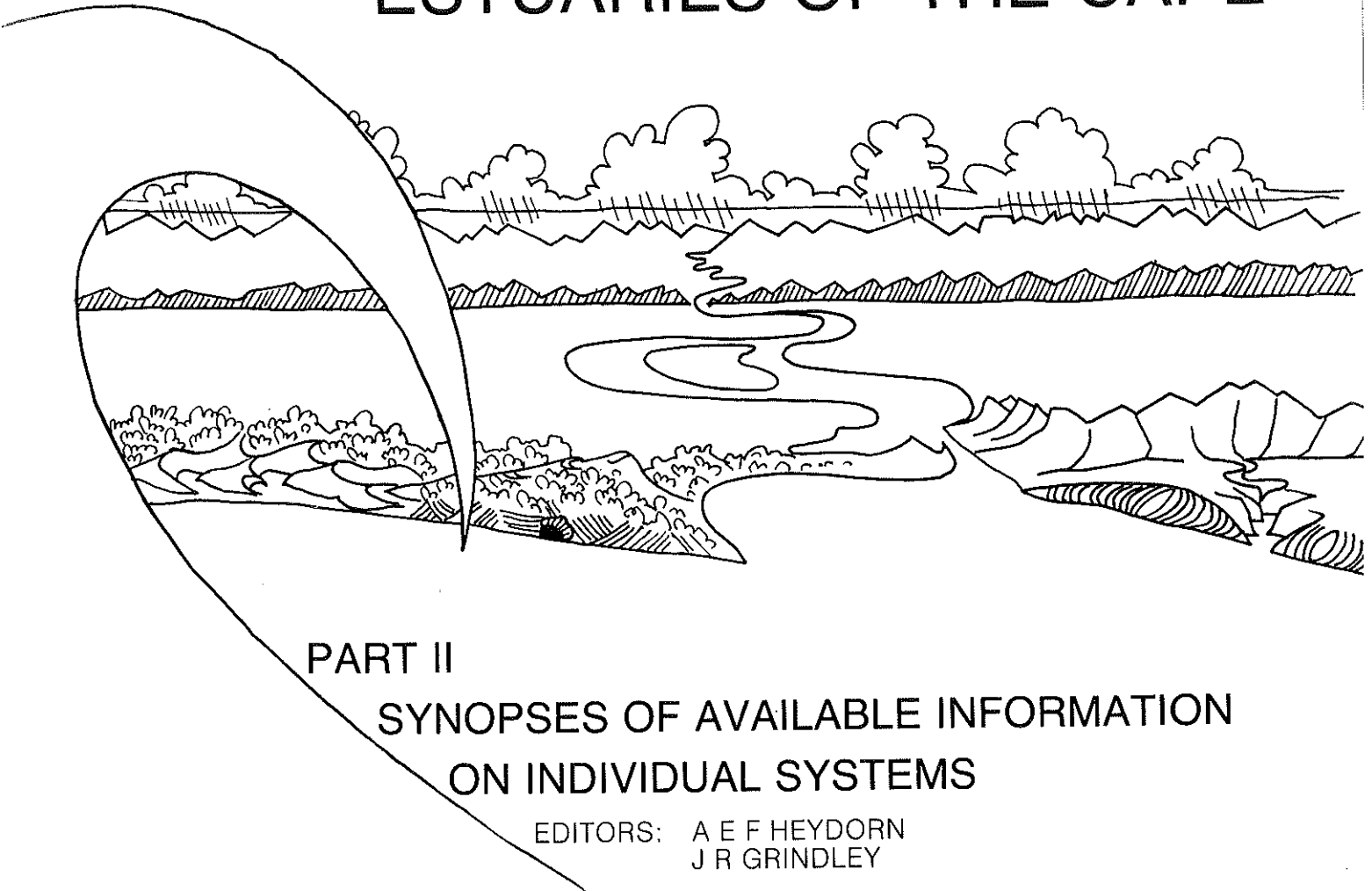


COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH  
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY  
ESTUARINE AND COASTAL RESEARCH UNIT – ECRU



# ESTUARIES OF THE CAPE



PART II

SYNOPSIS OF AVAILABLE INFORMATION  
ON INDIVIDUAL SYSTEMS

EDITORS: A E F HEYDORN  
J R GRINDLEY

REPORT NO. 16

**EERSTE (CSW 6)**

# ESTUARIES OF THE CAPE

## PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

### REPORT NO. 16: EERSTE (CSW 6)

(CSW 6 — CSIR Estuary Index Number)



FRONTISPIECE: EERSTE ESTUARY — ALT. 150 m, ECRU 82-12-20

COMPILED BY: J R GRINDLEY

ECRU Surveys : DECEMBER 1981 AND JUNE 1982  
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ESTUARINE AND COASTAL RESEARCH UNIT — ECRU  
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COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

ISBN 0 7988 1812 3 (Set)  
ISBN 0 7988 1813 1 (Part 2)  
ISBN 0 7988 2574 X (Rep. No. 16)

*Published in 1983 by:*

National Research Institute for Oceanology  
Council for Scientific and Industrial Research  
P.O. Box 320, Stellenbosch. 7600

*Printed by:*

CREDA PRESS, CAPE TOWN

## PREFACE

The Estuarine and Coastal Research Unit (ECRU) was established by the National Research Institute for Oceanology (NRIO) of the CSIR in 1979 with the following aims:

- to contribute information relevant to the development of a cohesive management policy for the South African coastline;
- to compile syntheses of all available knowledge on the 167 estuaries of the Cape between the Kei and the Orange rivers;
- to identify gaps in information, to conduct research to fill these and to stimulate Universities, Museums and other institutions to become involved in this kind of work;
- to contribute to *ad hoc* investigations carried out by NRIO on the impacts of proposed developments in the coastal environment, and especially in estuaries.

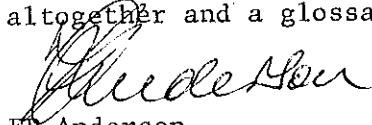
The Unit was established at the request of the Government, and the Department of Environment Affairs contributes substantially to the running costs.

In 1980 the Unit published its first report under the title "The Estuaries of the Cape, Part I - Synopsis of the Cape Coast. Natural Features, Dynamics and Utilization" (by Heydorn and Tinley)<sup>+</sup>. As the name of the report implies, it is an overview of the Cape Coast dealing with aspects such as climate, geology, soils, catchments, run-off, vegetation, oceanography, and of course, estuaries. At the specific request of the Government, the report includes preliminary management recommendations.

The present report is one of a series on Cape Estuaries being published under the general title "The Estuaries of the Cape, Part II". In these reports all available information on individual estuaries is summarized and presented in a format similar to that used in a report on Natal estuaries which was published by the Natal Town and Regional Planning Commission in 1978. It was found however, that much information is dated or inadequate and that the compilation of Part II reports is therefore not possible without brief prior surveys by the ECRU. These surveys are usually carried out in collaboration with the Botanical Research Institute and frequently with individual scientists who have special interest in the systems concerned. One of these is Prof JR Grindley of the University of Cape Town who is co-editor of the Part II series.

These surveys are, however, not adequate to provide complete understanding of the functioning of estuarine systems under the variable conditions prevalent along the South African coastline. The ECRU therefore liaises closely with Universities and other research institutes and encourages them to carry out longer-term research on selected estuarine systems. In this way a far greater range of expertise is involved in the programme and it is hoped that the needs of those responsible for coastal zone management at Local-, Provincial and Central Government levels can be met within a reasonable period of time.

Finally, the attempt has been made to write the Part II reports in language understandable to the layman. However it has been impossible to avoid technical terms altogether and a glossary explaining these is therefore included in each report.

  
F.P. Anderson  
DIRECTOR

National Research Institute for Oceanology  
CSIR

<sup>+</sup> CSIR Research Report 380

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## EERSTE RIVER

### 1. HISTORICAL BACKGROUND

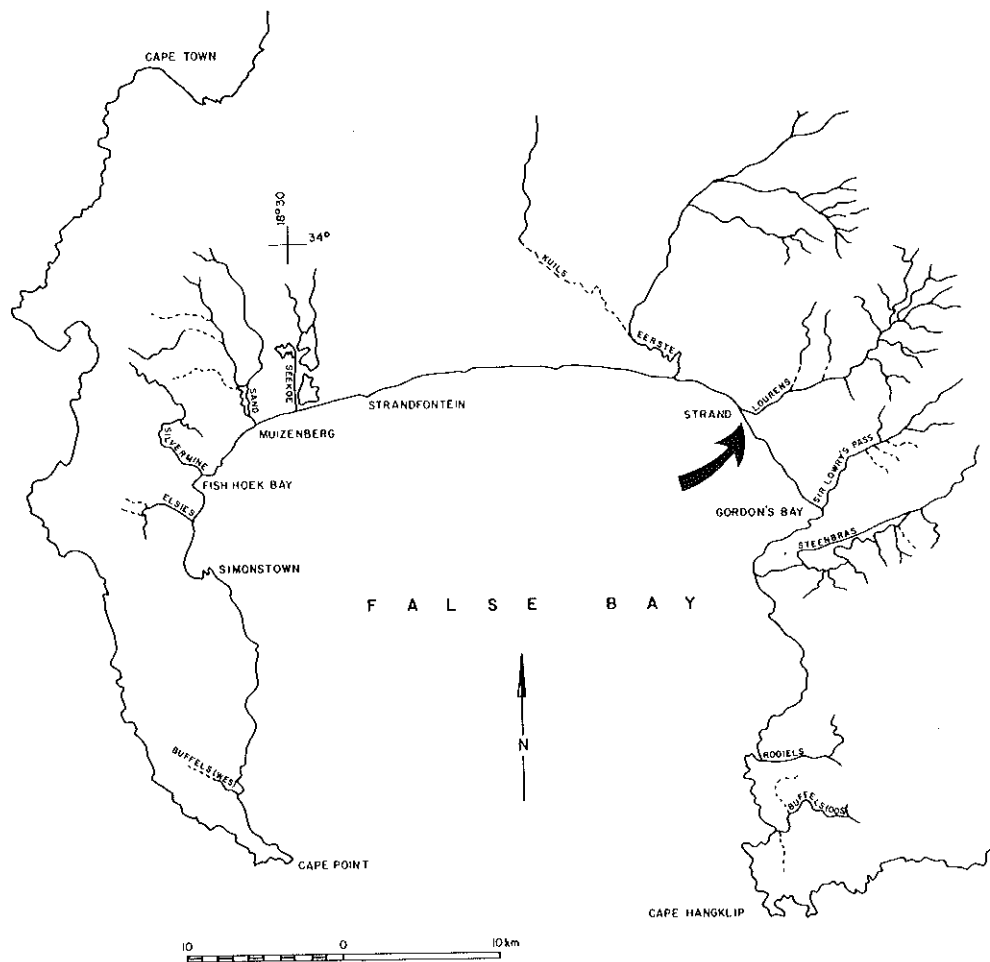
The Eerste ('first') was the first river encountered by the early settlers beyond the Cape Flats. The town of Stellenbosch, which is the second oldest in South Africa, was established on the banks of the Eerste River. When Governor Simon van der Stel first visited the area in November 1679 he was greatly attracted by its beauty. In that month the shallow valley is very beautiful, and after the winter rains the river would have been flowing strongly. The name Stellenbosch ('Van der Stel's bush') was given to the site of the Governor's camp, and by the following year the first settlers had arrived from Cape Town. There was ample water from the river and the streets were lined with furrows to take water to every house. Oak trees were planted and thatch-roofed houses were built in traditional styles. Stellenbosch today preserves many historical buildings including the Burgher House built in 1797 and the Kruithuis ('powder house') on the west side of the Braak or town square built in 1777 (Mayhew, 1978). The catchment of the major tributary, the Kuils River, was not developed extensively until the twentieth century. Development had mainly been agricultural but during this century the northern suburbs of Cape Town developed rapidly in the Kuils River catchment and extensive urbanization has taken place. The Municipalities of Durbanville, Bellville and Kraaifontein are included, while DF Malan Airport and the Mitchell's Plain housing development lie further south (Ninham Shand, 1979).

### 2. LOCATION

The Eerste River mouth is situated at 34°05'S, 18°46'E (1:50 000 Sheet 3418 BB, and is approximately 36 km south-east of Cape Town. A major tributary, the Kuils River joins the Eerste River four kilometres from the mouth. The extensive catchment of the Kuils River, which lies to the west of that of the Eerste River, is considered separately in some sections of this report.

#### 2.1 Accessibility

The estuary itself falls partly within a security fenced restricted area controlled by the chemical factory Kentron. The estuary can be viewed from the Sewage Works on the west bank which is accessible by road through Macassar Rownship. This can be reached from the N2 National Road. The estuary was accessible to the public until 1982 from Macassar Beach by walking along the beach. Access to the fenced area is restricted by virtue of an order issued by the Minister of Defence in terms of the provisions of sub-section (1) of Section 89 of the Defence Act, 1957 (Act No 44 of 1957) as amended.



## 2.2

### Local Authorities

The headwaters of the Eerste River fall within the Jonkershoek Forest Reserve (Department of Environment Affairs, Directorate of Forestry). The middle reaches of the Eerste River lie within the area of the Stellenbosch Municipality. Most of the remainder of the catchment area lies in areas controlled by the Stellenbosch Divisional Council.

The Kuils River catchment area falls under the control of a number of local authorities, namely the Municipalities of Durbanville, Brackenfell, Kraaifontein, Bellville and Kuilsrivier and the Divisional Councils of Stellenbosch, Cape and Paarl. Large tracts of land adjacent to the river are owned by the State and have been allocated to various government departments, mainly the Department of Defence and the Department of Internal Affairs. Extensive development has taken place in the Kuils River catchment including the Kuilsrivier, Brackenfell, Kraaifontein, Scottsdene and Kleinvlei residential areas and the Blackheath industrial area.



The Kuils River catchment has been affected by man-made drainage schemes so that substantial areas lying beyond the natural catchment have been drained to the Kuils River. Details of this modified *de facto* catchment boundary are described by Ninham Shand (1979). While local authorities cannot be held responsible for damage due to urbanization changing the general run-off characteristics within a natural catchment, the opinion has been expressed that they are responsible for any flood damages arising from "foreign" flood waters from beyond the natural catchment (Adv WG Burger in Ninham Shand, 1979).

### 3. ABIOTIC CHARACTERISTICS

#### 3.1 River Catchment

##### 3.1.1 Catchment Characteristics

###### *Area*

The Eerste River rises on Dwarsberg 60 km east of Cape Town at the head of Jonkershoek. The Eerste River catchment covers the eastern part of the Cape Flats lying to the west of the Hottentots Holland Mountains and south of the Tygerberg where the Kuils River tributary rises east of Kanonkop. The catchment area of the Eerste River has been reported as approximately 400 km<sup>2</sup> (SPB du Plessis, unpublished report 5/3/81). The area of the catchment and the mean annual run-off are not given by Noble and Hemens (1978) as the Eerste River is omitted from their list. However, the total area drained by the Kuils River as far as its confluence with the Eerste River is about 240 km<sup>2</sup> (Ninham Shand, 1979) and the Directorate of Water Affairs gives the catchment of the Eerste River above the gauging weir at the road bridge at Faure as 338 km<sup>2</sup>. The remaining area of the catchment below this point is approximately 80 km<sup>2</sup> which would give a total of about 418 km<sup>2</sup>. Van der Zel and Wicht (1974) give the total area of the catchment as 420 km<sup>2</sup>. The total catchment of the Eerste River system including the Kuils River is thus approximately 660 km<sup>2</sup>.

