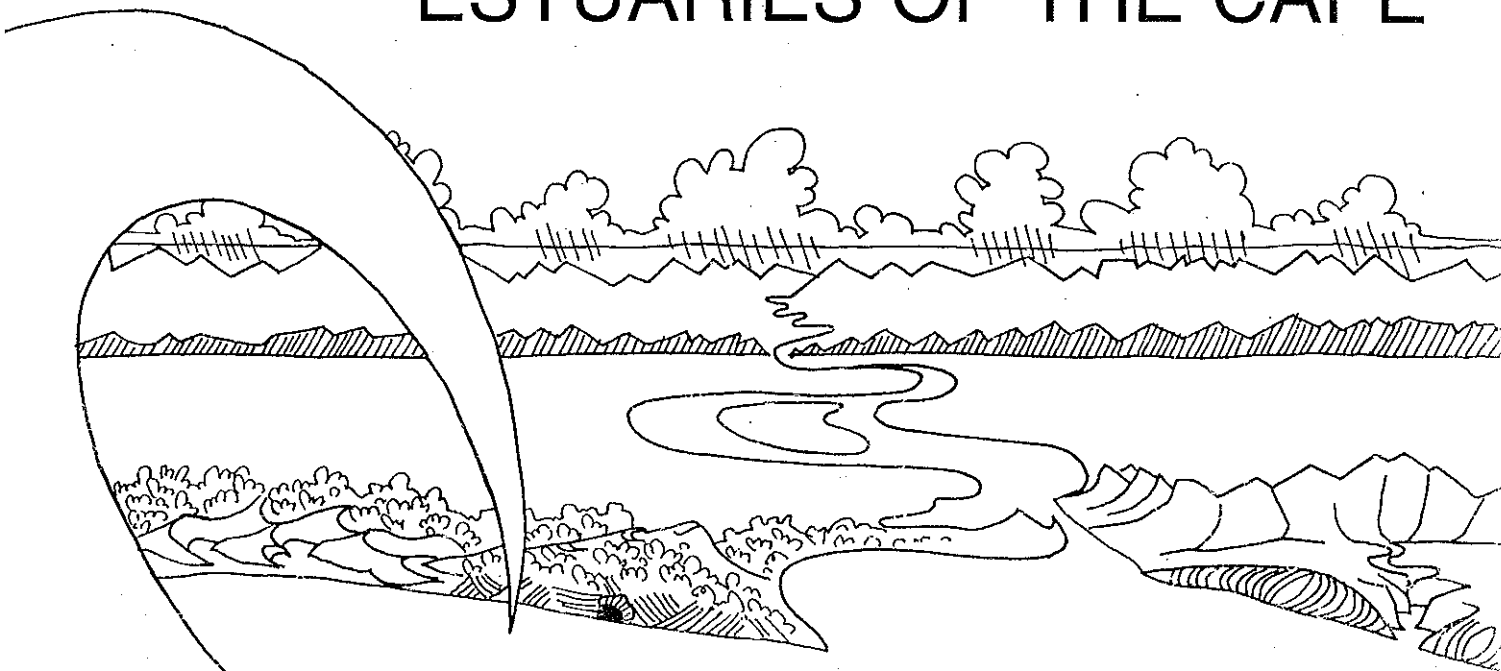


COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT – ECRU



ESTUARIES OF THE CAPE



PART II

SYNOPSIS OF AVAILABLE INFORMATION
ON INDIVIDUAL SYSTEMS

EDITORS: A E F HEYDORN
J R GRINDLEY

REPORT NO. 2

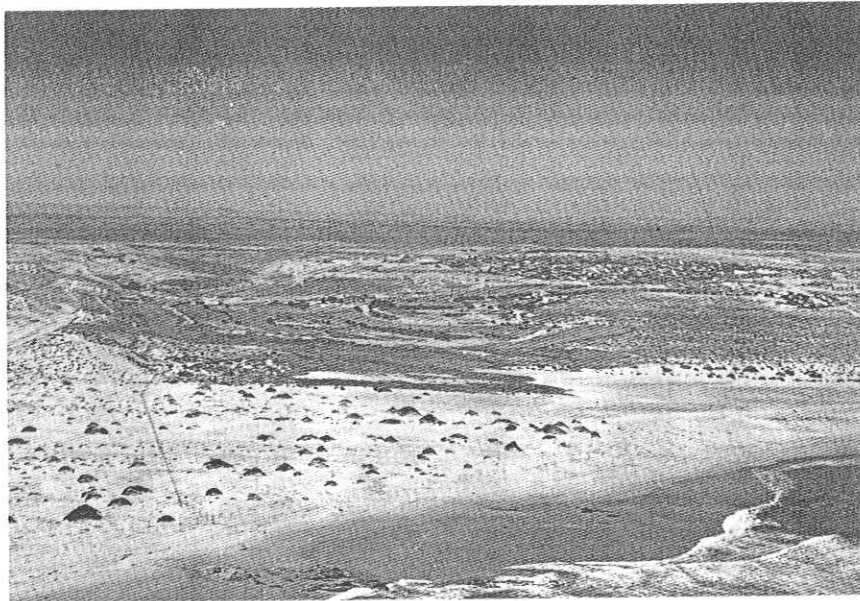
BUFFELS (CW3)

ESTUARIES OF THE CAPE

PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 2: BUFFELS (CW3)

(CW3 – CSIR Estuary Index Number)



FRONTISPIECE: BUFFELS ESTUARY – ALT. 150 m, ECRU 79-08-14

COMPILED BY : T J E HEINECKEN

ECRU SURVEY : 15 OCTOBER 1980
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ESTUARINE AND COASTAL RESEARCH UNIT – ECRU
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Preface :

The Estuarine and Coastal Research Unit (ECRU) was established by the National Research Institute for Oceanology 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 and to stimulate research at Universities, Museums and other institutions to fill these.

The Unit was established at the request of the Government and the Department of Water Affairs, Forestry and Environmental Conservation 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 interests in the systems concerned. One of these is Prof J R Grindley of the University of Cape Town who is co-editor of the Part II series.

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



F P Anderson
DIRECTOR

National Research Institute for Oceanology
CSIR

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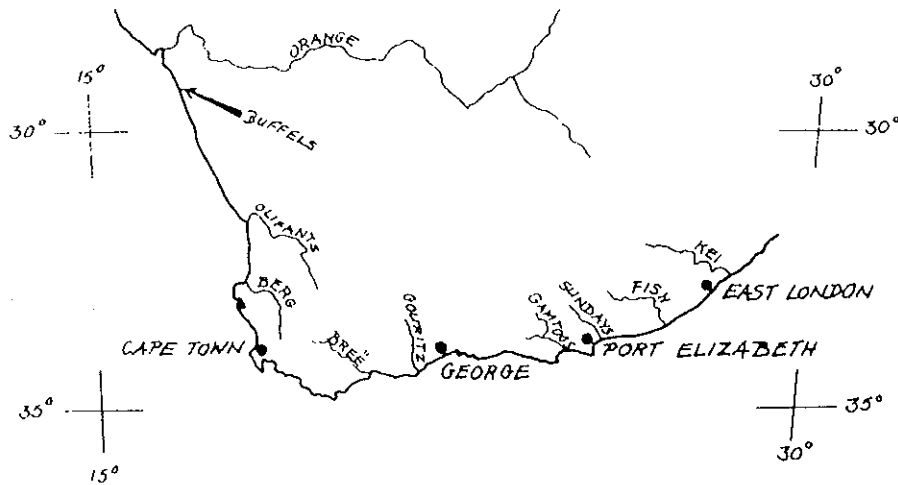
BUFFELS

1. SYNONYMS AND DERIVATIONS

Kleinsee, Kleinzee or Kleynezee. According to local residents of the Kleinsee mining settlement, the name Kleinsee refers to the pan situated behind the dunes at the mouth of the river.

