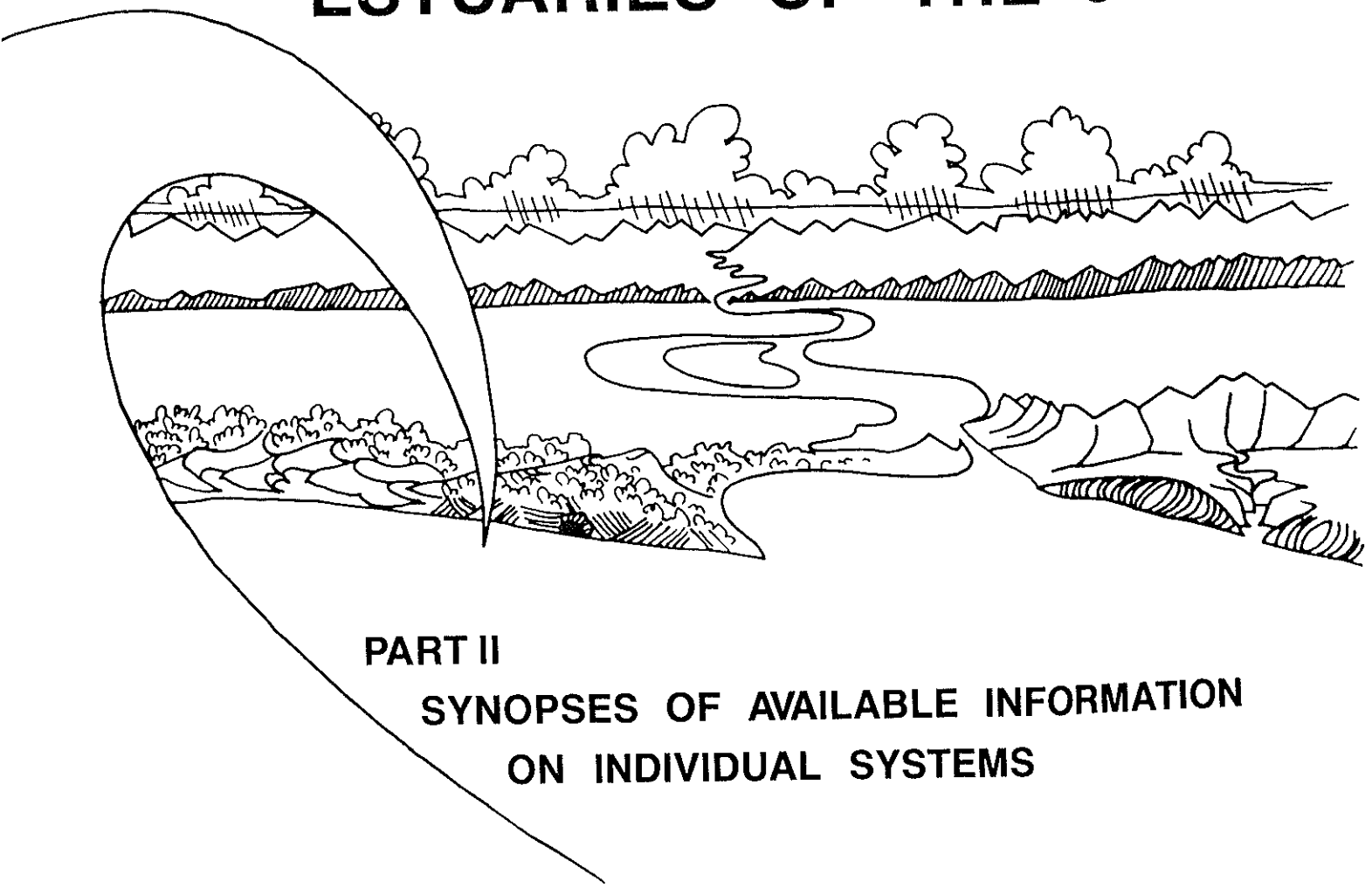
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT - ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 25

HEUNINGNES (CSW 19)

CSIR RESEARCH REPORT 424

Stellenbosch, South Africa
February 1984

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PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS
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FRONTISPIECE: THE HEUNINGNES ESTUARY – ALT. 500 m, ECRU 79-10-16

REPORT NO. 25: HEUNINGNES (CSW 19)

(CSW 19 – CSIR Estuary Index Number)

BY: I B BICKERTON

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HEUNINGNES

ECRU SURVEYS: 6-12 June 1983; 20-22 September 1983

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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, Muséums and other institutions to become involved in this kind of work;
>
> to contribute to *ad hoc* investigations carried out by NRIO on the impacts of proposed developments in the coastal environment, and especially in estuaries.

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

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

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

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* CSIR Research Report 380

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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HEUNINGNES

1. HISTORICAL BACKGROUND

1.1 Synonyms and Derivations

HONINGNEST	the old name of the river and estuary as used by Gohl (1944) and Walsh (1968)
HEUNINGNES	the present most commonly used name as indicated on the 1:50 000 Sheet 3420 CA and CC Bredasdorp

There appears to be some uncertainty regarding the origin of the name Heuningnes. According to Mr G D Kilpin, owner of De Mond farm (pers. comm.), the name Heuningnes originates from the presence of a beehive in a cave on the bank of the estuary. Alternatively the name Heuningnes was derived from the large numbers of wild bees and beehives which were found on the ridge Heuningrug which is situated just to the north of Zoetendalsvlei (P G Reyneke, Directorate of Forestry, pers. comm.)

The mouth and lower reaches of the estuary are situated within the De Mond Forest Reserve and the mouth of the Heuningnes is sometimes referred to as Die Mond (1:50 000 Sheet 3420 CA and CC).

1.2 Historical Aspects

The Heuningnes enters the sea between Arniston (or Waenhuiskrans) and Cape Agulhas, the southernmost point in Africa. As such the area has interesting historical associations.

According to Bulpin (1980), the name Agulhas was originally applied to Struisbaai (Golfo das Agulhas - gulf of the needles) but later given to the cape. The name Agulhas originated from the remarkable changes in magnetic forces noticed by the early mariners passing around the cape. The Africa Pilot (1980) gives the derivation of the name Agulhas as being from the resemblance of the off-lying sharp rocks to needles.

Arniston, which lies to the north-east of the mouth of the Heuningnes, was named after a transport ship that was wrecked there in May 1815. It is also known as Waenhuiskrans after the enormous cavern eroded in the limestone cliffs approximately 2 km south of the present town (Bulpin, 1980).

Zoetendalsvlei, the vlei which drains into the Heuningnes River, and Zoetendalsvallei the farm situated around it, were named after the Zoetendal which was wrecked on the adjacent coastline in 1673.

How or why the driftsands to the north and south of the mouth of the Heuningnes formed, is not clear. According to Walsh (1968), old Admiralty charts compiled during the years 1860, 1867 and 1869 show minor sand drifts along the Bredasdorp coast. During

more recent times, many farms on the Riversdale section of the coast were excessively subdivided into smallholdings. It therefore seems probable that intensive cultivation, grazing and burning on the sandy soil, together with trampling by stock *en route* to the infrequent water springs situated near the sea, led to denudation of the scanty vegetation with resultant sand-drifts (Walsh, 1968). It appears that destabilisation of the dunes at De Mond could have resulted from similar activities, in particular, grazing and trampling by stock (G D Kilpin, pers. comm.).

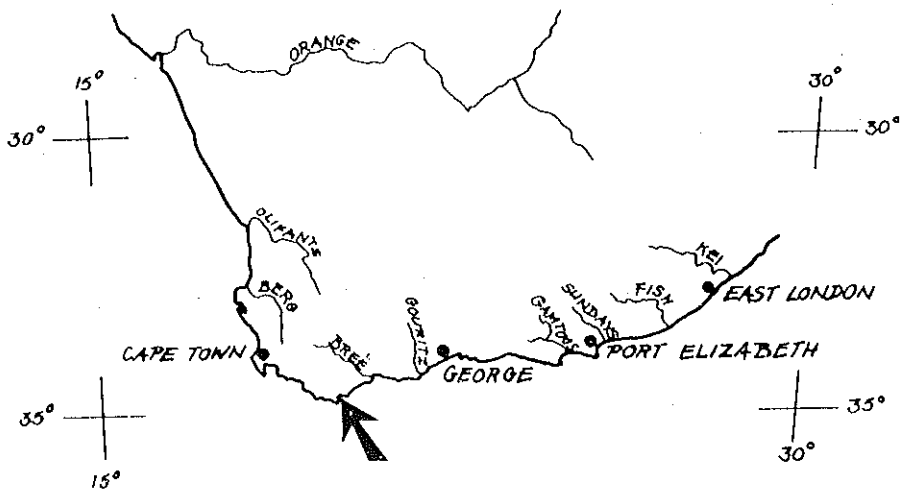
In 1937 Major P van der Byl and Mr M van Breda (landowners in the district) approached the Minister of Agriculture and Forestry in connection with the driftsand problem at De Mond. Following this, the Secretary for Agriculture and Forestry wrote to the Department of Lands requesting the expropriation of the land adjacent to the mouth of the Heuningnes (Directorate of Forestry, *in litt.)*. Mention was made of the threat posed by the driftsand to the river mouth and the fact that if the river mouth were to become blocked, approximately 24 000 ha of agricultural land would be flooded (Directorate of Forestry, *in litt.)*. During 1937 and 1938 assurance was given by the Minister to the landowners, that the Department would not plant rooikrans *(Acacia cyclops)* as part of the proposed dune reclamation programme.

In 1939 the Department of Agriculture and Forestry began buying up land around the Heuningnes Estuary with a view to stabilising the driftsands.

Dune reclamation work at De Mond was started by the Department of Forestry in 1942 when a large sand dune moved across the Heuningnes near its mouth (Walsh, 1968).

The mouth of the Heuningnes was kept open by the Department of Forestry until 1973 when it closed. The mouth remained closed for a long time, the bar being breached only by high spring-tides. In 1976 good rains fell and the mouth was opened by bulldozer and the tidal regime was reinstated (C Gaigher, Cape Department of Nature and Environmental Conservation, *in litt.*, P G Reyneke, Directorate of Forestry, pers. comm.).

2. LOCATION



The mouth of the Heuningnes is situated at 34° 43′S; 20°07′E (1:50 000 Sheet 3420 CA and CC Bredasdorp).

2.1 Accessibility

The estuary is accessible by a 23 km-long tar and gravel road from Bredasdorp (see Figure 1). The turnoff onto the gravel road leading to the mouth of the Heuningnes and De Mond Forest Reserve, is approximately 9 km from Bredasdorp on the Bredasdorp/Arniston road (1:50 000 Sheet 3420 CA and CC Bredasdorp). A permit issued by the Directorate of Forestry is necessary for access to the estuary. There are no other public access points.

2.2 Local Authorities

The lower reaches of the estuary fall within the De Mond Forest Reserve's Nature Reserve which is controlled by the Directorate of Forestry. Further upstream the estuary and river are bordered by privately owned farmlands.

The entire estuary and its catchment lie within the boundaries of the Bredasdorp/Swellendam Divisional Council.

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Catchment Characteristics

Area

The area of the Heuningnes catchment is given as 1 401 km^2 (Midgley and Pitman, 1969; Noble and Hemens, 1978; Day, 1981a and Pitman, *et al*, 1982). Heydorn and Tinley (1980) give the catchment area as 1 938 km^2. According to Pitman *et al* (1982) the effective catchment area is 1 185 km^2.

River length

The Heuningnes has two major tributaries. These are the Karsrivier and Nuwejaarsrivier (the latter flows into Zoetendalsvlei the overflow from which has a confluence with the Karsrivier). The length of the river from the mouth of the Heuningnes to the confluence of the Karsrivier and overflow channel from Zoetendalsvlei is 15 km (1:50 000 Sheet 3420 CA and CC Bredasdorp). The Karsrivier rises via many tributaries in the north-facing slopes of the Bredasdorpberge, the undulating area to the north of these mountains and also the mountains to the north-west of the Bredasdorpberge (1:250 000 Topographical Sheet 3319 Worcester). The length of the Karsrivier from its westernmost source, near the farm Fairfield, to its confluence with the Zoetendalsvlei overflow channel, is 75 km as measured on the 1:250 000 Topographical Sheets 3319 Worcester and 3420 Riversdale.

The Nuwejaarsrivier rises via many tributaries in the south-facing slopes of the Bredasdorpberge, the Koueberge to the west, the hills to the south of Elim and the north-facing slopes of

the Soetanysberg (1:250 000 Topographical Sheet 3319 Worcester). The length of the Nuwejaarsrivier from its westernmost source through Zoetendalsvlei to the confluence of the vlei's overflow channel with the Karsrivier, is 55 km as measured on the 1:250 000 Topographical Sheet 3319 Worcester.

Tributaries (See Figure 1)

As mentioned above, the major tributaries of the Heuningnes are the Karsrivier and the Nuwejaarsrivier (which flows through Zoetendalsvlei).

Of the many tributaries of the Karsrivier, six are named on the 1:250 000 Topographical Sheet 3319 Worcester. These are the Tweerivier, Leeurivier, Klein Soutrivier, Klipdrifrivier, Groot Sanddrif and the Grashoeksrivier. Downstream of the farm Nachtwacht, where the Karsrivier flows under the Bredasdorp/Arniston road bridge, the land is very flat and gradients are almost indiscernible. As a result, the course of the Karsrivier is not well-defined and run-off is via the Karsriviervlei through which the water flows, passing under the Bredasdorp/Struisbaai road. Downstream of this road crossing, the main channel becomes more distinct and a small stream the Poortrivier flows into the Kars (1:50 000 Sheet 3420 CA and CC Bredasdorp).

Of the many tributaries of the Nuwejaarsrivier, five are named on the 1:250 000 Topographical Sheet 3319 Worcester. These are the Kouerivier, Wolwegatskloofrivier, Jan Swartskraalrivier, Boskloofrivier and Uintjieskuilrivier. In the lower reaches of the Nuwejaarsrivier the topography is very flat and low-lying and several pans and vleis drain into the river. The pans named on the 1:50 000 Sheet 3419 DB and DD Elim are Waskraalsvlei, Voëlvlei and Soutpan. Further downstream the Nuwejaarsrivier flows into Zoetendalsvlei, the most southerly lake in Africa, which is approximately 8 km long along its north/south axis and 3 km wide at the middle.

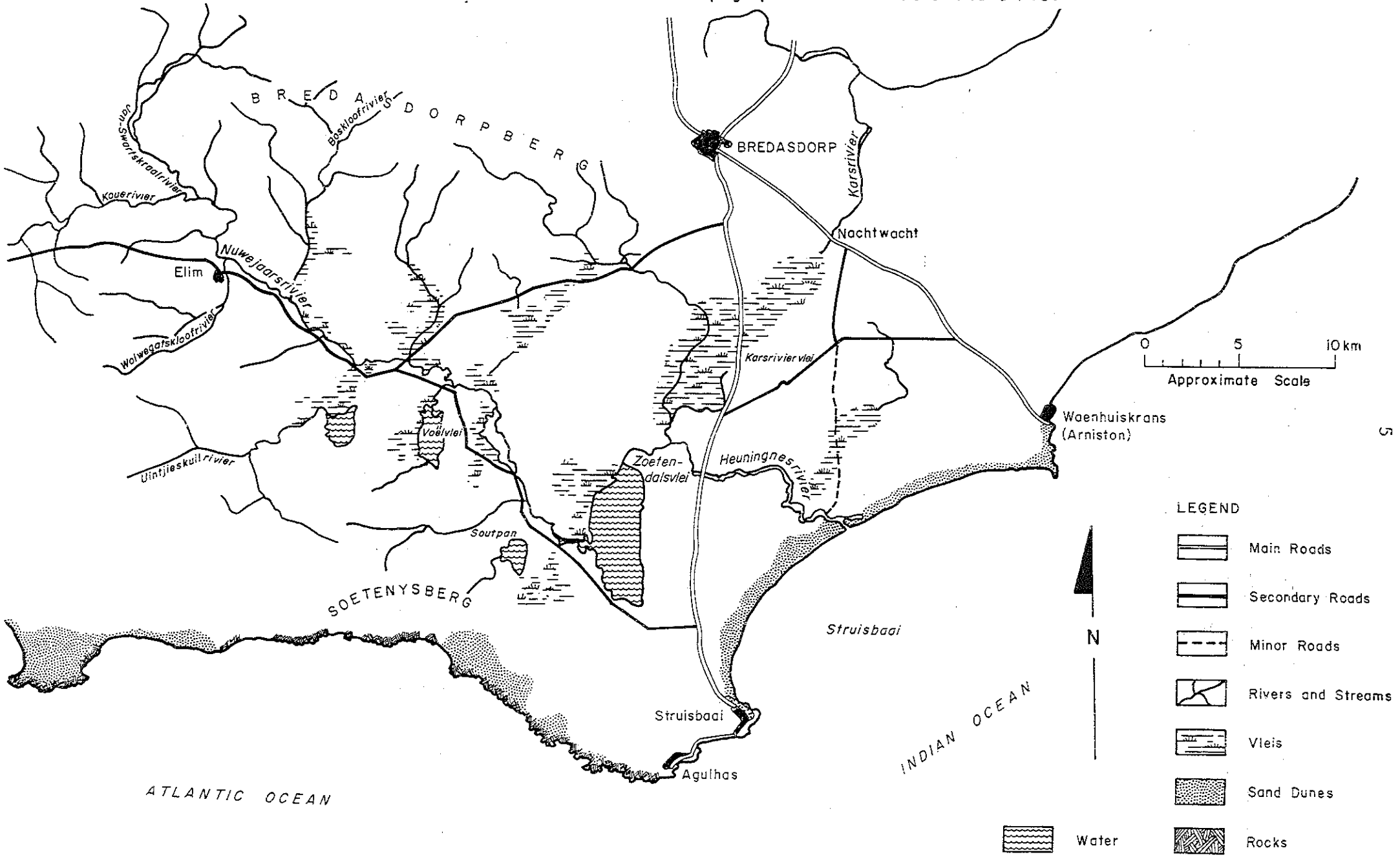
Geology

General geological history (from Visser, 1963 and Krige, 1973):

The geomorphological development of the area in which the Heuningnes and its catchment are situated, took place during the Tertiary and Recent (that is, during the past 70 million years) periods, beginning with prolonged erosion, after which the ocean covered most of the area now underlain by Bredasdorp Beds which consist of calcified dune sand. These occur along the whole coast up to the Potberg Mountain in a band varying from three to twenty kilometres in width. During the Miocene (that is, 26 to 7 million years ago) the ocean began to retreat and on this wave-cut platform the Bredasdorp Beds were left as inshore deposits. The beach sand was blown up in dunes that transgressed the former extension of the ocean. Subsequently the sea level rose again and a platform was cut over Bredasdorp and older formations. This terrace now stands at an average altitude of 18 m. As the sea retreated again, the beach sand was blown up in dunes locally on this younger marine terrace. Still

FIG. 1: Southern part of the Heuningnes catchment (that part of the Karsrivier catchment lying to the north of the Bredasdorpberge is excluded)

Drawn from 1:250 000 Topographical sheets 3319 and 3420.



later the sea-level sank further due to world-wide glaciation and another terrace was formed. Its maximum height is 7 m and it is preserved only in patches along the coast.