###### *River length*

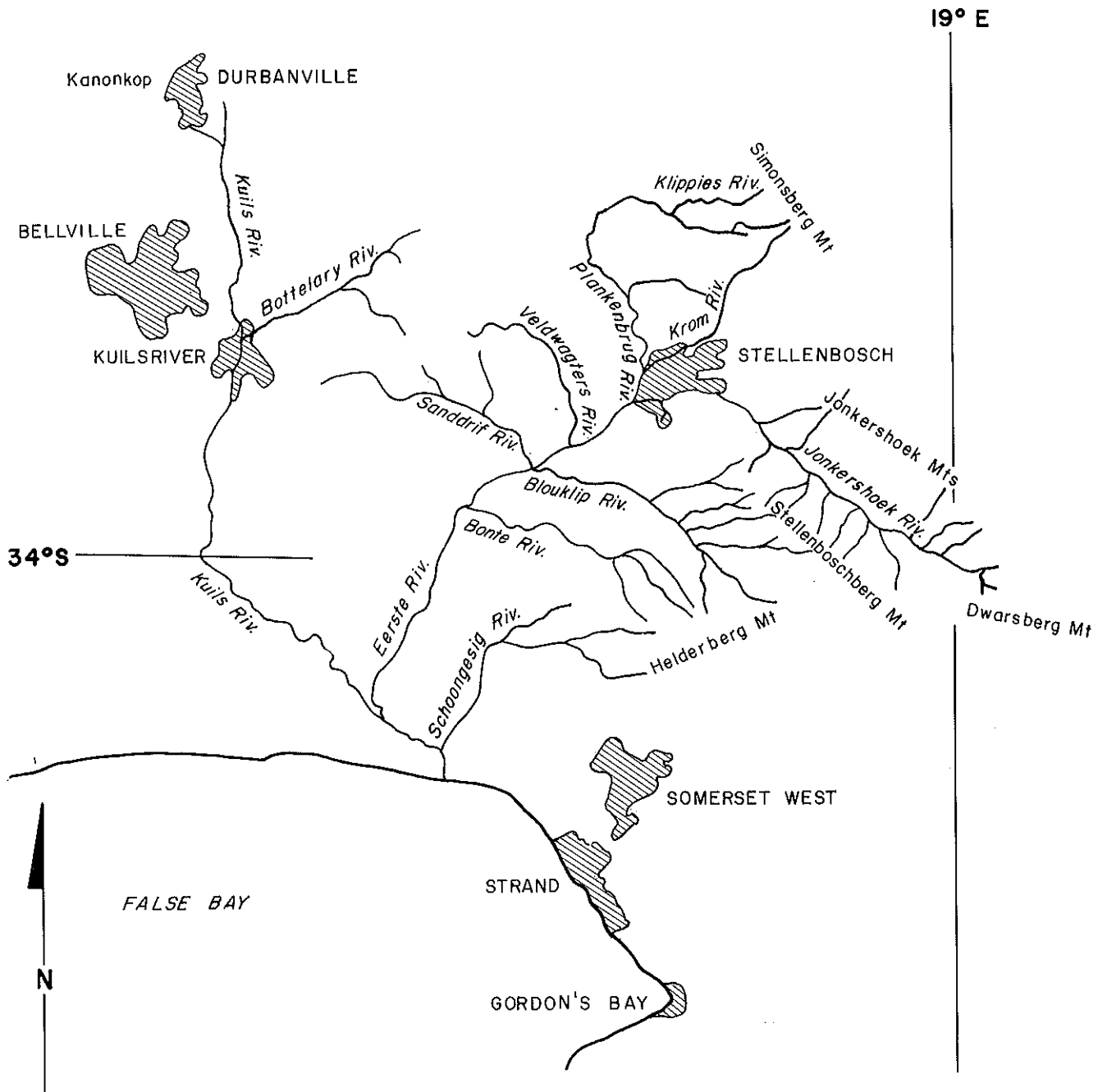
The Eerste River is a short river; its length has been given as 40 km (Van der Zel and Wicht, 1974; King, 1981). The major tributary, the Kuils River, is approximately 30 km long to its point of confluence with the Eerste.

###### *Tributaries*

Tributaries include the Blouklip, Bonte, Jonkershoek, Klippies, Krom, Plankenbrug, Sanddrif and Veldwagters. The Jonkershoek River has a number of normal minor tributaries within the Jonkershoek valley. The major tributary of the Eerste River is the Kuils River which itself has tributaries including the Bottelary, Langverwacht and Swart (see Figure 1).

**FIG. 1: Tributaries of the Eerste River**

(from 1:250 000 Topographic sheet 3318 Cape Town)



### *Geomorphology*

An account of some geomorphic aspects of the Eerste River system has been published by Beekhuis *et al* (1945). Features described include alluvial fans in the Jonkershoek valley, the development of the Stellenbosch alluvial flats and the formation of the estuary. Aspects of geomorphology are covered in a number of other publications including Ninham Shand (1979) and Wessels and Greeff (1980). Further details are given under *Geology* below.

### *Geology*

The Eerste River rises on Dwarsberg and various tributaries arise on the adjoining Jonkershoek, Stellenboschberg and Simonsberg Mountains which consist mainly of folded Quartzitic Table Mountain Sandstone. These mountains reach a height of 1 600 m.

Much of the catchment area consists of undulating hills with fertile soils overlying Cape Granite and Malmesbury Shale. The lower reaches of the Eerste River and Kuils River lie in the low-lying coastal plain on aeolian sands. The northern and western areas of the catchment are drained mainly by the Kuils River while the mountainous eastern areas are drained by the various tributaries of the Eerste River. The original mouth of the Kuils River is blocked by sand dunes and it was therefore forced to link into the Eerste River in its lower reaches. Marshes have developed in this area where the Kuils River has been diverted by natural processes in an easterly direction in some past time (Wessels and Greeff, 1980).

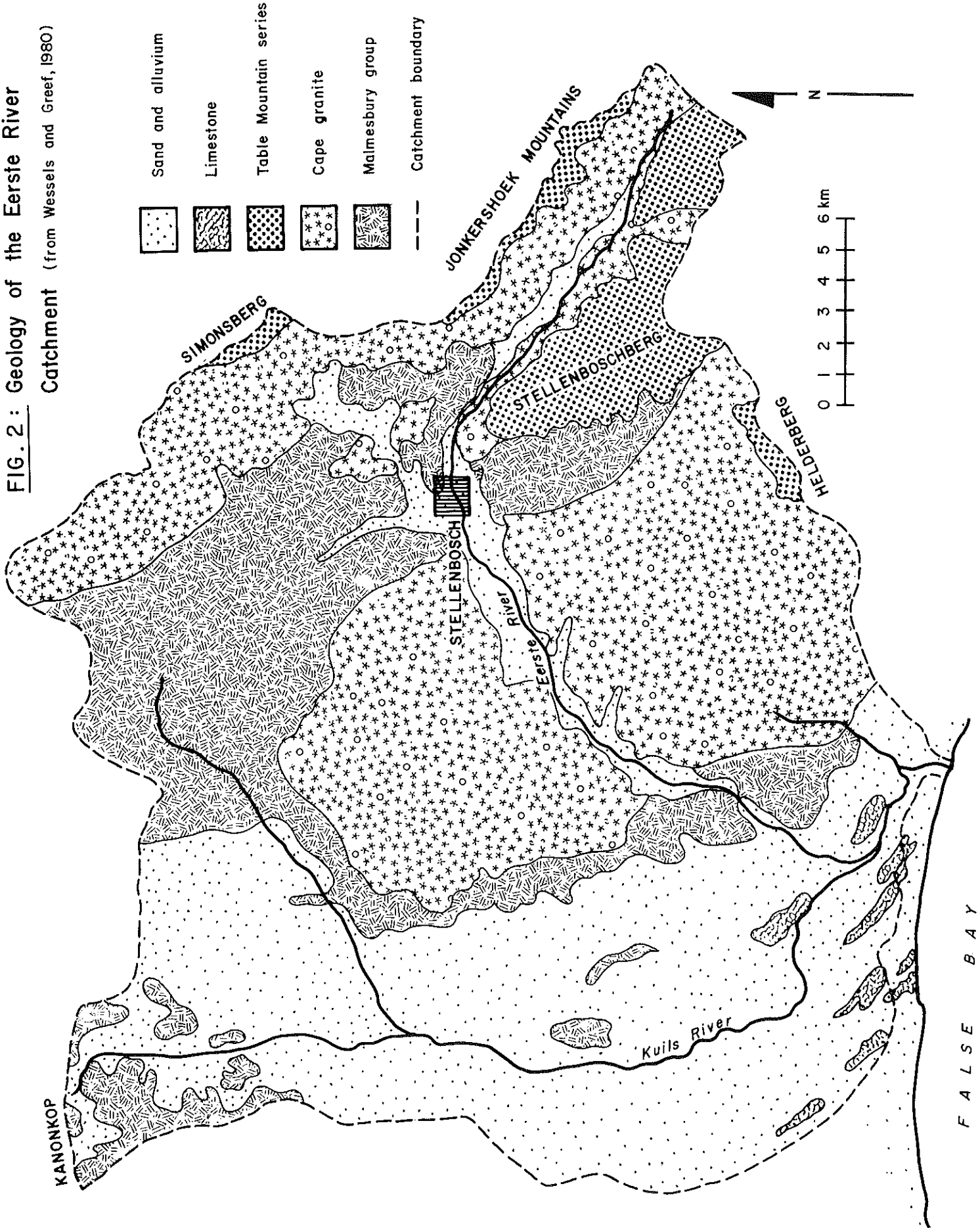
Rocks of the Malmesbury Group include shale, greywacke and siltstone, are Precambrian and about 800 million years old. Batholiths and plutons of Cape Granite penetrated this area during the tectonic period of formation of the Malmesbury group rocks. Most of the granite has a coarse porphyritic texture but adjoining the contacts with Malmesbury rocks the granite is fine-grained.

The Klipheuwel Formation including conglomerates and sandstone layers overlies the older Malmesbury rocks and Cape Granite in the Klapmuts area and is considered to be of late Pre-Cambrian age. Dolerite intrusions are present in several places and are of uncertain age as they penetrate Malmesbury, Cape Granite and Cape Supergroup rocks while some are cut off and covered by Cape Supergroup sediments and appear only in the older Pre-Cambrian basement rocks (Wessels and Greeff, 1980).

The Middle-Palaeozoic rocks of the Cape Supergroup lie discordantly on the erosion surface formed in Cambrian and Ordovician times, of the earlier formations. In the catchment area of the Eerste River system only the two lower units of the Table Mountain Group are present, namely the Graafwater formation (this has siltstone and shale at the base) and the Peninsula Formation (massive hard quartzitic sandstone of high purity with frequent crossbedding).

FIG. 2: Geology of the Eerste River

Catchment (from Wessels and Greef, 1980)



It is the resistant rocks of the Peninsula Formation which form the mountains on the eastern side of the catchment area. Mesozoic deposits of the Karoo Supergroup which may have overlain the Cape rocks no longer survive in this area.

Sediments on the Cape Flats formed in the Tertiary period when sinking of the coast allowed their deposition over the older rocks. These sediments include well-rounded stones and marine shells among which are *Ostrea prismatica*. These tertiary sediments are overlain by Quaternary sediments but the underlying material is well known from the Cape Flats Aquifer study (Wessels and Greeff, 1980). Generally the shell gravels are very porous and thus good aquifer material but being largely below sea-level and near the coast, sea water penetration would be a problem if ground-water extraction was attempted.

During the Quaternary period sediments including sand, silt, clay and mud accumulated in the drowned coastal area. Plant material collected in the vlei areas and led to the development of peat layers between sand layers. The presence of an excess of calcium carbonate in the form of shell fragments led to the formation of calcrete layers. Although the sediments were mainly introduced by the rivers, and later reworked by the sea, the wind also played an important role as reflected in the widespread crossbedding in the Aeolianite cliffs at Swartklip. Towards the interior the sands are darker grey or reddish-brown and scattered ferricrete and silicrete layers are present.

The catchment of the upper reaches of both the Kuils and the Bottelary Rivers are underlain by rocks of the Malmesbury Group. These are metamorphic sediments, consisting of quartzites, phyllite, greywacke and shales of Precambrian age and are covered by recent thin deposits of loam. Below the confluence of the above two rivers the geology is characterised by considerable depths of tertiary and recent deposits of loose sand and dune formations underlain by extensive clay lenses. Scattered deposits of gravel, sandstones and conglomerates together with irregular development of silicrete and calcrete occur throughout the area (Ninham Shand, 1979).

The nature of the geology of the upper catchments of the Eerste and Kuils Rivers is such that run-off is relatively high while subsurface flow will be small. In the predominantly sandy areas of the lower catchment, surface drainage is limited particularly in the sand dune areas while subsurface drainage is significant. This is confirmed by the presence of the high water table in the lower reaches of the Kuils and Eerste Rivers (Ninham Shand, 1979; Wessels and Greeff, 1980; Kok, 1970).

The succession of sediments characteristic of the catchment of the Eerste River system are illustrated in Figure 2.

### *Rainfall and Run-off*

The Eerste River and its tributaries lie within the winter rainfall region (Heydorn and Tinley, 1980). Yearly rainfall over its catchment ranges from 3 000 mm on the mountains to 700 mm or less on the coastal plain (Van der Zel, 1971). A hydroeconomic evaluation of forestry in the Eerste River catchment was carried out by Van der Zel and De Villiers (1975). About 80 percent of the rain falls in a series of winter downpours which bring the river down in spate. Only seven percent of the annual precipitation occurs between December and March, and as water is continually extracted from the river for urban and rural use, flow may cease in its lower reaches during these months (King, 1981). The Kuils River catchment is drier and mean annual precipitation ranges from about 800 mm in the eastern hills to about 500 mm near the coast (Ninham Shand, 1979).

The DF Malan Airport weather station is the only comprehensive meteorological station in the area (Ninham Shand, 1979) but a number of municipalities and other authorities keep rainfall and other meteorological records (Fuggle, 1981).

### *Flow records*

The average flow of the Eerste River is reported to be about  $70 \times 10^6 \text{ m}^3$  (Du Plessis, 1981). The longest flow record available is that for the measuring point G2M05 of the Directorate of Water Affairs in the Jonkershoek valley where two water-level recorders have been in operation since 1939. The catchment area above this point is, however, only  $31 \text{ km}^2$  so that only about 40 percent of the flow of the Eerste River (excluding the Kuils River) is measured at this point. Nevertheless, because of the distribution of rainfall in this area, as reported by Wicht *et al* (1969), and the topographical features of the terrain, approximately 97 percent of the run-off from above this point is measured. Measuring point G2M15 is at Faure and has a catchment of  $338 \text{ km}^2$  but because of erosion at the measuring point, records are available only for the years 1968 to 1972. The correlation between the values at Faure and Jonkershoek are sufficiently good for Wessels and Greeff (1980) to have used them in a regression model to establish synthetic series of figures for the period 1940 to 1975 for flow at Faure. As this is in the lower reaches and as there are no noteworthy tributaries below this point (except the Kuils River for which separate values have been compiled), these flow records are the best available for the Eerste. Great variations in flow exist as is shown by a maximum flow of  $167 \times 10^6 \text{ m}^3$  in 1941 and a minimum flow of  $48 \times 10^6 \text{ m}^3$  in 1969.