2. LOCATION

The Buffels mouth is located 151 km south of the Orange River at $29^{\circ} 41' S$ and $17^{\circ} 03' E$ (1:50 000 Sheet 2916 DB and 2917 CA)



2.1 Accessibility :

The rivermouth area and the Kleinsee settlement fall within a restricted zone controlled by De Beers Consolidated Diamond Mines (DBCMD) and security clearance from the Kleinsee security branch is required before entering the area. The settlement of Kleinsee is situated c. 100 km west of Springbok and c. 60 km south of Port Nolloth. Both routes are via good gravel roads.

3. ABIOTIC CHARACTERISTICS

3.1 Catchment :

Area

The Buffels River drains the western edge of the Bushmanland plateau north of the Kamiesberg as well as the western slopes of the Bushmanland/Namaqualand escarpment inland of Kleinsee. According to Heydorn and Tinley (1980) the catchment area of the Buffels is 9375 km². Memoranda

from Dept. of Agricultural Technical Services give the catchment area as 330 000 ha (3300 km²) and J.A.H. Marais (1972) records it as being 621 000 ha. (6210 km²).

River length

The Buffels River is 149 km long from the mouth up to where it divides into the Brak and Riembreek rivers.

Tributaries

The two main tributaries of the Buffels are the Brak and Riembreek, with numerous smaller tributaries joining the main stream before it reaches the sea.

Mean annual run-off

This has not been recorded. The catchment falls within the winter rainfall area and episodic floods occur occasionally (Heydorn and Tinley 1980).

J.A.H. Marais (1972) of the O'kiep Copper Company records that the main source of the Buffels River in the Kamiesberg receives an average annual precipitation of 305 millimeters (12 inches). The tributaries from the western "Bushmanland peneplain" receive 102 millimeters (4 inches) and the Springbok mountain tributaries 178 millimeters (7 inches) per annum. He goes on to say that "the Kamieskroon and Springbok sectors of the catchment area fall within the winter rainfall zone, whereas the Bushmanland peneplain enjoys only summer rainfall in the nature of stormy downpours occasionally resulting in torrential flowage of the river". According to Marais as well as Cornelissen (1968) there is a three year rainfall cycle but a steady decline in precipitation appears to have taken place since 1953.

Charts obtained from the Agricultural Technical Services' Extension Officer in Springbok show that the Buffels River source falls within an area with an annual precipitation of 201 - 250 mm / annum decreasing towards the coast which receives only 75 - 100 mm/annum.

3.2

Flow :

Virtually all of the tributaries and the main river will probably only have surface flow after substantial rains have fallen. The possibility exists however that subterranean flow occurs. This contention is supported by the high water table (0.4m) and low salinity (6 parts per thousand) which occurs in a dune slack at the mouth of the river.

During the ECRU survey in October 1980, standing surface water occurred in the pans and narrow channels in the main riverbed near the mouth (Fig. 1 and Table I). This free standing water at the mouth is due to the presence of a large sand-filled reservoir (aquifer) of up to 12 m in depth at the mouth and in the lower section of the river. (A.K. Cornelissen (1968) and J.A.H. Marais (1972)). A similar large subsurface reservoir occurs higher up the river at the base of Spektakelberg. Water is extracted from the Spektakelberg aquifer to supply water to the mines and towns of Nababeep, O'kiep, Carolusberg and Springbok, and from the Kleinsee aquifer to meet the water requirements of the Kleinsee settlement. In 1972 the yield from the Spektakelberg reservoir alone, was 2 266 545 m³/annum (J.A.H. Marais 1972).

The extraction of water from these aquifers has probably affected the overall watertable of the entire Buffels River system. It is likely that this has also resulted in less open water and hence ecological changes at, inter alia, the mouth and in the estuarine area.

According to the local residents of Kleinsee the last recorded flow at the rivermouth occurred during March 1980.

Flood history and level fluctuations

Cornelissen (1968) records that the Buffels River came down in flood in October 1945, April 1961, July 1962 and July 1963. Furthermore local inhabitants maintain that the river used to come down in flood every third year. Big floods "many metres deep" have been experienced by people living near the river and cracked, dried out, flood deposited silt was clearly evident at higher levels of the lower part of the estuary (ECRU Survey). According to Mr L. Benneto of Kleinsee, the river had last come down in flood during 1976 when it destroyed part of the golf course.

3.3

Obstructions :

(a) In the catchment

There are 12 minor road crossings over the river from the national road between Kamieskroon and Springbok down to Grootmis near the mouth (1:250 000 Topographical Sheet 2916). No information could be obtained on other obstructions.

(b) Near the mouth (Fig. 1)

A tarred road from Kleinsee to the mine, crosses the river 1,7 km from the mouth and a large embankment c. 12 m high carries this road. Provision for water throughflow is made by two box culverts of 2,50 x 2,50 m, at present riverbed level. Two culverts of similar dimensions at a higher level were damaged by previous floods (Plate I).

Further downstream towards the mouth, another two roads cross the dry riverbed, 1,1 km and 0,26 km from the mouth respectively. In the first case, inadequate provision is made for flood waters to flow under the road and in the second case no provision is made for any throughflow of water. A leveé of c. 700 m has been constructed in the riverbed to protect the golf course from floods (Plate II, Aerial Photography Job No. 13 of 1942 and Job No. 525 of 1964). This has the effect of preventing the river from spreading over its lower floodplain on which the golf course has been built. This leveé has been breached at times of high flow and it is inevitable that this will happen again.

An old "tailings dump" from the mine, which encroaches significantly on the natural river course is situated on the first major bend in the river, upstream from the mouth but this is being removed by De Beers at present (Fig. 1 and Plate III).

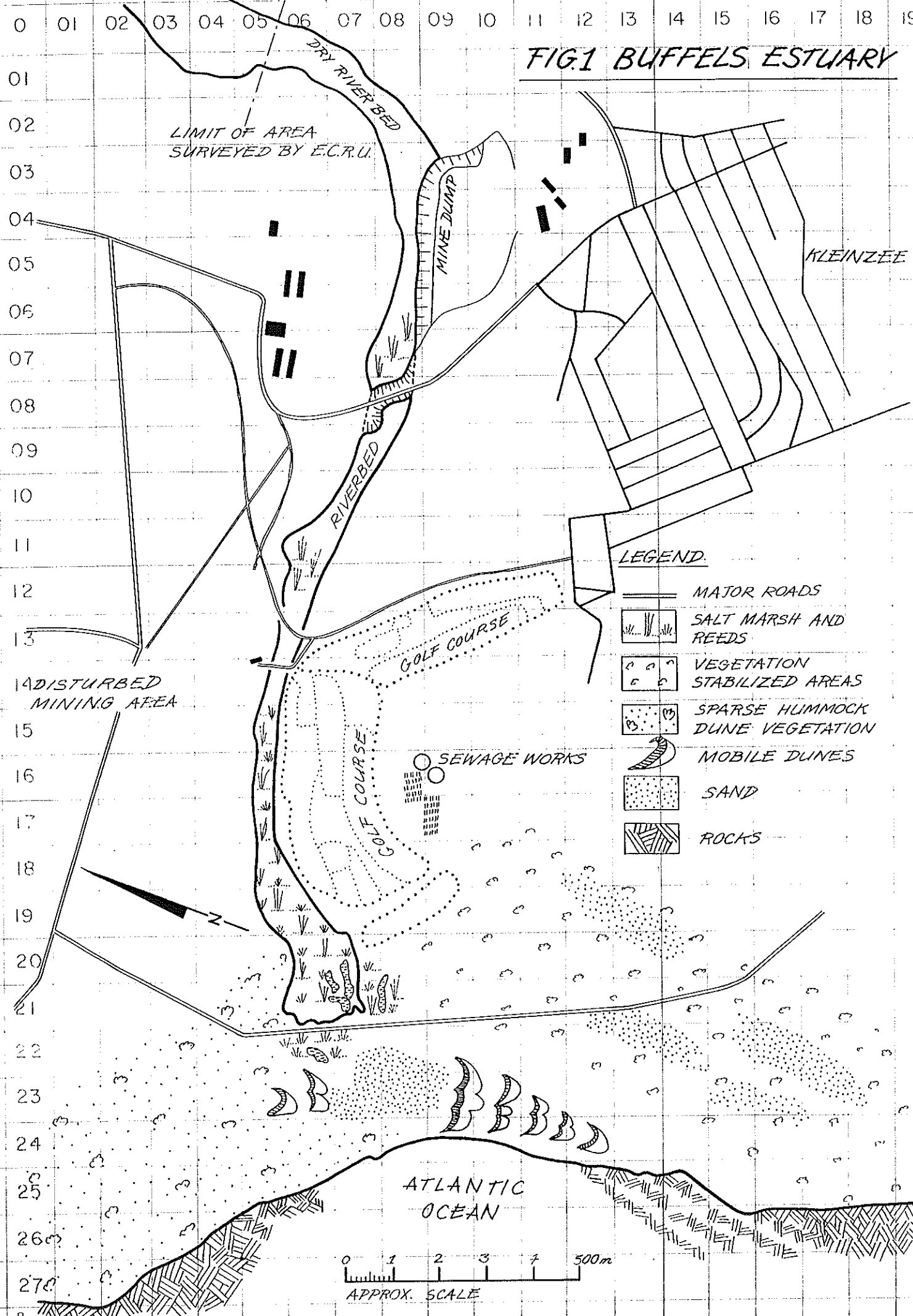
A dune-field of transverse barchan dunes stretches across the rivermouth - see sandbar characteristics. (Sect. 3.8).

