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EMA-D 9004

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**HYDROLOGICAL/HYDRAULIC STUDY OF NATAL
ESTUARIES**

DATA REPORT NO 29

UMHLANGA NS 16

submitted to

Town & Regional Planning Commission, Natal

March 1990

NS 16

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EMA-D9004

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Keywords:

Hydro-classification
Estuaries
Lateral stability
Siltation

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FOREWORD

Work involving the lateral stability of the lowest reaches of the uMhlanga (NS16) was done in the first half of 1987 in response to an *ad hoc* query by the Town Council of Uvongo concerning the mouth and beach areas.

It was logical to follow this work by a full report in the series on Natal estuaries but just before the report was completed the major floods of September 1987 occurred. It was therefore deemed appropriate to delay publication and evaluate the 1987 flood and post-flood conditions.

The main text of this report uses data up to 1985 and the Appendix covers the period from 1986 to date.

J.E. PERRY

March 1990

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BRIEF NOTESuMHLANGA NS 16Location

The uMhlanga (sometimes known as the Mhlangeni) discharges into the Indian Ocean on the Natal South Coast at 30°49'S, 30°24'E. The head of the reach under review is 1,2 km from the mouth (Photograph NS16/1). This position is an arbitrary line, selected at the maximum known estuarine limit, which could be identified on all the available aerial photographs. Although this is not ideal, it is the best possible selection under the circumstances because there is no bridge in the vicinity which could confine the flow.

Selection of Aerial Photographs

For the study of this "estuary", the unusual step has been taken of selecting three recent photographs (1983, 1984 and 1985) for which no run-off data are available. Furthermore, the selection of three successive year time slices is not desirable statistically as it does not compare with the spacing of earlier photographs that are available. However, the selection is justified for the following reasons:

- (a) the opportunity of studying the lowest reaches of the uMhlanga following a long, severe drought (August 1983), an interesting mouth configuration with an easterly swell and the first sign of a break in the drought (February 1984) and the return to "normal" (July 1985).
- (b) antecedent run-off conditions can be estimated for the 1983, 1984 and 1985 photographs

Hydro Data

The M.A.R. from a catchment of 38 km² is $9,60 \times 10^6$ m³ (23,6 % of the precipitation). Of particular interest to this study is the erratic nature of the run-off. This is quantified by

- (a) the high coefficients of variation for monthly run-off (Table NS16/XII) ranging from 74,8 to 198,6 per cent ($\bar{V} = 125,6 \%$)
- (b) the wide spectrum of annual and monthly run-off shown in Figures NS16/2 and 3 and
- (c) median run-off values well below the mean (Table NS16/XII).

The aforementioned Table and Figures are based upon simulated run-off data for tertiary catchments (Middleton et al., 1981). These data also reveal high monthly run-off periods, with major flood flows occurring in July 1931, November 1936, October 1954, March 1963 and lesser floods occurring in March 1927, June 1929, May 1959, December and January 1963/64 and October 1970 (Table NS16/XII and Figure NS16/3). For comment on the 1987 flood together with pre and post-flood conditions, please refer to the Appendix.

For classification purposes, current and antecedent run-off conditions must be considered for each of the time slices covered by the aerial photographs. The following important facts emerge regarding the eight relevant photographs:

- (1) 1937 below-average run-off but above-average two to five months previous and a major flood flow six months previous.
- (2) 1943 near-average run-off and likewise for six months previous, well above-average run-off for the next six months previous.
- (3) 1955 below-average run-off and likewise for two to three months previous, above-average for the next three months previous with a major flood flow eight months previous.
- (4) 1963 near-average run-off but above average one month previous and, for the period 1921 to 1976, the highest monthly run-off two months previous.

- (5) 1976 near-average run-off and for the month previous, above average two to three months previous but within a dry phase generally.
- (6) 1983 below-average run-off within a severe drought period.
- (7) 1984 near/slightly above-average run-off, previous three months above average following three years of severe drought.
- (8) 1985 below/near-average run-off.