Calculated monthly flow ranged from  $0,211 \times 10^6 \text{ m}^3$  in February 1970 to  $38 \times 10^6 \text{ m}^3$  in June 1942. The actual flows recorded at Faure in the years when the gauging station was operating, were not as high as the calculated values because of water extraction upstream but a flow of  $16,3 \times 10^6 \text{ m}^3$  was recorded in June 1968.

For four months from January to April 1970 no flow was recorded ( $0,00 \times 10^6 \text{ m}^3$  each month). Even during this drought period flow did not fall below  $0,107 \times 10^6 \text{ m}^3$  at Jonkershoek (G2M05) (River Flow Data, 1978) (see Figure 3).

A List of Hydrological Gauging Stations in the Eerste River system, including the Kuils River, has been published by the Division of Hydrology (Publication No. 12). The established gauging stations include G2M01 to G2M20 on the Eerste and G2M21 on the Kuils.

Details of flow records at these stations are published by the Division of Hydrology (River Flow Data, 1978).

The Eerste River has a steep gradient and forms rapids in the top seven km in the Jonkershoek valley where it is a mountain stream 5 - 7 m wide with an average gradient of 24 m/km. The substrate consists of boulders, stones and bedrock. The new Kleinplaas dam is situated in this area. There is a five km stretch through the foothills where the average gradient is 12 m/km and the width is 7 - 11 m while the substratum remains rocky and the flow swift. The lower river flows sluggishly through agricultural lands where the substratum consists of stones and pebbles on coarse sand. The width increases to 8 - 18 m and the average gradient drops to 2 m/km. The town of Stellenbosch is at the junction of the upper and lower sections of the river (King, 1981).

The Eerste River is now linked via the Riviersonderend-Berg River tunnel system to the Theewaterskloof scheme so that the flow of the Eerste river can be supplemented by water from the other sources (Heyns, 1974).

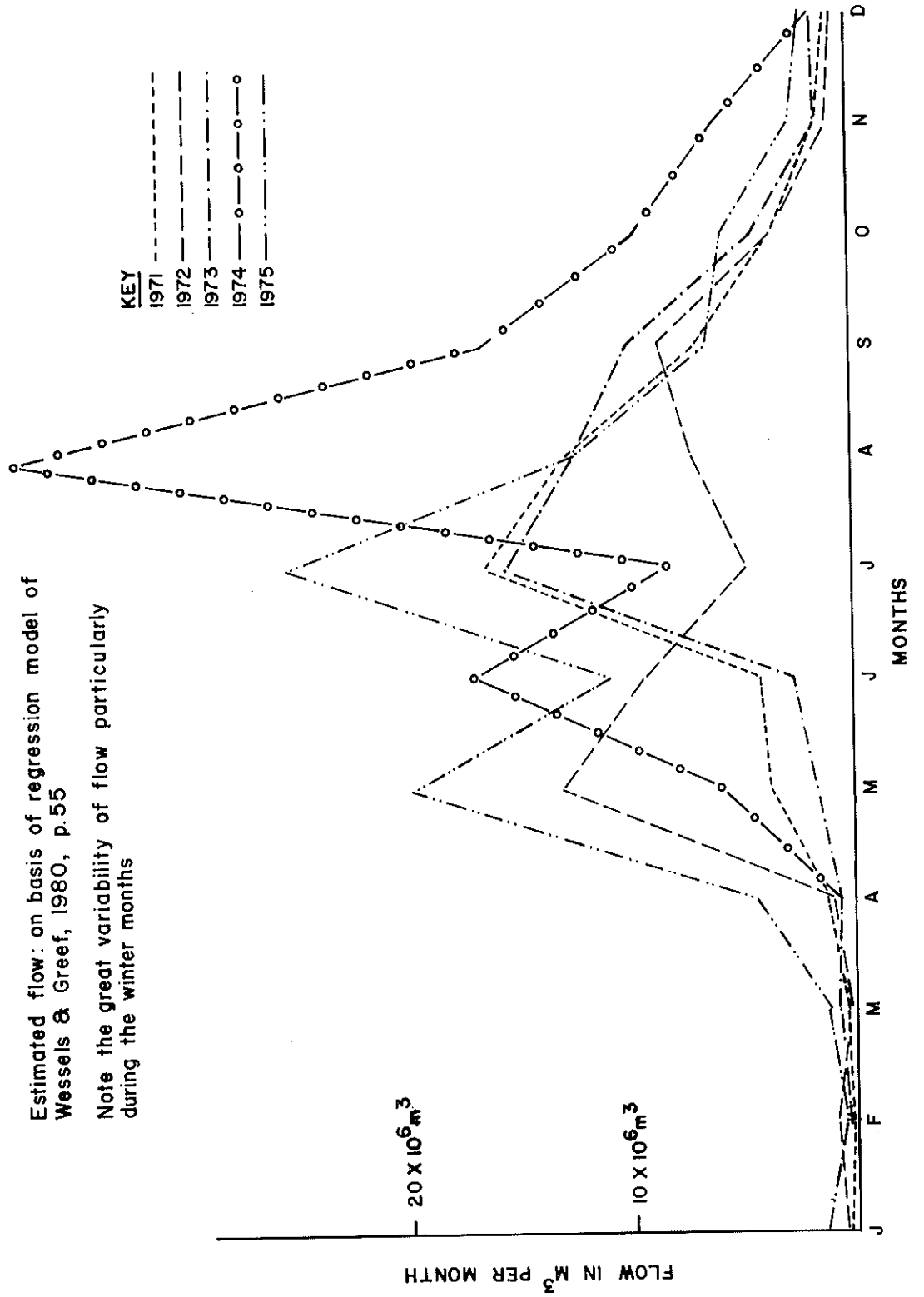
The mean annual run-off (m.a.r.) of the Kuils River under present conditions has been estimated as  $22 \times 10^6 \text{ m}^3$  at the Kuils/Eerste River confluence. Development of the undeveloped area zoned for urban use would increase the mean annual run-off to approximately  $27 \times 10^6 \text{ m}^3$ . Year-to-year variations in run-off may be considerable and m.a.r. may be as low as  $1 \times 10^6 \text{ m}^3$  with a recurrence interval of 10 years. The above flow excludes sewage effluent discharged into the river. Effluent from sewage works at Bellville, Kuilsrivier, Mfeleni and S.A. Coloured Corps presently contribute together an average of  $24\,000 \text{ m}^3/\text{day}$  (a total of about  $10 \times 10^6 \text{ m}^3$  per year). Sewage effluent may add  $35 \times 10^6 \text{ m}^3/\text{y}$  by the year 2000.

The influence of sewage effluent is minor as far as peak flows are concerned, but is very significant at times of low flow. 1-in-10 year low run-off may be increased from  $1 \times 10^6 \text{ m}^3$  to  $9 \times 10^6 \text{ m}^3$  while 1-in-10 year flood flow would be increased only from  $45 \times 10^6 \text{ m}^3$  to  $53 \times 10^6 \text{ m}^3$ . By the year 2000 sewage effluent flow will far exceed natural run-off flow (Ninham Shand, 1979).

**FIG. 3: Variations of monthly flow of the Eerste River at Faure in millions of cubic metres for 1971 - 1975**

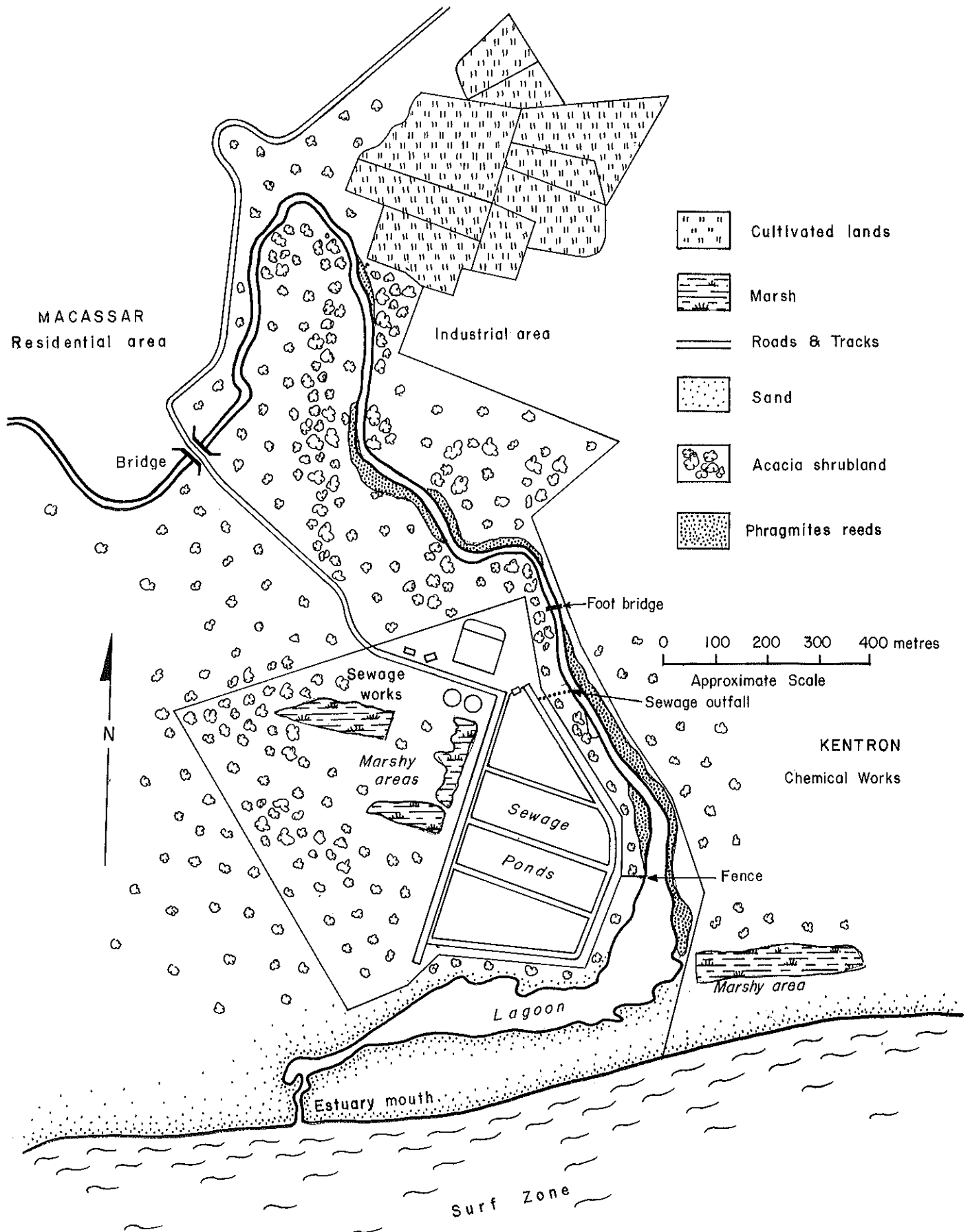
Estimated flow: on basis of regression model of Wessels & Greef, 1980, p.55

Note the great variability of flow particularly during the winter months





**FIG. 4:** Map of Eerste River Estuary drawn from aerial photographs, Job 326, Photos Nos. 362/3 of 21 April 1979



### 3.1.2 Land Ownership/Uses

The uppermost section of the Eerste River Catchment is owned by Directorate of Forestry of the Department of Environment Affairs. Forestry is the major land use in the Jonkershoek Valley with extensive plantations of *Pinus radiata* for timber production. This area is a forest reserve and outdoor recreation is important. A section of the Hottentots Holland Hiking Trail passes through the head of the Jonkershoek Valley.

The Cape Provincial Department of Nature and Environmental Conservation maintain a trout hatchery at Jonkershoek and a Nature Conservation Station at Assegaaibos nearby. There is a rich fynbos flora in the Jonkershoek Valley and 163 species of birds have been recorded.

The middle reaches of the river near Stellenbosch are lined by European trees including oaks, *Quercus robur*, white poplar, *Populus canescens* and Australian black wattle, *Acacia mearnsii*.

The Kuils River catchment area extends into the Municipalities of Durbanville and Bellville on the north-western and western side respectively, while DF Malan Airport and the Mitchell's Plain development lie to the south-west. To the north-west the catchment is bordered by the Kraaifontein municipal area but the whole of the eastern side is agricultural land. Talbot (1947) surveyed agricultural land utilization in the western Cape. The catchment extends south to the False Bay coast where the southern side of the dunes drains to the sea rather than into the Kuils River.

Over a major part of the catchment indigenous vegetation has been replaced by agricultural activities, urban development and alien vegetation. Port Jackson willow, *Acacia saligna*, Rooikrans, *Acacia cyclops*, Black wattle, *Acacia mearnsii*, white poplar, *Populus canescens* and other species have largely replaced the original vegetation. A few patches of indigenous fynbos and renosterveld still exist in the Durbanville area, at Brackenfell, in the Bottelary hills, at Blackheath and on the farm Vergenoegd. *Sesbania* has been reported to be threatening some sections of the river (Eikestadnuus, 80-01-18).

In its upper reaches the Kuils River runs in a well defined channel, but in the Kuilsrivier municipal area the valley opens out and the river enters a system of vleis connected by channels. Botanically the undisturbed wetland system of the lower Kuils River where indigenous riparian and marsh vegetation exists is of considerable importance. Alien vegetation including *Acacia* spp., water hyacinth, *Eichhornia crassipes*, and parrot's feather, *Myriophyllum aquaticum*, do not yet dominate these important wetlands. These marshes are important for the maintenance of the Cape Flats aquifer (Wessels and Greeff, 1980) and for aquatic birds. More than 86 species have been recorded there (Ninham Shand, 1979).

The main flow of the Kuils River crosses part of Vergenoegd farm both north and south of the N2 Freeway. In both cases there is not a defined channel and wide stretches of ground are subject to inundation. In recent years an increase in both the area inundated during the wet season and the period of inundation has been reported. At least part of this inundation is due to an increase in the amount of sewage effluent discharged to the river. As urbanisation in the catchment proceeds and sewage effluent discharge increases still further, inundation will inevitably extend further. The possibility of this part of Vergenoegd being acquired for nature conservation purposes has been recommended (Currie in Ninham Shand, 1979), provided that the agreement of the present owners can be obtained. If these wetlands, which are now almost continuously flooded, were to become a nature reserve no flood protection measures would be required but control of sewage effluent discharged into the river would however be required. The construction of the proposed Kleinvlei canal will aggravate the inundation of this area further.

The Kuils River joins the Eerste River about four kilometres from the mouth. In January 1982 the junction was about five kilometres from the mouth (upstream of the Kramat Road Bridge) but the confluence is ill-defined, as the rivers join in a vlei area intersected by a number of channels. On 14 January 1982 the Kuils River was found to have cut through a bank to join the Eerste River opposite the farm Zandvliet nearly a kilometre upstream of the confluence indicated on the trigonometrical survey map.

Some early maps show the river discharging directly into False Bay, but this outlet, if it existed, is blocked now by a series of vegetated sand dunes which has forced the river to turn eastwards to join the Eerste River (Ninham Shand, 1979).

### 3.1.3 Obstructions (Dams, bridges, weirs)

The Eerste River is dammed in the Jonkershoek valley by the Kleinplaas Dam which was built in 1981. Kleinplaas is to be a balancing/diversion dam on the Jonkershoek tributary, linked to the Theewaterskloof scheme, by the Berg River - Riviersonderend tunnel system. The Kleinplaas Dam is a 25 m-high composite structure of crest length 345 m with a concrete gravity spillway in the river section, flanked by embankments. The dam will be fed by the Jonkershoek river as well as the tunnel system and will divert water into the Stellenboschberg tunnel and also supplement the flow of the Eerste River (Directorate of Water Affairs, pers. comm.).