Greater resistance to weathering processes has left the Table Mountain Sandstone as the most prominent feature in the landscape forming high ground and mountain ranges while the less resistant shales have weathered to lower elevations, characterized by the rounded hilly nature of the Bokkeveld shales in the undulating country in the upper reaches of the Heuningnes catchment.

The following description of the geology of the Heuningnes catchment is based on interpretation of the 1:125 000 Geological Map 3419 C and D Gansbaai and 3420 C Bredasdorp and the 1:100 000 Geological Map of South Africa.

The geology of the upper catchment of the Karsrivier is dominated by Table Mountain Group sandstones, quartzite and shales of the Bredasdorpberge in the southern parts and Bokkeveld Shales in the undulating northern parts. Further downstream, east of Bredasdorp, the river traverses calcified dune sand and coastal limestone of the Bredasdorp Beds.

The geology of the upper catchment of the Nuwejaarsrivier is dominated by sandstone, quartzite and shales of the Table Mountain Group and sheared shale and fine-grained greywacke of the Malmesbury Group. Post Malmesbury, pre Cape granite outcrops occur on the south-facing slopes of the Bredasdorpberge. Further downstream near Elim, the Nuwejaarsrivier traverses shale and sandy shale of the Bokkeveld Group which persists eastwards almost to where the Nuwejaarsrivier enters Zoetendalsvlei.

There are two fault lines running almost east/west, one just south of the Bredasdorpberge and the other just north of Soetanysberg further south.

From Zoetendalsvlei and Nachtwacht almost to the mouth of the Heuningnes, the drainage system traverses calcified dune sand and coastal limestone of the Bredasdorp Beds. Approximately 2 km from the mouth, the Heuningnes estuary is situated on unconsolidated sand.

Climate and run-off

Climate

The Heuningnes and its catchment lie within the eastern extremity of climatic region M (Schulze, 1965). Climatic region M has a Mediterranean climate receiving most of its rainfall in the winter from about May to September and is characterized by a warm to hot and dry summer. The mean annual rainfall over most of the catchment is between 400 and 600 mm (Heydorn and Tinley, 1980). Midgley and Pitman (1969) and Pitman *et al* (1982) give the mean annual precipitation for the Heuningnes drainage system as 447 mm.

The rainfall is mainly cyclonic with some orographic rainfall occurring in the upper reaches of the catchment. Rain-bearing winds are mainly from the west (Walsh, 1968) or south-west. Rainfall is higher on the south faces of the mountains than on the north facing slopes. During the summer months easterly winds predominate.

Average daily temperatures (Schulze, 1965)

	Max (^{o}C)	Min (^{o}C)
January	28	15
July	17	6

Sunshine duration varies from about 60 per cent of the possible duration in July to over 70 per cent in January (Schulze, 1965).

Run-off

Midgley and Pitman (1969) in a report of the Hydrological Research Unit, University of the Witwatersrand, give the mean annual run-off for the Heuningnes drainage system as 30 000 morgen feet (78,3 x 10^{6} m^{3}). However, Pitman *et al* (1982) in an updated Hydrological Research Unit report give the mean annual run-off as 37,6 x 10^{6} m^{3} which supersedes the figure given in the 1969 report. Noble and Hemens (1978) and Heydorn and Tinley (1980) give the mean annual run-off as 78 x 10^{6} m^{3} but this figure probably originates from Midgley and Pitman (1969).

Flow measurements for the Karsrivier were obtained from a gauging station (G5MO5) at Nachtwacht from February 1953 to September 1960. Based on the records (Monthly flow records of gauging stations up to September 1960, 1968) for this seven year period, the mean annual run-off was calculated to be 42,5 x 10^{6} m^{3}. Figure 2 shows the changes in mean monthly flow rates for the Karsrivier at Nachtwacht for the period 1953 to 1960. The figure shows the low summer (November-April) and high winter (May-October) flows.

Pitman *et al* (1982) give simulated run-off figures for the Heuningnes catchment. The variation in mean monthly run-off, as calculated from the simulated runoff figures, is shown in Figure 3. The difference between summer and winter run-off is very marked.

Figure 4 shows the variation in annual run-off from 1924 to 1979 based on the data given in Pitman *et al* (1982). Flood periods can be seen clearly.

3.1.2 Land Ownership/Uses

Most of the catchment of the Heuningnes consists of privately owned farmland. Generally winter grain is alternated with pastures and lucerne in rotation. Seventy per cent of the vlei areas are usable and there is no farming in the dune veld. Livestock (mainly cattle and sheep) utilize the pastures during the summer months. (D Cronje, Agricultural Technical Services, pers. comm.).

FIG. 2: Mean monthly flow rates for Karsrivier for the period February 1953 to September 1960 as measured at G5M05 Nachtwacht.

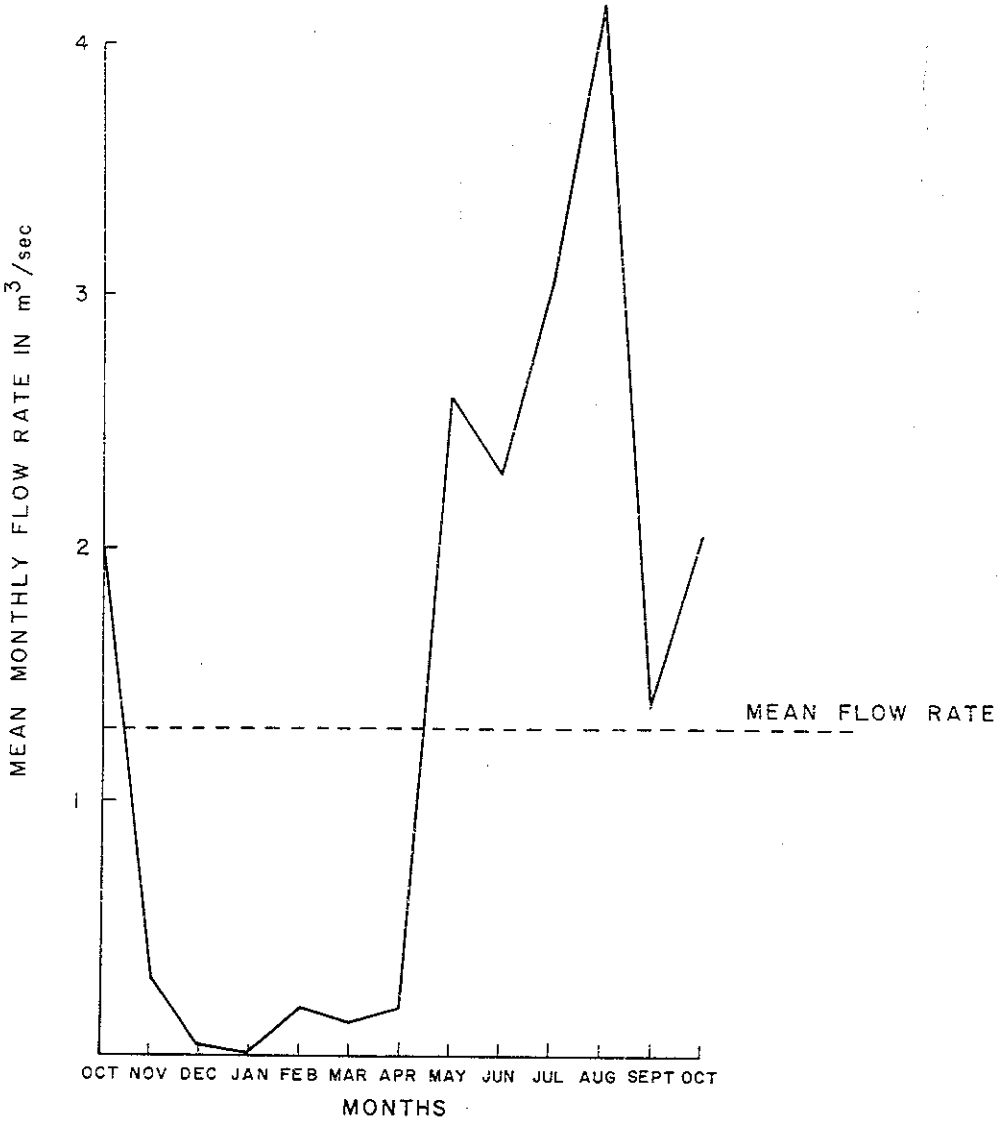
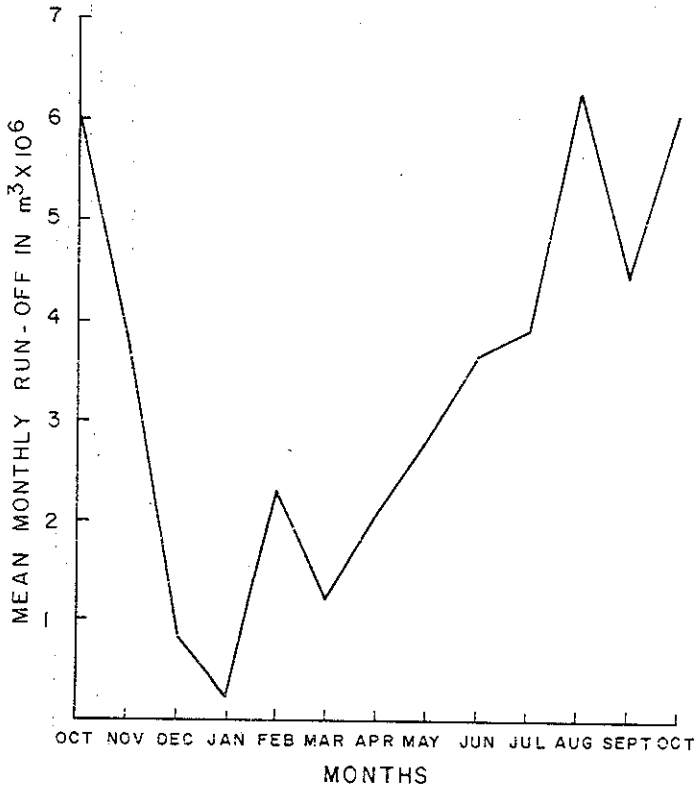


FIG. 3: Mean monthly run-off calculated from simulated run-off for the Heuningnes drainage system for the period 1924 to 1979. (after Pitman *et al*, 1982)



In the upper parts of the catchment wild flower-picking is carried out and near Bredasdorp and Elim there are pine and gum plantations. Lower down, reed-cutting is carried out for thatching purposes and Zoetendalsvlei is netted under licence for fish by the local farmers (M R van Breda, Local Farmer, pers. comm.).

3.1.3 Obstructions

There is an irrigation dam on the Karsrivier upstream of the Bredasdorp/Arniston roadbridge. The Bredasdorp/Arniston roadbridge was constructed in 1950 and downstream of it there is a weir where the Karsrivier enters Karsriviervlei. Where the Bredasdorp/Struisbaai road traverses Karsriviervlei there are five pipe culverts for the passage of water.

Several roads cross the Nuwejaarsrivier and the vleis and wetland areas on its floodplain before it enters Zoetendalsvlei.

Zoetendalsvlei acts as a reservoir for the Heuningnes and it is only when the vlei overflows that run-off to the sea occurs. Immediately downstream of the outflow channel from Zoetendalsvlei is a drift with several pipe culverts (M R van Breda, pers. comm.).

3.1.4 Siltation

According to Mr D Cronje, (Agricultural Technical Services pers. comm.) there is little water erosion because the topography is flat. However, wind erosion used to be an important factor when the land was ploughed and left open. More recently though, this practice has stopped. Instead of being left open the fields are put under grazing.

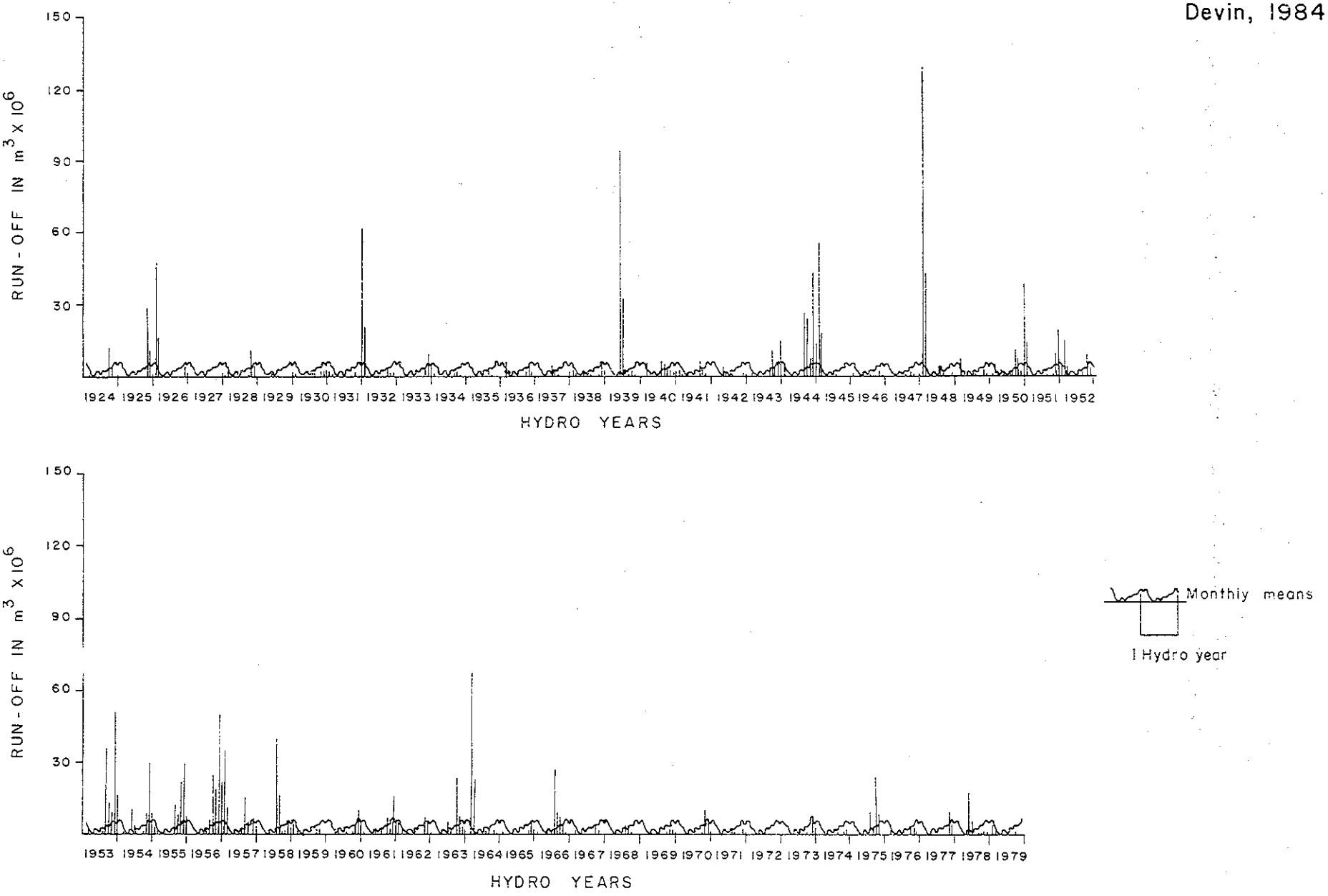
Generally it would appear that siltation rates associated with the Heuningnes are low as the gradients are not high and consequently the run-off does not account for much sediment transport.

3.1.5 Abnormal Flow Patterns

The flood history of the Heuningnes drainage system is not well-documented. However, records from the Van Breda Journal (1840-1944) held at Zoetendals Vallei indicate that floods occurred in the area in the following years:

26.06.1871	lands almost totally submerged, heaviest rains in Zoetendalsvlei in thirty years.
13.03.1880	bridge impassable, vlei growing full by the day.
05.09.1902	vlei has reached a mark higher than that witnessed by any of the present inhabitants. Heuningnes River was so flooded that only the tops of the causeway's posts could be seen.
30.01.1903	River still overtopping causeway on Bredasdorp/Struisbaai road.

FIG. 4: Simulated monthly run-off for the Heuningnes catchment for the period 1924 to 1979 (after Pitman *et al*, 1982). The mean monthly run-off is indicated for comparison with flood peaks (Figure from Devin, 1984)



18.12.1906 Heuningnes causeway impassable; the whole district was flooded.

01.08.1920 Excessive rain during the last two months has filled the vlei to the 1902 level.

Drought periods were recorded as follows:

15.02.1869 Zoetendalsvlei was only $2^1/_2$ feet deep in its deepest parts.

24.08.1909 Drought getting serious. The farm is beginning to suffer.

20.02.1910 Drought serious; Zoetendalsvlei water level getting very low.

17.06.1926 Drought experienced throughout the district.

23.06.1928 The past year has been very dry and conditions in the district have been very bad. Since 1901 the water levels in Zoetendalsvlei have not been so low.

13.12.1928 The vlei has reached its lowest level since 1869.

13.05.1929 The deepest part of the vlei which has been drying up consistently for 2 years is now 19 inches as compared with 30 inches in 1869. In the vlei there is dried mud to the south-west and north and sand to the east.

31.12.1930 Vlei water levels still very low for the fourth successive year.

13.04.1932 Driest summer in years.

21.06.1934 Drought still persisting.

01.09.1934 Lowest ever rainfall 1934 - 3,27 inches (83 mm)
1886 - 3,81 inches (97 mm)

Clearly these latter records indicate an extended drought period from 1926 to 1935 with the exception of the floods in late winter 1931.

According to Figure 4 which is based on simulated run-off data given in Pitman *et al* (1982), significant floods occurred between 1924 and 1979 in the following years:

Late winter 1925
Late winter 1931
Late summer 1939
Late winter 1944
Late winter 1947
Late winter 1950
Winter 1953
Winter 1954
Winter 1955
Winter 1956
Winter 1963
Summer 1964
Early winter 1966
Winter 1975
Late summer 1978

According to Mr C M Gaigher (CPA Department of Nature and Environmental Conservation) and Prof. J R Grindley (School of Environmental Studies, University of Cape Town) Zoetendalsvlei virtually dried up in 1970 after a period of prolonged drought. This resulted in large scale mortality of fish and salt crusts appeared on some areas of dried mud.

As the middle and lower reaches of the Heuningnes catchment are situated on the low-lying Bredasdorp coastal plain, the run-off is not rapid and extensive flooding of the vleis and marshes adjacent to the water courses occurs during wet periods. In some of the low-lying areas farmers have built drainage canals to allow the water to run off their lands.

3.2 Estuary

3.2.1 Estuary Characteristics

(This section is contributed by Dr G A W Fromme of the Sediment Dynamics Division, NRIO).

