COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
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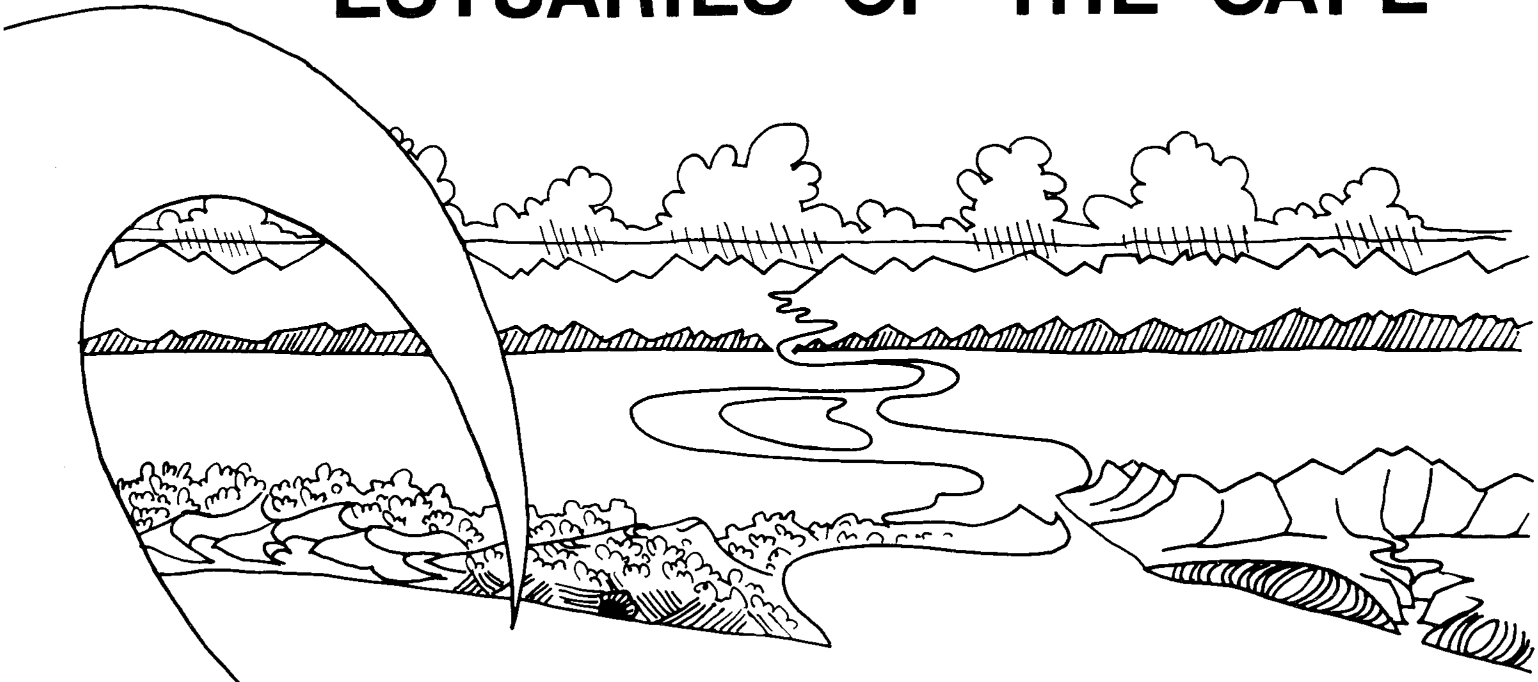
ESTUARINE AND COASTAL RESEARCH UNIT - ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 23

SWARTKOPS (CSE3)

CSIR RESEARCH REPORT 422

Stellenbosch, South Africa
January 1986

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PART II SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS
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REPORT NO. 23: SWARTKOPS (CSE3)

(CSE 3 – CSIR Estuary Index Number)

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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 "Estuaries of the Cape, Part I - Synopsis of the Cape Coast. Natural Features, Dynamics and Utilization" (by Heydorn and Tinley, CSIR Research Report 380). 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 "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.

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
CHIEF DIRECTOR

National Research Institute for Oceanology, CSIR

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SWARTKOPS

1. HISTORICAL BACKGROUND

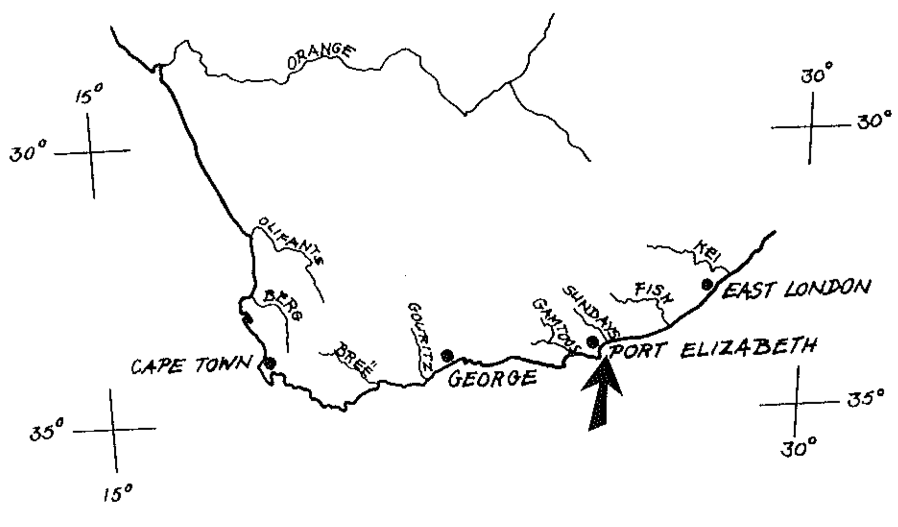
The Swartkops River valley was first populated as a result of the eastward migration of farmers from the Cape. By 1776 a number of farms were already established in the Algoa Bay area. The Swartkopswagendrift and Coegaswagendrift farms were established in 1776, while the farm Fishwater Flats was proclaimed by the Government in 1817. The present villages of Swartkops (established in 1850) and Redhouse, stand on Fishwater Flats and Swartkopswagendrift respectively. In 1817 the Dutch ship "Amsterdam" was wrecked between the Coega River mouth and the Swartkops. The wreckage washed up at the Swartkops River mouth and shortly afterwards this area was named Amsterdamhoek and the adjacent government land Amsterdam Flats.

The first road bridge across the Swartkops River was opened in 1859. It was damaged during a flood in 1876. A new bridge was built (the Wylde Bridge) and opened for traffic during 1879. The first railway bridge across the Swartkops River was built in 1875, and a second one at an unknown date. The present railway bridge was opened on 10 July 1955.

In 1897 the Zwartkops Valley Land Company purchased the farm Fishwater Flats, except the portion already acquired by the railway. By 1904 the Company had bought all the remaining land of the farm Zwartkopswagendrift. A number of erven (plots) were sold to private individuals and in 1952 the Port Elizabeth City Council bought the remainder. The South African Railways expropriated a portion of the ground for workshops in 1957 and purchased a further 1 708 morgen from the municipality in 1962. Part of Amsterdamhoek was purchased by the City Council in 1948 and the remainder in 1954.

The Zwartkops Yacht Club dates back to 1916. The Zwartkops Trust was established in 1968 with its main aims to preserve and protect the estuary and its environs as a recreational area, to impress the need for rational development in the area, to safeguard the environment and to maintain it in a healthy ecological state (Neethling, 1974).

Synonyms: Zwartkops Estuary. Original spelling.
Swartkops Estuary. Modern spelling.



2. LOCATION

The Swartkops Estuary is situated about 15 km north of the Port Elizabeth Harbour at 33°52'S and 25°38'E.

2.1 Accessibility

Two major access roads to the estuary branch off from the Port Elizabeth-Grahamstown highway. The first of these has its entrance point about 2 km south of the estuary, between the Phillips Carbon Black Factory and the Fishwater Flats Reclamation Plant and leads to Swartkops Village (Figure 1). Approximately midway through the village, it links up with a major through road to Redhouse, Perseverance and Uitenhage. There are numerous access points to the estuary in the vicinity of Swartkops and Redhouse villages and the Perseverance Siding.

The second major access road to the estuary joins the highway about 2 km north of the estuary (Figure 1). The former splits in two. One branch leads first eastwards to the beach and then southwards to the mouth of the estuary. The second goes west. It passes through Bluewater Bay Township, and then turns down the escarpment to the village of Amsterdamhoek. Here it links up with a road running along the water front of the lower reaches of the estuary. The western end of this joins up with the road from Swartkops Village.

2.2 Local Authorities

Port Elizabeth Municipality, Uitenhage Municipality, Despatch Municipality and above the escarpment, the Diaz Divisional Council.

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

The main catchment area of Swartkops River lies in the Groot Winterhoek Mountains to the west of Uitenhage (Reddering and Esterhuysen, 1981). The lower river receives water primarily from the Swartkops and the Elands Rivers which flow parallel to each other, in relatively steep narrow valleys, before joining shortly after entering the floodplain (Figure 2).

Another, but less important part of the catchment area is the lower-lying region bordering the Chatty and Swartkops Rivers, downstream of the confluence of the Elands River with the Swartkops (Table 1).

3.1.1 Catchment Characteristics

The upper Swartkops River flows through the Winterhoek Wilderness area under the control of the Directorate of Forestry. The Elands River flows through agricultural areas.

Area

The total catchment area is approximately 1 354 sq km and can be subdivided into three regions (Hill Kaplan Scott and Partners (HKS) Table 1).

River length

From the foothills of the Groot Winterhoek Mountains, the Swartkops and Elands Rivers meander seaward for about 155 km before joining and discharging into the estuary some 19 km lower down (1:500 000 Sheet SE 35/24).

FIG. I: Local features of the study area

(after HKS, 1974a)

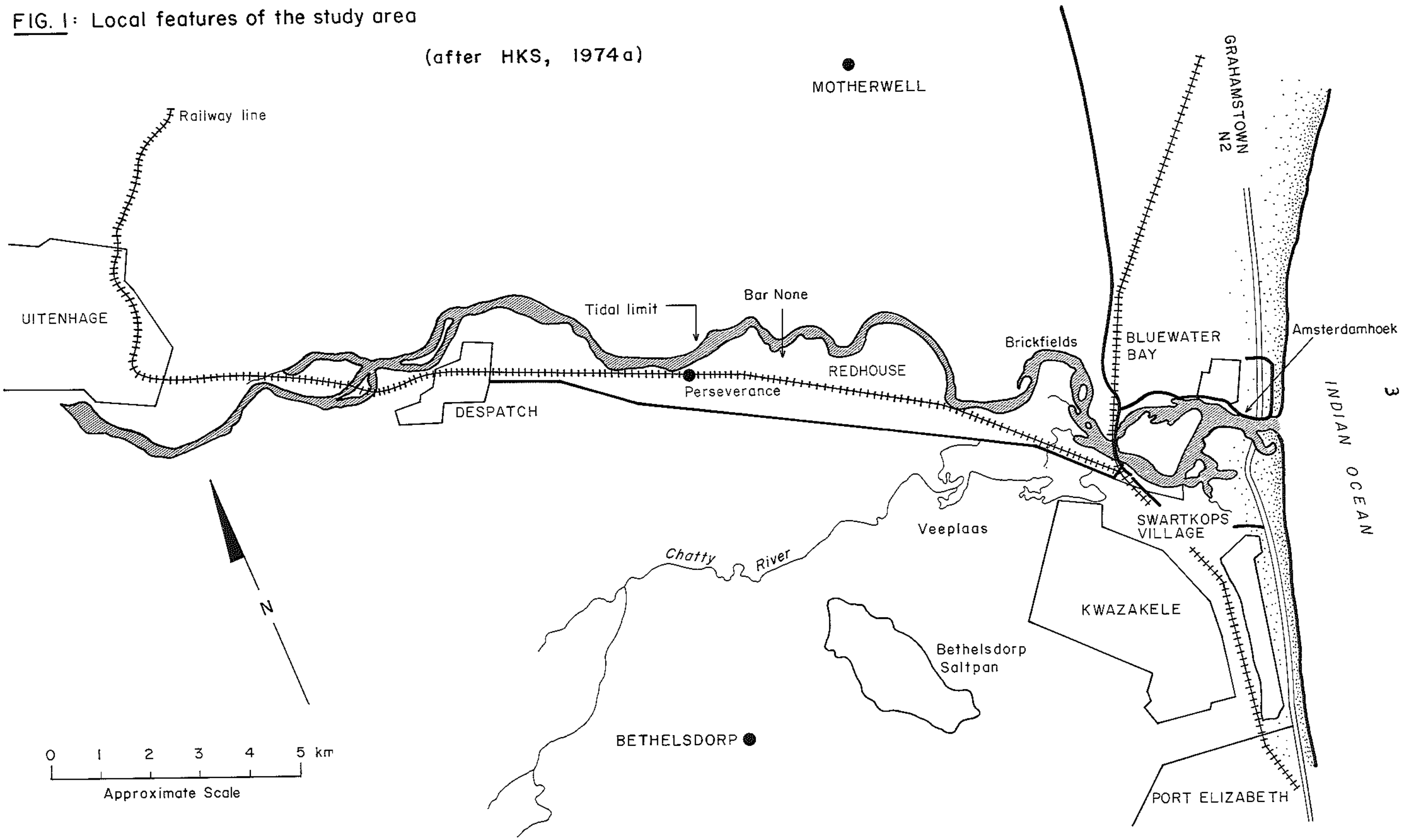


FIG. 2 : Regional features of the study area.
(after HKS, 1974a)

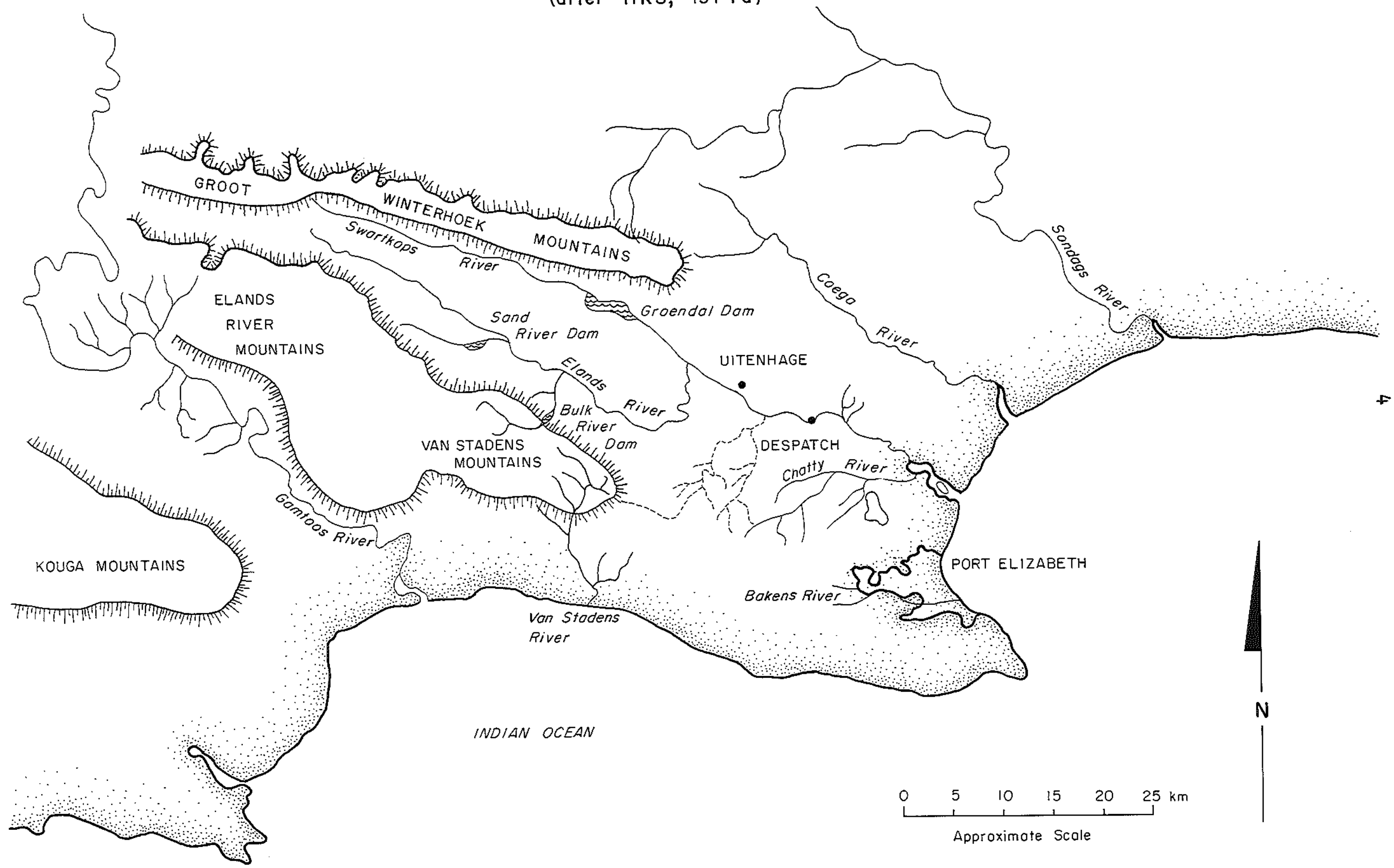


TABLE 1: Characteristics of the 3 sub-catchment areas of the Swartkops Estuary (from HKS, 1974b).

Sub-catchments	Area (sq. km.)	Mean annual run-off ($m^3 \times 10^6$)	Mean annual rainfall (mm)
I. Swartkops River downstream to its confluence with the Elands River	397	26,44	654
II. Elands River downstream to its confluence with the Swartkops River	448	38,28	706
III. Chatty and Swartkops Rivers downstream of the confluence of the Swartkops with the Elands River	509	19,44	547
TOTAL	1 354	84,16	-

Tributaries

Chase's Kloof and Waterkloof are tributaries of the Swartkops in the Winterhoek Mountains. The main tributary of the Swartkops River is the Elands River which is approximately 46 km in length (1:500 000 Sheet SE 35/24). It in turn has two smaller tributaries, the Bulk and Sand Rivers, having lengths of approximately 12 and 16 km respectively.

The only other tributary of any significance is the Chatty River (ca. 22 km in length) which enters the estuary about 0,5 km upstream of Swartkops Village (Figure 2). Originally the lower reaches of the Chatty River were ill-defined and it used to debouch into the estuary through a series of shallow channels scoured into the floodplain. A few years ago salt pans were established in most of this area and the river is now restricted to a narrow channel.

Geomorphology

In the mountainous catchment area the river course follows structural weaknesses and shale-filled synclines. It then meanders across a broad gravel floodplain eroded into poorly consolidated rocks of the Uitenhage Group (Reddering and Esterhuysen, 1981) and consists primarily of a series of medium to large sized pools connected by rapids. In droughts, the latter becomes a mere trickle, although a substantial flow is probably hidden below the gravel bottom (MacNae, 1957a). The banks of these lower and middle reaches of the river are usually low. Just east of Perseverance Siding the river flows over a causeway, which marks the limit of the tidal influence, 16,4 km from the river mouth (Figure 1).

Geology

Figure 3 shows the geological features in the catchment area. The upper region of the Swartkops River lies in the quartzites of the Table Mountain Group, while its tributary, the Elands River, flows over Bokkeveld Group shales, a region which tends to have well-drained acid soils. Below the confluence of these two

FIG. 3: The Geology of the Swartkops river catchment

(after Reddering and Esterhuysen, 1981)

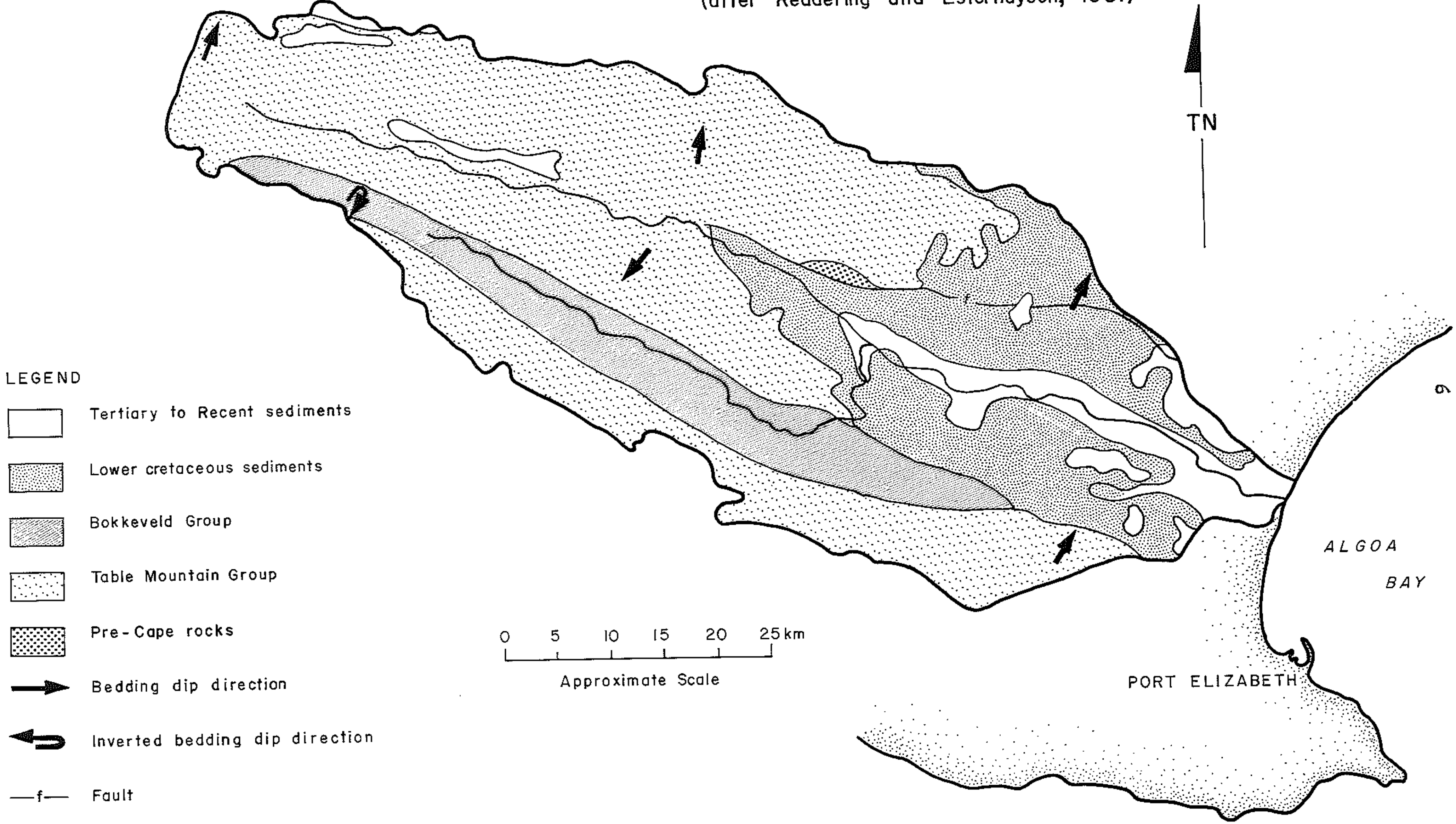
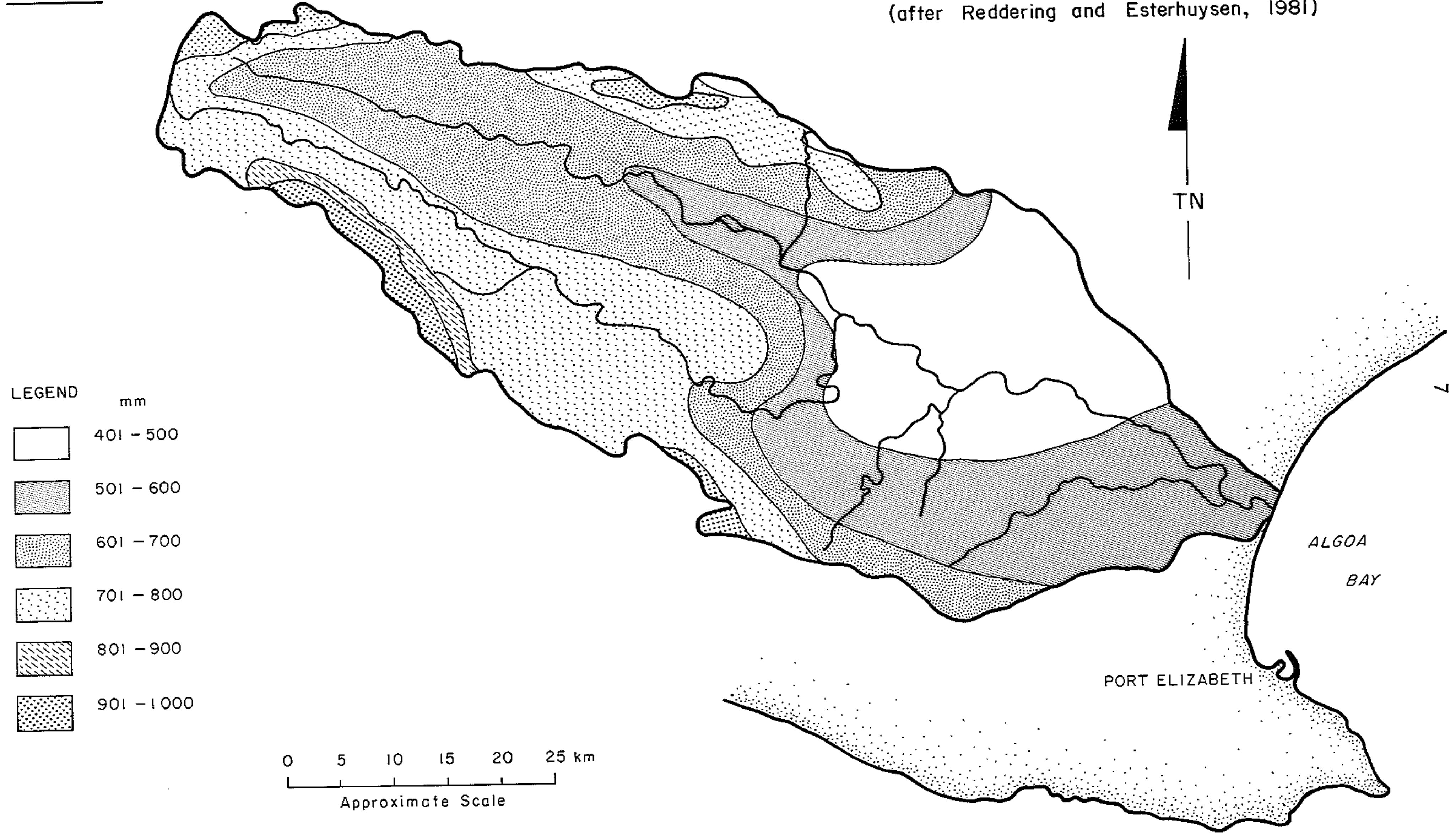


FIG. 4 : The mean annual precipitation of the Swartkops river catchment

(after Reddering and Esterhuysen, 1981)



rivers, the Swartkops River flows across the weakly consolidated shales of the Uitenhage Group, which tend to be poorly drained (Reddering and Esterhuysen, 1981).