3.4








Siltation :

Layers of dried out silt which crack into large blocks are evident in the lower reaches of the river. These were seen by Prof. J.R. Grindley in January 1979 and again during the ECRU survey. A thin layer (5-6 cm) of silt is present just under the sand in the dune slacks at the mouth (ECRU Survey). In an unpublished memorandum of the Department of

FIG.1 BUFFELS ESTUARY



LEGEND.

-  MAJOR ROADS
-  SALT MARSH AND REEDS
-  VEGETATION STABILIZED AREAS
-  SPARSE HUMMOCK DUNE VEGETATION
-  MOBILE DUNES
-  SAND
-  ROCKS

0 1 2 3 4 500m
APPROX. SCALE

Agricultural Technical Services written in 1975 it is stated : "When in flood all the west coast rivers are fast flowing "young" rivers which seldom flow out to sea and silt is deposited before reaching the estuaries."

Cornelissen (1968) records that flash-floods and muddy water tend to cause deposition of silt which adversely affects the recharging of the Spektakelberg and Kleinsee aquifers.

3.5 Land ownership/use :

(a) Catchment

Most of the land in the catchment consists of large privately owned farms as well as the Coloured Affairs area of Komaggas. In these areas sheep and goats are farmed on an extensive basis and in places, dryland lucern is cultivated. Intensive diamond mining takes place along the upper reaches of the riverbed and copper mining at the base of Spektakelberg. The underground water extraction by the O'kiep Copper Company to supply the surrounding towns and mines has already been mentioned. However this water supply is now augmented by the Henkries O'kiep pipeline from the Orange River (Dept. of Agricultural Technical Services Memorandum 1975 (unpublished)).

(b) Around the estuary

The entire rivermouth area is owned by De Beers Consolidated Diamond Mines and the mining settlement of Kleinsee with c. 450 Europeans and c. 600 Bantu, is situated at the rivermouth. Large scale open cast mining for alluvial diamonds takes place around the mouth area of the river, as well as in the surf-zone along the coast. Underground water is drawn from the sandy riverbed to supply the Kleinsee settlement, the mine and to irrigate a few hectares of pasture (Dept. of Agriculture Technical Services Memorandum 1975 (unpublished)). Other uses of the rivermouth area include golf (the golf course which is situated in the lower floodplain of the river has already been mentioned) and beach recreation, diving, fishing etc. in the vicinity of the rivermouth.

3.6 Local Authority :

The Namaqualand Divisional Council is the local authority for the area although actual control of the rivermouth and coastline is exercised by DBCDM.

3.7 Estuary uses :

Bird watching in the reed beds and pans at the mouth by some residents of Kleinsee.

3.8 Morphometry of the estuary :

Area

In 1942 the riverbed up to 1,5 km from the mouth was c. 480 ha in extent (Aerial Photography Job No. 13 of 1942). By 1980 the riverbed area had been reduced to c. 200 ha (Aerial Photography Job No. 348 of 1980) (Figs. 2 (a) and (b)).

Shape

As it approaches the coast, the river has a fairly narrow steep-sided course, which runs southwards towards the Kleinsee settlement before bearing west to run north of the settlement where it widens out at the mouth. The mouth itself is offset, to the south. Aerial photography of 1942 indicate that the mouth may have been situated well south of its present position (Aerial Photography, Job No. 13 of 1942).

FIG.2(a) CONFIGURATION OF THE BUFFELS ESTUARY (1942)