The Heuningnes Estuary extends approximately 12 km across the flat coastal plain of the Zoetendals Vallei farm area. It is, however, only the lower 2 km stretch which shows the characteristics of a proper estuary, such as strong tidal activity, instability and variability of the estuary banks and of the inlet channel, clear water with high salinities, and generally a strong influence of the littoral environment. A causeway in the intertidal zone, 1,3 km upstream of the mouth is a considerable obstruction to the tidal exchange and separates artificially the

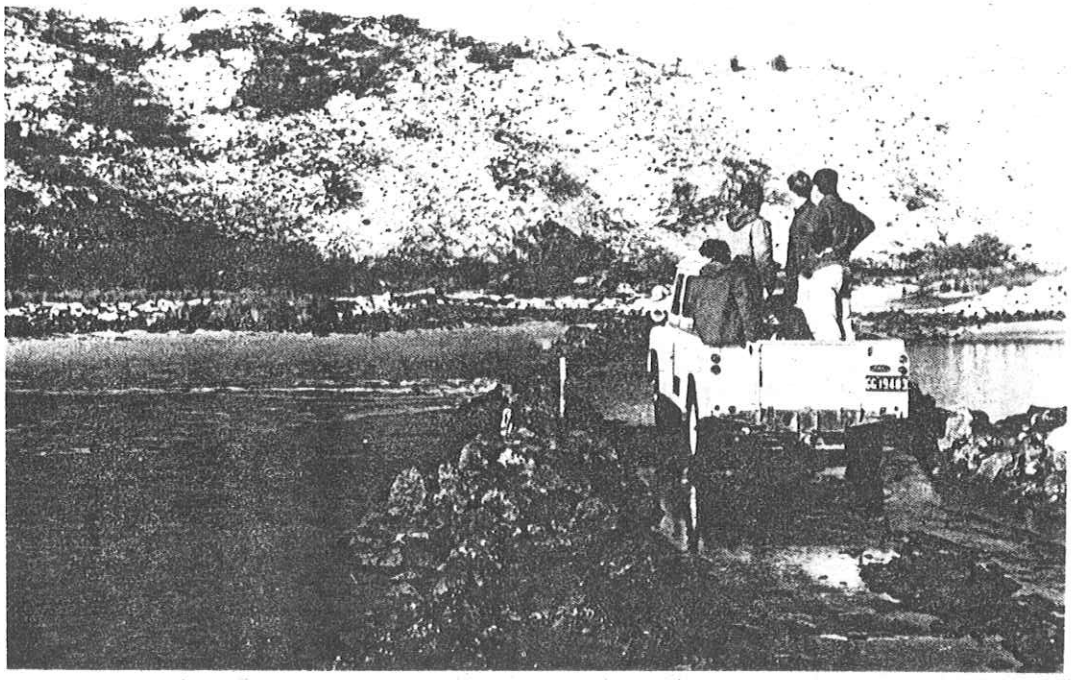
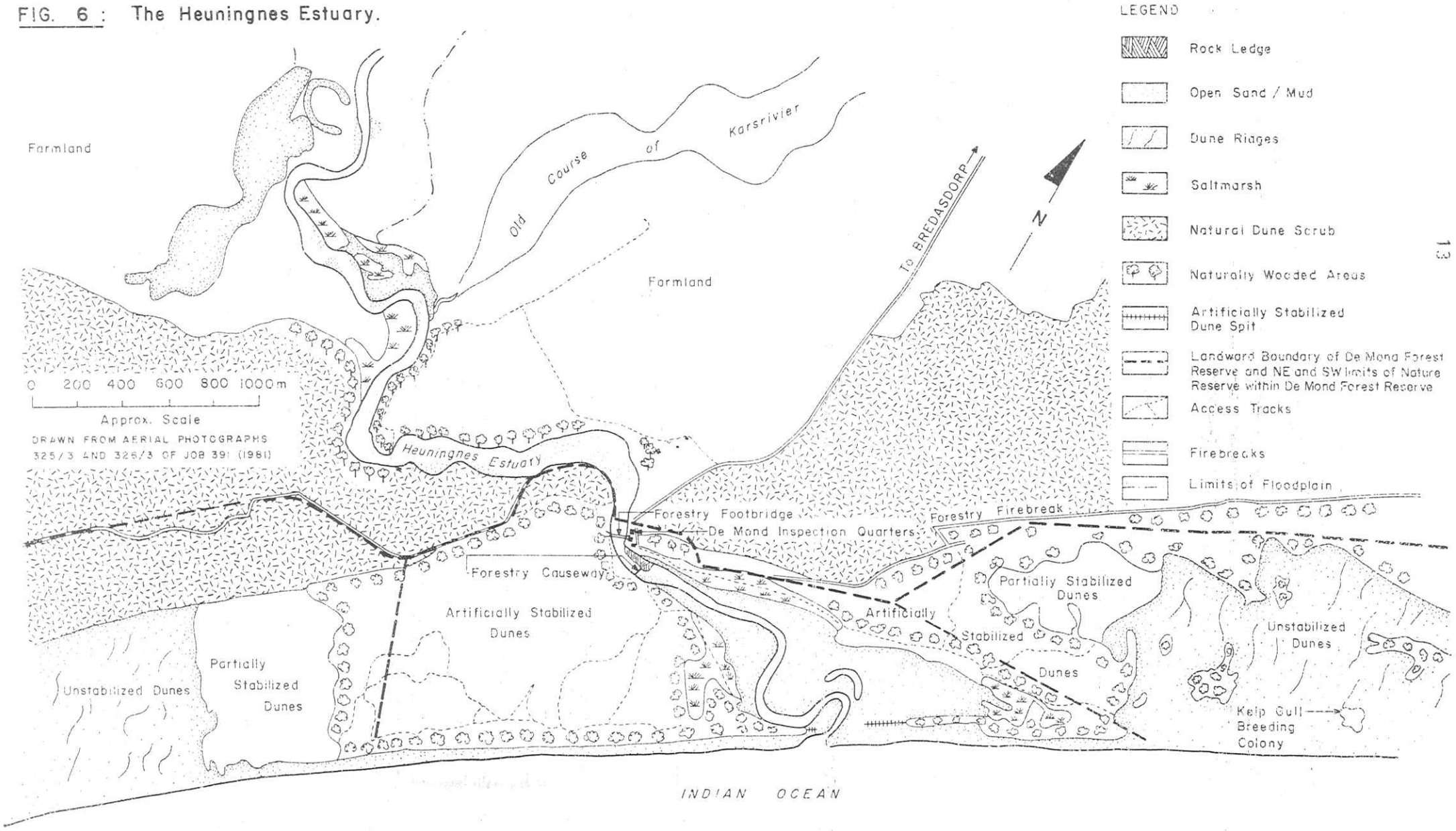


FIG. 5: Causeway constructed by the Directorate of Forestry to provide access to the southern bank of the Heuningnes. The photograph was taken during ebb tide. The difference in water level between the upstream (on right of photo) and downstream (on left of photo) sides of the causeway can be seen (ECRU: 83-06-07)

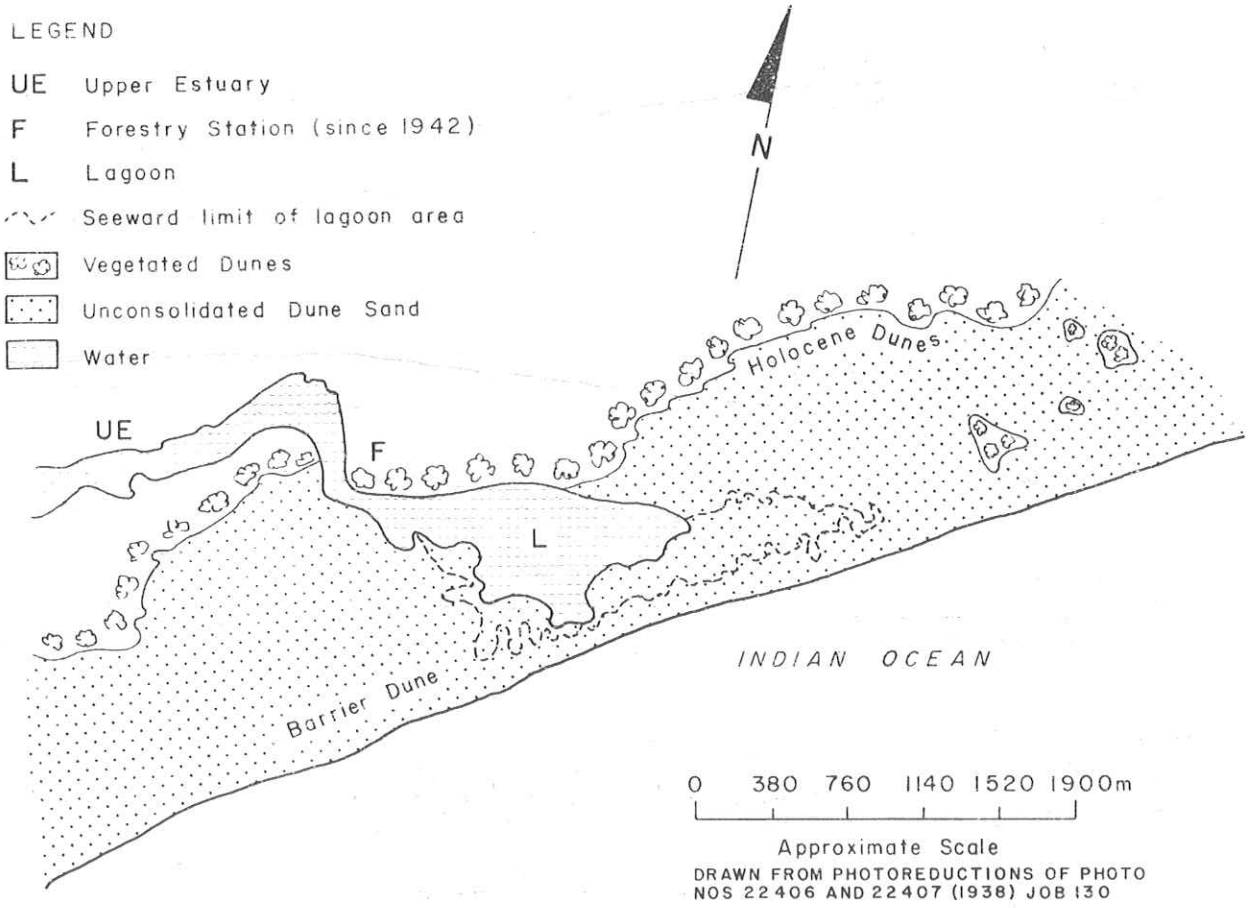
FIG. 6 : The Heuningnes Estuary.



lower estuary from the upper stretch of 9 km. As a result of this the upper estuary resembles a slackish turbid river flowing in a shallow channel incised into the coastal plain, with elevations of only 1 to 1,5 m above mean sea level.

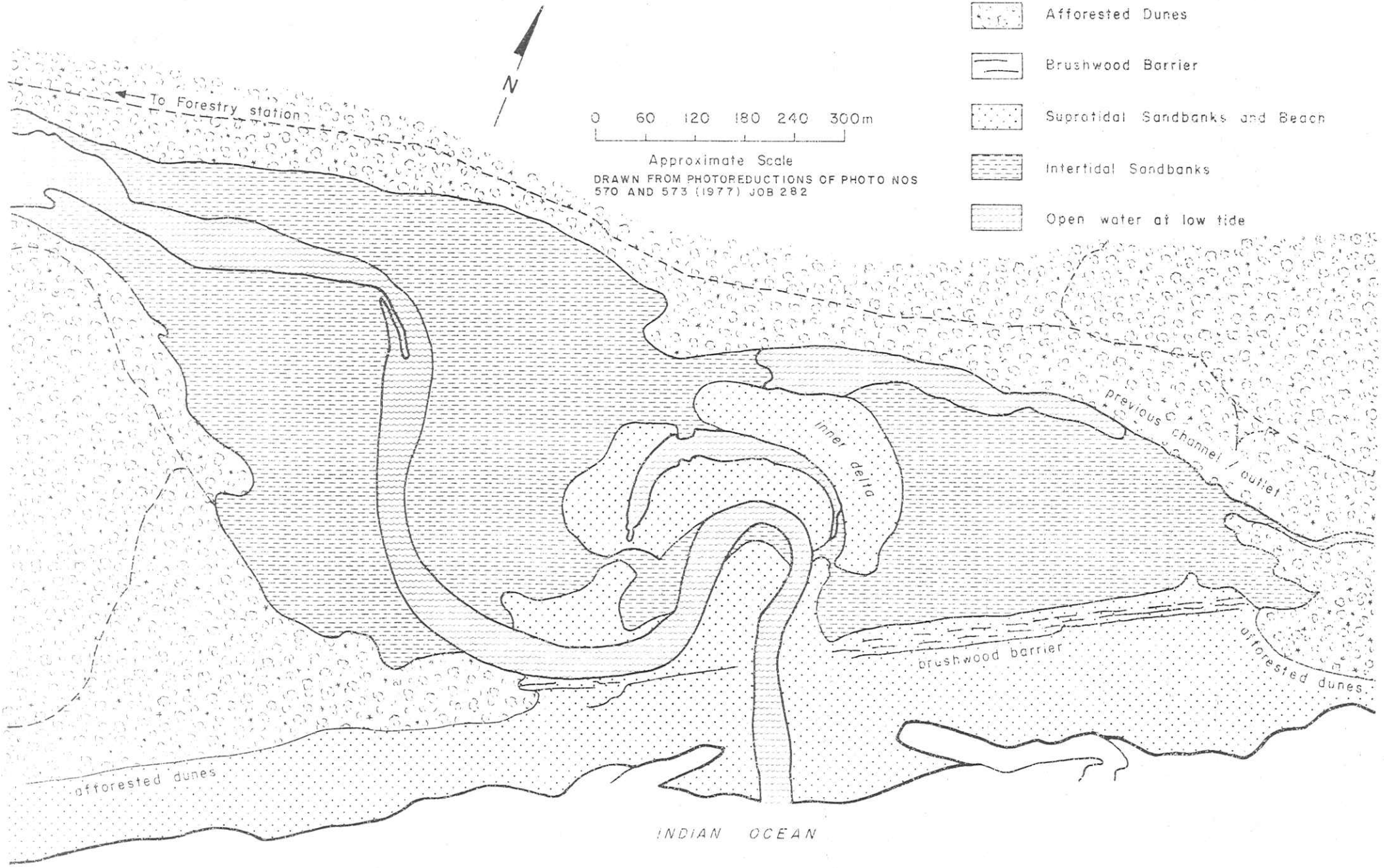
From the low-lying agricultural hinterland, which was virtually wetland before cultivation, the estuary breaks out to sea through a double dune ridge at De Mond Forestry Station. The landward dune ridge is more than 30 m high, covered by coastal shrubs, and runs parallel to the seaward ridge at a distance of half to one kilometre. The seaward ridge is lower, at the most 20 m high, and sparsely vegetated or barren dune sand. While the landward ridge marks the shoreline of the holocene marine transgression, 6 000 to 4 000 years B.P., with a mean sea level of +1,5 m (Tankard, 1975; Rogers, 1982), the seaward ridge represents the present barrier dune (see Figure 7).

FIG. 7: Heuningnes estuary mouth, natural condition in 1938.



In its natural state the lower estuary tended to dam up behind the barrier dune which was only occasionally breached during flood discharge from the Heuningnes River. As a result of this an elongated lateral lagoon was formed in the sandy slack between the two dune ridges. The extent of this lagoon can still be traced on aerial photographs (about 2,5 km long, see Figure 7).

FIG. 8: Heuningnes Estuary mouth after afforestation of barrier dune and confinement of inlet, 1977.



The lateral impoundment of the lower estuary behind the unconsolidated unstable hilly frontal dune made breachings of the dune possible at many places along the coastline in the past. It is probable that the estuary mouth was diverted during the period from the end of the 19th century to about 1930 from a point about 2 km west of its present position (Walsh, 1968), where, since the early 1940s, the mouth has been confined artificially by brushwood barriers and dune afforestation. A previous breaching site approximately 1 km east of the present mouth can also be distinguished on the aerial photographs (see Figure 8).

When the mouth was closed, excessive flooding of the hinterland occurred frequently. It was this condition that necessitated management of the estuary since the beginning of this century.

The aerial photographs show that the width of the natural opening of the estuary to the sea (between the abutments of the barrier dune) was about 900 m. This opening is now reduced to 120 to 150 m between the abutments of the artificial brushwood barrier. A significant feature of the lower estuary which formed after the mouth was kept permanently open, is a large inner (flood tidal) delta. This delta forced the mouth channel in a sharp bend to the south which results in erosion at the lagoon side of the western brushwood dune (see Figure 8). Previous channels and meanders in the mouth are evidence of the strong hydrodynamic forces in this estuary.

Hydraulics of the Lower Estuary

Firstly, the hydraulic features of the lower estuary are a consequence of the flatness of the area. This causes the estuary channel to meander irregularly over the sandy plain, between the two dune ridges. A channel or a tidal inlet once formed at a suitable site becomes easily choked and can subsequently be forced into another course. If the river discharge decreases during the dry summer season, channels and inlets sand-up and close completely, as is shown on an aerial photograph taken in 1976 (Job 243, Photo No. 004). This process is aggravated by the obstructive influence of the causeway at the head of the lower estuary.

Secondly, blockages of the mouth and often of the entire lower estuary basin were, in the past, caused by encroachment of sand blown from the beach or adjacent barrier dune fields into the lower estuary. As shown by the wind roses in Figure 10, it is the south-easterly winds which blow frequently and with high velocities during the spring and summer season when the beach and dune sand are dry and mobile, which are responsible for the ingress of sand into the estuary.

When reclamation works by the Department of Forestry started in the early 1940s the objective was to stop sand from being blown into the estuary in order to keep the mouth open and to prevent flooding. This was achieved by raising a littoral dune parallel with the coast (see Figure 9 and Plate I) by erecting a mechanical barrier of droppers and palings planted into the beach sand to support brushwood. The sand trapped by this "brushwood" fence was then stabilised by indigenous vegetation, which was also used to consolidate the surrounding drift sand dunes (Gohl, 1944).

FIG. 9: Artificially stabilized littoral dune created by the Directorate of Forestry at De Mond. The photograph was taken approximately 1 km to the south-west of the mouth of the Heuningnes (ECRU: 83-06-07)

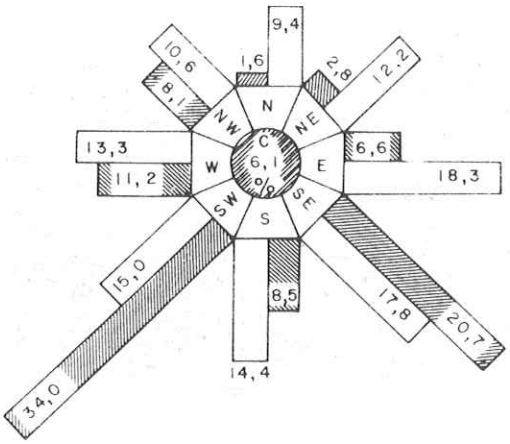
At the mouth, a 100 m wide gap was kept open in the brushwood barrier. This prevented the mouth channel from spreading over the flat surface of the estuary basin and concentrated the flow in a confined channel. In this way the flushing action by the tidal currents was increased.

