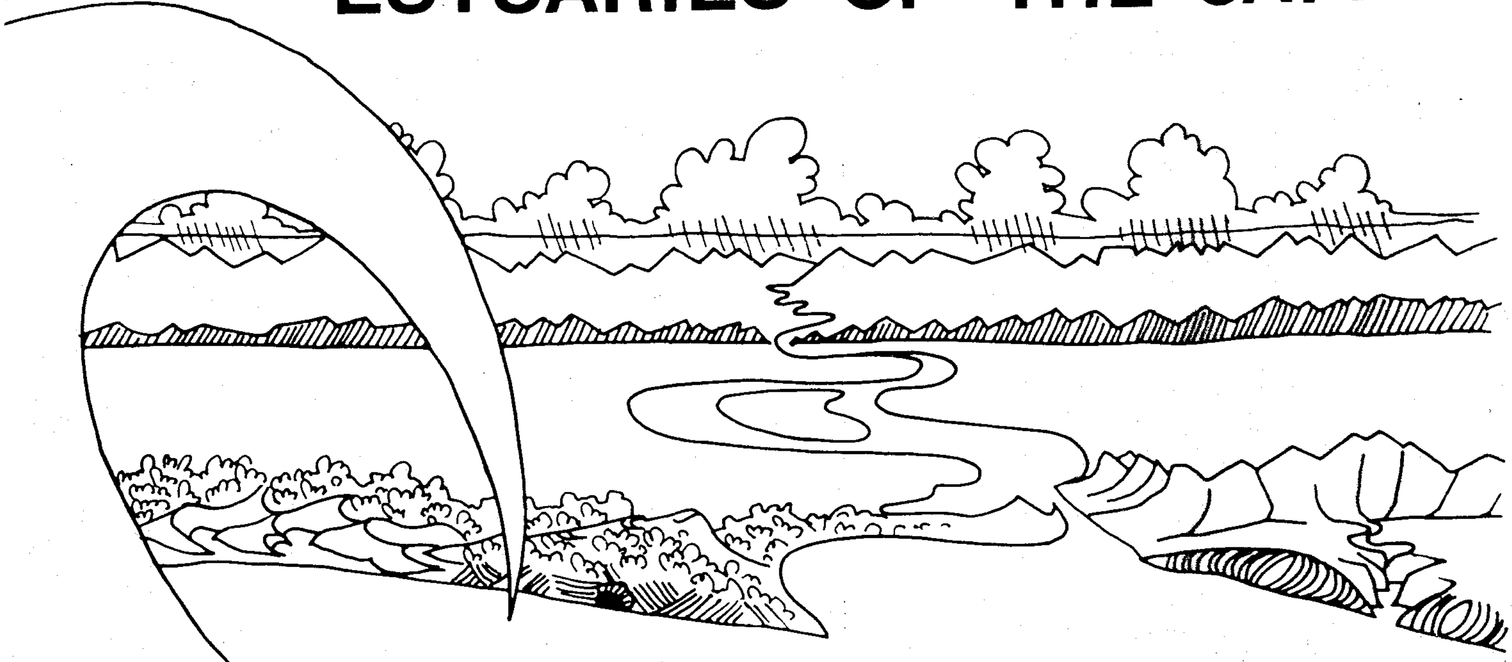
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT-ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 20

GROOT BRAK (CMS 3)

CSIR RESEARCH REPORT 419

Stellenbosch, South Africa
December 1983

ESTUARIES OF THE CAPE

PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS:
A E F HEYDORN, National Research Institute for Oceanology, CSIR, Stellenbosch
J R GRINDLEY, School of Environmental Studies, University of Cape Town

FRONTISPIECE: THE GROOT BRAK ESTUARY – ALT. 450 m. ECRU 79-10-16

REPORT NO. 20: GROOT BRAK (CMS 3)

(CMS 3 – CSIR Estuary Index Number)

BY: P D MORANT

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

CSIR RESEARCH REPORT 419

Stellenbosch, South Africa
December 1983

GROOT BRAK

ECRU SURVEYS: 12 and 13 November 1981
25 and 26 April 1983

SURVEY TEAM:	Dr AEF Heydorn	(ECRU - 12 - 13 November 1981)
	Dr PD Bartlett	(NRIO - 12 - 13 November 1981)
	Dr GAW Fromme	(NRIO - 12 - 13 November 1981)
	Mr IB Bickerton	(ECRU - 12 - 13 November 1981)
	Mr TJE Heinecken	(ECRU - 12 - 13 November 1981 and 25 - 26 April 1982)
	Mr PD Morant	(ECRU - 25 - 26 April 1983)
	Prof JR Grindley	(Univ of Cape Town - 12 - 13 November 1981)
	Mr R Stauth	(Univ of Cape Town - 12 - 13 November 1981)
	Ms A Breytenbach	(Botanical Research Inst - 12 - 13 November 1981)
	Ms R Parsons	(Botanical Research Inst - 12 - 13 November 1981)
	Mr M O'Callaghan	(Botanical Research Inst - 12 - 13 November 1981)

---oOo---

ISBN 0 7988 1812 3 (Set)
ISBN 0 7988 1813 1 (Part 2)
ISBN 0 7988 2586 3 (Rep. No. 20)

Published in 1983 by :

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

Printed by :

Associated Printing & Publishing Co (Pty) Ltd, Cape Town

PREFACE

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

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

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

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

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

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

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

FP Anderson
DIRECTOR

National Research Institute for Oceanology
CSIR

[+]CSIR Research Report 380

CONTENTS

GROOT BRAK

1. HISTORICAL BACKGROUND

1.1 Synonyms and derivations

Although the Trigonometrical Survey and the Hydrographic Office of the South African Navy use the Afrikaans name for the Groot-Brakrivier, amongst English speakers "Great Brak" and "Great Brak River" have common currency. In her book on the history of the town of Groot Brak, Margaret Franklin (1975) refers to the "Great Brak River".

The word "Brak" is derived from the brackish conditions caused by tidal movement in the river (R Searle, pers. comm.). Another possible derivation is that the vegetated spit on the western bank of the mouth is said to resemble a "brak" (mongrel).

1.2 History

The first reference to the Great Brak River was made in 1730 when its banks were reached by pioneering trek farmers. In 1745 the river became the eastern boundary of the Cape Colony in an area known as "De Verre Afgeleegene Districten". The eastern part of the Colony, between the Breë and Great Brak rivers fell under the jurisdiction of the Drostdy (magistrate) at Swellendam (Lowe Simpson and Associates, 1973). Francois le Vaillant described the area in 1782: "We crossed a plain, encircled with hills, beautifully covered with trees and bushes, about five miles in circumference. I found there thousands of pelicans and flamingoes... When we left the river, we had to climb a difficult and very steep mountain. With patience and hard work the top was reached (Great Brak Heights). The scenery which now appeared to the eye richly rewarded our trouble. We were admiring the most beautiful country on earth. This land bears the name of Outeniqua, meaning in Hottentot man laden with honey" (Franklin, 1975).

As the Cape Colony expanded northwards and eastwards during the nineteenth century, Great Brak River became a well-used outspan en route to George and further east. Roads were improved during the 1840s and in 1850 a causeway was built over the Great Brak River. This consisted of thirteen stone piers with twelve openings of 20 feet (6,1 m) each and was spanned with timber. This crossing became a toll bridge in 1852 (Franklin, 1975).

In 1859 Charles Searle arrived at Great Brak River and from then on the fortunes of Greak Brak and the Searle family have been almost inextricably intertwined.

Initially development at Great Brak centred on the river crossing. Tolls were levied at the causeway and the task of tollkeeper included the operation of the Post Office. Accommodation for travellers and shops were established giving rise to a classic river-crossing village. To ensure that the river did not back up and close the causeway the river mouth was opened artificially. Charles Searle was paid £2 annually by the George Divisional Council to perform this task (Franklin, 1975).

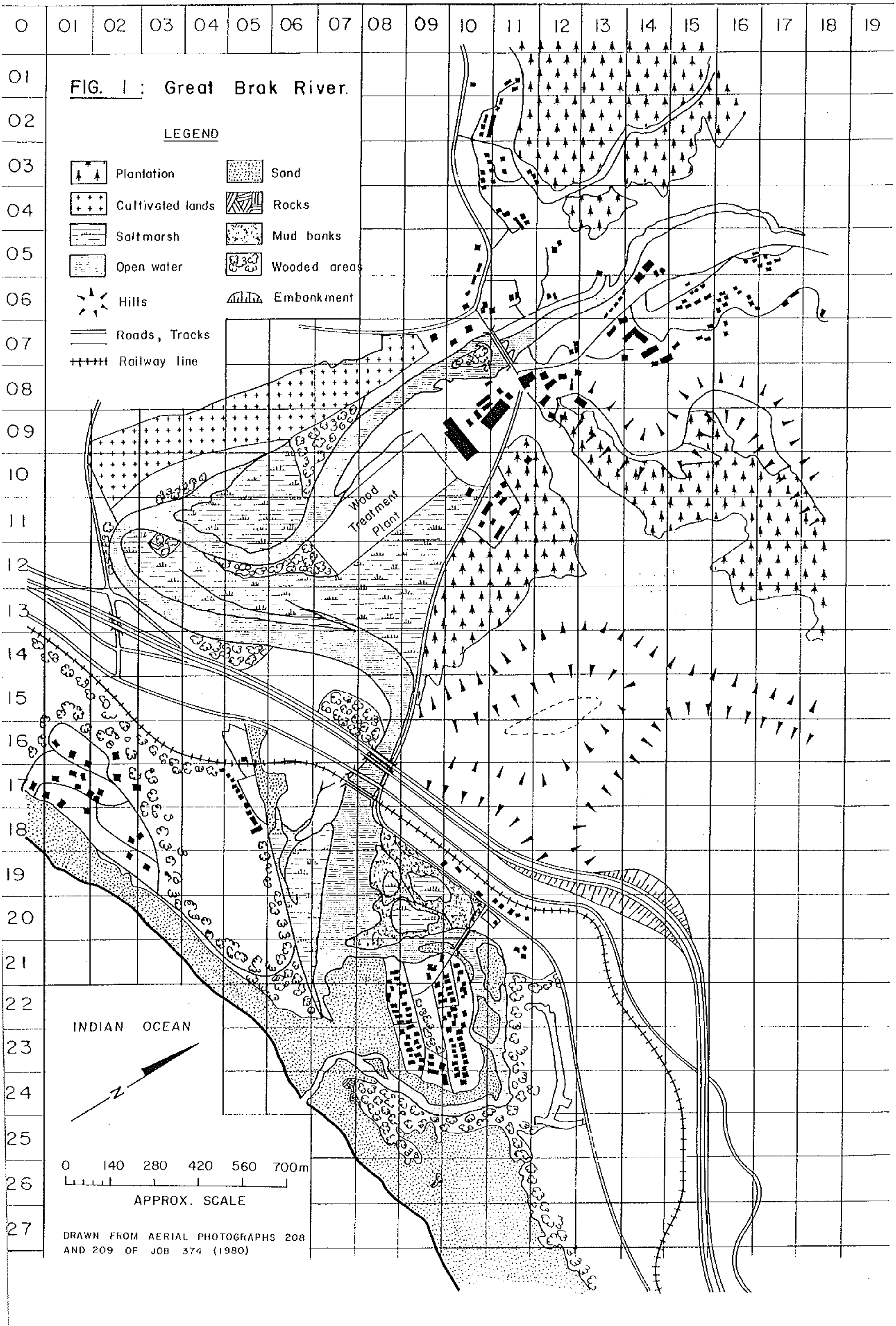
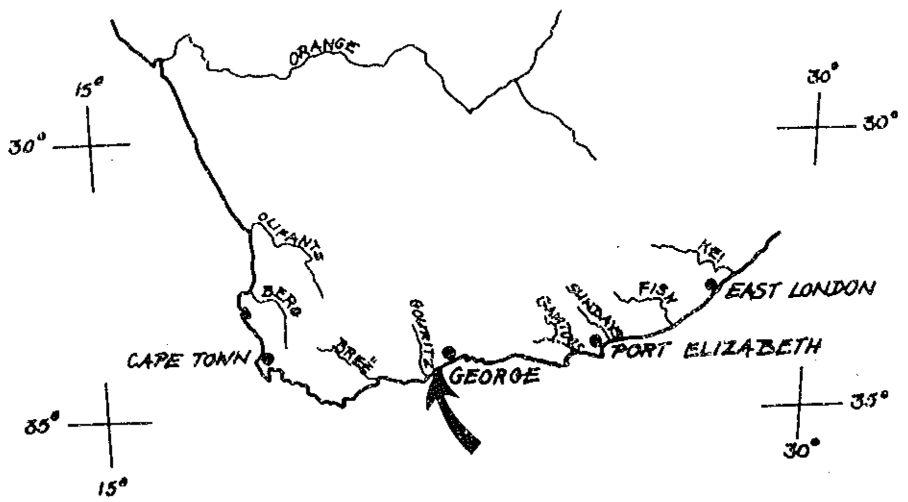


FIG. 1 : Great Brak River.
LEGEND
Plantation
Cultivated lands
Saltmarsh
Open water
Hills
Roads, Tracks
Railway line
Sand
Rocks
Mud banks
Wooded areas
Embankment
Wood Treatment Plant
INDIAN OCEAN
N
0 140 280 420 560 700m
APPROX. SCALE
DRAWN FROM AERIAL PHOTOGRAPHS 208 AND 209 OF JOB 374 (1980)

Despite a severe flood in 1867 and the Great Fire of 1869, development of Great Brak continued. In 1874 a 2 500 yard (2 286 m)-long diversion canal was built from the Great Brak River to provide water to power a cornmill (1875) and to operate a wool washery (1876). The same canal also provided water for the irrigation of crops in an area approximately 5 km long and 800 m wide along the river banks. The wool washery functioned until 1904 when the railway from Oudtshoorn to Port Elizabeth was completed. Thereafter it was more economical for farmers in the Little Karoo to send their wool to Port Elizabeth. The shoe factory was established in 1884 and the following year a tannery was built to provide leather for the shoe factory and for export. The tannery was moved to King William's Town in 1957. The railway line connecting Mossel Bay to George was opened in 1907 thus opening the Cape south coast to holidaymakers. Hydroelectric power generation began in 1910 and electric power was extended to the entire village in 1924.

2. LOCATION

The mouth of the Great Brak River lies at $34^{o}03'S$; $22^{o}14'E$. The nearest large towns are Mossel Bay, 24 km to the west, and George, 34 km to the east by road (N2). Cape St Blaize, marking the western extremity of Mossel Bay, lies 16 km SSW of the Great Brak Estuary. The major cities of Cape Town and Port Elizabeth lie, respectively, 420 km west and 369 km east of Great Brak.



2.1 Accessibility

The Great Brak Estuary is directly accessible from the National Road (N2) connecting Mossel Bay and George.

The new Garden Route Freeway passes over paired bridges to the north of the old National Road bridge; an interchange on the west bank of the river provides access to all parts of Great Brak. The railway line crosses the estuary to the south of the road bridges and provides a direct link between Mossel Bay and George. The nearest airport with scheduled services is the PW Botha Airport at George 34 km to the east. Little Brak has a landing strip for light aircraft and Mossel Bay a macadamised strip capable of handling medium aircraft (Hill Kaplan Scott and Partners, 1974).

2.2 Local Authorities

Great Brak initially was under the jurisdiction of the Drostdy at Swellendam (Lowe Simpson & Associates, 1973). In 1853 partitioning occurred and the George district was divided into nine field cornetcies two of which bordered the Great Brak River. The land to the west of the river fell under the control of Mossel Bay and that to the east under George.

Great Brak River now falls under the control of the Outeniqua Divisional Council (George). In 1944 Great Brak River was proclaimed a Local Area Board. Since 1 January 1975 Great Brak has had its own Municipality under the Outeniqua Divisional Council. The Great Brak River Municipality controls development on both sides of the river's lower reaches. The Municipality covers approximately 1 725 ha of which 70 percent is owned by a single private company, Searles Holdings Ltd. The company provides over 90 percent of the rates revenue for the Municipality. The Outeniqua Divisional Council is the authority responsible for the provision and maintenance of roads at Great Brak River, and controls the surrounding area while the Directorate of Forestry administers State Land in the catchment.