In the upper reaches of the Swartkops River, the water is soft, with a low mineral content, but by the time the water reaches the estuary, having run across marine beds of the Cretaceous Uitenhage Series, it has become quite brackish (McNae, 1957a).

Rainfall

The amount of precipitation varies considerably over the different regions of the catchment area (Figure 4). The average annual rainfall for the total area would appear to be less than 700 mm. Although the average rainfall is fairly evenly distributed throughout the year (Figure 5), a large proportion of the monthly rainfall often occurs over a few days (MacNae, 1957a; HKS, 1974b), which may then result in floods.

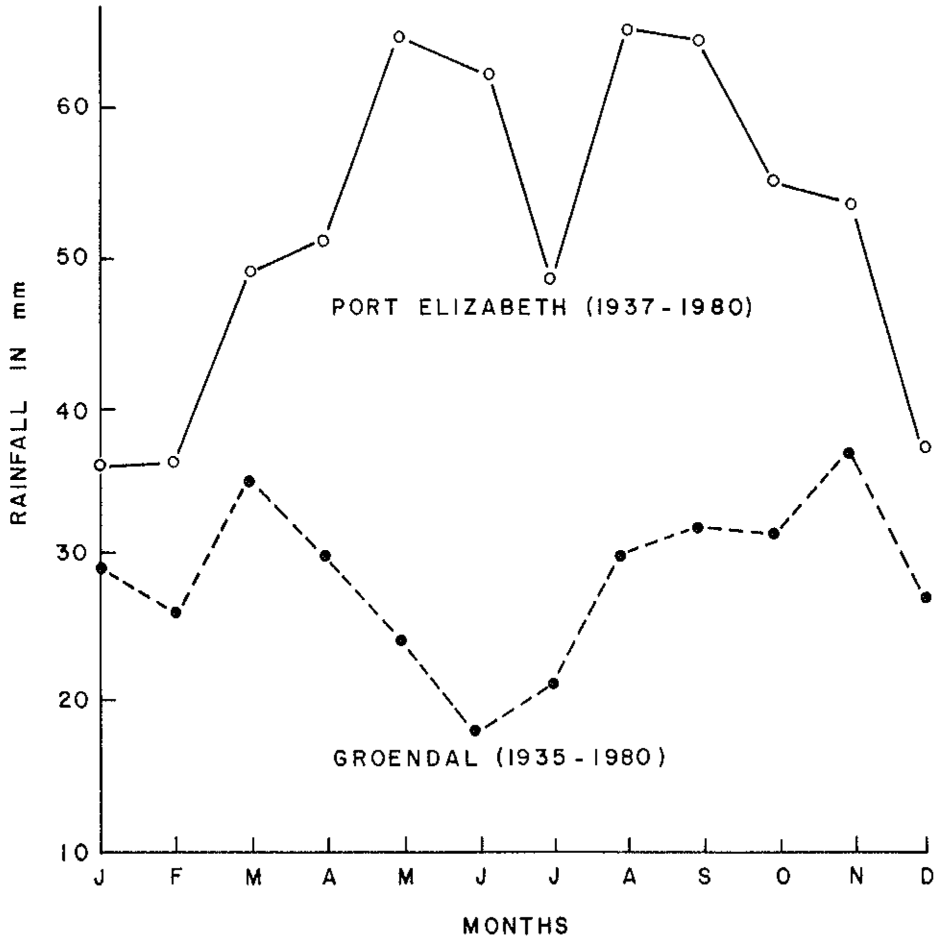


FIG. 5: Average monthly rainfall at Port Elizabeth and Groendal gauging stations.

Run-off

The mean annual run-off from the three major subcatchment areas is given in Table 1, which gives a total mean annual run-off for the lower Swartkops of 84,16 x 10^6 m^3 (HKS, 1974b) while Middleton *et al.* (1981) give the MAR as 75 x 10^6 m^3.

3.1.2 Land Ownership/Uses

The upper catchment areas of both the Swartkops and the Elands Rivers fall under the jurisdiction of the Directorate of Forestry. Much of the middle and lower reaches of the Swartkops and Elands Rivers are bordered by privately owned land, where market gardening and cattle and dairy farming are carried out.

In the vicinity of Uitenhage and Despatch there is considerable residential and industrial development, related chiefly to the wool and motor industries, and industries concerned with extractive processes. This land is either privately owned or leased from the Uitenhage Municipality. Below Despatch there are privately owned farms (Uitenhage Town Clerk, pers. comm.).

3.1.3 Obstructions

There are numerous artificial obstructions along the length of the Swartkops River and its tributaries.

The damming of the Swartkops River to form the Groendal Reservoir, which has a storage capacity of approximately 12 x 10^6 m^3 (HKS, 1974b) is probably the major obstruction to river flow. The storage capacity of the dam relative to the mean annual run-off is, however, small (only about 14 percent) and will have little effect on overall run-off to the Swartkops Estuary.

The two tributaries of the Elands River, the Bulk and Sand Rivers, are also dammed (see Figure 2). These reservoirs are also small and have little effect on the river flow. The construction of a new dam on the Elands River to store 80 x 10^6 m^3 of water has been proposed, but has been postponed indefinitely (HKS, 1974b).

Below the Groendal Dam, the Swartkops River is crossed by four causeways. At least two of these are built in such a way that they impede the flow of water and serve as small weirs.

In the vicinity of Uitenhage and Despatch, the river is spanned by four large road bridges and one railway bridge. The most westerly road bridge has a retaining wall below and functions as a small weir. The other bridges have relatively little effect on the flow of the river.

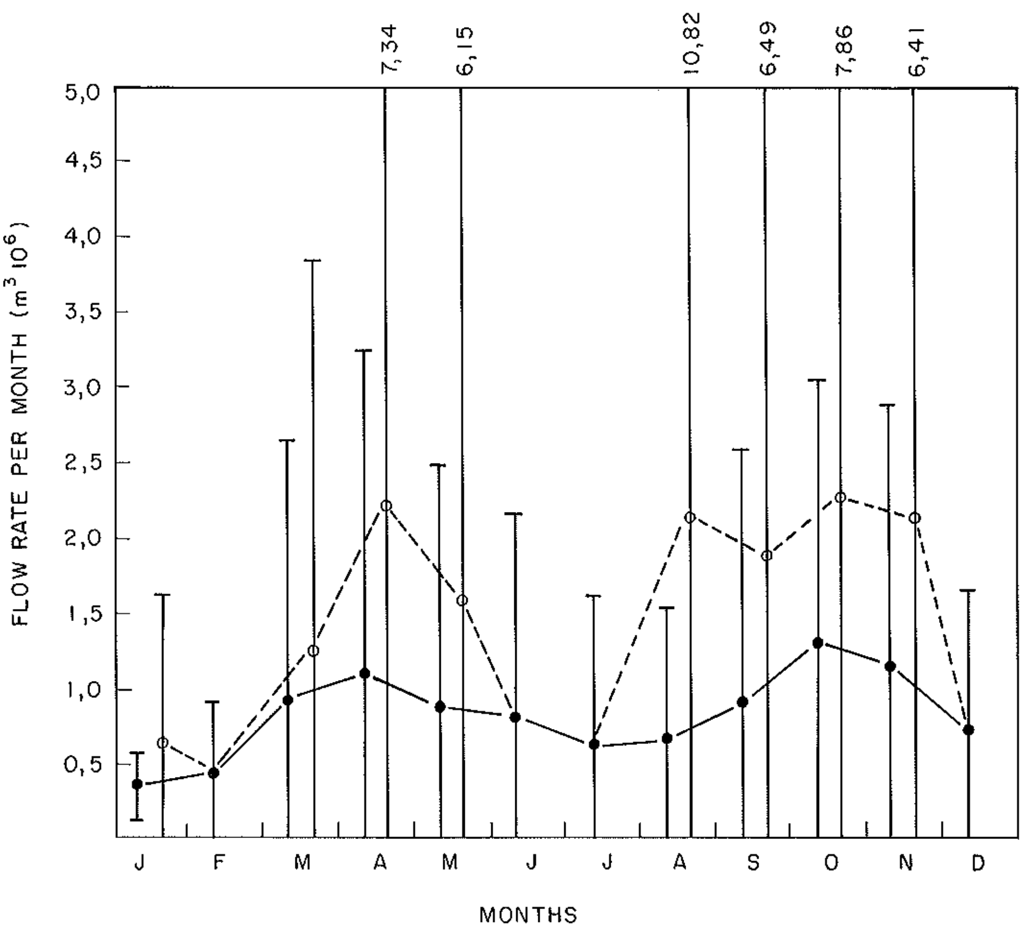
3.1.4 Siltation

The catchment area of the Swartkops River has not proved to be suitable for extensive agricultural development. Soil erosion and subsequent deposition of silt in the river has thus been largely avoided (HKS, 1974b). That which does enter the river is derived primarily from the poorly consolidated shale and sandstone of the Uitenhage Group. Compared to other Eastern Cape estuaries, the silt load of the Swartkops can be described as intermediate (Erasmus *et al.*, 1980). Data quoted by Middleton *et al.* (1981) show that the average estimated sediment yield from the Swartkops catchment is about 0,8 x 10^6 m^3/yr while that for the Sondags catchment is 9 x 10^6 m^3/yr.

3.1.5 Flow patterns

Spillway flow recordings for the Groendal dam are summarized in Figure 6a. The only stream flow gauge (station M1M04 - Middleton *et al.* 1981) for the Swartkops catchment is located on the Elands River at Longhill. Recordings were made from 6 April 1965 (Mr MacDonald, Department of Water Affairs, pers. comm.). Using data from Middleton *et al.* (1981) the simulated monthly run-off for the Swartkops catchment is plotted in Figure 6b. It is clear that the monthly run-off is usually small with occasional high flows during floods. The simulated annual run-off for the years 1921-1976 for the catchment is plotted in Figure 6c (Middleton *et al.*, 1981). For 29 percent of the time the annual run-off was below the mean annual run-off of 75 x 10^6 m^3 and for 71 percent of the time above it.

FIG. 6a: Average monthly river flow records measured at the Groendal Dam spillway.



3.1.6 Floods

The frequency and magnitude of floods in the catchment can clearly be seen on Figure 6b (Fromme, 1985). Severe floods (>120 to 160 x 10^6 m^3) occur mainly in summer with minor floods (>40 to 80 x 10^6 m^3) during the winter. Major floods (>80 to 120 x 10^6 m^3) occur during summer and winter. The periods of highest recorded flow rates at the Groendal Dam are given in Table 2. The occurrence of flows in Table 2 compares well with the simulated monthly run-off shown in Figure 6b.

Almost complete inundation of the Swartkops riverine and estuarine floodplains was reported in 1879, 1912, 1914, 1971 (HKS, 1974b) and 1979 *(Eastern Province Herald,* 1979).

FIG. 6b: Simulated monthly run-off for the Swartkops River 1921 - 1976.

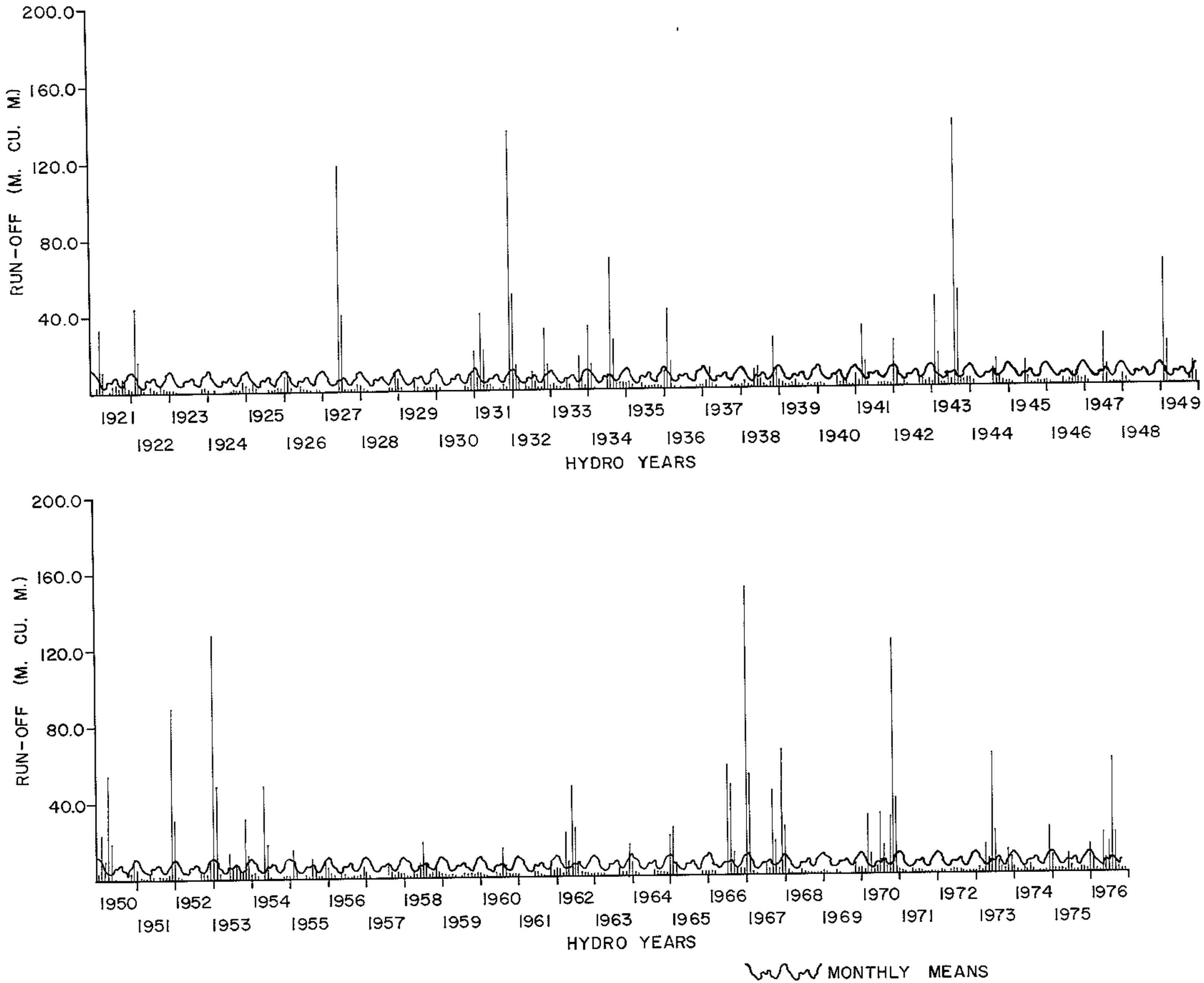
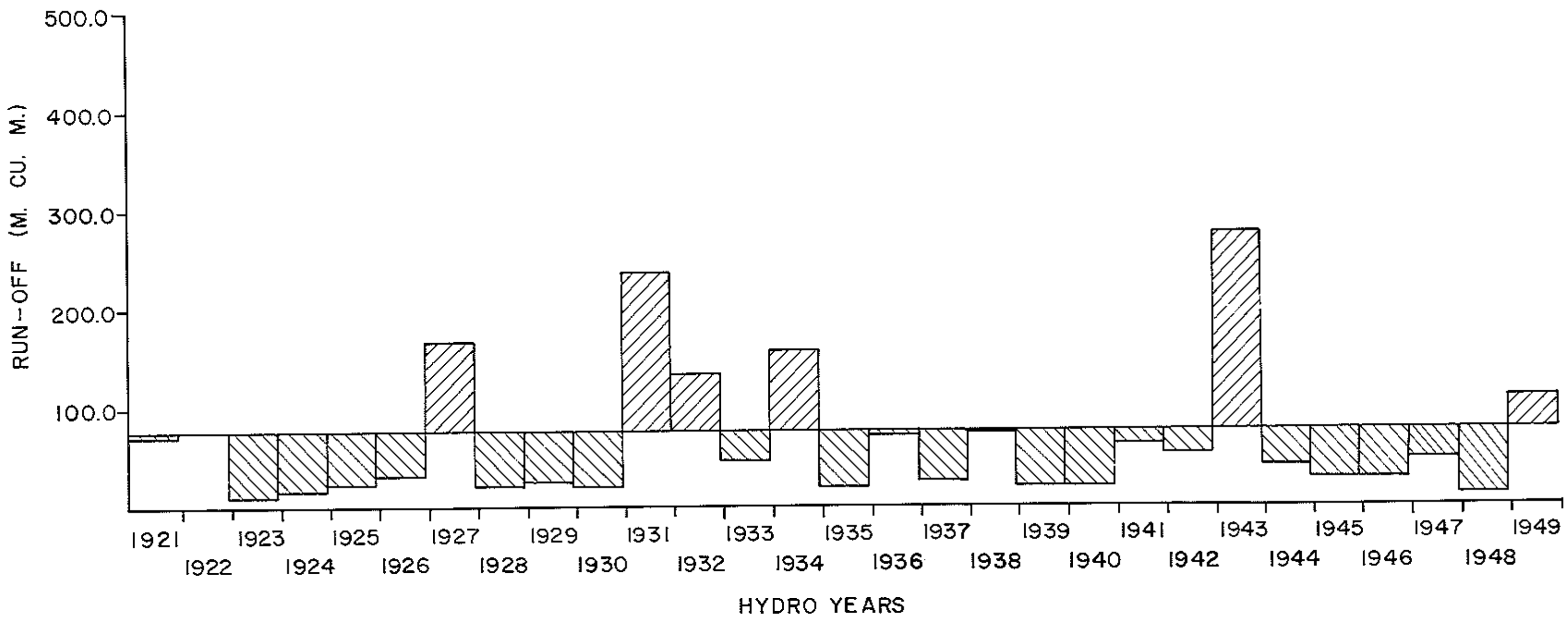
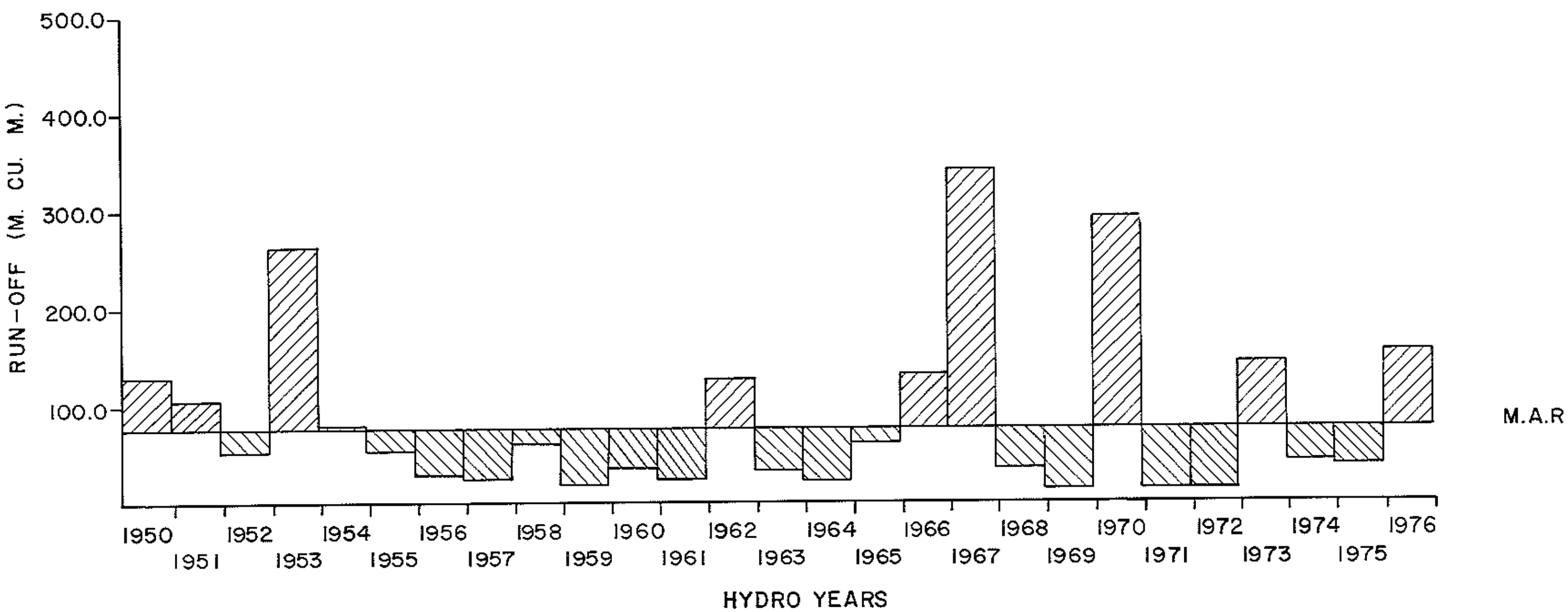


FIG. 6c: Simulated annual run-off for the Swartkops River 1921–1976.





From a simulated mathematical model of the August 1971 flood, the maximum height reached by floods was about 4,0 m and 1,7 m above the mid-tide levels in the upper and lower reaches of the estuary respectively (HKS, 1974b).

TABLE 2: Flood records of Groendal dam from 1938-1980. First column presents total monthly flow over Groendal Dam spillway ($m^3 \times 10^6$) during periods of flood and second column the maximum daily recording of flow during the month (m^3/s) (data for 1938-1974 from HKS, 1974b; data for 1974-1980 from Uitenhage City Engineer).

Date		Total flow for month ($m^3 \times 10^6$)	Maximum daily recording during month (m^3/s)
May	1944	26,36	227
November	1949	13,88	42
January	1951	11,61	57
September	1952	23,20	105
October	1953	30,98	227
March	1955	12,21	20
November	1956	19,71	116
April	1963	25,57	57
April	1967	13,10	74
September	1968	11,97	42
August	1971	50,22	425
March	1974	13,87	34
September	1975	15,82	28
May	1977	6,70	66
July	1979	17,06	99

3.2 Estuary

3.2.1 Estuary Characteristics

The estuary was formed when the Swartkops River Valley was drowned during the sea level rise after the Pleistocene. Its present serpentine configuration is a result of sediment fill (Reddering and Esterhuysen, 1981). A causeway, about a kilometre east of Perseverance Siding and 16,4 km from the sea, marks the limit of the tidal influence (Figure 1).

In the upper reaches, the estuary is narrow (ca. 90 m wide), channel-like, and twists its way through steep banks of muddy sand. The estuary widens slightly and becomes less convoluted in the middle reaches (between Bar None and the Brickfields). Below the Brickfields the steep banks flatten and the estuary broadens considerably (ca. 350 m wide). Large intertidal mudflats, islands and saltmarshes begin to appear. The latter increase in extent downstream, and are most extensive between the villages of Swartkops and Amsterdamhoek. The salt-marshes then give way to large sand banks and a rocky embankment on the south and north banks of the river mouth respectively (Figure 1).