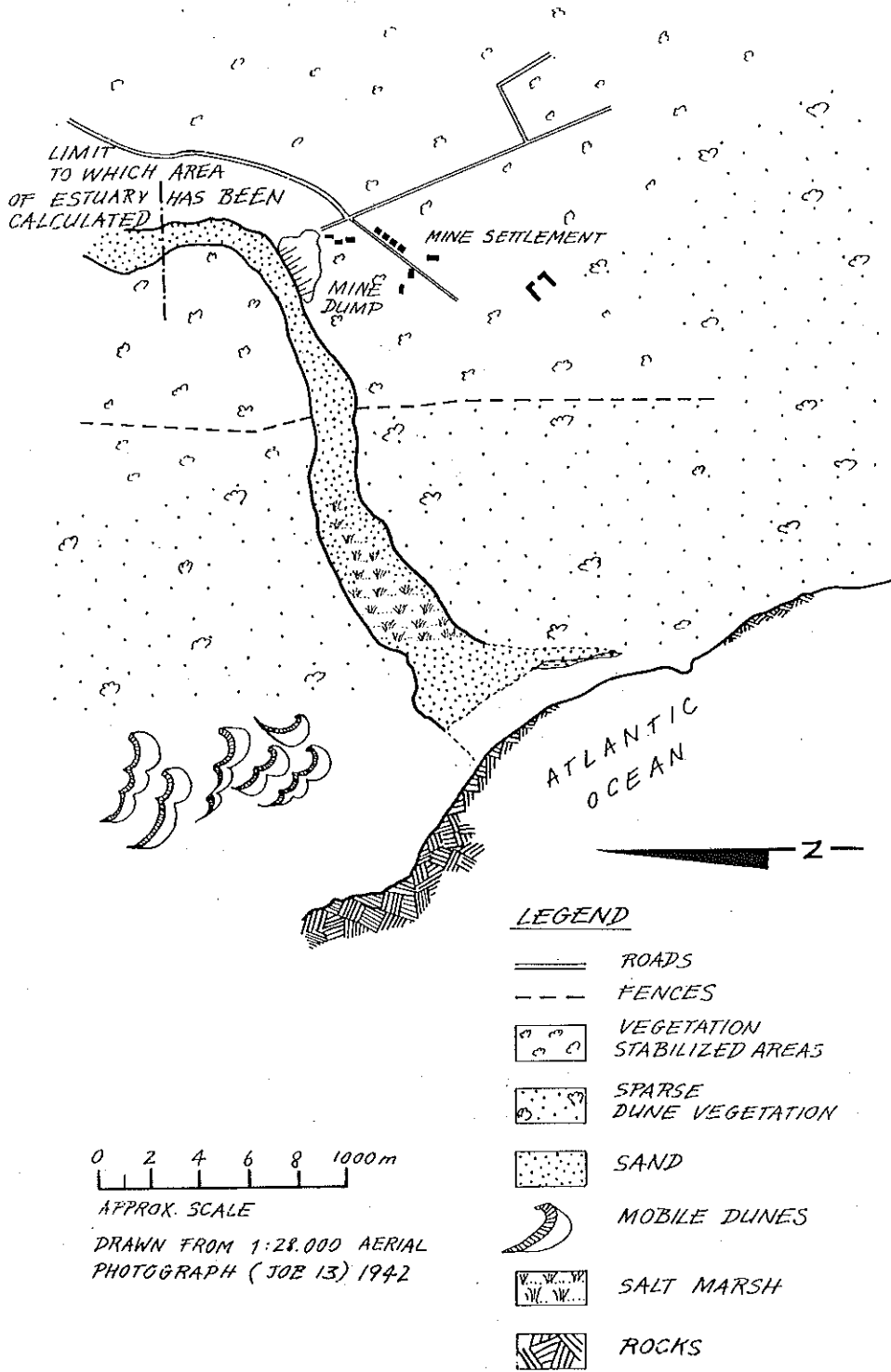
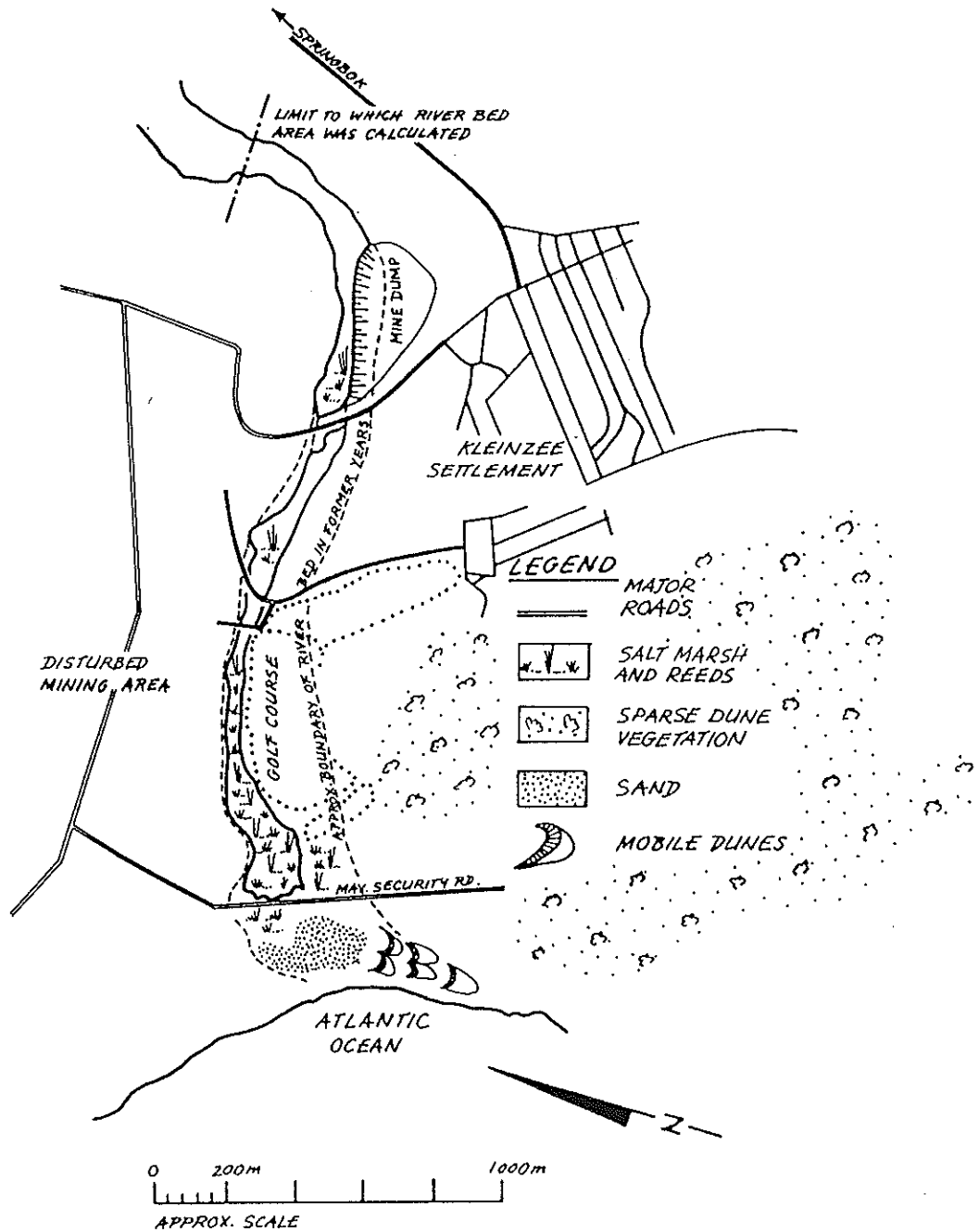


FIG.2(b) CHANGES IN CONFIGURATION OF THE BUFFELS ESTUARY (1980)



DRAWN FROM 1:20 000 AERIAL PHOTOGRAPH (JOB 398) 1980

Bathymetry

A dry sandy riverbed with shallow pans and channels in the lower reaches Fig. 1 and (Table 1). The aerial photographs of 1964 and 1976 show relatively large expanses of water at the mouth as compared with the situation at the time of the ECRU survey. (Aerial Photography Job No. 525 of 1964 and Job No. 763 of 1976)

3.9

Geomorphology :

Most of the area around the mouth consists of low scrub-covered dunes of windblown sand which overlies fossilised aeolian dunes which show evidence of crossbedding in places.

Inland, outcrops of calcrete eroded by marine terraces can be found and there is also evidence of strong metamorphic action (ECRU survey; R. Hazel pers. comm.)

Geology

The rocks in the area of the Buffels River are known as the Buffels Marine Complex which is a name given to the geological formations in the area by the DBCDM geologists at Kleinsee. At the rivermouth these rocks belong predominantly to the Namaqualand-Natal granite gneiss series (migmatite, gneiss, ultrametamorphic rocks) which are seen as seaward dipping layered formations of quartz, micaceous gneiss and schists (De Beers 1979).

Nature of bottom materials

The sediments at the mouth consist of a fine to medium quartzitic sand with fine silt in places (ECRU survey). In the shallow pans and channels at the mouth, layers of fine organic silt and mud occur (Table 1).

A screen analysis of the typical Buffels River sands indicates that the coarse sands are the predominant type (Cornelissen 1968).

Sandbar characteristics (see Frontispiece)

A shallow, slightly shelving seabed merges into the beach which slopes upwards at a gradient of 1 in 28 towards the rivermouth.

On 15 October 1980, the lowest point on the sandbar was c. 1,20 m above sea level at 15h40. From the S.A. Tide Tables 1980, it was calculated that this point of the sandbar was c. 0,49 m above Mean High Water Spring Level, which means that overtopping of the sandbar can take place during periods of extreme High Spring Tides.

The rivermouth consists of a flat dune slack between well-formed barchan dunes, (Fig. 3), which appear to be shifting northwards under the influence of prevailing south-westerly winds. The dunes increase in height from c. 1 m in the south to c. 7 m in front of the mouth. The presence of dried kelp in the dune slacks at the mouth, indicates that at some stage the sea had in fact washed up into the dune slacks as far as the salt marsh vegetation occurring at the seaward end of the riverbed (Fig. 1).

A newly constructed road, with no culverts, which crosses the riverbed near the mouth forms a substantial barrier to any exchange of water between the river and the sea.



FIG. 3. Dune slack between barchan dunes at the mouth of the Buffels River. (ECRU 80-10-15)

Configuration of the adjacent shore

Parallel bands of layered rock lying in a NE direction dipping seawards (west) occur at either side of the mouth area, which consists of a shallow sandy bay.

The seaward dipping bands of rock continue inland where the areas between these rock strata are filled with fine white sand.

3.10 Oceanography :

Major currents

The cold northward flowing Benguela current is the major system off the Cape West Coast. Under the influence of south to south-easterly winds, mainly in summer, inshore water is moved offshore causing upwelling of cold water of sub-Antarctic origin. Moisture laden air moving landwards over this cold upwelled water condenses to form heavy advective fog which is characteristic of the West Coast (Heydorn and Tinley 1980).

