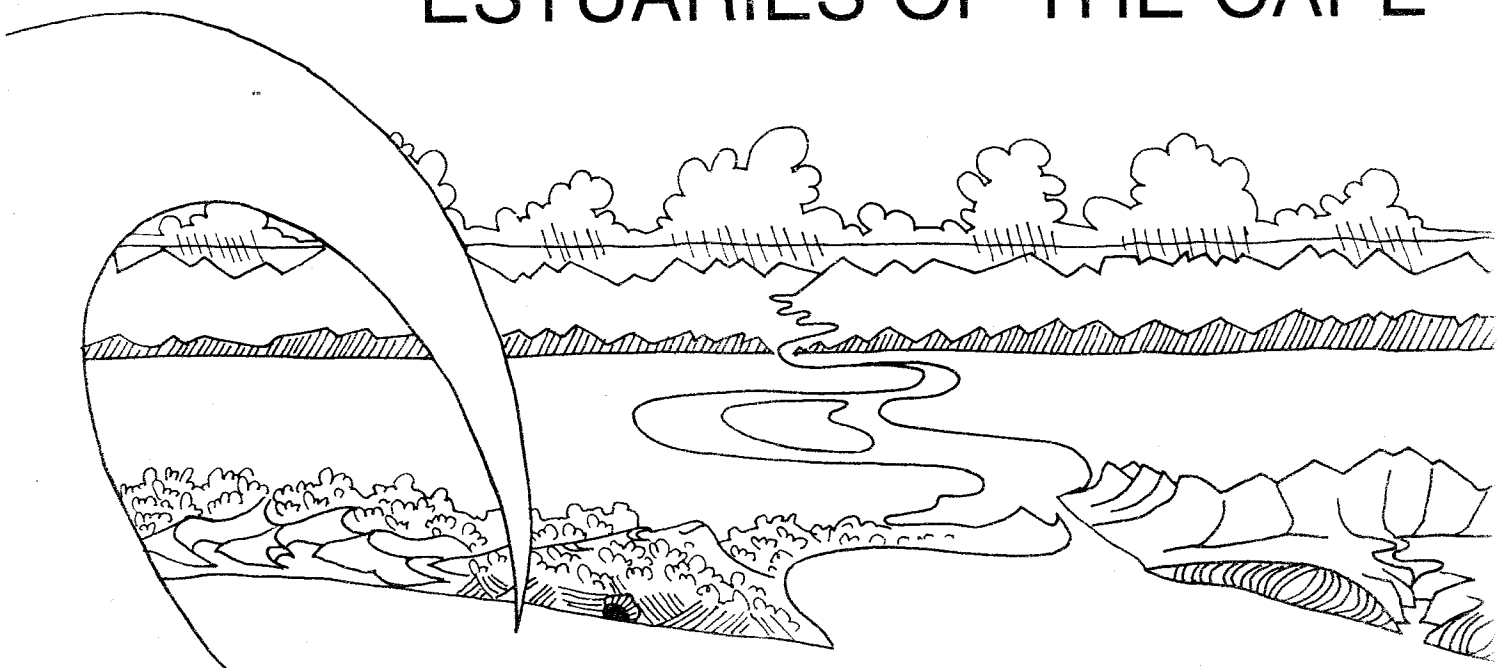
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
ESTUARINE AND COASTAL RESEARCH UNIT – ECRU

ESTUARIES OF THE CAPE



PART II
SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

EDITORS: A E F HEYDORN
J R GRINDLEY

REPORT NO. 3

GROEN (CW7)

CSIR RESEARCH REPORT 402

Stellenbosch, South Africa
June 1981

ESTUARIES OF THE CAPE

PART II: SYNOPSES OF AVAILABLE INFORMATION ON INDIVIDUAL SYSTEMS

REPORT NO. 3: GROEN (CW7)

(CW7 – CSIR Estuary Index Number)

FRONTISPIECE: GROEN ESTUARY – ALT. 500 m, ECRU 79–08–14

COMPILED BY : I B BICKERTON

ECRU SURVEY : 19–21 OCTOBER 1980

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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

* CSIR Research Report 380

FIGURES

TABLES

PLATES

APPENDICES

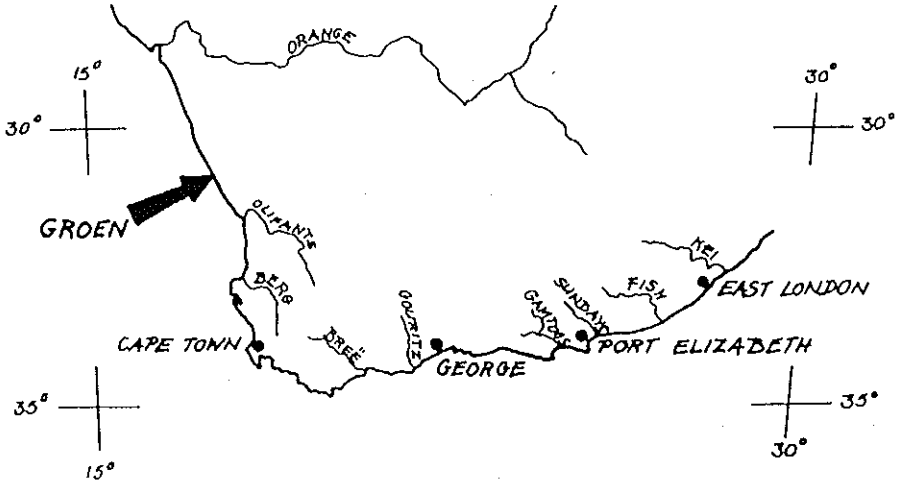
GROEN

1. SYNONYMS AND DERIVATIONS

No synonyms recorded.

2. LOCATION

30° 51' S 17° 35' E



The mouth of the Groen is situated approximately 31 km to the south of the Bitter River mouth, 66 km south of Hondeklipbaai and 267 km to the south of the Orange River mouth. (1:250 000 Topographical Sheet 3017, 1:1000 000 World Aeronautical Sheet ICAO 3396)

2.1 Accessibility :

Accessible by a 72 km gravel road from Garies. (1:250 000 Topographical Sheet 3017). Although the estuary falls within the prospecting zones of De Beers Consolidated Diamond Mines, the mouth area is open to the public and no permits are required.

3. ABIOTIC CHARACTERISTICS

3.1 Catchment :

Area

4500 km² (Heydorn and Tinley 1980).

River length

67 km up to the junction with the Kysrivier and Wilgerhoutsrivier near Loerkop (1:250 000 Topographical Sheet 3017, 1:500 000 Sheet SE 31/16½).

Tributaries

Kysrivier, Wilgerhoutsrivier, Swart-Doringrivier, Klipfonteinrivier (1:250 000 Topographical Sheet 3017, 1:500 000 Sheet SE 31/16½)

Mean annual run-off

The Groen falls within a region of episodic rainfall (Heydorn and Tinley 1980). The mean annual rainfall in the upper reaches of the catchment ranges between 150 and 200 mm, whilst in the lower reaches down to the coast, it varies from 100 to 150 mm (Le Roux and Ramsey 1979; Heydorn and Tinley 1980).

3.2 Flow

According to the local farmer, Mr Cornelissen, the Groen flows only occasionally, about once every five years.

The episodic nature of the flow is borne out by flow data for a tributary of the Groen, the Swart-Doringrivier (catchment area 2350 km²) for the period May 1967 to October 1979. These data were taken from River flow data, monthly summaries October 1960 - September 1970, (1978) and unpublished records obtained from the Department of Water Affairs (data for the period 1971 to 1979). From 1967 to 1979 a gauging station, situated at the national road bridge crossing the Swart-Doringrivier about 35 km south of Garies and 26 km from the confluence with the Groen was in operation. As this gauging station is the only known one in the Namaqualand coastal region, and also because flow patterns in Namaqualand rivers are so irregular, a fairly detailed flow history is given below.

The Swart-Doringrivier flowed continuously, although very irregularly from the end of April 1967 until September 1968 when it dried up. It did not flow again until March 1972 when there was a brief period of two days of run-off. The next period of flow occurred from December 1973 to February 1974. The river flowed sporadically from June to September 1974 during which time a maximum peak flow of 44,33 cumecs occurred on 23 August. This coincides with the floods in the Groen on 24 August (Mr Cornelissen pers. comm.). From September 1974 to October 1979, no further flow was recorded.

Much of the water flowing down the Swart-Doringrivier is probably absorbed by the sandy riverbed between the gauging station and the confluence with the Groen. Hence it is probably only during extreme floods (such as in August 1974), that surface flow from the Swart-Doringrivier actually reaches the Groen. However, the permanent surface water in the Groen Estuary is partially maintained by springs situated about 2,5 km upstream of the mouth. Flow from the Swart-Doringrivier probably charges the water table in the Groen riverbed which in turn supplies these springs.

Flood history and level fluctuations

The following account of the flood history was given by Mr Cornelissen, during the ECRU survey.

Extraordinary floods occurred on 10 April 1961 and again on 24 August 1974. In both cases, the mouth opened naturally. The flood in 1961 covered the floodplain to about 3 m above the riverbed and

reached 0,8 m up the wall of the farmhouse (Plate I). Water flowed through the windows of a prefabricated house used by De Beers Consolidated Diamond Mines, situated on the floodplain. The level reached by the 1974 flood was about 1,2 m lower than that in 1961. According to an article (Van Alle Kante) in Die Burger of 27 January 1981, the Groen flooded in March 1961.