N.B. Simulated run-off data are not available beyond hydro-year 1976. Therefore, the comments above for the 1983, 1984 and 1985 time slices are based upon local ground knowledge.

River Mouth and Beach

The river mouth lies in a cove, the rocks on the right (southern) bank being 200 m seawards of the rocks on the left bank. The mouth is closed for 65 per cent of the year (Begg, pers. comm.). When open, the mouth is often merely an "overflow channel" which hugs the rocks on the left (northern) bank (Photographs NS16/2, 3, 6 & 7). Under these conditions, the mouth morphometry shows a stable northerly-extending spit giving a beach width (to high-water line) of almost 100 m. While these conditions can prevail for long periods, the dynamic nature of the mouth morphometry should be understood with respect to wet/dry phases and flood flows. Furthermore, both natural and human influences should be considered.

Natural Influences

- (1) Typical rainy-season flood flows are exemplified by Photograph NS16/12. The river flows out to sea in the middle of the cove (almost at right angles to the road bridge) over a 60-80 m width. With the common easterly to

north-easterly swells entering the cove, the river flow at its seaward limit is diverted towards the rocks on the right (southern) bank. The latter is also true when flood waters have subsided (Photograph NS16/8).

- (2) The re-forming of the sand-spit after flood flows was observed by the writer in January 1978 when a southerly-extending spit was growing from the rocks on the left bank.
- (3) In a dry phase (a) the surf zone (and thus the littoral drift) is markedly closer inshore and (b) the outer bar almost vanishes. It needs a SUCCESSION of major flood flows within a wet phase (especially following a dry phase when sediment sources accumulate on land) to rebuild the outer bar.
- (4) An outer bar (a) affords some protection from sea attack during river break-out conditions (Photograph NS16/12) although the beach width is still understandably reduced by almost half, to 50 m and (b) provides material for the rebuilding of the sand-spits/beaches during subsequent dry season conditions when the onshore component of the onshore-offshore currents will be dominant.
- (5) The maximum peak discharge (estimated to be 368 cumecs by NPA Roads Department) during the period 1921-1977 was in March 1963. Photograph NS16/5 shows conditions almost two months after this major flood, indicating (a) a small overflow channel persisting against the left (northern) bank (b) a well-developed outer bar (c) a sand-spit/beach with of 52 m and (d) a "relic high-water line" (seen clearly only on the diapositive) which would give a sand-spit/beach width of barely 10 m; the latter representing conditions immediately after the devastating flood.
- (6) A few lesser floods occurred in the 18 months after the March 1963 major flood. This would have ensured a good sediment supply from the littoral drift and outer bar for a period of beach building to follow. Thereafter, during a prolonged dry phase (the only lesser flood flows occurring

in October and November 1970), the beach width was apparently fairly stable at about 100 m. This is confirmed, taking widths to high-water line, by 12 beach sections surveyed by G. Fromme (CSIR 1975/4 & 23) from 1972 to 1975: fluvial influences were minimal during this period.

- (7) The latter 12 sections reveal a beach elevation of approximately +3,5 m to M.S.L. on the landward side near the dunes for a width of approximately 70 m.
- (8) From observations during a wetter phase, Begg (1978) stated that the sand-spit was regularly overtopped at high tide. Following a drought period in the early 1980s, Begg (1984) reported that the mouth, which would then usually have been the "overflow channel", was regularly closed by the sea at spring tides.
- (9) The maximum water level recorded at the National Road bridge (NR bridge), about 200 m from the mouth, is approximately +3 m to M.S.L. When the "lagoon" breaches naturally, the maximum water level drop is 2,5 m.

In conclusion, while the mouth and beach morphometry may be "apparently stable" for several years, the mouth position can vary from left bank, to mid-cove, to right bank according to river flow stage and sea-swell conditions. Furthermore, the mouth can vary in a landward/seaward direction by 100 m according to antecedent wet/dry phases.