Waves

Waves which play a major role in nearshore erosion and sediment transport and deposition are influenced by many factors such as wind, fetch, tide, coast configuration, bottom topography, the earth's rotation and gravity (Heydorn and Tinley 1980). On the West coast waves generated in the South Atlantic, strike the coast generally from a SW or SSW direction. Measurements taken at Oranjemund 151 km north of the Buffels indicate that 50 percent of the waves attain a height of over 1,6 m (J. Rossouw pers. comm.).

At Buchu Bay 126 km north of the Buffels, the frequency of 95 percent of the waves is 10 - 15 seconds (Ashby, Harper and Van Schaik 1973). Aerial photographs taken in 1942, 1964, 1976, 1979 and 1980 all show the waves moving in a SSW direction off the Buffels Estuary.

Surf zone currents

An outward flowing rip current at the southern end of the beach in front of the rivermouth area at the time of the ECRU survey and the southern offset of the mouth, indicates a predominantly southward water movement.

Tides

The ECRU survey was carried out two days before Neap Tide, with high water at 18h40 and low water at 12h30. The tidal levels in 1980 at Port Nolloth, the nearest port to the Buffels River mouth were as follows :

LAT	MLWS	MHWS	HAT
-0,21	0,09	1,66	2,03

This gives a tidal range between MLWS and MHWS of 1,57 m.

3.11 Physico-chemical characteristics :

No previously available data could be traced. Those collected by the ECRU during October 1980 are presented in Table 1.

The high water table at the mouth due to the presence of an aquifer in the lower part of the river (See Section 3.2) results in relatively stable conditions prevailing in the open water pans and channels which are situated at the mouth.

Nutrients

At Grid ref. 2206 very little algae were present which suggests a lack of nutrients. Dense algal mats occurred however at Grid ref. 2007 suggesting probable concentration of nutrients at this site due to evaporation and run-off from the golf course. The golf course which is situated on the lower floodplain and above Grid ref. 2007, is irrigated entirely with water from the sewerage works which represents an added nutrient input into the system.

No data are available on nitrogen, inorganic carbon, phosphorous, dissolved solids, dissolved organic matter (D.O.M.), particulate organic matter (P.O.M.), or other nutrients.

3.12 Pollution :

Sewage

Due to a critical shortage of water, the settlement of Kleinsee makes full use of all the available water extracted from the aquifer situated in the sandy riverbed of the Buffels Estuary. This is done by purifying the sewage and waste water to the extent that it can be re-utilized for irrigation of gardens, sportsfields, the golf course and agricultural crops. The run-off would then also serve to recharge the aquifer to a certain extent.

TABLE 1 : Physico-chemical data collected during the ECRU survey
(See Fig. 1 with overlay for grid references).

Date	80-10-15		80-10-15	
Time	15h40		17h40	
State of mouth	C L O		S E D	
State of tide	Rising		Rising	
ECRU Grid ref.	2206		2007	
Position of Sampling site	Small pan in riverbed near mouth		Narrow shallow channel between riverbed at the mouth	
Depth (m) at Sampling site	0,10-0,30		0,05	
*Width (m)	-		-	
Diss. O ₂ (mg/l)	Top	-	-	
	Bottom	-	-	
Salinity (‰)	Top	6	16	
	Bottom	-	-	
Temp. (°C)	Top	26,7	-	
	Bottom	-	-	
pH	7		7-8	
Secchi disc transparency (m)	Clear to bottom		Clear to bottom	
Water colour	Colourless		Light green	
Substrate	Fine to medium sand overlying black anoxic sand/areas of fine organic silt		Fine black organic mud	

* Estuary/River width at sampling site

Other forms of pollution :

No data are available on possible pollution by oil, metals, pesticides or herbicides.

The dumping of excess rubble, grass cuttings and garden refuse takes place along the retaining embankments (leveés) separating the golf course from the main river course. General litter in the form of bottles, cold drink containers etc. was found below the golf course and along the lower riverbed.

3.13 Public health aspects :

No data are available on bacterial or other health hazards.

4. BIOTIC CHARACTERISTICS

Very limited published information is available on the Buffels Estuary and as the ECRU survey only entailed a brief visit to the system the data contained in the following sections should not be interpreted as being complete.

4.1 Flora :

Phytoplankton / diatoms

No published information could be traced and no data on phytoplankton and diatoms were collected during the ECRU survey.

Aquatic vegetation

(a) Estuary

At Grid ref. 2206 small amounts of filamentous algae were growing on roots and debris of other vegetation in the pans. At Grid ref. 2007 dense algal mats were present along the edges of the narrow, shallow channels (refer to Section 3.11 Nutrients)

(b) Adjacent shoreline

In the inter-tidal zone opposite the mouth the following marine algae were identified :

Caulacanthus divaricatus
Ecklonia maxima
Laminaria pallida
Cladophora capensis
Ulva sp.
Corraline alga

Bifurcaria brassicaeformis
Codium duthiae
Chaetomorpha sp.
Lithothamnion spp.
Porphyra capensis
Suhria vittata

Semi-aquatic vegetation

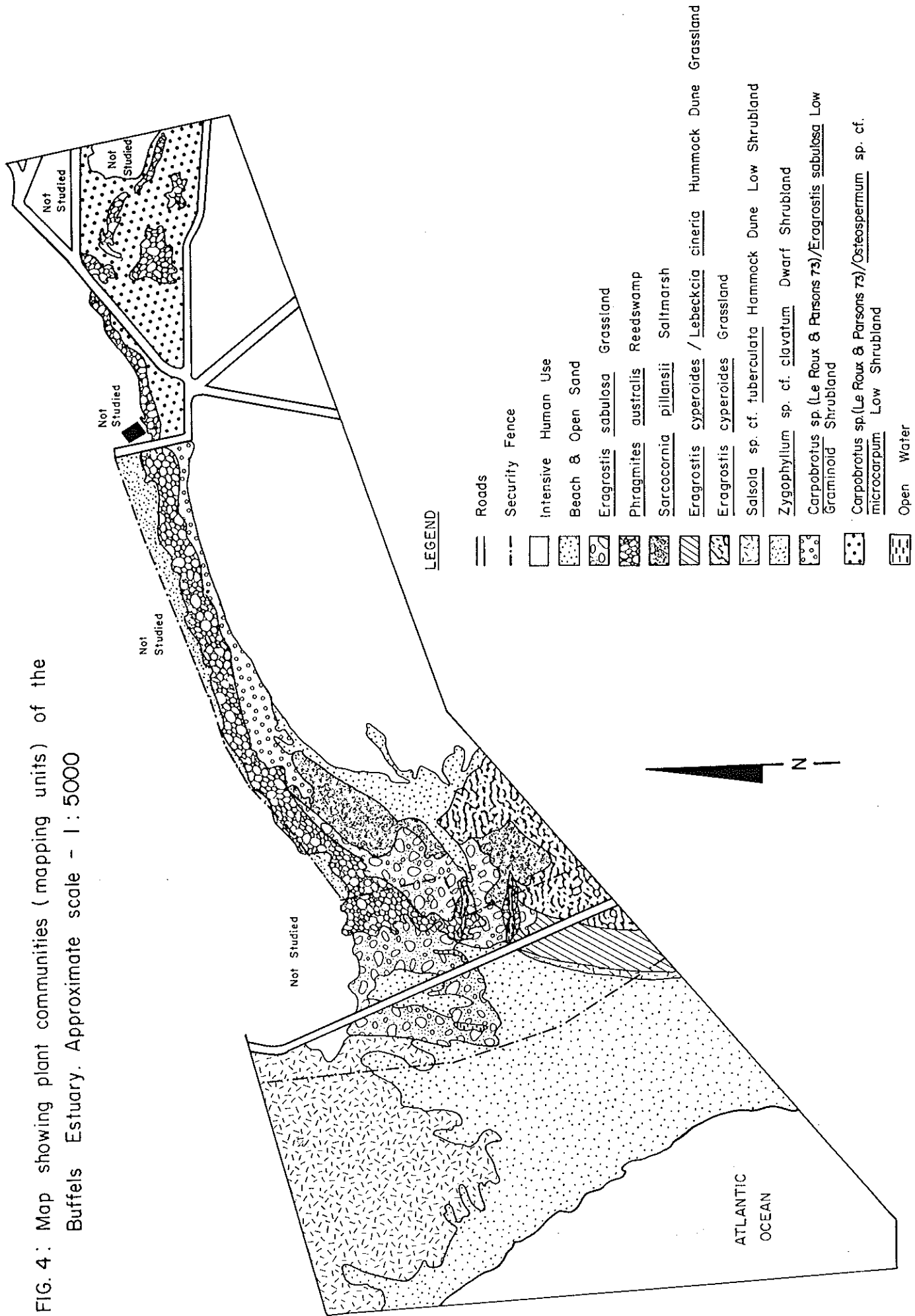
At Grid ref. 2206 the following species were noted : Eragrostis sabulosa
Cotula coronopifolia, Juncus kraussii and Sarcocornia sp.