The artificial confinement of the tidal inlet between the two brushwood barriers does not allow any large-scale migration of the mouth or the formation of a natural sand spit. According to Walsh (1968) the mouth moves slowly eastward and westward over a range of 100 m, thereby continuously attacking the brushwood abutments on both sides, but apparently seeking a course to the east (see Figure 8, previous channel/outlet).

The permanent opening created another new sand deposit within the estuary basin. This is the large flood tide delta which causes erosion problems at the inner side of the western brushwood dune (see Figure 11), as mentioned in Section 3.2.1. According to the local forest officer, Mr H O Swart, the Department stopped repairing this dune section in order to allow the estuary channel to breach the brushwood dune and to create a new mouth more in line with the river course at the west end of the western brushwood dune (see Figure 8).

FIG. 10: Wind distribution for Cape St. Blaize (Mossel Bay), 1976 - 80
(after rough data, Cape St. Blaize I.T Hunter, pers. comm.)

SPRING

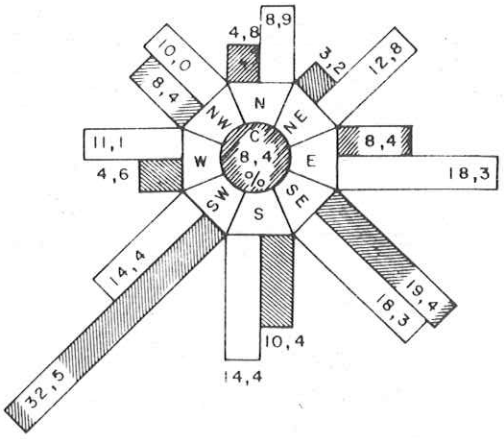


Percent Occurrence

Wind Speed (m/s)

c Calms

SUMMER

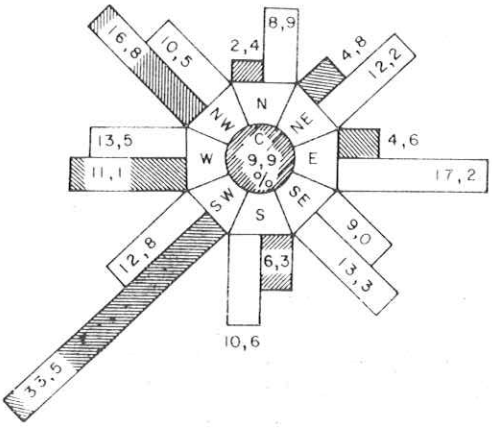


Percent Occurrence

Wind Speed (m/s)

c Calms

AUTUMN

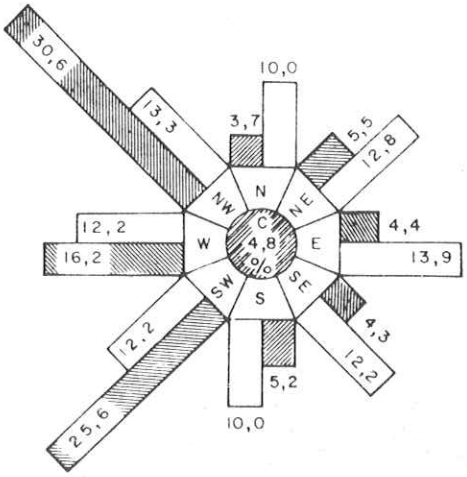


Percent Occurrence

Wind Speed (m/s)

c Calms

WINTER



Percent Occurrence

Wind Speed (m/s)

c Calms

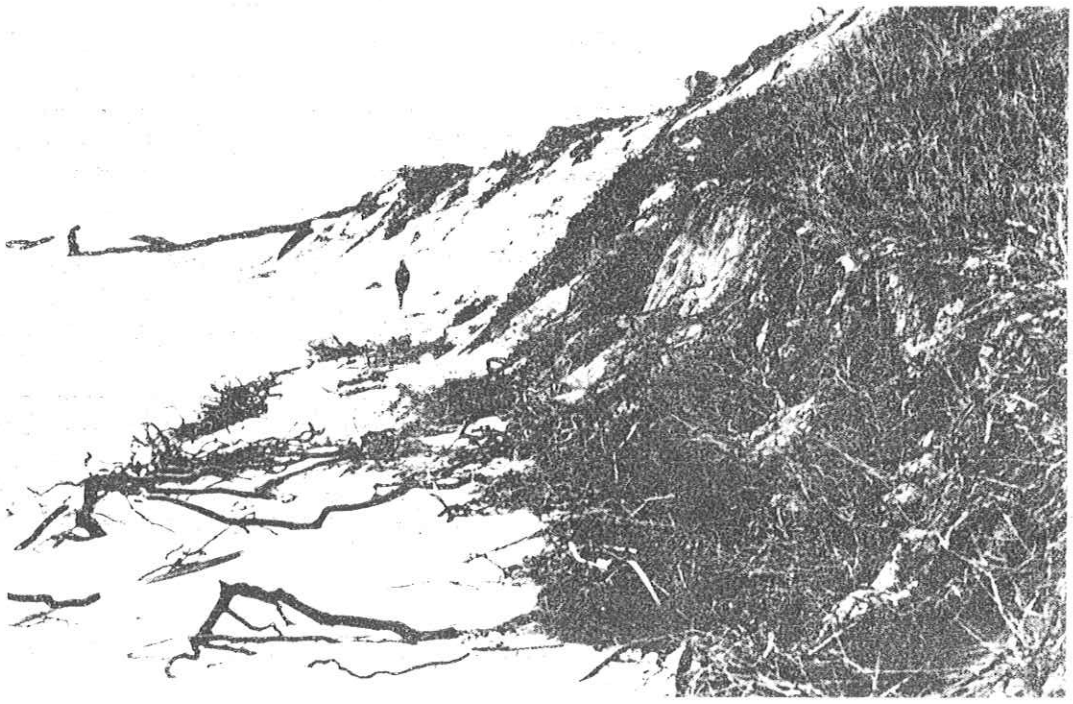


FIG. 11: Erosion of western brushwood dune at the mouth of the Heuningnes (ECRU: 83-06-10)

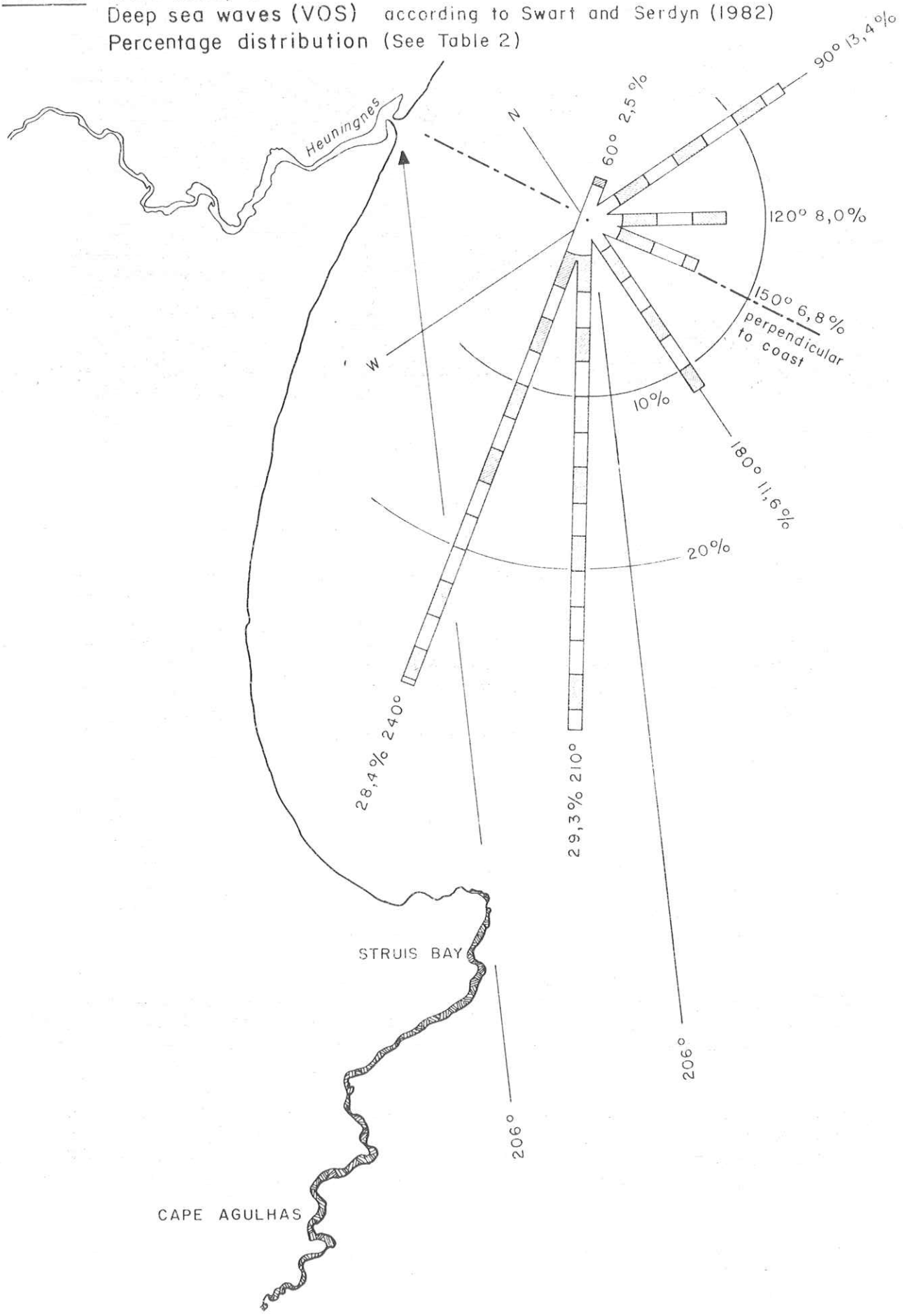
Any new permanent tidal inlet will, however, cause the formation of a new inner delta which in turn will cause deviation or blockage of the estuary channel. It seems that weak river discharge aggravated by the blockage of the upper estuary by the causeway and the very gentle gradient between the estuary and the sea, favours the influx of sand from the sea into the estuary.

Walsh (1968) also reported on attempts to canalize the mouth within a pair of parallel dune walls in line with the mouth channel and at right angles to the coast. This attempt failed, because the two walls were soon washed away as a result of the low elevation of the lower estuary relative to the sea (0,6 m below high-water mark). The walls can be seen on an aerial photograph taken in 1976 (Job 243, Photo No. 004).

The causeway at the head of the lower estuary, approximately 200 m below the pedestrian bridge at the Heuningnes Forestry Station, is linked to a natural flat rock sill in the centre of the estuary channel, by artificial boulders dumped in order to enable forestry vehicles to cross the estuary. This sill forms a severe obstruction to the tidal flow in the estuary.

The Sediment Dynamics Division of NRIO has calculated that in order to accommodate the full tidal flow at the location of the causeway, an opening of 5 m^2 is needed (e.g. 20 x 600 mm diameter concrete pipes). As the stability of the mouth is largely controlled by the tidal prism, it is evident that the removal of this obstruction will improve the condition of the mouth to a large extent.

FIG. 12: Wave Rose, Struisbaai.
Deep sea waves (VOS) according to Swart and Serdyn (1982)
Percentage distribution (See Table 2)



The Heuningnes is a good example of how the solution of one estuarine problem, that is the inundation of the agricultural hinterland, has created another one, namely the expensive continuous maintenance of an artificial mouth and to a certain extent degradation of the estuary itself.

Hydraulics of the Coast

Besides the wind the main driving force in coastal hydraulics is the wave conditions. For the coast off the Heuningnes Estuary (Struisbaai) a 20-year record of deep-sea-wave observations collected from 1960 to 1979 by voluntary observing ships (VOS; Swart and Serdyn, 1982) was analysed. The results are given in Tables 1 and 2 and Figure 12.

TABLE 1: Wave directions, median(x) and one-year's maximum wave-heights for Struisbaai, according to VOS data

Direction	Degrees	Occurrence(xx) (percent)	Wave-height (m)	
			Median(x)	Maximum/y
NE - ENE	60	2,5	2,15	6,3
E	90	13,4	2,25	7,0
ESE - SE	120	8,0	2,15	6,2
SE - SSE	150	6,8	2,30	5,8
S	180	11,6	2,30	6,6
SSW - SW	210	29,3	2,4 (+) 1,32	6,8 (+) 3,74
SW - WSW	240	28,4	2,5 (+) 0,50	7,8 (+) 1,56
All directions		100	2,4	7,75

(x) Median wave-height: The wave-height exceeded by 50 percent of the observations (read from a probability plot) during a 20-year period.

(xx) Calms omitted from computation.

(+) Value $\begin{matrix}\text{left}\\\text{right}\end{matrix}$ of (+) $\begin{matrix}\text{undiffracted}\\\text{after diffraction}\end{matrix}$

Waves approaching the shore obliquely cause a long-shore current in and near the breaker zone to flow in the downwave direction. The dominant deep-sea wave direction in the area is from the south-westerly sector during all seasons. Waves from south of the perpendicular to the beach at Heuningnes occur for 58 percent of the time. Strong wave diffraction of south-westerly waves occurs around the headland at Struisbaai. The wave-heights near the headland are lower than those on the open coast and the wave set-up (an increase in the mean water level inside the breaker zone due to wave breaking) decreases progressively along the shore in a south-westerly direction towards the headland. As a result, the longshore currents in the area are weaker than they would be on the open coast.

TABLE 2: Seasonal variation of wave directions, Struisbaai, according to Swart and Serdyn, 1982

Direction	Degrees	Occurrence (percent)			
		Spring	Summer	Autumn	Winter
NE - ENE	60	0,7	0,6	0,7	0,6
E	90	4,1	4,1	3,6	1,7
ESE - SE	120	2,2	2,0	2,9	0,9
NE - SE	60-120	7,0	6,7	1,9	3,2
SE - SSE	150	2,0	2,3	1,9	0,7
S	180	2,9	3,9	3,0	1,7
SSW - SW	210	7,7	9,9	6,3	5,6
SW - WSW	240	6,5	8,2	6,1	7,7
S - WSW	180-240	17,1	22,0	15,4	25,2

Note: Sum NE - SE = wave incidence from SE-ly sector
Sum S - WSW = wave incidence from SW-ly sector
SE - SSW (150°) = wave incidence nearly normal to coast, causing little sidewards water displacement

It is estimated that with the above background, 55 percent of the sediment transport is towards the north-east and 45 percent towards the south-west. This means that although the longshore currents persist longer in a north-easterly direction than in a south-westerly direction, the quantity of sand moved in either direction is nearly equal. This has the effect that the spit at the estuary mouth would normally grow slightly more in a north-easterly than a south-westerly direction with a resultant slow movement of the mouth towards the north-east. A comparison of a map of the area in 1880 and more recent aerial photographs shows that this is so. The stabilization of the bar on both sides of the mouth (since 1942), however, prevents this natural phenomenon of growing of the spit and movement of the mouth, from taking place.

Sediment Characteristics at Estuary Mouth related to Estuary and Beach Hydraulics

Sand samples from the inner delta and from the beaches adjacent to the estuary mouth were analysed for particle size. The slopes of the beaches adjacent to the estuary mouth were also measured. The results are given in Table 3.

This shows that the particle sizes are relatively large near the mouth, where strong tidal currents of about 1,0 to 1,2 m/s (in- and outgoing nearly equal) were measured on 12 June 1983 during spring-tide conditions. The sand particles on the inner delta decrease in size upstream, and they are also smaller at the beaches west of the mouth than they are east of it.

TABLE 3: Particle sizes of sand and slopes of beaches at the Heuningnes Estuary mouth

Location	Sand size (x) (micron)	Beach slope (degrees)
Inner delta (opposite mouth)	340	-
Inner delta (300 m upstream)	225	-
Beach 200 m east of mouth	310	3 to 6
Beach 150 m west of mouth	220	2 to 4

(x) General classification:
125 to 250 micron = fine sand
250 to 500 micron = medium sand

This indicates general directions of sand propagation:

(a) In the estuary from the mouth upstream into the estuary, which causes sanding-up of the estuary from the sea.

(b) Along the beach from the mouth in an easterly direction (relatively coarser sand from the mouth moving eastward). This is also supported by the steeper slopes of the beach east of the mouth compared with those west of it.

3.2.2 Land Ownership/Uses

As the lower reaches of the estuary fall within the boundaries of the nature reserve (See Figure 6) which lies within De Mond Forest Reserve, public access is by permit issued by the state forest officer at De Mond. No camping is permitted and the area is open to day-trippers and anglers only. No public vehicles are allowed into De Mond and power boating is prohibited.

On the adjacent shoreline, netting is carried out by holders of Sea Fisheries permits. During peak holiday periods, scrambler bikes and off-road vehicles illegally entering De Mond along the beach from Struisbaai, cause damage to the dune vegetation and regular policing by the state forest officer is necessary to prevent this.

Upstream of De Mond Forest Reserve, De Mond Farm (owned by Mr G D Kilpin) which borders on the north bank of the Heuningnes, is a proclaimed private nature reserve. The rest of the land bordering on the Heuningnes between De Mond Forest Reserve and the Bredasdorp/Struisbaai road bridge is also privately owned. The local landowners, Messrs Van Breda (Zoetendals Vallei), Albertyn (Zeekoevlei), Kilpin (De Mond Farm) and Findlay (lessee of land owned by Mrs D B Kilpin between De Mond State Forest and the Heuningnes on its south bank) and their families, have established the Heuningnes Riparian Owners' Association. The policy document of this association is given as Appendix XI.

The objective of this policy is to preserve the unspoilt nature of the Heuningnes for future generations and the rules include limited netting and bait collection and boating restricted to boats powered by electric or 2 H.P. internal combustion motors. Windsurfers and sailboats are to be restricted as far as possible. Owners have also agreed to protect the natural environment, preserving indigenous fauna and flora and eliminating alien vegetation.

3.2.3 Obstructions

From Zoetendalsvlei to the mouth of the Heuningnes there are the following obstructions to the flow of water;

(a) There is a low-lying drift with several pipe culverts across the channel just downstream of the Zoetendalsvlei outflow point. This drift is overtopped during high water levels and strong run-off from Zoetendalsvlei (M R van Breda pers. comm.). It may, however, be a restriction to water movement during low-flow periods.

(b) The old Riverside Bridge (6 spans) which used to carry the Bredasdorp/Struisbaai road was built in 1943 and is situated approximately 12 km upstream of the mouth. Just downstream of it is the site of the old drift which was used before 1943 and which has now been demolished (see Figure 13).