The Theewaterskloof Dam, the main storage unit of the water scheme, has a capacity of  $484 \times 10^6 \text{ m}^3$ . It will receive water from the Riviersonderend catchment direct as well as from the Berg River catchment through the tunnel system. The total mean annual run-off to Theewaterskloof is  $293,8 \times 10^6 \text{ m}^3$ . Via the Kleinplaas

dam and the Stellenboschberg tunnel water will reach irrigation areas below Stellenbosch in the Eerste River valley via the Helderberg and Papegaaiberg canals as well as Cape Town direct.

The Sonstraal Dam is situated on a small western tributary of the Kuils River on the boundary of the Durbanville municipal area. The dam has an area of 2,25 ha and situated at 33°50'S, 18°39'E and is 122 m above sea-level. There is an earthfill wall 6 m high and the dam is controlled by the Durbanville Municipality and provides water for their golf course. The Edwards Dam is situated in the Vygeboom area and is also a Durbanville Municipal dam as is the Golf Club Dam. Four species of fish are stocked and angling is by permit (McVeigh, 1978).

The Ida's Valley Dam 2,5 km north-east of Stellenbosch (33°54'S, 18°54'E) grid. ref. 3318 DD is situated on the Krom River tributary of the Eerste River and was constructed in 1953. It has a capacity of  $455 \times 10^3 \text{ m}^3$  an area of 6 ha, an altitude of 259 m and it has a 35 m concrete wall. This dam is controlled by the Stellenbosch Municipality and provides water for domestic and industrial use in Stellenbosch. The dam is surrounded by pine plantations and is stocked with three species of fish. (McVeigh, 1981).

There are a large number of bridges, and variable channel conditions in the courses of the Eerste and Kuils Rivers which may impede the free flow of water and increase upstream water levels. Details of the bridges and other obstructions on the Kuils River are presented in tables and an appendix in Ninham Shand (1979) which include estimated flow capacities.

#### 3.1.4 Siltation

Siltation has not been a major problem in the Eerste or Kuils Rivers. The mountainous upper catchment has been carefully managed by the Directorate of Forestry and is largely covered by natural vegetation. Although large areas of the catchment are agricultural land, soil erosion does not appear to have caused serious siltation of the rivers. The lower reaches of the rivers flow across the sandy Cape Flats but extensive areas of clayey alluvium present evidence of extensive deposition in earlier times.

During the building of the Kleinplaas Dam in Jonkershoek in 1981, brown silt laden water discoloured the river and fine clayey deposits were deposited in the lower reaches (Photographs by AEF Heydorn, 81-12-09).

#### 3.1.5 Abnormal flow patterns and flood history

As already mentioned, the Eerste River shows remarkable variations in flow. The winter spates play an important role in cleansing or rejuvenating the river (King, 1981), but seldom do much damage. The 1 in 50 year interval flood is estimated to be  $470 \text{ m}^3/\text{s}$ . Actual flooding is a rare occurrence. The last major flood of any importance occurred during July 1918, when much damage was done to roads and railways in the Stellenbosch area. The vineyards which border the river from Stellenbosch to

Faure were completely inundated and severe damage done to those situated on the floodplains of the river (Beekhuis *et al.*, 1945). Large logs on the banks of the estuary provide evidence of floods reaching the estuary.

A table of calculated peak flows (in m<sup>3</sup>/s) for various sections of the Kuils River catchment is presented by Ninham Shand (1979), p18). A 1 in 50 year interval flood is calculated to be 96 m<sup>3</sup>/s in the upper Kuils River, 98 m<sup>3</sup>/s in the Bottelary River, and 182 m<sup>3</sup>/s at the confluence with the Eerste River. This latter figure is slightly less than higher upstream owing to the attenuating effect of the Kuils River Vleis.

In the Kuils River valley numerous road bridges are liable to be over-topped at relatively frequent intervals. This matter has been brought to the attention of local authorities by Ninham Shand (1979). Areas that are particularly vulnerable to floods have been identified as: The Kuilsrivier Municipal Area, Mfleni Sewage Works, SA Coloured Corps Training Area, Vergenoegd Farm and the Macassar area (Ninham Shand, 1979). A report on 1 in 50 year flood lines within the Kuilsrivier municipal area has been prepared (Ninham Shand, 1977).

#### 3.1.6 Pollution of the Eerste River

The Directorate of Water Affairs in their River Surveys in the Western Cape have studied pollution of the Eerste River. Intensive sampling was carried out and chemical and bacteriological analyses were completed (Steer, 1964, 1965, 1966). The observations revealed that during the summer and autumn, water quality deteriorated significantly due to organic pollution together with low flow. Deterioration was particularly severe in the Plankenbrug River. Conditions gradually worsen until the advent of the first rains when the increase in flow alleviates the condition to some extent. Seasonally reduced activity of some riparian industries results in fair water quality in winter and spring but this deteriorates again each summer. The Department of Water Affairs approached various industries which are clearly established sources of pollution to ensure that appropriate action would be taken. Efforts were made to secure adequate disposal measures or to avoid further recurrence of accidental pollutant discharges. The quality of river water was monitored during the surveys to assess any changes.

The results of the monitoring surveys reported by Steer between 1964 and 1966 revealed a wide range of different water quality conditions including many cases of severe chemical and bacteriological pollution.

The following table of minimum and maximum values recorded indicates the extent of the variations in water quality for some of the most significant chemical components and variables:

Chlorides	3,19 - 3720 mg/l
Ammonia	0 - 1,65 mg/l
N Oxides	0 - 2,0 mg N/l
Oxygen Absorbed 4 hours	0 - 180 mg/l
Biochemical Oxygen Demand	0 - 45,0 mg/l
Dissolved Oxygen	0 - 11,0 mg/l
pH	3,05 - 9,3

Some bacteriological and parasitological values:

Total Coliforms membrane count per 100 ml	0 - 800 000
Confirmed <i>E. coli</i> I membrane count per 100 ml	0 - 160 000
<i>Salmonellae</i> in two litres of sample	0
Parasite units (ova)	0

Sampling of a series of stations within the Eerste River system is continuing. The following table includes minimum and maximum values recorded for all available samples from the Eerste River for the period 1975 to 1982:

pH	6,1 - 9,3
Total dissolved solids at 105°C	15 - 25 mg/l
Oxygen absorbed as O <sub>2</sub>	0,8 - 28 mg/l
Chemical Oxygen Demand as O <sub>2</sub>	24 - 128 mg/l
Free and saline Ammonia as N	<0,01 - 13,0 mg/l
Nitrate as N	<0,1 - 12,0 mg/l
Conductivity	0,038 - 1,8 Siemens/m
Ortho-phosphate	0,02 - 1,4 mg/l

#### *Pollution of the Kuils River*

It is clear that pollution in the Kuils River is a very real and rapidly growing threat. Analyses of samples of water drawn from various points in the river in April 1979 when natural flow was low were presented in an appendix to the report by Ninham Shand (1979). Grab samples of river water in April 1979 gave the following minimum values:

pH	6,9 - 7,6
Conductivity	0,088 - 0,205 Siemens/m
Total dissolved solids	528 - 1,230 mg/l
Sodium	96 - 244 mg/l
Ammonia	0,2 - 18 mg/l
Nitrates	2,0 - 3,6 mg/l
Phosphates	0,02 - 0,08 mg P/l
Oil and fats	20 mg/l

Various sewage works discharge effluent into the Kuils River and typical effluent analyses were presented in an appendix to the report by Ninham Shand (1979). The maximum values included were as follows, the Water Act General Standards being indicated in parentheses after each maximum value:

pH	10,6	(5,5 - 9,5)	
Chemical Oxygen Demand	268	(75 max)	mg/l
Ammonia	52	(10)	mg/l
Oxygen absorbed	32	(10 max)	mg/l
Nitrate	12,5	(-)	mg N/l
Conductivity	2,0	(-)	Siemens/m
Total dissolved solids	6 607	(500)	mg/l
Suspended solids	1 528	(28)	mg/l

The following table includes minimum and maximum values recorded for all available samples from the Kuils River and its tributaries for the period 1979 to 1982:

pH	6,6	-	8,2
Total dissolved solids at 105°C	244	-	2 100 mg/l
Suspended solids	1	-	52 mg/l
Oxygen absorbed as O <sub>2</sub>	2,6	-	18,6 mg/l
Chemical Oxygen Demand as O <sub>2</sub>	16	-	126 mg/l
Free and saline Ammonia as N	0,1	-	5,4 mg/l
Nitrate as N	1,0	-	26 mg/l
Conductivity	0,17	-	2,7 Siemens/m
Soap, oil and grease	0,05	-	0,2 mg/l
Ortho-phosphate	0,02	-	6,1 mg/l

An analysis of Kuils River water in March 1976, by the Habitat Study Group of the University of Cape Town (included as an appendix in the report by Ninham Shand, 1979), showed that even though pollution levels were high where the river enters the swamps near Vergenoegd, they were fairly low where the river leaves under the bridge of the Swartklip road. The values presented were:

	A Inflow to the Study Area	B Outflow from the Study Area
Dissolved Oxygen	3,2 mg/l	0 mg/l
Ammonia	1,1 mg/l	0,6 mg/l
pH	7	7
Nitrate	7,5 mg/l	1 mg/l
Phosphate	100 mg PO <sub>4</sub> /l	66 mg PO <sub>4</sub> /l

These samples indicated that the major pollutants (ammonia, nitrates and phosphates) decrease significantly through the swamp area, despite the inflow from the sewage station of the SA Coloured Corps Training Centre. In winter when the river carries more water, the concentrations of the pollutants in the water are lower. It is clear that these swamps perform a purifying function but if pollution levels in the inflow are increased, this could well result in the eutrophication of the entire system (Ninham Shand, 1979).

Attention has already been drawn to the discharge of sewage effluent into the Kuils River and as this increases there will be a decrease in the quality of river water, particularly because of the proportion of effluent to surface run-off. The main source of sewage effluent is, and will probably continue to be, the Bellville Municipal Works, which contributes a high percentage of the total effluent discharges into the Kuils River. The eutrophication caused by these effluents drastically alters the natural balance of flora and fauna of the river and reduces the hydraulic capacity of the river channel, as well as having undesirable aesthetic effects. This eutrophication will occur particularly in the swamps and vleis of the lower river which should be conserved as a natural area. Conditions could be greatly exacerbated in the event of accidental or deliberate discharge of poisonous substances into the river (Ninham Shand, 1979).

### 3.2 Estuary

*(This section is contributed by Dr GAW Fromme of the Sediment Dynamics Division, NRIO.)*

The Eerste River estuary (Figure 4) is a small estuary. It was omitted by Noble and Hemens (1978) in their list of South African estuaries and is not described by Day (1981) in his book on estuarine ecology.

#### 3.2.1 Estuary Characteristics

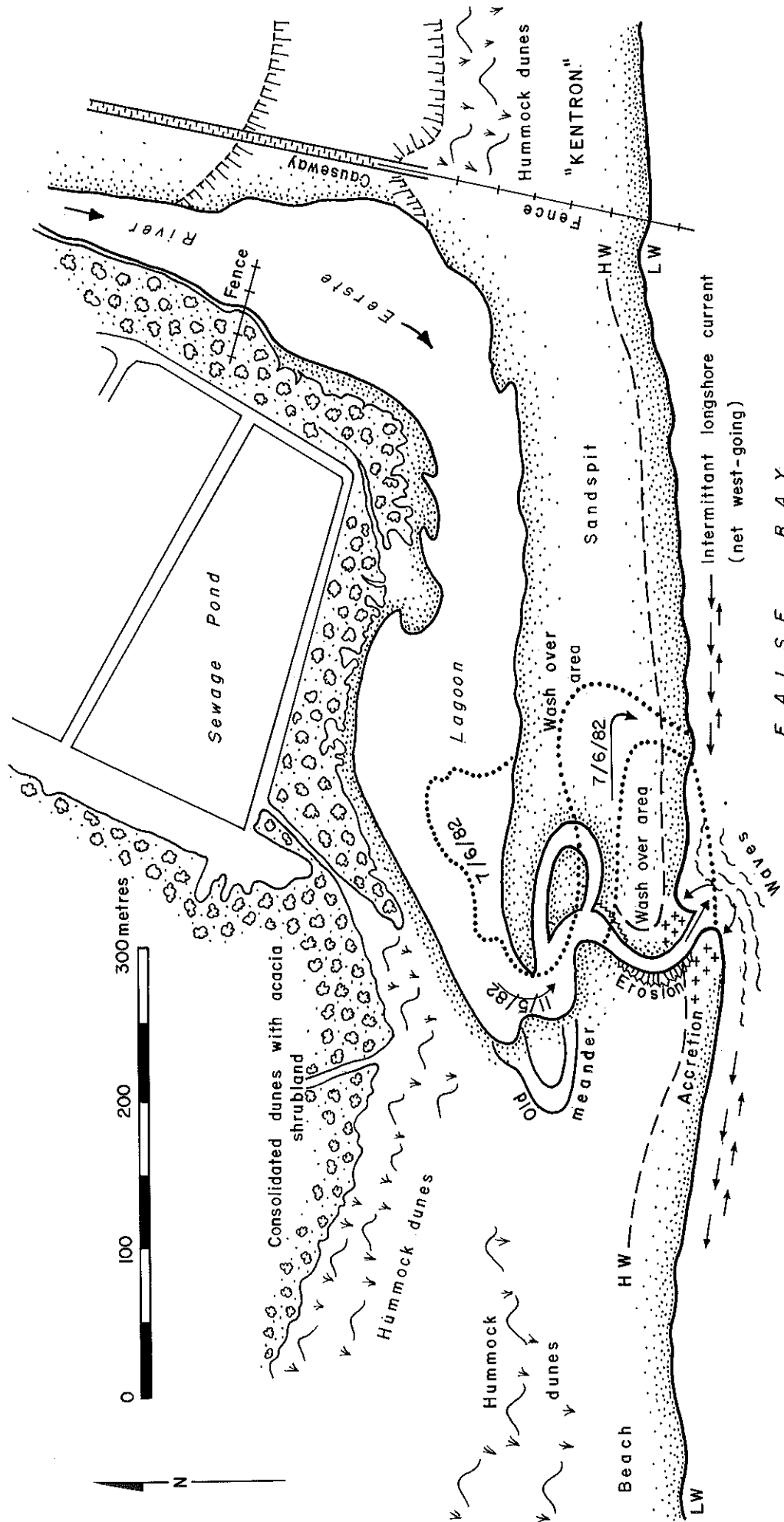
After passing through the coastal dunes near Macassar the Eerste River forms a small elongated lagoon in the slack of the backshore area of the beach. The main features of this "backshore lagoon" are shown in Figure 5. When the estuary is open it is only slightly tidal because of its high elevation (2 m above LWOST). The extent of tidal penetration on 1 December 1981 is shown in Figure 7. Observations on 7 June 1982 showed that during the peak of HWOST the water was still outflowing. The mouth then represented merely an overflow from the lagoon into the sea. Sea water does wash over the sandspit into the lagoon during high spring tides.