During the ECRU survey, indications of previous higher water levels above those which existed at the time of the survey were noted. These included white salt deposits 15 cm above the water level, algal flakes 30 cm up, brown silt deposits on salt marsh vegetation 1,5 m up (possibly the 1961 flood) and the edge of well established terrestrial vegetation 1,7 m above the water level in the estuary.

During drought conditions, the estuary is fed by the previously mentioned springs situated about 2,5 km upstream of the mouth.

3.3 Obstructions :

(a) In the catchment

There are two large concrete bridges for the national road at Garies about 65 km upstream of the mouth. There are also five low level road crossings on the road from Garies to the Groen mouth. Agricultural lands and fences are situated in the riverbed between Garies and the estuary.

(b) Near the mouth

On the floodplain, approximately 2,5 km from the mouth, a level bulldozed area and a helicopter pad (Figs. 1 and 2) encroach on the wetland source of the estuary. There are also several buildings and a windmill on the floodplain which are liable to affect management decisions at times of flood.

After a visit to the Groen at the end of March 1981, Mr R Stauth of the University of Cape Town reported that bulldozers had cleared another area of wetlands adjacent to the helicopter pad.

3.4 Siltation :

At the time of the ECRU survey there were signs of silt deposition on the shoreline vegetation around the estuary up to 1,5 m above the water level at the time.

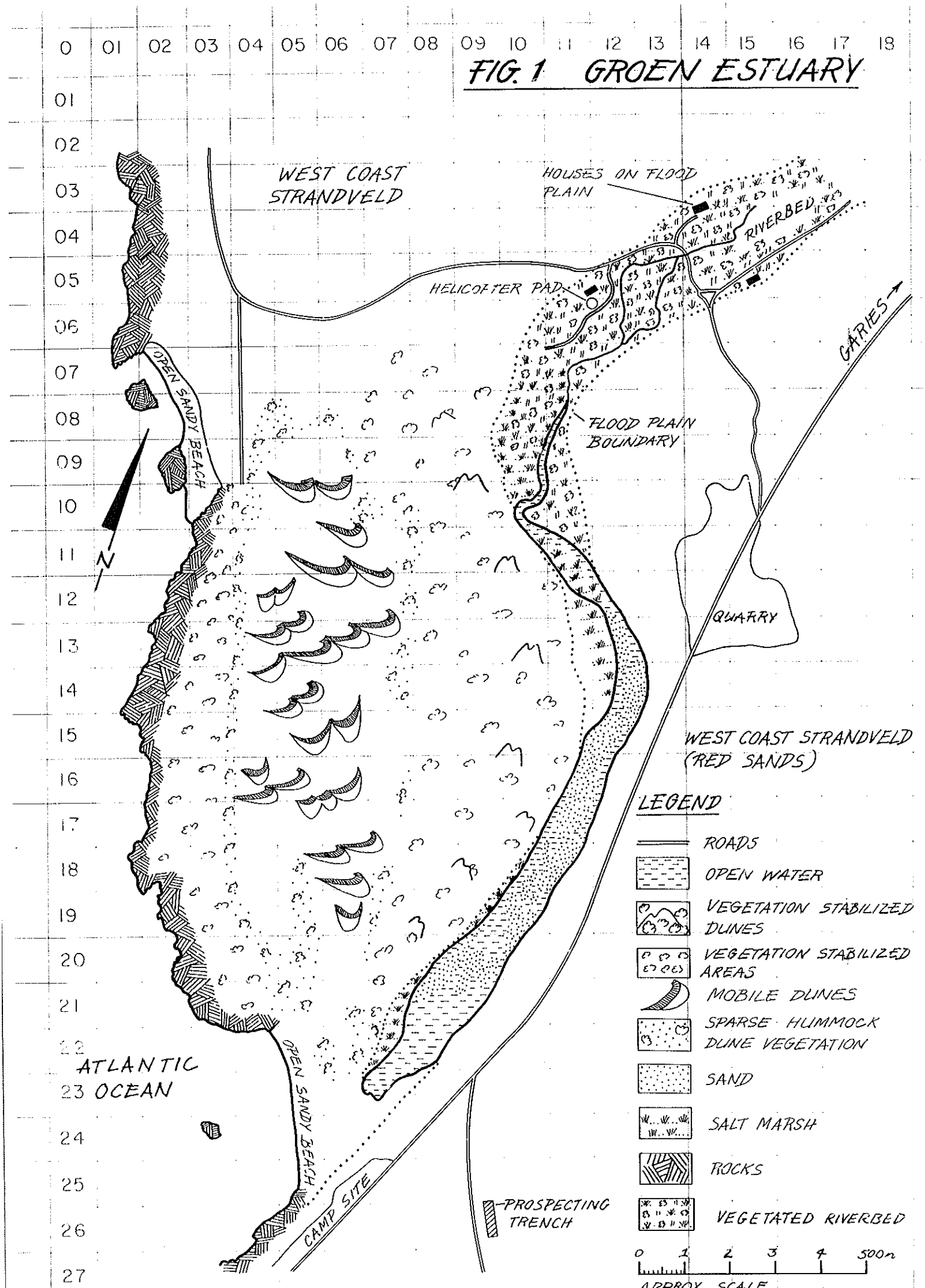
Most of the riverbed is firm sand or rock but covered by fine silt and organic debris apparently derived from decaying filamentous algae.

Salt had crystallized out around the margins of the estuary at the time of the ECRU survey.

At the top of the estuary 2 to 3 km upstream of the mouth, there is a raised floodplain (Figs. 1,2 and 3) 1,5 m above the riverbed, formed of brownish sand, through which two separate wider channels are cut. The southern bank at the foot of the slope has eroded banks up to 3 m high, of similar material. Dark grey clayey mud is present in the river channels. It is quite deep and sticky in the northern one.

During the ECRU survey there was no evidence of recent silt accumulation in the channels or lagoon, except for biogenic sludge

FIG. 1 GROEN ESTUARY



on the bottom. Eroded gravel from the road is being washed down to the lagoon. Serious erosion of the camping area is resulting in banks of silt and gravel being washed onto the beach. When the camping area is crowded, large amounts of dust are blown across the lagoon (Mr Cornelissen pers. comm.).

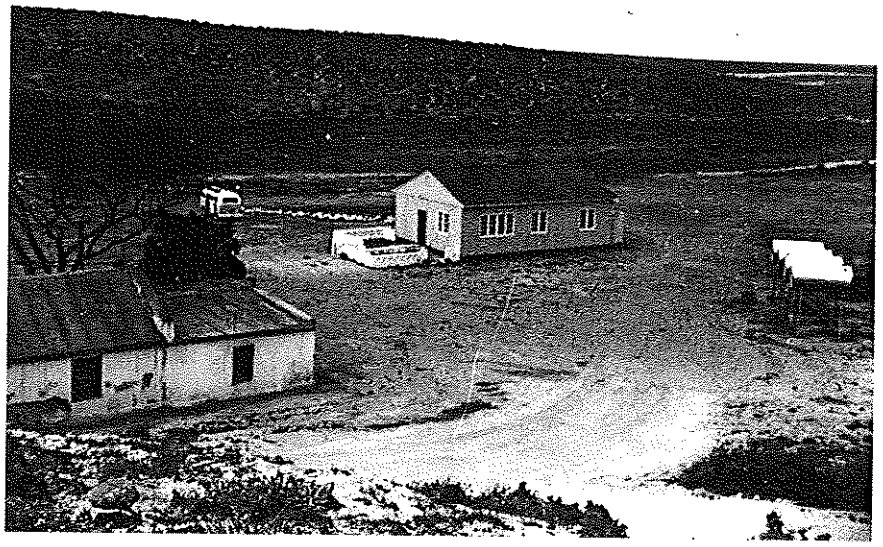


FIG. 2. Helicopter pad and associated buildings on floodplain approximately 2,5 km from the mouth. Fuel tanks can be seen on the right of the photo. (ECRU 80-10-21)

3.5 Landownership/use :

(a) Catchment

The catchment area is used for rough grazing and wheat farming. Many privately owned farm houses, sheds and windmills are situated in the river valley.

The Department of Water Affairs has prospected for water in the catchment.

(b) Around estuary

Mr Cornelissen has been farming the area around the Groen estuary on the farm Klipkuil since 1957. Much of the area is used for rough grazing of livestock. This farm is owned by De Beers Consolidated Diamond Mines.

Three farmhouses and the previously mentioned helicopter pad and associated store buildings are situated on the floodplain approximately 2,5 km from the mouth. North of the road near the head of the lagoon is a small gravel quarry, which was excavated for material for road repairs a few years ago. (Mr Cornelissen pers. comm.).

On the southern side of the mouth is the camping site (Fig. 4 & Plate II) which is on state land developed and controlled by the Namaqualand Divisional Council. Many corrugated iron "kleinhuisies",

rubbish drums, cement braai places and brightly coloured standing caravans largely dominated the campsite setting in an unsightly manner at the time of the ECRU survey. About 300 people camp at the Groen in season and fewer over long week-ends (Sweet pers. comm.). According to Mr Cornelissen, the number is a few hundred in season. Two water tanks at the campsite are kept supplied from 15 December to 15 January every year. The area is only serviced once a year by the Namaqualand Divisional Council on the grounds of high expense and low utilization (R Stauth pers.comm.).