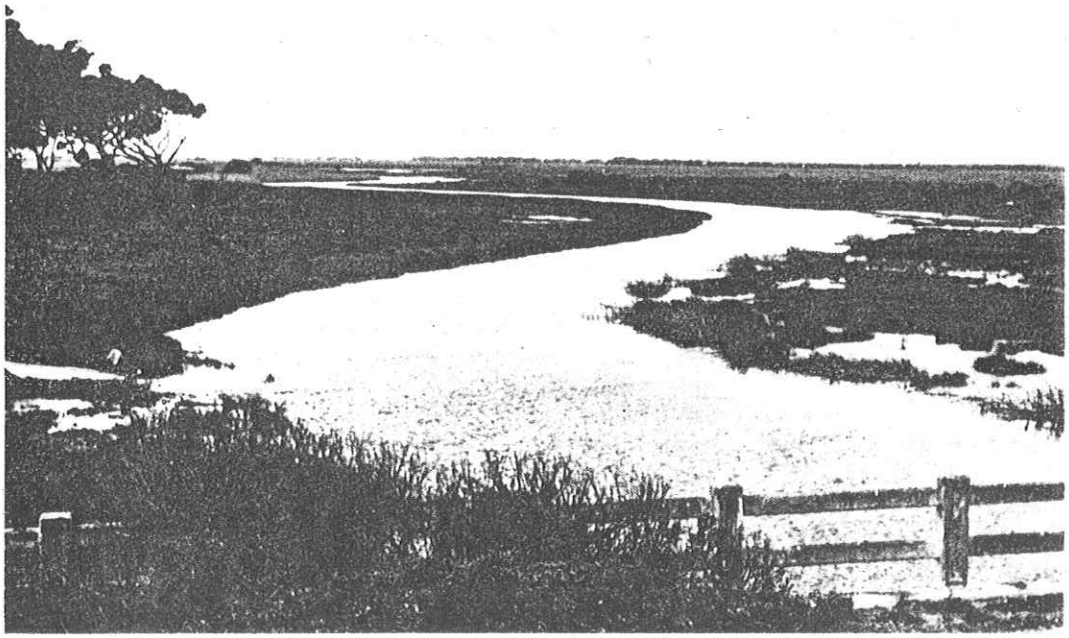


FIG. 13: Upper reaches of the Heuningnes Estuary during equinoctial high spring-tides. The old Riverside road bridge can be seen in the immediate foreground. The photograph was taken looking downstream. Note the flooding of the peripheral wetland areas (ECRU: 83-09-22)

(c) Just upstream of the old Riverside Bridge, is the New Riverside Bridge (4 spans) which was built in 1976 and carries the present Bredasdorp/Struisbaai Road.

(d) A suspension footbridge traverses the estuary on the upstream boundary of De Mond Forest Reserve, approximately 1,5 km from the mouth. It was built between 1974 and 1975 (P G Reyneke, Directorate of Forestry, pers. comm.).

(e) About 200 m downstream of the footbridge and approximately 1,3 km from the mouth, the Directorate of Forestry constructed the previously mentioned (see Section 3.2.1) causeway to allow vehicle access to the southern bank (see Figure 5 and Plate II). This causeway has been in use since 1944 (P G Reyneke, Directorate of Forestry pers. comm.).

3.2.4 Physico-chemical Characteristics

Physico-chemical data for Zoetendalsvlei and Voëlvlei were extracted from the Cape Piscatorial Society (1937), Louw (1968) and Barham (1968). For the Heuningnes Estuary, the sources of information were Mehl (1973), Day (1981a), Gaigher *(in litt.)* and the ECRU survey.

pH

According to The Cape Piscatorial Society (1937) the water in the main streams draining the Elandskloof Mountains and Bredasdorp Range is brown, vegetable-stained and acid with a pH of 4,5 to 5,0. Below Elim, where the mountain streams combine to form the Nuwejaarsrivier, the acidity of the mountain water was found to be neutralised with a pH of 7,0 and further downstream in Zoetendalsvlei the pH was 8,5 (the Cape Piscatorial Society, 1937).

Louw (1968) found the pH of Voëlvlei and Zoetendalsvlei to be 8,5 during a survey in May 1968.

Monthly pH values at three sampling stations in the Heuningnes Estuary for the year 1971 (mouth open conditions) were in the range of 8,0 to 8,6 (Mehl, 1973). Most of the readings were fairly consistent between 8,2 and 8,4 which is close to the normal pH value of seawater (Day, 1981b).

Temperature

Louw (1968) measured twenty-four hour surface temperature ranges of 17,2°C - 20,0°C for Voëlvlei and 16,7°C - 18,9°C for Zoetendalsvlei during a survey in May 1968. In June 1969 a temperature of 14,8°C was measured at night (J R Grindley, School of Environmental Studies, University of Cape Town, pers. comm.).

Surface temperatures at three sampling stations in the Heuningnes Estuary were recorded by Mehl during a study of the White Steenbras *(Lithognathus lithognathus)* during 1971. These data are shown in Table 4 below.

TABLE 4: Average monthly surface water temperatures (°C) for 1971, recorded at three stations on the Heuningnes Estuary (after Mehl, 1973)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	24.0	19,0	19,0	18,5	15,0	14,5	13,5	12,0	16,0	16,0	19,5	18,5
2	24,0	20,0	20,0	19,0	14,5	14,0	13,5	13,5	17,5	16,0	23,0	21,5
3	24,0	21,0	21,0	19,0	14,0	14,5	13,5	15,0	16,5	16,0	22,0	19,5

Location of sampling stations (see Figure 6)

1 - approximately 1 km upstream of the mouth
2 - approximately 2 km upstream of the mouth
3 - approximately 12 km upstream of the mouth (at Riverside Bridge)

Day (1981a) gives the following seasonal means determined from Mehl's data:

Summer	Autumn	Winter	Spring
19,8 °C	17,5 °C	13,3 °C	17,3 °C

The temperature data collected during the ECRU survey in June 1983 can be seen in Table 5. These ranged from 11,0 °C to 15,7 °C.

Transparency

Secchi disc measurements taken in Zoetendalsvlei in May 1968 were 0,36 m (Louw, 1968) and 0,46 m (Barham, 1968).

During the ECRU survey, water transparency (see Table5) decreased from the mouth upstream to the Riverside Bridge. Transparencies ranged from 0,8 m at this bridge to more than 1,8 m opposite the Forestry Inspection Quarters, approximately 1,5 km upstream of the mouth. The high readings indicate the strong influence of the sea high up into the estuary.

Salinity

The water in Zoetendalsvlei is reported to be slightly brackish but potable (Barham, 1968). A vlei salinity of 5,2 parts per thousand was measured during drought conditions in June 1969 by Prof. J R Grindley (School of Environmental Studies, University of Cape Town). A salinity of 20 parts per thousand was measured at the drift on the farm Vissersdrift downstream of the Zoetendalsvlei outflow in May 1968 (Barham, 1968).

Mehl (1973) gives monthly salinities for three stations in the Heuningnes during 1971 when the mouth was open. These data are plotted in Figure 14.

FIG. 14: Monthly surface water salinities for 1971 (mouth open condition), from three stations on the Heuningnes Estuary.

(From Mehl, 1973)

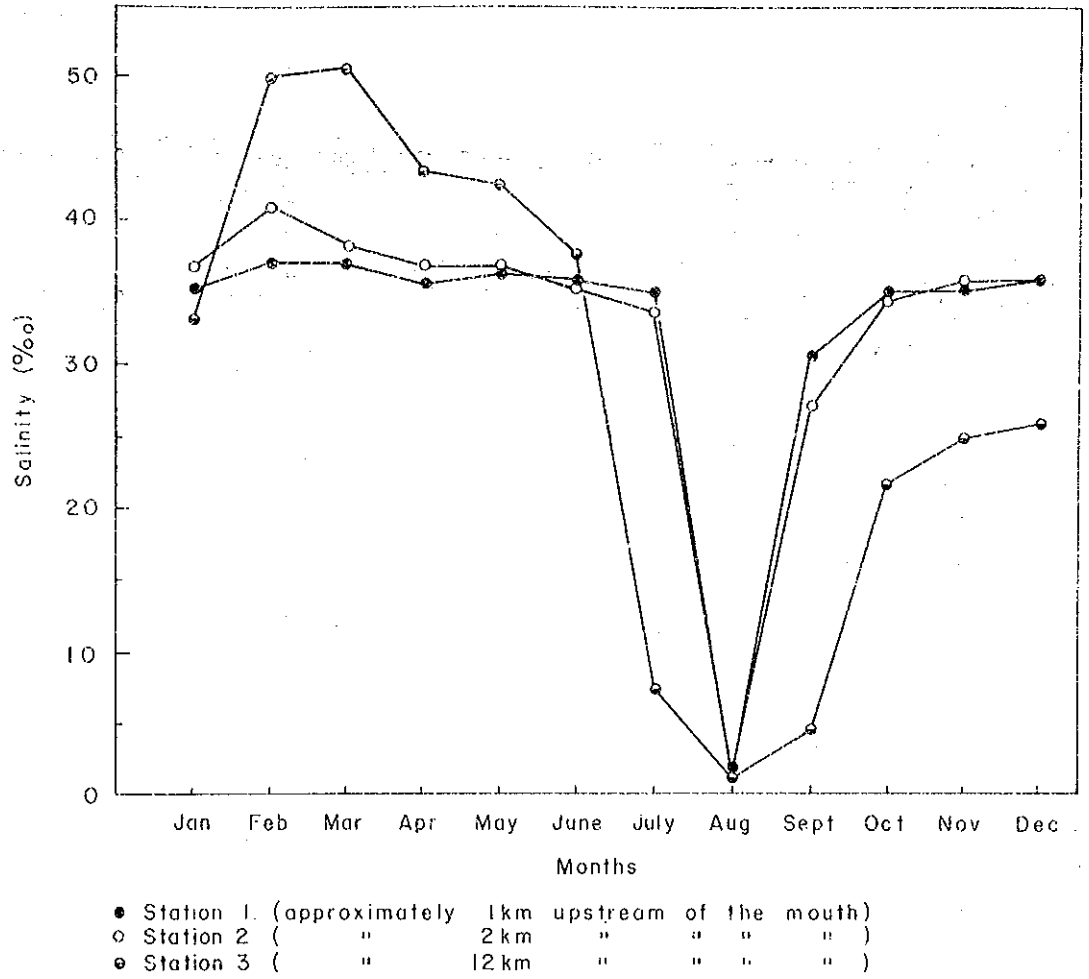
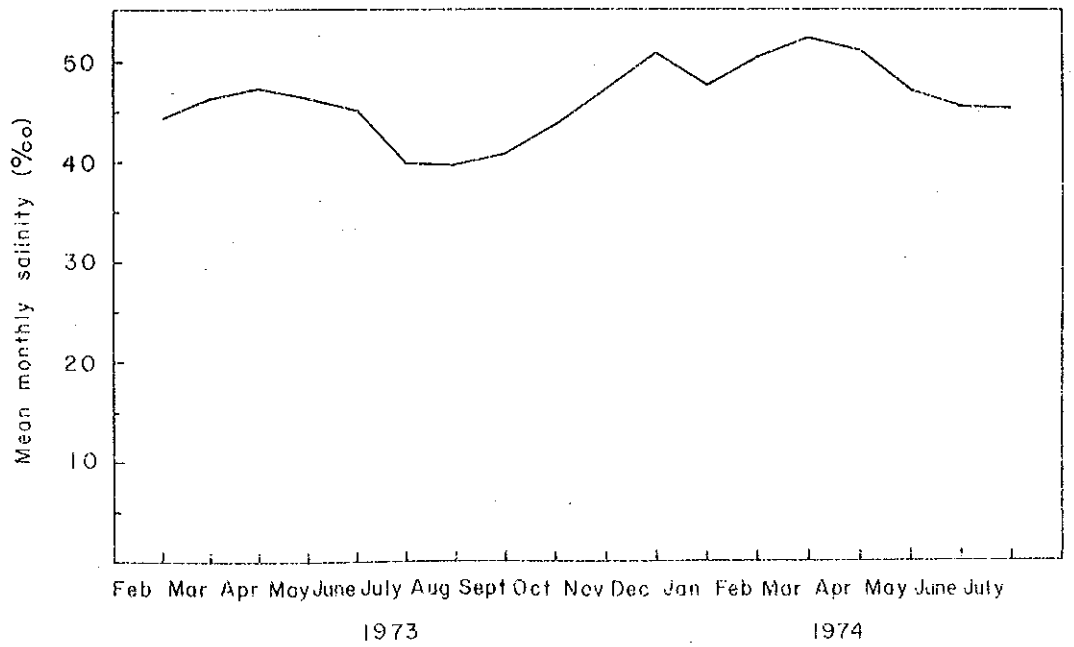


FIG. 15: Mean monthly surface salinities calculated from chlorinities measured weekly by the CPA Department of Nature and Environmental Conservation at a point approximately 1,5km upstream of the mouth from February 1973 to July 1974 during an extended period of mouth closure. Chloride ion concentrations from Gaigher (*in litt*).



Salinities in the lower reaches of the estuary calculated from chlorinities measured by the CPA Department of Nature and Environmental Conservation during the extended period of mouth closure from February 1973 to July 1974 are shown in Figure 15. These calculations are, however, based on the proportion of chloride in seawater and may therefore be slightly inaccurate. The salinity data collected during the ECRU survey are given in Table 5.

The above-mentioned data show that when the mouth of the Heuningnes is open, the lower reaches of the estuary are dominated by seawater particularly during the dry months from October to May. At such times a reversed salinity gradient due to evaporation exceeding freshwater inflow can occur, resulting in salinities as high as 50 parts per thousand having been recorded 12 km upstream of the mouth. However, when Zoetendalsvlei overflows in the winter months and with run-off from the Karsrivier entering the estuary, the saline water is flushed out and salinities throughout are appreciably lowered.

During the period of mouth closure from 1973 to 1976 when there was minimal run-off from the catchment, hypersaline conditions existed in the lower reaches of the estuary (see Figure 15) with salinities reaching as high as 55 parts per thousand in March 1974. Salinities were,however, slightly reduced to the 40s in the winter months of 1973 and 1974, presumably by winter rainfall and run-off.

TABLE 5: Physico-chemical data for the Heuningnes Estuary collected during the ECRU Survey in June 1983

Date	83-06-08	83-06-08	83-06-07	83-06-09
Time	11h45	09h10	16h40	15h40
State of mouth	O P E N			
State of tide	Midway between neaps and springs			
	High at 13h25	Low at 07h17	Low at 19h24	High at 14h04
Sampling station number	1	2	3	4
Sampling station locality	1,5 km upstream of mouth	2,6 km upstream of mouth - on bend	6 km upstream of mouth	12 km upstream of mouth - Riverside road-bridge
Depth (m)	1,8	2,0	2,0	1,5
* Width (m)	80	50	40	30
Salinity (p.p.t.)				
Surface	34	30	26	23
Bottom	35	32	30	23
Temperature (°C)				
Surface	12,3	11,0	14,5	
Bottom	13,3	12,0	15,7	15,6
Secchi transparency (m)	Greater than depth	1,8	1,0	0,8
Substrate	Medium sand	Sandy mud	Sandy mud	Sandy mud

* Estuary/River width at sampling site.

Surface and bottom salinities measured during the ECRU survey (Table 5) indicated that stratification does occur in the Heuningnes, particularly in the middle reaches.

Surface salinities measured during an ECRU visit in September 1983, when there was a strong outflow from Zoetendalsvlei, were 2 parts per thousand at the Riverside Bridge (12 km upstream of the mouth) and 8 parts per thousand in the estuary opposite the Forestry Inspection Quarters.

According to Mr P G Reyneke of the Directorate of Forestry, the water from the Forestry borehole, which is situated behind the dunes on the western bank of the estuary due west of the Forestry Inspection Quarters, has become more brackish with time. This could be a result of the mouth being kept permanently open.

Dissolved Oxygen (DO) and nutrients

Barham (1968) recorded a dissolved oxygen content of approximately 4 parts per million (milligrams per litre) during a survey of Zoetendalsvlei in May 1968. No other dissolved oxygen data for the Heuningnes could be found, but with the estuary being permanently open and usually strongly under the influence of tidal action, oxygen levels close to saturation can be expected.

No information on nutrient levels in the Heuningnes could be traced. Extensive use of fertilizers (superphosphates) is made, but there is probably little enrichment of the waterways because of the low run-off (D Cronje, Agricultural Technical Services, pers. comm.).

3.2.5 Pollution and Public Health Aspects

In February 1971 the grounding of the tanker *Wafra* caused serious oil pollution along the coast in the vicinity of Cape Agulhas. As a precaution, a barrier of straw bales was strung across the mouth of the Heuningnes to prevent oil from entering the estuary (P G Reyneke, Directorate of Forestry, pers. comm.). The Heuningnes was closed at the time of the grounding of the *Oriental Pioneer* in July 1974 and was therefore not affected by the resultant pollution.

Herbicides and pesticides are used extensively in the catchment of the Heuningnes and crop spraying by air is commonly carried out (D Cronje, Agricultural Technical Services, pers. comm.).

No information on the bacteriology of the Heuningnes Estuary was obtained, but because of the undeveloped nature of the lands adjacent to the estuary there are probably no serious public health hazards.

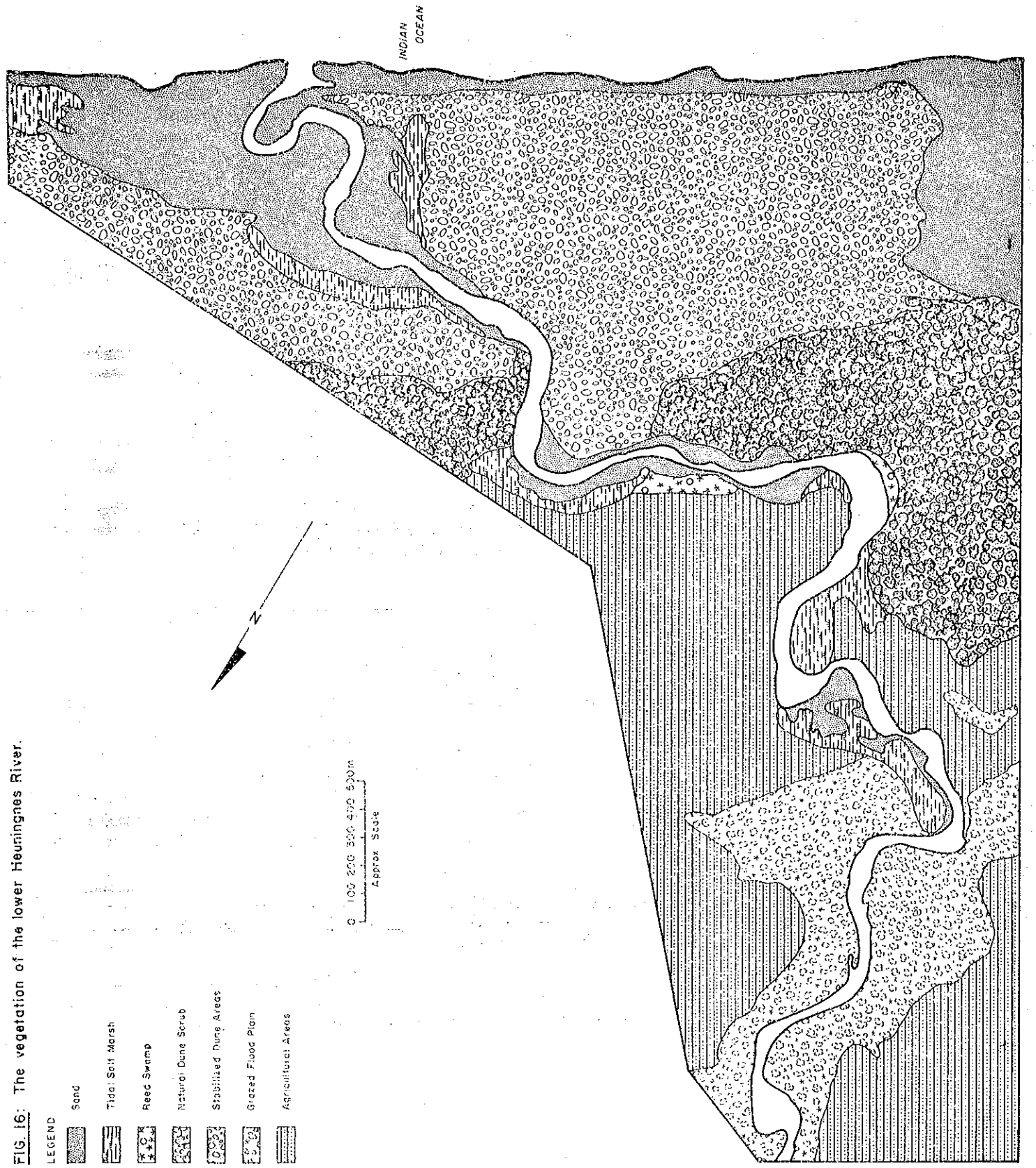


FIG. 16: The vegetation of the lower Heuningnes River.