Area

The areas of the various sections of the estuary are given in Table 3.

TABLE 3: The surface areas calculated for the various sections of the estuary (taken from Talbot, 1982)

Region	Area (ha)
Subtidal	142
Total Intertidal	ca. 360
Bare mud/sand	180
Zostera capensis beds	14
Spartina maritima beds	82
Triglochin bulbosa beds	1
Sarcocornia perennis beds	55
Chenolea diffusa beds	28

Depth

Depth profile surveys performed along the length of the Swartkops Estuary by both HKS (1974b) and Reddering and Esterhuysen (1981) revealed that the main channel had a more or less uniform depth of about 3,0 m in relation to MSL along its length. The shallowest areas (ca. 2,0 m deep) were recorded mainly in the broad lower reaches, while the deepest (ca. 3,75 m) were found in the narrower upper reaches and mouth regions. There were no exceptionally deep areas. There was a 7 m hole at the Settlers bridge (Grindley, 1976) but this no longer exists.

Geology

The Swartkops Basin consists of an upper base of shale and mudstone from the Cretaceous system. The latter is overlain disconformably by marine sedimentary deposits in the high lying regions and by various alluvial deposits in the flood plain. Underlying the entire system are the harder Table Mountain sandstones and quartzites.

The deposits of the Cretaceous System found in the Swartkops Basin can be divided into three formations (Reddering and Esterhuysen, 1981), namely

(a) (lower) Enon Formation (fluvial conglomerate)
(b) (middle) Kirkwood Formation (fluvial conglomerate)
(c) (upper) Sundays River Formation (marine sandstone and shale)

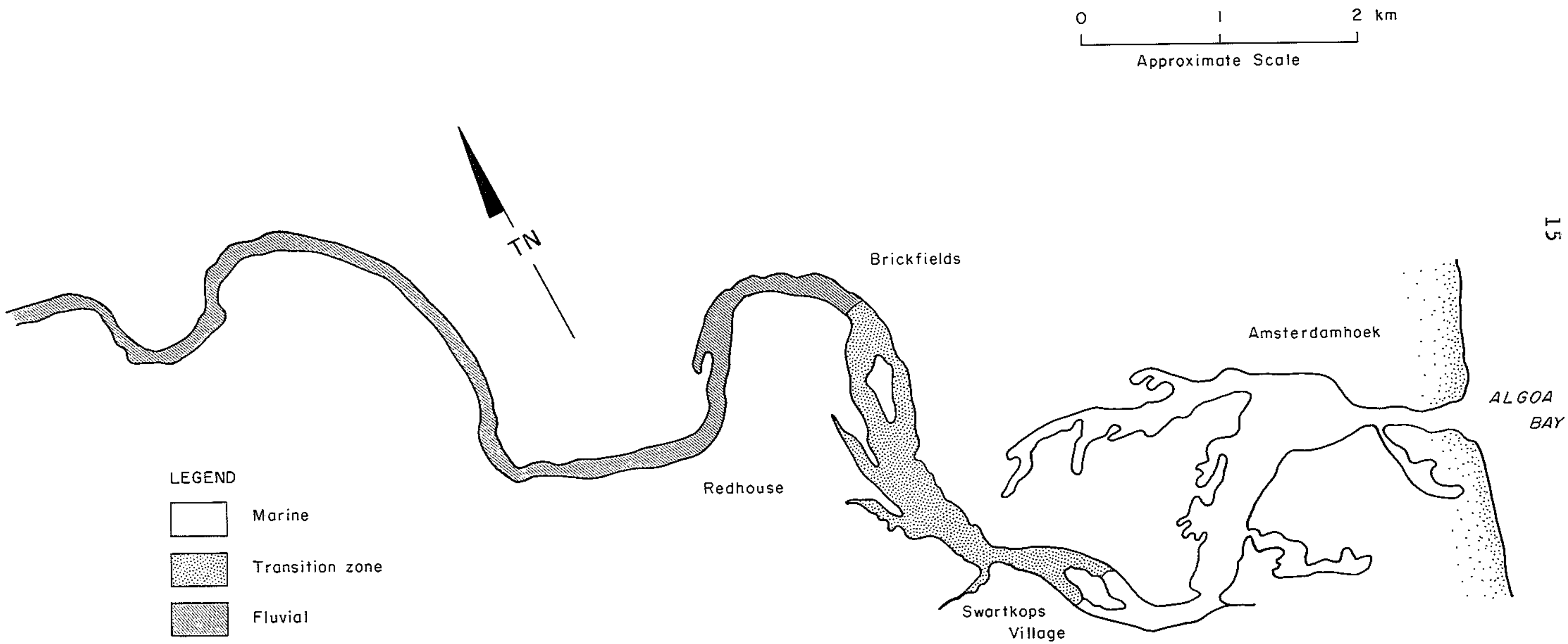
The first two formations occur as outcrops in the basin, while the third forms the northern escarpment and the major part of the hills to the south of the Swartkops River. The Alexandria Formation of the Tertiary age overlies the Cretaceous Sediments and forms a capping on the hills in the south and the plateau area to the north of the escarpment. Late Tertiary to Recent Deposits of estuarine and marine origin occur in the valley and as raised beaches along the coastal fringe. The latter are usually covered with Recent windblown dune sand (HKS, 1974a).

Bottom Sediment

The distribution and origin of bottom sediments within the Swartkops Estuary are shown in Figure 7. Fluvial deposits are predominant in the upper and middle reaches of the estuary (up to the Brickfields), while in the lower sections of the lower reaches (Swartkops Village to the river mouth) marine sediments dominate. Between the above two regions, there is a transition zone of mixed sediments (Reddering and Esterhuysen, 1981).

FIG. 7: Sediment source of the Swartkops Estuary

(after Reddering and Esterhuysen, 1981)



The main channel (subtidal region) of the lower reaches consists primarily of a coarse sandy substrate. This grades into a much finer substrate in the middle reaches, which in turn transforms into a coarse substrate with varying amounts of silt in the upper reaches (Table 4).

The intertidal region of the mouth consists of clean fine sand on the large expansive south bank (Table 4) and a very narrow rocky shore with an artificial embankment on the north.

TABLE 4: Substrate properties for the various regions of the estuary. The mean values are given for: median particle diameter (MD) in phi units, percentage subsieves* and shear strength. The water (LWMST) and subtidal values were calculated from values given by McLachlan (1972) and Hanekom (1980).

* The percentage of material passing through a sieve mesh of 0,063 mm

Region	Factor	Mouth region	Lower reaches	Tippers Creek	Middle reaches	Upper reaches
Intertidal	MD (phi units)	2,31	2,60	3,21	2,48	1,84
Subtidal	MD (phi units)	-	2,40	2,70	1,90	1,10
Intertidal	% subsieves	0,5	16,7	44,9	23,5	6,8
Subtidal	% subsieves	-	2,14	19,16	20,47	11,02
Intertidal	shear (g/cm^2)	24,5	-	27,0	32,3	15
Subtidal	shear (g/cm^2)	-	-	-	-	-

3.2.2 Mouth Dynamics

(This section is an abstract from Fromme, 1985)

Evolution of the estuary

The present flood plains, river bed and major meanders of the Swartkops Estuary were formed subsequent to a period of high sea levels (Flandrian Transgression, 12 000 to 4 000 years B.P.) when the sea level regressed gradually from about MSL +3 m to the present level (MSL ±0 m).

It seems that, since the general morphology of the estuary was laid down during this period of 4 000 years to present, only minor changes in configuration have taken place. On the other hand, there are clear indications, that, contrary to the general belief (e.g. of residents of Amsterdamhoek), the cross-sectional areas upstream of Settlers Bridge have increased since 1903. Only at the bridge itself has the cross-sectional area decreased because of the artificial constriction of the estuary mouth channel by the bridge. With the exception of some minor variations which are normal in the natural behaviour of an estuary, such as changing sand banks (e.g. opposite Amsterdamhoek) the Swartkops Estuary appears to have reached a very stable phase in the course of its evolution (Figure 8).

Hydrology

The Swartkops River is marked by low run-off and occasional but rare spate floods. The estuary mouth is kept open mainly by the action of strong tidal currents which exceed the average river flow by sixty times.

Flooding in the Swartkops Valley has been a major problem in the past. Consequently the Swartkops River Valley Hydrological Study Committee is identifying the issues relating to the development of the Swartkops River Valley that require further detailed investigation. Many of the problems facing the committee stem from inadequate knowledge of the flood characteristics of the river. A mathematical model simulating the hydrological properties of the estuary was prepared by Hill Kaplan Scott and Partners in 1972 to provide such information. This model has been further developed and improved at the National Research Institute for Oceanology and the University of Port Elizabeth to include such variables as incoming tide flows and wind.

Calibration data for the NRIO 1-D Hydrodynamic Numerical Model have been collected. Several special runs of the model to answer specific queries have been carried out, including those related to the determination of 100 year flood levels. These runs of the model were successful but some features requiring attention were highlighted. The interpretation of the cross-sectional area for high flood levels (2 m above MSL) requires information on flow on the floodplain. The original model had ignored flow on the floodplain and simply extrapolated main channel cross-sections upwards. This had the result that flood levels were predicted far too high at the upstream locations. In adjusting for this, assumptions have had to be made regarding generalized sections to cater for floodplain flow in the absence of more accurate level data. Such data are required for further flood level runs to refine the results. The constrictions at the new and old bridges and the estuary mouth need to be described in more detail to predict flood effects accurately in future.

Practical questions that arise include the possible effects of further engineering modifications on this floodplain. The extent of constriction which would be tolerable in the construction of the new highway bridge alongside the existing one needs to be established. Any restriction of flood waters that might increase flood levels upstream in the sensitive Redhouse area would be intolerable. Whether a breakthrough culvert in the old road bridge embankment would be valuable or whether it would accentuate flooding levels downstream at Amsterdamhoek are further questions. What effect the removal of part of the banks protecting the saltpan works opposite Redhouse would have on flood levels is not yet certain. At this stage answers to some of these questions are available but further investigations are required.

Sedimentology and hydraulics

The results of several surveys indicate that the sedimentation rate in the Swartkops Estuary is low and that the tidal inlet is unlikely to be blocked by riverine sediments. However, surveys carried out since 1903 seem to indicate that the cross-sectional areas of various sections taken in the Swartkops Estuary are not decreasing (Fromme, 1984). Blocking of the estuary mouth from the sea by the north-east going longshore sand drift is improbable. This is because of the damping of the predominant heavy south-westerly sea conditions in the diffraction area of Algoa Bay, which attenuates the generation of strong littoral currents, and because of the lack of sand along the beaches north-east of the Port Elizabeth harbour (Figure 9).

FIG. 8: Swartkops Estuary, 20 April 1979.

(From Aerial Photograph 326/216 - 217)

LEGEND TO FIGURE 8:

AH	Amsterdamhoek	Village
BB	Bluewaterbay	Village
SM	Swartkops mouth	Village
SB	Settlers (N2) bridge	
BH	Blue Hole	
SA	Sand bank opposite Amsterdamhoek	
44	1944 - breaching of S A (remnants of channel)	
TC	Tippers Creek	
MC	Present main channel	
AC	Ancient channel	
FF	Fishwater Flats	
SV	Swartkops Village	

The sand present in the mouth area is moved in and out of the estuary mouth by strong tidal currents. In a complex combination with the north-east going long-shore currents off the mouth which, in this area, are losing energy and tend to become bi-directional or on/off-shore currents, sand shoals and sand spits are formed in front of the mouth. These depositions cause frequent migrations of the inlet which may be up to 0,5 km south of the most northerly position of the mouth next to the rocks at the north-bank. Although never blocking the estuary mouth itself, the lagoon adjacent to the Blue Hole and its channel which connects it to the main estuary (mainly in the vicinity of the SW-head of Settlers Bridge) is often eroded or choked by these mouth variations.

Lord *et al.* (1985) showed that sand movement across the Cape Recife headland, south of Port Elizabeth has been stopped. The obstruction of the sand supply by vegetation and construction on the headland and the construction of Port Elizabeth harbour causes an area of beach erosion to occur which propagates through the bay (Swart, 1985). Prestedge *et al.* (1985) show that progressive erosion at a rate of about 3 to 4 m/yr (for the past 30 years) is taking place at New Beach south of the Swartkops Estuary mouth. The area of maximum erosion is moving north-eastwards. The erosion of the beaches in Algoa Bay can be expected to continue until a new equilibrium bay shape is reached, but in the area of the Swartkops Estuary, erosion of more than 130 m during the next 30 years is not expected.

In the report 'Algoa Bay coastal erosion investigation (1970)' various schemes were proposed including the extension of the Dolos barrier up to the Swartkops mouth, combined with beach reclamation works seaward of the Dolos barrier by

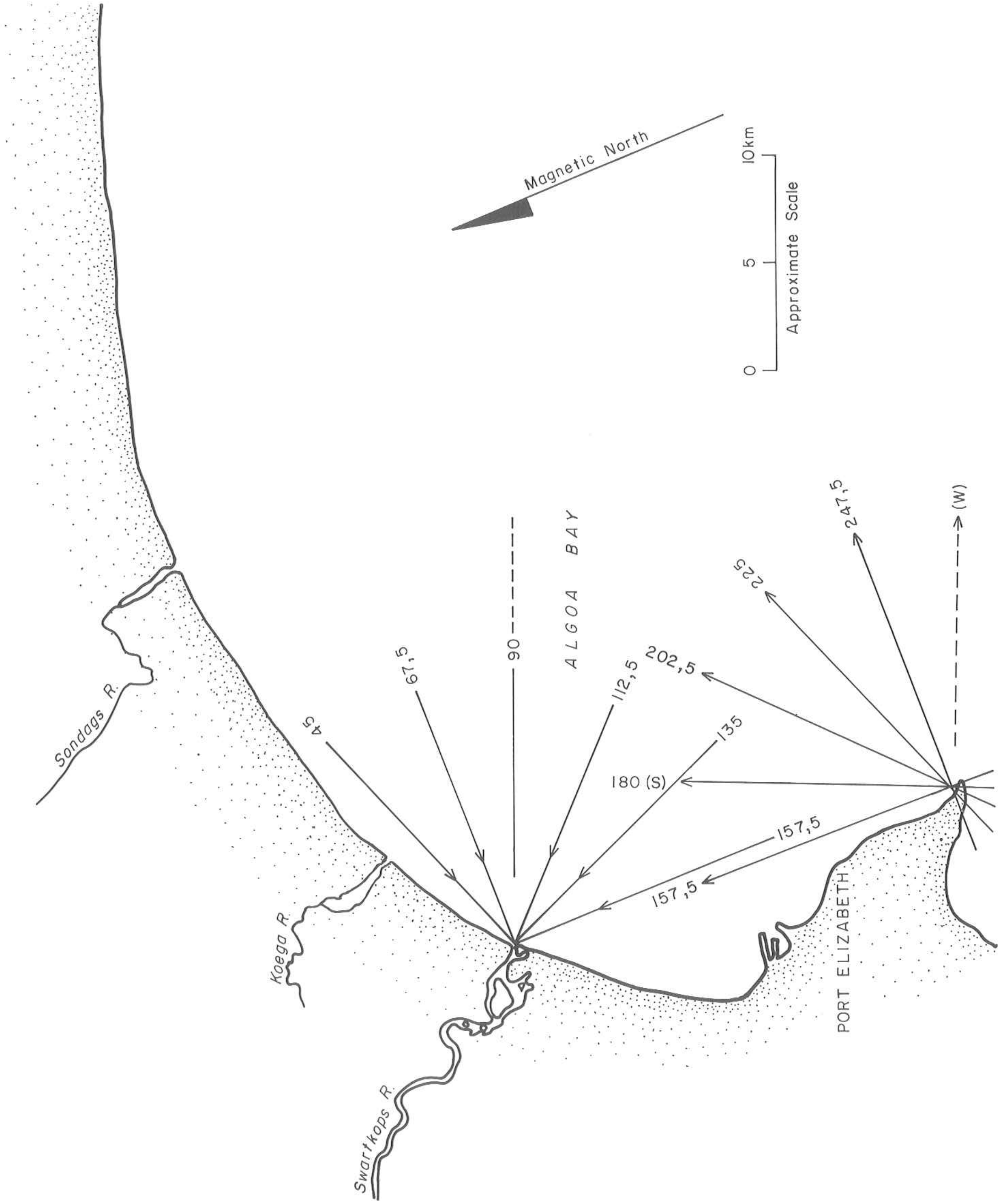


FIG. 9: Wave directions at the Swartkops Estuary mouth. (after Fromme, 1985)

artificial renourishment, to restore the natural sedimentary balance. To arrest the sand in the area and to maintain the built-up beaches, a scheme of groynes was suggested. As a borrow area for the necessary sand, dredging of the lower Swartkops Estuary was suggested. This would also improve the water circulation and the conditions for navigation, water sport and recreation. The Blue Hole area was dredged in 1981 apparently to increase the area for oyster farming (Prestedge *et al.*, 1985). According to this report it is important to carry out any further dredging in such a way as to improve water circulation through tidal flushing with the aim to improve the ecological potential of the area.

3.2.3 Land Ownership/Uses

The Swartkops Estuary Basin is administered by the City of Port Elizabeth, which is also the major land owner and controls the majority of the important leases (HKS, 1974a). Future land use and activity patterns in the area are therefore under the authority of the City Council. The South African Transport Services, however, has jurisdiction over the area on the south bank between the National Road, the sea and the river mouth.

The Swartkops Estuary is situated close to the major urban areas of Port Elizabeth and Uitenhage/Despatch and the adjoining land is used for a variety of purposes. These include residential townships, industrial estates and railway workshops. There are three major residential concentrations namely Swartkops, Redhouse and Amsterdamhoek/Bluewater Bay. The former two villages are located on the river terraces adjoining the waterway, while Amsterdamhoek, a linear development, is found on relatively high ground between the estuary and the slope of the escarpment. Bluewater Bay is on the plateau above. The new Motherwell residential area for Blacks is also being established on the plateau further to the west.

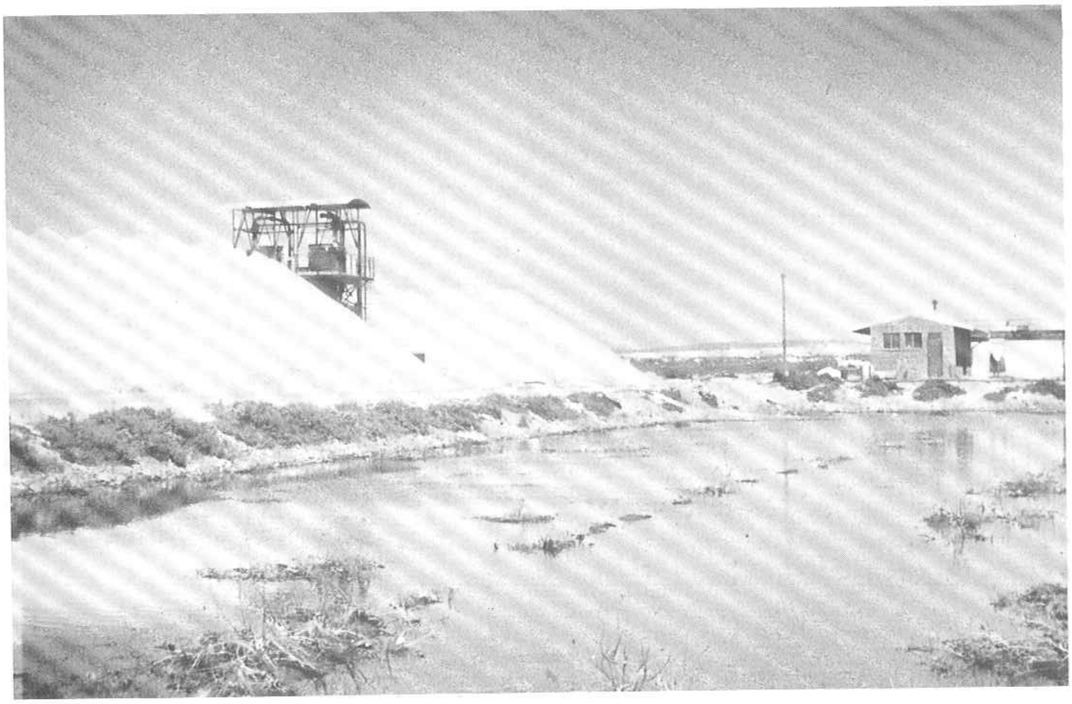


Fig. 10: Salt extraction from evaporation pans is an important industry in the Swartkops Estuary area but there have been conflicts of interest between these developments and the conservation of the estuary. (Photo: J.R. Grindley, May 1971).

The main industrial activities bordering the estuary are as follows:

(a) Numerous salt pans, which obtain their salt water from the estuary. The initial concentration pans are situated on both the north and south banks. The final concentration pans are south of the Redhouse Village (Figures 10 and 12). The total salt production amounts to approximately 75 000 tonnes per annum (Stauch Vorster and Partners, 1977).

(b) Clay mining for the manufacturing of bricks occurs on the escarpment north of Swartkops Village (Figure 12). Approximately 45 million bricks per annum are being produced.

(c) The power station, southwest of Swartkops Village, cycles about 50 megalitres of water per hour from the estuary, for cooling purposes. The water intakes are just below Swartkops Village and water re-enters the estuary above the road and railway bridge, at a temperature about 3°C higher than ambient (Malan, 1978)(Figures 12 and 13).

(d) To the south and southeast of Swartkops Village there are large railway marshalling yards and depots (Figure 12).

(e) Fishwater Flats sewage treatment works, situated about 2 km from the mouth of the estuary (Figure 11 and 12) deals with industrial and domestic sewage.

(f) The major new Markman industrial area is on the plateau north of the estuary.

Agricultural activity in the estuarine floodplain is limited because of the saline nature of most of the soil. Market gardening and dairy farming are carried out on a very limited scale.

3.2.4 Obstructions

The major artificial obstructions to tidal flow within the estuary, are the following (Fromme, 1985):

(a) The saltpans at Redhouse cause damming of flood waters upstream, constriction and channel erosion at the saltworks with subsequent deposition and sanding-up downstream.

(b) The railway and road bridges at Swartkops Village together with their causeways, have since 1879 not only constricted tidal flow in the main channel of the estuary, but have also blocked the major side arm of Tippers Creek, causing an impedement of estuarine water circulation. Flood levels upstream of the bridges may be up to one metre above those downstream.

(c) The construction of the N2-Settlers Bridge near the estuary mouth has confined estuarine flow to the rocky north bank. Although the bridge span (200 m) allows sufficient flood discharge, the long southern causeway impedes the natural migration tendencies of the mouth channel.

Fig. 11: View across Fishwater Flats area with the N2-freeway in the foreground, Phillips Carbon Black Factory and the Sewage Treatment Works. Beyond to the left of the salt marshes are the South African Transport Services yards and the village of Swartkops, while the quarries of the brickworks are visible on the escarpment in the background. (Photo: J.R. Grindley, February 1983).