3. ABIOTIC CHARACTERISTICS

3.1 River Catchment

3.1.1 Catchment Characteristics

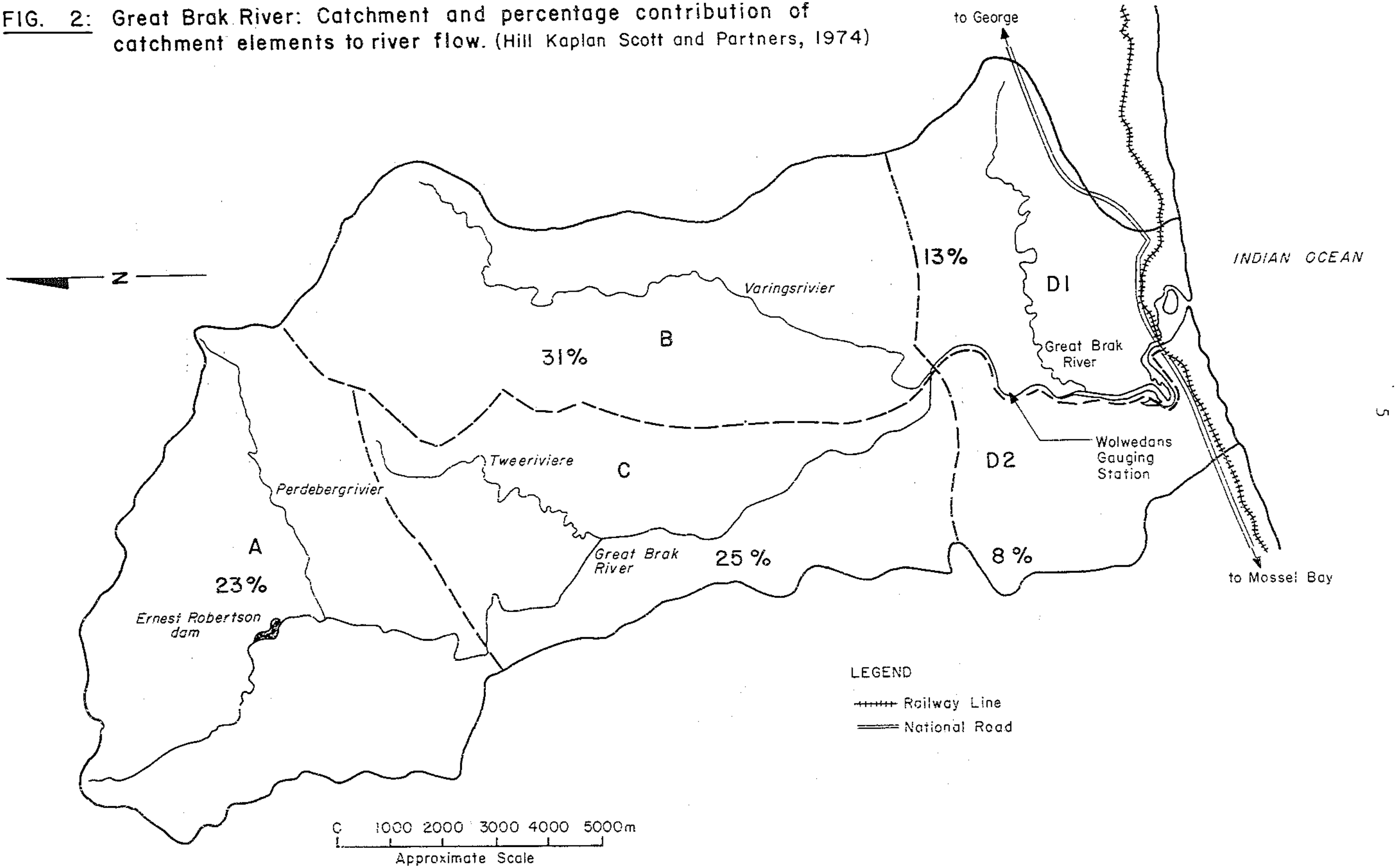
The area of the Great Brak catchment is given as:

192 km^2	(Day, 1981; Midgley and Pitman, 1969; Noble and Hemens, 1978)
163 km^2	(Hill Kaplan Scott and Partners, 1974)
131 km^2	(River flow data, 1978).

River length

The length of the river as measured from the start of the longest tributary depicted on a map of the catchment by Hill Kaplan Scott (HKS) and Partners (1974) is 28,5 km. On the 1:50 000 topographic

FIG. 2: Great Brak River: Catchment and percentage contribution of catchment elements to river flow. (Hill Kaplan Scott and Partners, 1974)



map 3422 AA Mosselbaai the length is 29,3 km. The main tributaries of the Great Brak are the Perdebergrivier, Tweeriviere and Varingsrivier. There are five catchment areas in the Great Brak system (Figure 2):

Catchment area	% contribution
Perdebergrivier	23
Tweeriviere	25
Varingsrivier	31
Unnamed stream "D1" (HKS, 1974)	13
Unnamed stream "D2" (HKS, 1974)	8
	100

The Great Brak River rises on the slopes of the Engelseberg (1521 m) in the Outeniqua Mountain range 25 km in a straight line from the river mouth. The catchment is relatively long and narrow being about 25 km long and reaching a maximum of about 8 km in width. Much of the river system drains an elevated coastal platform 150 - 300 m high. The main tributaries of the Great Brak River and the river itself are deeply incised into this platform.

Geology

The following description is based on an interpretation of the 1:250 000 Geological Sheet 3322 Oudtshoorn. The headwaters of the Great Brak rise on the quartzitic sandstones of the Peninsula Formation of the Table Mountain Group. These sandstones, forming the spine of the Outeniqua Mountain range, display the characteristic east-west strike of the folded rocks of this area. The strata of the Peninsula Formation dip southwards. The Great Brak runs southwards through the quartz schists of the Sandkraal Formation of the Kaaimans Sub-group. These rocks are of the Namibian Period of the Pre-Cambrian/Cambrian age. The Sandkraal Formation is extensively thrust faulted; this is a legacy of the orogenic processes that gave rise to the mountains of the Cape Fold Belt. To the south of the Sandkraal Formation the river runs on Tertiary/Quaternary valley alluvial deposits lying between bluffs consisting of gneissic granite, granodiorite and albitite intrusions of mid-Namibian age. Closer to the sea the valley alluvial deposits lie between the reddish mudstones and sandstones ("Poortjie sandstone") of the Teekloof Formation of the Adelaide Subgroup of the Beaufort Group (Karoo Sequence). The heights to the east of the river consist mainly of Cretaceous conglomerates of the Enon Formation. Finally the river enters the sea via an estuary mouth consisting mainly of quartzitic aeolian and marine sands. The mouth is bounded to the east by low aeolianite (dune rock) cliffs.

Rainfall

Great Brak lies in Climatic Region A (Schulze, 1965) which receives more or less equal amounts of rain in all seasons with slight peaks in spring and autumn. The topography affects the amount of rainfall received: the mountains in the vicinity of George receive about 1 100 mm per annum whereas the plains south of Riversdale in the west of the region receive only 400 mm.

Normally there are 8 - 12 rain days a month. The rain is mainly cyclonic or orographic. The region has a generally mild climate although temperatures may be extremely high during northerly "berg" winds. The region receives 50 percent of the possible sunshine (Schulze, 1965).

	Average daily temperatures (°C)		Extreme temperatures (°C)	
	Max	Min	Max	Min
January	26	15	42	4
July	19	7	32	-4

Rainfall (mm) - Great Brak River (HKS, 1974)

	J	F	M	A	M	J	J	A	S	O	N	D	Year
1967	23,3	77,1	94,0	160,0	97,5	32,2	54,5	35,0	90,0	22,5	50,5	18,5	755,1
1968	-	4,0	65,7	44,8	37,0	100,0	9.0	30,5	22,0	31,5	80,0	22,0	446,5
1969	23,9	31,0	37,0	39,5	8,7	55,8	19,5	16,5	30,5	38,5	25,5	5,0	330,7
1970	48,5	50,5	17,0	13,5	20,0	18,0	17,5	47,0	30,0	75,5	19,0	75,0	432,5
1971	17,0	73,9	50,9	55,5	62,0	25,5	142,0	111,0	3,5	36,5	73,5	27,5	678,3
1972	45,5	91,5	51,5	38,0	46,0	34,5	47,5	44,0	23,5	12,5	20,0	27,0	481,5
Mean	26,4	54,7	42,6	58,5	45,2	44,2	48,5	47,3	33,2	36,2	44,7	29,2	520,8

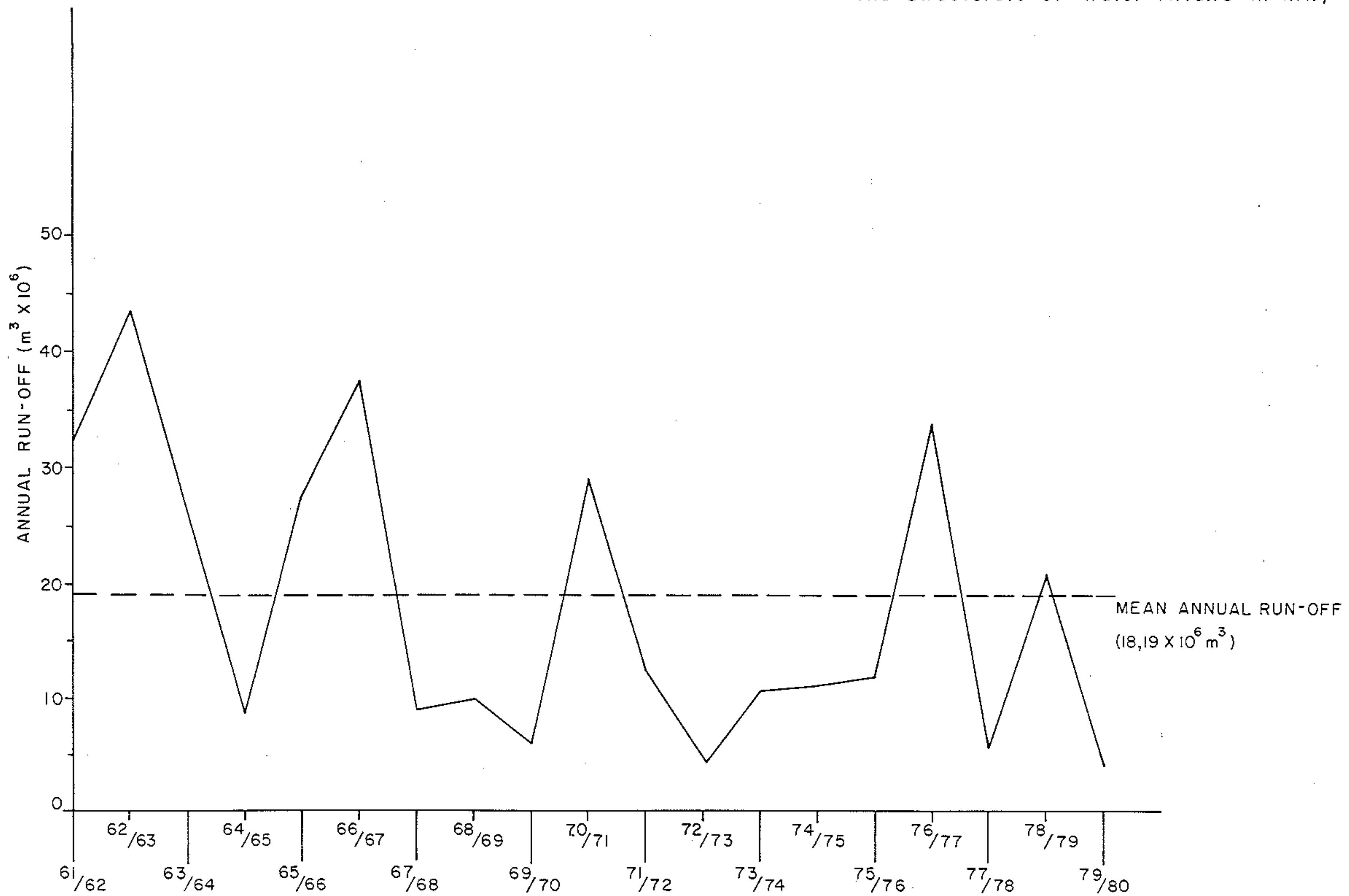
A high incidence of cloud, frequent light drizzle, coastal fogs and changeable weather are characteristic of the region. The Outeniqua Mountains, acting as a high coastal barrier, are a key factor in producing these localised conditions. The precipitation occurs mostly as light rain i.e. less than 1 mm/day and occurs on an average of 124 days per year (HKS, 1974).

Run-off and rate of flow

The mean annual run-off (MAR) as measured at the Wolwedans gauging station for the period 1961 - 1980 was 18,19 x 10^6 m^3. Annual run-off fluctuates widely: from 4,3 x 10^6 m^3 in 1979/80 to 44,5 x 10^6 m^3 in 1962/63 (Figure 3).

The normal rate of flow in the Great Brak has been considerably reduced during recent years by afforestation, damming of small tributaries by farmers and the building of the Ernest Robertson dam (WMS Franklin, *in litt.*, 1979).

<u>FIG. 3</u>: Great Brak River: Total annual run-off 1961/62 - 1979/80 (Information from River Flow Data, 1978 and Directorate of Water Affairs *in litt.*)



3.1.2 Land Ownership/Uses

(This section is contributed by R Stauth, School of Environmental Studies, University of Cape Town.)

Forestry and agriculture are the principal land uses in the catchment. Forestry plantations were established in 1911 and approximately one-third of the catchment is under State forest (Mr van Rijn, Government Forester, Jonkersberg Plantation, pers. comm.). In addition to the Jonkersberg plantation, which includes 4 000 ha of indigenous vegetation and 4 900 ha of pine *(Pinus pinaster* and *P. radiata)*, there are several small private plantations besides those managed by the municipalities of Mossel Bay and Great Brak River. The State has adopted a policy of clearing alien vegetation (*Acacia* spp.) and burning large blocks of fairly flat land to increase timber and water yields from the catchment.

Agricultural production in the catchment appears to be profitable with about 90% of suitable land already cleared (Mr Blomerus, Chief Extension Officer, Outeniqua Experimental Farm, pers. comm.). The present agricultural pattern consists of stock-farming pastures (40 percent), wheat (30 percent) and vegetables (30 percent). The characteristic deep red soils in the region do not erode readily, The farms are generally contoured and well managed. However, infestations of black wattle *(Acacia mearnsii)* occur in drainage channels and along major watercourses and more small dams are being built on private lands, all of which reduce run-off to the river.

3.1.3 Obstructions

The catchment is a major source of water for the municipalities of Mossel Bay and Great Brak River. Mossel Bay receives approximately 1 800 megalitres annually from the 422 megalitre capacity Ernest Robertson dam built in 1954 - 1956 and situated 25 km upstream from Great Brak (Mr Collen, Town Engineer, Mossel Bay, pers. comm.). Searles Holdings, which has servitudes on the water remaining in the Great Brak River, receives approximately 400 megalitres annually from a 20 km furrow running from Friemersheim in the Outeniqua Mountains to a series of holding dams (Coenraad, Osdam, Power and Klipdam with a total capacity of 70 million gallons or 318 220 m^3) near the town (W Jonker, Company Engineer, pers. comm.). This water is utilized for Searles' industrial operations including hydro-electric power generation and the needs of Great Brak River and other communities in the area. The tail-race of the hydro-electric power station discharges into the Great Brak River. As mentioned previously, there are numerous small dams on the various tributary streams comprising the catchment of the Great Brak River. For example, there are six irrigation dams on the Varing River alone. These impoundments serve to reduce water flow in the main stream considerably and thus contribute to the problem of sand infilling the channels at and near the mouth of the estuary.

3.1.4 Siltation

Little sediment is transported downstream by the Great Brak River and its tributaries. This is probably due to the well-vegetated catchment, good farming practice and the evenly distributed (seasonally) light rainfall in the area.