Terrestrial vegetation

(This section is contributed by Miss R. Parsons of the Botanical Research Institute and Miss A. Le Roux of the Cape Department of Nature and Environmental Conservation.)

This area falls into Acock's Veld Type 34 (b), Strandveld proper which he describes as an open semi-succulent scrub (Acocks 1975). The area around the river has however been subject to intensive human interference.

FIG. 4: Map showing plant communities (mapping units) of the Buffels Estuary. Approximate scale - 1 : 5000



Nine main plant communities (mapping units) were identified. Their structure, species composition and area are shown in Appendix I and their spatial distribution in Fig. 4. Only dominant species were listed. The cover of the communities varied from 5 percent (Salsola sp. cf. tuberculata Hummock Dune Low Shrubland) to 100 percent found in the Sarcocornia pillansii Saltmarsh. The height varied from 0,25 m (Zygophyllum sp. cf. clavatum Dwarf Shrubland) to 2,5 m reached by the Phragmites australis Reeds swamp. The highest species diversity was found in the Eragrostis cyperoides Grassland and the Zygophyllum sp. cf. clavatum Dwarf Shrubland (both 7 spp.) while the Salsola sp. cf. tuberculata Hummock Dune Low Shrubland has the lowest diversity with only 1 species.

The nine plant communities can be consolidated into five main plant formations namely reeds swamp, saltmarsh, grassland, low shrubland (0,25 - 1,00 m) and dwarf shrubland (less than 0,25 m). The low shrubland covers the largest areas (10,40 ha) followed by the grassland (5,37 ha), reeds swamp (3,37 ha), saltmarsh (1,48 ha) and dwarf shrubland (0,75 ha). There is also a large zone of intensive human use (14,31 ha) which is represented mainly by the golf course.

The golf course which has been developed on the floodplain is protected by an artificial embankment (See section 3.3 Obstructions : (b) Near the mouth and Plate IV) on which the Carpobrotus sp. (Le Roux and Parsons 73)* Eragrostis sabulosa Low Graminoid Shrubland is found. A disturbing feature was the presence of Kikuyu grass (Pennisetum clandestinum) cuttings which have been dumped in the riverbed. This was seen to be taking root in a number of places on the outer edges of the Phragmites australis Reeds swamp. This grass which spreads easily and rapidly could become a problem if the practice of dumping grass cuttings from the golf course in the riverbed is continued. Two alien species Wild Tobacco (Nicotiana glauca) and Rooikrans (Acacia cyclops) were seen growing in the dry riverbed. A. cyclops may spread rapidly especially where the natural vegetation has been disturbed and its spread could lead to the elimination of the indigenous vegetation.

4.2 Fauna :

Zooplankton

No data available.

Fauna on

(a) hard substrates

Dominant inter-tidal benthic organisms identified from the rocks in front of the mouth included : limpets, (Patella granularis,

* Le Roux and Parsons species No's e.g. (Le Roux and Parsons 73) refer to samples unidentified, by the B.R.I. at the time of writing.

Patella granitina, P. argenvillei, P. compressa, P. miniata,
periwinkels and welks, (Oxystele variegata, Turritella capensis,
Burnupena delalandii) and the mussels, (Aulacomya ater and Choromytilus
meridionalis).

(b) soft substrates

At Grid ref. 2206 a scoop net sample collected consisted of a large number of aquatic organisms which were present in the fine silt layer on the bottom of the pan - (to be identified by J.R. Grindley).
At Grid ref. 2007 the entire surface of the dried out mudpans, occurring between the vegetation, has a powdery texture which was caused by "earthworm-like" mounds. This was due to the burrowing of a small Carabid beetle Pagonus lamprus (Plate II). The activities of this beetle must have a significant effect on the turnover and aeration of the mud in the dried out pans situated in the riverbed. On the beach a series of 6 trenches 2 m x 0,2 m x 0,2 m, were dug in a staggered, diagonal line from the water's edge up to the High Water Mark. The only specimen collected was one isopod (Pontogeloides latipes) from the trench closest to the water's edge. A sample of kelp beetles (Pachyphaleria capensis) feeding on washed up kelp was collected for identification. No evidence of the white mussel (Donax serra) was found.

(c) Vegetation

No data available.

Insects

Refer to Section 4.2 Fauna on (b) soft substrates

Other invertebrates

Carapace casts of rock lobster, (Jasus lalandii) and the crab (Ovalipes punctatus) were found on the beach as well as cuttlefish (Sepia officinalis) cartilages.

Fish

A shoal of c. 400 juvenile mullet (c. 8 cm in length) were seen in the shallows along the beach. No fish were seen in the shallow pans and water channels of the estuary.

Reptiles and amphibians

The small Namaqua Rain Frog (Breviceps namaquensis) occurs in the dunes near the mouth of the river (J.C. Greig pers. comm.).

Birds

The following birds were recorded at the estuary and in the vicinity of Kleinsee during the ECRU survey on 14 October 1980.

On beach

A flock of 76 waders was seen feeding near stranded kelp.

<u>Roberts No.</u>	<u>Species</u>	<u>No. seen</u>
R235	White-fronted Sandplover	60
R251	Curlew Sandpiper	17
R232	Turnstone	5
R255	Sanderling	37
R212	Coot	10
R233	Ringed Plover	1

<u>Roberts No.</u>	<u>Species</u>	<u>No. seen</u>
R256	Ruff	4
R686	Cape Wagtail	5
R 47	White-breasted Cormorant	1
R 48	Cape Cormorant	27
R287	Southern Black-backed Gull	150
R289	Hartlaub's Gull	355
R288	Grey-headed Gull	4

Grid ref, 2206 (Pool near mouth)

<u>Roberts No.</u>	<u>Species</u>	<u>No. seen</u>
R258	Common Sandpiper	1
R270	Stilt	2
R 90	South African Shelduck	2
R509	African Sandmartin	4
R686	Cape Wagtail	2
R495	White-throated Swallow	2

Phragmites marsh and upper river

R263	Greenshank	1
R245	Blacksmith Plover	3
R583	Karoo Scrub Robin	4
R803	Masked Weaver	2
R746	Pied Starling	1
R735	Wattled Starling	12
R808	Red Bishop Bird	c.54
R576	Stone Chat	1
R318	Namaqua Dove	3
R311	Rock Pigeon	1
R786	Cape Sparrow	abundant

Other birds observed by Mr A.J. van Wyk of Kleinsee over a period of time are :

R 1 Ostrich	R525 Grey Tit
R105 Secretary bird	R242 Crowned Plover
R 54 Grey Heron	R275 Dikkop
R566 Karoo Chat	R 87 Lesser Flamingo
R564 Mountain Chat	R123 Rock Kestrel
R808 Red Bishop Bird	R 42 White Pelican
R815 Yellow Bishop Bird	R368 Spotted Eagle Owl
R 61 Cattle Egret	R359 Barn Owl
R733 European Starling	R737 Cape Glossy Starling
R506 Rock Martin	R775 Cape White-eye
R522 Pied Crow	R751 Malachite Sunbird
R784 House Sparrow	R231 Black Oystercatcher

Mammals

At Grid ref. 2206 (Fig. No. 1) signs of surface burrowing moles, possibly one of the golden mole species, were seen as well as the tracks of Water Mongoose (Atilax paludinosus) and Bat-eared Fox (Otyocyon megalotis) or Silver Fox (Vulpes chama)

At Grid ref. 2007 (Fig. No. 1) abundant tracks indicated a lot of activity by small mammals (rodents, small carnivores and buck). Tracks of the following species could be identified. Black-backed Jackal (Canis mesomelas), Porcupine (Hystrix sp.), Steenbuck (Raphicerus campestris), Cape Wild cat (Felis lybica) and Water Mongoose (Atilax paludinosus).