As shown in Figure 6 the lagoon extended originally to both sides of the exit of the river onto the beach area. The eastern arm was cut off by the construction of a causeway in 1977 which left a confined stagnant water body. This has become a marshy area east of the Kentron security fence. The changes are apparent in Aerial photographs taken in 1977 (Job No 786, Photo No 0651) and in 1980 (Job 374, Photo No 258). At present only the western arm of the lagoon is functioning.

During an ECRU survey on 11 May 1982, during LWST, the water discharge through the meander-shaped mouth channel was approximately  $3 \text{ m}^3/\text{s}$ . Depths of the estuary are shown in Figure 7.

Sedimentologically the mouth area of the Eerste River consists of





F A L S E B A Y

**FIG.5:** The Estuary of the Eerste River, 11 May and 7 June 1982 (basic plan : Aerial photograph, Job 326, Photo No. 361/3 of 21 April 1979 )

three zones. A relatively flat foreshore of fine sand, as described by Glass (1980), fronts a relatively steep intertidal beach face of coarse sand, while a flat or landward sloping backshore of medium sand contains the lagoon. The sand at the bottom of the lagoon is overlain by grey mud indicating some siltation from the river bed further upstream.

### 3.2.2 Mouth Dynamics

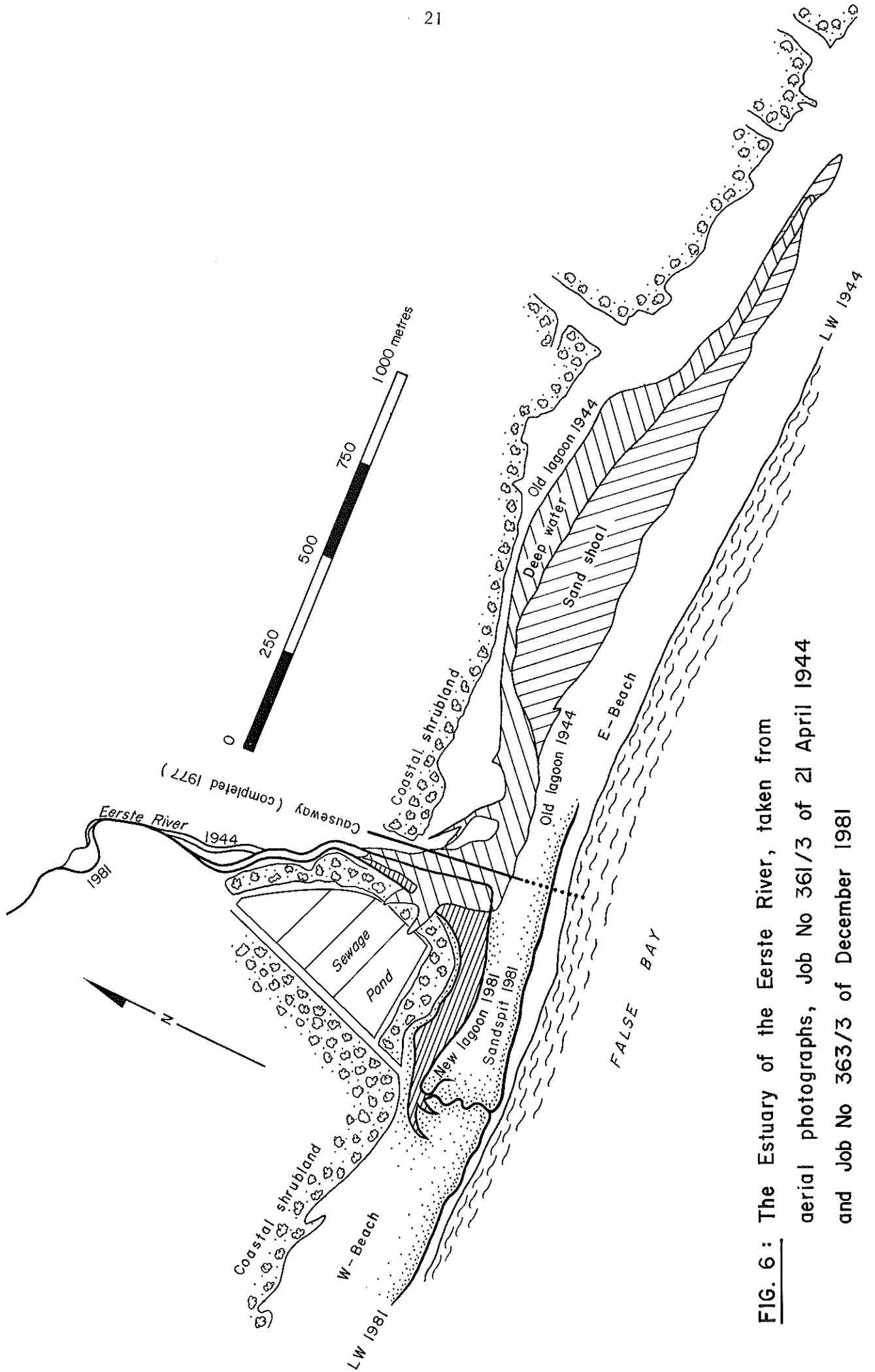
According to Glass (1980) the mouth of the Eerste River becomes closed during summer and breaks open after the first winter rains in about May. At present the mouth appears to remain open most of the year. A record of aerial photographs from 1938 to 1981 shows considerable variation in the extent and configuration of the lagoon. In 1938 there was a weakly developed western lagoon arising from channels in the area of the present sewage works and an extensive eastern lagoon (>2 500 m long and 250 m wide) opening to the sea at its eastern end. By 1944 the eastern lagoon had shrunk to a length of 1 800 m. By 1953 a western lagoon, 400 m long, had developed and the eastern arm had apparently dried up. In 1979, after the eastern arm had been cut off by the construction of the causeway in 1977, the western arm became a deep-water lagoon 650 m long and a 100 m wide opening at the western end. It is apparent that the estuary may take many forms from a more widened outlet channel to a lagoon several hectares in extent, held by a wind-and wave-built sandbar. The mouth may be greatly out of alignment with the river or may be closed entirely except at high spring tide (Harrison, 1978).

The dynamics of the Eerste River mouth are governed by seasonal variations in river flow and wave energy. The incidence of relatively high wave energy causes the build-up of a high beach bar.

The beach bar causes deviation of the river where, in the slack of the backshore area, a "backshore lagoon" is formed. The lagoon breaches the bar during the winter rains at a site where the bar is low. Strong meandering of this overflow channel indicates a rather attenuated pattern of discharge (see Figure 5).

Wave data covering a 20-year period on wave direction, height and period (Swart and Serdyn, 1982) and wave refraction diagrams for False Bay (Valsbaai Strandverbeteringe, 1980) were used to compute the *total inshore wave energy* and the *average energy - wave height* at each river mouth studied for the series of ECRU Part II reports on False Bay. Rossouw (1982) and Shipley (1964) include additional wave data.

It was found that the inshore wave energy for the Eerste River mouth was 10 percent above the mean calculated for the ten river mouths around False Bay. The average energy-wave height was 0,99 m, which represents a medium energy beach.



**FIG. 6:** The Estuary of the Eerste River, taken from aerial photographs, Job No 361/3 of 21 April 1944 and Job No 363/3 of December 1981

A predominantly west-bound nearshore current prevails (Glass, 1980; Harris, 1978). Coarse sand from the outflow channel was found to be deposited more to the west than to the east of the mouth.

#### *Tidal range*

The tidal range between Mean Low Water Spring and Mean High Water Spring in False Bay is approximately 1,48 m (South African Tide Tables, 1979).

#### 3.2.3 Land Ownership

The estuary lies in a State-owned beach area which in terms of the Sea Shore Act and the 'Admiralty reserve' legislation are administered by the Department of Community Development, Land Affairs Branch.

The area east of the estuary is owned by Kentron and is a Restricted Area, as is the channel of the estuary north of the Kentron boundary fence on the West bank. Access to this area is restricted by virtue of an order issued by the Minister of Defence in terms of the provisions of sub section (1) of section 89 of the Defence Act, 1957 (Act No 44 of 1957) as amended. In 1982 it was announced that the lagoon and beach area would also be fenced and included in the Restricted Area (Kentron security officer, pers. comm.).

The area west of the estuary is occupied by the Macassar Sewage Works which is owned and administered jointly by the Municipalities of Strand and Somerset West.

The Macassar township which is an Asiatic residential area lies to the north-west of the estuary beyond the limits of the estuarine area.

Provincial beacons were not apparent but were reported by Harrison (1978) to be present. Provincial Proclamation No 162 of 1958 provides for the establishment of these beacons.

#### 3.2.4 Obstructions

A high concrete bridge crosses the Eerste River 3 km from the mouth carrying the road to the Macassar Sewage Works, but this has sufficient clearance for minimal obstruction of flood waters. This bridge is beyond the observed limit of tidal penetration. A small temporary wooden bridge crosses the estuary channel near the observed tidal limit 1,5 km from the mouth. This temporary crossing would be carried away by any major flood and is thus not an obstruction. Outcrops of rock of the Malmesbury group near the sewage outfall in the channel are a natural obstruction and collect driftwood. A short section of fence on the west bank of the estuary 900 m from the mouth at the boundary of the Kentron controlled area had flood debris adhering to it indicating some degree of obstruction. The Kentron boundary fence, embankment

and road causeway on the east side of the estuary are a complete obstruction totally isolating the wetland area which was formerly the eastern area of the estuary. The Macassar Sewage Works has been constructed in part of the original estuarine flood plain and the 1938 air photograph indicates old distributary channels in that area (Job No 126 38 of 1938).

### 3.2.5 Physico-chemical Characteristics

Surface temperatures ranged from 10°C in June to 26°C in December. In June 1982 surface temperatures ranged from 10°C to 14°C. A maximum of 26,0°C was recorded in December 1981 (Bartlett and Hennig, 1982). During sampling in December 1981 temperatures ranged from 19°C at the mouth to 26°C in the sheltered reaches near the Kentron factory where the bottom temperature was 19°C at 1,8 m.

Surface salinities in winter were 0 parts per thousand throughout at LWST on 82-06-07 with river water flowing out strongly. At HWST waves were flooding over the sandbar and salinities ranged from 22 parts per thousand in the mouth to 1 part per thousand at the surface 350 m upstream. The salinity in the surf 100 m west of the mouth was reduced to 25 parts per thousand. On 24 June 1982 a surface salinity of 7 parts per thousand was measured 350 m from the mouth and 2 parts per thousand 600 m from the mouth.

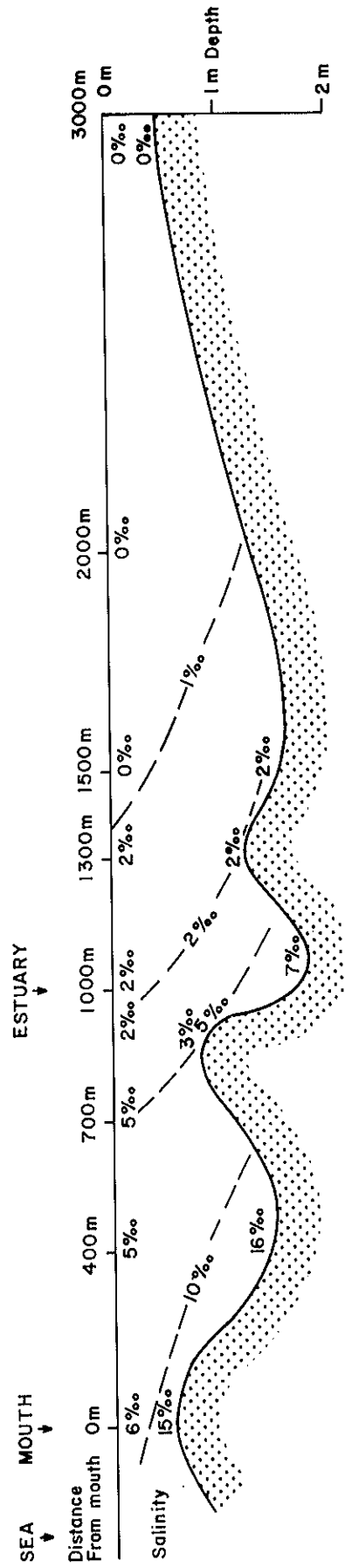
In summer when the river flow is reduced, if the mouth is open, the estuary may show substantial tidal penetration. On 1 December 1981 surface salinities ranged from 6 parts per thousand in the mouth to 0 parts per thousand at the Kentron footbridge 1 500 m from the mouth. Bottom salinities ranged from 15 parts per thousand in the mouth to 2 parts per thousand at 1,6 m depth at the footbridge while a salinity of 16 parts per thousand appeared on the bottom of the lagoon area at 1,5 m depth. The salt wedge pattern of isohalines is illustrated in Figure 7. When the mouth is closed by a sandbar in summer the estuary may become hypersaline as reported in December, 1958 (Harrison, 1978). The tidal range 600 m from the mouth of the estuary was 50 cm on 1 December 1981 and 45 cm on 7 June 1982.

Dissolved oxygen concentrations in summer (1 December 1981) ranged from 6,8 ppm to 10,8 ppm in the surface water of the estuary. In bottom water, values ranged from 4,0 ppm to 8,5 ppm. Dissolved oxygen concentrations at the sewage outfall in the estuary were 9,4 ppm on the surface and 8,5 ppm on the bottom. Dissolved oxygen concentrations in winter (24 June 1982) ranged from 8,5 ppm to 10,4 ppm.

Water transparency measured by Secchi disc ranged from 0,75 m in the lagoon area to 0,30 m in the upper reaches of the estuary.

Chemical analysis by the Marine Chemistry Division of NRIO during pollution monitoring surveys of the Eerste River estuary gave the

FIG. 7: Hydrological section of Eerste River Estuary on 1 December 1981.



following range of values for surface waters:

pH	8,0 to 8,7	(the latter at the sewage outfall)
Oxygen absorbed	0,006 to 0,011	mg/g
Salinity	0,7 parts per thousand upstream to 36,75 parts per thousand	(the latter at the mouth)
Dissolved Oxygen	4,66 to 9,90	mg/ℓ (the latter at the sewage outfall)
Ammonia	18,63 - 19,19	μmol/ℓ
Nitrite	0,60 - 11,35	μmol/ℓ (the latter at the sewage outfall)
Nitrate	15,38 - 1 490,97	μmol/ℓ (the latter at the sewage outfall)
Phosphate	1,00 - 285,61	μmol/ℓ (the latter at the sewage outfall)
Silicate	3,11 - 184,12	μmol/ℓ (the latter at the sewage outfall)

(Bartlett and Hennig, 1982).

The following ranges of dissolved organic carbon concentrations were recorded:

Total carbon	25,1 - 33,3	mg/ℓ
Inorganic carbon	13,0 - 27,2	mg/ℓ
Organic carbon	2,3 - 12,1	mg/ℓ

(Bartlett and Hennig, 1982).

Details of all values including interstitial and sediment core samples and their effects on meiofauna are given by Bartlett and Hennig (1982). Biochemical and bacteriological information regarding the operation of the Macassar Sewage Works is maintained by International Consulting and Laboratory Services (ICLS) in Cape Town.

Details of physico-chemical conditions in the Eerste River beyond the estuary (north of the National Road) are given by King (1981), Steer (1964, 1965, 1966), Water Affairs (1982) and Ninham Shand (1979).