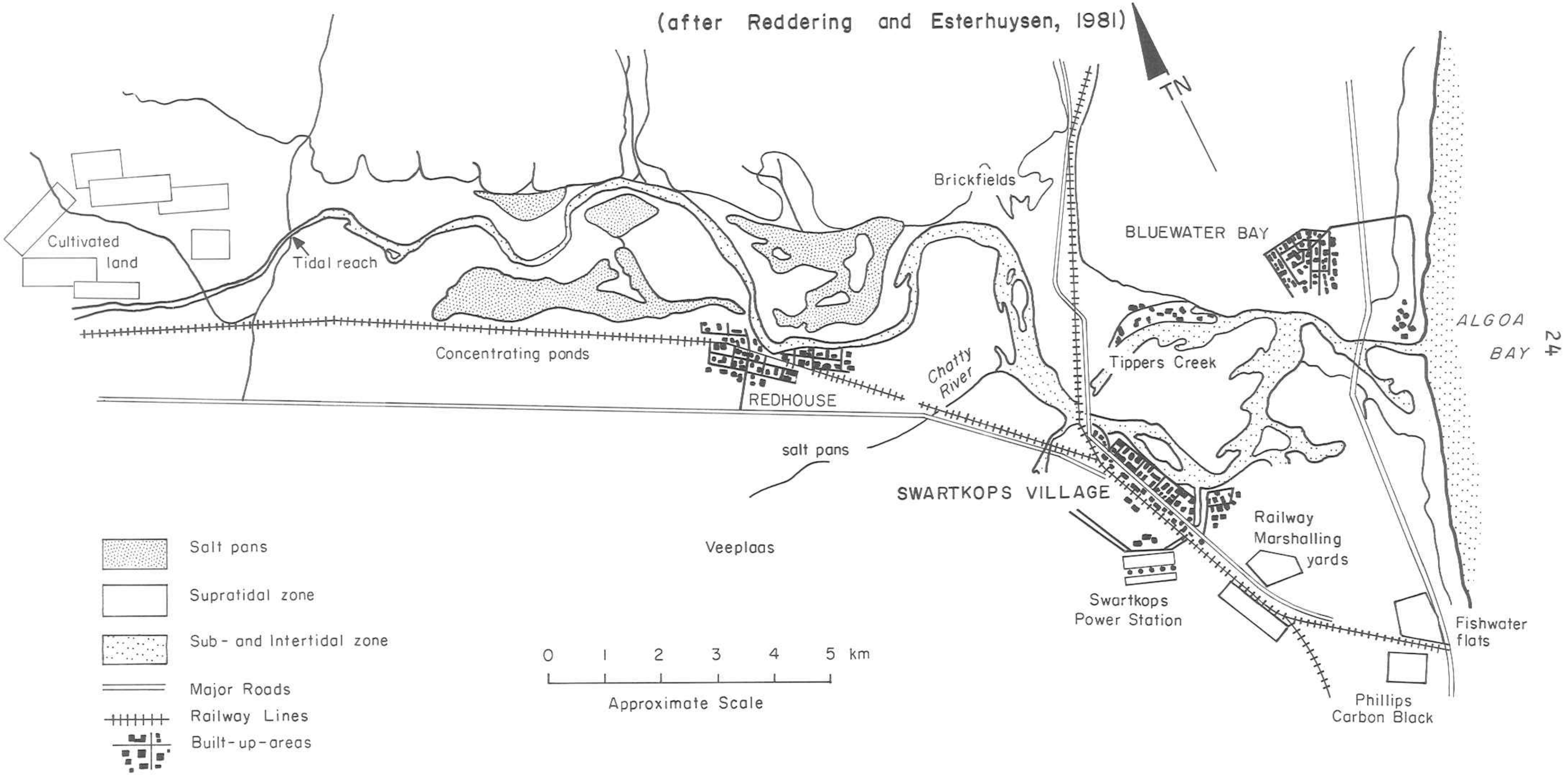
3.2.5 Physico-chemical Characteristics

Temperature

The temperatures recorded in the different reaches of the estuary were generally similar (Table 5) and so were those of the surface and bottom waters (difference usually less than 1°C) (Woolridge, 1979). The range and the mean annual temperatures recorded in the estuary were approximately 13-27°C and 21°C respectively (see Table 5). Maximum water temperatures were recorded from mid to late summer (December-March). Thereafter a marked drop in temperature is evident with lower temperatures recorded during June.

FIG. 12: Salt pans and tidally affected areas in the Swartkops Estuary.

(after Reddering and Esterhuysen, 1981)



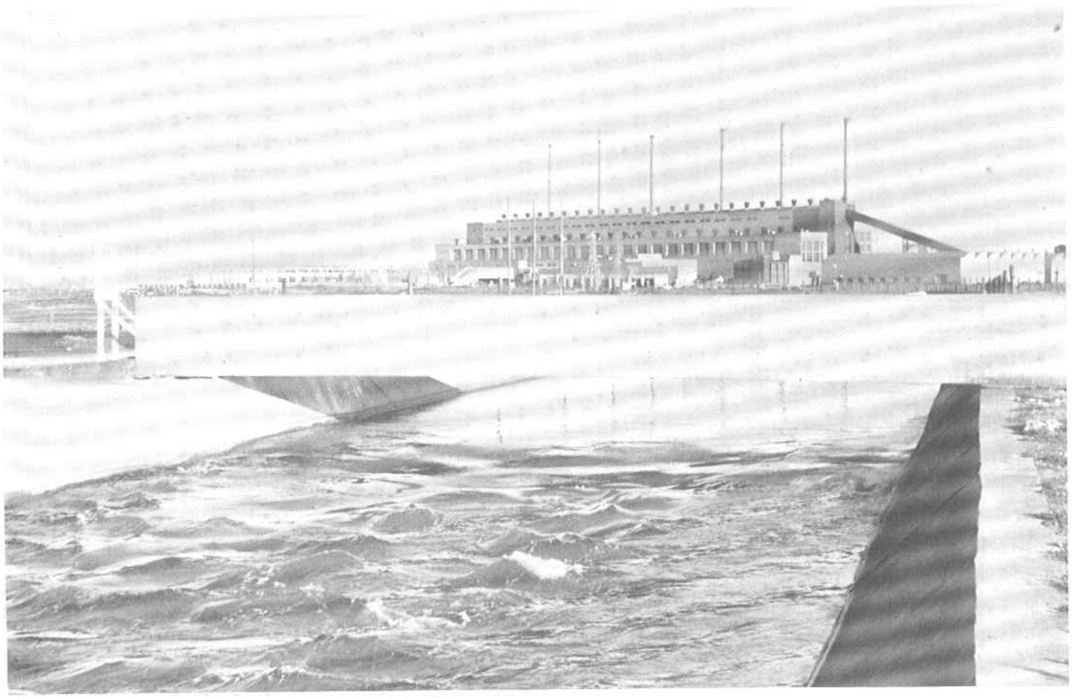


Fig. 13: The outflow of thermal effluent in the form of cooling water from the Swartkops Power Station into the estuary. This outflow causes raised temperatures upstream of Swartkops Village while the intake grids lie downstream of the village. (Photo: J.R. Grindley, May 1971).

Salinity

The salinity regime within the estuary appears to vary from year to year, depending on the amount of rain. In general the mean annual salinity value varies between 33,0 parts per thousand (mouth) to 19,2 parts per thousand in the upper reaches. Extremes in salinity fluctuations were most apparent in the upper estuary whereas the salinity in the mouth area remained fairly constant (Table 5).

Hypersaline conditions have been noted in the upper reaches by Marais (1975) and Grindley (1976). During the years 1969 to 1972 values up to 42 parts per thousand were recorded in the upper reaches of the estuary. These conditions developed during the summer months as a result of high evaporation and low freshwater inflow.

The difference between surface and bottom salinity is generally small (1-2 parts per thousand), but can be greater in the middle and upper reaches (Grindley, 1976; Melville-Smith, 1978; Woolridge, 1979).

Turbidity

The waters of the Swartkops Estuary are reasonably clear having a mean Secchi disc reading of approximately 1,5 m (Table 5).

pH

The pH recorded within the Swartkops Estuary was generally constant around 8,0 (Table 5), with little difference (ca. 0,1) being noted between surface and bottom waters (McLachlan, 1972).

Dissolved Oxygen

The waters of the estuary are well oxygenated, having a more or less constant value around 4,5 ml O_2/l, (McLachlan, 1972).

TABLE 5: A summary of important abiotic variables in the different regions of the estuary. McLachlan (1972) and Wooldridge (1979) took readings at 10 and 14 stations along the length of the estuary during the periods December 1971 to November 1972 and November 1976 to October 1978 respectively.

Factor	Mouth region	Lower reaches	Middle reaches	Upper reaches
Temperature (°C)				
range	19-25	15-26	14-27	14-26
mean	19	21	20	20
Salinity (°/oo)				
range	33-35	5-35	3-35	3-35
mean	34	30	26	22
Secchi disc reading (m)				
mean	1,5	1,2	1,5	1,3
Dissolved O_2 (O_2 ml/l)				
mean	4,49	4,59	4,97	5,03
pH				
mean	8,0	8,1	8,0	8,0

Nutrients

Erasmus, *et al.*, (1980) and Watling (1981) determined the levels of ammonia, nitrite, nitrates, phosphates and total phosphorus at six stations along the length of the Swartkops Estuary, during the periods May 1979 to May 1980 and June 1980 to May 1981 respectively. Their results are summarized in Table 6 and Figure 14. The nutrient status of the Swartkops Estuary is described by Emmerson (1985).

In the Swartkops Estuary there was a marked fluctuation in the nutrient levels during the survey period. The nitrate levels were much lower for the 1980/81 period than they were for the 1979/80 period, while the reverse was observed for phosphate concentrations (Table 6). The above situation was probably largely due to variations in river flow rates, as the latter apparently affects the nutrient content of the estuary (Watling, 1981). In addition to the above, the nitrate levels in the estuary had a marked seasonal variation with a peak in winter (Figure 14). There is no evidence of winter die-back of halophytes (*Spartina* etc.), while *Zostera* has virtually disappeared from the Swartkops during the past two years. The phosphate levels showed no clear seasonal trend but floods appear to depress the phosphate concentrations (Figure 14). The nutrient levels increased towards the upper reaches, indicating the terrestrial origin of most of the estuarine nutrients (Watling, 1981). Net nutrient exports from the estuary were recorded for ammonia, nitrite, nitrate, phosphate and silicate with total nutrient exports of 4,7 to 6,8 tonnes per day (Emmerson, 1985).

FIG. 14: Nitrate and phosphate levels in the Swartkops River.
(after Erasmus et al 1980 and Watling 1981)

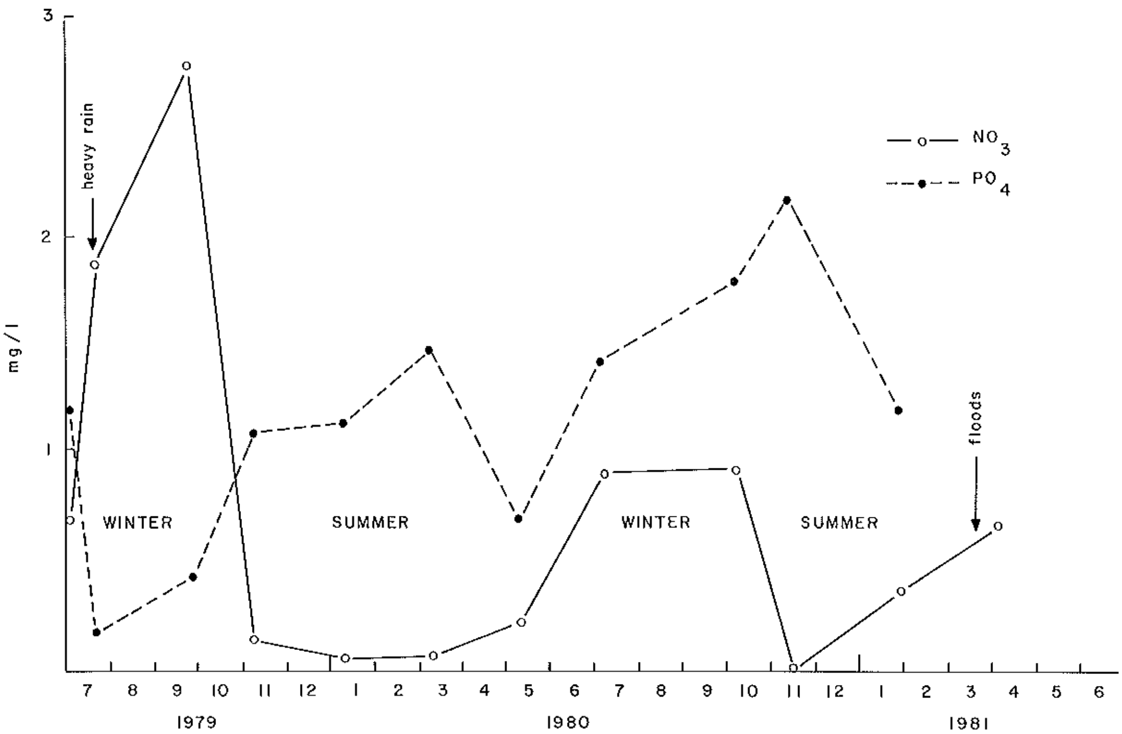


TABLE 6: Mean nutrient levels in the Swartkops Estuary and Algoa Bay during summer and winter during the periods (a) May 1979 - May 1980 and (b) June 1980 - May 1981. (ND = no data).

Area	Season	Total ammonia $\mu g l^{-1}$	Nitrite $\mu g l^{-1}$	Nitrate $\mu g l^{-1}$	Phosphate $\mu g l^{-1}$	Total phosphorus $\mu g l^{-1}$	Silicate $\mu g l^{-1}$
Swartkops	(a) summer	3	14	134	883	1070	ND
	(a) winter	12	4	2029	381	635	ND
	(b) summer	11	13	215	1640	1767	ND
	(b) winter	2	8	317	1984	2212	1140
Algoa Bay	(a) summer	3	3	24	116	ND	ND
	(a) winter	18	5	146	398	608	ND
	(b) summer	1	6	84	316	456	ND
	(b) winter	3	6	122	ND	ND	ND

3.2.6 Pollution

Although no industrial or sewage effluent is discharged into the estuary itself, it enters the river freely near Uitenhage and Perseverance. There are four main sources (HKS, 1974b):

(a) the wool washing factory situated about 1,5 km upstream of Uitenhage;

(b) sewage outfall near Nivens Bridge;

(c) Uitenhage sewage works outfall, which discharges about 4,5 million litres of tertiary treated sewage a day near De Mist Bridge;

(d) the tannery at Perseverance.

The water of the river thus becomes highly mineralized and therefore contains large amounts of inorganic substances. The river has, however, a large regeneration ability and is able to oxidize the incoming material. Most of the effluent is apparently broken down before it reaches the estuary (HKS, 1974d). The Department of Water Affairs has set up a control unit to monitor the effluent discharges within the estuary.

A detailed survey of heavy metal concentrations in the Swartkops Estuary has been conducted by Watling and Watling (1982). They concluded that the estuary exhibits clear indications of man-derived heavy metal concentrations. The villages of Redhouse, Swartkops and Amsterdamhoek, together with the brickworks are the areas most affected. The Swartkops area may obtain a contribution from the power station effluent while Uitenhage and Despatch effluent probably contribute to the contamination of the Redhouse area. The Fishwater Flats sewer outfall appears to be a further source of contamination but the metals have only been noted in the water column and not in the sediments. Oysters grown in the Blue Hole at the mouth have accumulated zinc, copper, lead and nickel to levels greater than the normal metal concentrations in the estuary. In general, however, the metal concentrations are not excessively high and should be no cause for concern at present.

A study was undertaken by the Department of Zoology, University of Port Elizabeth in 1983, to obtain information about the residue levels of organochlorine compounds such as PCBs (polychlorinated biphenyls) and DDT (dichlorodiphenyltrichloroethane) and its metabolites in six estuaries along the eastern cape coast of South Africa. DDE (a degradation product of DDT) and PCB residues were found to be present in all the biological samples analysed. The highest residue levels found were 5 200 mg/g for PCB and 1 729 mg/g wet mass for total DDT.

The geometric mean of PCB residues in the fish samples from the Swartkops River was found to be 76,3 mg/g and for DDE 10 mg/g (De Kock and Marais, in preparation). The following table summarizes the geometric mean of the residues found in the species analysed:

Species	Geometric mean of residues found expressed as mg/g wet wt.
Argyrosomus hololepidotus (kob)	72,4
Mugil cephalus (flathead mullet)	50,3
Liza richardsoni (southern mullet)	20,3
Pomadasys commersonni (spotted grunter)	283,9
Gilchristella aestuarius (estuarine round-herring)	178,0
Elops machnata (tenpounder)	242,8
Tachysurus feliceps (sea-catfish)	42,3

HKS (1974c) provide quantitative data on the degree of atmospheric pollution in the lower reaches of the Swartkops Estuary. They concluded that the average background fallout pollution is approximately 3-5 tonnes/km^2/month. This background fallout consists of local fine sand and silt (about 80-85 percent) and the remainder consists of organic "dust" of vegetable origin in various stages of degradation. The greatest fallout of industrial pollution of 15 tonnes/km^2/month was found at the Swartkops Village, which originates mainly from the Swartkops power station and coal-fired steam railway engines which pass through the area relatively frequently. About 25 percent of this fallout consists of volatile matter present as unburnt substances in cinders or coal dust.

3.2.7 Public Health Aspects

Bacteriology

From a study of the available physico-chemical and bacteriological data on the Swartkops River, HKS (1974a) concluded that the river's self purification ability appears to be high and that it appears to be unaffected by the pollutant load.

The water entering the estuary at Perseverance is chemically and bacteriologically of reasonable quality, except during periods of temporary overloading of the Uitenhage sewage works or during floods. Some form of control is desirable to prevent excessive sewage discharges. A review of water chemistry and bacteriology was prepared by Saenger (1973), and further information is provided by Grindley (1974) and Emmerson (1985).

4. BIOTIC CHARACTERISTICS

4.1 Flora

4.1.1 Phytoplankton

Eighteen species of nanoplankton flora belonging to three classes namely, Prasinophyceae, Chrysophyceae and Haplophyceae have been identified from the Swartkops Estuary (see Appendix I). Temperature and salinity appear largely to determine the species composition and their abundance within the estuary (Henrici and Pienaar, 1975).

Phytoplankton production was measured by the C^{14} technique and the average daily production rates were found to vary between 77,9 and 942,3 mgC m^{-2} day^{-1} in summer. There was a trend for production to be higher further up the estuary (near Redhouse) than at the mouth and this also applies to chlorophyll-a concentration and therefore biomass. The presence of fuel oil derived from boat engines appears to have a measurably detrimental effect on the photosynthesis of the micro algae when the five species investigated are combined (Hilmer, 1982).

Phytoplankton and nanoplankton species found in sediments are listed in Appendix II. Dye (1978) determined epibenthic algal production in the mudflats regions of the estuary to be 116,48 gC m^{-2} y^{-1} (SD = 85,47) and 53,04 gC m^{-2} y^{-1} (SD = 18,56). Diatoms and other microplankton on bottom sediments are of significance in the diets of fish (Masson and Marais, 1975).

4.1.2 Aquatic and Semi-aquatic Vegetation

Appendix III lists species of seaweeds and macrophytes found in the Swartkops Estuary. An account of the seaweeds of the estuary was published by Pocock (1955).

Zostera capensis appears to be the only major aquatic macrophyte in the estuary covering an area of approximately 13,7 ha or 2,8 percent of the estuary. Approximately 59 percent of the *Zostera* beds are found in Tippers Creek and 99 percent within 6 km of the river mouth (Talbot, Bate and Robertson (in prep.)). The standing crop of *Zostera* appears to fluctuate seasonally. Talbot *et al.* (in prep.) reported a virtual doubling of the above and below ground biomass in the estuary from July to December 1981; from 3,84 to 7,22 and from 3,92 to 6,02 tonnes dry mass respectively. The *Zostera* plants also serve as a substrate for a large number of epiphytic algae, which have an estimated standing crop of 5,62 tonnes dry mass. However, *Zostera* has virtually disappeared from the Swartkops since these measurements were made. Standing crop at present is very low. Although reasons for the disappearance of *Zostera* are not known, it is thought that a fungal disease or a change in sediment characteristics due to floods, may have affected the growth.

Mr C J Ward of Natal University (pers. comm.) reported fairly large concentrations of *Ruppia spiralis* in the polluted waters of the Chatty River, a tributary of the Swartkops.

Periodic infestations of water hyacinth *(Eichhornia crassipes)* have been reported in the lower reaches of the Swartkops River and would appear to be partly related to excessive outflow of nutrients from the Uitenhage sewage works. Similar periodic "blooms" have been recorded for *Enteromorpha* species which are common in any stagnant area of water in the Swartkops River valley.

4.1.3 Aquatic and Semi-aquatic Vegetation of the Saltmarshes

Vegetated saltmarshes, covering an area of approximately 166 ha (Table 7), are concentrated in the lower reaches of the estuary (MacNae, 1957a). The plant species of this region showed an overlapping zonal distribution from approximately the mid-tide level to HWMST (Pierce, 1979). *Spartina maritima* (rice grass) occurs from the mid-tide level and was succeeded by *Triglochin bulbosa, Sarcocornia perennis* (= *Arthrocnemum perenne), Chenolea diffusa* and *Limonium linifolium* (sea thrift) up the tidal gradient. *Spartina maritima* covered approximately 82 ha or 49 percent of the vegetated marsh and had a total standing crop of 448 tonnes dry mass and a primary production of 496 tonnes dry mass per annum. *Triglochin bulbosa* occurs as a narrow band and was never very abundant. The group comprising *Sarcocornia perennis, Chenolea diffusa* and *Limonium linifolium,* covered 50 percent of the saltmarsh and contributed approximately 759 tonnes dry mass towards the estimated total standing biomass of the marsh (Figure 15 and Table 7).

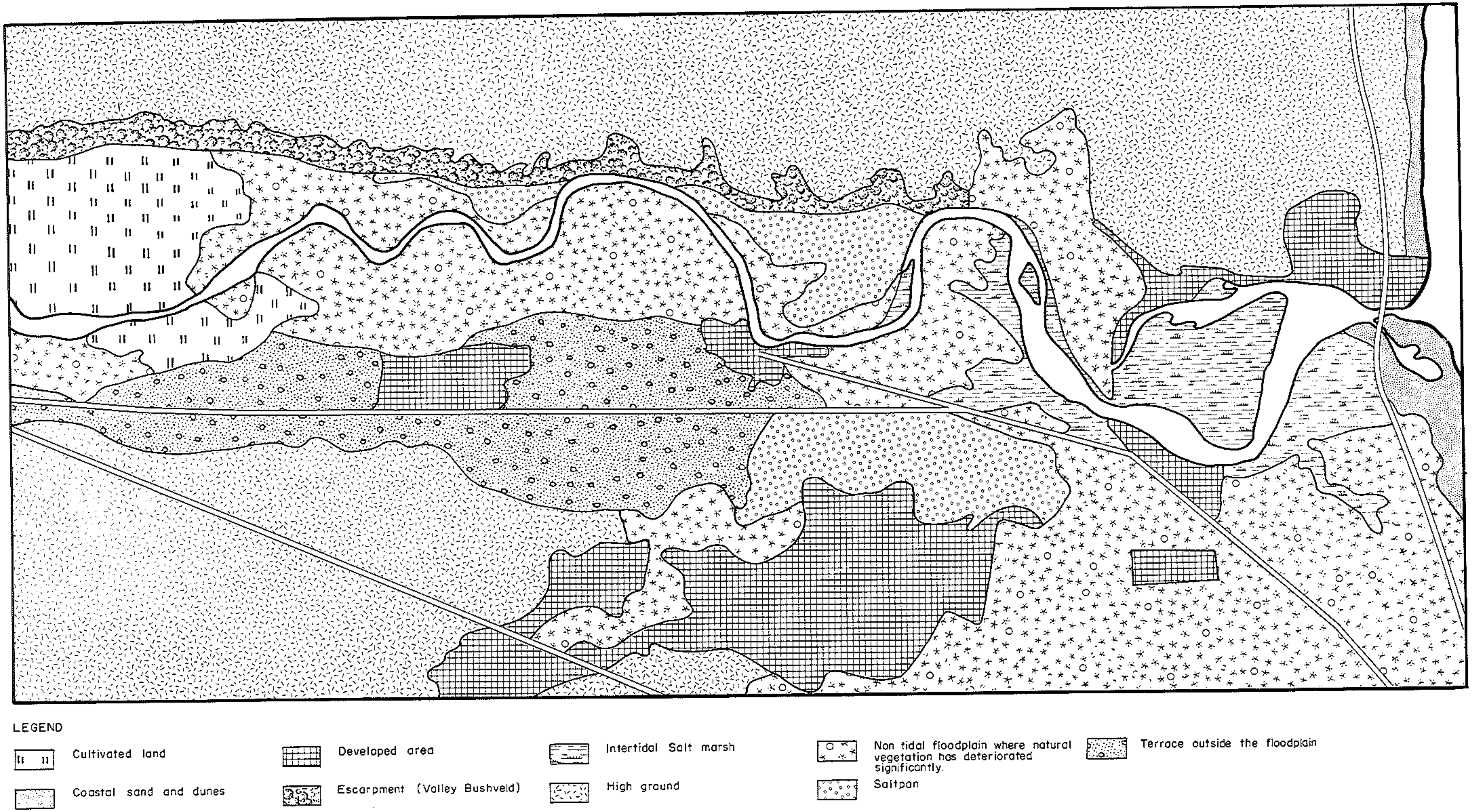


FIG. 15: Vegetation of the Swartkops Basin.

(Revised from Hill *et al* (1974c))

TABLE 7: Standing crops per square metre of saltmarsh vegetation (taken from Baird and Winter, 1979), the area covered by the various species (taken from Talbot, 1982) and total calculated biomass.

	Biomass (dry) g/m^2		Area ha	Total biomass tonnes
Spartina maritima	546		82	448
Trichlochin bulbosa	210		1	2
Sarcocornia perennis	1290			
Chenolea difusa	889	914	83	759
Limonium linifolium	563			

4.1.4 Terrestrial Vegetation

Much of the original vegetation in the Swartkops Basin has been affected by man, mainly by developments such as:

(1) The villages of Redhouse, Swartkops, Amsterdamhoek and Bluewater Bay, as well as on farms close to Perseverance and at Totteridge Park (Figure 15), where land has been cultivated.