A large scat pile, probably of Water-mongoose, containing the remains of amphipods, birds feathers and small bones, was found at Grid ref. 2007. The following species are recorded for the area covered by the 1:50 000 topocadastral map of Kleinsee 2916DB and 2917CA - Cape Fur Seal (Arctocephalus pusillus) (Stuart and Lloyd 1978).

5. SYNTHESIS

Although the Buffels River has a relatively large catchment compared with most other major rivers of the Cape Province (8th largest catchment in the Cape) it only flows into the sea at times of exceptionally high rainfall. The reasons for this are that the major part of the catchment lies between the 100 - 200 mm mean annual isohyets and that the geological formation of the river basin is such that it forms two large aquifers which absorb much of the river flow.

The presence of one of these aquifers at the mouth of the Buffels River provides fresh water and thus allowed for the development of the Kleinsee mining settlement. The aquifer also results in a high water table and permanent pans at the rivermouth which support well developed riverine plant communities. These in turn provide ideal habitats for numerous forms of West Coast fauna in an otherwise extreme environment. This is borne out by the large number and variety of birds and mammals recorded at the rivermouth during the ECRU survey. The mining activities and development of recreational facilities at the Buffels River mouth have significantly reduced the effective size of this estuary.

Furthermore the mine "tailings" dump, various embankments across the river and the lower half of the golf course are likely to be damaged when floods do occur and thus cause further degradation of the estuary.

The complete re-cycling of sewage effluent as practiced at Kleinsee instead of disposal into the sea or estuary, is, however, an excellent example of water conservation which could be followed by many other local authorities.

The vast scale of open cast mining practiced immediately to the north of Kleinsee, illustrates how drastically the coastal environment can be altered by this form of industry, thereby substantially reducing future options for the use of this environment once the diamond yield has been depleted. This matter is presently receiving the urgent attention of both the Government and Mining Authorities. It is hoped that an effective balance between economically viable mining operations and longer term environmental preservation will result from these deliberations. The efforts of DBCDM in applying effective land use management techniques should not be overlooked and, as a matter of fact can serve as an example in other areas on the West coast where diamond mining takes place.

6. ACKNOWLEDGEMENTS

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GLOSSARY OF TERMS USED IN PART II REPORTS

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

epifauna: animal life found on the surface of any substrate such as plants, rocks or even other animals.

epiphyte: a plant living on the surface of another plant without deriving water or nourishment from it.

episodic: sporadic and tending to be extreme.

estuary: a partially enclosed coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage (Day 1981).

eutrophication: the process by which a body of water is greatly enriched by the natural or artificial addition of nutrients. This may result in both beneficial (increased productivity) and adverse effects (smothering by dominant plant types).

flocculation (as used in these reports): the settlement or coagulation of river borne silt particles when they come in contact with sea water.

fluvial (deposits): originating from rivers.

food web: a chain of organisms through which energy is transferred. Each "link" in a chain feeds on and obtains energy from the preceding one.

fynbos: literally fine-leaved heath-shrub. Heathlands of the south and south-western Cape of Africa.

geomorphology: the study of land form or topography.

gill net: a vertically placed net left in the water into which fish swim and become enmeshed, usually behind the gills.

habitat: area or natural environment in which the requirements of a specific animal or plant are met.

halophytes: plants which can tolerate salty conditions.

HAT (Highest Astronomical Tide) and LAT (Lowest Astronomical Tide): HAT and LAT are the highest and lowest levels respectively, which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions; these levels will not be reached every year. HAT and LAT are not the extreme levels which can be reached, as storm surges may cause considerably higher and lower levels to occur (South African Tide Tables 1980).

hummock (dune): a low rounded hillock or mound of sand.

hydrography: the description, surveying and charting of oceans, seas and coastlines together with the study of water masses. (flow, floods, tides etc.).

hydrology: the study of water, including its physical characteristics, distribution and movement.

indigenous: belonging to the locality; not imported.

intertidal: generally the area which is inundated during high tides and exposed during low tides.

isohyets: lines on maps connecting points having equal amounts of rainfall.

isotherms: lines on maps joining places having the same temperature at a particular instant, or having the same average, extremes or ranges of temperature over a certain period.

lagoon: an expanse of sheltered, tranquil water. (Thus Langebaan lagoon is a sheltered arm of the sea with a normal marine salinity; Knysna lagoon is an expanded part of a normal estuary and Hermanus lagoon is a temporarily closed estuary (Day 1981)).

limpid: clear or transparent.

longshore drift: a drift of material along a beach as a result of waves breaking at an angle.

littoral: applied generally to the seashore. Used more specifically it is the zone between high- and low-water marks.

macrophyte: any large plant as opposed to small ones. Aquatic macrophytes may float at the surface or be submerged and/or rooted on the bottom.

marls: crumbly mixture of clay, sand and limestone, usually with shell fragments.

matrix: medium in which a structure is embedded.

meiofauna: microscopic or semi-microscopic animals that inhabit sediments but live quite independently of the macrofauna, or benthos.

metamorphic: changes brought about in rocks within the earth's crust by the agencies of heat, pressure and chemically active substances.

MHWS (Mean High Water Springs) and MLWS (Mean Low Water Springs): the height of MHWS is the average, throughout a year when the average maximum declination of the moon is 23°, of the height of two successive high waters during those periods of 24 hours (approximately once a fortnight) when the range of the tide is greatest. The height of MLWS is the average height obtained by the two successive low waters during the same periods (South African Tide Tables 1980).

morphometry: physical dimensions such as shape, depth, width, length etc.

osmoregulation: the regulation in animals of the osmotic pressure in the body by controlling the amount of water and/or salts in the body.

pathogenic: disease producing.

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

phytoplankton: plant components of plankton.

piscivorous: fish eating.

plankton: microscopic animals and plants which float or drift passively in the water.

quartzite: rock composed almost entirely of quartz recemented by silicon. Quartzite is hard, resistant and impermeable.

riparian: living on the banks of rivers or streams.

rip current: the return flow of water which has been piled up on the shore by waves, especially when they break obliquely across a longshore current.

salinity: the proportion of salts in pure water, in parts per thousand by mass. The mean figure for the sea is 34,5 parts per thousand, written 34,5 ‰.

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 cartilagenous fishes).

trophic level: a division of a food chain defined by the method of obtaining food either as primary producers, or as primary, secondary or tertiary consumers.

trough: a crescent shaped section of beach between two cusps.

wetlands: areas that are inundated or saturated by surface or ground water frequently enough to support vegetation adapted to life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

zooplankton: animal components of plankton.

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Trig. Survey, Mowbray, 1:28 000, 1942.
- {BUFFELS RIVER MOUTH} Bl. and Wh., Job No. 525/64. Photo No. 1164.
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- {BUFFELS RIVER MOUTH} Bl. and Wh., Job No. 763/76. Photo No. 7397.
Trig. Survey, Mowbray. 1:50 000, 1976.
- {BUFFELS RIVER MOUTH} Colour, Job No. 326/79, Photo No. 102/4
Dept. Land Surveying, Univ. of Natal. 1:10 000, 1979.
- {BUFFELS RIVER MOUTH} Bl. and Wh., Job No. 348, Photo No. 73
Dept. Land Surveying, Univ. of Natal. 1:20 000, 1980.