Human interference e.g. construction of bridges, the abstraction of water from the river for agricultural, industrial and domestic use and the construction of dams all influence the quantity of silt brought down by the river (Sales, 1977). As early as 1814 it was necessary for people to assemble several times every year to open the mouth of the river (Franklin, 1975). This may have been a consequence of siltation or just to make it possible to ford the river safely because of the water backed-up behind the bar. Another reason for breaching the bar was to permit the passage of boats into the estuary from the open sea.

3.1.5 Abnormal Flow Patterns

Lowe Simpson and Associates (1973) state that the Great Brak River has a long history of floods which occurred at irregular intervals.

The following major floods were recorded at the Wolwedans gauging station (Directorate of Water Affairs, *in litt.*).

Date	Flow rate
9 April 1972	141 897 cusecs (4 017,5 cumecs)
22 August 1971	1 848 216 cusecs (52 327,7 cumecs)
6 August 1971	223 264 cusecs (6 321,2 cumecs)
8 October 1970	450 933 cusecs (12 767,1 cumecs)

In addition, according to Mrs Douglas of the Great Brak River village museum, major floods occurred in 1905, 1932, 1939, Jan. 1951, Sept. 1962, 1964 and May 1977. Major flooding also occurred in April 1981 when 120 mm rain fell in 36 hours, which was the second time in two months that the river came down in flood (Cape Times, 28 April 1981.

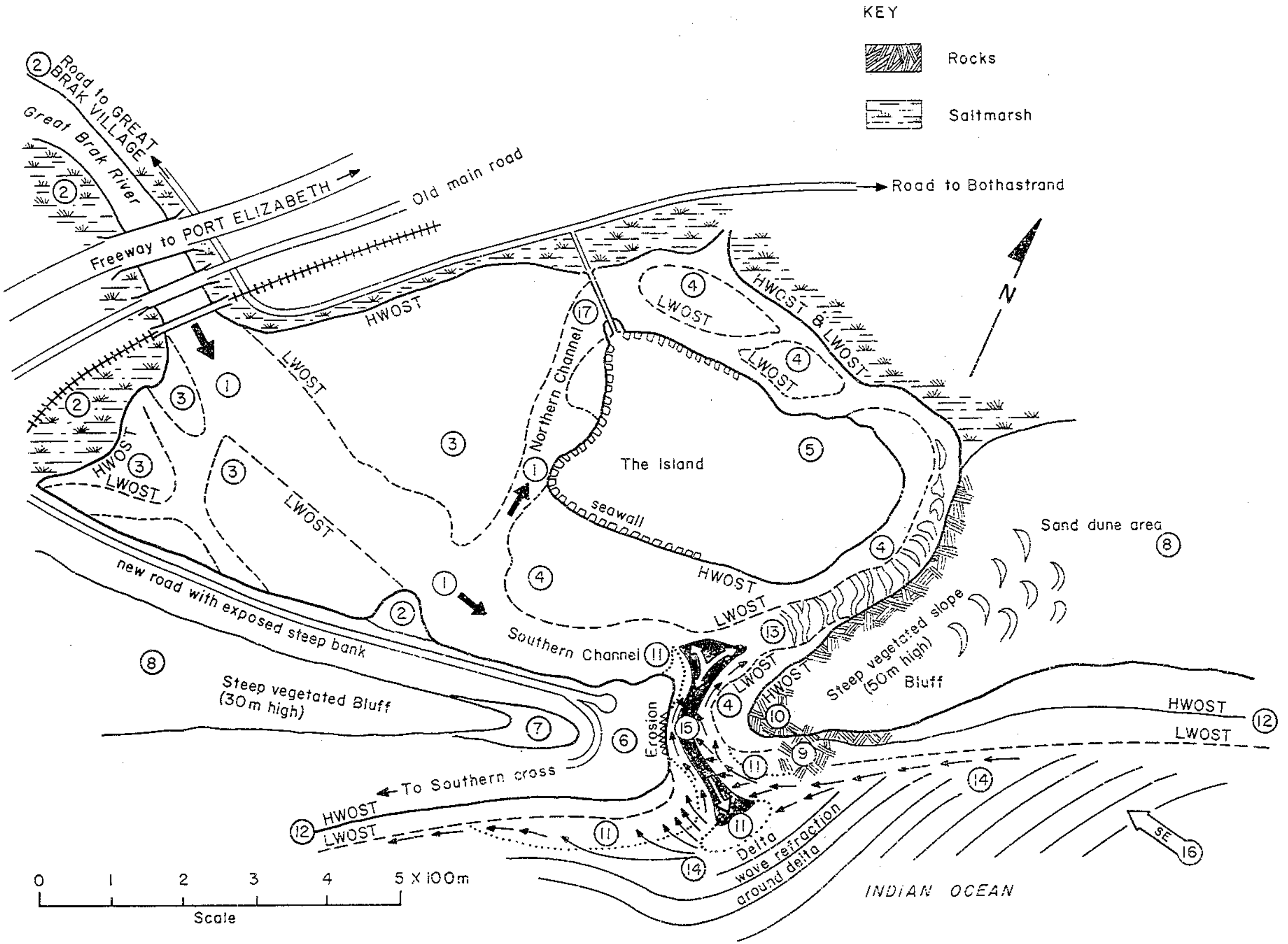
3.2 Estuary

3.2.1 Estuary Characteristics

(Sections 3.2.1 and 3.2.2 have been contributed by Dr GAW Fromme of the Sediment Dynamics Division, NRIO.)

The estuary mouth is bounded by a low rocky headland on the east and by a sandspit on the west. Immediately inland of the periodically open mouth channel the estuary widens into a lagoon basin containing a permanent sandy island which is called The Island.

FIG. 4: Great Brak River mouth, 13 November 1981.



LEGEND TO FIGURE 4: Great Brak River Estuary 13 November 1981

(1) River course and northern and southern channel.

(2) Floodplains of upper estuary (seasonally flooded, mostly saltmarshes).

(3) Tidal mudbanks (terrestrial, chiefly organic sediment).

(4) Tidal sandbanks (marine sediment).

(5) The Island.

(6) Sandspit, washed over only by high waves during high water tides, otherwise stable.

(7) Old bar deposit ("spine" of sandspit).

(8) 30 to 50 m-high dune bluffs; on the eastern bank resting on a 20 m basal layer of dune rock (10).

(9) Tidal rock platform, periodically covered by sand.

(10) 20 m-high heavily eroded and broken cliffs of calcareous sandstone, conglomerate and lumachelle, representing an ancient (? Tertiary) deposit of dune rock.

(11) Submerged sandbanks and delta formations around the estuary mouth, mostly fresh depositions caused by strong littoral sand movement (14).

(12) Beach (between LWST and backshore).

(13) Megaripples 3 - 5 m apart, on bed of easterly section of northern channel, showing tendency to move upstream.

(14) Longshore (littoral) sand transport, moving in a westerly direction (under the influence of a south-easterly swell) (16).

(15) Deep section of estuary mouth channel; scoured by tidal currents, ending seaward at the tidal delta (11).

(16) South-easterly swell breaking in an angle of 30^{o} obliquely against the beach, generating a westbound sand movement (14).

(17) Narrow bridge connecting The Island to the mainland.

LWOST, HWOST low and high water ordinary spring tide water edges.

Geomorphology of the estuary

Between the village of Great Brak and the Garden Route Freeway bridges the river meanders through a wide floodplain. Immediately seaward of the freeway bridges the river enters the lagoon basin about 1 km long and 0,5 km wide. The basin is bounded by the hilly coastal plain in the north and by the approximately 30 m-high bush-covered dune ridge to the south. The dunes east of the mouth form a bluff about 50 m high consisting of 20 m basal dune rock, probably of Tertiary age, overlain by a partly vegetated field of transverse barchan-type dunes. The Hersham residential area has been developed in this area.

The sandy island 400 m x 250 m in size occupies the eastern half of the lagoon basin. Originally bush-covered, The Island is now occupied by a development of 90 houses of which 12 are permanently inhabited. During the ECRU survey of 12 - 13 November 1981 a narrow northern channel flowed around the island on its west, north and east sides and a wider southern channel enclosed the island to the south (Figure 4). South of The Island both channels combined into a mouth about 40 m wide. During high tide the mouth channel varies between one and two metres in depth. This tidal inlet is periodically open.

Bathymetry

Water depths were measured around The Island during low water ordinary spring tide (LWOST) and high water ordinary spring tide (HWOST) on 12 and 13 November 1981:

Measuring location relative to confluence of northern and southern channels		Water depths (m)	
		LWOST	HWOST
Northern Channel	300 m upstream	0,6	1,2
	600 m upstream	0,4	1,0
Southern Channel	150 m upstream	0,8	1,5
	400 m upstream	0,2	0,9
Mouth Channel	175 m downstream	0,3	not measured

The area between The Island and the bridges is relatively shallow i.e. 200 mm during low water and about 800 mm during high spring tides.

Bottom material

In both side channels around The Island the sand is of marine origin with a fine- to medium-grain size whereas in the combined mouth channel the sand grains are medium-sized. Upstream of the narrow bridge in the northern channel and upstream of the southern channel the bottom sediment consists chiefly of dark terrestrial organic-rich mud.

3.2.2 Mouth Dynamics

History of mouth behaviour

The Great Brak river village museum contains photographs taken in 1920, 1943, 1956, 1970 and 1973 which show typical changes at the lower estuary and of the tidal inlet.

1920: The Island is almost unaltered from the natural state. A sandbar blocks the southern channel while the northern channel carries more water than can be seen on later photographs.

1943: The water-level around The Island is high (floods?). The northern channel is in full flow whereas the southern channel is closed by a sandbar behind which lies a pool.

1956: The situation is similar to that prevailing during the ECRU survey of November 1981. The southern channel is open and joins the northern channel at the sea front of The Island. Influx of sea sand is detectable in the form of streamlined sandbanks in the northern channel which overlap the Prawn Island (the large mud bank northwest of The Island).

1970: Little water in the northern channel with water concentrated against the steep rocky bank on the east side. Complete closure of the southern channel by a sandbar. (Photograph probably taken during low water spring tide.)

1973: The northern channel is open and the southern channel is closed except for a narrow stream of water around the sea side of The Island (probably photographed during low water spring tide).

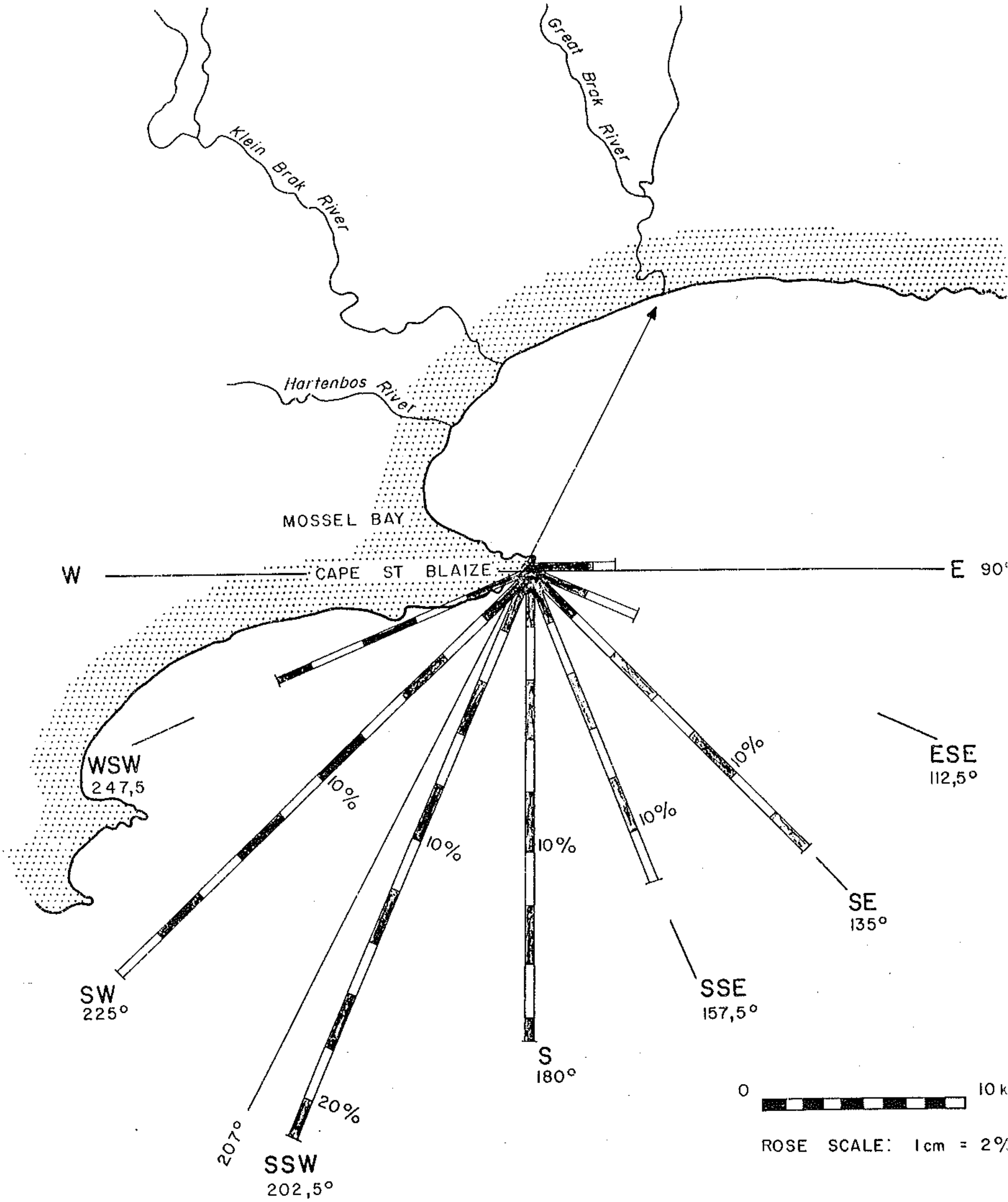
Inshore oceanography

Ocean currents

The current and circulation patterns of the coastline in the Mossel Bay area are not well understood (Harris, 1978). This is due to the scarcity of data for the area and, also, the complexity of the circulation patterns. The Agulhas Current follows the edge of the Agulhas Bank (approximately 130 km off the coastline at Mossel Bay), its influence over the bank is sometimes apparent but this is intermittent and may form vortices. Wind-induced currents thus become more important (Harris, 1978). The predominant winds blow from the south-east in summer and from the north-west in winter (Heydorn and Tinley, 1980).

Harris (1978) notes the relatively high percentage frequency of both slack water and onshore currents off the coast west and east

FIG. 5: Wave Rose, Cape St. Blaize
Deep sea waves (clinometer)
percentage distribution
1968 - 72 inclusive



of Mossel Bay. He also emphasizes the fact that oil from the *Venpet/Venoil* collision off Plettenberg Bay in December 1977, moved inshore and was deposited along the coastline east of Mossel Bay. For four days prior to the deposition of the oil, the wind had a strong onshore component.

Waves and surf-zone currents

Littoral sediment movement and the mouth dynamics of the Great Brak are influenced by the wave climate in the region. The results of an analysis of wave clinometer measurements collected at Cape St Blaize during 1967 - 1972 (Ashby *et al.*, 1973a) are summarized in a wave rose (Figure 5). These observations are supported by deep-sea wave data provided by voluntary observing ships (Swart and Serdyn, 1981).

The wave rose (Figure 4) shows that, because of the shelter provided by Cape St. Blaize, the mouth of the Great Brak River lies in an area which theoretically can receive only direct deep-sea waves from east of 207^{o} i.e. roughly from SSW to east. Waves coming from a direction west of 207^{o} will, however, also enter Mossel Bay since they will be diffracted anti-clockwise around Cape St. Blaize and arrive at the coast with an angle less than that of the original deep-sea wave. Waves from SSW will be affected by diffraction and, consequently, approach the coastline at Great Brak River with an angle of less than 202,5^{o}. The percentage occurrence of the two main types of wave incidence is 32,5 for the easterly and 67,5 for the westerly deep-sea wave direction.