(2) Veeplaas (Figure 12), where there has been haphazard development and surface disturbance of the soil.

(3) High lying areas of the Chatty River floodplain (Figure 12), where the nâtural cover (dense scrub growth) has been removed to cultivate crops. Weed species are prevalent and soil erosion has occurred over much of the area.

(4) The area south and southwest of the Swartkops Power Station (Figure 12) where the environment has been destroyed almost completely by man's activities.

(5) On the borders of the various salt concentration pans scattered along the length of the estuary (Figure 12). The ground has either been excavated or the leaching of the brine solution from the pans has made it unfavourable for plant growth. Where the land is vegetated, it is almost completely ruderal or weedy.

(6) At a newly surveyed township south of Perseverance, the indigenous scrub has been removed.

Fig. 16: Flourishing growths of *Spartina maritima* in the salt marshes south of Tippers Creek. (Photo: J.R. Grindley, 1975).

Vegetated areas in the Swartkops Basin which are relatively unaffected by man are as follows (Jacot Guillarmod, 1974):

(a) *Coastal area*

The sand dunes along the coast are colonized by plants such as *Arctotheca populifolia* (sea pumpkin), *Stipagrostis zeyheri* (witgras), *Suaeda maritima* (inkbos), *Passerina rigida* (gonnabas), *Felicia echinatus* (bloublommetjies), *Heteroptilis suffruticosa* and *Plantago carnosa*. The general condition of the plants in the area is good.

(b) *The estuarine floodplain*

Much of the floodplain in the lower and middle reaches is covered by succulent scrubs and herbs such as *Sporobolus virginicus* (brakgrass), *Juncus kraussi* (rietjies), *Asparagus capensis* (katdoring), *Atriplex vestita* (salt bush), *Suaeda* maritima *(inkbos)*. Galenia *spp*. *Crassula* sp. and *Zygophyllum morgsana* (leeubossie).

In the upper reaches of the estuary, the floodplain supports varied vegetation, and is different to that found elsewhere in the floodplain. There is a fair cover of grass species (e.g. *Themeda triandra* (rooigras), *Digitaria* spp. (finger grass), *Cynodon dactylon* (kweek) and *Sporobolus virginicus* (sandkweek) and many sand loving plants such as *Ursinia* and *Carpobrotus* (sour fig). Clumps of shrubby plants also occur, including *Salvia aurea* (brown sage), *Nylandtia spinosa* and a succulent *Tetragonia*. Taller clumps of bushes and shrubs are found on the higher ground, as well as a fair number of *Aloe* spp.

(c) *River and Estuarine terraces above the floodplain*

The area southwest of Redhouse Village is the most fertile part of the basin and supports a vigorous plant growth. The naturally occurring vegetation is varied and includes the grasses: *Themeda triandra*, *Sporobolus* sp. and *Cynodon dactylon*, the herbs: *Albuca* spp. *Asparagus* spp. *Carpobrotus* sp. and *Cotula* sp. and shrubs: *Aloe africana*. *A. striata*, *A. humilis*, *Rhus longispina* (taaibos), *Schotia afra* (boerboon) and *Euphorbia* spp. The only weed of any concern is the *Opuntia* (prickly pear).

Further southwest of the above area, the soil becomes poorer and supports a relatively more open vegetation, such as grass and clumps of shrubby plants (e.g. *Acacia karroo*).

(d) *The escarpment*

The area is a narrow strip of dry clay soil, which is extremely steep in parts. The vegetation is a forest type of mixed species, consisting of *Euphorbia* spp., *Sideroxylon*, *Cussonia*, *Ptaeroxylon* (sneezewood) and *Portulacaria* (elephant bush). Other shorter (understorey) growths also occur (e.g. wild geraniums) *Pelargonium* spp. and various Aizoaceae (vygies). Several weed species occur towards the coast, for example *Senecio pterophorus*, *Opuntia ficus-indica* (prickly pear) and *Acacia cyclops* (rooikrans). The section of the escarpment from the brickfields to a point opposite Perseverance should be protected as a Nature Reserve as proposed by the Zwartkops Trust and the Co-ordinating Council for Nature Conservation in the Eastern Cape.

(e) *High ground*

The plant growth on the plateau area is fairly uniform throughout. Plant height is about 2 m or more and the typical plants recorded were: *Aloe* spp. *Euclea* spp., *Carissa bispinosa*, *Schotia afra*, *Scutia myrtina*, *Pelargonium peltatum*, *Senecio* spp. Further inland *Portulacaria afra*, *Acacia karroo*, *Sideroxylon enerme* and *Grewia* sp. occur (Figure 15).

4.2 Fauna

4.2.1 Zooplankton

To date 52 species of zooplankton have been identified, while another 24 phena remain unidentified (Appendix V). Of the above, 37 were holoplanktonic species (that is, permanently planktonic), the rest were meroplanktonic (temporarily planktonic) e.g. larvae of decapods. The majority of the holoplanktonic forms were copepods and the most dominant species included:

(a) *Pseusodiaptomus hessei*, usually most abundant in the middle and upper reaches of the estuary, having peak numbers in early summer (October - December). It is also a pioneer species exploiting new waters after floods (Grindley, 1974, 1976; Wooldridge, 1979).

(b) *Acartia natalensis* and *A. longipatella* showed a clear spatio-temporal pattern of distribution. *A. longipatella* appeared in the zooplankton fauna in late autumn, reached maximum abundance in winter and spring, before decreasing to be succeeded by *A. natalensis*. The latter reached maximum abundance in summer and autumn (Wooldridge, 1979).

In the cycle, *A. natalensis* first appeared in the upper estuary and subsequently spread seawards, with maximum densities being found in the upper reaches. *A. longipatella*, on the other hand, first appeared in the middle and lower estuary, attaining maximum abundance in water of higher salinity than *A. natalensis* (Wooldridge, 1979).

After a flood, the pioneer species, *Pseudodiaptomus hessei*, was succeeded by either of the above species depending on the season (Grindley, 1974, 1976; Wooldridge, 1979).

In terms of biomass, mysids were the most important. Near the mouth of the estuary they generally formed over 70 percent of the total zooplankton biomass. *Mesopodopsis slabberi* was the most dominant species in this region. The abundance of *Mesopodopsis slabberi*, and mysids in general, decreased upstream. Above Swartkops Village, the latter generally contributed less than 40 percent of the total biomass. In the middle and upper reaches *M. slabberi* was replaced by *Gastrosaccus brevifissura* as the dominant mysid (Wooldridge, 1979).

4.2.2 Meiofauna

The highest densities of meiofauna in the estuary appeared to be in the saltmarshes, where their distribution and biomass fluctuate in relation to the vegetation type as follows:

Spartina: 1,17 x 10^6 m^{-2} (0,257 g dry mass m^{-2})

Trichlochin: 75,6 x 10^6 m^{-2} (16,630 g dry mass m^{-2})

Chenolea: 51,6 x 10^6 m^{-2} (11,242 g dry mass m^{-2})
(from Baird and Winter, 1979).

Generally within the estuary, nematodes are the dominant group accounting for about 84 percent of the total meiofauna. Marine nematodes identified so far are listed in Appendix VI. The meiofauna shows two peaks of abundance, one in spring and one autumn, in both the mudflats and sandbanks. The summer minimum is due to low oxygen conditions while the winter minimum is due to low temperatures (Dye and Furstenberg, 1978).

Probably the next most important group are the harpacticoid copepods. In the sand flats, the latter make up about 11,5 percent of the meiofauna. Their numbers, however, decrease in the muddy regions as they are intolerant of low oxygen concentrations. The remaining 4,5 percent of the meiofauna consist of oligochaetes, polychaetes, flat-worms and gastrotrichs.

4.2.3 Macrofauna

A total of 122 species of macrobenthos have been recorded for the Swartkops Estuary (Appendix VII) and Grindley (1974).

In the soft substrata the dominant burrowing macrobenthic species appeared to be the mud prawn, *Upogebia africana*, the sand prawn, *Callianassa kraussi*, the grapsoid crabs of the genus *Cleistostoma* and the bivalves of the genus *Solen*. These formed approximately 80, 11, 3 and 3 percent respectively of the total standing biomass (Hanekom, 1980).

U. africana were found mainly in the muddy intertidal regions of the lower reaches, where the mean usually ranged from about 200-300 individuals per m^2. The sand prawn, *C. kraussi*, had a very wide distribution both vertically and horizontally within the estuary. The largest populations were recorded in the "Blue hole" (in the mouth region) and the upper reaches of the estuary. In the former area the highest densities (*ca.* 90 individuals/m^2) were recorded in the mid-tide region, while in the upper reaches the greatest numbers (*ca.* 100-300 individuals/m^2) were found in the borders of the sub- and intertidal regions.

The two species of the genus *Cleistostoma, C. algoense* and *C. edwardsii* tended to be spatially separated. The latter colonized (densities *ca.* 20 individuals/m^2) the more solid sand and muddy substrates, while *C. algoense* preferred the silty water-logged *Zostera* beds of the creek where they occur in fairly high numbers *(ca.* 70 individuals/m^2).

The large bivalves, *Solen capensis* and *S. corneus* occurred in relatively low densities *(ca.* 6 and 20 individuals/m^2 respectively). As with the previous genus, the two species tended to be spatially separated. The former was restricted to the sandy areas below the Swartkops road and railway bridges, while *S. corneus* colonized the muddier areas above the bridges and in the creeks (Hanekom, 1980).

The species diversity of macrobenthic invertebrates of the saltmarshes is typically low, but with a relatively high biomass. Three species occur abundantly namely two grapsoid crab species *Sesarma catenata* and *Cleistostoma edwardsii,* and a small hydrobiid gastropod *Assiminea (bifasciata?)*. The numbers and biomass for these species are as follows (Baird and Winter, 1979; Els, 1982):

S. catenata	53 individuals/m^2	8,4 g dry mass/m^2
C. edwardsii	99 individuals/m^2	4,06 g dry mass/m^2
A. (bifasciata?)	1912 individuals/m^2	6,2 g dry mass/m^2 (shell free)

4.2.4 Insects

MacNae (1975b) reported that large numbers of flies hover over wracks of dead *Spartina* and *Zostera* washed up on the shore of the estuary and that countless tiny midges hide among them. The species of flies which have been identified are *Canace cala, Canace* sp. and *Xanthocanace* sp. and *Hydrophorus praecox* of the family Dolichopodidae and *Lispe cilitanus* of the family Muscidae.

Except for the above there appear to be few other prominent insects. Pierce (1979) recorded only one insect consumer of *Spartina maritima*, namely, a member of the family Miridae.

4.2.5 Fish

The species of fishes occurring in the Swartkops Estuary are listed in Appendices VIII and IX. Appendix VIII summarizes the results of fish nettings carried out in the Swartkops Estuary in 1915 by FitzSimons, whose original manuscript records are still in the Port Elizabeth Museum. Appendix IX provides a list of the species of fishes known to occur in the Swartkops Estuary including species from the Swartkops Estuary in the collections of the JLB Smith Institute of Ichthyology, Rhodes University.

Fishing has been carried out in the Swartkops Estuary for a very long time and there were problems in regulating the fishery even in the early days. The first legislative measure dealing with fishery matters in South Africa was the Act of 1883 with regard to netting in the Swartkops. From time to time various restrictions have been imposed on fishing and bait gathering activities and as early as the year 1912 it was resolved to carry out some investigations to throw light on the many disputed points regarding the fish resources of the estuary. It was agreed to close the estuary to netting for three years and to carry out investigations in the meanwhile by means of experimental nettings and other observations. There was considerable controversy about the alleged declining availability of fish in the estuary and as early as 1913 representations were made to the Government to introduce restrictions on angling operations in addition to those on netting.

A total of 86 species of fish have been recorded in the Swartkops Estuary (Appendix IX). Beckley (1983) sampling with a small, fine mesh seine net, in the *Zostera* beds of the lower reaches of the estuary, recorded 39 species. *Hepsetia breviceps* (Cape silverside), the Mugilidae (mullets), *Rhabdosargus holubi* (Cape stumpnose) and *Gilchristella aestuarius* (estuarine round-herring) constituted approximately 46, 20, 12 and 9 percent respectively of the total catch in terms of numbers.

Winter (1979) using a larger, coarser mesh seine net and sampling at four sites along the length of the estuary recorded 48 species. Numerically, the most important species were *Gilchristella aestuarius (ca.* 54 percent), followed by *Hepsetia breviceps (ca.* 19 percent) and *Rhabdosargus holubi (ca.* 6 percent), while in terms of mass the mullets *Liza dumerili (ca.* 47 percent) and *L. richardsoni (ca.* 14 percent) dominated the catches.

From gill net catches made along the length of the estuary Marais and Baird (1980a), recorded 21 species. The spotted grunter, *Pomadasys commersonni,* dominated gill net catches both in terms of numbers (17 percent) and mass (29 percent). The Mugilidae (5 species) as a group was the next most important comprising 25 and 42 percent in terms of numbers and mass respectively.

P. commersoni was the most abundant angling fish caught. In terms of numbers and mass it comprised approximately 84 percent of the total recorded catches (Marais and Baird, 1980b). It was followed by *Lithognathus lithognathus* (white steenbras), *Argyrosomus hololepidotus* (kob) and *Lichia amia* (leervis).

The dangerous Zambezi Shark, *Carcharhinus leucas,* has been recorded from the Swartkops Estuary (JLB Smith Insitute of Ichthyology collections). A Miss T Toft was attacked by a shark on 3 February 1920 (Davies, 1964).

Marais and Baird (1980a) comparing their catches (gill nets) with those (seine net) of FitzSimons (1915), suggested a drastic decrease in the relative abundance of *Rhabdosargus holubi* since the turn of the century and an increase in the numbers of *Pomadasys commersonni.* If however, the seine net catches of Winter (1979) were taken and the values for the small fish species of the families Antherinidae, Clupeidae, Gobiidae and Soleidae, which can only be caught in a fine mesh net, were excluded, the basic trends observed were similar to those recorded by FitzSimons (1915) (Table 8). The Mugilidae and *Rhabdosargus holubi* dominated the catches, with other species being far less common.

The main discrepency between the results of the two surveys was the relative number of *Diplodus sargus* caught (Table 8). This however, was most likely due to differences in the mesh sizes used, as *D. sargus* is a marine species, and usually it is only the small juveniles which enter the estuaries (see Van der Elst, 1981; Beckley, 1983). It would thus appear as if no major changes have occurred in the relative abundance of the various fish species in the Swartkops Estuary.

Summaries of FitzSimons' (1915) work only include the mass values of the larger specimens collected (Appendix VIII). The largest specimens of *Rhabdosargus holubi, Pomadasys commersonni, Pomatomus saltatrix* an *Lichia amia* recor e by FitzSimons (1918) appear comparable to the mean values recorded in the gill net and angling catches documented by Marais and Baird (1980a, 1980b). In the case of *Argyrosomus hololepidotus* and *Lithognathus lithognathus,* however, the largest specimens of FitzSimons (namely 32 and 16 kg respectively) were considerably (> 4 times) heavier than the mean values of Marais and Baird. This might suggest that the larger and therefore older individuals of the above two fish populations have been significantly reduced over the 70 years since the survey. This phenomenon could influence the future juivenile recruitment in the estuary.

TABLE 8: The relative abundance (expressed as a percentage of the total) of the major fish species recorded in seine net catches of FitzSimons (1915) and Winter (1979) and gill net catches of Marais and Baird (1980a). In the case of Winter (1979) values of the fish species belonging to the families Antherinidae, Clupeidae Gobiidae and Soleidae were excluded.

Species name	Common name	Relative abundance (%) recorded by:		
		FitzSimons	Winter	Marais & Baird
Rhabdosargus holubi	Cape stumpnose	46	34	9
Mugilidae	Mullet	34	43	44
Lithognathus lithognath''s	White steenbras	7	2,5	1
^rgyrosomus hololeptidotus	Kob	4	0,3	4
Tachysurus feliceps	Sea-catfish	3	0,8	6
Pomadasys commersonni	Spotted grunter	2	0,8	18
Pomatomus saltatrix	Elf	2	0,1	1
Lichia amia	Leervis	1	0,1	6
Monodactylus falciformis	Cape moony	< 1	<0,1	5
Diplodus sargus	Blacktail	< 1	15	< 1
Lithognathus mormyrus	Sand steenbras	< 1	0,5	< 1
Elops machnata	Skipjack	< 1	<0,1	5
Pomadasys olivaceum	Piggy	< 1	0,3	< 1
		n=17 311	n=2 665	n=1 235

Ichthyoplankton

Seventeen species of larval fish caught in plankton nets in the Swartkops Estuary have been identified (Appendix X). Although ichthyoplankton was present in the estuary throughout the year, it was only abundant during the summer months, November to February. A few dominant species, for example, the Gobiidae (56 percent) and a clupeid species, *Gilchristella aestuarius* (31 percent) accounted for 87 percent of all the fish larvae found. The former group was abundant in the mouth and lower reaches, while *G. aestuarius* was found mainly in the lower and middle reaches (Mellville-smith and Baird, 1980).

4.2.6 Amphibians and Reptiles

Amphibians and reptiles known to occur at the Swartkops Estuary and in adjoining areas are listed in Appendices XI (Amphibia) and XII (Reptiles) (A de Villiers, Cape Department of Nature and Environmental Conservation (CDNEC), *in litt.).*

Among the Amphibia the Cape Sand Frog, *Tomopterna delalandii* is a small burrowing frog that breeds in freshwater slacks and has been observed feeding on invertebrates on sandy beaches. The Clicking Stream Frog, *Strongylopus grayii,* breeds in seepage zones adjacent to the estuary. The Raucous Toad, *Bufo rangeri,* and the Leopard Toad, *Bufo pardalis,* breed and feed in the veld adjacent to the estuary. The former breeds in winter and the latter in summer. The Rain Frog, *Breviceps adspersus pentheri,* is a small microhylid that lays its eggs in moist soil where they develop within the egg and emerge as fully formed froglets.

Among the lizards the spotted gecko, *Pachydactylus maculatus*, is common in debris along the strand line. The dwarf chameleon, *Bradypodion ventrale*, is common in the Valley Bushveld adjacent to the estuary. The legless skink, *Acelotes anguina*, is a species endemic to the Algoa Bay region and prefers sandy soils. Smith's Skink, *Mabuya homalocephala smithii*, is a medium sized skink that feeds in the valley bushveld undergrowth. The Rock Agama, *Agama atra*, a common lizard, utilizes debris at the strand line, and also calcrete and rock outcrops. The common girdled lizard, *Cordylus cordylus*, is adapted for living in rock cracks and is common in the calcrete and conglomerate rocks of the valley floor.

Among the snakes the Brown House Snake, *Lamprophis fuliginusus*, and the Olive House Snake, *Lamprophis inornatus*. are common harmless rodent-eaters. The latter is restricted to the moister areas of the Cape coastal region. The slug-eater, *Duberria lutrix*, is a small, shy, harmless snake, common in adjacent damp areas, that feeds on slugs. The Red-lipped Snake, *Crotaphopeltis hotamboeia*, is a medium-sized, back-fanged, but clinically harmless snake, that feeds exclusively on amphibians, and which is common in the adjacent moist areas. The Boomslang, *Dispholidus typus*, is a large, but shy, clinically-dangerous back-fanged snake, that is common in the valley bushveld, which feeds mainly on birds and chameleons. The Puff-adder, *Bitis arietans*, is a large viper, common in the coastal regions. It feeds mainly on rodents, and is attracted to suburban situations by the increase in food. Although clinically dangerous, the incidence of death from puff-adder bites is less than 1 per cent. The Cape Cobra, *Naja nivea*, is a large, diurnal, dangerously-venomous snake. It is common in undisturbed open bush, along the valley cliffs, but is soon eliminated in suburban situations. It is responsible for most snakebite deaths in the Eastern Cape (i.e. one to two deaths per year). The Sea Snake, *Pelamis platurus*, is a pelagic, marine hydrophid which occassionally strands on the beaches of Algoa Bay. Its venom is not as toxic as other hydrophids, and it is unlikely to cause death, despite its much-maligned name.

Among the tortoises the Angulate Tortoise, *Chersina angulata*, is the commonest tortoise in the Eastern Cape coastal regions, and can reach densities of 40 tortoises/hectare in suitable situations.

Among the turtles the Loggerhead Turtle, *Caretta caretta*, and the Green Turtle, *Chelonia mydas*, may be found in the estuaries of the Eastern Cape, and individuals seem to take up residence in certain estuaries. They feed on the dense *Zostera* beds. Loggerhead turtles breed on the Natal coast but the nearest Green turtle breeding rookery is Europa Island in the Mocambique Channel. Whether local turtles migrate back to breed, or are non-breeding vagrants, is unknown (A de Villiers, CDNEC, *in litt.*).

4.2.7 Birds

The Swartkops Estuary was found to contain the largest population of waders (Charadrii) of all estuaries in the southern and eastern Cape, with the exception of the Knysna Lagoon (Underhill, *et al.*, 1980). Schramm (1978) also showed it to be a very important overwintering area for Palaearctic waders. Information on the birds of the estuary can be found in Edwards (1971) and in the East Cape Wild Bird Society newsletters (Blake, 1973; Edwards and Tree, 1971; Grindley, 1974; Every, 1976; Martin, 1984).

A detailed study of the avifauna of the estuary is currently underway and Appendix XIII documents the mean number of birds counted during regular weekly surveys of the estuary in January 1984 and July 1984 (Martin, *in litt.*). Palaearctic migrant waders and terns (Sternidae) formed 84 percent of the total birds on the estuary in January and 35 percent of the total in July, indicating the great importance of the Swartkops as a year-round feeding area for migrant shorebirds (Charadridae). Four species, Grey Plover, Curlew Sandpiper, Common Tern and Whimbrel, make up 77 percent of the Palaearctic migrants.

The mud banks from Settler's Bridge to 1 km above the Swartkops rail bridge support the majority of birds using the estuary (Schramm, 1978) and the adjacent saltmarsh provides roosting areas. Due to frequent human disturbance a large area of mudbank and salt marsh needs to be maintained to protect the birds from disturbance.

Appendix XIV from McGill (1985) lists all the birds sighted within the past 2 years on the Swartkops Estuary as well as in the adjacent saltpans and bush. Nine of the species listed (indicated by an asterisk) are regarded as being rare, vulnerable or threatened (Siegfried, *et al.*, 1976). Six of these species regularly use one particular saltpan in the valley. The Caspian Tern breeds on the saltpan forming what is probably the second largest colony in South Africa. The nests of Greyheaded Gulls (Randall and Hosten, 1983), Whitebreasted Cormorants, Sacred Ibis and the largest Kelp Gull colony in the area are also found on this saltpan. However, human disturbance has resulted in the removal of a large number of eggs in the past, including those of the Caspian Tern. The saltpans support a large number of Greater Flamingos and several Lesser Flamingos and provide safe roosting and feeding areas for many waders. It is vital that this area receives protection, ideally by incorporating it into the proposed nature reserve along the northern escarpment of the Swartkops River.

The most important invertebrate prey item of the birds on the estuary is the mudprawn *(Upogebia africana)*. Any major change in the abundance and distribution of the mudprawn will be reflected in a change in the bird population and therefore regular bird counts of the estuary should be carried out as a convenient means of monitoring its biological status.

4.2.8 Mammals

A survey of mammals occurring in the Swartkops River valley has been conducted by Stuart *et al.* (1980) and Stuart (1981). The majority of mammal species occur in the upper reaches of the estuary on the west bank and escarpment in the area of the proposed Nature Reserve. A list of mammals is given in Appendix XV. Most of these species are seldom seen but the Cape Grey Mongoose, Vervet Monkey and Striped Mouse are more commonly observed than the others.

5. SYNTHESIS AND RECOMMENDATIONS

The Swartkopswagendrift farm was established in 1776. Since those early settler days in the 18th Century the Swartkops Estuary has been recognized as an important local feature. The estuary is rich and productive and supports good fish populations. Fishing was carried out in the Swartkops Estuary from those early times and there were problems in regulating these activities even then. The first legislation dealing with fishing matters in South Africa was the Act of 1883 with regard to netting in the Swartkops. The Swartkops Estuary supports large numbers of birds, including the largest population of waders in the eastern Cape. This is important in view of South Africa being a signatory to the Ramsar convention (Carp, 1972).

The Swartkops Estuary is an exceptionally valuable environmental feature for the Port Elizabeth metropolitan area. Just as Cape Town has Table Mountain, so Port Elizabeth has the Swartkops Estuary as a natural area. Despite the extensive urban and industrial development that now surrounds it, the estuary is in remarkably good condition. Port Elizabeth thus has a unique resource - a fine large estuary fulfilling its natural ecological functions and providing valuable recreational opportunities within the urban fabric. To maintain this resource is a considerable challenge to conservation, for while the natural ecology of the Swartkops Valley and Estuary must be maintained, the valley is part of a rapidly developing region and thus cannot all be set aside as a natural wilderness.