Just to the south of the campsite, diamond prospecting was carried out on strips of land in July 1980 (Fig. 4).

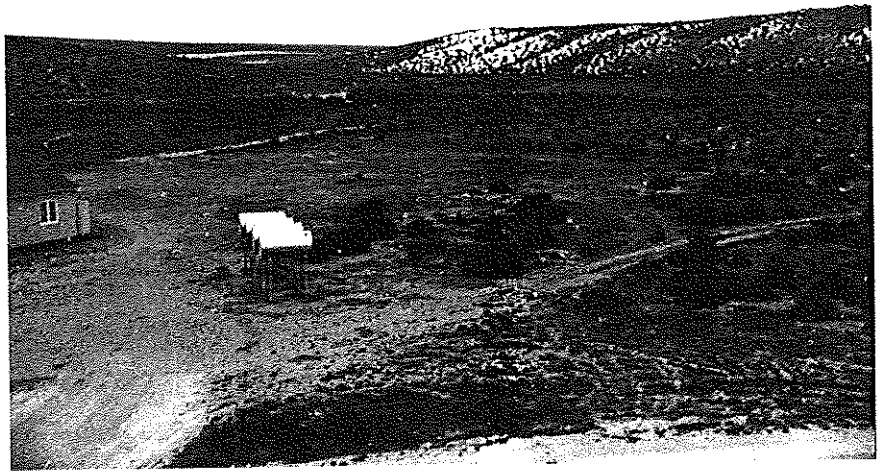


FIG. 3. Groen floodplain approximately 2,5 km from the mouth, looking downstream. The helicopter pad is on the left of the photograph , and the upper reaches of the estuary in the left background. (ECRU 80-10-21)

Series of 1,5 m diameter prospecting holes were drilled and refilled. De Beers Consolidated Diamond Mines attempted to reduce environmental damage to a mimimum by using this method. Diamond divers work on the adjacent coast and often camp in the vicinity of the Groen Estuary.

Kelp harvesting under permit is carried out over the coastal strip from the southern bank of the Groen in the north to the northern bank of the Olifants Estuary in the south. This activity has been reported to be causing a certain amount of damage to the environment in the concession area.

Extended strandloper midden deposits were seen on the dune plume north of the mouth during the ECRU survey.

An area encompassing the Groen estuary and the coastline northwards towards and including the Spoeg estuary, has been proposed as a Coastal Park and Reserve. In January 1980, people at the campsite circulated a petition against this because they did not wish to have their fishing activities restricted. At the time of writing, negotiations between De Beers Consolidated Mines and top Government Officials were in progress concerning this matter.

Beach buggies have been reported to be tearing up the dune vegetation in recent times (Mr Cornelissen pers. comm.) and the tracks of such vehicles were seen in the dunefields to the north of the estuary.

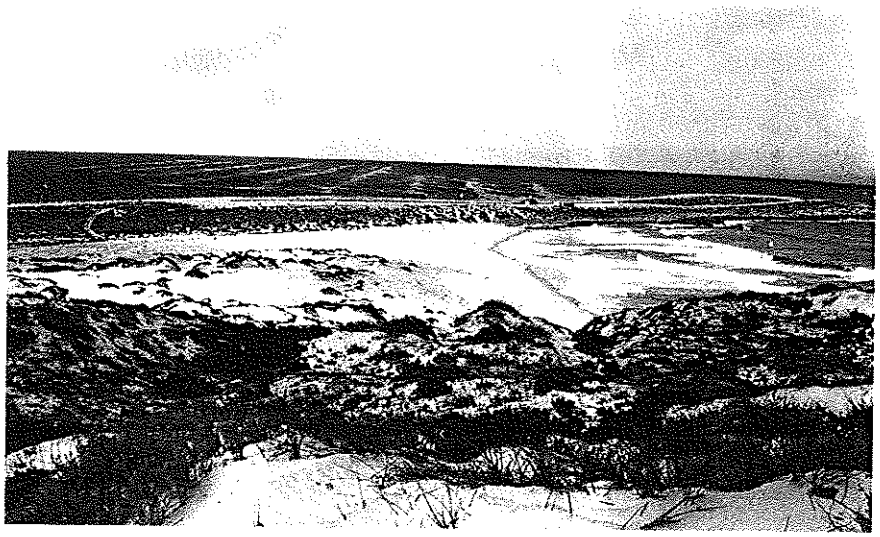


FIG 4. Groen mouth from the dune plume looking southwards. The campsite with cleared diamond prospecting strips behind can be seen in the background. (ECRU 80-10-21)

3.6 Local authority :

The Namaqualand Divisional Council administers the camping area, whilst the land surrounding the estuary falls under the jurisdiction of the Namaqualand Division of De Beers Consolidated Mines.

3.7 Estuary uses :

Fish netting. The local farmer and a diamond diver working in the area both claimed to have netted fish.

A net was seen in the estuary in 1978 (A le Roux pers. comm.).

Recreational angling and crayfishing during holiday periods.

3.8 Morphometry of the estuary :

Area

The total estuarine area (including the floodplain) up to 2,5 km from the mouth, is approximately 28 ha. The total open water area at the time of the ECRU survey was about 13 ha. (Fig. 1).

Shape (See Fig. 1)

The lagoon (Plate III) consisting of the lower part of the estuary is about 1000 m long and from 100 to 150 m wide. There is a winding channel leading off at the top end of the lagoon, which turns northwards and divides around an island. The eastern branch is about 30 cm deep and the western branch is shallower. At the time of the ECRU survey there was a small side channel with a hypersaline pool on the southern side about 1 km from the mouth. Beyond the island there is a big curve in the channel towards the north-east. The channel eventually divides into two narrower channels cut into the surrounding floodplain. The northern channel ends at the helicopter pad. The southern channel finishes in two pools with a dry gully extending beyond the road.

Bathymetry

The maximum depth was 1,5 m at the time of the ECRU visit. The deepest point was about 250 m from the mouth. Most of the north-eastern part of the lagoon was about 30 cm deep.

In the channels in the upper reaches of the estuary, the water was about 30 cm deep.

3.9 Geomorphology :

Geology

(After Coward (1981) unpublished)
The geology of the riverbed and inland catchment area is predominated by granites of the Namaqualand Natal metamorphic complex. Along the coast, these bedrock granites are overlain by unconsolidated sands with fluvial and terrestrial gravels, shells, limestone and calcrete cappings.

The Groen, as is the case with other Namaqualand rivers, has been incised into granite bedrock and can be seen as a small water course running down a wide shallow valley. The valley is filled with alluvium and rounded granite boulders. Granite outcrops can be seen in places in the valley and also along virtually the whole of the adjacent coastline.

Diamonds have been found in a terrace on the southern side of the Groen River, near its mouth on the farm, Klipkuil. The terrace lies from 9 to 14 m above the riverbed and is formed of coarse shingle containing water-worn boulders of granite and surface quartzite, up to 1 m in diameter.

Nature of bottom materials

See Table 1 and Fig 1 with overlay for substrate observations made during the ECRU survey.

A core taken to 70 cm at the edge of the lagoon at the mouth, revealed brownish-grey medium-grained sand, probably of marine origin.

Sandbar characteristics (See Fig. 4 and Plate 3)

At the time of the ECRU survey, the beach was about 40 m wide rising from the sea with a slope of 1:15 to the crest of the sandbar which was about 1 m above MHWS. The crest of the sandbar was about 1 m higher than the water level in the lagoon.

The total width of the sandbar from the edge of the lagoon to the sea was about 230 m and scattered over it were rounded stones and kelp.

Configuration of Adjacent Shore

There are rocky granitic points to the north and south of the 400 m long beach and an isolated reef about 200 m offshore of the middle of the beach (Fig. 1).

As with other Namaqualand river mouths, there is an extensive mobile dune plume of bare white quartzitic sand, stretching north-east from the sandbar area (Fig. 1).

3.10 Oceanography :

Major currents

The Namaqualand coastline is under the influence of the northward-flowing Benguela Current and the characteristic upwelling of cold nutrient-rich water of sub-Antarctic and South Atlantic origin. Upwelling is enhanced during summer, by the prevalence of southerly to south-easterly winds, which tend to move inshore surface water away from the coast, thereby making room for the deeper-lying cooler water (Heydorn and Tinley 1980).

The influence of the Benguela Current, combined with predominantly southerly winds, is largely responsible for the cool climate at the coast and the prevalence of fog during the nights and in the mornings.

Waves

The prevailing swells are generated in the South Atlantic and approach the West Coast, predominantly from a south-westerly or south south-westerly direction. They reach a height of over 1,6 m for 50 percent of the time in the nearshore area, as measured at Oranjemund, approximately 280 km to the north of the Groen (J Rossouw pers. comm.). Wave frequency at Buchu Bay, approximately 253 km to the north of the Groen is 10 - 15 seconds for 95 percent of the waves (Ashby, Harper and Van Schaik 1973).

The wave and swell patterns of the West Coast play a major role in the longshore distribution of marine sediments, erosion and deposition phenomena and hence also in beach and dune formation (Tankard and Rogers 1978).