In a diffraction area such as this half-heart-shaped bay, the longshore currents are complex and contain a component due to the longshore variation in wave height within the diffraction area, which in turn gives rise to a longshore variation in wave set-up. (Wave set-up is the build-up of a higher mean water level inside the surfzone than outside which is associated with the momentum flux in progressive waves.) This means that the water level in the surfzone will be higher at Great Brak than at Hartenbos to the west. A gradient from east to west in the water level in the surfzone will thus be created resulting in a westward flowing surfzone current and, consequently, a net longshore sediment displacement to the west. *In situ* observations made during the ECRU surveys indicated that the west-bound component predominates.

Tides

The tidal range for Mossel Bay as calculated from the South African Tidal Tables (1981) is 1,75 m between MLWS and MHWS.

Conclusions on mouth dynamics

The sediment movement and basic dynamics at the Great Brak River mouth (as far as could be established by the study of historical photographs, aerial photography, the geomorphology, inshore oceanography, relevant local information and observations by the Sediment Dynamics Division (SDD), NRIO on 12 and 13 November and 5 December 1981), led to the following conclusions:

1. There is an open active northern channel and an infrequently open southern channel.

2. The mouth reacts to influences from both the sea including storm tides and littoral sand movement, and terrestrial factors including floods and catchment management.

3. The southern channel forms a direct route to the sea and functions when the river is in spate after the sandbar at the mouth has been breached.

4. During periods of low river flow a sandbar develops in the southern channel. Sand transported by the west-bound longshore drift, wave action in the mouth and local wave refraction around the delta closes the channel and outflow is confined to the northern channel.

5. After the sandbar in the southern channel is breached, flow in the northern channel is much reduced and sandbanks of marine origin form in the channel. The situation is aggravated by the influx of windblown sand from the dunes on the bluff to the east.

6. If the natural functioning of the estuary is not disturbed flow through the northern channel will be maintained. If the mouth is opened prematurely the scouring action of the outflowing water is greatly reduced. This reduces the amount of sand removed from the northern channel. The northern channel is becoming shallower as a result of reduced water flow in the river by dams and water abstraction in the catchment.

3.2.3 Land Ownership/Uses

(This section is contributed by R Stauth, School of Environmental Studies, University of Cape Town.)

The principal landowner in the estuarine zone is Searles Holdings Ltd., which employs about 1 200 people in the area (BF Puchert, Managing Director, pers. comm.). The two major industries are footwear and timber: there is a shoe factory, a sawmill, a timber processing plant and a timber frame housing business. The Searles company operates plantations in the estuarine zone, a hydro-electric power station, engineering workshops, general retail stores and an automobile dealership and workshop. The company also owns various dwellings in Great Brak River, and is engaged in resort development involving coastal land.

Another concern, Outeniqua Houtbehandelings (OHB), operates a pole treatment plant on the east bank of the river which forms part of the floodplain.

A number of other industries and developments are also on the floodplain; most of these areas have not been flooded in living memory.

Residential developments in the area include Great Brak village, The Island and the following townships: Bergsig (extensions 1, 2 and 6), Greenhaven (extensions 3 and 4) and Southern Cross (extension 5). Two new townships have recently been approved: extension 7 (part of Bergsig), and Hersham Beach. The permanent population of the Great Brak area in 1980 was 919 Whites occupying 368 dwelling units and 4 250 Coloureds in 759 housing units (Mallows Louw Hoffe and Orme, 1981).

Some of these townships are regarded as recreational housing areas. The Island (76 erven, 100 percent built) lies within the estuary, Southern Cross (106 erven with another 50 planned; about 50 percent of original erven built) on the west side of the mouth; and Hersham Beach (88 erven, perhaps 300 more planned - still in the early development stage) on the east side of the mouth. Approximately 15 percent of the homes at The Island and Southern Cross are permanently occupied.

Although The Island has not been flooded since it was developed, expenses have been incurred in building and maintaining a retaining wall around the island. Houses at the southern end are threatened by erosion from incoming tides when the front channel is open and it may ultimately be necessary to dredge out the northern channel (Figure 3) to keep The Island as an island. Both Southern Cross and Hersham Beach are located in sensitive coastal dune areas. However, building regulations prevent levelling of hills or the removal of vegetation and positive action has been taken to stabilize the dunes at Hersham Beach before commencement of development. Nevertheless, a road has been constructed immediately behind the beach at Southern Cross in an area which appears to be vulnerable to undercutting and slumping. The ultimate consequences of development in the primary dune zone may take years to materialize and are not always forseeable. However, in general, these townships appear to be well-planned and should not suffer unduly due to environmental disturbance.

There are three caravan parks which are fully booked in season: a caravan park for Coloureds (50 sites) on the beach three km west of Southern Cross; the Great Brak River Caravan Park (48 campsites) located south of the old national road on the west bank; and the Pine Creek Caravan Park (privately owned, 142 sites) on the west bank opposite the main business area of the village. The White population more than doubles during the holiday season and currently there is a great demand for holiday and retirement homes (Mr van Rensburg, former Town Clerk, Great Brak River, pers. comm.).

The estuarine and coastal zones at Great Brak River are used for industrial and recreational activities and both Searles Holdings Ltd. and the Municipality "want to attract to it people wishing to retire, holiday makers, light industry and commercial development in order to provide job opportunities for the local population" (Mallows Louw Hoffe and Orme, 1981). The Municipality wants more industrial and business stands to stimulate economic growth but Searles own virtually all the remaining land suitable for new developments. The Searles management has no plans for industrial expansion in the valley and further industrial development will apparently be limited to the coastal hill at Nauwelyks where the sawmill is sited. This is because of engineering, space and flood constraints in the valley. However, Searles feel that the area has great potential for tourism and holiday developments (BF Puchert, Managing Director, pers. comm.).

Great Brak River still has a low ratio of development to natural environment (about 75 percent of the Municipality consists of open space) which could help to provide recreational facilities for general public use on a section of the coast which is rapidly becoming built up (Cape Provincial Administration, 1973). There is a basic conflict between recreational housing developments and general recreational use. Present development plans indicate that Great Brak River and its coastline could become part of a solid ribbon of development eventually linking Mossel Bay and George.

3.2.4 Obstructions

There are five bridges across the estuary of the Great Brak River. That nearest to the mouth is a narrow single lane road bridge giving access to The Island. This bridge obstructs water flow in the northern channel: "Unfortunately when the bridge was built an inadequate number of spans was designed and a large amount of fill was dumped into the river which directly influenced the flow of water and resulted in the main channel changing its course" (WMS Franklin, 1979, *in litt.*). In times of flood the river opens the southern channel and discharges directly into the sea. When the river flow returns to normal, sand transported by longshore currents and waves closes the southern channel, and the river flow reverts to the northern channel. However, the road bridge to The Island has attenuated the flow in the northern channel with the result that sand, blown in from the dunes on the bluff to the east, is no longer adequately scoured from the channel. The effect of this obstruction by the bridge and consequent shallowing of the northern channel is that the southern channel remains open for much longer than it did in the past (WMS Franklin, *in litt.*). The natural tendency is for the southern channel to migrate northwards towards The Island. The channel remains open to the sea close to the south side of The Island, and thus exposes The Island to wave attack.

The railway bridge, the old National Road bridge and the new paired freeway bridge all cross the estuary relatively close to one another (Figure 1 grid references 1608 and 1708). In addition, the pylons of the old railway bridge still stand between the new railway bridge and the old National Road Bridge. The embankments of the new freeway have decreased the capacity of the floodplain to absorb floodwater and have blocked a flood dissipation route over the old National Road. All floodwater is now forced to pass under three bridges before reaching the lower estuary. The railway bridge, in particular, has very little clearance at high spring tides when the mouth is open. The flood situation could be further aggravated if floodwaters were to reach the pole yard (Figure 1 grid reference 1108), as there is a possibility that poles could be carried downstream and form a dam at the three bridges which could cause backflooding of the whole floodplain (Hill Kaplan Scott, 1974; Stauth, 1982).

The fifth bridge is situated 4,8 km upstream from the mouth and links the eastern and western parts of Great Brak River village. The bridge is near the limit of tidal effect in the estuary. This bridge, the Charles Searle bridge, was built in 1964 to replace the causeway constructed in 1850 (Franklin, 1979). The original 1850 causeway was designed with floating decks so that it would be passable under flood conditions. However, the mechanism never functioned as designed (Franklin, 1979). The Charles Searle Bridge was constructed on the original 13 piers of the causeway and there has therefore been no reduction in the degree of obstruction to the river flow although Sales (1977) states that the bridge has little effect in reducing river flow.

3.2.5 Physico-chemical Characteristics

Two surveys of the Great Brak River have been made by the Marine Pollution Monitoring Group, NRIO. The first survey (Table 1) was made in August 1978 when the estuary mouth was closed and was part of the National Marine Pollution Monitoring Programme (Eagle, *et al.*, 1979). Trace metal data from this survey were published separately (Watling and Watling, 1980). The second survey was made in November 1981 specifically for ECRU (Tables 2 and 3).

pH

In both 1978 and 1981 pH values were typically marine (about 8,0) at the downstream end but decreased as the salinity decreased. The freshwater source is a "black-water" river system which has extremely acidic water as shown by the pH value of 4,3 obtained from the Ernest Robertson Dam.

Temperatures

In winter (August 1978, Table 1) the water was distinctly warmer above Great Brak village (16,4 $^{\circ}$C) than at the mouth (12,6 $^{\circ}$C) whereas in summer (November 1981, Table 2) there was little difference in temperature along the length of the estuary. Surface and bottom measurements made during the November 1981 survey show that there was no apparent temperature stratification (Table 2).

Transparency

The water throughout the estuary was clear but in the upper reaches heavy peat-staining ("black-water") limited light penetration (Secchi disc reading of 0,6 m during the November 1981 survey).

TABLE 1: Physico-chemical data - Great Brak River: 18 August 1978: Low Tide: 09h34

Station Number	Grid. Ref.*	Time	Salinity Parts per Thousand	Total Phosphorus (μmol/ℓ)	Silicate (μmol/ℓ)	Nitrite (μmol/ℓ)	Nitrate (μmol/ℓ)	OA mg/g	Dissolved Oxygen (mg/ℓ)	Temp. (°C)	pH
19	2507	09h00	24,12	0,80	12,87	0,10	72,80	0,005	9,00	11,1	7,96
1	2307	09h15	23,11	0,25	3,14	0,10	241,3	0,006	7,14	12,6	8,06
2	2210	09h50	24,09	0,42	15,14	0,09	99,55	0,006	7,27	12,3	7,90
3	1409	10h10	23,97	1,05	10,32	0,18	249,4	0,005	6,99	13,6	8,04
4	1202	11h30	23,16	0,17	16,16	0,16	224,2	0,005	7,04	13,8	8,02
5	0804	12h10	22,31	1,24	20,00	0,16	147,3	0,006	7,06	14,0	8,00
6	0611	12h30	22,29	0,94	21,46	0,26	219,2	0,007	7,13	14,9	7,98
7	0612	12h50	10,96	0,12	47,30	0,24	220,2	0,006	8,17	16,0	7,83
8	0613	12h20	05,28	0,42	21,35	0,19	232,3	0,009	8,10	16,4	7,38

*See Figure 1.

TABLE 2: Physico-chemical data - Great Brak River: Surface Water Samples: 12 November 1981

Time of low tide: 09h30 (Low Water Spring Tide)

Station Number	Grid Ref.*	Time of Sampling	Salinity Parts per Thousand	Phosphate (µmol/ℓ)	Silicate (µmol/ℓ)	Nitrite (µmol/ℓ)	Nitrate (µmol/ℓ)	Ammonia (µmol/ℓ)	Dissolved Oxygen (mg/ℓ)	Temp. (°C)	pH	Total Dissolved Carbon (mg/ℓ)	Dissolved Inorganic Carbon (mg/ℓ)	Dissolved Organic Carbon (mg/ℓ)
10 Surface	2307	15.10	35,8	1,36	2,80	+	2,45	1,02	7,59	17,8	8,1	25,2	25,6	0
11 Surface	2411	15.30	35,9	0,87	2,91	+	2,18	1,11	7,47	18,0	8,2	23,4	25,0	0
Bottom			35,9	0,56	2,51	+	2,11	2,64	7,38	18,0		24,5	26,2	0
12 Surface	2009	15.50	35,9	0,55	3,38	+	2,35	2,31	7,13	19,1	8,1	21,8	24,1	0
Bottom			36,0	0,52	3,17	+	1,94	0,94	7,21	18,8		23,8	25,7	0
13 Surface	1409	16.10	35,9	0,57	2,98	+	2,35	2,35	7,03	19,0	8,2	22,8	24,5	0
Bottom			35,9	1,51	3,28	+	2,30	3,12	7,20	18,8		23,8	26,1	0
14 Surface	1103	16.25	28,5	0,64	22,09	+	3,63	3,63	6,71	20,5	8,0	20,0	21,1	0
Bottom			35,0	0,64	12,20	+	3,65	1,82	6,97	19,4		21,0	20,0	1,0
15 Surface	0809	17.00	20,0	0,94	42,25	+	6,25	4,11	6,25	22,2	7,6	15,6	8,1	7,5
Bottom			25,0	0,64	28,02	+	3,95	3,63	5,32	21,6		16,1	11,8	4,3
16 Surface	0711	17.15	3,0	-	-	+	-	-	-	20	7,3	-	-	-
Bottom			2,2	-	-	+	-	-	-	19		-	-	-
Ernest Robertson Dam		-	1,0	1,60	18,2	0,40	0,30	2,80	-	-	4,3	21,8	0,5	21,3
13 November 1981 Time of low tide: 10h10 (Low Water Spring Tide)														
19	2507	11.45	38	0,61	9,79	+	4,93	2,95	-	-	8,1	22,2	21,9	0,3
20	2406	11.55	25	0,59	36,03	+	4,88	7,28	-	-	8,0	21,6	14,7	6,9
21	2306	12.15	30	0,89	24,75	+	5,47	2,54	-	-	8,1	24,6	18,7	5,9
22	2307	12.30	25	1,10	32,13	+	6,27	3,88	-	-	8,0	22,2	16,9	5,3

+Not detected *See Figure 1

TABLE 3: Physico-chemical data - Great Brak River: Interstitial Water Samples: 13 November 1981

Time of low tide: 10h10 (Low Water Spring Tide)

Station Number	Grid. Ref.*	Time of Sampling	Salinity Parts per Thousand	Phosphate (µmol/ℓ)	Silicate (µmol/ℓ)	Nitrite (µmol/ℓ)	Nitrate (µmol/ℓ)	Ammonia (µmol/ℓ)	Dissolved Oxygen (mg/kg)	pH	Total Dissolved Carbon (mg/ℓ)	Dissolved Inorganic Carbon (mg/ℓ)	Dissolved Organic Carbon (mg/ℓ)
MB3/19	2507	11.45	36	1,34	19,51	<	12,30	2,59	-	8,0	28,6	28,3	0,3
20	2406	11.55	38	1,98	19,83	0,97	21,86	2,19	-	8,0	29,8	27,3	2,5
21	2306	12.15	38	1,58	13,36	<	12,23	2,71	-	8,2	26,3	24,3	3,7
22	2307	12.30	36	1,96	17,18	<	6,27	2,95	-	7,9	28,5	24,8	3,7

* See Figure 1

Salinity

In November 1981 chemical samples were taken at about high water spring tide (Table 2). There was considerable penetration of salt water up to Great Brak village (Figure 1, grid ref. 0808). At the time of sampling evidence of a salt wedge structure (stratification) was found at stations 14 and 15 (Figure 1, grid refs. 0808 and 1102). In August 1978 the mouth of the Great Brak was closed by a sandbar and the freshwater flow was low. Salinity values of about 23 parts per thousand were found throughout the estuary up to Great Brak village above which values were lower: 10,96 parts per thousand and 5,28 parts per thousand at stations 16 (Figure 1, grid ref. 0611) and 17 (Figure 1, grid ref. 0613), respectively. When the mouth was closed in August 1978 the influence of the sea was removed but the freshwater flow was still strong enough to more than compensate for evaporation losses since the salinities ranged from 5,28 to 24,12 (Table 1).