### 3.2.6 Pollution

The Eerste River estuary receives treated sewage effluent directly from the adjacent Macassar Works serving Somerset West and Strand as well as indirectly from the sewage works upstream on the Eerste and Kuils Rivers. Effluents from various industries including wineries are also discharged at times. Data regarding the degree of pollution of the waters of the Eerste and Kuils Rivers which enter the estuary have been presented in Section 3.1.6. The results of pollution monitoring surveys of the Eerste River estuary have been published by Bartlett and Hennig (1982). Studies of the pollution of the river waters which enter the estuary indicate the presence of oil, fats and soap as well as of various nutrients. Pesticides and herbicides must almost certainly be present in the river water draining from this agriculture area. The range of metal concentrations recorded by Bartlett and Hennig (1982) are as follows: (Figures represent the nitric-perchloric acid leachable concentration of

metals in the <1 mm fraction of the sediments, µg/g dry mass.)

Cd	0,04 - 0,05
Cu	0,16 - 0,34
Fe	521 - 613
Mn	4,8 - 6,5
Ni	all less than 1,0
Pb	0,67 - 1,15
Zn	1,12 - 1,69

The discharge of polluted water into False Bay has been noted by Cloete (1979) and Gasson (1980).

In February 1959 all fish life in the estuary was destroyed by pollution at a time when the river was completely dry. Freshwater flow was restored in April but bad winery and distillery pollution "in flagrant defiance of the law" discoloured the water of the estuary (Harrison, 1978).

### 3.2.7 Public Health Aspects (Bacteriology, etc.)

Bacteriological investigations of the estuary have been carried out irregularly by the Department of Health (Oelofse, pers. comm.). Bacteriological investigations in the waters of the Eerste and Kuils Rivers which enter the estuary have been reported by Steer (1964, 1965, 1966), Ninham Shand (1979) and Water Affairs (1982) and have been mentioned in Section 3.1.6 of this report.

## 4. BIOTIC CHARACTERISTICS

### 4.1 Flora

*(This section has been largely contributed by Mr M O'Callaghan of the Botanical Research Institute.)*

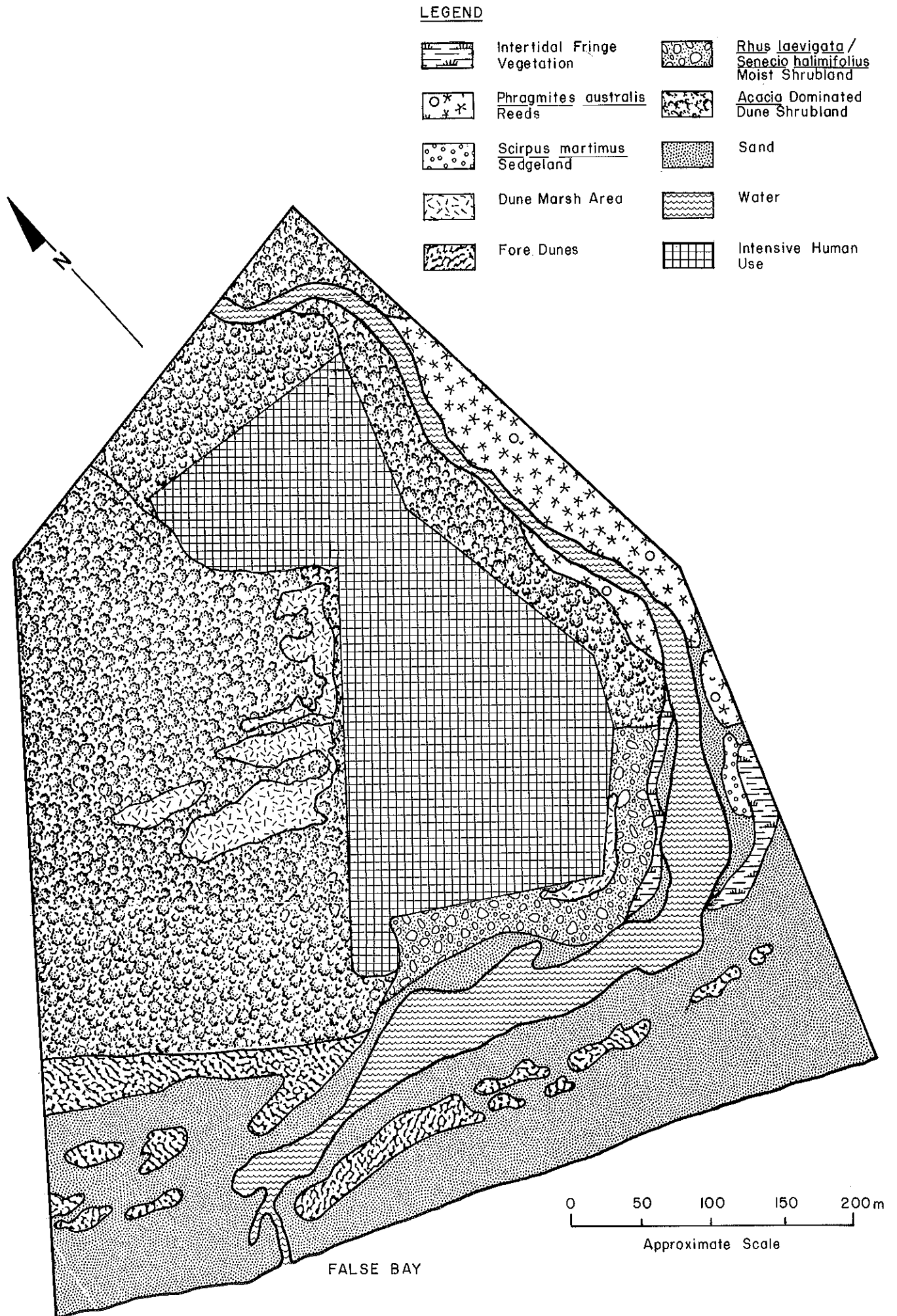
The general configuration of the Eerste River estuary is shown in Figure 4. Figure 8 shows the spatial distribution of the semi-aquatic and terrestrial vegetation mapping units while Appendix I shows some of the species and physical features of each unit, as established during the ECRU surveys of December 1981 and June 1982.

#### 4.1.1 Phytoplankton/Diatoms

A thin scum of diatoms and blue-green algae was apparent on the northern bank of the estuary in December 1981. A small diatom bloom is apparent in the estuary opposite the sewage outfall in the coloured aerial photograph of 21 April 1979 (Job No 326 Photo no 362/3). High nutrient levels resulting from sewage effluent discharge and polluted river inflow favour eutrophication. Water transparency in the lagoon is greater than in the upper estuary, presumably because of tidal exchange (see Section 3.2.5).



FIG. 8: Vegetation mapping units recognised at the Eerste River Estuary.



## 4.1.2 Algae

Macro-algae washed up on the beach adjoining the mouth include *Ecklonia maxima*, *Gigartina radula* and fragments of several species of red algae.

Within the estuary *Enteromorpha* and *Cladophora* were recorded and fragments of *Ulva* were obtained in D-net drags. Filamentous algae were not abundant or prominent in this estuary during our visits.

## 4.1.3 Aquatic Vegetation

No aquatic angiosperms were found in the estuary.

## 4.1.4 Semi-aquatic Vegetation

- (a) Inter-tidal Fringe Vegetation: Along restricted areas of both banks, the inter-tidal area is fringed with *Cotula coronopifolia* (gansgras). Along the eastern bank patches of *Scirpus maritimus* are found.
- (b) *Phragmites australis* Reeds: This common reed (fluitjiesriet) lines the banks of the estuary channel with *Scirpus littoralis* in a few places.
- (c) *Scirpus maritimus* Sedgeland: An area on the east bank at supra-tidal level.
- (d) Dune Marsh Area: Adjacent to the sewage works marshy areas are present with *Paspalum vaginatum* (an alien grass), *Typha capensis* (bulrush) and numerous European weeds.

## 4.1.5 Terrestrial Vegetation

- (a) Fore Dunes: The hummock dunes to the west of the river have a sparse covering of *Eragrostis cyperoides* (steekriet) and *Tetragonia decumbens* (klappiesbrak). Numerous herbs and shrubs, such as *Heteroptilis suffruticosa* and *Chrysanthemoides monilifera* are also present. To the east of the mouth, *Agropyron distichum* (sea wheat) dominates with *Arctotheca populifolia* (sea pumpkin), *Senecio elegans* and other dune plants.
- (b) *Rhus laevigata*/*Senecio halimifolius* Moist Shrubland: This area includes *Acacia cyclops* (rooikrans) and is allied to the *Acacia* dominated dune shrubland. The soil is moister, particularly in winter. Shrubs such as *Senecio halimifolius* (tabakbos), *Rhus laevigata* and *Atriplex vestita* (saltbush) are found here.
- (c) *Acacia* Dominated Dune Shrubland: On the seaward side of this vegetation it merges with the fore dune vegetation. Further inland dune shrubs such as *Pelargonium capitatum*, *Rhus laevigata* (duine taaibos), *Metalsia muricata* (blombos) and others become evident. In the open areas (*Ehreharta villosa* (pypgras) is prevalent. Further north a fine leaved

sclerophyllous open scrub with broader leaved shrubs such as *Rhus* species and *Euclea racemosa* (bos gwarrie) is found. *Sideroxylon inerme* (melkhout) is present near the river. The vegetation of this area is infested with aliens, especially *Acacia cyclops* (rooikrans) while *Acacia saligna* (Port Jackson) predominates along the west bank of the river.

Degradation of the vegetation has been caused mainly by the encroachment of alien plants, grazing and trampling. Some of the larger shrubs and trees have been removed by the residents of the nearby housing scheme for fuel, as apparently coal cannot be used in these tenements. Unfortunately the use of natural wood for fuel is favoured above that of the alien *Acacias*.

The dune fynbos on limestone outcrops at the northern end of Figure 8 was not studied during this investigation. It is recommended that a detailed study of this area be undertaken as this vegetation type is becoming increasingly rare on the Cape Flats.

Details of the vegetation studied are given in Appendix I.

## 4.2 Fauna

### 4.2.1 Zooplankton

Zooplankton samples were taken on 1 December 1981 in the widest part of the lagoon (about 200 m from the mouth, and in the upper reaches from the Kentron footbridge (about 1 400 m from the mouth). The zooplankton was very sparse in both areas. The plankton was dominated by Harpacticoid Copepoda and Ostracoda in both areas. There were three species of Harpacticoids including ovigerous females of one species. Post larval fish (*Liza richardsoni*) were present.

### 4.2.2 Aquatic Invertebrates

#### (a) Hard substrata

There was no invertebrate fauna on hard substrata in the estuary. Even the common estuarine tubeworm *Picopomatus enigmatica* did not appear to be present.

#### (b) Soft substrata

Specimens of the crown crab, *Hymenosoma orbiculare*, and the shrimp, *Palaemon pacificus*, occur in small numbers in the estuary. One specimen of *Palaemon* was heavily parasitized. Considerable numbers of the sand prawn, *Callinassa kraussi*, burrow in the sand of the estuary. No burrows were present adjoining the mouth but up to 15/m<sup>2</sup> were found on the banks of the lagoon and up to 74/m<sup>2</sup> in the back waters left by old meanders of the mouth channel. C Gaigher (pers. comm.) recorded 60 - 80/m<sup>2</sup> with 5 specimens per 20 holes near the mouth. Mud banks in the estuary include chironomid larvae and oligochaete worms 1 - 2 mm in length. Meiofauna present in the sand include Nematoda, Harpacticoid Copepoda,

Flatworms, Polychaeta, Oligochaeta and others and counts are tabulated in Bartlett and Hennig (1982). On the sandy beach outside the mouth the shells of the following Mollusca indicated their presence in the area.

*Choromytilus meridionalis* Kr  
*Crassostrea margaritacea* Lam.  
*Donax serra* Roding  
*Perma perna* Linn.  
*Sepia (Hemisepia) typica* (Steenstrup)  
*Schizodesma spengleri* Linn.  
*Tellina alfredensis* Bartsch  
*Venus verrucosa* Linn.

(c) On vegetation

No data.

4.2.3 Insects

Insects collected included chironomid midges and their larvae, dragonflies, kelp flies, staphylinid beetles, other beetles, house flies, water boatmen, ceratopogonid larvae and dead may-fly nymphs.

4.2.4 Other Invertebrates

Specimens of the millipede, *Archilulus moreleti* (Lucas) were found under stones at the HWST level. Their habitat was wet and it appears that this introduced Palaearctic species is capable of adapting itself to a number of different types of habitat (Dr RF Lawrence, of Port Alfred, pers. comm.). Two species of spiders were collected on the banks of the estuary. The introduced garden snail, *Helix aspersa*, occurs on bank vegetation and the indigenous snail, *Trigonephrus* sp. (Connolly, 1939), is common on *Tetragonia fruticosa* and other dune plants at the estuary.

4.2.5 Fish

Several species of fish occur in the estuary. A gill net set for 2 hours in daylight on 82-12-04 caught 33 specimens of *Liza richardsoni* (Smith) between 202 mm and 302 mm in length. A few drags with a D-net caught 36 Knysna sand gobies, *Psammogobius knysnaensis* (Smith), 1 small sole, *Heteromycteris capensis* (Kaup), some juvenile and post-larval stages of *L. richardsoni* between 20 mm and 65 mm and some crustaceans. Leervis, *Lichia amia* (Linnaeus) are caught in the estuary occasionally (S Krohn of Somerset West, pers. comm.). Shoals of several hundred juvenile *L. richardsoni* frequent the sewage outfall in the upper estuary.

Sea-run rainbow trout have been recorded in the Eerste River estuary on a number of occasions and it was suggested that the estuary is habitable by trout even in the worst of summer droughts (Harrison, 1958 rev. 1978). It was postulated that many high-conditioned silvery rainbows repopulated the lower reaches

of the river, which were dry during summer droughts, after the first autumn rains. Trout in the upper reaches become dark and lose condition in summer (Harrison, 1958 rev. 1978). A trout was first reported in False Bay by Gilchrist (1904). An article on the migration of trout in the rivers of False Bay was published by Harrison and Hey (1947). Appendix II gives a list of the fish recorded.

#### 4.2.6 Amphibians and Reptiles

Mole snakes, *Pseudapsis cana*, were observed on two occasions. Appendices III and IV give a list of the amphibians and reptiles recorded for the area. Records are from Poynton (1964), Greig and Burdett (1976), FitzSimmons (1943 and 1962) and unpublished records from the Cape Department of Nature and Environmental Conservation. Endangered species according to McLachlan (1978) are indicated.

#### 4.2.7 Birds

Appendix V lists the species recorded at the estuary and the adjoining sewage works during the ECRU investigations on 81-12-02 and 82-06-24 and the waders (Charadrii) and other birds at the Eerste lagoon on 76-02-04 as recorded by the Wader Study Group (Summers *et al.*, 1976; Underhill and Cooper, 1982).

#### 4.2.8 Mammals

The spoor of a Grysbok, *Raphicercus melanotis*, was observed on the banks of the estuary by T Heinecken on 82-06-24. Numerous burrows of rodents appear in the screenings tip of the sewage works adjoining the estuary. The spoor of the Cape clawless otter, *Aonyx capensis*, and the water mongoose, *Atilax paludinosus*, appear on the banks of the estuary. The Cape dune mole-rat, *Bathyergerus suillus*, is common and its burrow heaps are prominent around the estuary.

Appendix VI gives a list of the mammals recorded as being present in the area (Stuart *et al.*, 1980). Rare and threatened species are indicated (Meester, 1976, and Skinner *et al.*, 1977).