4. BIOTIC CHARACTERISTICS

4.1 Flora

(This section is contributed by Mr M O'Callaghan of the Botanical Research Unit, Stellenbosch).

4.1.1 Algae

No information available.

4.1.2 Aquatic Angiosperms

The aquatic vegetation of this river includes *Ruppia* sp, noted approximately 3 km from the mouth during the ECRU Survey. Further upstream, the water is rather turbid and aquatic plants are sparse.

4.1.3 Semi-Aquatic Vegetation

The salt marshes near the mouth occur on sandy substrates. They are dominated by *Limonium* spp and *Salicornia* cf *meyerana* with some *Sarcocornia* spp.Unfortunately, these marshes are almost entirely cut off from the river by artificial levees and are flooded only during exceptionally high-tides. This restriction of tidal interaction has allowed plants with terrestrial affinities, e.g. *Tetragonia decumbens, Chrysanthemoides monilifera* and others to encroach into this area.

It is therefore recommended that the levees be breached to allow tidal inundation and the roads which traverse these salt marshes should then be placed above the flood areas.

The salt marshes further upstream are more typical and are situated on mud. They consist of *Sarcocornia perennis* at the low water mark followed by *S. decumbens*. A mixed zone is then found with *Chenolea diffusa* and *Sueda maritima*. *Limonium scabrum* is found at the high water mark and the top of the salt marsh is often bound by *Juncus kraussii*.

Floodplain vegetation is usually found between the salt marshes and the terrestrial vegetation. However, along this river, these flood plains have been severely degraded by cattle grazing and trampling and other agricultural development. Remnants of this vegetation type include *Sarcocornia pillansiae* and *Chrysanthemoides incana*.

Patches of reeds *(Phragmites australis)* are also found near the river banks approximately 3 km from the mouth and further upstream. However, these patches, especially near the mouth, are small and seem to be in a poor condition, due possibly to the high salinity of this river.

4.1.4 Terrestrial Vegetation

Seven mapping units were identified at the Heuningnes Estuary. The spatial distribution of these is shown in Figure 16 while Appendix I lists the species and physical features of each

unit. The terrestrial vegetation adjacent to the estuary consists of dune scrub. As can be seen from Figure 16, much of this area has been successfully artificially stabilised. Full details of this process can be obtained from the Directorate of Forestry. Briefly it entails the planting of *Ammophila arenaria* (marram grass) on the bare sand which is fertilised to enhance the growth of this pioneer. During the planting of marram grass, the seeds of numerous scrub species, such as *Myrica cordifolia* (wax berry), *Chrysanthemoides monilifera* (bietou), *Chironia baccifera* (bitterbos), *Metalasia muricata* (blombos) and others, are sown and soon become dominant. Eventually, numerous seedlings enter the area from the natural dunes and become established. However, there are at this stage few species in these stabilized areas.

In very exposed areas, the sand is often first 'trapped' by placing brushwood branches, cut from the established areas, on the sand.

The dense natural dune vegetation consists of taller shrubs e.g. *Colpoon compressum, Euclea racemosa, Pterocelastrus tricuspidatus;* numerous restioids such as *Restio eleocharis, Thamnochortus paniculatis, Ficinia lateralis* and a variety of herbs.

Small patches of riparian scrub containing species such as *Lycium ferocissimum, Zygophyllum morgsana, Salvia aurea, Rhus lucida* and others, are found along the river.

Steep dunes which have been built up on either side of the mouth are being eroded by the river and the sea. The flood plains and salt marshes possibly indicate previous river courses and it might be advisable to let the mouth of the river breach naturally in these areas.

4.2 Fauna

4.2.1 Zooplankton

No records of zooplankton in the Heuningnes estuary are available, but the zooplankton of Zoetendalsvlei was sampled by Prof. J R Grindley (School of Environmental Studies, University of Cape Town) in June 1969. A list of the zooplankton specimens included in his samples is given in Appendix II.

A total of 14 species were represented in these two samples with a mean dry biomass of 9,86 mg/m^3. The dry biomass values of the samples were 5,6 mg/m^3 and 14,1 mg/m^3.

The zooplankton species recorded from Zoetendalsvlei are typical of estuaries in the southern Cape. The same species were probably common throughout most of the Heuningnes system (J R Grindley, School of Environmental Studies, University of Cape Town, *in litt.*).

4.2.2 Aquatic Invertebrates

Surveys of Zoetendalsvlei carried out in 1937 (The Cape Piscatorial Society, 1937) and 1968 (Louw, 1968 and Barham, 1968) revealed the occurrence of the following aquatic invertebrates

in the vlei: the freshwater snail *Bulinus tropica*, the freshwater mussel *Cafferia caffer*, the estuarine amphipod *Grandidierella lignorum*, the freshwater crab *Potamonautes perlatus*, Chironomid *(Leptocerus)* larvae and damselfly *(Ischnura senegalensis)* larvae.

When Prof. J R Grindley (School of Environmental Studies, University of Cape Town) visited Zoetendalsvlei when it was virtually dry during 1970, he noted sub-fossil specimens of the surf clam *Schizodesma spengleri* and an oyster species *Ostrea* (probably *atherstonei)* protruding from the Bredasdorp Limestone rocks on the bed of the empty vlei. These fossils were probably remnants of an earlier littoral environment when sea level was higher than at present and much of the Bredasdorp Coastal Plain was inundated. Live specimens of the estuarine mussel *Arcuatula* (previously *Lamya) capensis* were also found in the vlei.

Mehl (1973) in an analysis of gut contents of the White Steenbras in the Heuningnes in 1971, found 36 invertebrate food species (see Appendix III). These had probably all been taken in the estuary.

A list of the aquatic invertebrate species recorded for the Heuningnes Estuary can be seen in Appendix IV. The list comprises records from Day (1981a), specimens collected by the Forest officer at De Mond Forestry Reserve and species recorded during the ECRU survey in June 1983. Seventeen species are listed, although the list is far from complete. During a survey of the Heuningnes by the University of Cape Town in September 1973, 18 species of macro-invertebrates were recorded.

Mr P G Reyneke (Directorate of Forestry, pers. comm.) reported the previous occurrence of pencil bait *Solen* sp. above the Forestry suspension foot bridge. He also mentioned that oysters and octopuses had disappeared from the estuary when the mouth closed, but that the octopus had returned since the mouth had been open.

Barham (1979) studied spawning of the bloodworm *Arenicola loveni* in the Heuningnes Estuary from 1968 to 1970 when the mouth was open. He found that spawning occurred in late summer and on two consecutive occasions spawning occurred in the first week in February. Gaigher *(in litt.)* has documented the extinction and recolonisation of bloodworm in the Heuningnes Estuary before, during and after the period of extended mouth closure from 1973 to 1976. Prior to 1972 an extensive population of bloodworm occurred in much of the Heuningnes Estuary. Exploitation of bloodworm for bait was carried out by the CPA Department of Nature and Environmental Conservation (who had a research station there) on behalf of a limited number of permit holders of the Bredasdorp Angling Club. After closure of the mouth in 1973 the bloodworm population declined and had been eliminated by March 1974. By January 1977 (6 months after re-opening of the mouth), bloodworm had again become established in the immediate vicinity of the mouth and had extended into the estuary by January 1979. The large marine population of bloodworm which occurs on the sheltered Struisbaai beach to the south-west was probably the source of recruitment for recolonisation of the Heuningnes (Gaigher, *in litt.)*.

Gaigher *(in litt.)* surveyed the distribution and abundance of the burrowing sand prawn *Callianassa kraussi* and the mud prawn *Upogebia africana* on 16 January 1979. Three areas downstream of the De Mond Forestry Inspection Quarters in the lower estuary, were sampled. No *U. africana* were found, but *C. kraussi* densities ranged from 32 to 83 prawns per 20 cores sampled with a prawn pump. The densities of burrow openings ranged from 58 to 200 per square metre. Upstream of the De Mond Forestry Reserve boundary *C. kraussi* was less common but occurred in small numbers up to 3 km downstream of the Bredasdorp/Struisbaai road bridge. Low numbers of *U. africana* were present in the muddy regions of the middle reaches of the estuary (Gaigher *in litt.* and ECRU survey).

The invertebrate fauna of the Heuningnes appears to be dominated by marine and typically estuarine species. As the estuary is normally tidal for 12 km this is to be expected. However, the occurrence of species such as the hermit crab *Diogenes brevirostris*, the sea hare *Notarchus* sp., the false limpet *Siphonaria oculus* and the necklace shell *Natica* sp., 3 km upstream of the mouth (as was recorded during the ECRU survey) indicates a strong marine influence, as these invertebrates are normally found closer to the mouths of other Cape estuaries of a size similar to that of the Heuningnes. The occurrences of the ginger prawn *Penaeus japonicus* and the giant mud crab *Scylla serrata* (both tropical species) at the Heuningnes, are the southernmost for these species in southern Africa.

4.2.3 Fish

Fish surveys of Zoetendalsvlei were carried out in winter 1937 (Cape Piscatorial Society, 1937), winter 1968 (Barham, 1968 and Louw, 1968) and winter 1980 (McVeigh, 1980). A list of the fish species for Zoetendalsvlei based on these surveys is given in Appendix V. One indigenous and four exotic freshwater species and five marine or estuarine species were recorded. Of particular note is the use of Zoetendalsvlei by marine species such as the mullet *(Mugil cephalus* and *Liza richardsoni)* and white steenbras *(Lithognathus lithognathus)*. Zoetendalsvlei is only connected to the Heuningnes after periods of high rainfall which cause the vlei to overflow. Hence these marine species may be landlocked for long periods and consequently (mullet in particular) reach exceptional sizes (Gaigher *in litt.)*. Records from the Van Breda Journal (1840-1944) indicate that in February 1869 during dry conditions (that is Zoetendalsvlei not connected to the sea) "springers" *(M. cephalus)* "2 ft $1^1/_2$ in" (65 cm) long, "harders" *(L. richardsoni)* "1 ft 6 in" (46 cm) long and "steenbras" *(L. lithognathus)* "2 ft 3 in" (69 cm) long were caught in the vlei.

Zoetendalsvlei is an important feeding area for marine fish, particularly southern mullet *(L. richardsoni)* and flathead mullet *(M. cephalus)* as is borne out by catch figures given by Barham (1968), Louw (1968) and McVeigh (1980).

In 1944, 2 000 bass fingerlings were introduced into Zoetendalsvlei (Cape of Good Hope Provincial Administration. Inland Fisheries Department, 1944). These probably account for the presence of bass in Zoetendalsvlei today.

A list of fish species which occur in the Heuningnes Estuary and its tributaries (Grashoek and Kars rivers) is given in Appendix VI. It comprises two freshwater species and 22 marine/estuarine species. The strong marine influence on the Heuningnes is indicated by the occurrence of fish species such as the baardman *(Umbrina capensis)*, galjoen *(Coracinus capensis)*, zebra *(Diplodus cervinus)* and the strepie *(Sarpa salpa)* in the estuary. These species are not often found in the typical estuarine environment.

According to P G Reyneke (Directorate of Forestry, pers. comm.) blaasops do occur at the mouth of the Heuningnes and the seahorse *(Hippocampus* sp.) has been netted in the estuary.

When Zoetendalsvlei overflows into the Heuningnes, large numbers of carp *(Cyprinus carpio)* are washed down into the estuary where they succumb to the saline conditions (H O Swart, Directorate of Forestry, pers. comm.). This was seen during a visit to the Heuningnes by ECRU personnel in September 1983.

4.2.4 Reptiles and Amphibians

No specimens of reptiles or amphibians were collected during the ECRU survey. However, a list of species recorded for the area covered by the 1:50 000 sheet 3420 CA and CC Bredasdorp in which the Heuningnes Estuary is centrally situated, was obtained from A L de Villiers *(in litt.)* of the CPA Department of Nature and Environmental Conservation. As the list of recorded species for the area is incomplete, species which are likely to occur there are also included. The list is given in Appendix VII.

Eight frog species, six snake species and two species of tortoise have been recorded for the area. Of these only the Arum frog is listed in the South African Red Data Book as being rare or threatened (McLachlan, 1978). Of the species likely to occur in the area the Cape dwarf chameleon is considered to be rare or threatened (McLachlan, 1978).

4.2.5 Birds

Wader counts for Zoetendalsvlei and the Heuningnes Estuary, carried out during the summer of 1975/76, have been published by Summers *et al* (1976). Data from more recent counts of waterbirds (Underhill and Cooper 1983) are given in Appendices VIII and IX. Summer counts for the lower estuary (1977/78, 1979/80 and 1980/81) indicated a maximum of 24 species whereas nine species were present during the Winter 1980 count. The differences in number of species between summer and winter was largely due to the use of the estuary by migratory waders in the summer months. The summer 1980/81 count for the lower and upper estuary up to 3 km upstream of the mouth indicated 28 species of waterbird.

Zoetendalsvlei is clearly an important waterbird habitat with a total of 39 water-associated species comprising 7 267 birds having been recorded there in the 1980/81 summer (Appendix VIII). Of these there were eight migrant and six resident wader species making up 3 221 birds.

The lower reaches of the Heuningnes Estuary are utilized largely by shore birds. Two species recorded (Appendices VIII and IX), the Caspian Tern and Damara Tern, are listed as being threatened in the South African Red Data Book (Siegfried *et al*, 1976) and both of these use the lower reaches of the Heuningnes for roosting and feeding. The upper reaches of the estuary appear to be used more by typical estuarine and freshwater species as was borne out by the presence there of large numbers of Egyptian Geese and South African Shelduck during the ECRU Survey in June 1983.

The dune areas to the north-east and south-west of the Heuningnes are important areas for several species of seabird. In particular, 300 pairs of Kelp Gulls and several pairs of Caspian Terns regularly nest in the dunes a few kilometres to the north-east of the Heuningnes mouth, within the boundaries of De Mond Forestry Reserve. South Africa's rarest breeding seabird, the Damara Tern, has also been recorded breeding within the boundaries of the reserve (Burger *et al*, 1980).

Other species such as the Black Oystercatcher and Blue Crane also breed in the dunes to the north-east and south-west of the Heuningnes (Burger *et al* 1980). De Mond Forestry Reserve is therefore an important seabird breeding area, particularly so for the Damara Tern, as De Mond is the only known breeding site on the South African coastline for this species.

4.2.6 Mammals

Stuart *et al* (1980, unpublished) have recorded twelve mammal species for the area covered by the 1:50 000 Topocadastral Sheet 3420 CA and CC Bredasdorp and an additional ten species for De Mond Forestry Reserve have been recorded by the Directorate of Forestry (see Appendix X).

Of the species recorded, the Cape Greater Gerbil and Aardwolf are listed as being threatened in the South African Red Data Books (Meester, 1976 and Skinner *et al*, 1977).

As De Mond is managed as a Nature Reserve, the fauna found there, in particular the large mammals, are afforded good protection.

5. SYNTHESIS

The Heuningnes drains the low-lying coastal plain of Bredasdorp. Because of the flat topography of the plain, many of the drainage channels are not well-defined and run-off into the estuary occurs via vleis and marshes which constitute large areas of wetland. Consequently long periods of heavy rainfall, often cause extensive flooding of the lower-lying areas and some of the farmers have dug drainage canals to keep the water off their lands.

The hydrology of the Heuningnes is variable in that run-off via the estuary occurs only when Zoetendalsvlei overflows and/or there is flow from Karsriviervlei. At other times the estuary, being kept permanently open artificially, is tidally dominated.

The low gradients of the land and the resultant poor drainage into the Heuningnes coupled with the occurrence of driftsands, in the late 1800s and early 1900s, which moved across and closed the estuary, frequently caused backflooding into the wetland areas. It is not clear whether the establishment of driftsands occurred as a natural phenomenon or whether mobilization of the sand was induced by human activities. In any event, the back-flooding problem was so serious by 1937 that representation was made to the Department of Agriculture and Forestry to rectify the situation.

The dune stabilisation programme carried out by the Directorate of Forestry appears to have changed the hydrological regime of the Heuningnes as follows:

(a) The mouth used to remain closed for long periods during the dry summer months and would open naturally only after extensive water-level build-up with associated back-flooding after or during the wet winters. Strong flood flows would also have breached the barrier dune but at a position south-west of the present mouth position. Closure thereafter would have been associated with a north-easterly migration of the mouth. A net north-easterly migration of the mouth with time appears to be indicated from comparison of historical maps and aerial photographs. This is borne out by the occurrence of pencil bait *(Solen capensis)* shells in an upright (living) position in dune slacks approximately 2 km south-west of the present mouth position (ECRU survey). As pencil bait is typically associated with estuary mouths, its occurrence in the dune slack would suggest that the Heuningnes previously opened to the sea at this position.

(b) Since stabilisation of the barrier dunes, the mouth has been confined between brushwood-built abutments close to where it was in 1938. It does, however, still migrate north-eastwards and south-westwards over short distances under the influence of longshore drift as is evidenced by aerial photography dating back to 1961. This movement is restricted by the continuous maintenance of the brushwood barriers through the Forestry reclamation programme. According to Mr H O Swart, Forest Officer at De Mond, flood flows do, however, penetrate the brushwood-built barrier dune on its south-western side after very heavy rainfall periods.