Dissolved Oxygen

During the ECRU survey (November 1981) dissolved oxygen levels were about 7 mg/ℓ i.e. about 90 percent of saturation. At station 15 (Figure 1, grid ref. 0809) saturation decreased to 70 percent in the bottom water. The river water contains significant amounts of organic material which might account for the slightly lower oxygen values.

During the Marine Pollution Monitoring Group survey in August 1978, dissolved oxygen levels were constant throughout the estuary at about 80 percent saturation.

Nutrients

Nitrate and Nitrite

In November 1981 the nitrate levels were quite low 1,94 - 6,27 µmol/ℓ) and can be considered as being within the normal range for a clean estuary (Table 2). The nitrate level was lower in the Ernest Robertson Dam indicating that the river obtains its nitrate loading from run-off from the surrounding areas. However, during the August 1978 survey high nitrate concentrations were detected. This indicates that leached nitrate was accumulating in the estuary as a consequence of the mouth being closed. During the November 1981 survey nitrite was not detectable. In a well-oxygenated system there should be little or no reduction of nitrate. In August 1978 nitrite levels were very low (Eagle, *et al.*, 1979).

Ammonia

Levels of ammonia were low (0,94 - 4,11 µmol/ℓ) during the November 1981 survey. These were, however, higher than in the Hartenbos Estuary (Bickerton, 1982) but considerably lower than in various polluted systems that have been studied. They give no cause for concern.

Phosphate

The levels of phosphate were essentially constant throughout the estuary (ECRU survey, 12 November 1981, Table 2) but were perhaps lower than might be expected in a Cape south coast estuary. During the August 1978 survey (Table 1) phosphate levels were more varied but the mean value (0,60 µmol/ℓ) was similar to that recorded in 1981.

Silicate

Silicate levels were typical for a Cape estuary (ECRU survey, 12 November 1981). Levels were lowest at the seaward (marine) end and highest at the upstream (freshwater) end. The dam water gave a value of 18 µmol/ℓ (Table 2) whereas the highest value of the estuarine water was 48 µmol/ℓ. This indicates that the silicate is derived from geological sources in the catchment; the acidic "black-water" (pH about 6,0) provides a more aggressive medium for dissolution of silica. In 1978 silicate levels were noticeably, higher throughout, reflecting the dominance of the freshwater at that time.

Dissolved Carbon

Dissolved organic carbon (DOC) was not detected at the sites within the estuary under direct influence of sea water at high tide. The river is an important source of DOC as is shown by the high level at the dam and also at station 15 (Figure 1, grid ref. 0808). High levels of dissolved inorganic carbon (DIC) in the lower estuary showed the sea to be an important source of DIC. The DIC content was nil (or negligible) at the source of the river but increased as the river flowed through the catchment. Samples taken after low tide at the marine stations (19-22: Figure 1, grid refs. 2507, 2406, 2306, and 2307 respectively) showed that the large amounts of "black water" flowing into the sea had depleted the DIC level and that the DOC level had risen. Sampling station 19, to the east of the mouth, was not influenced directly by the river.

The majority of the chemical variables showed that the Greak Brak River was in a clean and healthy state with no sign of pollution. Levels of interstitial nutrients in samples of sand collected from the beach area (stations 19 - 22) were within the usual range for an unpolluted site (Table 3). Some differences between the data for the 1978 and 1981 surveys are evident. In 1978 the mouth was closed and the chemistry was more uniform throughout the estuary since the influence of the sea was absent. The organic debris from the wood treatment plant (Figure 1, grid ref. 1107) adds to the organic loading in the sediment as is reflected in the high OA (oxygen absorbed) values and also provides some shoreline debris. High levels of certain toxic metals e.g. zinc, copper and lead in the sediments are a cause for concern (Watling and Watling, 1980). The concentrations in the sediments should decrease particularly after severe floods, as occurred in 1980, when large amounts of sediment were carried out to sea.

3.2.6 Pollution

Disposal of sewage at Greak Brak River is either by means of septic tanks where soil conditions are suitable or by conservancy tanks where they are not (WMS Franklin, *in litt.*, 1979). The contents of the conservancy tanks are transported by road tanker to a site near the railway line on Searles property for dumping. No other treatment is carried out. In the Coloured residential area, Greenhaven, a Pasveer ditch is in operation which functions satisfactorily under the supervision of the Municipality (WMS Franklin, *in litt.*, 1979). The effluent from the Pasveer ditch is tested regularly and the Departments of Health and Water Affairs are both satisfied with the standards maintained. The Pasveer ditch effluent runs into the Great Brak River via a *Phragmites* reed-filled water course. No plans have been made to install a sewage reticulation system and treatment plant. In fact, two new townships have been approved by the Townships Boards for which septic tank sewage disposal is considered adequate (WMS Franklin, *in litt.*, 1979). However, Hill Kaplan Scott and Partners (1974) state ... "with improvements in the standard of living it is likely that in the future the role of seepage of soakaways will be insufficient in certain areas where under present conditions the seepage is adequate. A water-borne sewerage scheme with activated sludge or conventional treatment is likely to be necessary at Great Brak River to cater for those areas where septic tanks are unsuitable".

Major sources of pollution have been removed from the valley in recent years. In 1957 the tannery was moved to King William's Town and, in 1977, the sawmill was moved to a coastal hill west of the river.

The newly completed freeway bisects the floodplain reducing its area and has caused visual and noise pollution in the lower valley and the possible danger of major flooding (Lowe Simpson and Associates, 1973; Heydorn and Tinley, 1980). The wood treatment plant is also a source of noise pollution besides being an eyesore.

Oil

There was no evidence of oil pollution at Great Brak River at the time of the ECRU survey in November 1981. Possible sources of marine oil pollution include Mossel Bay harbour, particularly the oil discharge buoy at Voorbaai, and offshore shipping. A major oil pollution incident occurred in December 1977 when the sister oil tankers *Venpet* and *Venoil* collided some 40 nautical miles offshore from Plettenberg Bay. Large amounts of oil entered the Greak Brak Estuary and were deposited on the mudflats and sandbanks. This resulted in large-scale mortalities of the shore crab *Cyclograpsus punctatus* and of the mud prawn *Upogebia capensis*. Immediately after the cleaning-up operations a 70 percent reduction in the number of prawn and crab holes was noticed. Re-colonization took place gradually from the surrounding clean areas (Moldan *et al.*, 1979).

Metals

Watling and Watling (1980) undertook an extensive survey of metal concentrations in sediments of estuaries entering Mossel Bay. In the Great Brak Estuary levels of copper, lead, zinc, cobalt, nickel and cadmium were high and the presence of these metals probably indicates industrial contamination. Most notable was a sample from station 14 (Figure 1, grid reference 0808) which contained 1,13 percent chromium. Watling and Watling (1980) state "This represents gross contamination by man and the source of this metal must be located during a future survey of the estuary". The most obvious source of this chromium is the tannery which was transferred to King William's Town in 1957. It seems likely that the levels of chromium will decline with time but with lower river flow (see Section 3.1.3 above) the metal could be retained within the estuarine system for a considerable period. Meanwhile the chromium remains a potential threat to the flora and fauna of the estuary particularly if the sediments are remobilized during a flood period (Watling and Watling, 1980).

4. BIOTIC CHARACTERISTICS

4.1 Flora

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

The configuration of the lower Great Brak estuary is shown in Figure 1, while Figure 6 shows the spatial distribution of the semi-aquatic and terrestrial vegetation mapping units. Appendix I shows some of the species and physical features of each unit, as established during the ECRU survey of November 1981.

4.1.1 Algae

Caulerpa has been reported from the deeper water below The Island bridge (Heydorn, 1979), possibly in association with *Ruppia* and *Zostera* (see below).

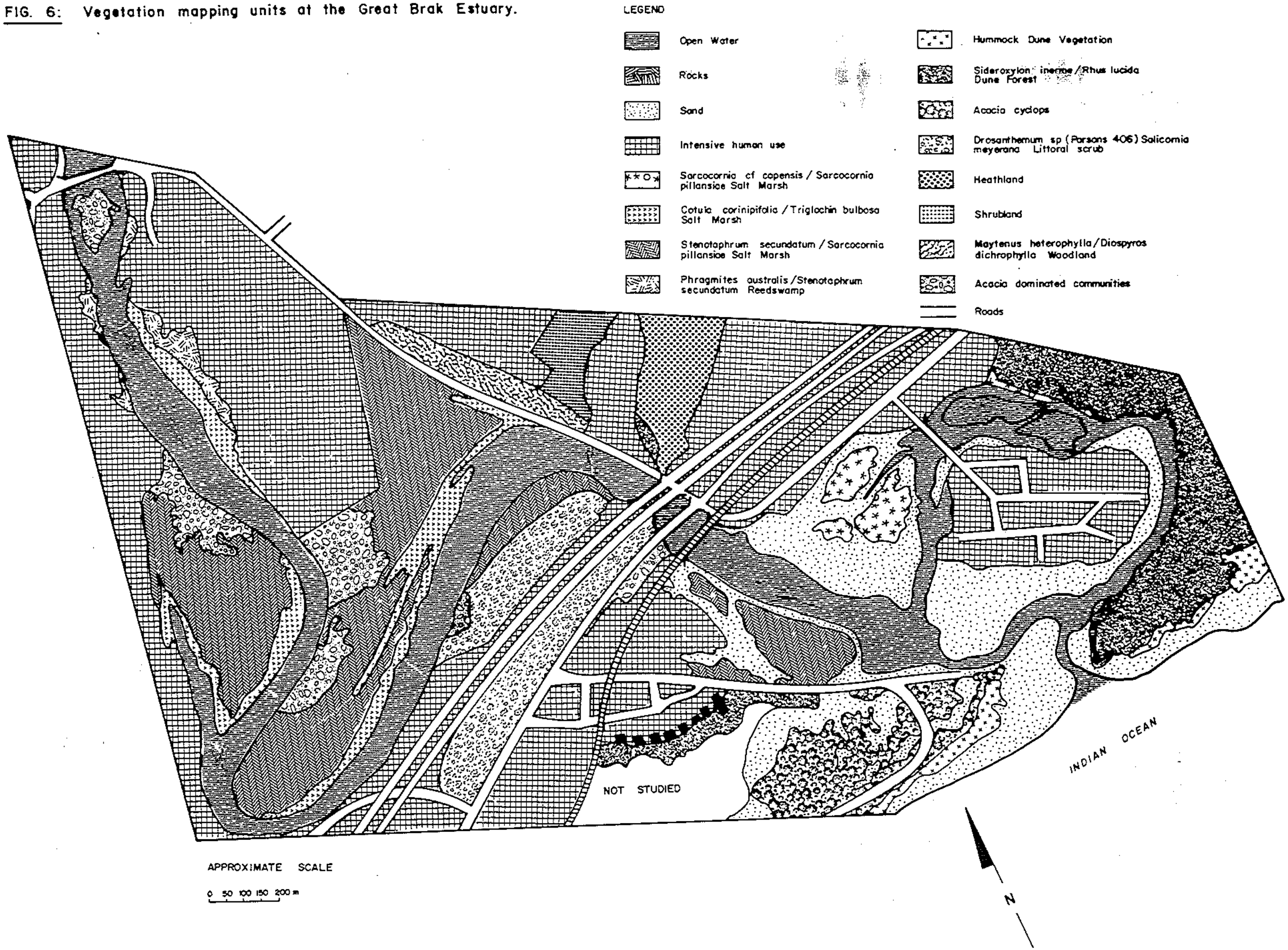
4.1.2 Aquatic Vegetation

Day (1981) reports that well developed *Zostera capensis* beds are to be found in this estuary. Heydorn (1979) reports that *Zostera* and *Ruppia* beds were common in the deeper water between The Island and the new freeway, but these beds might be endangered by unconsolidated embankments. During the ECRU survey (12 October 1981), only small patches of *Zostera capensis* were found in the deeper channels on the north-eastern side of The Island bridge.

4.1.3 Semi-aquatic Vegetation

The semi-aquatic vegetation was divided into four main mapping units, namely:

FIG. 6: Vegetation mapping units at the Great Brak Estuary.



(a) *Sarcocornia* cf *capensis/Sarcocornia pillansiae* Salt Marsh: The mud flats to the north-west of The Island bridge have a sparse covering of *Sarcocornia* cf *capensis, S. pillansiae, Sporobolus virginicus* (brakgras) and *Cotula coronopifolia* (gansgras).

(b) *Cotula coronopifolia/Triglochin bulbosa* Salt Marsh: In the bend of the river, the tidally covered muddy banks have a sparse covering of *Triglochin bulbosa* (arrow grass) and *Cotula coronopifolia* with *Sarcocornia* cf *capensis* and *Cynodon dactylon* (Bermuda quick grass). On the western bank adjacent to the sawmill *C. coronopifolia* and *C. dactylon* are predominant.

(c) *Stenotaphrum secundatum/Sarcocornia pillansiae* Dry Salt Marsh: Relatively large areas are covered by *Stenotaphrum secundatum* (buffalo grass) and *Sarcocornia pillansiae* with *Disphyma crassifolia* and *Cotula coronopifolia*. The area south of the saw mill does, however, have a number of elements from the nearby *Drosanthemum* sp., (Parsons 406)[+]/*Salicornia meyerana* and *Acacia* dominated communities.

(d) *Phragmites australis/Stenotaphrum secundatum* Reed Swamps: This unit covers relatively small areas approximately 3 km inland.

4.1.4 Terrestrial Vegetation

Six main terrestrial vegetation mapping units were identified:

(a) Hummock Dune Vegetation: The dunes to the east and west of the river mouth have similar vegetation consisting of *Ammophila arenaria* (marram grass), *Arctotheca populifolia* (sea pumpkin) and *Passerina paludosa* (gonna), while *Trachyandra divaricata* and *Galenia secunda* (vanwyksbossie) are found to the east.

The rocky outcrops on the western banks of the mouth have a different vegetation with *Myrica cordifolia* (wax berry), *Carpobrotus edulis* (Hottentots fig) and *Limonium scabrum* (sea lavender). However, large areas of the older dunes are dominated by *Acacia cyclops* (rooikrans).

(b) *Sideroxylon inerme/Rhus lucida* Dune Forest: Apart from the *Acacia cyclops* intrusions, there are well developed and aesthetically appealing dune forests on the western and eastern banks of the river. These forests include *Sideroxylon inerme* (milkwood), *Rhus lucida* (wild currant), *Carissa bispinosa* (lemoenbessie) and *Zygophyllum morgsana* (leeubos). On the western side of the river, the dune forest seems to be more stunted and includes *Capparis citrifolia* (wild lemon) and *Rhoicissus digitata* (bobbedruif).

([+]Parsons species numbers e.g. (Parsons 406) refer to specimens not yet identified at the time of writing.)

Towards the top of the eastern dune, the vegetation becomes sparse and is dominated by *Sutherlandia frutescens* (eendjiesblom) and *Ammophila arenaria* with *Chrysanthemoides monolifera* (bietou) and *Carpobrotus edulis*.

The removal of vegetation from these dunes (as for the proposed hotel, Figure 1, grid ref. 2111) might result in severe sand dune slumping such as can be noted near the cottages at the northern end of the western dunes.

(c) *Drosanthemum* sp. (Parsons 406)/*Salicornia meyerana* Littoral Scrub: As *Salicornia meyerana* is common in this vegetation type, it might be regarded as being semi-aquatic. However, many terrestrial elements are present, such as *Rhus lucida*, *Lycium afrum* (kraaldoring), *Drosanthemum* sp. (Parsons 406), *Pseudognaphalium undulatum* and *Elytropappus rhinocerotis* (renosterbos).

In areas near the new freeway where water is allowed to accummulate, *Typha capensis* (bulrush), Cyperaceae (Parsons 474) and *Cotula coronopifolia* are found.

(d) Heath- and Shrublands: These vegetation units have a number of species in common and no single species attains true dominance. The vegetation unit described as 'heathland' is found on the north-west facing sandstone-clay conglomerate (Geological Series 1:250 000, 3322, Oudtshoorn) and contains *Erica* sp. (Parsons 411), *Phylica purpurea*, *Eriocephalus* cf *africanus* (kapokbossie), *Bobartia orientalis* Subsp. *orientalis* (geelblombiesie), *Aloe ferox* (ware alwyn) and a number of grasses and restioids e.g. *Hyparrhenia hirta* (blougras), *Ficinia* cf *gracilis* and *Restio* cf *fruticosus* (kanett).