Human Influences

- (1) Begg (1978) reported that artificial breaching of the sandbar had to be undertaken by the Town Board to prevent (a) the golf course becoming swampy (b) inundation of septic tanks at the caravan park and (c) malfunctioning of storm water drains. Later, however, Begg (1984) stated that the Borough of Uvongo has a strict policy not to interfere with the mouth. This is fortunate as it ensures optimal conditions for both the position of breaching and

the flushing out of the "lagoon". Unfortunately, the "lagoon" is occasionally dug open, at random, by holiday-makers.

- (2) There is a road bridge, the NR bridge, approximately 200 m from the mouth. The first bridge at this site was completed in 1932. It had 11 spans and a total width of 101,2 m. The bridge was damaged in the 1963 flood and superseded by a new bridge in 1971. The bridge has three spans with a total width of 77,7 m. The position of the right abutment of both bridges is almost identical but the left abutment of the newer bridge is further downstream and the pier alignment is $11,5^\circ$ to the north of that of that old bridge.

Neither bridge design inhibits the natural flood path of the river in a south-easterly direction to an approximate mid-cove position (Photograph NS16/12). The resultant detailed mouth and beach morphometry depends more on the "natural influences" as outlined in the preceding section.

Land-use

(a) **Agriculture**

There has been virtually no cultivation on the flood plain and none on the valley sides for the period under review.

(b) **Structures**

The old and new NR bridges, 200 m from the mouth were completed in 1932 and 1971 respectively.

(c) **Urbanization**

The residential and resort areas of Windsor-on-Sea and St Michael's on Sea are situated above the valley sides to the north and south of the mouth respectively.

Siltation

The lowest reaches of the uMhlanga show severe siltation throughout the period under review. Two-thirds of the flood plain are occupied by fluvial silt and swamps (Table NS16/I) while channel avulsion occurs, factors which are indicative of siltation.

Two very important physical factors that cause this siltation are (a) the highly erratic run-off and (b) the river gradient. The overall gradient of the uMhlanga is 1:37 (very steep), checking to 1:295, approximately, in the lowest 1,2 km where the river emerges from an incised meandering course. This check in river gradient, close to the coast, causes reduced river flow velocities which in turn cause deposition. The position is compounded by the fact that the river mouth is closed for 65 per cent of the year, favouring deposition behind the sandbar. Man has further aggravated the position by building embankments for the NR bridge across the flood plain. Siltation has occurred upstream of these embankments, short though they are. For a sediment source, one must look to erodible soils and livestock/agricultural malpractices in the catchment. From a sediment production map of South Africa (Rooseboom, 1975) a maximum sediment yield of 15 200 tons per year is derived for the uMhlanga catchment. This represents a rate of 400 tons/km²/yr, which is high.

Bearing in mind that the rate of siltation in the lower reaches is not steady but results from major hydro events, one should study the changes in siltation from two view points:

- (a) spatially (area-changes over time) and
- (b) vertically (aggradation/degradation over time).

- (a) Changes in areas of siltation over time

Aerial measurements of the flood plain from the eight time slices of aerial photography quantify the changes in siltation areas from 1937-1985 (Table NS16/I). River stage should be comparable and if this is not the case, allowances must be made.

(N.B. there is a maximum range of 2,5 m in water levels at the NR bridge for normal open and closed mouth conditions). One must also examine carefully which changes in vegetated or built-up areas have been at the expense of the 1937 baseline "recent" siltation areas. The "recent" siltation area in 1937 comprised fluvial sand/silt plus swamp areas (68 % of the flood plain). In subsequent time slices, the siltation areas comprised the following:

fluvial sand/silt
 swamp/marsh
 increase of vegetated and built-up areas since 1937 (these being at the expense of 1937 "recent" silted areas).