### 5. SYNTHESIS

The Eerste River estuary is not large or important, but the Eerste River and its major tributary the Kuils River serve important agricultural, industrial, urban and conservation areas. This river system thus has a significance much greater than might be expected from a consideration of its small and poorly developed estuary. Little is known about the estuary itself. It was omitted by Noble and Hemens (1978) in their list of South African estuaries and is not described by Day (1981) in his book on estuaries. By contrast there is an extensive literature on the catchment area of this river system and the rivers themselves, as may be seen from the list of references in this report.

The Eerste River was the first river encountered on leaving Cape Town by early settlers and agricultural and urban developments in the catchment appeared in early years. During this century the northern suburbs of Cape Town as well as Stellenbosch and Somerset West have developed rapidly, and so the Eerste and Kuils Rivers have been affected correspondingly. Changed patterns of run-off, physical modification and various forms of pollution have had marked impacts on these rivers. Both the Eerste River and the Kuils River are severely polluted today. There has been substantial public concern about the condition of these rivers and various pollution investigations have been and are being carried out. A wide range of industrial pollutants are involved but sewage pollution resulting in increased nutrient levels has been most intensively studied. In this report only a summary of the findings, indicating the ranges of values recorded, is presented. It is regrettable that the Eerste River system is so polluted today as its headwaters lie in mountain catchment areas controlled by the Department of Environment Affairs so that the water is of perfect quality above Stellenbosch.

A remarkable degradation of water quality has taken place in recent years starting in 1942 with the establishment of small industries in Stellenbosch (D Hey, School of Environmental Studies, U.C.T. pers. comm.). The river has a poor natural summer flow which over the years has become aggravated by water usage including summer irrigation. Today this is compounded by the discharge of effluents and drains into the diminished flow so that at times most of the flow of both the Eerste and the Kuils is made up of such discharges. However good the quality of sewage effluent discharges, they inevitably have a major impact on the natural ecology of the river. The volume of effluents will inevitably increase so that it is important that control of their quality be rigidly enforced.

In recent years the Eerste River has been largely dependent on the regular occurrence of winter spates (King, 1981). The Kleinplaas Dam in Jonkershoek will not necessarily limit such winter spates but this rejuvenating factor will be reduced unless carefully planned discharges are released. The dam will provide a means to establish an increased summer flow and will provide compensation water. However, regular flow alone will not rectify the problems.

In the 1940 s protective legislation was introduced against pollution, which was the first of its kind in South Africa, and a number of cases were instituted against industrial concerns. However, although the prosecutions were successful the polluters were either cautioned or discharged or some minimal fine imposed (D Hey, pers. comm.).

Concern about the condition of the river is now widespread. This was, for example, expressed at a meeting of riparian owners and authorities in 1981, during which positive action including a multidisciplinary study was requested. Appropriate recommendations

for future management and control of this river system are required. The waste waters of the Kuils River deserve similar consideration. The effluent discharges and the river water itself might be used for industrial processes or for irrigation where high nutrient levels would not be a problem. However, if the water is used to recharge the Cape Flats aquifer or for direct augmentation of urban water supplies, different quality standards will have to be enforced. Ninham Shand (1979) recommended that studies be undertaken of various aspects of the discharge of nutrients into the Kuils River. The studies should include their ecological effects, the costs involved in reducing nutrient discharge, the possible alternative uses of the water and the possibility of a direct sea outfall.

Pollution is not the only problem resulting from catchment development, and increased run-off from paved surfaces and roofs has together with effluent discharges, greatly increased flow particularly in the Kuils River (Ninham Shand, 1979). This has led to almost permanent flooding of the Kuils River swamps which were in the past only seasonally flooded (J Faure, local farmer, pers. comm.). This is further aggravated by the introduction of water from various other catchments through water supplies from Steenbras, Wemmershoek, Vogelvlei and Theewaterskloof systems. Complex legal problems have resulted as local authorities might be held responsible for flood damage caused by water derived from other catchments.

The swamp and vlei areas in the lower reaches of the Kuils River are ecologically important wetlands which should be conserved as a nature reserve. This area is one of the few remaining marshland swamp systems in the Western Province. The main area involved is on the south side of the N2 Freeway upstream of the Strandfontein Road, but there are some areas north of the freeway where the marshes extend upstream and broaden out to form the Nooiensfontein Vlei. There is a rich aquatic vegetation, and more than eighty-six species of aquatic and semi-aquatic birds have been identified in this area. Recommendations including botanical and ornithological reports on the area are included as appendices in the report by Ninham Shand (1979). The possible importance of this marsh area in reducing the concentrations of pollutants entering from the Kuils River has been indicated in the pollution section of this report. Marsh plants can play a valuable role in taking up unwanted nutrients.

Water Hyacinth *Eichhornia crassipes* is found in almost all of the lower reaches of the Kuils and Eerste Rivers. The Hyacinth thrives on the nutrients in sewage effluent and tends to block waterways, thereby aggravating the flooding potential. The parrot's feather *Myriophyllum aquaticum* has also become a problem covering large areas of water in the lower reaches of Kuils River. It has been recommended that the control of these aquatic weeds be referred to the Department of Nature and Environmental Conservation of the CPA for specialist study (Ninham Shand, 1979).

Geomorphologically the estuary of the Eerste River is interesting. The river does not flow directly to the sea because of a wave-built sand bar blocking the river at the beach. Formerly the river formed a fairly extensive marsh behind the bar. The prolonged nature of this stoppage was indicated by the depth of black alluvium which has accumulated. The river was braided and choked and its course was progressively shifted by dunes (Beekhuis *et al.*, 1945). The Macassar Sewage Works is now established in the western part of the estuarine marsh, while the eastern arm of the marsh is cut off by a causeway and the Kentron boundary fence. The sewage works and maturation ponds are several metres above river level and should be safe from flooding, but the low-lying Kentron marsh area to the east is liable to be flooded. The geomorphology of the Kuils River is particularly interesting, as some early maps show the river discharging directly into False Bay, while today it is a tributary of the Eerste.

Although pollution monitoring results indicate substantially increased nutrient levels in the estuary, the limited diversity and abundance of plankton, benthic invertebrates and meiofauna suggest that there are other causes of faunal mortality. It has been suggested that periodic discharges of industrial and organic effluents have had a severe impact on sensitive fauna (Bartlett and Hennig, 1982).

Despite its small size and polluted condition the Eerste River estuary is an attractive area which supports a notable range and number of aquatic birds and, at least in the past, also sea-run rainbow trout (Harrison, 1958). It is regrettable that it has now become inaccessible to the public particularly in view of the fact that both the Lourens River Estuary and the Rooiels Estuary on the eastern side of False Bay have also been closed by security fencing. It is desirable that pollution control be improved and that the public be allowed access to this estuary.

6.

#### ACKNOWLEDGEMENTS

Thanks are due to the following persons, institutions and organizations for the data, information and assistance they supplied during the preparation of this report:

Mr A Oelofse of Strand Municipality, Mr S Krohn of Somerset West, Mr Vos and Mr Van Noordwyk of Kentron, Mr Mokke of Macassar Sewage Works, Dr RF Lawrence of Port Alfred, Mrs J King of the University of Cape Town, Dr J Lusher of the Directorate of Water Affairs, Messrs R Boycott and AL de Villiers of the Cape Department of Nature and Environmental Conservation and Mr J Cooper of the FitzPatrick Institute of African Ornithology.

As the collection of data for this report was essentially a team effort the assistance of all members of ECRU is acknowledged.

The survey was carried out at the request of the Department of Environment Affairs. The encouragement of this Department, the Steering Committee for Estuarine and Coastal Research and the SA National Committee for Oceanographic Research is gratefully acknowledged.



7. GLOSSARY OF TERMS USED IN PART II REPORTS

- abiotic: non-living (characteristics).
- aeolian (deposits): materials transported and laid down on the earth's surface by wind.
- alien: plants or animals introduced from one environment to another, where they had not occurred previously.
- alluvium: unconsolidated fragmental material laid down by a river or stream as a cone or fan, in its bed, on its floodplain and in lakes or estuaries, usually comprised of silt, sand or gravel.
- anaerobic: lacking or devoid of oxygen.
- anoxic: the condition of not having enough oxygen.
- aquatic: growing or living in or upon water.
- arcuate: curved symmetrically like a bow.
- barchanoid (dune): crescent-shaped and moving forward continually, the horns of the crescent pointing downwind.
- bathymetry: measurement of depth of a water body.
- benthic: bottom-living.
- berm: a natural or artificially constructed narrow terrace, shelf or ledge of sediment.
- bimodal: having two peaks.
- biogenic: originating from living organisms.
- biomass: a quantitative estimation of the total weight of living material found in a particular area or volume.
- biome: major ecological regions (life zones) identified by the type of vegetation in a landscape.
- biotic: living (characteristics).
- breaching: making a gap or breaking through (a sandbar).
- calcareous: containing an appreciable proportion of calcium carbonate.
- calcrete: a sedimentary deposit derived from coarse fragments of other rocks cemented by calcium carbonate.
- Chart Datum: This is the datum of soundings on the latest edition of the largest scale navigational chart of the area. It is -0,900 m relative to land levelling datum which is commonly called Mean Sea Level by most land surveyors.
- coliforms: members of a particularly large, widespread group of bacteria normally present in the gastro-intestinal tract.
- community: a well defined assemblage of plants and/or animals clearly distinguishable from other such assemblages.
- conglomerate: a rock composed of rounded, waterworn pebbles 'cemented' in a matrix of calcium carbonate, silica or iron oxide.
- culsp: a sand spit or beach ridge usually at right angles to the beach formed by sets of constructive waves.
- "D" net: a small net attached to a "D" shaped frame riding on skids and pulled along the bottom of the estuary, used for sampling animals on or near the bottom.
- detritus: organic debris from decomposing plants and animals.
- diatoms: a class of algae with distinct pigments and siliceous cell walls. They are important components of phytoplankton.
- dynamic: relating to ongoing and natural change.
- ecology: the study of the structure and functions of ecosystems, particularly the dynamic co-evolutionary relationships of organisms, communities and habitats.
- ecosystem: an interacting and interdependent natural system of organisms, biotic communities and their habitats.
- eddies: a movement of a fluid substance, particularly air or water, within a larger body of that substance.
- endemic: confined to and evolved under the unique conditions of a particular region or site and found nowhere else in the world.
- enon: most striking formation in the Cape. Crammed with pebbles and boulders, phenomenally embedded and massive, yellow or brilliantly red in colour, producing remarkable hills. Curiously carved into crags and hollows.

- epifauna: animal life found on the surface of any substrate such as plants, rocks or even other animals.
- epiphyte: a plant living on the surface of another plant without deriving water or nourishment from it.
- episodic: sporadic and tending to be extreme.
- estuary: a partially enclosed coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage (Day 1981).
- eutrophication: the process by which a body of water is greatly enriched by the natural or artificial addition of nutrients. This may result in both beneficial (increased productivity) and adverse effects (smothering by dominant plant types).
- flocculation (as used in these reports): the settlement or coagulation of river borne silt particles when they come in contact with sea water.
- fluvial (deposits): originating from rivers.
- food web: a chain of organisms through which energy is transferred. Each "link" in a chain feeds on and obtains energy from the preceding one.
- fynbos: literally fine-leaved heath-shrub. Heathlands of the south and south-western Cape of Africa.
- geomorphology: the study of land form or topography.
- gill net: a vertically placed net left in the water into which fish swim and become enmeshed, usually behind the gills.
- habitat: area or natural environment in which the requirements of a specific animal or plant are met.
- halophytes: plants which can tolerate salty conditions.
- HAT (Highest Astronomical Tide) and LAT (Lowest Astronomical Tide):  
HAT and LAT are the highest and lowest levels respectively, which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions; these levels will not be reached every year. HAT and LAT are not the extreme levels which can be reached, as storm surges may cause considerably higher and lower levels to occur (South African Tide Tables 1980).
- hummock (dune): a low rounded hillock or mound of sand.
- hydrography: the description, surveying and charting of oceans, seas and coastlines together with the study of water masses (flow, floods, tides etc.).
- hydrology: the study of water, including its physical characteristics, distribution and movement.
- indigenous: belonging to the locality; not imported.
- intertidal: generally the area which is inundated during high tides and exposed during low tides.
- isohyets: lines on maps connecting points having equal amounts of rainfall.
- isotherms: lines on maps joining places having the same temperature at a particular instant, or having the same average, extremes or ranges of temperature over a certain period.
- lagoon: an expanse of sheltered, tranquil water. (Thus Langebaan lagoon is a sheltered arm of the sea with a normal marine salinity; Knysna lagoon is an expanded part of a normal estuary and Hermanus lagoon is a temporarily closed estuary (Day 1981)).
- limpid: clear or transparent.
- littoral: applied generally to the seashore. Used more specifically it is the zone between high- and low-water marks.
- longshore drift: a drift of material along a beach as a result of waves breaking at an angle.

- macrophyte: any large plant as opposed to small ones. Aquatic macrophytes may float at the surface or be submerged and/or rooted on the bottom.
- marls: crumbly mixture of clay, sand and limestone, usually with shell fragments.
- matrix: medium in which a structure is embedded.
- meiofauna: microscopic or semi-microscopic animals that inhabit sediments but live quite independently of the macrofauna, or benthos.
- metamorphic: changes brought about in rocks within the earth's crust by the agencies of heat, pressure and chemically active substances.
- MHWS (Mean High Water Springs) and MLWS (Mean Low Water Springs): the height of MHWS is the average, throughout a year when the average maximum declination of the moon is  $23^\circ$ , of the height of two successive high waters during those periods of 24 hours (approximately once a fortnight) when the range of the tide is greatest. The height of MLWS is the average height obtained by the two successive low waters during the same periods (South African Tide Tables 1980).
- morphometry: physical dimensions such as shape, depth, width, length etc.
- osmoregulation: the regulation in animals of the osmotic pressure in the body by controlling the amount of water and/or salts in the body.
- pathogenic: disease producing.
- photosynthesis: the synthesis of carbohydrates in green plants from carbon dioxide and water, using sunlight energy.
- phytoplankton: plant components of plankton.
- piscivorous: fish eating.
- plankton: microscopic animals and plants which float or drift passively in the water.
- quartzite: rock composed almost entirely of quartz recemented by silicon. Quartzite is hard, resistant and impermeable.
- riparian: adjacent to or living on the banks of rivers, streams or lakes.
- rip current: the return flow of water which has been piled up on the shore by waves, especially when they break obliquely across a longshore current.
- salinity: the proportion of salts in pure water, in parts per thousand by mass. The mean figure for the sea is 34,5 parts per thousand, written  $34,5\text{‰}$ .
- secchi disc: a simple instrument used to measure the transparency of water.
- sheet flow: water flowing in thin continuous sheets rather than concentrated into individual channels.
- slipface: the sheltered leeward side of a sand-dune, steeper than the windward side.
- teleost: modern day bony fishes (as distinct from cartilaginous fishes).
- trophic level: a division of a food chain defined by the method of obtaining food either as primary producers, or as primary, secondary or tertiary consumers.
- trough: a crescent shaped section of beach between two cusps.
- wetlands: areas that are inundated or saturated by surface or ground water frequently enough to support vegetation adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.
- zooplankton: animal components of plankton.

8.

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#### Maps

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#### Aerial Photographs

- {EERSTE ESTUARY} Bl. & Wh. Job No. 126, Photo No. 11697, Trig. Survey, Mowbray. 1:25 000, 1938.
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- {EERSTE ESTUARY} Bl. & Wh. Job No. 374, Photo No. 258, Dept. Land Surveying, Univ. of Natal. 1:20 000, 1980.
- {EERSTE ESTUARY} Col. Job No. 391, Photo No. 363/3, Dept. Land Surveying, Univ. of Natal. 1:20 000, 1981.