Surf zone currents

At the time of the ECRU survey, there were several rotating cells of water in the arcuate bay at the mouth. These cells gave rise to drift currents moving northwards and southwards from the middle of the bay close and parallel to the beach. These drifts fed into rip currents moving seawards past the rocky promontories on the northern and southern sides of the bay as well as on either side of the reef in the centre of the bay situated about 200 m off the beach.

Tides

The ECRU survey was carried out approximately midway between neap and spring tides. High tides were at 00h04 and 12h32 on 20 October 1980 and at 00h56 and 13h18 on 21 October 1980. Low tides were at 06h21 and 18h47 on 20 October 1980 and at 07h05 and 19h31 on 21 October 1980.

Tidal levels in 1980 for Port Nolloth (189 km north of the Groen 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 and between LAT and HAT of 2,24 m (South African Tide Tables 1980).

3.11 Physico-chemical characteristics :

Apart from data collected by the ECRU on 20 October 1980 the only previous information was that in a report by Professor J R Grindley based on observations in January 1979. Additional observations were made by ECRU personnel in February 1981 and R Stauth of the University of Cape Town at the end of March 1981. These data are presented in Tables 1 and 2 overleaf.

These values represent stages (See Fig. 6) in changing conditions during a no-flow situation which is likely to be prevalent in the Groen for prolonged periods. During flow periods, which are infrequent, the estuary is flushed with freshwater with a corresponding lowering of salinity. When the mouth is breached during floods, sea water probably enters the lagoon once the level has dropped and the estuary becomes tidal, until such time as the mouth is closed by marine sediments. During no-flow periods, evaporation over the large shallow lagoon (Plate III) results in a steady escalation of salinity with time. It is during these periods, that the lagoon is fed by the springs situated on the floodplain about 2,5 km from the mouth. These springs are, however, unable to compensate for the evaporative water loss and there is a net reduction in water volume with a corresponding rise in salinity in the lagoon.

This situation was born out when A E F Heydorn and T J E Heinecken paid a fleeting visit to the Groen on 11 February 1981 with a party of Government Officials. At this time the salinity at the mouth of the lagoon (Grid Ref. 2306) was 117 parts per thousand, at the head of the lagoon (Grid Ref. 1512) 115 parts per thousand, at the spring in the northern channel (Grid Ref. 0512) 47 parts per thousand, and at the spring in the southern channel (Grid Ref. 0613) 6 parts per thousand. When R Stauth visited the Groen at the end of March 1981 the salinity in the lagoon had further risen to 125 parts per thousand and much salt had crystallized out at the water's edge.

The springs on the floodplain do, however, appear to maintain the upper reaches of the estuary in a biologically viable condition, particularly in the southern channel (Grid Ref. 0613) where the salinity did not rise from October 1980 (7-8 parts per thousand) to February 1981 (6 parts per thousand). During this period salinities lower down in the lagoon increased by up to 45 parts per thousand.

Nutrients

The high oxygen levels (Table 2) measured throughout the estuary during the ECRU survey were probably due to dense concentrations of algae and phytoplankton resulting from eutrophication. Eutrophication is probably a feature of the Groen during no-flow periods when concentration of nutrients results from net evaporative water loss and a consequent reduction in water volume in the system.

TABLE 1 : Physico-chemical data collected by Prof J R Grindley in January 1979.
See Fig. 1 with overlay for grid references.

Date		79-01-10	79-01-10	79-01-10	79-10-10	79-01-10	79-01-10	79-01-10
State of mouth		C L O S E D						
ECRU Grid Ref.		2306	2208	1811	1512	1412	1111	0612
Position of Sampling site		At mouth	200m from mouth S.bank	700m from mouth S.bank	1 km from mouth S.bank	1,1km from mouth S.bank	Middle reaches of estuary	Uppermost reaches of estuary
Diss. O_2 (mg/ℓ)	Top	5,0	8,8	12,0	No data	4,2	No data	7,8
	Bottom	2,9	8,6	11,5	No data	3,5	No data	10,4
Surface Salinity (°/₀₀)		118	95	91	44	29	18	12
Surface Temp. (°C)		27,0	27,0	33,0	24,2	27,0	28,5	29,5

TABLE 2 : Physico-chemical data collected during the ECRU survey. See Fig. 1 with overlay for grid references.

Date		80-10-20	80-10-20	80-10-20	80-10-20	80-10-20
Time		13h00	18h00	17h00	15h00	15h15
State of mouth		C	L O S E	D		
State of tide		Just turning to outgoing, high at 12h32	About to turn to incoming. Low at 18h47	Outgoing Low at 18h47	Outgoing, high at 12h32	Outgoing high at 12h32
ECRU Grid Ref.		2108	1512	1111	0613	0512
Position of Sampling site		300 m from mouth on south bank	1 km from mouth on south bank	Middle reaches of estuary	Uppermost reaches of water in est.S.channel	Uppermost reaches of water in est.N.chan.
Depth (m) at Sampling site		From shore out 0,2 - 1,5	0,5	0,4	0,2	0,2
*Width (m)		150	100	10	2-3	2-3
Diss. O_2	Top	9,1	11,4	12,3	Variable 26,0-14,6	No data
(mg/ℓ)	Bottom	6,7	10,5	21,4	No data	No data
Salinity	Top	66	65	47	7-8	10
(‰)	Bottom	70	66	56	7-8	10
Temp.	Top	21,3	20,8	24,7	24,6-27,6	No data
(°C)	Bottom	21,3	21,0	27,0	24,6-27,6	No data
pH		7,0	No data	8,0	7,0	No data
Secchi disc transparency (m)		0,5	0,2	0,3	Greater than water depth	Greater than water depth
Water colour		Olive green	Dark brown due to flamingo disturbance	Olive green	Slightly greenish	No data
Substrate		Sandy at edge. Black mud ± 4m out	Medium-grained black anoxic sand	Medium.coarse gr. sand with black anoxic layers	Fine black anoxic silt	No data

* Estuary/River width at sampling site.

Other nutrients

No data.

3.12 Pollution :

Sewage, Oil, Metals, Pesticides, Herbicides and other forms of pollution

There was no evidence of pollution due to any of the above factors at the time of the ECRU survey.

No other data are available.

3.13 Public health aspects :

Bacteriology

No data.

Others

No data.

4. BIOTIC CHARACTERISTICS

Little previous information on the plant and animal life of the Groen Estuary could be found. The observations below, made by the ECRU during its two-day visit are superficial, but nevertheless give an indication of the importance of the range of animal and plant life of this wetland in an otherwise arid environment. This initial survey should be followed up with a more detailed one at a later stage.

4.1 Flora :

Phytoplankton/diatoms

During the ECRU survey Prof J R Grindley took a plankton sample near the mouth (Grid Ref. 2108) which is yet to be analysed. At the time, olive green water was recorded throughout the estuary. This would suggest the presence of phytoplankton.

Aquatic vegetation

(a) Estuary

Filamentous algae were observed throughout the estuary during the ECRU survey. With the strongly saline conditions in the lagoon in March 1981, there had been considerable mortality of algae as indicated by a strong smell of hydrogen sulphide (R Stauth pers. comm.).

Beds of the aquatic grass Potamogeton pectinatus were present in the southern channel about 2,5 km from the mouth (Grid Ref. 0613) during the ECRU survey. This aquatic macrophyte, which is intolerant of moderate salinities (greater than about 30 parts per thousand, (Day 1981b)) is probably only able to survive in the Groen due to the moderating influence of spring water on the salinity in the upper reaches.

(b) Adjacent shoreline

The kelp Ecklonia maxima occurs in the nearshore region on the shoreline adjacent to the Groen mouth and kelp plants are washed up on the beach in substantial numbers. Other marine algae noted during the ECRU survey were :

Ulva sp., Enteromorpha sp., Caulacanthus divaricatus, coralline algae.

Semi-aquatic vegetation

Sarcocornia natalense formed a carpet on the northern bank near the mouth and Sarcocornia pillansii fringed the bank and spread around the upper channels of the estuary and occasionally elsewhere (See Fig. 5) at the time of the ECRU survey and also in January 1979 (Grindley 1981).

The upper channels also contained small cyperaceae near the top and were fringed with Juncus acutus (See Fig. 5). This latter species was also present in places along the edges of the lagoon.

Terrestrial vegetation

(Contribution by Miss R Parsons, Botanical Research Institute, and Miss A le Roux, C.P.A. Department of Nature and Environmental Conservation).

This region falls into Acocks Veld Type 34(b), Strandveld Proper, which is an open, semi-succulent scrub (Acocks 1975).

On the northern side of the mouth there are extensive sand dunes stabilized to a large extent by the vegetation, one of the dominant species being Eragrostis cyperoides. There was more water in the estuary at the time of the survey than there had been when the Aerial Photography, Job No. 326 of 1979 was taken. Thus some of the areas mapped as open sand were under water at the time of the ECRU survey (where possible this has been corrected). Parts of the water surface were completely covered by a yellow-green filamentous algae which formed a dense mat.