The shrubland is found on the south-facing gneissic granite slope and contains *Helichrysum* sp. (Parsons 468), *Erica glumaeflora*, *E. imbricata* (raasheath), numerous restioids (*Restio* cf *patens*, *Thamnochortus* cf *pluristachys*) and herbaceous plants (*Hypoxis* cf *villosa* (inkbol) *Satyrium* sp. (Parsons 427), *Ornithogalum dubium* (chincherinchee)).

Hakea sericea is a common alien in both these communities and the encroachment of pine trees from adjacent plantations should also be controlled.

(e) *Maytenus heterophylla*/*Diospyros dichrophylla* Woodland: In this vegetation unit, the canopy species, such as *Maytenus heterophylla* (common spike thorn), *Diospyros dichrophylla* (poison peach), *Commelina africana* and *Rhus lucida*, are relatively sparse while most of the ground cover consists of shrubs (*Passerina rubra*, *Elytropappus rhinocerotis*), herbs (*Crassula subulata*, *Stachys gracilifolia*, *Sebaea aurea*) and grasses (*Eustachys paspaloides*, *Eragrostis curvula*, *Themeda triandra*), while ferns are not uncommon.

If the adjacent pine plantations are not economically viable, a gradual and controlled removal of these aliens could result in an interesting transgression between this community and the nearby heath- and shrublands.

(f) *Acacia* Dominated Communities: *Acacia cyclops* (rooikrans) and *A. mearnsii* (black wattle) successfully outshade competing plants, thereby decreasing ground cover. This can be seen clearly immediately below the village bridge where they compete with *Acacia karroo* and on the eastern bank of the river competing with *Lycium afrum*, *Rhus glauca* and *Salicornia meyerana.* However, some 'weed' species (*Oxalis pes-caprae*, *Briza minor*, *Sonchus* spp.) may form a sparse undergrowth.

To the south of the saw mill *A. cyclops* and *A. mearnsii* dominate in the salt marsh and *Salicornia/Drosanthemum* communities. As the soil binding ability of the natural vegetation is decreased by the presence of these invasive species, these areas may be severely eroded during times of flood.

4.2 Fauna

4.2.1 Zooplankton

Grindley sampled zooplankton at seven stations at night on 29 January 1969 in the estuary from the marsh to above the bridge at Groot Brak Village. 23 species were recorded with a mean zooplankton biomass of 14,09 mg/m^3 (Unpublished information). A list of the zooplankton species found is presented in Appendix II.

4.2.2 Meiofauna

Eagle *et al.* (1979) collected meiofaunal samples from Mossel Bay and noted that the populations consisted chiefly of nematodes and harpacticoid copepods with smaller numbers of flatworms, polychaetes, oligochaetes, archiannelids, mystacocarids and other organisms. The relative numbers of these organisms and the depths at which they occur in the substrate are used as indicators of the degree of pollution of the aquatic environment. They concluded that the beaches and rivers around Mossel Bay are largely unpolluted although point sources of pollution do exist.

4.2.3 Invertebrates

Day (1981) states that the aquatic fauna is rich. Prior to the ECRU survey of November 1981 the only studies carried out were those by a University of Cape Town (UCT) team in May 1950 (UCT Zoology Department field notes) and a survey following the pollution of the coast as a result of the *Venpet/Venoil* oil tanker collision (Moldan *et al.*, 1979). The UCT team noted that the sand prawn, *Callianassa*, and the mud prawn, *Upogebia*, were abundant, the bivalve, *Loripes clausus*, was "surprisingly common" and at the head of the estuary the fresh water shrimp, *Palaemon capensis*, was recorded in an estuary for the first time. When oil from the *Venpet/Venoil* disaster entered the estuary most of the crabs and prawns were smothered in their burrows by "chocolate mousse" (emulsified crude oil) (Moldan *et al.*, 1979; Day, 1981).

4.2.4 Fish

The estuarine fish fauna is listed in (Appendix IV). The Spot damsel fish *Abudefduf sordidus* was found by the UCT survey team in 1950. This is much further south than its normal range (Day, 1981).

4.2.5 Amphibians and Reptiles

No attempt to collect amphibians and reptiles was made during the ECRU survey. However, eight species of frog, two of tortoise and eight of snake have been recorded from the area covered by the 1:50 000 topographical sheet 3422 AA Mosselbaai (AL de Villiers, Dept Nature and Environmental conservation *in litt.*) (Appendix V).

4.2.6 Birds

The Great Brak Estuary does not appear to be particularly important for water birds; few ducks, cormorants, gulls and migrant Palaearctic waders occur there (Appendix VI). Most notable are the 40 Ringed Plovers *Charadrius hiaticula* recorded by Summers *et al.* (1976).

Limited refuge areas, particularly at high tide, and heavy recreational pressure in summer are probably responsible for the small numbers of birds using the estuary.

4.2.7 Mammals

Twelve species of mammals likely to occur in the environs of the Great Brak Estuary are listed in Appendix VII. The species have been extracted from the list compiled by Stuart *et al.* (1980) for the area covered by the 1:50 000 topographical Sheet 3422 AA Mosselbaai. The larger predators such as the leopard and the honey badger are probably confined to the upper catchment areas and are unlikely to occur in the vicinity of the estuary itself.

5. SYNTHESIS

For more than a century the Great Brak River, its catchment and estuary have been subject to modification and management. The catchment, particularly the raised coastal plateau, is extensively farmed while the upland areas and the seaward slopes of the Outeniqua Mountains are under forest plantations. There are numerous impoundments on the Great Brak River and its tributaries. These range from the Ernest Robertson Dam to farm dams on the minor streams (section 3.1.3). Generally the effect of these dams has been to reduce flow in the Great Brak River with deleterious consequences for the dynamics of the estuary particularly in the vicinity of The Island. However, despite these dams, extensive flooding has occurred at Great Brak on a number of occasions because once the dams are full, floodwaters flow from the catchment unchecked - see section 3.1.5. The silt load of the river is low, despite the intensive agricultural activity, and this can be attributed to the natural stability of the soil.

The estuary mouth closes during periods of low river flow with the result that the river dams up behind it until such time as breaching is caused by high water level. During the last century, prior to the construction of the bridge at Great Brak village, high water levels made the fording of the river hazardous (Franklin, 1975). It was the practice to breach the bar whenever the water level rendered crossing difficult. Another less important motive for opening the river mouth was to allow the entry of small boats from ships lying offshore (section 3.1.4). In March 1983 the mouth was opened in order to flush the estuary as exceptionally low rainfall had reduced river flow to virtually nothing with the result that a build-up of coliform bacteria had occurred (Dr HJK Alheit, Mayor of Great Brak, pers. comm.). The main source of the coliforms is the Pasveer ditch sewage treatment plant which discharges via a *Phragmites*-filled watercourse into the Great Brak River.

The main industrial activity in the environs of the estuary consists of a timber treatment works, a saw mill and a shoe factory (section 3.2.3). Until 1957 there was a tannery which probably was the source of the chromium, present in quite high concentration in the estuarine sediments of Great Brak (Watling and Watling, 1980; section 3.2.5). The pole treatment yards are on the flood plain (Figure 3, grid refs. 1008 and 1108) and present a dual threat to the estuary. Firstly, there is a risk of spillage of the toxic chemicals used to treat the timber and secondly, in the event of a flood the timber itself may be washed downstream to jam against the bridges (Figure 1, grid ref. 1608). Such a log jam could cause the river to back-up and flood large areas. Furthermore, should such a log jam collapse, the resultant water release could be catastrophic to The Island and its environs. It is for these reasons that it is recommended that no extensions to the pole-treatment yard should be permitted and efforts should be made to relocate the plant on high ground away from any threat of flooding.

The elevated chromium levels and the occasional build-up of coliform bacteria, in the river and estuary have caused pollution (section 3.2.6). Thus, as mentioned above, the Pasveer ditch and the timber-treatment works appear to be the main potential sources of pollution at present. Another potential hazard is oil pollution from the sea, such as occurred after the *Venpet/Venoil* collision in 1977 (section 3.2.6). Oil exploration is currently taking place off the Southern Cape coast and should commercially exploitable finds be made, a greater oil pollution hazard might be created.

The Great Brak Municipality proposes to locate a caravan park on the northern side of the road embankment (Figure 1, grid ref. 1507) (JT Olivier, Town Clerk of Great Brak, pers. comm.). Provided that the fixed structures, such as office and ablution blocks, are placed on the southern side of the site away from the water's edge they are unlikely to be damaged by minor floods. However, extensive capilal development at such a site should be avoided.

The erosion of the seaward side of The Island is currently the most serious problem affecting the Great Brak Estuary. The Island, sandy and low-lying (section 3.2.1) is occupied by a development of 90 houses. The western and northwestern portions of The Island have been surrounded by a sea-wall (Figure 1, grid refs. 2108 - 2110) in an attempt to prevent damage by river and tidal scour. The northeastern and eastern shoreline is gently graded and stabilized by vegetation (grasses). The problem is confined to the southern, seaward-facing shore where considerable erosion takes place on occasions. A number of factors contribute to this erosion including: reduction of river flow hence less scouring of the northern channel; constriction of the northern channel by the access bridge and its approaches (Figure 1, grid refs. 2010, 2110) and input of sand (windblown) into the northern channel from the dune environment (Hersham housing scheme) on the cliffs to the east. The result of the shallowing of the northern channel is that when the water level in the estuary is high (due either to floods or to spring tides) the bulk of the outflowing water passes to the south of The Island rather than through the northern channel. The effect has been to erode the shoreline so that homeowners on the seaward side of The Island have been forced to build shore protection structures which have had limited success. *Ad hoc* efforts to protect the south shore may be effective in the short-term. An intensive hydraulic model study would be required to determine whether the erosion will continue or whether a new low-water flow equilibrium will be established. Such a study would be costly and is beyond the means of the homeowners on The Island.

The embankment for the new paired freeway, without provision of adequate culverts for the disposal of floodwaters, could have a number of consequences. First, the ability of the floodplain of the lower Great Brak Estuary to absorb and disperse floodwaters, has been substantially reduced. Secondly, should any blockage of the channel under the bridge take place, e.g. by logs from the timber processing works, a serious situation could arise. As the embankments for the western approaches of the freeway, the national road and the railway line occupy a large area, the importance of retaining the flood-absorbing capabilities of the remaining portions of the floodplain is strongly emphasised. It is thus undesirable that any further developments on the floodplain be permitted and if possible, the timber treatment plant be relocated away from the floodplain.

The Great Brak Estuary has been endowed with great scenic beauty and recreational potential. Should these features be lost because of ill-conceived developments, it is unlikely that industrial activity could compensate for the loss of income from the tourist trade or residential development. Loss of aesthetic attraction and ecological viability would certainly lead to reduction in the value of existing capital investments and the quality of life in the area.

The Great Brak Estuary and environs thus offer a great challenge for progressive development with the needs of existing industries and residential areas having to be catered for, while making full allowance for the expansion of tourism and recreation which are likely to become the greatest economic asset of Great Brak.

6. ACKNOWLEDGEMENTS

Thanks are due to the following persons, institutions and organizations for the information and assistance received during the compilation of this report:
Great Brak River: Mr WMS Franklin, former Managing Director, Searles Limited; Mr R Searle; Mr BF Puchert, Managing Director, Searles Limited; Mr W Jonker, Company Engineer, Searles Limited; Dr HJK Alheit, Mayor of Great Brak; Mr JT Olivier, Town Clerk, Great Brak; Mr van Rensburg, former Town Clerk, Great Brak; Mrs Douglas, Great Brak River Museum. Mossel Bay Municipality: Mr Collen, Town Engineer. Department of Agriculture: Mr Blomerus, Chief Extension Officer, Outeniqua Experimental Farm. Directorate of Forestry: Mr van Rijn, Government Forester, Jonkersberg Plantation. Cape Department of Nature and Environmental Conservation: Messrs AL de Villiers and C Gaigher. University of Cape Town: Professor JH Day, Emeritus Professor of Zoology; Mr J Cooper, Percy FitzPatrick Institute of African Ornithology. National Research Institute for Oceanology: Drs GA Eagle and PD Bartlett. Mr and Mrs GL Hunter, Stellenbosch.

The advice and assistance of all members of ECRU is acknowledged.

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

7. GLOSSARY OF TERMS USED IN PART II REPORTS

ABIOTIC: non-living (characteristics).

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

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

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

ANAEROBIC: lacking or devoid of oxygen.

ANOXIC: the condition of not having enough oxygen.

AQUATIC: growing or living in or upon water.

ARCUATE: curved symmetrically like a bow.

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

BATHYMETRY: measurement of depth of a water body.

BENTHIC: bottom-living.

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

BIMODAL: having two peaks.

BIOGENIC: 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 o 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.

References:

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

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

8. REFERENCES

Literature Cited

ASHBY, D.J., HARPER, A. and VAN SCHAIK, C. (1973a). Nearshore wave clinometer data from 1967 to 1972. Stellenbosch. CSIR Report MEW 177, ME 1262. 2pp & 211 tables.

ASHBY, D.J., HARPER, A. and VAN SCHAIK, C. (1973b). Deep sea wave clinometer data from 1967 to 1972. Stellenbosch. CSIR Report MEW 178, ME 1263. 2pp & 191 tables.

BICKERTON, I.B. (1982). Estuaries of the Cape: Part II: Synopses of available information on individual systems. Rep. No. 11. Hartenbos (CMS1). Heydorn, A.E.F. and Grindley, J.R. (eds.). Stellenbosch. CSIR Research Rep. 410. 54pp.

CAPE PROVINCIAL ADMINISTRATION (1973). Cape Coastal Survey. Report No. 2. Section D. Tsitsikamma River to Gouritz River. Cape Town. 142pp.

DAY, J.H. (ed.) (1981). Estuarine ecology with particular reference to southern Africa. Cape Town, A.A. Balkema, 411pp.

EAGLE, G.A., GREENWOOD, P.J., HENNIG, H.F - K.O. and ORREN, M.J. (1979). Preliminary pollution surveys around the south-western Cape coast. Part 1: Mossel Bay. S. Afr. J. Sc. 75: 453-456.

FITZSIMONS, V.F.M. (1962). Snakes of Southern Africa. Cape Town, Purnell, 423pp.

FRANKLIN, M. (1975). The story of Great Brak River. Cape Town, C. Struik, 248pp.

GREIG, J.C., BOYCOTT, R.C. and DE VILLIERS, A.L. (1979). Notes on the elevation of *Rana fasciata montana* (FitzSimons, 1946) to specific rank, and on the identity of *Rana fasciata sensu* (Burchell, 1824) (Anura: Ranidae). Ann. Cape Prov. Mus. (Nat. Hist.) 13(1): 1-30.

HARRIS, J.F.W. (1978). Review of coastal currents in Southern African waters. Pretoria. S. Afr. Natl. Sci. Programmes Rep. 30. 103pp.

HILL, KAPLAN, SCOTT and PARTNERS (1974). The Great Brak River engineering report. Cape Town. 21pp.

HEYDORN, A.E.F. (1979). Overview of present knowledge on South African estuaries and requirements for their management. S. Afr. J. Sci 75 (12): 544-546.

HEYDORN, A.E.F. and TINLEY, K.L. (1980). Estuaries of the Cape. Part I. Synopsis of the Cape coast. Natural features, dynamics and utilization. Stellenbosch. CSIR Research Report 380. 96pp.

LOW SIMPSON and ASSOCIATES (1973). The Great Brak River preliminary report. Cape Town. 68pp.

MALLOWS LOUW HOFFE and ORME (1981). Great Brak River development plan. Cape Town. 58pp.

MIDGLEY, D.C. and PITMAN, W.V. (1969). Surface water resources of South Africa. Report no 2/69. Hydrological research unit. Univ. of Witwatersrand. 127pp.

MOLDAN, A., CHAPMAN, P. and FOURIE, H.O. (1979). Some ecological effects of the Venpet-Venoil collision. Marine pollution bulletin 10: 60-63.