APPENDIX I

Species composition and physical features of the plant communities (mapping units) of the Buffels River Estuary.

	5	90	100	90	100	90	15	30	30	50	40	Open Water	Beach and Open Sand	Intensive Human Use	Roads	Total
<i>Salsola</i> sp. cf. <i>tuberculata</i>	13,58	6,08	2,95	6,72	1,55	0,83	2,76	1,46	1,46	3,17	1,50	0,10	24,68	28,53	4,09	100,00
Huncock Dune Low Shrubland	6,81	3,05	1,48	3,37	0,83	0,83	2,76	0,73	0,73	1,59	0,75	0,05	12,38	14,31	2,05	50,16
<i>Salsola</i> sp. cf. <i>tuberculata</i>	0-1,0	0-0,5	0-0,75	0-2,5	0-0,75	0-0,75	0-0,75	0-0,75	0-0,75	0-0,5	0-0,25					
Huncock Dune Low Shrubland																
<i>Eragrostis sabulosa</i>																
<i>Sarcocornia pillansii</i>																
Saltmarsh																
<i>Phragmites australis</i>																
Reedswamp																
<i>Carpobrotus</i> sp. (Le Roux & Parsons 73) / <i>Eragrostis sabulosa</i> Low Graminoid Shrubland																
<i>Carpobrotus</i> sp. (Le Roux & Parsons 73) / <i>Osteospermum</i> sp. cf. <i>microcarpum</i> Low Shrubland																
<i>Eragrostis cyperoides</i> / <i>Lebeckia cinerea</i> Hunnock Dune Grassland																
<i>Eragrostis cyperoides</i> Grassland																
<i>Zygophyllum</i> sp. cf. <i>clavatum</i> Dwarf Shrubland																
<i>Salsola</i> sp. cf. <i>tuberculata</i>																
<i>Sarcocornia natalense</i>																
<i>Eragrostis</i>																
<i>Sarcocornia pillansii</i>																
<i>Juncus</i> sp. (Le Roux & Parsons 27)																
<i>Phragmites australis</i>																
<i>Acacia cyclops</i>																
<i>Carpobrotus</i> sp. (Le Roux & Parsons 73)																
<i>Nicotiana glauca</i>																
<i>Blackiella inflata</i>																
<i>Osteospermum</i> sp. cf. <i>microcarpum</i>																
<i>Forskaeola</i> sp. (Le Roux & Parsons 31)																
<i>Eragrostis cyperoides</i>																
<i>Lebeckia cinerea</i>																
<i>Atriplex bolusii</i>																
<i>Othonna floribunda</i>																
<i>Galenia fruticosa</i>																
<i>Lycium</i> sp. (Le Roux & Parsons 3)																
<i>Tetragonia fruticosa</i>																
<i>Zygophyllum</i> sp. cf. <i>clavatum</i>																
<i>Droseranthemum</i> sp. (Le Roux & Parsons 4)																
<i>Psilocaulon</i> sp. (Le Roux & Parsons 6)																
<i>Lampranthus</i> sp. (Le Roux & Parsons 29)																
<i>Pteronia glabrata</i>																

APPENDIX II Summary of available information

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC												BIOTIC												Summary of available information									
		Physio-graphy			Physics			Geomorphology			Chemistry			Other			Flora			Fauna							Food Webs								
		Catchment characteristics	Morphology	Hydrology	Density variations	Circulation & mixing	Geology	Paleoenvironment	Sediment transport & deposition	General chemistry	Eutrophication	Metal residues	Pesticide residues	Bacteriology	Management	Aquaculture	Modelling	Conservation	Utilization	Historical	Halophytes	Phytoplankton	Terrestrial	Zooplankton	Other invertebrates	Insects	Fauna on hard substrates	Fauna on soft substrates	Fish	Reptiles & Amphibians	Birds	Mammals	Food Webs		
		Insufficient data																																	
Sources of information																																			
Acocks	1975																																		
Ashby, Harper and van Schaik	1973																																		
Coetzee and Rogers	1976																																		
Cornelissen	1968																																		
Coward	1981																																		
De Beers Cons. Mines Ltd	1979																																		
Heydorn and Tinley	1980																																		
Marais	1972																																		
Memoranda-Agric. Tech. Services	1975																																		
South African Tide Tables	1980																																		
Stuart and Lloyd	1978																																		
L. Benneto (pers. comm.)	1980																																		
J.C. Greig, (pers. comm.)	1980																																		
R. Hazel (pers. comm.)	1980																																		
J. Rossouw, (pers. comm.)	1981																																		
A.J. van Wyk, (pers. comm.)	1980																																		
ECRU Survey (October)	1980																																		

ESTUARY / RIVERMOUTH / LAGOON		A B I O T I C										B I O T I C										Summary of available information													
		Physio- graphy	Physics			Geomor - phology				Chemistry			Other				Flora			Fauna				Food Webs											
YEAR (DATE OF INFORMATION)																																			
Insufficient data												Sources of information																							
MAPS																																			
S.A. 1:50 000 Sheet 2916 DB & 2917 CA												1974																							
S.A. 1:250 000 Topo.Sheet 2916												1978																							
S.A. 1:1000 000 Geological Map												1970																							
A.T.S. Chart, Springbok (unpublished)												1980																							
AERIAL PHOTOGRAPHY																																			
Trig Survey																																			
Job No. 13												1942																							
Job No. 525												1964																							
Job No. 763												1976																							
University of Natal: Land Surv. Dept.												1979																							
Job No. 326												1980																							
Job No. 348																																			

NOTES

PLATES I, II and III Overleaf

PLATE I :

Major road embankment
across the Buffels River
1,7 km from the mouth.

(ECRU 80-10-15)

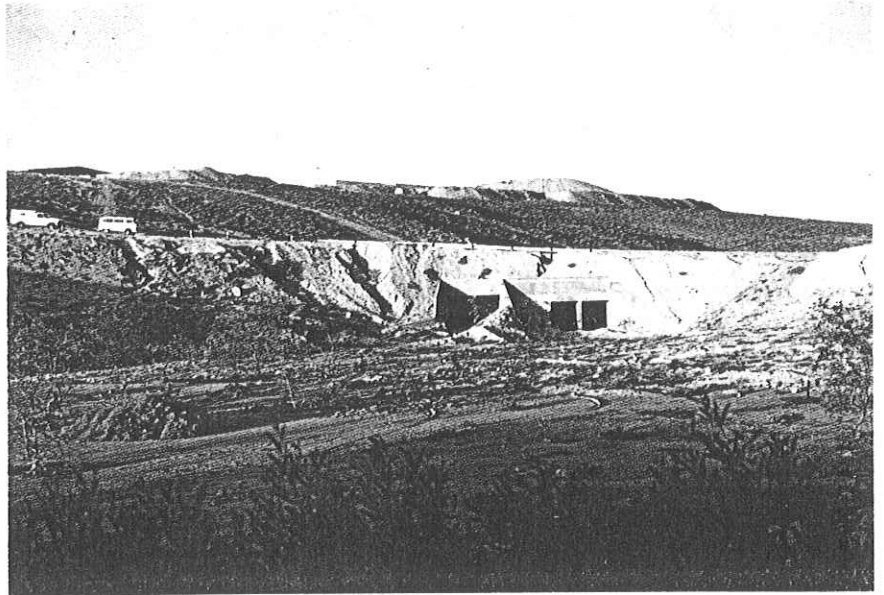


PLATE II :

Embankment protecting
the Golf Course, on the
right of the photograph.
Riverine vegetation
on the left.

(ECRU 80-10-15)



PLATE III :

The mine "Tailings"
dump encroaching on
the riverbed at the
first major bend in the
river.

(ECRU 80-10-15)