Eighteen main vegetation mapping units were identified and their spatial distribution may be seen in Fig. 5. The species composition and physical features of each mapping unit is shown in Appendix I. Only dominant species were listed. The Ruschia sp. (Le Roux and Parsons 64)* Dwarf Shrubland had the lowest cover with a total cover of only 1 percent while the Sarcocornia spp Saltmarsh had the highest cover (100 percent). The average cover of the vegetation appears to be between 30 and 40 percent. This low cover is indicative of the arid environment. The vegetation mapping unit with the highest species diversity was found on stable white sand just above the rock front to the north of the mouth (Othonna sp. (Le Roux and Parsons 78)/ Limonium equisetinum / Chrysocoma sp. (Le Roux and Parsons 79) Dwarf Shrubland). This is probably a type of Succulent Karoo, with 15 species being recorded here. The Eragrostis cyperoides Hummock Dune Grassland had the lowest species diversity with only 1 species recorded. The 18 mapping units can be consolidated into four main plant formations : grassland, dwarf shrubland(height less than 0,25 m), low shrubland (height 0,25 - 1,0 m) and saltmarsh. Of these the low shrubland was the most extensive, covering an area of about 68,50ha, followed by dwarf shrubland (9,16 ha), grassland (8,37ha) and saltmarsh(6,03 ha) out of the total area of 135,66ha studied.

Although there are disturbances such as diamond prospecting, a camping site and gravel pits in the area, the vegetation in the immediate vicinity of the river appears to be in good condition. The two communities on the southern side of the mouth just below the camping site show signs of disturbance. Gravel from the camping site has washed into them and erosion furrows have formed. This could eventually lead to the elimination of these communities. Trampling could also be a problem in these two communities.

* Le Roux and Parsons species numbers e.g. Le Roux and Parsons 64, refer to specimens unidentified by the B.R.I. at the time of writing.

Another disturbing factor was vehicle tracks in the dune area to the north of the mouth. If vehicles are allowed in this region they could have serious consequences for the vegetation. This vegetation is very important for the stabilization of the dunes and once destroyed it would be very difficult to re-establish.

Upstream in the Zygophyllum morgsana Low Shrubland and the Drosanthemum sp. (Le Roux and Parsons 4) Low Shrubland ,the previously mentioned buildings are situated in the riverbed. Except for the immediate vicinity of the buildings where the vegetation has been cleared and Eucalyptus trees planted, there appears to be relatively little disturbing effect on the vegetation.

4.2 Fauna :

Note : As mentioned at the beginning of Section 4, only cursory observations were possible during the ECRU survey and the lists below should not be interpreted as being representative of all animals in the habitats mentioned.

Zooplankton

As mentioned under Section 4.1, a plankton sample, which is yet to be analysed, was taken by Prof. J R Grindley during the ECRU survey. Previous samples taken during a midsummer period revealed the presence of 6 species with a dry biomass of 8,5 mg/ m^3 (Grindley 1979).

Fauna on

(a) Hard substrates

The following intertidal animals were found to be abundant on the adjacent shoreline, living on the rocks:

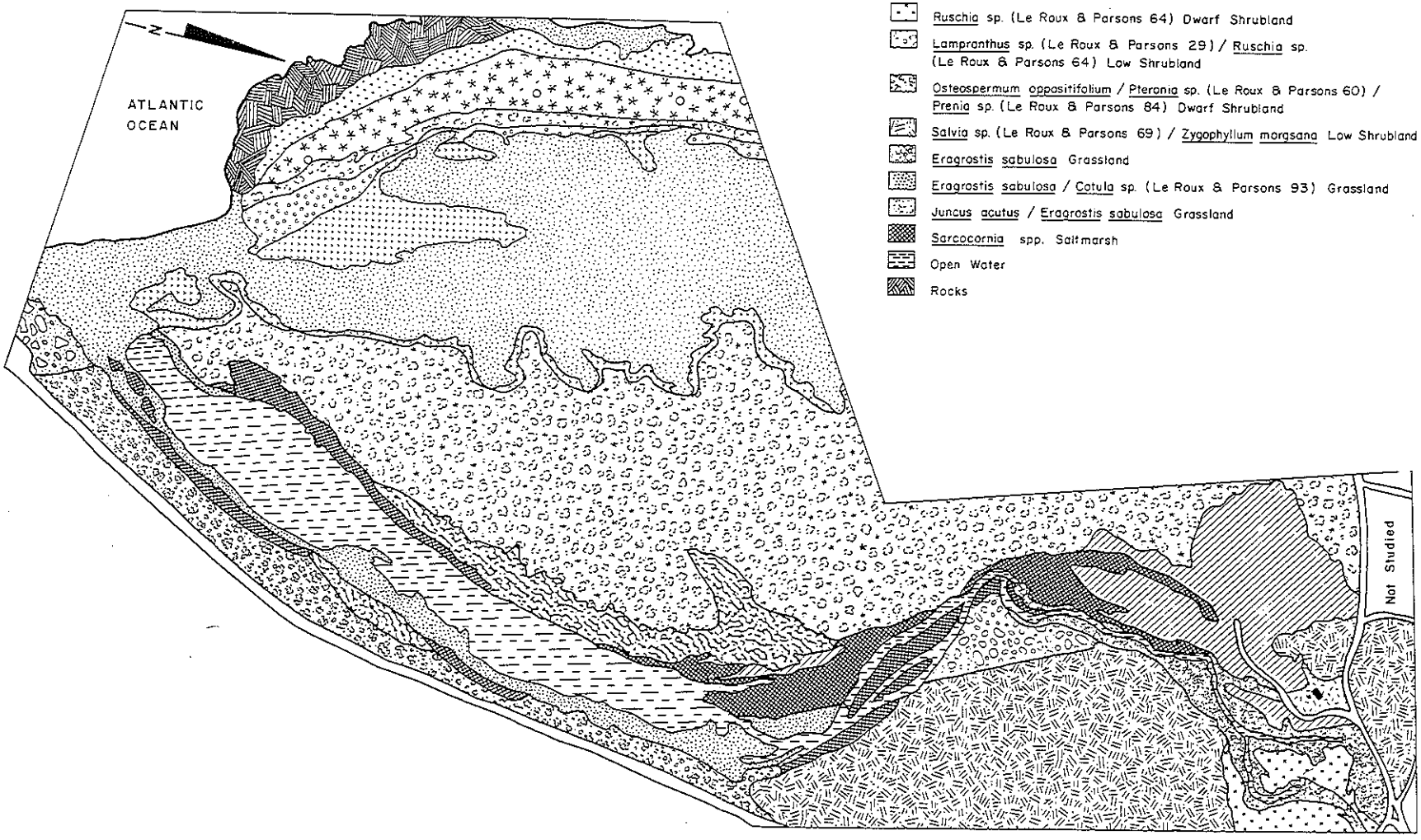
Crumb-of-bread sponge	Hymeniacedon perlevis
Cape reef worm	Gunnarea capensis
Spiny lobster	Jasus lalandii
Black mussel	Choromytilus meridionalis (very few)
Ribbed mussel	Aulacomya ater
Blue periwinkle	Littorina africana
Periwinkles	Oxystele variegata
	O. tigrina
Whelks	Argobuccinnum argus
	Burnupena delalandii
Limpets	Patella miniata
	P. granitina
	P. granularis
	P. argenvillei
	P. compressa
	P. cochlear
Starfish	Patiriella exigua
Red bait	Pyura stolonifera

(b) Soft substrates

The following intertidal animals were found to be common on the sandy beach at the mouth of the Groen :

Isopod	Tylos granulatus
Sandhoppers	Talorchestia sp.

FIG. 5: Vegetation mapping units of the Groen Estuary
Approximate scale — 1: 6 400



LEGEND

- Roads
- Beach & Open Sand
- Eragrostis cyperoides Hummock Dune Grassland
- Eragrostis cyperoides / Arctotheca populifolia Grassland
- Lebeckia cinerea / Lycium sp. (Le Roux & Parsons 3) Low Shrubland
- Eragrostis cyperoides / Lebeckia cinerea Low Graminoid Shrubland
- Othonna sp. (Le Roux & Parsons 78) / Limonium equisetinum / Chrysocoma sp. (Le Roux & Parsons 79) Dwarf Shrubland
- Drosanthemum sp. (Le Roux & Parsons 4) Low Shrubland
- Osteospermum oppositifolium Low Shrubland
- Eragrostis cyperoides / Tetragonia decumbens Low Graminoid Shrubland
- Zygophyllum morgsana Low Shrubland
- Ruschia sp. (Le Roux & Parsons 64) Dwarf Shrubland
- Lampranthus sp. (Le Roux & Parsons 29) / Ruschia sp. (Le Roux & Parsons 64) Low Shrubland
- Osteospermum oppositifolium / Pteronia sp. (Le Roux & Parsons 60) / Prenia sp. (Le Roux & Parsons 84) Dwarf Shrubland
- Salvia sp. (Le Roux & Parsons 69) / Zygophyllum morgsana Low Shrubland
- Eragrostis sabulosa Grassland
- Eragrostis sabulosa / Cotula sp. (Le Roux & Parsons 93) Grassland
- Juncus acutus / Eragrostis sabulosa Grassland
- Sarcocornia spp. Saltmarsh
- Open Water
- Rocks

A four minute (200 m) "D" net haul in the lagoon (Grid Ref. 2108) during the ECRU survey did not yield any fauna.

During the ECRU survey, Mr Cornelissen mentioned that he had attempted to introduce burrowing prawns (either Callianassa or Upogebia into the estuary. No signs of either species could be found either in the sandy substrates at the mouth or elsewhere in the estuary. It is unlikely that either species would be able to survive the unstabl conditions found in the Groen, for any length of time.