NOBLE, R.G. and HEMENS, J. (1978). Inland water ecosystems in South Africa - a review of research needs. Pretoria. S. Afr. Natl. Sci. Programmes Rep. 34. 150pp.

POYNTON, J.C. (1964). The Amphibia of Southern Africa: a faunal study. Ann. Natal Mus. 17: 1-334.

RIVER FLOW DATA, monthly summaries October 1960 to September 1970 (1978). Dept. Water Affairs. Division of hydrology. Pretoria. Hydrological information publication no. 10. 338pp.

SALES, P. (1977). Silting problems in the Great Brak River. Hons. Project. Dept. Town and Regional Planning, Univ. of Cape Town.

SCHULZE, B.R. (1965). Climate of South Africa. Part 8. General survey. Pretoria. Weather Bureau Publication 28. 330pp.

SOUTH AFRICAN TIDE TABLES (1981). Tokai. C.P. The hydrographer. South African Navy. 260pp.

STAUTH, R.B. (1982). The Great Brak River Case Study. Research Report No 34. School of Environmental Studies, University of Cape Town. 119pp.

STUART, C.T., LLOYD, P.H. and HERSELMAN, J.C. (1980). Preliminary distribution maps of mammals of the Cape Province (excluding Cetacea) C.P.A. Dept. Nature and Environmental Conservation. (Unpublished Research Report): Mammals. 176pp.

SUMMERS, R.W., PRINGLE, J.S. and COOPER, J. (1976). The status of coastal waders in the South Western Cape, South Africa. Western Cape Wader Study Group. 162pp.

SWART, D.H. and SERDYN, J. de V. (1981). Statistical analysis of visually observed wave data from voluntary observing ships (VOS) for the South African coast. Stellenbosch. CSIR Report Series T/... (unpublished).

UNDERHILL, L.G., COOPER, J. and WALTNER, M. (1979). The status of waders (Charadrii) and other birds in the coastal region of the Southern and Eastern Cape, Summer 1978/79. Western Cape Wader Study Group. 248pp.

WATLING, R.J. and WATLING, H.R. (1980). Metal surveys in South African estuaries. III Hartenbos, Little Brak and Great Brak Rivers. Pretoria. CSIR Special Report FIS 205. 44p.

Maps

SOUTH AFRICA 1:10 000 Orthomap 3422 AA 10. Die Eiland, 1st Edition. Mowbray. Director General of Surveys. 1975.

SOUTH AFRICA 1:50 000 Sheet 3422 AA Mosselbaai, 1st edition. Pretoria. Government Printer. 1977.

SOUTH AFRICA. 1:250 000 Sheet 3322 Oudtshoorn, 2nd edition. Pretoria. Government Printer. 1973.

SOUTH AFRICA 1:250 000 Topocadastral Sheet 3322 Oudtshoorn. 1st edition. Pretoria. Government Printer. 1960.

SOUTH AFRICA 1:250 000 Geological Series 3322 Oudtshoorn. Pretoria. Government Printer. 1979.

SOUTH AFRICAN NAVY 1:150 000 Chart SAN 122. Youngsfield, Cape. The Hydrographer. 1975.

SOUTH AFRICAN NAVY 1:150 000 Chart SAN 123. Youngsfield, Cape. The Hydrographer. 1976.

CAPE COAST RECREATIONAL LAND USE CLASSIFICATION 1:50 000 (Cape Town. Cape Provincial Administration). (no date) 38pp bound.

Aerial Photography

{GROOT BRAK ESTUARY}. Bl. & Wh. Job No. 140 39, Photos Nos. 34297-99. Trig. Survey, Mowbray. 1:20 000, 1940.

{GROOT BRAK ESTUARY}. Bl. & Wh. Job No. 403, Photo No. 4035. Trig. Survey, Mowbray. 1:30 000, 1957.

{GROOT BRAK ESTUARY}. Bl. & Wh. Job No. 492, Photo No. 347. Trig. Survey, Mowbray. 1:30 000, 1963.

{GROOT BRAK ESTUARY}. Bl. & Wh. Job No. 621, Photos Nos 1011-13, Trig. Survey, Mowbray. 1:36 000, 1968.

{GROOT BRAK ESTUARY}. Bl. & Wh. Job No. 736, Photo No. 0996. Trig. Survey, Mowbray. 1:60 000, 1974.

{GROOT BRAK ESTUARY}. Colour. Job No. 326, Photos Nos 371-74. Dept. Land Surveying, Univ. of Natal. 1:10 000, 1979.

{GROOT BRAK ESTUARY}. Bl. & Wh. Job No. 349, Photo No. 26. Dept Land Surveying. Univ. of Natal. 1:10 000, 1980.

{GROOT BRAK ESTUARY}. Bl. & Wh. Job No. 374, Photos Nos. 208-9. Dept. Land Surveying, Univ. of Natal. 1:20 000, 1980.

{GROOT BRAK ESTUARY}. Colour. Job No. 391, Photos Nos. 301/3-303/3. Dept. Land Surveying, Univ. of Natal. 1:20 000, 1981.

APPENDIX I: Species composition and physical features of the vegetation mapping units of the area studied at the Great Brak Estuary.

Mapping Unit	+Area (ha)	% of area studied	Cover (%)	Average Height (m)
Sarcocornia pillansiae/ Sarcocornia cf *capensis* Salt Marsh	2,59	0,96	70	0,15
Cotula coronopifolia/ Triglochin bulbosa Salt Marsh	5,36	2,00	20	0,05
Stenotaphrum secundatum/ Sarcocornia pillansiae Dry Salt Marsh	32,24	12,00	40	0,30
Phragmites australis/ Stenotaphrum secundatum Reed Swamps	4,34	1,62	70	1,75
Hummock Dune Vegetation	2,17	0,81	5	0,40
Sideroxylon inerme/ Rhus lucida Dune Forest	14,08	5,24	100	2,50
Acacia cyclops	5,45	2,03	75	2,00
Drosanthemum sp. (Parsons 406/*Salicornia meyerana* Littoral Scrub	9,50	3,54	80	0,40
Heathland	4,20	1,56	40	1,00
Shrubland	2,40	0,89	75	1,00
Maytenus heterophylla/ Diospyros dichrophylla Woodland	2,56	0,95	95	1,50
Acacia Dominated Communities	6,92	2,58	80	1,50
Water	38,46	14,31		
Sand	30,93	11,51		
Rocks	0,28	0,10		
Extensive Human Disturbance	107,18	39,89		
Total	286,66			

(+estimated values)

APPENDIX I: (Cont.)

Sarcocornia pillansiae/Sarcocornia cf *capensis* Salt Marsh

Chenolea diffusa (r); *Cotula coronopifolia* (r); *Cynodon dactylon* (+); *Disphyma crassifolia* (+); *Sarcocornia* cf *capensis* (2); *S. pillansiae* (2); *Spergularia marginata* (r); *Sporobolus virginicus* (1); *Stenotaphrum secundatum* (1); *Triglochin bulbosa* (r).

Cotula coronopifolia/Triglochin bulbosa Salt Marsh

Cotula coronopifolia (1); *Cynodon dactylon* (1); *Juncus kraussii* (r); *Sarcocornia* cf *capensis* (+); *Triglochin bulbosa* (1).

Stenotaphrum secundatum/Sarcocornia pillansiae Salt Marsh

Acacia cyclops (+); *Chenolea diffusa* (+); *Cotula coronopifolia* (r); *Cynodon dactylon* (1); *Disphyma crassifolia* (1); *Limosella aquatica* (r); *Sarcocornia pillansiae* (2); *Senecio rosmarinifolius* (+); *Sporobolus virginicus* (+); *Stenotaphrum secundatum* (3).

Phragmites australis/Stenotaphrum secundatum Reed Swamp

Cyperaceae (Parsons 474) (r); *Phragmites australis* (3); *Stenotaphrum secundatum* (5).

Hummock Dune Vegetation

Agropyron distichum (1); *Ammophila arenaria* (1); *Arctotheca populifolia* (+); *Cassine aetheopica* (+); *Crassula* sp. (Parsons 374) (+); *Ficinia lateralis* (r); *Gazania rigens* (+); *Gladiolus guenzii* (+); *Heteroptilis suffruticosum* (+); *Lampranthus antemeridianus* (r); *Limonium scabrum* (r); *Metalasia muricata* (r); *Myrica cordifolia* (+); *Passerina paludosa* (+); *Scaevola thunbergii* (+); *Senecio elegans* (+); *Sutera penduncu1ata* (r); *Tetragonia decumbens* (+).

Also found on the older dunes:

Acacia cyclops (1); *Carpobrotus edulis* (+); *Chrysanthemoides monolifera* (+); *Haplocarta lyrota* (+); *Silene crassifolium* (+); *Sutherlandia frutescens* (+).

Sideroxylon inerme/Rhus lucida Dune Forest

Acacia cyclops (1); *Asparagus africanus* (1); *Carissa bisponsa* (2); *Cassine tetragona* (1); *Chenolea diffusa* (+); *Chrysanthemoides monolifera* (1); *Cussonia thyrsiflora* (2); *Diospyros dichrophylla* (+); *Euphorbia erythrina* (+); *Grewia occidentalis* (+); *Pelargonium peltatum* (+); *Rapanea melanophleos* (+); *Rhus laevigata* (+); *R. lucida* (3); *Scolopia zeyheri* (1); *Sideroxylon inerme* (3); *Solanum rigescens* (+); *Zygophyllum morgsana* (+).

Also found on dune to west of river:

Capparis citrifolia (1); *Hypoestis aristata* (+); *Rhoicissus digitata* (1).

Acacia cyclops

Acacia cyclops (5).

APPENDIX I: (Cont.)

Drosanthenum sp. (Parsons 406)/*Salicornia meyerana* Littoral Scrub

Acacia cyclops (2); *A. mearnsii* (+); *Chrysocoma tenuifolia* (+); *Carpobrotus edulis* (+); *Cotula coronopifolia* (+); *C. heterocarpa* (+); *Cynodon dactylon* (2); *Drosanthenum* sp. (Parsons 406) (4); *Disphyma crassifolia* (r); *Elytropappus rhinocerotis* (r); *Ficinia littoralis* (+); *Helichrysum teretifolium* (+); *Hypoxis* cf *villosa* (+); *Juncus kraussii* (+); *Limosella aquatica* (r); *Lycium afrum* (+); *Pelargonium* sp. (Parsons 484) (+); *Polypogon monspeliensis* (r); *Pseudognaphalium undulatum* (1); *Relhania genestifolia* (+); *Rhus lucida* (1); *Salicornia meyerana* (3); *Setaria verticillata* (+); *Sonchus asper* (+); *S. oleraceus* (+); *Sporobolus* sp. (Parsons 483) (+); *Stenotaphrum secundatum* (+); *Typha capensis* (+).

Heathland

Aloe ferox (+); *Bobartia orientalis* subsp. *orientalis* (+); *Colpoon compressum* (+); *Diospyros dichrophylla* (r); *Elytropappus rhinocerotis* (1); *Erica* sp. (Parsons 411) (2); *Ficinia* cf *gracilis* (+); *Eriocephalus africanus* (+); *Hakea sericea* (+); *Helichrysum paniculatum* (+); *H. teretifolium* (+); *Hyparrhenia hirta* (1); *Metelasia* sp. (Parsons 433) (1); *Passerina vulgaris* (1); *Phylica purpurea* (1); *Polygala myrtiflora* (+); *Psoralea* sp. (Parsons 415) (1); *Restio* cf *fruticosus* (r); *Restio triflorus* (1); *Thamnochortus pluristachys* (r); *Ursinia heterodonta* (+).

Shrubland

Aspalathus millefolia (+); *A. nigra* (r); *Athrixia capensis* (+); *Bobartia orientalis* sub sp. *orientalis* (+); *Chrysanthemoides monolifera* (+); *Cliffortia arcuata* (+); *Commelina africana* (r); *Corymbium* sp. (Parsons 455) (r); *Crassula subulata* (+); *Cullumia aculeata* var *aculeata* (+); *Cymbopogon plurinodus* (+); *Erica glumaeflora* (+); *E. imbricata* (r); *E. parviflora* (+); *E. versicolor* (+); *Erica* sp. (Parsons 411) (1); (Parsons 446) (1); Parsons 447) (+); (Parsons 457) (+); *Eriocephalus africanus* (2); *Eroeda capensis* (1); *Ficinia* cf *capilifolia* (+); *Helichrysum crispum* (+); *H. paniculatum* (+); *H. teretifolium* (+); *Helichrysum* sp. (Parsons 468) (2); *Leptocarpus* cf *burchellii* (1); *Leucodendron salignum* (+); *Lobelia coronopifolia* (+); *Metalasia* sp. (Parsons 433) (+); (Parsons 445) (+); *Ornithagalum dubium* (+); *Plagiochloa uniolae* (r); *Relhania pungens* (1); *Restio cuspidatus* (+); *R. fruticosa* (+); *R.* cf *patens* (+); *Satyrium* sp. (Parsons 427) (+); *Scabiosa columbaria* (+); *Thamnochortus* cf *pluristachys* (+); *Themeda triandra* (+); *Veronia capensis* (+).

Maytenus heterophylla/biospyros dichrophylla Woodland

Acacia cyclops (+); *Anthospermum aethiopicum* (1); *Anthospermum* sp. (Parsons 357) (1); *Asparagus* sp (+); *Bobartia orientalis* sub sp. *orientalis* (r); *Carissa bispinosa* (+); *Cassine aethiopica* (1); *Commelina africana* (1); *Crassula subulata* (+); *Cyanella lutea* (+); *Diospyros dichrophylla* (2); *Ehrharta delicatula* (1); *Elytropappus rhinocerotis* (+); *Eragrostis curvula* (1); *Erica* sp. (Parsons 411) (1); *Eustachys paspaloides* (1); *Grewia occidentalis* (r); *Haplocarta lyrota* (+); *Helichrysum* sp. (Parsons 362) (+); *Maytenus heterophylla* (1); *Monsonia emarginata* (+); *Nemesia versicolor* (+); *Passerina rubra* (1); *Pelargonium odoratissimum* (r); *Polypogon monspeliensis* (1); *Rhus lucida* (1); *Rhoicissus digitata* (+); *Sebaea aurea* (+); *Setaria verticillata* (+); *Sonchus oleraceus* (+); *Sporobolus virginicus* (1); *Stachys graciliflora* (+); *Tephrosia* sp. (Parsons 367) (+); *Themeda triandra* (+).

APPENDIX I: (Cont.)

Acacia Dominated Communities

Acacia cyclops (2); *A. karroo* (+); *A. mearnsii* (1); *Aloe arborescens* (r); *Anagillis arvensis* (+); *Briza minor* (r); *Budleia saligna* (r); *Carpobrotus edulis* (r); *Conyza scabrida* (+); *Datura stramonium* (+); *Disphyma crassifolia* (1); cf *Exomis microphylla* (2); *Juncus kraussi* (r); *Lepidium africanum* (+); *Lycium afrum* (1); *Nemesia versicolor* (+); *Oxalis pes-caprae* (1); *Phytolacca octandra* (r); *Pseudognaphalium undulatum* (+); *Rhoicissus digitata* (r); *Rhus glauca* (1); *Ruschia tenella* (+); *Scirpus littoralis* (r); *Senecio elegans* (r); *Stenotaphrum secundatum* (2); *Sonchus asper* (+); *S. oleraceus* (1); *Ursinia* sp. (Parsons 476) (+); *Zantedeschia aetheopica* (r).

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% of area
\+ - occasional plants, cover less than 1% of area
1 - abundant, cover 1 - 5% of area
2 - any number, cover 6 - 25% of area
3 - any number, cover 26 - 50% of area
4 - any number, cover 52 - 75% of area
5 - any number, cover 76 - 100% of area.

APPENDIX II: Zooplankton recorded from the Great Brak Estuary by Prof JR Grindley (Unpublished information)

PROTOZOA
Foraminiferan sp.

NEMATODA
Nematode sp.

POLYCHAETA
Polychaete larvae

OSTRACODA
Ostracod spp.