The Working Committee for the Coastal Zone of the Council for the Environment is compiling a national policy for the South African coastal zone, as well as guidelines for development types within the various components of the coastal zone. This includes developments affecting estuaries and problems of the kinds identified by the Zwartkops Trust are specifically addressed in these guidelines. The Minister for Environment Affairs and Fisheries has requested the preparation of environmental impact studies in respect of all developments which encroach on beaches, disturb sand dunes or have an effect on riverside vegetation and estuarine ecology (Hon John Wiley, Press Statement, 15 February 1984).

Fig. 17: View across the extensive salt marshes lying to the south of Tippers Creek with the village of Swartkops and the Swartkops Power Station in the background. (Photo: J.R. Grindley, September 1984).

Regional Planning

The Port Elizabeth City Council in whose area the estuary is located, is very conscious of the fact that the Swartkops Estuary is extremely vulnerable to the pressures of urban development. In 1977 the City Council adopted a Structure Plan for the river valley that had as its principal objective the preservation of the estuary and the development of its recreational potential whilst at the same time ensuring that the demand for land for urban expansion could be met without detriment to the natural environment.

In terms of the Government's development plan, Port Elizabeth/Despatch/Uitenhage is a priority area. The Greater Algoa Bay Planning Authority (GABPA) is investigating various development proposals for this area. The development of a major Black township for more than 100 000 people at Motherwell north of the estuary has been approved and the planning of various roads and other communication links through the area is receiving attention. The question of the renewal of the licences for the controversial salt pans near Redhouse is also being considered. Flood control in the estuary and the influence of developments in the catchment and in the Uitenhage/Despatch metropolitan area are receiving serious attention at present. The development of the Port Elizabeth metropolitan area into the chief centre of industry in the Eastern Cape Region over the past fifty years has resulted in the intrusion of buildings and other structures into the floodplain of the river and estuary. Residential developments, quarrying, brick works, power generating stations, salt evaporation pans and other industries together with road and rail bridges have combined to present a serious threat to the safe passage of floods which are a periodic occurrence in this area. The present increase in urban population in the metropolitan area serves to emphasize the need for carefully co-ordinated planning to avoid flood disasters or other environmental problems in this sensitive area.

The overall transport network in the valley needs further careful attention. The results of the Environmental Study (HKS, 1974a *et seq.)* had not been finalised when the main arterial routes were fixed. Having regard for all the factors arising from that environmental study and from later information it is now necessary to re-assess the overall network affecting the valley. Some of the present proposals appear to be unsatisfactory and have led to criticism from the Zwartkops Trust, the Co-ordinating Council for Nature Conservation in the Eastern Cape, the Council for the Habitat and other bodies.

The Swartkops Basin is thus an area requiring intensive and careful planning. Fortunately, the Environmental Study prepared by Hill Kaplan Scott and Partners (HKS, 1974a *et seq.)* provides a comprehensive information base. This information is further supplemented by a large number of academic studies cited in this report which have been carried out by the University of Port Elizabeth and others. These studies, however, have all concentrated on the estuary whereas the upper sections of the valley in the Despatch and Uitenhage areas are less well-documented. Improved information here would be of value as upstream developments in the catchment may be very important to areas downstream including the estuary. Under these circumstances the Swartkops River Valley Structure Plan prepared in 1975 by Stauch Vorster and Partners on the basis of available information, is of special significance. This has been further updated and amended as Report No. 5 (Stauch Vorster and Partners, 1977). This report is a policy and statutory plan that now forms the basis of the developing Strategy Plan. This will involve the phasing of comprehensive reports on planning strategy leading to Master Plans for development.

A point stressed by the planners is that the whole area is one environmental unit which should not be fragmented and, within this context, the planning of communication links requires further attention. Any housing development should not interfere with the right of public access to the banks of the river and estuary. Private development should in general not be permitted to hold exclusive rights to the water front except possibly if there are newly created stretches of water.

Flooding

As mentioned in Section 3.2.2 of this report, flooding in the Swartkops Valley has been a major problem in the past. Flood levels in the estuary are affected by urban development higher up the valley as a result of increased stormwater run-off into the river. Both surface water run-off and foulwater discharge need to be considered. The canalization proposals of the Uitenhage and Despatch municipalities may improve the discharge of flood waters upstream but might aggravate conditions elsewhere. It has been suggested that the Department of Water Affairs install a flow gauging station, fitted with an automatic water level recorder near to the upper tidal limit of the estuary. This would not only supply a record of flood behaviour but would facilitate monitoring the effects of continuing development. Such measurements would also allow the calculation of the total pollution load from pollution measurements.

In a preliminary report on Swartkops River Flood Control prepared by the Eastern Cape Circle Engineer of the Department of Water Affairs (H L Horn, *in litt.*, 5 August 1983) it is proposed that a joint planning group including the city Engineers of Port Elizabeth, Uitenhage and Despatch and other appropriate bodies should consider legal controls; in particular, whether the State President should be requested to declare a certain area as a Government Water Control Area for the purpose of appointing a competent Advisory Board. Such an Advisory Board might propose appropriate control measures or institute such controls necessary to achieve protection from the effects of floods.

Salt Industry

The salt industry occupies large areas of floodplain but the salt pans are aesthetically unattractive. The salt industry was reported to be inadequately controlled and a source of severe environmental degradation and blight (Stauch Vorster and Partners, 1975). While the salt industry is claimed to be economically important to Port Elizabeth it was pointed out that revenue from other forms of development could be much greater. However, the industry is entrenched in the Swartkops Valley and the leases have several years to run, until 1989 at least. It was suggested that negotiations should be entered into with the salt producing companies to eliminate conflicts and to establish new controls (Stauch Vorster and Partners, 1975).

Coastal Amenities: Blue Hole/New Beach

The increasing Coloured and Black populations of Port Elizabeth, whose spending power has risen rapidly in recent years, require quality beach and coastal amenities. Consequently various developments are being planned including Joorst Park between the Swartkops and Coega estuaries and at the New Beach/Blue Hole area adjacent to the southwest shore of the Swartkops mouth. Of these the New Beach/Blue Hole project is of direct importance to the Swartkops Estuary. At present an oyster farming concession operates in the artificial (dredged) lagoon adjacent to the Blue Hole and in the Blue Hole itself. The environmental constraints to this development include fluvial floods, springtides (particularly when they occur in conjunction with strong easterly winds) and beach erosion. The coast between the Swartkops Estuary and Port Elizabeth harbour has regressed considerably: beach protection works have become necessary to protect the N2 Freeway, the railway yards and Deal Party industrial area. Consequently adequate set-back lines for fixed structures at New Beach were determined (Prestedge *et al.*, 1985). The southwestern embankment of the Settlers Bridge protects the project site from major fluvial floods. However, fluvial floods in conjunction with springtides almost certainly cause extensive flooding of the New Beach/Blue Hole area. The hummock dunes and foredunes between the site and the sea provide shelter from the wind and all but the highest seas. These dunes will require careful management e.g. stabilization with natural vegetation and the provision of formal walkways. The problem of the oyster farm will have to be resolved since shellfish farming and intensive recreation are not compatible. As long as the development is carried out according to sound engineering and coastal zone management principles it should provide an attractive amenity.

Conservation

A number of State and local bodies are concerned with the Swartkops, its management and conservation. The original proposals for nature reserves have been modified on the basis of reports received from the Town Clerk of Port Elizabeth, the Zwartkops Trust and the Eastern Province Light Tackle Boat Angling Association. The established Structure Plan for the area accepted by the City Council allows for the preservation of the saltmarsh areas but the threat of various encroachments still remain. Especially the saltmarshes between Tippers Creek and the main channel, which are largely unspoilt, deserve strict conservation. Once exploitation is prohibited disturbance by the public is likely to be minimal. The saltmarshes between Swartkops Village and the National Road to Settlers Bridge are used for recreational purposes such as bait collection by many people. Properly controlled exploitation of resources of the area through application of regulations is probably preferable to preventing any exploitation or public access. On the other hand, it is essential that further encroachment by development be prohibited particularly for the areas between the railway bridge and the brickfields, the area between the railway bridge and Redhouse and the saltpans opposite Redhouse. The exact demarcation of the areas to be protected will require further attention. In doing so, public access to popular bait collecting banks should, however, not be disrupted unnecessarily so as to avoid public reaction against conservation effort. Bait collecting banks should be excluded from reserve areas where exploitation is prohibited to avoid adverse public reaction. Extending the enforcement of present conservation legislation and preventing the encroachment of further development are essential in addition to the establishment of reserves (Grindley and Cooper, 1979).

In addition to the conservation of the estuary, establishment of the proposed Zwartkops Nature Reserve along the northern escarpment of the estuary from the brickfields to a point opposite Perseverance needs urgent attention. The vegetation of this area is in particularly good condition and contains a large diversity of plants as recorded by Jacot Guillarmod (1974). This dense vegetation, up to 5 m in height in places, forms a closed canopy and serves to bind the shallow top soil protecting the underlying clay. The prime purpose of the Reserve is to protect the vegetation of the area but this will indirectly afford protection to the rich bird life and remaining animal life of this area adjacent to the river and the saltpans. The area is bounded on the riverside by a gravel road that runs along the foot of the escarpment and at the top of the escarpment by the Municipal boundary fence except when kloofs penetrate beyond this. The total area is approximately 400 hectares in extent. It is steep with gradients up to 1 in 1,75 so that the conservation of the vegetation is essential if massive erosion is to be avoided. Ample evidence already exists in adjoining areas of the consequences of removing the bush on such slopes. Detailed proposals for this Reserve have been prepared by the Zwartkops Trust and the Co-ordinating Council for Nature Conservation in the Eastern Cape (Prof R A Lubke, 1 June 1983, *in litt.*). Most of the land concerned is owned by the Port Elizabeth Municipality but areas north of the boundary, owned by the East Cape Administration Board and Erf 104 in private ownership, need to be acquired.

The Zwartkops Trust has played an important role in the planning and control of the Swartkops Estuary and environs. Although the Trust has no statutory or other official powers, it acts as a liaison body between Government departments and Local Authorities and helps to protect the estuary in many ways. Notices signify that the area is "under the protection of the Zwartkops Trust" (see Figure 18). The Trust has published information on the estuary and a guide to legislation affecting the tidal waters of the Swartkops River. The combined efforts of the Port Elizabeth City Council, various conservation bodies and many members of the public need all the support possible. It is of great importance that not only must the future ecological viability of the estuary be insured, but also its recreational function for all people.

The value of this is inestimable especially so in these days where the consequences of socio-economic pressures are becoming so starkly evident in many parts of South Africa.

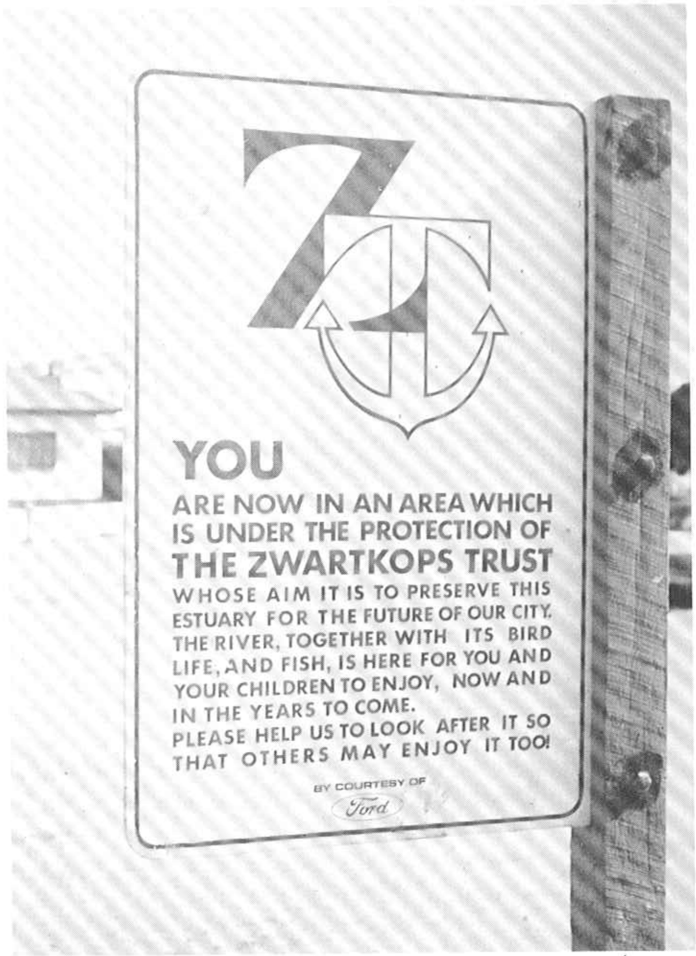


Fig. 18: A notice board of the Zwartkops Trust advertising their conservation activities in the Swartkops Estuary area. (Photo: J R Grindley, May 1971).

6. ACKNOWLEDGEMENTS

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Date	Job No.	Photos Nos	Scale	Colour	Source
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1958	422	6366	1:36 000	B&W	Trig. Survey
Dec. 1980	374	102-106, 114	1:20 000	B&W	University of Natal
April 1980	349	73	1:20 000	B&W	University of Natal
1979	326	216, 217	1:10 000	Col.	University of Natal
Dec. 1981	391	20/4-205/4	1:20 000	Col.	University of Natal

8. 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: orginating 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 the 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.

CUSP: 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.

EDDY: 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.

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 saline 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.

ISOBATH: a line joining points of equal depth of a horizon below the surface.

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 to the shore.

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.

MEIOFAUNA: microscopic or semi-microscopic animals that inhabit sediments but live quite independently of the benthic macrofauna.

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^{o}, 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.

OLIGOTROPHIC: poor in nutrients and hence having a paucity of living organisms.

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.

PERIPHYTON: plants and animals adhering to parts of rooted aquatic plants.

PHOTOSYNTHESIS: the synthesis of carbohydrates in green plants from carbon dioxide and water, using sunlight energy.

PHYTOPLANKTON: plant component 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 silica. 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.

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.

WAVE HEIGHT (average energy wave height): an index which reflects the distribution of average incident wave energy at inshore sites along the coast presented as a wave height.

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 component of plankton.

References:

DAY, J.H. (ed.)(1981). Estuarine ecology with particular reference to Southern Africa. Cape Town, A.A. Balkema.

SOUTH AFRICAN TIDE TABLES (1980). Retreat C.P. The Hydrographer. South African Navy.

APPENDIX I: Nanoplankton flora species occurring in the Swartkops Estuary. (Day, 1981).

	Summer	Winter
Prasinophyceae		
Heteromastix longifilis	o	o
Platymonas sp.	o	
Pyramimonas ? amylifera	o	o
Pyramimonas orientalis		o
Pyramomonas disomata		?
Pyraminmonas sp.	o	
Chrysophyceae		
Apidinella spinifera	o	
Paraphysomonas butcheri	o	
Sphaleromantis marina	o	
Haptophyceae		
Chrysochromulina ephippium	o	
Chrysochromulina ericina		o
Chrysochromulina regularis		o
Chrysochromulina strobilus		o
Prymnesium parvum		o
Prymnesium ? saltans	o	
Imantonia rotunda	o	
Hymenomonas carterae	?	o
Emiliana huxleyi	?	o

o present

APPENDIX II: Phytoplankton and nanoplankton in sediments of the Swartkops Estuary. (Data from Masson and Marais, 1975).

	Mouth	Middle reaches	Upper reaches	Head
Diatoms				
Naviculoid diatoms	+	+	+	+
Nitzschia sp.	+	x	+	+
Synedra sp.	x	x	x	-
Synedra ulna	+	+	-	-
Amphora sp.	x	x	+	+
Cyclotella meneghiniana	+	x	-	-
Fragilaria sp.	x	o	-	-
Surirella sp.	o	o	o	-
Amphiprora paludosa var. *subsalina*	x	x	-	-
Nitzschia sigma	x	x	-	-
Nitzschia transvalensis	o	o	-	-
Stauroneis sp.	o	-	-	-
Coscinodiscus lacustris	o	o	-	-
Tabellaria flocculosa	o	-	-	-

APPENDIX II: (cont.)

	Mouth	Middle reaches	Upper reaches	Head
Pinnularia sp.	x	o	-	-
Nitzschia closterium	-	o	-	o
Melosira sp.	-	o	-	-
Pleurosigma sp.	-	o	-	-
Campylodiscus sp.	-	o	-	-
Diploneis bombus	-	o	o	-
Navicula sp. (in tubes)	-	-	o	-
Gyrosigma variipunctatum	-	-	x	-
Navicula humerosa	-	-	o	-
Synedra fulgens	-	-	o	-
Paralia sulcata	-	-	o	-
Biddulphia aurita	-	-	-	o
Nitzschia spathulata	-	-	-	x
Donkinia sp.	-	-	-	x
Amphiprora sp.	-	-	-	o
Cocconeis scutellum	-	-	-	x
Gyrosigma sp. (in tubes)	-	-	-	o
Achnanthes sp.	-	-	-	o
Bacillaria paradoxa	-	-	-	o
Hantschia virgata	-	-	-	o
Ditylum brightwellii	-	-	-	o
Desmids				
Cosmarium sp.	o	-	-	-
Euastrum sp.	o	-	-	-
Closterium sp.	o	-	-	-
Chlorophyta				
Scendesmus sp.	o	o	-	-
Prediastrum sp.				
Foraminifera	-	o	-	o

o present x frequent + abundant

APPENDIX III: Seaweeds and macrophytes recorded in the Swartkops Estuary (from Day, 1981).

ALGAE

Codium tenue
Enteromorpha bulbosa
Enteromorpha intestinalis
Gracilaria verrucosa
Lyngyba confervoides
Ulva spp.

SPERMATOPHYTA

Chenolea diffusa
Cotula coronopifolia
Cyperus textilis
Samolus porosus
Sarcocornia capensis
Sarcocornia decumbens
Spergularia salina
Sporobolus virginicus
Stenotaphrum glabrum

APPENDIX III: (cont.)

Galenia secunda	*Sarcocornia natalensis*	*Stenotaphrum secundatum*
Juncus kraussii	*Sarcocornia perennis*	*Triglochin bulbosum*
Limonium linifolium	*Sarcocornia pillansiae*	*Triglochin striata*
Phragmites australis	*Scirpus maritimus*	*Zannichellia aschersoniana*
Potamogeton pectinatus	*Scirpus litoralis*	*Zostera capensis*
Salicornia meyeriana	*Spartina maritima*	

APPENDIX IV: Natural vegetation found in the coastal sand dunes, salt marshes and the escarpment north of the estuary. (Information from A. Jacot Guillarmod extracted from Hill Kaplan Scott and Partners, (1974d)).

Coastal Sand and Dunes

Triglochin bulbosa (No common name), *Stipagrostis zeyheri* (Witgras), *Juncus kraussii* (Rietjies, Rush), *Chenolea diffusa* (Soutbossie), *Suaeda maritima* (Inkbos), *Sarcocornia decumbens* (Seekoraal), *Salicornia meyeriana* (Seekoraal), *Passerina rigida* (Gonnabas), *Aster echinatus* (Bloublommetjie), *Cnidium suffruticosom, Plantago carnosa, Ursina chrysanthemoides, Arctotheca nivea* (Sea pumpkin). *Tetragonia decumbens* (Klappiesbrak) and *Scaevola thunbergii.*

Salt Marshes

Stenotaphrum secundatum (Coarse couch grass), *Sporobolus virginicus* (Brakgras, Sandkweek), *Cynodon dactylon* (Fine couch grass, Hardekweek), *Zostera capensis* (Seegras), *Triglochin bulbosa, Phragmites australis* (Reed, Fluitjiesriet), *Sporobolus virginicus* (Brakgras), *Spartina martitima* (Strandkweek), *Eragrostis* spp. (Love grass, Blousaadgras), *Cyperus* spp. (Wateruintjies, Sedges), *Scirpus littoralis* (Sedge), *Juncus kraussii* (Rush, Biesie), *Asparagus capensis* (Katstert, Katdoring), *Bulbine frutescens, Rumex* spp. (Dock, sorrel, suring), *Chenopodium* spp., *Exomis microphylla* (Brakbossie), *Chenolea diffusa* (Soutbossie), *Sarcocornia meyeriana* (Seekoraal), *Suaeda maritima* (Brakbos), *Suaeda vera* (Brakbos, Inkbos), *Sarcocornia decumbens* (Seekoraal), *Sarcocornia perenne, Sarcocornia natalensis, Disphyma crassifolia* (Vygie), *Ruschia* sp. (Vygie, Mesem), *Atriplex vestita* (Saltbush, Karoobrak), *Aspalathus cinerascens, Lessertia stenoloba, Centella coriacea* (Varkoortjies), *Limonium linifolium* (Sea lavender), *Lycium tenue.*

Escarpment

Aloe pluridens (French aloe), *Aloe africana* (Uitenhaagsalwyn), *Gasteria ?nigricans, Bulbine* sp., *Chlorophytum* sp., *Behnia reticulata* (Witbessieklimop), *Asparagus asparagoides* (Cape smilax), *Asparagus* sp. *?racemosus, Sansevieria thyrsiflora* (Mother-in-law's Tongue), *Haemanthus,* sp., *Tritonia* sp., *Antholyza aethiopica* (Suurknol), *Viscum* sp. (Mistletoe, Voëlent), *Rhoiacarpos capensis, Carpobrotus edulis,* Various *mesembryanthemums, Portulacaria afra* (Elephant food, Spekboom), *Boscia oleoides* (Witgatboom, Emigrants' tree, Shepherd's tree), *Maerua cafra, Crassula lycopodioides* (Lizard's tail, Skilpadkos), *Cotyledon ?velutina, Crotalaria* sp. *?capensis, Acacia karoo* (Thorn tree, Doringboom), *Schotia afra* (Boerboom), *Dolichos gibbosus* (Rankertjie, Wild pea), *Tephrosia* sp. *Pelargonium peltatum* (Ivy-leaved geranium, Kolsuring), *P. inquinans* (Scarlet geranium), *Pelargonium* spp. (Geraniums), *Oxalis* sp. (Sorrel, Suring), *Zygophyllum divaricatum, Zygophyllum morgsana* (Leeubossie), *Clausena anisata* (Perdepis), *?Fagara capensis* (Knobthorn, Lemoenboom), *Ptaeroxylon obliquum* (Sneezewood, Nieshout), *Polygala* sp. *oppositifolia ?myrtifolia* (Septemberbossie), *Euphorbia*

APPENDIX IV: (cont.)

ledienii (Noorsdoring), *Euphorbia triangularis* (Chandelier tree, Naboom), *Euphorbia* sp. *?grandidens* (Naboom), *Rhus* spp. *Putterlickia pyracantha* (Wolwedoring), *Maytenus cymosa* (Pendoring), *Pterocelastrus tricuspidatus* (Rooikershout, Cherrywood), *Rhamnus prinoides* (Redwood, Blinkblaar), *Rhoicissus tomentosa* (Wild grape, Wildedruiwe), *Grewia* sp. *?occidentalis* (Four corners, Booghout), *Sida longipes* (Sutherland's curse, Spider legs), *Abutilon* sp. (Chinese lanterns), *Dovyalis* sp. *Gnidia polystachya*, *Myrsine africana* (Cape myrtle, Mirting), *Cussonia spicata* (Cabbage tree, Kiepersol), *Sideroxylon inerme* (Milk wood, Melkhout), *Diospyros* spp. (Monkey apple), *Euclea undulata* (Gwarrie, Ghwarrie), *Jasminum angulare* (Wild jasmine, Wildejessamin), *Olea africana* (Wild olive, Olievenhout), *Azima tetracantha* (Beesting bush, Byangelbos), *Buddleia salviifolia* (Sagewood, Wildesalie), *Secamone frutescens* (Melktou), *Cynanchyum* sp. (Melktou) *Sarcostemma viminale* (Melkbos), *Carissa bispinosa* (Num nums, Lemoenbessie), *Ehretia rigida* (Wild lilac, Cape lilac), *Solanum* sp. (Potato creeper), *Plectranthus* sp., *Barleria* sp., *Peristrophe cernua*, *Hypoestes* spp., *Zehneria* sp., *Pteronia incana* (Vaalbos), *Senecia angulatus*, *Chrysanthemoides monilifera* (Bietou), *Brachylaena* sp. (Lepelbos).