The artificial maintenance of the mouth in a permanently open condition may have caused an increase in the salinity of the groundwater around the estuary. The increased brackishness of the Forestry borehole water with time could be as a result of this (see Section 3.2.4 *Salinity)*.

Sediments are moved upstream during flood tides by both tidal and wave energy and at times by southerly winds, whereas their downstream movement would be under the influence of tidal energy

from ebb-tide outflow only when there is no run-off from the catchment. For this reason there could be a net accumulation of marine sand in the lower reaches of the estuary with a major source of supply being the barrier dunes continuously built up by the maintenance of the brushwood barriers on either side of the mouth.

By decreasing the restriction caused by the Forestry causeway, the tidal prism of the Heuningnes will be increased. This is likely to result in greater erosion of marine sediments in the lower estuary, particularly during ebb-tide flows. The cross-sectional area recommended by the Sediment Dynamics Division of NRIO, for uprating of the causeway, being 5 m^2 would require the installation of a minimum of 12 x 750 mm (or 20 x 600 mm) pipes. This recommendation is strongly supported in this report as its implementation will facilitate the management of the mouth area.

The Heuningnes Estuary is not particularly rich in intertidal salt marsh areas which are biologically important to an estuary. An extensive salt marsh area is situated on the north banks of the estuary in its lower reaches (see Figures 6 and 16). This area is inundated by extreme high spring-tides, but is cut off from the estuary by an artificially created rubble embankment running along the interface between the sandflats and the salt marsh area to protect the Forestry access track. It is recommended that this embankment either be removed or that gaps be created in it to allow greater ease of inundation during high spring-tides. If necessary, the Forestry track running toward the mouth to provide access could be relocated further away from the estuary, particularly where it runs along the edge of the salt marsh.

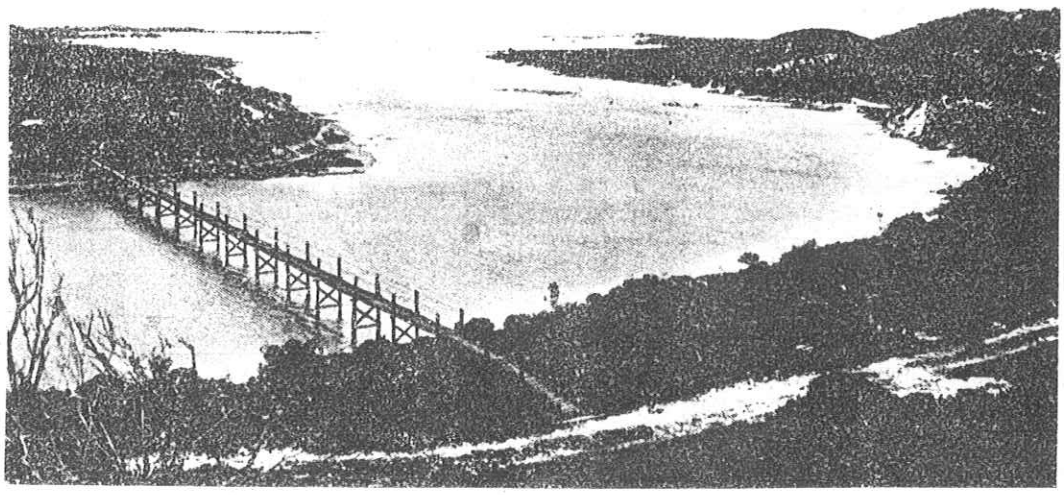


FIG. 17: Lower reaches of the Heuningnes Estuary during high neap-tides. The uppermost rocks of the Forestry causeway can just be seen protruding above the water surface in the background to the right of the centre of the photograph (ECRU: 82-11-24)

Since the lower reaches of the Heuningnes fall within the De Mond Forestry Reserve, the estuary is well protected from human interference. Access to the upper reaches is also restricted as the adjacent land is privately owned. Because of this the Heuningnes has been proposed for inclusion in the Project Aqua list (Noble, 1974). Project Aqua in South Africa is an attempt to evaluate at a national level, the conservation status both of aquatic biotopes and of habitats of threatened aquatic species in existing conserved areas and the possible need for additional aquatic sites to be conserved (Noble, 1974).

De Mond is also an important area for seabird breeding. About 300 pairs of Kelp Gulls *(Larus dominicanus)* and several pairs of Caspian Terns *(Hydropogne caspia)* breed in a colony to the north-east of the mouth of the estuary (see Section 4.2.5). As the area between Struisbaai and the Heuningnes Estuary is presently the only confirmed breeding area for the Damara Tern *(Sterna balaenarum)* (South Africa's rarest breeding seabird), it is imperative that the tern's feeding and nesting grounds in the area be protected (Burger *et al*, 1980). The following are some of the more important recommendations made by those authors:

(1) No dune slacks within 300 m of the beach should be vegetated.

(2) If at all possible consideration should be given to acquiring the coastal dune system south-westwards to the Struisbaai Estate A boundary and north-eastwards to the Klippe rugt/Dolla's Downes Boundary.

(3) Access to the Forestry land along the beach from either Struisbaai or Arniston should not be allowed for persons either on foot or in vehicles.

(4) Entrance of official vehicles into areas where Damara Terns might be nesting should be kept to an absolute minimum during the period of 1 November to 28 February.

(5) Annual censuses should be undertaken to determine the number of Damara Terns within De Mond Forestry Reserve and to ascertain their breeding success.

(6) The De Mond Forestry Reserve should be registered with the Ramsar Convention on the Conservation of Wetlands of International importance, especially as Waterfowl Habitat, since it fulfills the criteria for eligibility, such as supporting an appreciable number of endangered species.

Two documents are fundamental to the future management of the Heuningnes. The first is the proposed Forestry Management Plan for the next decade which was drawn up by Mr P G Reyneke of the Directorate of Forestry. This document is presently being approved by the Directorate and will be implemented as from 1984.

The second document, is the policy document drawn up by the Heuningnes Riparian Owners Association which is given in Appendix XI. The initiative of the local landowners in drawing up

such a document is to be commended and their efforts to conserve the upper reaches of the estuary should be supported. However, the approval of the Cape Department of Nature and Environmental Conservation should be obtained as this statutory body has certain regulations regarding the control of the Heuningnes. A further point concerning this policy document is that allowance is made for waterskiing for 500 yards below the Bredasdorp/Struisbaai roadbridge. As the river is only 15-20 m wide over this stretch and waterskiing would require the use of a powerful outboard motor, such activities are likely to result in serious bank erosion and cannot be supported.

The threat posed by high water levels in the Heuningnes, to the farmlands situated on the coastal plain of Bredasdorp, reduces the possibility of leaving the mouth to manage itself. However, the maximum water level in the estuary above which inundation of any farm land occurs, should be established. A gauge plate could be set up opposite the Forestry station to ascertain the maximum level. This would give an indication of the maximum water level which could be allowed during any future mouth closure and above which artificial breaching of the mouth should be carried out.

Under the Forestry management policy the open mouth should be allowed to migrate back and forth depending on the longshore drift and run-off conditions. The recommendations in this report concerning increased tidal exchange through the Forestry causeway should help to solve the management problems at the mouth.

6. ACKNOWLEDGEMENTS

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7. GLOSSARY OF TERMS USED IN PART II REPORTS

ABIOTIC: non-living (characteristics).

AEOLIAN (deposits): materials transported and laid down on the earth's surface by wind.

ALIEN: plants or animals introduced from one environment to another, where they had not occurred previously.

ALLUVIUM: unconsolidated fragmental material laid down by a river or stream as a cone or fan, in its bed, on its floodplain and in lakes or estuaries, usually comprised of silt, sand or gravel.

ANAEROBIC: lacking or devoid of oxygen.

ANOXIC: the condition of not having enough oxygen.

AQUATIC: growing or living in or upon water.

ARCUATE: curved symmetrically like a bow.

BARCHANOID (dune): crescent-shaped and moving forward continually, the horns of the crescent pointing downwind.

BATHYMETRY: measurement of depth of a water body.

BENTHIC: bottom-living.

BERM: a natural or artificially constructed narrow terrace, shelf or ledge of sediment.

BIMODAL: having two peaks.

BIOGENIC: 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°, 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.

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APPENDIX I: Physical features of the vegetation mapping units and species found at the Heuningnes River

	Area (ha)	% of area studied	Cover (%)	Height (m)
Salt marshes	28,15	4,15	90	0,20
Grazed Flood Plains	69,72	10,20	5	0,50
Reed Swamps	3,13	0,46	100	1,50
Natural Dune Scrub	89,90	13,26	80	1,50
Stabilized Dune Areas	190,68	28,13	60	0,80
Agricultural Areas	155,20	22,89		
Sand	101,86	15,02		
Water	39,37	5,81		
Total	678,01			

Salt Marshes and Flood Plain

Carpobrotus acinaciformis (+); *Chenolea diffusa* (4); *Chrysanthemoides incana* (+); *C. monilifera* (r); *Juncus kraussi* (1); *Limonium kraussianum* (+); *L. scabrum* (3); *Metalasia muricata* (r); *Plantago carnosa* (+); *Sarcocornia capensis* (+); *S. decumbens* (2); *S. perennis* (+); *S. pillansiae* (+); *Salicornia* cf *meyerana* (2); *Sporobolus virginicus* (1); *Sueda inflata* (+); *S. maritima* (+).

Terrestrial vegetation

Ammophila arenaria (+); *Asparagus suaveolens* (+); *Chrysanthemoides monilifera* (+); *Chironia baccifera* (1); *Ehrharta villosa* (+); *Euclea racemosa* (+); *Ficinia lateralis* (+); *Helichrysum crispum* (r); *Metalasia muricata* (2); *Myrica cordifolia* (2); *Nylandtia spinosa* (1); *Passerina* sp (+); *Restio eleocharis* (2); *Rhus crenata* (+); *R. glauca* (+); *Scirpus nodosus* (+); *Sutherlandtia fruticosa* (r); *Thesium* sp (+); *Trachyandra divaricata* (1).

In addition to the above, the following species are also found in the natural dune and riparian scrub:

Bonatea speciosa (+); *Carissa bispinosa* (+); *Cussonia thyrsiflora* (+); *Euphorbia mauritanica* (+); *Lachenalia* sp (+); *Lasiochloa* sp (+); *Lycium ferocissimum* (+); *Olea exasperata* (1); *Pterocelastrus tricuspidatus* (+); *Pteronia* cf *uncinata* (+); *Rhus laevigata* (+); *R. lucida* (+); *Salvia aurea* (+); *Sideroxylon inerme* (1); *Stenotaphrum secundatum* (1); *Thamnochortus paniculatus* (+); *T. fraternis* (+); *Tylecodon paniculatus* (r); *Zygophyllum morgsana* (+).

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

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

APPENDIX II: List of zooplankton specimens and relative abundance from two samples taken in Zoetendalsvlei in June 1969 by Prof. J R Grindley (School of Environmental Studies, University of Cape Town)

		Sample 1	Sample 2
OSTRACODA	Ostracod spp.	++	+
COPEPODA	Copepod nauplii	++	+
	Acartia natalensis		+
	Harpacticoid spp.	+	+
	Harpacticus sp.		+++
	Pseudodiaptomus hessei	++	+++
CLADOCERA	*Daphnia* sp.		+
MYSIDACEA	*Mesopodopsis africana*		+
AMPHIPODA	*Corophium* sp.		+
MOLLUSCA	Lamellibranch larvae		+
OSTEICTHYES	Fish larvae	+	

APPENDIX III: Invertebrate food species identified from the stomachs of 437 white steenbras collected in the Heuningnes Estuary during 1971 (from Mehl, 1973).

Species

PROTOZOA
- Sarcodina
  - *Foraminifera* sp

ASCHELMINTHES
- Nematoda
  - *Contracaecum* sp
- Acanthocephala
  - *Rhadinorhynchus* sp

ANNELIDA
- Polychaeta
  - *Arenicola loveni*
  - *Eunice* sp
  - *Lumbrinereis* sp
  - *Nereis* sp
  - *Pomatoleios kraussii*
  - *Sthenelais* sp
- Echiurida
  - *Ochaetostoma capense*
- Sipunculida
  - *Golfingia capensis*

CRUSTACEA
- Cirripedia
  - *Chthamalus* sp
- Amphipoda
  - *Ampithoe ramondi*
- Tanaidacea
  - *Leptochelia* sp

APPENDIX III: (Cont.)

Macrura
Betaeus jucundus
Palaemon pacificus
Anomura
Callianassa kraussi
Diogenes brevirostris
Upogebia africana
Brachyura
Cleistostoma edwardsii
Cyclograpsus punctatus
Hymenosoma capensis
Thaumastoplax spiralis

MOLLUSCA
Amphineura
Ischnochiton sp
Pelecypoda
Kellya? sp
Psammotellina capensis
Tellina sp
Gastropoda
Assiminea globulus
Haminea alfredensis
Rissoa capensis
Scala sp
Siphonaria capensis
Tricolia capensis

ECHINODERMATA
Echinoidea
Echinocardium cordatum
Parechinus angulosus
Holothuroidea
Epitomapta knysnaensis

APPENDIX IV: Aquatic invertebrates recorded in the Heuningnes Estuary. Records from Day (1981a), the ECRU Survey in June 1983 and specimens collected by the Directorate of Forestry.

Species	Common name	Source of Record
ANNELIDA		
Polychaeta		
Arenicola loveni	Bloodworm	Day (1981a)
Ficopomatus enigmatica	Tube worm	ECRU survey
CRUSTACEA		
Mysidacea		
Rhopalophthalamus terranatalis	Mysid	ECRU survey
Macrura		
Penaeus japonicus	Ginger prawn	Day (1981a)
Palaemon pacificus	Sand shrimp	ECRU survey

APPENDIX IV: (Cont.)

Species	Common name	Source of Record
Anomura		
Callianassa kraussi	Burrowing sand prawn	ECRU survey
Upogebia africana	Mud prawn	ECRU survey
Diogenes brevirostris	Common hermit crab	ECRU survey
Brachyura		
Cleistostoma edwardsii	crab	ECRU survey
Cyclograpsus punctatus	Common shore Crab	ECRU survey and Forestry
Hymenosoma orbiculare	Crown crab	ECRU survey
Scylla serrata	Giant mud crab	Day (1981a) and Forestry
MOLLUSCA		
Gastropoda		
Notarchus sp	Sea hare	ECRU survey
Nerita albicilla	Common nerite	Day (1981a)
Siphonaria oculus	False limpet	ECRU survey
Natica sp	Necklace shell	ECRU survey

APPENDIX V: Fish species recorded from Zoetendalsvlei. Records from Cape Piscatorial Society (1937), Barham (1968), Louw (1968) and McVeigh (1980). Common names according to Smith (1975) and Bruton *et al* (1982).

Fresh Water

Indigenous species

Common name	Species
Cape kurper	*Sandelia capensis*

Exotic species

Common name	Species
Largemouth bass	*Micropterus salmoides*
Spotted bass	*M. punctulatus*
Bluegill sunfish	*Lepomis macrochirus*
Carp	*Cyprinus carpio*

Marine/Estuarine

Common name	Species
Estuarine round-herring	*Gilchristella aestuarius*
Cape moony	*Monodactylus falciformis*
Flathead mullet	*Mugil cephalus*
Southern mullet	*Liza richardsoni*
White steenbras	*Lithognathus lithognathus*

APPENDIX VI: Fish species recorded for the Heuningnes Estuary and its tributaries. Records from Barnard (1943), Day (1981a), ECRU survey, Reyneke (pers. comm.), Hamman *(in litt.)* and Kilpin *(in litt.)*. Common names according to Smith (1975) and Bruton *et al* (1982).

Fresh Water

Common name	Species
Cape galaxias	*Galaxias zebratus*
Cape kurper	*Sandelia capensis*

Marine/Estuarine

Common name	Species
Estuarine round-herring	*Gilchristella aestuarius*
Sea barbel	*Tachysurus feliceps*
Cape sole	*Heteromycteris capensis*
Blackhand sole	*Solea bleekeri*
Longnose pipefish	*Syngnathus acus*
Leervis	*Lichia amia*
Elf	*Pomatomus saltatrix*
Kob	*Argyrosomus hololepidotus*
Baardman	*Umbrina capensis*
Cape moony	*Monodactylus falciformis*
Galjoen	*Coracinus capensis*
Spotted grunter	*Pomadasys commersonni*
Zebra	*Diplodus cervinus*
Blacktail	*Diplodus sargus*
White steenbras	*Lithognathus lithognathus*
White stumpnose	*Rhabdosargus globiceps*
Strepie	*Sarpa salpa*
Flathead mullet	*Mugil cephalus*
Southern mullet	*Liza richardsoni*
Cape silverside	*Hepsetia breviceps*
Knysna sandgoby	*Psammogobius knysnaensis*
Prison goby	*Caffrogobius multifasciatus*

APPENDIX VII: Check list of Reptiles and Amphibians recorded from (X) and likely to occur in (L) the area covered by the 1:50 000 Topo-cadastral Sheet 3420 CA and CC Bredasdorp in which the Heuningnes Estuary is centrally situated (A L de Villiers, Cape Department of Nature and Environmental Conservation *in litt.)*. Threatened species listed in the South Africa Red Data Book (McLachlan, 1978) are indicated with an asterisk.

Lizards

Common name	Scientific name	X/L	Source of record
Ocellated gecko	*Pachydactylus geitje*	L	
Marbled gecko	*Phyllodactylus porphyreus*	L	

APPENDIX VII: (Cont.)

Common name	Scientific name	X/L	Source of record
*Cape dwarf chameleon	*Bradypodion pumilum*	L	
Rock agama	*Agama atra*	L	
Golden sand lizard	*Acontias meleagris*	L	
Silver sand lizard	*Scelotes bipes*	L	
Common skink	*Mabuya capensis*	L	
Cape speckled skink	*Mabuya homalocephala*	L	
Yellow-throated plated lizard	*Gerrhosaurus flavigularis*	L	
Short-legged plated lizard	*Tetradactylus seps*	L	
Long-tailed seps	*Tetradactylus tetradactylus*	L	
Cape girdled lizard	*Cordylus cordylus*	L	
Cape snake lizard	*Chaemosaura anguina*	L	

Tortoises

Common name	Scientific name	X/L	Source of record
Angulate tortoise	*Chersina angulata*	X	Greig & Burdett (1976)
Padloper tortoise	*Homopus areolatus*	X	Greig & Burdett (1976)
Cape terrapin	*Pelomedusa subrufa*	L	

Snakes

Pink earth snake	*Typhlops lalandei*	L	
Black worm snake	*Leptotyphlops nigricans*	L	
Brown watersnake	*Lycodonomorphus rufulus*	X	FitzSimons (1962)
Olive house snake	*Lamprophis inornatus*	L	
Southern shovel snout	*Prosymna sundevallii*	X	FitzSimons (1962)
Mole snake	*Pseudaspis cana*	L	
Southern slug-eater	*Duberria lutrix*	L	
Common egg-eating snake	*Dasypeltis scabra*	L	
Herold snake	*Crotaphopeltis hotamboeia*	L	
Cape many-spotted snake	*Amplorhinus multimaculatus*	L	
Boomslang	*Dispholidus typus*	L	
Spotted skaapsteker	*Psammophylax rhombeatus*	L	
Whip snake	*Psammophis notostictus*	X	FitzSimons (1962)
Cross-marked sand snake	*Psammophis crucifer*	X	FitzSimons (1962)
Coral snake	*Aspidelaps lubricus*	L	
Spotted dwarf garter snake	*Elaps lacteus*	X	FitzSimons (1962)
Cape cobra	*Naja nivea*	L	
Yellow-bellied sea snake	*Pelamis platurus*	X	FitzSimons (1962)

APPENDIX VII: (Cont.)