COPEPODA
Acartia natalensis
Halicyclops sp.
Harpacticoid
Harpacticus sp.
Pseudodiaptomus nessei
Tegastes sp.

CIRRIPEDIA
Nauplius larvae
Cypris larvae

APPENDIX II: (Cont.)

MYSIDACEA
Gastrosaccus brevifissura
Mesopodopsis africana
Rhopalopthalamus terranatalis

CUMACEA
Iphinoe truncata

AMPHIPODA
Austrochiltonia subtenuis
Corophium sp.

DECAPODA
Crab zoaea larvae
Palaemon pacificus

MOLLUSCA
Lamellibranch larvae

PISCES
Fish eggs
Fish larvae

APPENDIX III: Invertebrate species recorded from the Great Brak River Estuary.

Sources: JH Day *in litt.* and C Gaigher *in litt.*

1. On sand or sandy mud substrate

Common name		Scientific name
Bristle worms	-	*Polychaete* worms
Isopods	-	*Pontogeloides latipes* and other spp.
Isopod	-	*Pseudosphaeroma barnardi*
Isopod	-	*Exosphaeroma hylecoetes*
Amphipod	-	*Urothoe* sp.
Sand shrimp	-	*Palaemon pacificus*
Indian or white prawn	-	*Penaeus indicus*
Common hermit crab	-	*Diogenes brevirostris*
Sand prawn	-	*Callianassa kraussi*
Mud prawn	-	*Upogebia africana*
Crown crab	-	*Hymenosoma orbiculare*
Shore crab	-	*Cyclograpsus punctatus*
Marsh crab	-	*Sesarma catenata*
Three-spot swimming crab	-	*Ovalipes punctatus*
Crab	-	*Cleistostoma edwardsii*
Small mussel	-	*Tellina* sp.
Freshwater mussel	-	*Musculus virgiliae*
Burrowing mussel	-	*Eumarcia paupercula*
Razor shell/pencil bait	-	*Solen capensis*
Burrowing clam	-	*Loripes clausus*
Beach whelk	-	*Bullia* sp.
Necklace shell	-	*Natica ? genuana*

APPENDIX III: (Cont.)

Common name		Scientific name
Mud winkle	-	*Assiminea orata*
Mud whelk	-	*Nassa kraussiana*
Sea heart urchin	-	*Echinocardium cordatum*

2. In *Zostera* and *Caulerpa* beds

Common name		Scientific name
Isopod	-	*Exosphaeroma hylocoetes*
Sand shrimp	-	*Palaemon pacificus*
Indian prawn	-	*Penaeus indicus*
Pistol/cracker shrimp	-	*Alpheus crassimanus*
Broken-backed shrimp	-	*Hippolyte kraussiana*
Common hermit crab	-	*Diogenes brevirostris*
Mud prawn	-	*Upogebia africana*
Marsh crab	-	*Sesarma catenata*
Bivalve mollusc	-	*Psammotellina capensis*
Burrowing mussel	-	*Eumarcia paupercula*
Mud whelk	-	*Nassa kraussiana*
Necklace shell	-	*Natica* sp.
Sea-hare	-	*Notarchus leachi*

3. On rocks, pilings and other hard substrates

Common name		Scientific name
Tube worm	-	*Mercierella enigmata*
Barnacle	-	*Balanus amphitrite*
Isopod	-	*Ligia* sp.
Oyster	-	*Ostrea* sp.
Shipworm	-	*Teredo* sp. (holes only)
Limpet	-	*Siphonaria* sp.
Black periwinkle	-	*Littorina knysnaensis*
Variegated periwinkle	-	*Oxystele variegata*
Mud winkle	-	*Assiminea orata*

APPENDIX IV: Marine fish species recorded at Great Brak River Estuary.

Sources: JH Day *in litt.* and C Gaigher *in litt.*

Common name		Scientific name
Stumpnose	-	*Rhabdosargus holubi*
Groovy mullet	-	*Liza dumerili*
Southern mullet	-	*Liza richardsoni*
Flathead mullet	-	*Mugil cephalus*
Cape moony	-	*Monodactylus falciformis*
Bareheaded goby	-	*Gobius nudiceps*
Knysna sandgoby	-	*Psammogobius knysnaensis*
White steenbras	-	*Lithognathus lithognathus*
Sandsole	-	*Solea bleekeri*
Estuarine round-herring	-	*Gilchristella aestuarius*
Longnose pipefish	-	*Syngnathus acus*
Spot damsel	-	*Abudefduf sordidus*

APPENDIX V: A checklist of amphibians and reptiles (excluding lizards) recorded for the area covered by the 1:50 000 topographic sheet 3422 AA Mosselbaai (AL de Villiers, *in litt.*)

Amphibians: Records from Poynton (1964) and Greig, Boycott and De Villiers (1979)

Common name		Scientific name
Sand toad	-	*Bufo angusticeps*
Raucous toad	-	*Bufo rangeri*
Cape sand frog	-	*Tomopterna delalandii*
Cape river frog	-	*Rana fuscigula*
Striped grass frog	-	*Rana fasciata*
Spotted rana	-	*Rana grayii*
Common caco	-	*Cacosternum boettgeri*
Bronze caco	-	*Cacosternum nanum*

Tortoises: Records from Greig and Burdett (1979)

Common name		Scientific name
Angulated tortoise	-	*Chersina angulata*
Padlopertjie or Parrot's-beak tortoise	-	*Homopus areolatus*

Snakes: Records from FitzSimons (1962)

Common name		Scientific name
Brown house snake	-	*Boaedon fuliginosus*
Natal green snake	-	*Philothamnus natalensis*
Southern shovel-snout	-	*Prosymna sundevalli*
Herald snake	-	*Crotaphopeltis hotamboeia*
Rhombic skaapsteker	-	*Psammophylax rhombeatus*
Cross-marked grass snake	-	*Psammophis crucifer*
Southern dwarf garter snake	-	*Elaps lacteus*
Cape cobra	-	*Naja nivea*

APPENDIX VI: A. Bird counts at Great Brak River

Roberts Number	Species Common Name	Summers, Pringle & Cooper (1976) Waders only	Underhill, Cooper & Waltner (1980)	J Cooper *in litt.*	ECRU survey (JRG) 81-11-11	ECRU survey (IBB) 81-11-12
47	White-breasted Cormorant	-	-	1	6	6
50	Reed Cormorant	-	-	1	4	-
55	Black-headed Heron	-	-	1	1	-
59	Little Egret	-	-	1	-	-
96	Yellow-billed Duck	-	-	-	2	1
97	Red-billed Teal	-	-	-	-	4
231	Black Oystercatcher	1	-	-	2	-
232	Turnstone	1	2	-	-	-
233	Ringed Plover	40	6	5	-	4
235	White-fronted Sandplover	6	11	33	2	-
236	Chestnut-banded Sandplover	3	-	-	-	-
237	Kittlitz's Sandplover	2	-	3	-	-
238	Three-banded Sandplover	1	-	2	1	-
241	Grey Plover	6	15	-	-	-
245	Blacksmith Plover	2	-	-	-	6
251	Curlew Sandpiper	15	8	-	2	-
253	Little Stint	9	-	-	-	-
255	Sanderling	13	6	-	-	-
257	Terek Sandpiper	1	-	-	-	-
258	Common Sandpiper	8	4	6	-	6
263	Greenshank	14	17	2	8	1
268	Whimbrel	1	4	4	1	-
270	Stilt	4	-	-	-	-
287	Kelp Gull	-	3	44	3	-
290	Caspian Tern	-	-	1	-	-
291	Common Tern)	-	-		-	-
	) "Comic" Tern			1		
294	Arctic Tern)	-	-		-	-
296	Sandwich Tern	-	2	16	-	-
394	Pied Kingfisher	-	-	1	-	7
686	Cape Wagtail	-	7	4	8	1

B. Other bird species recorded in the environs of Great Brak River (ECRU Survey, November 1981)

Roberts Number	Common name
130	Black-shouldered Kite
152	Jackal Buzzard
311	Rock Pigeon
316	Cape Turtle Dove
493	European Swallow
502	Greater Striped Swallow
509	African Sand Martin
517	Fork-tailed Drongo
551	Sombre Bulbul
733	European Starling
745	Red-winged Starling
786	Cape Sparrow
808	Red Bishop
846	Pin-tailed Whydah

APPENDIX VII: Mammals: the following species, likely to occur in the environs of the Great Brak River, have been extracted from the list of mammals recorded by Stuart *et al.* (1980) for the area covered by the 1:50 000 topographic sheet 3422AA Mosselbaai

Common name		Scientific name
Horse-shoe bat	-	*Rhinolophus capensis*
Chacma baboon	-	*Papio ursinus*
Cape greater gerbil	-	*Tatera afra*
Cape pouched mouse	-	*Saccostomys campestris*
Striped mouse	-	*Rhabdomys pumilio*
Brown rat	-	*Rattus norvegicus*
Black rat	-	*Rattus rattus*
Cape dune molerat	-	*Bathyergus suillus*
Honey badger (Ratel)	-	*Mellivora capensis*
Cape grey mongoose	-	*Herpestes pulverulentus*
African wild cat	-	*Felis libyca*
Leopard	-	*Panthera pardus*

APPENDIX VIII: Guide to available information.

ESTUARY / RIVERMOUTH / LAGOON: GREAT BRAK (Estuary)

Guide to available information		Sources of information:	Ashby *et al*	Ashby *et al*	Bickerton	Cape Provincial Administration	Day	Eagle	FitzSimons	Franklin	Greig *et al*	Harris	Hill Kaplan Scott	Heydorn	Heydorn & Tinley	Low Simpson	Mallows *et al*	Midgley & Pitman	Moldan	Noble & Hemens
YEAR (DATE OF INFORMATION)			1973a	1973b	1982	1973	1981	1979	1962	1975	1979	1978	1974	1979	1980	1973	1981	1969	1973	1978
MANAGE-MENT		Historical								*										
		Conservation/Utilization				*								*	*	*	*			
		Management/Planning				*								*	*	*	*			
		Legislation																		
		Water																		
BIOTIC		Food webs/Ecosystems																		
	Fauna	Mammals																		
		Birds																		
		Reptiles							*											
		Amphibians									*									
		Fish																		
		Molluscs																		
		Crustaceans					*												*	
		Other aquatic invertebrates																	*	
		Terrestrial invertebrates																		
		Zooplankton																		
	Flora	Terrestrial vegetation																		
		Semi-aquatic vegetation																		
		Aquatic vegetation																		
		Algae																		
		Phytoplankton																		
		Microbiology																		
ABIOTIC	Chemistry	Pollution					*	*											*	
		Eutrophication																		
		General Chemistry			*															
		Salinity																		
	Physics	Circulation and mixing																		
		Hydrology / Flood regime											*					*		
		Oceanography	*	*								*								
		Climate																		
	Geology	Sedimentology																		
		Palaeoenvironment																		
		Geology																		
	Physio-graphy	Morphology																		
		Dams/Obstructions																		
		Catchment characteristics																		*

APPENDIX VIII (Cont.)

ESTUARY / RIVERMOUTH / LAGOON: GREAT BRAK (Estuary)

Guide to available information

		Sources of information	Poynton	River Flow Data	Sales	Schulze	South African Tide Tables	Stauth	Stuart *et al*	Summers *et al*	Swart & Serdyn	Underhill *et al*	Watling & Watling
MANAGEMENT		Historical											
		Conservation/Utilization						*					
		Management/Planning						*					
		Legislation											
		Water											
BIOTIC		Food webs/Ecosystems											
	Fauna	Mammals							*				
		Birds								*		*	
		Reptiles											
		Amphibians	*										
		Fish											
		Molluscs											
		Crustaceans											
		Other aquatic invertebrates											
		Terrestrial invertebrates											
		Zooplankton											
	Flora	Terrestrial vegetation											
		Semi-aquatic vegetation											
		Aquatic vegetation											
		Algae											
		Phytoplankton											
		Microbiology											
ABIOTIC	Chemistry	Pollution											*
		Eutrophication											
		General Chemistry											*
		Salinity											
	Physics	Circulation and mixing											
		Hydrology / Flood regime		*									
		Oceanography					*				*		
		Climate				*							
	Geology	Sedimentology			*								
		Palaeoenvironment											
		Geology											
	Physiography	Morphology											
		Dams/Obstructions											
		Catchment characteristics											
YEAR (DATE OF INFORMATION)			1964	1978	1977	1965	1981	1982	1980	1976	1981	1979	1980

PLATE I:

Aerial view of the Great Brak Estuary. Note the large timber yard on the floodplain, the embanked approaches to National Road bridges and The Island. (ECRU, 83-07-12).

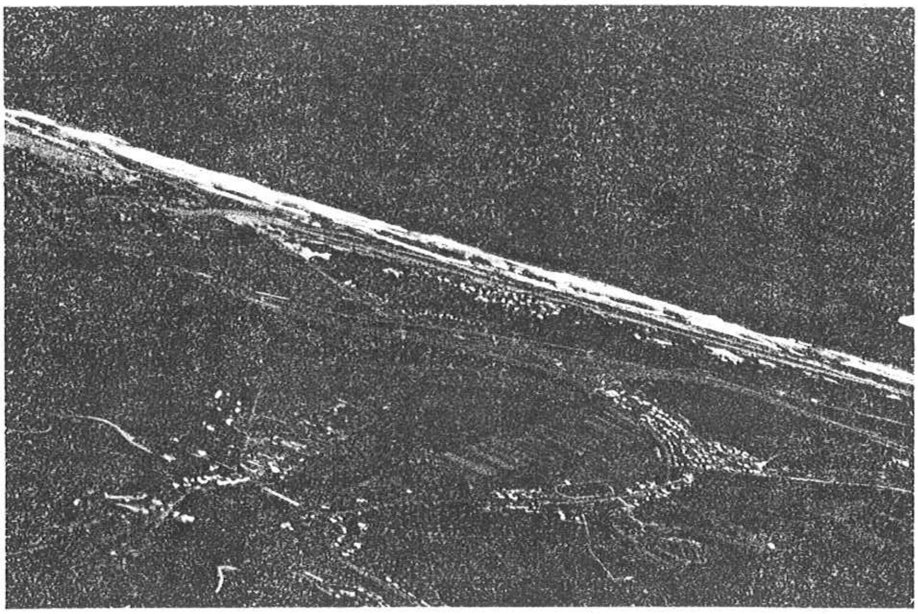


PLATE II:

View south to the National Road bridges (under construction) and the old road bridge. Note the numerous supporting piers which restrict water flow. (ECRU, 81-01-27).

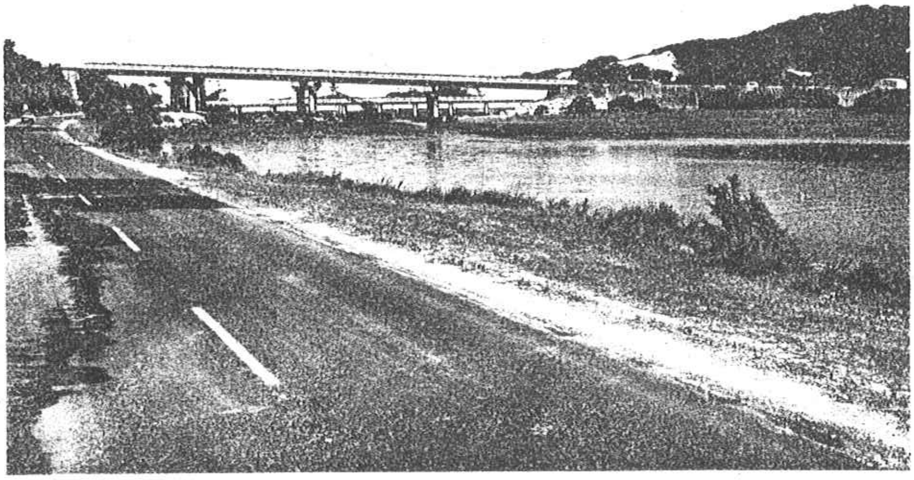


PLATE III:

Erosion of the seaward (south) shore of The Island. The posts provided support for brushwood piled against the shore in an attempt to prevent erosion. (GL Hunter, February 1983).