APPENDIX V: Zooplankton species found in the Swartkops Estuary. (Sources: Grindley (1976), Oliff (1976), Wooldridge (1979) and Day (1981)). (+ = present in estuary)

Species	No/m^3	km from mouth
CNIDARIA		
Pleurobrachia sp.	9,5	5
Lensia sp.	4,8	5
Diphyes sp.	0,3	3
POLYCHAETA		
Desdemona sp.	0,3-3,2	7
DIPTERA		
Chironomus sp. larvae	1,6	11
CLADOCERA		
Penilia avirostris	0,3	0,5
Evadne sp.	0,3-0,6	3,5
CALANOID COPEPODA		
Paracalanus crassirostris	44-179	1,5-5
Paracalanus parvus	1	1,5-3
Paracalanus aculeatus	1,6	5
Pseudodiaptomus hessei	37-8800	5-11
	0-40000	1-13
Pseudodiaptomus nudus	0,3-6	1,5-5
Acartia natalensis	1,6-546	7-11
	0-46000	1-13
Acartia africana	1,3-17	1,5-3
Acartia longipatella	8-3880	5-11
	0-40000	1-13
Acartia clausi	+	1,5-3
Acartia filosa	+	1,5-3
Labidocera sp.	0,3-1,3	5-9
Tortanus capensis	0,3-30	1,5-9

APPENDIX V: (cont.)

Species	No/m³	Km from mouth
Calanoides carinatus	+	-
Centropages chierchiae	+	-
Clausocalanus furcatus	+	-
Porcellidium sp.	+	-
Tegastes sp.	+	-
CYCLOPOID COPEPODA		
Oithona brevicornis/nana	1,6-12,7	5 & 9
Oithona sp.	1,0-9,8	1,5-5
Oithona similis	+	1,5-5
Oithona plumifera	+	1,5-5
Corycaeus sp.	1,9-2,5	1,5-3
Cyclopetta sp.	0,3	7
Halicyclops sp.	0,3-38	7
Ergasilis sp.	1,6-6,3	7,9 & 11
HARPACTICOID COPEPODA		
Clytemnestra sp.	1,6	5
Enterpina acutifrons	0,3-0,6	1,5-3
MYSIDACEA		
Gastrosaccus brevifissura	0-4654	5-9
	2-450	1-13
Gastrosaccus psammodytes	-	1,2
Rhopalophthalmus terranatalis	0,3-119	5-10
Mesopodopsis slabberi	0,6-813	5-11
	2-19875	1-6
Tenagomysis ? sp.	0,3	1,5-3
AMPHIPODA		
Melita zeylanica	0,3-12,7	7
Paramoera capensis	+	-
Grandidierella lignorum	0,3-63,5	1,5-10
Corophium triaenonyx	-	-
Corophium sp.	1,6-7,9	7
ISOPODA		
Cirolana sp.	0,3-1,0	7
Lanocira sp.	0,3-1,6	7
Paranthura sp.	7,9-32	7
Synidotea sp. (setifer?)	3,2	11
Sphaerpma annandalei ?	+	-
DECAPODA		
Upogebia africana larvae	0,6-8	1,5-9-10
Hymenosoma orbiculare larvae	0,3-13	5-11
Palaemon pacificus	+	1-13
UROCHORDATA		
Oikopleura sp.	9,2-116	1,5-3
UNIDENTIFIED SPECIES		
Medusae	2,8-8,3	1,5-5
Cyphonautes larvae	1,3	1,5-3
Actinula larvae	1,6	5

APPENDIX V: (cont.)

Species	No/m^3	Km from mouth
Cytherid ostracoda	1,6-4,0	5-7
other ostracoda	0,3-7,9	1,5-10
Chaetognatha	0,3-9,5	3-9
polychaete larvae	0,3-3,2	1,5-3 & 7
Copepod nauplii	0,6-3,2	1,5-7
Tegastid harpacticoids	1,3-1,9	7
other harpacticoids	1,6-11,1	1,5-9
Caligoid copepoda	0,3	7
Monstrilloida	0,3-0,6	3-5
cirripede nauplii	6,3-19,0	7-10
cirripede cypri	0,3-1,6	1,5-5
Tanaidea	0,3-48	5-9
Cumacidea	0,3-16	1,5-10
Gammarids	0,3-0,6	9-10
Sphaeromids	0,3-7,9	7
Cryptoniscid larvae	1,6-5,6	5-9
caridean larvae	0,3-3,5	7-10
brachyuran larvae	0,3-1168	1,5-11
gastropod larvae	6,3-169	1,5-11
pelecypod larvae	1,6-6,3	5-7
ascidian larvae	0,3	1,5

APPENDIX VI: List of marine Nematode genera so far identified from the Swartkops Estuary. (From Dye and Furstenberg, 1981).

Note: To date, 52 genera have been identified of which the dominant one is *Theristus* and the subdominant ones are *Cobbia*, *Pomponema*, *Rhips*, *Leptogastrella* and *Axonolaimus*.

ORDER 1	ARAEOLAIMIDA	ORDER 3	DESMODORIDA	ORDER 5	ENOPLIDA
Fam.	Axonolaimidae	Fam.	Desmodoridae	Fam.	Enoplidae
Subfam.	Axonolaiminae		n.g.	Subfam.	Enoplolaiminae
Genus	*Axonolaimus*	Subfam.	Spiriniinae	Genus	*Enoplolaimus*
	Odontophara	Genus	*Onyx*		*Mesocanthion*
	n.g.		n.g.	Subfam.	Enoplinae
Subfam.	Diplopeltinae	Subfam.	Metachromadorinae	Genus	*Enoplus*
Genus	*Araeolaimus*		n.g.	Subfam.	Enoploidinae
		Subfam.	Desmodorinae	Genus	*Enoploides*
ORDER 2	MONHYSTERIDA	Genus	*Desmodora*	Subfam.	Trileptinae
		Sub-		Genus	*Fenestrolaimus*
Fam.	Linhomoeidae	genus	*Croconema*		*Trileptium*
	n.g.	Fam.	Ceramonematidae	Fam.	Tripyloididae
Fam.	Monhysteridae	Subfam.	Dasynemellinae	Genus	*Bathylaimus*
Subfam.	Monhysterinae	Genus	*Dasynemoides*	Fam.	Oncholaimidae
Genus	*Cobbia*			Subfam.	Oncholaimellinae

APPENDIX VI: (cont.)

	Gonionchus	ORDER 4	CHROMADORIDA	Genus	*Viscosia*
	Leptogastrella				*Oncholaimellus*
	Mesotheristus	Fam.	Comesomatidae		*Oncholaimus*
	Paramonhystera	Subfam.	Sabatieriinae		*Monocholaimus*
	Theristus	Genus	*Laimella*		n.g.
	Trichotheristus	Subfam.	Dorylaimopsinae	Fam.	Enchelidiidae
Subfam.	Xyalinae	Genus	*Dorylaimopsis*	Subfam.	Eurystominae
Genus	*Xyala*	Subfam.	Comesomatinae		n.g.
	n.g.1	Genus	*Comesoma*		
	n.g.2	Fam.	Chromadoridae		
Fam.	Siphonolaimidae	Subfam.	Euchromadorinae		
	n.g.	Genus	*Rhips*		
Fam.	Scaptrellidae	Genus	*Actinonema*		
Genus	*Scaptrella*		*Graphonema*		
		Subfam.	Hypodontoliminae		
		Genus	*Hypodontolaimus*		
			Dichromadora		
			Nygmatonchus		
		Subfam.	Chromadorinae		
		Genus	*Chromadorina*		
		Fam.	Cyatholaimidae		
		Subfam.	Pomponematinae		
		Genus	*Pomponema*		
		Subfam.	Paracanthonchinae		
		Genus	*Paracanthonchus*		
			Paracyatholaimus		
		Subfam.	Cyatholaiminae		
		Genus	*Metacyatholaimus*		
		Fam.	Choniolaimidae		
		Genus	*Choniolaimus*		
			n.g.		

APPENDIX VII: Macrobenthic invertebrates found in the Swartkops Estuary and major areas of colonization (Modified from data given by Emmerson *et al.*, 1982).

Species	Major areas of colonization km from mouth
CNIDARIA	
Actinia equina	0-1
Pseudactina flagellifera	0-1
NEMERTEA	
Polybranchiorhynchus dayi	1-4
ECHIURIDA	
Ochaetostoma capensis	1-4

APPENDIX VII: (cont.)

Species	Major areas of colonization km from mouth
POLYCHAETA ERRANTIA	
Ceratonereis erythraensis	2-4
Clymene glandularis	1-5
Deopatra neopolitana	1-4
Glycera tridactyla	1-4
Harmothoe aequiseta	3
Lumbrineris tetraura	0-2
Nephtys hombergi	1-2
Nephtys tulearensis	0-2
Nereis willeyi	3-10
Nereis succinea	1-3
Perinereis falsovariegata	1-2
Sthenelais boa	1-3
POLYCHAETA SEDENTARIA	
Arenicola loveni	1-2
Capitella (capitata?)	7-10
Chaetopterus varieopterus	1-3
Goniadopsis incerta	0-2
Ficopomatus (= Mercierella) enigmatica	1-2
Magelona papillicornis	0-2
Nerine cirratulus	0-2
Notomatus fauvelii	0-2
Orbinia (augrapequensis?)	0-1
Pectinaria pseudokoreni	1-3
Prionospia sexoculata	9-10
Thelepus plagiostoma	1-3
Sabellastarte longa	1-3
CIRRIPEDIA	
Balanus amphitrite	0-1
Balanus elizabethae	0-1
Chthamalus deutatus	0-1
AMPHIPODA	
Corophuum triaenonyx	1-2
Grandidierella lignorum	7
Melita zeylancia	2-5, 7
Orchestia ancheidos	1
Orchestia rectipalma	2-5
Talorchestia australis	1-2
Urothoe pulchella	7
ISOPODA	
Cirolana (fluviatilis?)	7
Eurydice longicomis	1-2
Exosphaeroma hylecoetes	1-2
Lanocira sp	7
Panathura	7

APPENDIX VII: (cont.)

Species	Major areas of colonization km from mouth
Paridotea ungulata	2-5
Pontogeloides latipes	1-2
Synidotea (variegata?)	11
Tylos capensis	1-2
MACRURA	
Alpheus crassimanus	1-5
Artemia salina	Saltponds
Betaeus juncundus	1-2
Hippolyte kraussiana	2-5
Palaemon pacificus	Tippers creek
Penaeus canaliculatus	Tippers creek
Penaeus indicus	Tippers creek
Penaeus japonicus	Tippers creek
Penaeus latisulcatus	Tippers creek
Penaeus monodon	Tippers creek
Penaeus semisulcatus	Tippers creek
ANOMURA	
Callianassa kraussi	2 & 11
Diogenes brevirostris	1-7
Porcellana streptocheles	0-1
Upogebia africana	2-8
BRACHYURA	
Cleistostoma algoense	1-8
Cleistostoma edwardsii	1-8
Cyclograpsus punctatus	1-3
Dotilla fenestrata	1-2
Hymenosoma orbiculare	2-5
Plagusia chabra	0-1
Rhyncoplax bovis	0-1
Scylla serrata	2-5
Sesarma catenata	2-5
MOLLUSCA : AMPHINEURA	
Acanthochiton garnoti	Tippers creek
Chiton tulipa	1-5
MOLLUSCA : BIVALVIA	
Artina squamifera	2-7
Brachidontes ? variabilis	2-5
Bomia africana	1-3
Crassostrea margaritacea	1 & 3
Donax serra	0-1
Donax sordidus	0-1
Dosinia hepatica	5-9
Eumarcia paupercula	5-11
Lamya capensis	2-5
Lima africana	1 & 3
Loripes clausus	2-5

APPENDIX VII: (cont.)

Species	Major areas of colonization km from mouth
Lucina edentiula	2
Macoma litoralis	2-14
Musculus virgiliae	15
Papyridea papyracea	1-5
Perna perna	0-1
Psammotellina capensis	1-3
Solen capensis	1-5
Solen corneus	1-7
Tivela compressa	5-7
MOLLUSCA : GASTROPODA	
Aplysia spuria	0-1
Assiminea bifasciata ?	2-7
Berthella granulata	0-1
Crepidula hepatica	0-1
Cymatium doliarum	0-1
Dendrodoris	0-1
Diodora mutabilis	0-1
Godiva quadricolor	0-1
Halcion pectunculus	0-1
Halcion pruinosa	0-1
Haminea alfoedensis	0-1
Littorina africana var. *knysnaensis*	0-1
Nassarius kraussianus	Modderspruit
Natica tecta	0-1
Notarchus leachii	1-3
Philine asperta	1-3
Oxystele sinensis	0-1
Oxystele tigrina	0-1
Oxystele variegata	0-1
Siphonaria oculus	0-1
Turbo cidaris	0-1
ECHINODERMATA	
Amphipholis squamata	1-2
Patiriella exigua	1-2
Ophiothrix triglochin	0-1
Echinocardium cordatum	1-2
Parenchinus augulosa	1-5
TUNICATA	
Ascidia sp	1-2
Pyura stolonifera	1-5

APPENDIX VIII: Summary of results of fish netting in the Swartkops Estuary in 1915 (FitzSimons, 1915).

Scientific name	Common name	Number caught		Maximum weight (kg)
		Range	Mean per netting	
Rhabdosargus holubi	Stumpnose	0-3036	293	1
Mugil cephalus	Flathead mullet	9-591	169	3
Mugil tricuspidens etc	Mullet	0-398	51	2,5
Lithognathus lithognathus	Steenbras	1-142	44	16
Argyrosomus hololepidotis	Kob	0-321	23	32
Tachysurus feliceps	Sea barbel	0-491	20	1
Pomadasys commersonni	Spotted grunter	0-144	15	1,5
Pomatomus saltator	Elf	0-52	14	1,5
Lichia amia	Leervis	0-29	6	1
Torpedo marmoratus	Electric skate	0-22	1	7
Monodactylus falciformis	Moon fish	0-12	1	0,1
Diplodus cervinus	Zebra	0-4	-	1
Myliobatis cervus	Sting-ray	0-3	-	12
Rhinobatus annulatus	Sand-shark	0-1	-	3
Trigla capensis	Gurnard	0-1	-	2,5
Diodon hystrix	Porcupine fish	0-1	-	-
Raja rhizacanthus	Skate	0-7	-	(2m across)

APPENDIX IX: A species list of fish caught in the Swartkops Estuary between 1977 and 1982 by seine net, gill net, plankton net and divers. (Modified from Winter, 1979).

Key:
1 = Number as in Smith 1965.
2 = G = Gill net (data from Marais and Baird 1980(a)).
P = Plankton net (data from Melville Smith, 1978).
D = Diver.
F = Angling (data from Marais and Baird, 1980(b)).
Sb = Seine net (data from Beckley (in press)).
Sw = Seine net (data from Winter, 1979).
3 = Common name as in Smith 1975

	Number[1]	Catch method[2]	Common name[3]
CLASS OSTEICHTHYES			
ORDER ANTHERINIFORMES			
Belonidae			
Tylosurus crocodilus	229	G	crocodile needlefish
Exocoetidae			
Hemiramphus far	222	P Sw	spotted halfbeak
Hypopramphys knysnaensis	218	Sw	halfbeak
ORDER CLUPEIFORMES			
Clupeidae			
Etrumeus teres	106	P	redeye round-herring
Gilchristella aestuarius	108	P Sw Sb	estuarine round-herring
Engraulidae			
Stolephorus commersonii	119	P Sw Sb	tropical anchovy

APPENDIX IX: (cont.)

	Number[1]	Catch method[2]	Common name[3]
ORDER ELOPIFORMES			
Chanidae			
Chanos chanos	105	G F Sw	milkfish
Elopidae			
Elops machnata	100	G P F Sw	tenpounder
ORDER GASTEROSTEIFORMES			
Fistulariidae			
Fistularia petimba	361	Sw	smooth flutemouth
Syngnathidae			
Syngnathus acus	350	P Sw Sb	longnose pipefish
ORDER PERCIFORMES			
Ambassidae			
Ambassis gymnocephalus	637	Sw	bald glassy
Ambassis natalensis	634	Sb	slender glassy
Atherinidae			
Hepsetia breviceps	893	S F Sw Sb	Cape silverside
Blennidae			
Omobranchus woodi	965	P Sb	kappie blenny
Carangidae			
Caranx sp.		G F Sw	kingfish
Lichia amia	539	G F Sw Sb	leerfish
Scomberoides sp.		Sw	queenfish
Trachunes capensis	501	Sb	maasbanker
Chaetadontidae			
Chaetodon auriga	592	D	threadfin butterflyfish
Chaetodon blackburnii	606	D	brownburnie
Chaetodon kleinii	600	D	whitespotted butterflyfish
Chaetodon lunula	598	D	halfmoon butterflyfish
Chaetodon marleyi	591	D	doubleash butterflyfish
Chaetodon vagabundus	599	D	vagabond butterflyfish
Heniochus acuminatus	590	D	coachman
Clinidae			
Clinus superciliosus	986	P Sb	super klipvis
Gerreidae			
Gerres rappi	632	Sw	evenfin pursemouth
Lutjanidae			
Lutjunus fulviflamma	659	Sb	dory snapper
Gobiidae			
Glossogobius qiurus	919	P Sw	tank goby
Gobius multifasciatus	927a	P Sw Sb	prison goby
Caffrogobius nudiceps	927	P	barehead goby
Psammogobius knysnaensis	906	P Sw Sb	Knysna sand goby

APPENDIX IX: (cont.)

	Number[1]	Catch method[2]	Common name[3]
Monodactylidae			
Monodactylus falciformis	580	G P F Sw S	Cape moony
Mugilidae			
Liza dumerili	884	G F Sw Sb	groovy mullet
Liza macrolepis	886	G	largescale mullet
Liza richardsoni	887	G F Sw Sb	southern mullet
Liza tricuspidens	882	G F Sw Sb	striped mullet
Mugil cephalus	877	G F Sw Sb	flathead mullet
Myxus capensis	890	G F Sw Sb	freshwater mullet
Valamugil buchanani	888	G Sb	bluetail mullet
Mullidae			
Pseydupeneus pleurotaenia	571	Sb	red-mottled goatfish
Oplegnathidae			
Oplegnathus conwayi	461	D	Cape knifejaw
Platycephalidae			
Platycephalus indicus	1063	G P F Sw	bartail flathead
Pomacanthidae			
Pomacanthodes semicirculatus	584	D	semicircle angelfish
Pomacentridae			
Abudefduf saxatilis	761	D	sergeant major
Abudefduf sordidus	760	D	spot damsel
Pomadasydae			
Pomadasys commersonni	679	G P F Sw Sb	spotted grunter
Pomadasys hasta	686	Sw	javelin grunter
Pomadasys olivaceum	675	Sw Sb	piggy
Pomatomidae			
Pomatomus saltatrix	547	G F Sw	elf
Sciaenidae			
Argyrosomus hololepidotus	552	G P F Sw	kob
Scobbridae			
Scomberomorus commerson	840	Sw	king mackerel
Siganidae			
Siganus canaliculatus	901	Sw	white-spotted rabbitfish
Sparidae			
Acanthopagrus berda	707	G F Sw	riverbream
Diplodus cervinus	714	Sw Sb	wildeperd
Diplodus sargus	713	F Sw Sb	blacktail
Lithognathus lithognathus	726	G F Sw	white steenbras
Lithognathus mormyrus	727	G F Sw	sand steenbras
Rhabdosargus globiceps	708	F Sb	white stumpnose
Rhabdosargus holubi	709	G P F Sw Sb	Cape stumpnose
Rhabdosargus sarba	710	S Sw	Natal stumpnose
Sarpa salpa	731	G F Sw Sb	strepie
Sparodon durbanensis	711	Sb	mussel cracker
Spondyliosoma emarginatum	739	Sb	steentjie

APPENDIX IX: (cont.)

	Number[1]	Catch method[2]	Common name[3]
Serranidae			
Epinephelus quaza	435	Sb	yellowbelly rock cod
Theraponidae			
Pelates quadriliniaetes	402	Sb	trumpeter
Terapon jarbua	401	Sw	thornfish
ORDER PLEURONECTIFORMES			
Soleidae			
Heteromycteris capensis	321	P Sw Sb	Cape sole
Solea bleekeri	328	P Sw Sb	blackhead sole
ORDER SILURIFORMES			
Ariidae			
Tachysurus feliceps	165	G F Sw	sea catfish
ORDER TETRAODONTIFORMES			
Balistidae			
Laputa ungazi	1138	Sw	Pando filefish
Stephanolepis auratus	1140	Sb	porky
Ostraciontidae			
Ostracion lentiginosus	1176	D	white-spotted boxfish
Ostracion tuberculatus	117	D	boxy
Tetrosomus concatenatus	1174	D	triangular boxfish
Diodontidae			
Lophodiodon calori	1184	Sb	fourbar porcupine fish
Tetraodontidal			
Amblyrhynchotes honckenii	1198	Sw	evileyed blaasop
Arothron hispidus	1207	Sw Sb	white-spotted blaasop
Arothron immaculatus	1203	Sb	blackedged blaasop
Chelonodon laticeps	1202	Sw	bluespotted blaasop
CLASS CHONDRICHTYES			
ORDER RAIJIFORMES			
Dasyatidae			
Gymnura natalensis	86	G Sw	butterflyray
Myliobatidae			
Myliobatis aquila	75	G Sw	eagleray
Rhinobatidae			
Rhinobatus annulatus	43	Sw	lesser guitarfish
Torpedinidae			
Torpedo sinuspersici	71	G	marbled electric ray
FRESHWATER SPECIES			
Centrarchidae			
Mycropterus salmoides		G	largemouth bass

APPENDIX IX: (cont.)

Additional species of fishes recorded in the holdings of the JLB Smith Institute of Ichthyology (M Bruton, *in litt.*, 9 September 1983)

Pachymetopon aeneum	(Sparidae)
Coryphaena hippurus	(Coryphaenidae)
Sphyraena genie	(Sphyraenidae)
Lobotes surinamensis	(Lobotidae)
Lutjanus argentimaculatus	(Lutjanidae)
Austroglossus pectoralis	(Soleidae)
Caranx sexfasciatus	(Carangidae)
Caranx ignobilis	(Carangidae)
Trachynotus africanus	(Carangidae)
Alextis ciliaris	(Carangidae)
Trachyurus delagoae	(Carangidae)
Pachycentrum canadum	(Pachycentridae)
Aluterus scriptus	(Balistidae)
Cantherines pardalis	(Balistidae)
Engraulis capensis	(Engraulidae)
Stolephorus holodon	(Engraulidae)
Antennarius striatus	(Antennariidae)
Nomeus gronovii	(Nomeidae)
Drepane punctata	(Ephippidae)
Trichiurus lepturus	(Trichuridae)
Carcharinus brachyurus	(Carcharinidae)
Mustelus sp.	(Carcharinidae)
Galeorhinus galeus	(Carcharinidae)
Squalus megalops	(Squalidae)
Torpedo fuscomaculata	(Torpedinidae)
Raja clavata	(Rajidae)
Raja miraletus	(Rajidae)
Megalops cyprinoides	(Megalopidae)
Pliotrema warreni	(Pristiophoridae)
Chelidonichthys capensis	(Triglidae)
Chelidonichthys kumu	(Triglidae)
Chelidonichthys queketti	(Triglidae)
Gerres punctatus	(Gerreidae)
Eleotris fusca	(Eleotridae)
Siganus sutor	(Siganidae)
Ophisurus serpens	(Ophisuridae)
Halaelurus natalensis	(Seyliorhinidae)
Stromataeus fiatola	(Stromateidae)
Chaetodon mendoncae	(Chaetodontidae)
Merluccius capensis	(Merlucciidae)

Additional species of indigenous freshwater and estuarine fish recorded by the Albany Museum (P. Skelton, *in litt.*, 9 September 1983)

Barbus afer	*Barbus pallidus*
Sandelia capensis	*Anguilla mossambica*
Gilchristella aestuarius	*Atherina breviceps*
Monodactylus falciformis	*Glossogobius tenniformis*
Mugil cephalus	*Myxus capensis*
Liza richardsoni	*Pomadasys commersoni*

APPENDIX IX: (cont.)

Additional species of alien freshwater fish recorded by the Albany Museum

Oreochromis mossambicus	*Tilapia sparmanii*
Cyprinus carpio	*Lepomis macrochirus*
Micropterus dolomien	*Micropterus salmoides*

(*Micropterus punctulatus* was introduced in the past but may have died out).

APPENDIX X: Larval fish in the Swartkops Estuary in order of percentage composition which each species formed of the total number of larvae sampled (November 1976 - October 1978). The mean number of each species/m^3 water positively sampled and the maximum (modal) and minimum sizes sampled over the same period are also recorded. (From Melville-Smith and Baird, 1980).