Several freshwater crabs (Potamonautes perlatus) were seen in the Potamogeton beds in the southern channel (Grid Ref. 0613) at the head of the estuary. The occurrence of these crabs emphasized the value of the alleviating influence of the springs on the salinity in the upper reaches.

(c) Vegetation

No fauna was noted on the vegetation during the ECRU survey.

Insects

Several Tenebrionid beetles were seen around the estuary during the ECRU survey.

Other invertebrates

Cuttlefish shells (Sepia officianalis and Sepia sp.) were found on the adjacent shoreline and the dried shells of terrestrial snails and millipedes were seen around the estuary during the ECRU survey.

Fish

Gill netting in the lagoon near the mouth (Grid Ref. 2108) over a 23 hour period yielded 9 mullet. The catch consisted of 2 Mugil cephalus (Total length (T.L.) = 26,0 cm and 44,5 cm) and 7 Liza richardsoni (T.L. = 23,0 cm, 24,0 cm (2), 25,0 cm(2) and 27,0 cm) Day, Blaber and Wallace (1981) give the recorded salinity ranges for these two species as being : M. cephalus, 5,2 - 70 parts per thousand; L. richardsoni, 5,6 - 59,4 parts per thousand. As the salinity in the lagoon at the time was between 66 and 70 parts per thousand, it is unlikely that either species survived for very long after the ECRU survey. Surprisingly no dead mullet were found during the survey. A four minute (200 m) "D" net haul in the same area yielded no fish.

The size ranges of fish obtained by Prof J R Grindley in January 1979 were Mugil cephalus : 33,5-40,0 cm. Liza richardsoni: 21,0-25,5 cm. The greater lengths recorded during ECRU survey presumably represent growth during the intervening 21 months.

Clinid fish inhabit the rock pools on the adjacent rocky shoreline.

Reptiles and Amphibians

During the ECRU survey many sand lizards and the tracks of a snake were seen in the dunes. Barking geckos were heard in the catchment area in the early evening.

In February 1981 during a brief visit to the Groen, T J E Heinecken of the ECRU collected a sub-adult dune lizard (Agama hispida hispida) at the campsite.

The small tortoise Homopus signatus occurs in the rocky environment at the rivermouth (J C Greig pers. comm.).

Birds

The following birds were recorded for the Groen Lagoon and the area up to 1 km upstream of the lagoon, by Prof J R Grindley (11 January 1979), J Cooper, Percy Fitzpatrick Institute of Ornithology, (in litt; for 19 January 1980) and during the ECRU survey (20 October 1980).

Roberts No.		Number seen 79-01-11 (J R Grindley)	80-01-19 (J Cooper)	80-10-20 (ECRU)
5	Black-necked Grebe	-	12	10
6	Cape Dabchick	-	4	1
47	White breasted Commorant	-	5	3
48	Cape Commorant	-	-	1
54	Grey Heron	-	1	4
86	Greater Flamingo	-	49	282
87	Lesser Flamingo	-	-	13
89	Egyptian Goose	-	-	1
90	South African Shelduck	4	2	2
94	Cape Shoveller	-	1	-
96	Yellow-billed Duck	-	12	-
98	Cape Teal	30	34	38
169	Black Harrier	-	-	2
212	Red-knobbed Coot	4	72	50
233	Ringed Plover	-	7	2
235	White-fronted Sandplover	3	5	8
236	Chestnut-banded Sandplover	3	-	-
237	Kittlitz's Sandplover	-	6	2
238	Three-banded Sandplover	-	18	3
241	Grey Plover	-	1	-
245	Blacksmith Plover	-	5	4
251	Curlew Sandpiper	106	73	32
253	Little Stint	25	61	3
255	Sanderling	-	1	10
256	Ruff	-	9	3
258	Common Sandpiper	1	-	2
262	Marsh Sandpiper	-	5	-
263	Greenshank	8	2	3
264	Wood Sandpiper	-	1	-
269	Avocet	19	24	3
270	Black-winged Stilt	5	9	2
287	Southern Black-backed Gull	-	-	6
290	Caspian Tern	1	-	-
306	White-winged Black Tern	3	3	-
493	European Swallow	12	-	-
509	African Sand Martin	4	-	-
686	Cape Wagtail	5	9	8

The species composition of the January and October 1980 counts are similar but fewer species were present in January 1979 when water levels were higher and a smaller area of mudflats was exposed.

Terrestrial birds seen around estuary

105	Secretary Bird
123	Cape Rock Kestrel
506	Rock Martin
525	Grey Tit
566	Karoo Chat
722	Bokmakierie
746	Pied Starling
786	Cape Sparrow
873	Cape Bunting
866	Yellow Canary

Additional terrestrial species recorded in March 1981 by R Stauth.

Roberts No.	Species
318	Namaqua Dove
522	Pied Crow
576	Stone Chat
785	Great Sparrow
799	Cape Weaver

R Stauth also reported having seen 330 flamingoes (Lesser and Greater) in several early morning flights, flying from the north towards the south. The largest flock contained over 100 birds and 6 Greater Flamingoes and 1 Lesser Flamingo landed in the lagoon, but stayed for only a short while, before departing in a southerly direction.

Mammals

During the ECRU survey, the local farmer, Mr Cornelissen, reported that the Cape Wild Cat (Felis lybica) and the Caracal (Felis caracal) were common in the area. He mentioned that from time to time both of these species cause problems with his livestock.

Large numbers of field mice (possibly the Striped Mouse Rhabdomys pumilio) were seen at the campsite at the mouth during the ECRU survey.

Tracks of both Steenbok (Raphicerus campestris) and water mongoose (Atilax paludinosus) were seen around the estuary and there were concentrated Water Mongoose tracks on the banks of the upper part of the lagoon (Grid Ref. 1512).

5. SYNTHESIS

The state of knowledge of the Groen is poor. The area, being remote, has received little attention in the past and the bulk of information in this report originates from the ECRU survey.

Although the Groen flows infrequently, probably once in about five years, surface water is always present in the estuary, even during dry periods and often when river mouths on the coastline between the Groen and Orange, 267 km to the north, are dry. The water body in the estuary appears to be partially maintained during dry periods, by springs situated in the upper reaches of the estuary on the flood-plain.

The occurrence of perennial water at the Groen makes it an important wetland habitat on the Namaqualand Coast. During the ECRU survey, this was evident from the diversity and abundance of aquatic bird life recorded there, relative to the five estuaries lying to the north along the 200 km stretch of coastline between the Groen and Holgat rivers. Twenty seven species of water-associated birds were seen at the Groen. These included both species of flamingo of which there was a large mixed flock of 295 birds feeding in the lagoon (Plate III). The Spoeg and Buffels were the only other estuaries to the north where substantial bird numbers were recorded.

Excessive salinity due to evaporation in the lower reaches of the closed estuary after an extended no-flow period does, however, place a severe environmental constraint on the biological viability of the system. Day and Grindley (1981), as well as other authors, have documented the marked reduction in species richness of both the flora and fauna of estuaries, when salinities have risen above 60 parts per thousand. Salinities in the lower parts of the Groen escalated from 66 parts per thousand in October 1980, to 125 parts per thousand in March 1981. It would appear that excessively saline conditions which occur periodically in the lower reaches, can only be alleviated by river run-off. Very little aquatic life is able to survive in salinities of the order of 125 parts per thousand. Such extreme saline conditions do, however, appear to be moderated in the upper reaches of the estuary, by the diluting effect of the springwater, thereby emphasizing the importance of the wetland source to the system. A representation of a generalized hydrological cycle for the Groen Estuary, based on the minimal available information, can be seen in Fig. 6 overleaf.

The reduction in salinity from 118 parts per thousand to 70 parts per thousand, between January 1979 and October 1980, combined with a lowering of water level through evaporation, is at first puzzling. However, on comparison of the data in Tables 1 and 2 it can be seen that in January 1979 the dense weed barrier in the middle of the lagoon was separating water masses of different salinity. Salinities at the mouth end ranged from 91 - 118 parts per thousand while upstream of the weed barrier, salinities ranged from 18 - 44 parts per thousand. Mixing processes after the eventual breakdown of the weed barrier apparently led to the salinity gradient from 47 - 70 parts per thousand in October 1980. Further evaporation in succeeding months led to the hypersaline conditions in March 1981.

The siting of farm houses and outbuildings and the establishment of the level area incorporating the helicopter pad with refuelling tanks (Fig. 2) and more recently an area bulldozed on the wetlands in the lower reaches of the river, are likely to create recurring problems when the river comes down in flood. The importance of protecting floodplains and their associated wetlands from the inroads of development, has been mentioned by many authors in the past, but has more recently been emphasized by Heydorn and Tinley (1980). In the case of the Groen, the wetlands have four major functions. They serve:

(a) to contain floodwaters and silt during episodic floods.

(b) as a source of freshwater during no-flow periods.

(c) as a source of organic detritus on which the estuarine foodweb is based.

(d) as an "oasis" in an arid area, making the Groen a particularly important area for water-associated birds traversing the Namaqualand Coast.