Recent areas of siltation, with open water areas given in brackets below, are summarized as percentages of the flood plain area as follows:

<u>1937</u>	<u>1943</u>	<u>1955</u>	<u>1963</u>	<u>1976</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>
68	69	60	70	72	74	78	61
(16)	(19)	(29)	(14)	(16)	(12)	(11)	(28)

Two clear facts emerge:

- (i) Open water areas exhibit no particular trend. They are dependent upon mouth open/closed condition and river stage.
- (ii) Stage for stage, there has been a small but steady increase in siltation areas from 1937 to 1985.

(b) Aggradation/degradation over time

These changes naturally cannot be assessed from aerial photographs directly. Some features may be inferred, however. As previously mentioned, channel avulsion occurs: this is indicative of aggradation.

From cross-sections taken at the site of the NR bridges, the following data are derived (N.B. all measurements are in metres and all elevations metres to M.S.L.).

	<u>1930</u>	<u>19-10-68</u>
Average bed level (below +1)	-0,42	+0,61
Channel width	100	86,5
Thalweg elevation	-1,60	+0,40

The cross-sections were surveyed prior to the building of the two bridges and the average bed levels (and thalweg elevations) shown above quantify the net aggradation. The latter is the result of the scour and fill process during several floods between 1930 and 1968 - the dominance of scour/fill depending upon antecedent catchment conditions and the shape of the flood hydrograph. For the post-1987 flood conditions, see the Appendix.

Lateral Stability

For easy visual reference, an envelope of mobility, lines of measurement and lateral shift are superimposed on an orthophoto (Photograph NS16/11).

Lateral displacement is greatest at stations 3, 4 and 5 (Figure NS16/1 and Table NS16/XI). Here channel avulsion has occurred. Had an aerial photograph been available for this period with the river in full spate, the lateral shift at the mouth would have been 100 m instead of 12 m. The average lateral displacement of 36,6 m (that is, 118,5 % of the average river width) with a coefficient of variation of 38,8 per cent indicates unstable conditions.

River widths are stage-dependent (Table NS16/X).

The sinuosity averages 1,18 (ranging from 1,16 to 1,22). The slight variations reflect differing flow stages and mouth conditions.

Overall the uMhlanga shows considerable siltation and has been unstable for the period under review: 1937-1985.

Details of the classification may be found in Tables NS16/II-IX and an abstract of results is given in Table NS16/I.

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ABBREVIATIONS/SYMBOLS/TERMS USED

DWA	Department of Water Affairs
NPA	Natal Provincial Administration
M.A.R.	Mean annual run-off
L.B.	Left bank
R.B.	Right bank
L.V.S.	Left valley side
R.V.S.	Right valley side
P	Perimeter
$\bar{x}$	Arithmetic mean
s	Standard deviation
V	Coefficient of variation $\frac{s}{\bar{x}}$
MSL	Mean sea level
R	River
d/s	Downstream
u/s	Upstream
_____	Maximum value
-----	Minimum value
N.R.	No record
Head of reach	An arbitrary control point selected at the first convenient place u/s of the maximum known limit of saline penetration/tidal influence where the R is confined (preferably a bridge e.g. to facilitate demarcation of flood-plain areas).

BASIC DATA/CALCULATIONS

Lateral displacement (1937-1985)	$\bar{x}$	36.6	m	(118.8	$\bar{R}$ width)
Relative lateral stability (1937-1985)	$\bar{V}$	38.8	%		
Area of catchment		38.0	km ²		
Area of flood plain/valley		20.3	ha		
Area of envelope of mobility		9.7	ha		
Simulated run-off ($\times 10^6$ m ³)	M.A.R.	9.60	s	4.98	
(1921-1976)	$\bar{V}$	51.92	%		
Major floods:	July 1931, Nov. 1936, Oct. 1954, March 1963, (Sept. 1987)				
Lesser floods:	3/27, 6/29, 5/59, 12/63, 1/64, 10/70, 2/84, 2/85				