APPENDIX I: Physical features and species of the vegetation mapping units recognized at the Eerste River Estuary.

Mapping Unit	Area <sup>+</sup> (ha)	% of area studied (%)	Cover (%)	Height (m)
Intertidal Fringe Vegetation	0,29	0,95	80	0,30
<i>Phragmites australis</i> Reeds	1,27	4,14	100	3,00
<i>Scirpus maritimus</i> Sedgeland	0,09	0,29	80	0,50
Dune Marsh Area	0,58	1,89	50	0,90
Fore Dunes	2,00	6,53	5	0,30
<i>Rhus laevigata/Senecio halimifolius</i>	2,29	7,47	100	1,00
Moist Shrubland				
<i>Acacia</i> Dominated Dune Shrubland	9,40	30,41	60	3,00
Sand	6,15	20,07		
Water	2,40	7,83		
Intensive Human Use	6,17	20,14		
Total	30,64			

(<sup>+</sup>Estimated values)

Intertidal Fringe Vegetation

*Cotula coronopifolia* (1); *Paspalum vaginatum* (+); *Scirpus nodosus* (+).

*Phragmites australis* Reeds

*Phragmites australis* (5).

*Scirpus maritimus* Sedgeland

*Scirpus maritimus* (5).

Dune Marsh Area

*Cotula coronopifolia* (1); *Juncus dregeanus* (1); *Paspalum vaginatum* (1);  
*Phragmites australis* (r); *Scirpus nodosus* (+); *Typha capensis* (+);  
*Zantedeschia aethiopica* (+).

Fore Dunes

*Acacia cyclops* (+); *Agropyron distichum* (+); *Arctotheca populifolia* (+);  
*Carpobrotus acinaciformis* (+); *C. edulis* (r); *Chrysanthemoides monilifera*  
(r); *Cynodon dactylon* (+); *Eragrostis cyperoides* (1); *Heteroptilis*  
*suffruticosa* (+); *Manulea tormentosa* (+); *Metalasia muricata* (r); *Myrica*  
*cordifolia* (r); *Psoralea fruticosa* (r); *P. repens* (+); *Senecio elegans*  
(+); *Scirpus nodosus* (+); *Tetragonia decumbens* (+); *T. fruticosa* (+).

*Rhus laevigata/Senecio/halimifolius* Moist Shrubland

*Acacia cyclops* (1); *A. saligna* (+); *Atriplex vestita* (+); *Carpobrotus*

*acinaciformis* (+); *Cynodon dactylon* (+); *Ehrharta villosa* (1); *Ficinia cf dunensis* (+); *Metalasia muricata* (+); *Nidorella foetida* (+); *Paspalum vaginatum* (1); *Oxalis pes-caprae* (r); *Rhus laevigata* (+); *Senecio halimifolius* (1); *Stenotaphrum secundatum* (+).

Acacia cyclops Dune Shrubland

*Acacia cyclops* (5); *Carpobrotus acinaciformis* (1); *C. edulis* (1); *Chasmanthe aethiopica* (1); *Chrysanthemoides monilifera* (1); *Ehrharta villosa* (2); *Euclea racemosa* (1); *Galenia secunda* (+); *Knowltonia capensis*; *Metalasia muricata* (+); *Pelargonium capitatum* (1); *Pennisetum clandestinum*; *Pterocelastrus tricuspidatus* (1); *Rhus laevigata* (+); *R. glauca* (+); *Sideroxylon inerme* (r); *Tetragonia decumbens* (+); *T. fruticosa* (2); *Trachyandra divaricata* (+); *Zantedeschia aethiopica* (r).

Note: The symbols in brackets following each species name represent Braun-Blanquet Cover Classes as follows:

- r - 1/few individuals, cover less than 0,1% of area
- + - occasional plants, cover less than 1% of area
- 1 - abundant, cover 1-5% of area
- 2 - any number, cover 6-25% of area
- 3 - any number, cover 26-50% of area
- 4 - any number, cover 51-75% of area
- 5 - any number, cover 76-100% of area.

APPENDIX II

CLASS PISCES (Fish)

Southern mullet	-	<i>Liza richardsoni</i>
Estuary sole	-	<i>Heteromyeteris capensis</i> (Kaup)
Knysna Sand-goby	-	<i>Psammogobius knysnaensis</i> (Smith)
Leervis	-	<i>Lichia amia</i> (Linnaeus)
Rainbow trout	-	<i>Salmo trutta</i>

Common and scientific names from Smith (1975) and Van der Elst (1981).

APPENDIX III

CLASS AMPHIBIA (Frogs and Toads)

Common platanna;	<i>Xenopus laevis</i> : CDNC (76-07-23)
Cape ghost frog;	<i>Heleophryne purcelli</i> : Poynton (1964); Boycott (1982)
Sand toad	<i>Bufo angusticeps</i> : Poynton (1964)
Raucous toad;	<i>Bufo rangeri</i> : Poynton (1964)
Cape rain frog;	<i>Breviceps gibbosus</i> : CDNC (73-05-09)
Strawberry rain frog;	<i>Breviceps acutirostris</i> : Poynton (1964)
Cape sand frog;	<i>Tomopterna delandii</i> : Boycott ( <i>pers. obs.</i> )
Cape rana;	<i>Rana fuscigula</i> : CDNC (78-07-26)
Spotted rana;	<i>Rana grayii</i> : CDNC (73-03-31)
Cape grass frog;	<i>Rana montana</i> : Greig, Boycott and De Villiers (1979) Poynton (81-09-64)
Dainty frog;	<i>Cacosternum boettgeri</i> : CDNC (76-07-25)
Chirping frog;	<i>Arthroleptella lightfooti</i> : CDNC (73-11-01)

APPENDIX IV

## CLASS REPTILIA

## SUBORDER SERPENTES (Snakes)

Pink earth snake;	<i>Rhinotyphlops lalandei</i> : FitzSimons (1962)
Brown water snake	<i>Lycondonmorphus rufulus</i> : Boycott (pers. obs.)
Augora house snake	<i>Lamprophis aurora</i> : FitzSimons (1962)
Mole snake	<i>Pseudaspis cana</i> : FitzSimons (1962)
Russet garden snake	<i>Duberia lutrix</i> : FitzSimons (1962)
Herald snake	<i>Crotamphopeltis hotamboeia</i> : FitzSimons (1962)
Spotted Skaapsteker	<i>Psammophylax rhombeatus</i> : FitzSimons (1962)
Cross-marked sand snake	<i>Psammophis crucifer</i> : FitzSimons (1962)
Dwarf garter snake	<i>Elaps lacteus</i> : FitzSimons (1962)
Rinkals	<i>Hemachatus haemachatus</i> : FitzSimons (1962)
Cape cobra	<i>Naja nivea</i> : FitzSimons (1962)

## CLASS REPTILIA

## SUBORDER SAURIA (Lizard)

Marbled gecko	<i>Phyllodactylus prophyreus</i> : FitzSimons (1943)
Rock agama	<i>Agama atra</i> : FitzSimons (1943)
Cape spiny agama	<i>Agama hispida</i> : FitzSimons (1943)
Cape dwarf chameleon	<i>Bradypodion pumilum</i> : FitzSimons (1943)
Speckled skink	<i>Mabuya homalocephala</i> : FitzSimons (1943)
Common skink	<i>Mabuya capensis</i> : FitzSimons (1943)
Plated lizard	<i>Tetradactylus seps</i> : FitzSimons (1943)
Girdled lizard	<i>Cordylus cordylus</i> : FitzSimons (1943)

## CLASS REPTILIA

## ORDER CHELONIA (Tortoises)

Geometric tortoise	<i>Psammobates geometricus</i> : Greig and Burdett (1976)
Angulate tortoise	<i>Chersina angulata</i> : Greig and Burdett (1976)
Padloper	<i>Homopus areolatus</i> : CDNC (76-08-25)
Cape terrapin	<i>Pelomedusa subrufa</i> : CDNC (77-03-18)

APPENDIX VBirds

Roberts Number	Species	+ 76-02-04	Estuary 81-12-01	82-06-24	Sewage 81-12-01	Works 24-06-82
4	Crested Grebe	0	0	0	1	0
6	Cape Dabchick	0	0	0	5	3
47	White-breasted Cormorant	0	33	51	0	0
48	Cape Cormorant	0	2	0	0	0
50	Reed Cormorant	0	5	1	0	0

Roberts Number	Species	+ 76-02-04	Estuary 81-12-01	82-06-24	Sewage 81-12-01	Works 24-06-82
54	Grey Heron	0	1	0	0	0
59	Little Egret	0	1	1	0	0
89	Egyptian Goose	0	4	0	0	0
96	Yellow-billed Duck	0	0	0	6	4
98	Cape Teal	0	2	0	2	4
212	African Coot	0	6	0	32	8
231	Black Oystercatcher	4	2	4	0	0
233	Ringed Plover	2	0	0	0	0
235	Whited-fronted Sandplover	3	4	1	0	0
238	Treble-banded Sandplover	6	0	4	0	0
245	Blacksmith Plover	15	21	10	3	1
251	Curlew Sandplover	35	39	5	0	0
253	Little Stint	6	4	0	0	0
256	Ruff	0	1	0	0	0
262	Marsh Sandpiper	1	0	0	0	0
263	Greenshank	3	4	1	0	0
270	Stilt	0	0	2	0	0
287	Kelp Gull	0	82	3	0	0
289	Hartlaubs Gull	0	82	5	0	0
290	Caspian Tern	0	1	0	0	0
291	Common/Arctic Tern	0	8	0	0	0
296	Sandwich Tern	0	280	0	0	0
298	Swift Tern	0	4	0	0	0
394	Pied Kingfisher	0	1	0	0	0
686	Cape Wagtail	0	2	2	2	2

+Observations on 4 February 1976 by Wader Study Group (Summers *et al.*, 1976).

APPENDIX VI: Mammals recorded by Stuart *et al.*, (1980) for the area covered by the 1:50 000 Sheet 3418BB Somerset West.

+indicates rare, threatened species (Meester, 1976 and Skinner *et al.*, 1977).

Common name	Species
Melck's House Bat	- <i>Eptesicus melckorum</i>
Geoffrey's Horseshoe Bat	- <i>Rhinolophus clivosus</i>
Egyptian Fruit Bat	- <i>Rousettus aegyptiacus</i>
Dwarf Shrew	- <i>Suncus etruscus</i>
Chacma Baboon	- <i>Papio ursinus</i>
Southern Elephant Seal	- <i>Mirounga leonina</i>
Grysbok	- <i>Raphicenus melanotis</i>
Cape Greater Gerbil	- <sup>+</sup> <i>Tatera afra</i>
Verreauxs Rat	- <sup>+</sup> <i>Praomys verreauxi</i>
Black and White Dormouse	- <i>Graphiurus ocellaris</i>
Cape Dune Molerat	- <i>Bathyergus suillus</i>
Cape Clawless Otter	- <i>Aonyx capensis</i>
Cape Wild Cat	- <i>Felis libyca</i>
Serval	- <sup>+</sup> <i>Felis serval</i>
Leopard	- <sup>+</sup> <i>Panthera pardus</i>

APPENDIX VII: Summary of available information

ESTUARY / RIVERMOUTH / LAGOON	ABIOTIC										BIOTIC																																												
	Physiography		Physics		Geomorphology		Chemistry		Other		Flora		Fauna																																										
YEAR (DATE OF INFORMATION)	Summary of available information																																																						
	Morphology		Circulation & mixing		Paleoenvironment		Sediment transport & deposition		General chemistry		Eutrophication		Metal residues		Pesticide residues		Bacteriology		Management		Aquaculture		Modelling		Conservation		Utilization		Historical		Halophytes		Phytoplankton		Terrestrial		Zooplankton		Other invertebrates		Insects		Fauna on hard substrates		Fauna on soft substrates		Fish		Reptiles & Amphibians		Birds		Mammals		Food Webs
	Sources of Information																																																						
	Acocks																																																						
	Bartlett and Hennig																																																						
	Beekhuis et al																																																						
	Boycott																																																						
	Cape of Good Hope Provincial Proclamation 162																																																						
	Cape of Good Hope Provincial Proclamation 357																																																						
	Cape Provincial Administration																																																						
	Cloete																																																						
	Connolly																																																						
	Day																																																						
	Du Plessis																																																						
	FitzSimons																																																						
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	Fuggle																																																						
	Gasson																																																						
	Gilchrist																																																						
	Glass																																																						
	Greig, Boycott and De Villiers																																																						



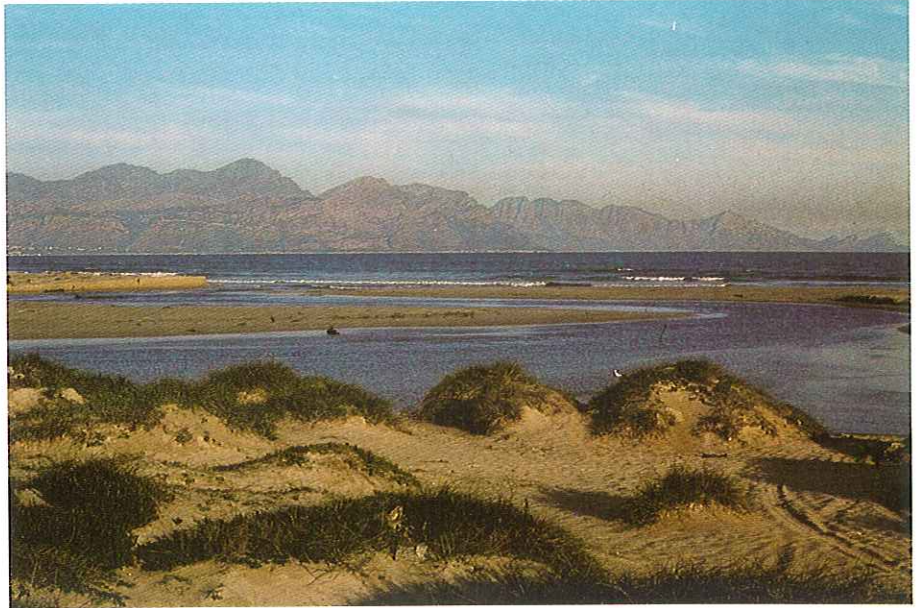






PLATE I:

Eerste estuary mouth in open condition looking south east across False Bay to Kogelberg in the background. The mouth channel changes its position from time to time and newly eroded sand banks are evident in two places in this picture. The hummock dunes in the foreground are covered by the Steekriet, *Eragrostis cyperoides* (J.R. Grindley, 1982-06-07).

PLATE II:

Eerste estuary approximately 1 300 metres from the mouth where it is a reed fringed channel about 10 metres wide. The reeds are predominantly the fluitjiesriet, *Phragmites australis*. An isolated outcrop of rocks of the Malmesbury series occurs at this point which accumulates floating logs and other litter. (J.R. Grindley, 1981-12-03).

PLATE III:

The sewage outfall approximately 1 300 metres from the mouth of the Eerste estuary. The outflowing treated effluent attracts large numbers of juvenile fish at times. The adjacent vegetation in the picture includes the fluitjiesriet, *Phragmites australis* and Rooikrans, *Acacia cyclops* (J.R. Grindley, 1981-12-03).