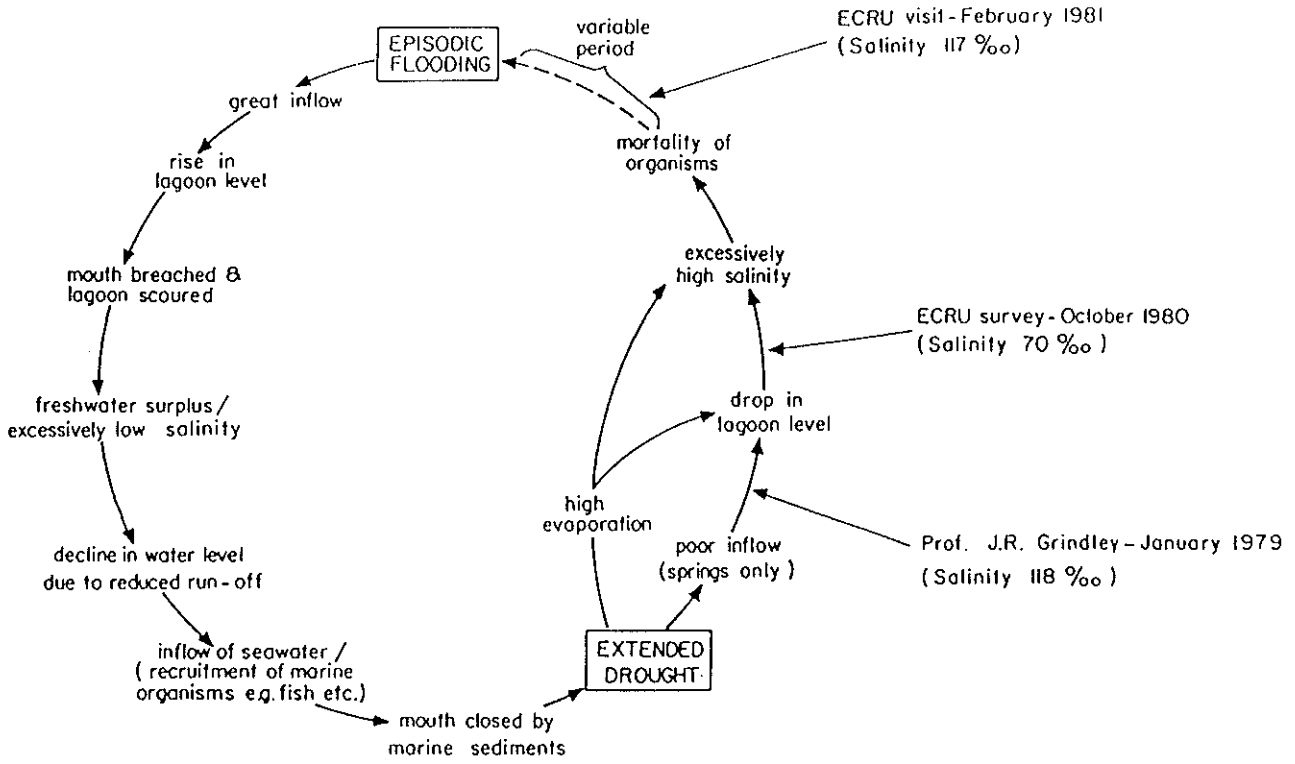


FIG. 6. Generalized hydrological cycle for the Groen Estuary. The time periods for the completion of one cycle would depend on the frequency and degree of episodic flooding. The stages in the cycle at which the Groen was visited by the ECRU are indicated.

The existence of the Groen as a biologically viable estuary (when salinity permits), is therefore largely dependent on the wetlands. For this reason and also because the Groen is one of the few Namaqualand estuaries incorporating a well-established wetland, any further development of this exceptionally important area should be curtailed.

In 1961 a flood covered the floodplain and reached 0,8 m up the walls of a farmhouse situated on the floodplain (Plate I). In 1974 floodwaters almost reached the same house. In both of these floods, the rivermouth opened naturally. However, just before flooding, attempts

to open the mouth artificially, have been made by the local farmers, whose property and crops are threatened by the rising waters (Mr Cornelissen pers. comm.). This is ecologically deleterious, as breaching of the sandbar not only prevents the water from spreading naturally amongst the wetland fringe areas, but also from building up to a level which would enable scouring to take place.

At the time of the ECRU survey, the visual impact of the camping site and access road, detracted from the aesthetic appeal of the estuary and its surroundings. Better servicing of the present facilities would improve but not resolve this situation.

With the exception of the disturbance of the wetlands at the head of the estuary and recent diamond prospecting just south of the mouth, the Groen is as yet relatively undisturbed by mining operations. Coastal Park status has been proposed for the Groen Estuary and its adjacent coast to the north. This matter is receiving attention at top Government level. The Namaqualand Division of De Beers Consolidated Mines is playing a key role in this context and special mention is made of their outstanding co-operation during the ECRU survey and in subsequent discussions about the establishment of a Coastal Park. Such a park would preserve an important part of the last remaining undisturbed sections of the Namaqualand coastline, whilst at the same time offering an outstanding recreational and educational facility on the Namaqualand Coast.

6. ACKNOWLEDGEMENTS

The collection of field data for this report was essentially a team effort and the assistance of the other members of the ECRU survey team is acknowledged. De Beers Consolidated Mines granted permission for the survey to be carried out in areas under their jurisdiction and as already mentioned, have assisted in every other possible way. This is deeply appreciated.

Thanks are due also to Mrs A Mauve of the Botanical Research Institute for identifying the aquatic grasses, Prof M Smith of the J L B Smith Institute of Ichthyology for identifying the mullet specimens and Mr R C Boycott of the Cape Department of Nature and Environmental Conservation for identifying the dune lizard. Mr J Cooper of the Percy Fitzpatrick Institute very kindly supplied unpublished bird census data. Information from Prof J R Grindley's report on observations in January 1979 has been incorporated in this report.

The report cover is based on the one designed by Dr K L Tinley for Part I of the Cape Estuaries series. Thanks are also due to Miss Ronel Nel and the girls of the NRIO drawing office for the preparation of the figures, Mrs S Armbruster for typing this report and Mrs H Heydorn for literature reviews and proof-reading.

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7. GLOSSARY OF TERMS USED IN PART II REPORTS

abiotic: non-living (characteristics).
aeolian (deposits): materials transported and laid down on the earth's surface by wind.
alien: plants or animals introduced from one environment to another, where they had not occurred previously.
alluvium: unconsolidated fragmental material laid down by a river or stream as a cone or fan, in its bed, on its floodplain and in lakes or estuaries, usually comprised of silt, sand or gravel.
anaerobic: lacking or devoid of oxygen.
anoxic: the condition of not having enough oxygen.
aquatic: growing or living in or upon water.
arcuate: curved symmetrically like a bow.
barchanoid (dune): crescent-shaped and moving forward continually, the horns of the crescent pointing downwind.
bathymetry: measurement of depth of a water body.
benthic: bottom-living.
berm: a natural or artificially constructed narrow terrace, shelf or ledge of sediment.
bimodal: having two peaks.
biogenic: 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 °/₀₀.

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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{GROEN RIVER} Colour. Job No. 326. Photo nos. 87/4, 88/4, 89/4, 90/4. Dept. of Land Surveying, Univ. of Natal 1:10 000, 1979
{GROEN RIVER} Bl. & Wh. Job No. 348, Photo no. 69. Dept. of Land Surveying, Univ. of Natal. 1:20 000, 1980.

APPENDIX I Overleaf

APPENDIX I

Species composition and physical features of the vegetation mapping units of the Groen Estuary.

	Eragrostis cyperoides Hummock Dune Grassland	*Eragrostis cyperoides/Arctotheca populifolia* Grassland	*Eragrostis cyperoides/Tetragonia decumbens* Low Graminoid Shrubland	*Lebeckia cinerea/Lycium* sp. (Le Roux & Parsons 3) Low Shrubland	*Eragrostis cyperoides/Lebeckia cinerea* Low Graminoid Shrubland	*Othonna* sp. (Le Roux & Parsons 78) *Limonium equisetinum/Chrysocoma* sp. (Le Roux & Parsons 79) Dwarf Shrubland	*Drosanthemum* sp. (Le Roux & Parsons 4) Low Shrubland	*Osteospermum oppositifolium* Low Shrubland
Total Cover (%)	20	15	35	45	40	35	30	40
Height (m)	0-0,50	0,-0,50	0-0,30	0-0,75	0-0,50	0-0,20	0-0,50	0-0,
Area (ha)	4,59	1,46	0,69	33,71	4,87	2,25	6,79	4,
% of Area studied	3,38	1,08	0,51	24,85	3,59	1,66	5,01	3,
Eragrostis cyperoides	*	*	*	*	*			
Arctotheca populifolia		*		*				
Tetragonia decumbens			*					
Carpobrotus edulis			*					
Chrysanthemoides monilifera			*					
Lebeckia cinerea			*	*	*	*		
Helichrysum sp. (Le Roux & Parsons 75)				*				
Pharnaceum microphyllum				*				
Euclea sp. (Le Roux & Parsons 36)				*				
Conicosia sp. (Le Roux & Parsons 74)			*	*	*	*		
Trachyandra divaricata				*	*	*		*
Atriplex bolusii				*	*	*		
Arctotis decurrens					*			
Lampranthus sp. (Le Roux & Parsons 81)					*			
Psilocaulon sp. (Le Roux & Parsons 6)					*	*	*	
Hypertelis angrae-pequenae					*	*	*	
Othonna sp. (Le Roux & Parsons 78)						*		
Limonium equisetinum						*		
Chrysocoma sp. (Le Roux & Parsons 79)						*		
Tetragonia fruticosa						*	*	*
Drosanthemum sp. (Le Roux & Parsons 4)							*	
Helichrysum sp. (Le Roux & Parsons 52)								*
Eriocephalus sp.								*
Othonna sedifolia								*
Zygophyllum divaricatum								*
Vanzijlia sp.								*
Cephalophyllum spongiosum								*
Othonna floribunda								*
Ruschia verdifolia								*
Aridaria noctiflora								
Osteospermum oppositifolium								*
Pteronia sp. (Le Roux & Parsons 60)								
Prenia sp. (Le Roux & Parsons 84)								
Euphorbia brachiata								
Pteronia sp. (Le Roux & Parsons 61)								
Berkheya fruticosa								
Salvia sp. (Le Roux & Parsons 69)								
Zygophyllum morgsana			*	*			*	
Galenia fruticosa						*		*
Cephalophyllum sp.								*
Lycium sp. (Le Roux & Parsons 3)				*	*	*		
Ruschia sp. (Le Roux & Parsons 64)								
Ruschia sp. (Le Roux & Parsons 80)					*			*
Asparagus capensis var. *littoralis*					*	*		
Lampranthus sp. (Le Roux & Parsons 29)						*		
Eragrostis sabulosa						*		
Manochlamys albicans								
Cotula sp. (Le Roux & Parsons 93)								
Hebenstreitia cordata								
Juncus acutus								
Sarcocornia pillansii								
Sarcocornia natalense								