Within the Reach

Cultivation:	L.V.S.	R.V.S.	Flood Plain	To Channel Edge
	Nil	Nil	0-10%	Nil
Bridges & Embankments:	Position (m from head of reach)	Date		
Old National Road	1005	1932		
New National Road	1000	1971		
Freeway	65			1986]

Canals: Nil

Urbanization/Industry: Nil

Sandbar breaching: by Town Board to prevent (a) golf course becoming swampy, (b) inundation of caravan park's septic tanks & (c) malfunctioning storm water drains. Occasionally by holiday markets.

Others:

Upstream of the Reach

Dams: Nil

Construction/Canalization immediately upstream of reach:

[N.B. new Freeway $\neq$ at head of reach, 1986]

Land-use malpractices/Silt supply: Max. Sediment Yield 15200 tons/yr
i.e. 400 tons/km²/yr (Rooseboom 1975)

Marked siltation indicative of land-use malpractices in the catchment

STABILITY FOR PERIOD UNDER REVIEW (1937-1985)

Unstable

RIVER UMHLANGA, ? 57 % ESTUARINE, REACH from -, 1,3 km from mouth. REF. DWAT 402 n
 AERIAL PHOTO DATE 2-5-37 TIME 1314 CATCHMENT AREA 38,0 km², M.A.R. 9,60 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use	Slumping	Valley Sides (Not Well-defined)	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	9	12
✓ hilly	✓ grass	scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees	65	43
plains	moderately forested (25-75%)	mainly cultivated		grass	23	42
	heavily forested (75-100%)	✓ scattered settlement		cultivated		
	✓ riverine forest: tributaries	partly built-up		built-up	3	3
		urbanized				

Comments

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>1180</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>159</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>20,3</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u> </u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u> </u>		✓ aggrading/degrading		

Comments

River Mouth

Characteristics	Measurements	Comments
* open/closed	right bank breakwater length <u> </u> m	
✓ natural/artificial	left bank breakwater length <u> </u> m	
canalized	rock sill level <u> </u> m to MSL	
✓ sandy	cliffs on left bank: height <u> </u> m to MSL	
✓ rocks on right/left bank	spit/bare: direction of growth <u>0</u>	
✓ outer bar	length of spit/bare <u>160</u> m	
silt plume (fluvial)	length stabilized <u>NIL</u> m	
✓ suspended sediment (marine)	width <u>97</u> m	

Comments * overflow channel

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>16</u>	swamp, marsh <u>25</u>
indefinite	average width <u>159</u> m	sand (marine) <u>13</u>	cultivated <u> </u>
fragmentary	maximum width <u>330</u> m	sand, silt (fluvial) <u>43</u>	built-up <u>1</u>
✓ continuous	area <u>20,3</u> ha	trees, bush <u>2</u>	sea <u> </u>
		grass <u> </u>	

Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG TERM MEAN/HIGH

Pattern	Measurements	Island/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>1284</u> m	none	stagnant/still	none
sinuous	*aerial length <u>1067</u> m	✓ occasional (1)	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,20</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>3,2</u> ha	split	✓ irregular	✓ channel junction bars
irregular meanders	perimeter <u>4075</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: <u> </u>			diagonal bars
lake/s	river slope 1: <u> </u>			sand waves/large dunes
lagoon	river width $\bar{x}$ = <u>25,7</u> m	s = <u>18,1</u> m		

Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/ <u>NR bridge</u>	R. confined	<u>1005 m</u>
logs	minor	rail bridge/s <u> </u>		
boulders	major	causeway <u> </u>		
vegetation		weir/dam <u> </u>		
		fish traps <u> </u>		
		embankment/s <u> </u>		
		groynes <u> </u>		
		canals <u> </u>		
		drainage furrows <u> </u>		
		others <u> </u>		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	reeds <u>55</u> <u>13</u> %	slightly unstable
progression and cut-offs	rock/boulders	trees <u>9</u> <u>4</u> %	moderately unstable
mainly cut-offs	protected/stabilized		✓ unstable
entrenched loop development	cultivation to channel edge		highly unstable
✓ irregular lateral activity			
✓ avulsion			

Comments

RIVER UMHLANGA, ? 57 % ESTUARINE, REACH from -, 1,3 km from mouth.