Species	% composition by number	Mean no/m^3 water	Length (mm)		
			min.	(modal)	max.
Gobiidae	56,233	1,324	2	(3)	18
Gilchristella aestuarius	31,124	0,907	2	(5)	28
Omobranchus woodi	6,725	0,306	3	(4)	22
Psammogobius knysnaensis	3,209	0,133	2	(3)	11
Hepsetia breviceps	0,865	0,074	4	(12)	20
Rhabdosargus sp.	0,519	0,056	6	(13)	20
Monodactylus falciformis	0,268	0,030	6	(8)	10
Argyrosomus hololepidotus	0,207	0,048	2	(3)	16
Etrumeus teres	0,205	0,063	14	(22)	33
Stolephorus commersonii	0,185	0,044	18	(28)	33
Solea bleekeri	0,127	0,039	4	(5)	6
Elops machnata	0,094	0,021	31	(34)	39
Heteromycteris capensis	0,057	0,033	7	(9)	10
Unidentified larvae	0,050	0,063	-	-	-
Syngnathus acus	0,036	0,042	10	(12)	14
Pomadasys sp.	0,019	0,029	10	(15)	19
Platycephalus indicus	0,018	0,046	7	(11)	12
Hemirhamphus far	0,015	0,018	6	(--)	31
Clinus superciliosus	0,012	0,035	16	(--)	26
Blenniidae	0,009	0,028	8	(--)	14

APPENDIX XI: Amphibian species which can be expected in the estuary area and adjacent veld. (A de Villiers (CDNEC) *in litt.*).

RANIDAE	
Cape Sand Frog	*Tomopterna delalandii*
Clicking Stream Frog	*Strongylopus grayii*
BUFONIDAE	
Raucus Toad	*Bufo rangeri*
Leopard Toad	*Bufo pardalis*
MICROHYLIDAE	
Rain Frog	*Breviceps adspersus pentheri*

APPENDIX XII: The following species of reptiles have been recorded or can be expected to be found in the estuary area and adjacent veld. (A de Villiers (CDNEC) *in litt.*).

SAURIA (lizards)

Gekkonidae	
Spotted gecko	*Pachydactylus maculatus*
Chamaeleonidae	
Common dwarf chameleon	*Bradypodion ventrale*
Scincidae	
Legless skink	*Scelotes anguina*
Smiths skink	*Mabuya homalocephala smithii*
Agamidae	
Rock agama	*Agama atra*
Cordylidae	
Common girdled lizard	*Cordylus cordylus*

SERPENTES (snakes)

Colubridae	
Brown House Snake	*Boaedon fuliginosus*
Black House Snake	*Lamphrophis inornatus*
Slug eater	*Duberria lutrix*
Red-lipped snake	*Crotaphopeltis hotamboeia*
Boomslang	*Dispholidus typus*
Viperidae	
Puff-adder	*Bitis arietans*
Night adder	*Causus rhombeatus*
Elapidae	
Cape Cobra	*Naja nivea*
Sea snake	*Pelamis platurus*

CHELONIA (tortoises and turtles)

Angulate tortoise	*Chersina angulata*
Green turtle	*Chelonia mydas*
Loggerhead turtle	*Caretta caretta*

APPENDIX XIII: Mean number of birds counted in January 1984 and July 1984 from weekly counts of the Swartkops River' (Martin *in litt.*).

Common Name	January 1984	July 1984
Whitebreasted Cormorant	1	7
Cape Cormorant	0	53
Reed Cormorant	1	21
Grey Heron	7	1
Goliath Heron	2	1
Purple Heron	0	1
Great White Egret	0	2
Little Egret	14	53
Yellowbilled Stork	1	0
Sacred Ibis	4	81
African Spoonbill	0	39
Yellowbilled Duck	8	2
Cape Teal	0	1

APPENDIX XIII: (cont.)

Common Name	January 1984	July 1984
Osprey	0	1
Black Oystercatcher	22	14
Ringed Plover	44	3
Whitefronted Plover	20	105
Kittlitz's Plover	5	24
Sand Plover	18	3
Grey Plover	646	164
Blacksmith Plover	0	1
Turnstone	135	51
Terek Sandpiper	34	17
Common Sandpiper	4	0
Greenshank	182	24
Knot	2	0
Curlew Sandpiper	582	25
Little Stint	4	0
Sanderling	118	0
Ruff	4	0
Bartailed Godwit	24	0
Curlew	43	37
Whimbrel	388	94
Blackwinged Stilt	0	29
Kelp Gull	429	446
Greyheaded Gull	10	0
Caspian Tern	6	5
Swift Tern	0	13
Sandwich Tern	6	1
Common Tern	460	77
Little Tern	21	0
Pied Kingfisher	1	5
Giant Kingfisher	0	2
Total	3 246	1 403
Number of Species	33	34

APPENDIX XIV: Birds sighted within the past 2 years on the Swartkops Estuary and adjacent area (McGill, 1985).

Roberts'+ no.	Common name	Roberts'+ no.	Common name
3	Jackass Penguin*	67	Little Egret
6	Great Crested Grebe	71	Cattle Egret
7	Blacknecked Grebe	81	Hamerkop
8	Dabchick	84	Black Stork*
55	Whitebreasted Cormorant	90	Yellowbilled Stork*
56	Cape Cormorant	91	Sacred Ibis
58	Reed Cormorant	94	Hadeda Ibis
60	Darter	95	African Spoonbill
62	Grey Heron	96	Greater Flamingo*
63	Blackheaded Heron	97	Lesser Flamingo*
64	Goliath Heron*	102	Egyptian Goose
65	Purple Heron	103	South African Shelduck
66	Great White Egret	104	Yellowbilled Duck

APPENDIX XIV: (cont.)

Roberts'+ no.	Common name	Roberts'+ no.	Common name
105	African Black Duck	335	Little Tern
106	Cape Teal	339	Whitewinged Tern
112	Cape Shoveller	348	Feral Pigeon
113	Southern Pochard	349	Rock Pigeon
117	Maccoa Duck	350	Rameron Pigeon
118	Secretary Bird	352	Redeyed Dove
127	Blackshouldered Kite	354	Cape Turtle Dove
136	Booted Eagle*	355	Laughing Dove
148	African Fish Eagle*	385	Klaas's Cuckoo
152	Jackal Buzzard	386	Diederik Cuckoo
160	African Goshawk	391	Burchell's Coucal
165	African marsh Harrier	395	Marsh Owl
170	Osprey	401	Spotted Eagle Owl
172	Lanner Falcon	415	Whiterumped Swift
181	Rock Kestrel	417	Little Swift
198	Rednecked Francolin	418	Alpine Swift
203	Helmeted Guineafowl	424	Speckled Mousebird
208	Blue Crane	426	Redfaced Mousebird
228	Redknobbed Coot	428	Pied Kingfisher
244	African Black Oystercatcher	429	Giant Kingfisher
245	Ringed Plover	431	Malachite Kingfisher
246	Whitefronted Plover	435	Brownhooded Kingfisher
248	Kittlitz's Plover	451	Hoopoe
249	Threebanded Plover	460	Crowned Hornbill
251	Sand Plover	465	Pied Barbet
254	Grey Plover	486	Cardinal Woodpecker
255	Crowned Plover	488	Olive Woodpecker
258	Blacksmith Plover	494	Rufousnaped Lark
262	Turnstone	507	Redcapped Lark
263	Terek Sandpiper	518	European Swallow
264	Common Sandpiper	520	Whitethroated Swallow
269	Marsh Sandpiper	523	Pearlbreasted Swallow
270	Greenshank	526	Greater Striped Swallow
271	Knot	529	Rock Martin
272	Curlew Sandpiper	533	Brownthroated Martin
274	Little Stint	541	Forktailed Drongo
281	Sanderling	545	Blackheaded Oriole
284	Ruff	547	Black Crow
286	Ethiopian Snipe	550	Whitenecked Raven
288	Bartailed Godwit	566	Cape Bulbul
289	Curlew	568	Blackeyed Bulbul
294	Avocet	572	Sombre Bulbul
295	Blackwinged Stilt	577	Olive Thrush
297	Spotted Dikkop	596	Stonechat
298	Water Dikkop	601	Cape Robin
312	Kelp Gull	614	Karoo Robin
315	Greyheaded Gull	635	Cape Reed Warbler
322	Caspian Tern*	638	African Sedge Warbler
324	Swift Tern	643	Willow Warbler
326	Sandwich Tern	645	Barthroated Apalis
327	Common Tern	664	Fantailed Cisticola
328	Arctic Tern	669	Greybacked Cisticola

APPENDIX XIV: (cont.)

Roberts'+ no.	Common name
677	Levaillant's Cisticola
681	Neddicky
686	Spotted Prinia
690	Dusky Flycatcher
698	Fiscal Flycatcher
700	Cape Batis
710	Paradise Flycatcher
713	Cape Wagtail
716	Richard's Pipit
727	Orangethroated Longclaw
732	Fiscal Shrike
742	Southern Tchagra
746	Bokmakierie
757	European Starling
759	Pied Starling
760	Wattled Starling
764	Glossy Starling
769	Redwinged Starling
775	Malachite Sunbird
783	Lesser Doublecollared Sunbird
785	Greater Doublecollared Sunbird
792	Black Sunbird
796	Cape White-eye
801	House Sparrow
803	Cape Sparrow
810	Spectacled Weaver
813	Cape Weaver
814	Masked Weaver
824	Red Bishop
846	Common Waxbill
860	Pintailed Whydah
872	Cape Canary
877	Bully Canary
878	Yellow Canary
879	Whitethroated Canary
881	Streakyheaded Canary
885	Cape Bunting

* Threatened species listed in the South African Red Data Book (Siegfried *et al.*, 1976) are indicated with an asterisk. The status of these birds has been revised in the latest Red Data Book (Brooke, 1984).

\+ Roberts' numbers according to Maclean, 1985.

APPENDIX XV:

Mammals of the Swartkops

The following are a list of the mammals recorded by Stuart *et al.* (1980) and Stuart (1981) for the area covered by the quarter degree grid 3325 DC.

Common name	Scientific name
ORDER CARNIVORA	
Cape clawless otter	*Aonyx capensis*
Striped weasel	*Poecilogale albinucha*
Striped polecat	*Ictonyx striatus*
Large spotted genet	*Genetta tigrina*
Yellow mongoose	*Cynictis penicillata*
Cape grey mongoose	*Herpestes pulverulentus*
Water mongoose	*Atilax paludinosus*
ORDER CHIROPTERA	
Schreiber's long-fingered bat	*Mincopterus schreibersi*
Wahlberg's epauletted fruit bat	*Epomophorus wahlbergi*
ORDER INSECTIVORA	
Forest shrew	*Myosorex varius*
Dwarf shrew	*Suncus etruscus*
Red musk shrew	*Crocidura flavescens*

APPENDIX XV: (cont.)

Common name	Scientific name
ORDER PRIMATES	
Vervet monkey	*Cercopithecus aethiops*
ORDER ARTIODACTYLA	
Bushpig	*Potamochoerus porcus*
Grysbok	*Raphicerus melanotis*
ORDER RODENTIA	
Bush karoo rat	*Otomys unisulcatus*
Vlei rat	*Otomys irroratus*
Saunders vlei rat	*Otomys saundersae*
Grey pygmy tree mouse	*Dendromus melanotis*
SA pygmy gerbil	*Gerbillurus paeba*
Cape short-tailed gerbil	*Desmodillus auricularis*
Striped mouse	*Rhabdomys pumilio*
Pygmy mouse	*Mus minutoides*
House mouse	*Mus musculus*
Multimammate rat	*Praomys natalensis*
Brown rat	*Rattus norvegicus*
Black rat	*Rattus rattus*

APPENDIX XVI: Guide to available information

ESTUARY / RIVERMOUTH / LAGOON: SWARTKOPS ESTUARY

Guide to available information

Section	Subsection	Topic	Algoa Bay Coastal Erosion Invest.	Baird and Winter	Barnard	Beckley	Blake	Brooke	Bruggeman	Carp	Davies	Day	De Kock and Marais	Dye	Dye	Dye and Furstenberg	Dye and Furstenberg	Edwards	Edwards and Tree	Els
MANAGE-MENT		Historical									*									
MANAGE-MENT		Conservation / Utilization								*		*								
MANAGE-MENT		Management / Planning										*								
MANAGE-MENT		Legislation								*		*								
MANAGE-MENT		Water																		
BIOTIC		Food webs / Ecosystems		*						*		*								
BIOTIC	Fauna	Mammals																		
BIOTIC	Fauna	Birds					*	*		*		*						*	*	
BIOTIC	Fauna	Reptiles																		
BIOTIC	Fauna	Amphibians																		
BIOTIC	Fauna	Fish		*	*	*					*	*	*							
BIOTIC	Fauna	Molluscs		*								*								
BIOTIC	Fauna	Crustaceans		*								*								*
BIOTIC	Fauna	Other aquatic invertebrates												*		*	*			
BIOTIC	Fauna	Terrestrial invertebrates																		
BIOTIC	Fauna	Zooplankton										*								
BIOTIC	Flora	Terrestrial vegetation																		
BIOTIC	Flora	Semi-aquatic vegetation		*								*								*
BIOTIC	Flora	Aquatic vegetation		*		*						*								
BIOTIC	Flora	Algae		*								*			*					
BIOTIC	Flora	Phytoplankton		*								*								
BIOTIC		Microbiology																		
ABIOTIC	Chemistry	Pollution							*			*	*							
ABIOTIC	Chemistry	Eutrophication							*			*								
ABIOTIC	Chemistry	General Chemistry							*			*								
ABIOTIC		Salinity										*		*		*	*			*
ABIOTIC	Physics	Circulation and mixing										*								
ABIOTIC	Physics	Hydrology / Flood regime																		
ABIOTIC	Physics	Oceanography	*																	
ABIOTIC	Physics	Climate																		
ABIOTIC	Geology	Sedimentology	*									*		*		*	*			
ABIOTIC	Geology	Palaeoenvironment																		
ABIOTIC	Geology	Geology																		
ABIOTIC	Physio-graphy	Morphology	*									*								
ABIOTIC	Physio-graphy	Dams/Obstructions																		
ABIOTIC	Physio-graphy	Catchment characteristics										*								
YEAR (DATE OF INFORMATION)			1970	1979	1943	1983	1973	1984	1972	1972	1964	1981	-	1977	1978	1978	1981	1971	1971	1982

APPENDIX XVI: (cont.)

ESTUARY / RIVERMOUTH / LAGOON: SWARTKOPS ESTUARY

Category	Subcategory	Guide to available information / Sources of information	Emmerson	Emmerson, Watling and Watling	Erasmus et al	Every	FitzSimons	Fromme	Gilchrist	Grindley	Grindley	Grindley and Cooper	Hanekom	Harrison et al	Hecht	Henrici and Pienaar	Heydorn and Tinley	Hill Kaplan Scott and Part. (a)	Hill Kaplan Scott and Part. (b)	Hill Kaplan Scott and Part. (c)
MANAGEMENT		Historical					*		*											
		Conservation / Utilization								*		*					*			
		Management / Planning								*		*					*	*		
		Legislation										*					*			
		Water												*						
BIOTIC		Food webs / Ecosystems		*						*					*					
	Fauna	Mammals																		
		Birds		*		*				*										
		Reptiles																		
		Amphibians																		
		Fish		*			*		*	*										
		Molluscs		*						*										
		Crustaceans		*						*			*		*					
		Other aquatic invertebrates								*										
		Terrestrial invertebrates																		
		Zooplankton								*	*									
	Flora	Terrestrial vegetation																		
		Semi-aquatic vegetation		*						*										
		Aquatic vegetation								*										
		Algae								*										
		Phytoplankton								*						*				
		Microbiology												*						
ABIOTIC	Chemistry	Pollution	*		*					*				*						
		Eutrophication	*		*					*										
		General Chemistry	*		*					*										
		Salinity		*						*	*		*		*	*			*	
	Physics	Circulation and mixing						*		*									*	
		Hydrology / Flood regime						*												*
		Oceanography						*									*		*	
		Climate															*		*	*
	Geology	Sedimentology						*		*										
		Palaeoenvironment																		
		Geology																		
	Physiography	Morphology						*		*								*	*	
		Dams/Obstructions																	*	
		Catchment characteristics															*	*	*	
YEAR (DATE OF INFORMATION)			1985	1982	1980	1976	1915	1985	1918	1974	1976	1979	1980	1959	1973	1975	1980	(a) 1974	(b) 1974	(c) 1974

APPENDIX XVI: (cont.)

ESTUARY / RIVERMOUTH / LAGOON: SWARTKOPS ESTUARY

Guide to available information

Group	Subgroup	Item	Hill Kaplan Scott and Part. (d) 1974	Hilmer 1982	Huizinga 1984	Jackson 1975	Jacot Guillarmod 1974	Lord, Illenberger, McLachlan 1985	MacLean 1985	MacNae (a) 1957	MacNae (b) 1957	Malan 1978	Marais 1975	Marais 1982	Marais and Baird (a) 1980	Marais and Baird (b) 1980	Martin 1984	Masson and Marais 1975	Mc Gill 1985	Mc Lachlan 1972
MANAGEMENT		Historical																		
		Conservation/Utilization	*	*																
		Management/Planning			*															
		Legislation																		
		Water			*															
BIOTIC		Food webs/Ecosystems																		
	Fauna	Mammals																		
		Birds							*								*		*	
		Reptiles																		
		Amphibians																		
		Fish				*				*	*		*	*	*	*		*		
		Molluscs								*	*									*
		Crustaceans								*	*									
		Other aquatic invertebrates																		
		Terrestrial invertebrates																		
		Zooplankton																		
	Flora	Terrestrial vegetation	*				*													
		Semi-aquatic vegetation	*				*			*	*									
		Aquatic vegetation	*				*			*	*									
		Algae	*				*			*	*									
		Phytoplankton		*									*					*		
		Microbiology																		
ABIOTIC	Chemistry	Pollution										*								
		Eutrophication																		
		General Chemistry																		
		Salinity			*					*	*									
	Physics	Circulation and mixing										*								
		Hydrology / Flood regime			*									*						
		Oceanography						*												
		Climate																		
	Geology	Sedimentology						*												
		Palaeoenvironment																		
		Geology																		
	Physiography	Morphology																		
		Dams/Obstructions																		
		Catchment characteristics	*																	

YEAR (DATE OF INFORMATION) / Sources of information: as given in column headers above.

APPENDIX XVI: (cont.)

ESTUARY / RIVERMOUTH / LAGOON: SWARTKOPS ESTUARY

Guide to available information

			Mc Lachlan and Grindley	Mellville-Smith	Mellville-Smith and Baird	Middleton **et al**	Neethling	Noble and Hemens	Olliff	Pierce	Pierce	Preliminary Investigation of...	Prestedge	Pocock	Randall and Hosten	Reddering and Esterhuysen	Saenger	Schramm	Siegfried **et al**	Smith
YEAR (DATE OF INFORMATION)			1974	1978	1980	1981	1974	1978	1976	1979	1983	1965	1985	1955	1983	1981	1973	1978	1976	1965
MANAGEMENT		Historical					*													
MANAGEMENT		Conservation/Utilization																		
MANAGEMENT		Management/Planning				*							*							
MANAGEMENT		Legislation																		
MANAGEMENT		Water				*											*			
BIOTIC		Food webs/Ecosystems																		
BIOTIC	Fauna	Mammals																		
BIOTIC	Fauna	Birds													*			*	*	
BIOTIC	Fauna	Reptiles																		
BIOTIC	Fauna	Amphibians																		
BIOTIC	Fauna	Fish		*	*															*
BIOTIC	Fauna	Molluscs	*																	
BIOTIC	Fauna	Crustaceans	*																	
BIOTIC	Fauna	Other aquatic invertebrates																		
BIOTIC	Fauna	Terrestrial invertebrates																		
BIOTIC	Fauna	Zooplankton																		
BIOTIC	Flora	Terrestrial vegetation																		
BIOTIC	Flora	Semi-aquatic vegetation								*	*									
BIOTIC	Flora	Aquatic vegetation																		
BIOTIC	Flora	Algae												*						
BIOTIC	Flora	Phytoplankton																		
BIOTIC		Microbiology															*			
ABIOTIC	Chemistry	Pollution							*								*			
ABIOTIC	Chemistry	Eutrophication							*											
ABIOTIC	Chemistry	General Chemistry							*								*			
ABIOTIC		Salinity		*	*							*					*			
ABIOTIC	Physics	Circulation and mixing		*	*															
ABIOTIC	Physics	Hydrology / Flood regime																		
ABIOTIC	Physics	Oceanography											*			*				
ABIOTIC	Physics	Climate				*										*				
ABIOTIC	Geology	Sedimentology											*							
ABIOTIC	Geology	Palaeoenvironment														*				
ABIOTIC	Geology	Geology																		
ABIOTIC	Physiography	Morphology														*				
ABIOTIC	Physiography	Dams/Obstructions				*														
ABIOTIC	Physiography	Catchment characteristics						*								*				

Sources of information: columns above.

APPENDIX XVI: (cont.)

ESTUARY / RIVERMOUTH / LAGOON: SWARTKOPS ESTUARY

Guide to available information

		Sources of information	Smith	Stauch Vorster and Part.	Stuart	Stuart, Lloyd and Herselman	Swart	Talbot	Talbot	Talbot, Bate and Robertson	Taylor and Morris	Underhill Cooper and Waltner	Van der Elst	Van der Merwe	Watling	Watling and Watling	Winter	Wooldridge	Zwartkops Trust	Zwartkops Trust
MANAGEMENT		Historical																		
		Conservation / Utilization									*			*						
		Management / Planning		*										*						
		Legislation																		*
		Water																		
BIOTIC		Food webs / Ecosystems																		
	Fauna	Mammals			*	*														
		Birds										*							*	
		Reptiles																	*	
		Amphibians																		
		Fish	*					*					*				*		*	
		Molluscs																	*	
		Crustaceans																	*	
		Other aquatic invertebrates																		
		Terrestrial invertebrates																		
		Zooplankton																*	*	
	Flora	Terrestrial vegetation									*									
		Semi-aquatic vegetation																		
		Aquatic vegetation								*										
		Algae																		
		Phytoplankton																		
		Microbiology							*											
ABIOTIC	Chemistry	Pollution													*	*				
		Eutrophication																		
		General Chemistry													*	*				
		Salinity																*		
	Physics	Circulation and mixing																		
		Hydrology / Flood regime																		
		Oceanography					*											*		
		Climate																		
	Geology	Sedimentology					*													
		Palaeoenvironment																		
		Geology																		
	Physiography	Morphology		*																*
		Dams/Obstructions																		
		Catchment characteristics																		
YEAR (DATE OF INFORMATION)			1975	1977	1981	1980	1985	1978	1982		1981	1980	1981	1974	1981	1982	1979	1979	1971	1975

NOTES

PLATE I:

Settlers Bridge carrying the N2 freeway across the mouth of the estuary. The houses of Amsterdamhoek face the river while Bluewater Bay lies above the escarpment. This view is from the Aloe Reserve on the escarpment while the water of the Blue Hole may be seen beyond the causeway of the bridge. (Photo: J R Grindley, September 1984).

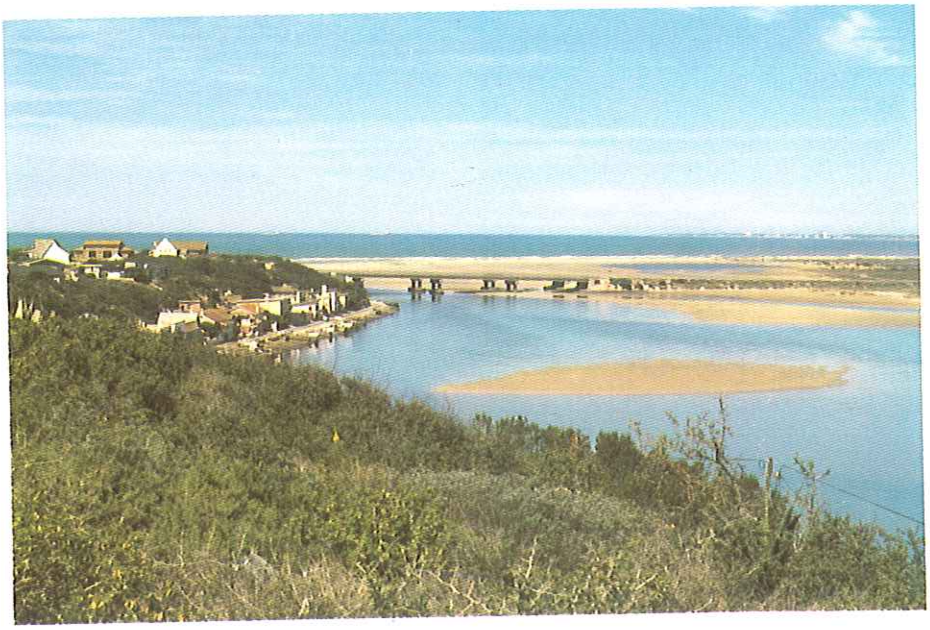

PLATE II:

View from Bluewater Bay across the lower reaches of the estuary with the village of Swartkops and the Swartkops Power Station in the background. The salt marshes of Fishwater Flats lie in the background to the left while the salt marshes south of Tippers Creek are on the right. (Photo: J R Grindley, September 1984).

PLATE III:

An aerial view of the Swartkops Estuary showing the extensive salt marshes of the lower reaches and salt pans in the background. The village of Swartkops is to the left of centre and the brickworks to the right. The village of Redhouse is in the middle distance behind the first salt pans. (Photo: J R Grindley, April 1971).