Frogs

Common name	Scientific name	X/L	Source of record
Common platanna	*Xenopus laevis*	X	Poynton (1964)
Sand toad	*Bufo angusticeps*	X	Poynton (1964)
Raucous toad	*Bufo rangeri*	L	
Sand rain frog	*Breviceps rosei*	X	Poynton (1964)
Cape mountain reed frog	*Breviceps montanus*	L	
Cape sand frog	*Tomopterna delalandii*	X	Poynton (1964)
Cape rana	*Rana fuscigula*	X	Poynton (1964)
Spotted rana	*Rana grayii*	X	CDNEC
Common caco	*Cacosternum boettgeri*	X	Poynton (1964)
Rattling kassina	*Kassina wealii*	L	
*Arum frog	*Hyperolius horstockii*	X	Poynton (1964)

APPENDIX VIII: Summer 1980/81 waterbird counts for the Heuningnes Estuary and Zoetendalsvlei (after Underhill and Cooper, 1983). Threatened species listed in the South African Red Data Book (Siegfried *et al* 1976) are indicated with an asterisk.

Roberts No.	Species	Heuningnes Estuary up to 1,5 km upstream of mouth High-tide 81-01-09	Heuningnes Estuary up to 1,5 km upstream of mouth Low-tide 81-01-12	Zoetendalsvlei 81-01-10
47	White-breasted Cormorant	11	20	10
50	Reed Cormorant	0	0	36
52	Darter	0	0	82
54	Grey Heron	3	0	17
57	Purple Heron	0	0	14
59	Little Egret	3	1	1
60	Yellow-billed Egret	0	0	3
61	Cattle Egret	0	0	107
81	Sacred Ibis	0	0	34
88	Spur-winged Goose	0	0	210
89	Egyptian Goose	0	0	1 067
90	South African Shelduck	0	0	122
94	Cape Shoveler	0	0	5
95	Yellow-billed Duck	0	0	285
*149	Fish Eagle	0	0	2
167	African Marsh Harrier	0	0	5
208	Purple Gallinule	0	0	2
210	Moorhen	0	0	2
212	Red-knobbed Coot	0	0	1 979
231	Black Oystercatcher	6	2	0
233	Ringed Plover	59	23	50
235	White-fronted Sandplover	5	7	5

APPENDIX VIII: (Cont.)

Roberts No.	Species	Heuningnes Estuary up to 1,5 km upstream of mouth High-tide 81-01-09	Heuningnes Estuary up to 1,5 km upstream of mouth Low-tide 81-01-12	Zoetendalsvlei 81-01-10
237	Kittlitz's Sandplover	0	0	256
238	Three-banded Sandplover	0	0	29
241	Grey Plover	12	54	0
245	Blacksmith Plover	2	0	71
250	Ethiopian Snipe	0	0	10
251	Curlew Sandpiper	121	100	1 058
253	Little Stint	3	23	591
254	Knot	50	81	0
255	Sanderling	314	59	0
256	Ruff	0	0	1 020
259	Green Sandpiper	2	0	0
262	Marsh Sandpiper	0	0	19
263	Greenshank	7	1	22
264	Wood Sandpiper	0	0	87
265	Bar-tailed Godwit	0	1	0
267	Curlew	1	0	2
268	Whimbrel	8	8	0
270	Black-winged Stilt	0	0	1
287	Kelp Gull	8	8	2
*290	Caspian Tern	4	2	1
291/294	Common/Arctic Tern	0	8	0
296	Sandwich Tern	6	3	0
*300	Damara Tern	13	8	0
305	Whiskered Tern	0	0	4
	Unidentified terns	0	1 000	0
394	Pied Kingfisher	0	0	3
397	Malachite Kingfisher	0	0	1
686	Cape Wagtail	2	0	52

Summary of counts	Heuningnes Estuary up to 1,5 km upstream of mouth High-tide 81-01-09	Heuningnes Estuary up to 1,5 km upstream of mouth Low-tide 81-01-12	Zoetendalsvlei 81-01-10
Total number of birds	640	1 409	7 267
Number of species	21	19	39
Wader Numbers			
Migrants	577	350	2 849
Residents	13	9	372
TOTAL	590	359	3 221
Wader Species			
Migrants	10	9	8
Residents	3	2	6
TOTAL	13	11	14

APPENDIX IX: Summer 1977/78 and 1979/80 and Winter 1980 bird counts for the Heuningnes Estuary (after Underhill and Cooper 1983). Threatened species listed in the South African Red Data Book (Siegfried *et al* 1976) are indicated with an asterisk.

Roberts No.	Species	Lower Estuary up to 1,5 km upstream of the mouth Low-tide 77-12-16	Lower Estuary up to 1,5 km upstream of the mouth Low-tide 79-12-26	Upper Estuary 1,5 km to 3 km upstream of mouth Low-tide 79-12-27	Lower Estuary up to 1,5 km upstream of the mouth 79-07-18
47	White-breasted Cormorant	8	18	4	15
48	Cape Cormorant	0	0	0	3
50	Reed Cormorant	4	5	2	1
54	Grey Heron	1	2	2	5
59	Little Egret	0	0	0	2
61	Cattle Egret	0	2	9	0
212	Red-knobbed Coot	0	0	350	0
231	Black Oystercatcher	2	4	0	2
232	Turnstone	0	2	0	0
233	Ringed Plover	160	68	24	0
235	White-fronted Sandplover	4	24	2	9
237	Kittlitz's Sandplover	0	3	0	0
238	Three-banded Sandplover	0	0	2	0
241	Grey Plover	30	22	22	0
245	Blacksmith Plover	0	0	28	0
251	Curlew Sandpiper	92	160	110	0
253	Little Stint	1	200	60	0
254	Knot	0	80	12	0
255	Sanderling	42	0	0	0
258	Common Sandpiper	2	1	4	0
262	Marsh Sandpiper	0	0	1	0
263	Greenshank	2	3	9	0
266	Bar-tailed Godwit	0	2	0	0
267	Curlew	1	6	14	0
268	Whimbrel	13	2	2	1
275	Cape Dikkop	5	0	0	0
	Unidentified waders	300	0	0	0
287	Kelp Gull	0	15	0	5
*290	Caspian Tern	0	3	0	0
291/294	Common/Arctic Tern	12	0	0	0
296	Sandwich Tern	0	36	0	0
298	Swift Tern	0	240	0	0
*300	Damara Tern	14	4	0	0
394	Pied Kingfisher	0	0	1	0

APPENDIX IX: (Cont.)

Summary of counts	Lower Estuary up to 1,5 km upstream of the mouth Low-tide 77-12-16	Lower Estuary up to 1,5 km upstream of the mouth Low-tide 79-12-26	Upper Estuary 1,5 km to 3 km upstream of mouth Low-tide 79-12-27	Lower Estuary up to 1,5 km upstream of the mouth 79-07-18
Total number of birds	693	902	658	43
Number of species	18	23	19	9
Wader Numbers				
Migrants	643	546	258	1
Residents	6	31	32	11
TOTAL	649	577	290	12
Wader Species				
Migrants	9	11	10	1
Residents	2	3	3	2
TOTAL	11	14	13	3

APPENDIX X: A checklist of mammals recorded for the area covered by the 1:50 000 Topo-cadastral Sheet 3420 CA and CC Bredasdorp. Records from Stuart *et al* (1980, unpublished). Threatened species listed in South African Red Data Books (Meester 1976 and Skinner *et al* 1977) are indicated with an asterisk.

Common name	Scientific name
Southern Elephant Seal	*Mirounga leonina*
*Cape Greater Gerbil	*Tatera afra*
Cape Dune Molerat	*Bathyergus suillus*
Cape Fox	*Vulpes chama*
Cape Clawless Otter	*Aonyx capensis*
Egyptian Mongoose	*Herpestes ichneumon*
Cape Grey Mongoose	*H. pulverulentus*
Water Mongoose	*Atilax paludinosus*
Red Meerkat	*Cynictis penicillata*
*Aardwolf	*Proteles cristatus*
Cape Wild Cat	*Felis lybica*
Caracal	*Felis caracal*

Additional species recorded by the Directorate of Forestry for De Mond Forestry Reserve.

Common name	Scientific name
Chacma Baboon	*Papio ursinus*
Striped Polecat	*Ictonyx striatus*
Spotted Genet	*Genetta* sp

APPENDIX X: (Cont.)

Common name	Scientific name
Striped Mouse	*Rhabdomys pumilio*
Cape Molerat	*Georychus capensis*
Porcupine	*Hystrix africaeaustralis*
Grysbok	*Raphicerus melanotis*
Grey Duiker	*Sylvicapra grimmia*
Vaal Rhebok	*Pelea capreolus*
Cape Fur Seal	*Arctocephalus pusillus*

APPENDIX XI: Heuningnes Riparian Owners Association Regulations

The Heuningnes River from the Bredasdorp/Struisbay road to the Forestry footbridge is bounded by Private ground and State Forest Reserve and is thus inaccessable to the public except by permit through the Forest Reserve.

In order to preserve this beautiful, quiet and unspoilt estuary for our own and future generations enjoyment, we now agree to form an association of the riparian owners to be known as the Heuningnes Riparian Owners Association, which will consist of the following, defined as OWNERS.

Mr and Mrs M van Breda and their children
Mr and Mrs P Albertyn and their children
Mr and Mrs J Findlay and their children
Mr and Mrs G Kilpin and their children

The Association will liaise closely with the Forestry Department and Nature Conservation in order to comply with legal requirements and be of mutual assistance.

Any other persons using the river may only do so with an owner's permission and will be defined as a FRIEND.

Rules:

1. Netting: Only provided the net is licensed by Nature Conservation. Friends may only net with owners permission and with owners net.

2. Bait: Owners may collect bait along the river having due regard to other member's privacy. Friends to collect bait only within the boundaries of the owner who gives them permission. No bait to be removed to fish elsewhere.

3. Shooting: At owner's discretion.

4. Boating:

   (a) No speedboats. (But temporary exemption to Mr P Albertyn re skiing for 500 yds below bridge on Bredasdorp/Struisbay road, that is, Eksteen boundary).

APPENDIX XI: (Cont.)

(b) Owners may use an electric motor or 2 H.P. internal combustion motor.

(c) Windsurfers and sailboats to be restricted as far as possible.

5. Privacy of individual owners: There is agreement that owners ought to respect each others privacy. Nevertheless, owners agree that they have the right to move freely up and down the river and would allow, each other (owners) the privilege of access to each others shares.

6. Environment: We agree to protect the natural environment, preserving indigenous fauna and flora and eliminating alien vegetation.

7. Any owner may call a meeting to discuss any misuse of the river, and owners will assist one another in controlling the river.

Apart from this there will be a meeting once a year to be held in rotation on owners farms.

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC														BIOTIC																		MANAGEMENT				
		Physiography			Geology			Physics				Chemistry					Flora				Fauna									Food webs/Ecosystems									
HEUNINGNES (Estuary)		Catchment characteristics	Dams/Obstructions	Morphology	Geology	Paleoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing	Salinity	General Chemistry	Eutrophication	Pollution	Microbiology	Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals	Water	Legislation	Management / Planning	Conservation / Utilization	Historical
Sources of information		Guide to available information																																				
Africa Pilot	1980																																				*
Barham	1968											*	*											*	*	*	*										
Barham	1979																							*													
Barnard	1943																										*										
Bruton *et al*	1982																										*										
Bulpin	1980																																				*
Burger *et al*	1980																												*					*	*		
Cape of Good Hope Prov Ad In Fis Dept	1944																										*										
Cape Piscatorial Society	1937												*											*	*	*	*										
Day	1981a	*																						*	*	*	*										
Day	1981b												*																									
Devin	1984									*																												
FitzSimons	1962																												*								
Gohl	1944						*																														*
Greig and Burdett	1976																												*								
Heydorn and Tinley	1980	*						*		*																											
Krige	1973				*																																
Louw	1968												*											*	*	*	*										

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC														BIOTIC																		MANAGEMENT				
		Physiography			Geology			Physics				Salinity	Chemistry			Microbiology	Flora				Fauna										Food webs/Ecosystems								
HEUNINGNES (Estuary)		Catchment characteristics	Dams/Obstructions	Morphology	Geology	Paleoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing		General Chemistry	Eutrophication	Pollution		Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals		Water	Legislation	Management / Planning	Conservation / Utilization	Historical
Sources of information		Guide to available information																																				
McLachlan	1978																										*	*									
McVeigh	1980																									*											
Meester	1976																													*							
Mehl	1973											*	*											*	*	*											
Midgley and Pitman	1969	*						*																													
Monthly Flow Records	1968									*																											
Noble	1974																																				
Noble and Hemens	1978	*								*																									*	*	
Pitman *et al*	1982	*						*		*																											
Poynton	1964																										*										
Roberts	1978																												*								
Rogers	1982				*		*																														
Schultze	1965							*																													
Siegfried *et al*	1976																												*								
Skinner *et al*	1977																													*							
Smith	1975																									*											
Stuart *et al*	1980																													*							
Summers *et al*	1976																												*								

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC														BIOTIC																		MANAGEMENT				
		Physiography			Geology			Physics				Salinity	Chemistry			Microbiology	Flora				Fauna										Food webs/Ecosystems		Water	Legislation	Management/Planning	Conservation/Utilization	Historical
HEUNINGNES (Estuary)		Catchment characteristics	Dams/Obstructions	Morphology	Geology	Palaeoenvironment	Sedimentology	Climate	Oceanography	Hydrology/Flood regime	Circulation and mixing		General Chemistry	Eutrophication	Pollution		Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals						
Sources of information		Guide to available information																																				
Swart and Serdyn	1982							*																														
Tankard	1975				*		*																															
Underhill and Cooper	1983																												*									
van Breda Journal	1840 – 1944									*																*												
Visser	1963				*																																	
Walsh	1968						*																													*		*
D Cronje (pers.comm.)	1983													*	*																	*		*	*		
I T Hunter (pers.comm.)	1983							*																														
G D Kilpin (pers.comm.)	1983																																					*
P G Reyneke (pers.comm.)	1983		*									*			*											*	*				*			*	*	*	*
H O Swart (pers.comm.)	1983																									*								*			
M R van Breda (pers.comm.)	1983		*																																*	*	*
Directorate of Forestry (*in litt.*)	1984																																					*
C M Gaigher (*in litt.*)	1984									*		*	*											*	*		*											*
J R Grindley (*in litt.*)	1984					*				*		*	*									*				*												
K C D Hamman (*in litt.*)	1983																									*												
G D Kilpin (*in litt.*)	1983																									*												
A L de Villiers (*in litt.*)	1983																										*	*										

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC													BIOTIC																	MANAGEMENT					
		Physiography			Geology			Physics				Salinity	Chemistry			Flora					Fauna										Food webs/Ecosystems						
HEUNINGNES (Estuary)		Catchment characteristics	Dams/Obstructions	Morphology	Geology	Palaeoenvironment	Sedimentology	Climate	Oceanography	Hydrology / Flood regime	Circulation and mixing		General Chemistry	Eutrophication	Pollution	Microbiology	Phytoplankton	Algae	Aquatic vegetation	Semi-aquatic vegetation	Terrestrial vegetation	Zooplankton	Terrestrial invertebrates	Other aquatic invertebrates	Crustaceans	Molluscs	Fish	Amphibians	Reptiles	Birds	Mammals	Water	Legislation	Management / Planning	Conservation / Utilization	Historical
Sources of information		Guide to available information																																		
Maps - S.A.																																				
1: 50 000 Sheet 3420 CA and CC	1969	*	*	*						*																										*
1: 50 000 Sheet 3419 DB and DD	1969	*	*	*						*																										
1: 250 000 Sheet 3319	1975	*																																		
1: 250 000 Sheet 3420	1973	*																																		
1: 125 000 Geo. Ser. 3419C,D,3420C.	1963				*																															
1:1000 000 Geol. Map	1970				*																															
Aerial Photography																																				
Trig. Survey																																				
Job No. 13038	1939	*		*			*			*																										*
Job No. 461	1961	*		*			*			*																										*
Job No. 719	1973	*		*			*			*																										*
Land Survey Dept. Univ. of Natal																																				
Job No. 243	1976			*			*			*											*														*
Job No. 282	1977			*			*			*											*														*
Job No. 326	1979			*			*			*											*														*
Job No. 349	1980			*			*			*																										*
Job No. 391	1981			*			*			*											*														*

PLATE I:

A view of the brushwood barrier dune maintained by the Directorate of Forestry in order to keep the mouth of the Heuningnes in an open condition. The photograph was taken from the south-western side of the mouth (ECRU 80-06-27).

PLATE II:

Heuningnes Estuary approximately 1,2 km upstream of the mouth, looking upstream during low tide. The natural rock ledge protruding from the north bank can be seen on the right of the photo. It is linked to the south bank by the Forestry causeway which can be seen in the central part of the photo (ECRU 83-06-10)

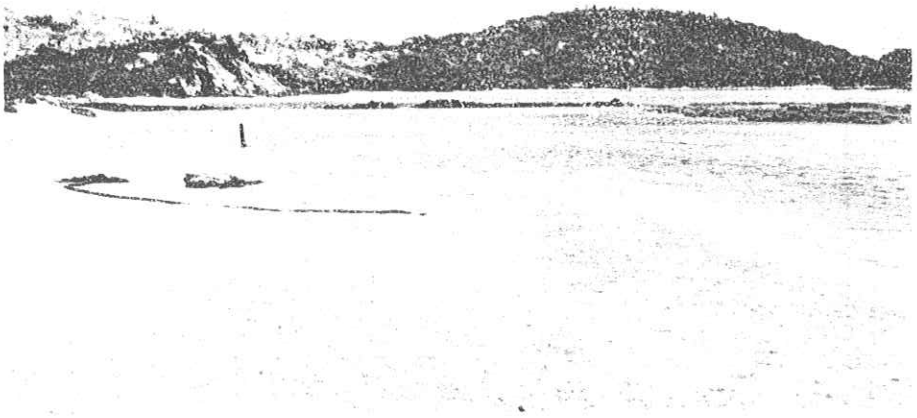

PLATE III:

Artificial dune stabilization being carried out by the Directorate of Forestry at De Mond. Well-established Marram grass can be seen on the lower left of the photo, newly planted Marram grass in the right foreground and brushwood on the dune crests in the background (ECRU 83-06-07).