	Zygophyllum morgsana Low Shrubland	*Ruschia* sp. (Le Roux & Parsons 64) Dwarf Shrubland	*Lampranthus* sp. (Le Roux & Parson[s] 29)/*Ruschia* sp. (Le Roux & Parson[s] 64) Low Shrubland	*Osteospermum oppositofolium*/ *Pteronia* sp. (Le Roux & Parsons [illegible]) Dwarf Shrubland	*Salvia* sp. (Le Roux & Parsons 69) *Zygophyllum morgsana* Low Shrubland	*Eragrostis sabulosa* Grassland	*Eragrostis sabulosa*/ *Cotula* sp. (Le Roux & Parsons 93) Grassland	*Juncus acutus*/ *Eragrostis sabulosa* Grassland	*Sarcocornia* spp. Saltmarsh	Open Water	Beach and Open Sand	Rocks	Roads	Total
	15	1	45	40	30	60	50	80	100					
0	0-0,75	0-0,20	0-0,75	0-0,25	0-0,75	0-0,15	0-0,20	0-1,0	0-0,80					
ed	0,37	1,57	1,47	5,34	15,97	0,10	0,17	2,05	6,03	10,56	27,34	2,66	3,04	135,66
	0,27	1,16	1,0E	3,94	11,77	0,07	0,13	1,51	4,44	7,78	20,15	1,96	2,24	99,99
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								*	*					

ESTUARY / RIVERMOUTH / LAGOON

GROEN

(Estuary)

Insufficient data *

Sources of Information	YEAR (DATE OF INFORMATION)	ABIOTIC: Physiography: Catchment characteristics	Physiography: Morphology	Physics: Hydrology	Physics: Density variations	Physics: Circulation & mixing	Geomorphology: Geology	Geomorphology: Paleoenvironment	Geomorphology: Sediment transport & deposition	Chemistry: General chemistry	Chemistry: Eutrophication	Chemistry: Metal residues	Chemistry: Pesticide residues	Bacteriology	Other: Management	Other: Aquaculture	Other: Modelling	Other: Conservation	Other: Utilization	Other: Historical	BIOTIC: Flora: Halophytes	Flora: Phytoplankton	Flora: Terrestrial	Fauna: Zooplankton	Fauna: Other invertebrates	Fauna: Insects	Fauna: Fauna on hard substrates	Fauna: Fauna on soft substrates	Fauna: Fish	Fauna: Reptiles & Amphibians	Fauna: Birds	Fauna: Mammals	Food Webs
				*	*	*		*	*	*	*			*				*		*	*		*	*	*	*	*	*	*		*	*
Summary of available information																																	
Acocks	1975																						°										
Ashby, Harper and Van Schaik	1973			°																													
Coward (unpublished)	1981						°		°																								
Day	1981a		°	°																													
Day	1981b																				°												
Day, Blaber and Wallace	1981																												°				
Day and Grindley	1981																																°
Grindley	1979																							°									
Grindley	1981		°	°		°				°	°										°	°	°					°	°		°	°	
Heydorn and Tinley	1980	°	°	°																													
Le Roux and Ramsey	1979			°																													
Riv.fl.data mth sum.Oct.'60-Sept.'70	1978			°																													
Roberts	1978																													°			
South African Tide Tables	1980			°																													
Tankard and Rogers	1978								°																								
Truswell	1977						°	°	°																								
Water affairs flow data:StnF5M01(unp.)	1981			°																													
J. Cooper (pers. comm.)	1981																													°			

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC																				BIOTIC												
		Physio-graphy		Physics			Geomor-phology			Chemistry				Bacteriology	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		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	
GROEN (Estuary) (Continued)																																		
Insufficient data																																		
Sources of Information	Summary of available information																																	
Mr Cornelissen (pers. comm.)	1980			°											°			°	°								°				°		
J.C. Greig (pers. comm.)	1980																													°				
A. le Roux (pers. comm.)	1980																		°															
J. Rossouw (pers. comm.)	1981			°		°																												
R. Stauth (pers. comm.)	1980									°					°				°		°										°			
C. Sweet (pers. comm.)																			ó															
ECRU Survey (October	1980	°	°	°		°	°	°	°	°	°				°			°	°	°	°	°	°	°	°	°	°	°	°	°	°			
ECRU Visit (February)	1981									°																								
MAPS																																		
S.A. 1:50 000 Sheet 3017 DC	1972	°	°				°																											
S.A. 1:250 000 Topo. Sheet 3017	1973	°																																
S.A. 1:500 000 Sheet SE31/16½	1976	°																																
World Aeronaut. Chart 1:1000 000 3396	1977	°					°																											
S.A. 1:1000 000 Geological Map	1970						°																											
AERIAL PHOTOGRAPHY																																		
Trig Survey																																		

ESTUARY / RIVERMOUTH / LAGOON	YEAR (DATE OF INFORMATION)	ABIOTIC																					BIOTIC												
		Physio-graphy	Physics			Geomor-phology		Chemistry					Bacteriology	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		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	
GROEN (Estuary) (continued)																																		
Insufficient data																																		
Sources of Information	Summary of available information																																	
Job No. 12	1943		o	o			o		o																									
Job No. 409	1958		o	o			o		o																									
Job No. 587	1967		o	o			o		o																									
Univ. of Natal:Land Surv. Dept.																																		
Job No. 326	1979		o	o			o		o																									
Job No. 348	1980		o	o			o		o																									

PLATES I, II and III Overleaf

PLATE I :

Houses on floodplain showing 1961 flood level as indicated by Mr Cornelissen, the local farmer. The helicopter pad and associated buildings can be seen in the background.
(ECRU 80-10-21)

PLATE II :

Campsite at mouth of Groen Estuary.
(ECRU 80-10-19)

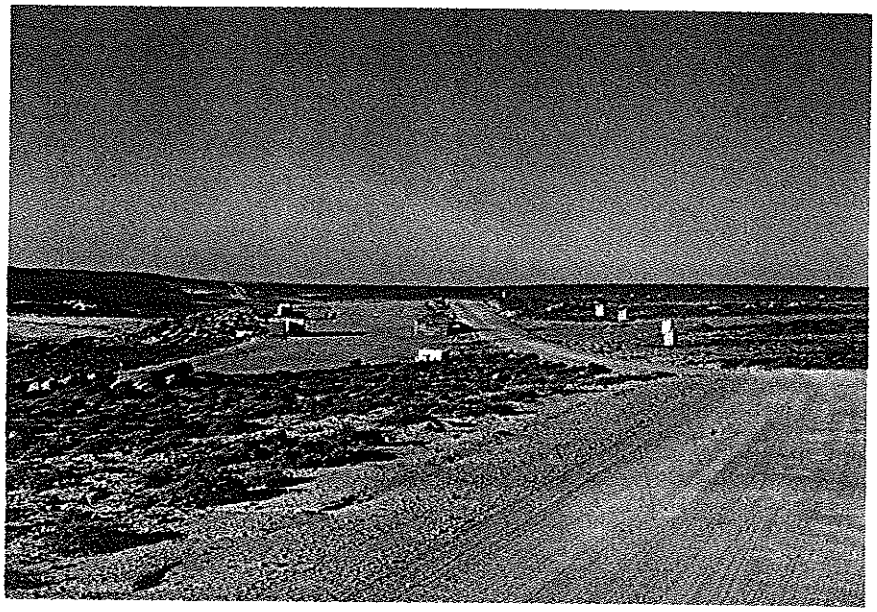

PLATE III :

Lower reaches of the Groen Estuary. The substantial sand-bar at the mouth and the shallow-ness of the lagoon, as indicated by the feeding flamingoes, can be seen. The camping site is in the left background of the photo.
(ECRU 80-10-21)