REF. DWAT 402 n

AERIAL PHOTO DATE Dec '43 TIME 10h17 CATCHMENT AREA 38,0 km², M.A.R. 9,60 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use
mountainous	almost none	none
✓ hilly	✓ grass	scattered cultivation
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated
plains	moderately forested (25-75%)	mainly cultivated
	heavily forested (75-100%)	✓ scattered settlement
	✓ riverine forest: tributaries	partly built-up
		urbanized

Valley Sides (Not Well-defined)

Slumping	Vegetation and Land-use	Left	Right
✓ none	coastal dune forest	9	12
occasional	sand		
frequent	trees	65	43
	grass	23	42
	cultivated		
	built-up	3	3
	Comments		

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>1180</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>159</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>20,3</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head	continuous	partly entrenched	entrenched	aeolian
of reach _____ m to MSL		entrenched		
valley slope 1: _____		✓ aggrading/degrading		
			Comments	

River Mouth

Characteristics	Measurements	Comments
* open/closed	right bank breakwater length _____ m	
✓ natural/artificial	left bank breakwater length _____ m	
canalized	rock sill _____ level _____ m to MSL	
✓ sandy	cliffs on left bank: height _____ m to MSL	
✓ rocks on right/left bank	spit/bar: direction of growth <u>356</u> °	
outer bar	length of spit/bar <u>170</u> m	
silt plume (fluvial)	length stabilized <u>NIL</u> m	
✓ suspended sediment (marine)	width <u>97</u> m	
		Comments * overflow channel

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>19</u>	swamp, marsh <u>25</u>
indefinite	average width <u>159</u> m	sand (marine) <u>10</u>	cultivated
fragmentary	maximum width <u>330</u> m	sand, silt (fluvial) <u>44</u>	built-up <u>1</u>
✓ continuous	area <u>20,3</u> ha	trees, bush } <u>1</u>	sea
		grass }	
			Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern	Measurements	Island#/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>1310</u> m	none	stagnant/still	none
sinuous	*aerial length <u>1076</u> m	✓ occasional (1)	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,22</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>3,8</u> ha	split	✓ irregular	✓ channel junction bars
irregular meanders	perimeter <u>3870</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
lagoon	river width $\bar{x}$ = <u>25,9</u> m	s = <u>23,1</u> m		
			Comments *whole reach	

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/ <u>NR bridge</u>	<u>R. confined</u>	<u>1005</u>
logs	minor	rail bridge/s _____		
boulders	major	causeway _____		
vegetation		weir/dam _____		
		fish traps _____		
		embankment/s _____		
		groynes _____		
		canals _____		
		drainage furrows _____		
		others _____		
			Comments	

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	reeds <u>55</u> <u>13</u> %	slightly unstable
progression and cut-offs	rock/boulders	trees <u>9</u> <u>4</u> %	✓ moderately unstable
mainly cut-offs	protected/stabilized		✓ unstable
entrenched loop development	cultivation to		highly unstable
✓ irregular lateral activity	channel edge		Comments
✓ avulsion			

RIVER uMHLANGA, ?100 % ESTUARINE, REACH from -, 1,2 km from mouth.

REF. DMA T 402 n

AERIAL PHOTO DATE June/July '55 TIME 13h09 CATCHMENT AREA 38,0 km², M.A.R. 9,60 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use	Slumping	Valley Sides (Not Well-defined)	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest		9	12
✓ hilly	✓ grass	scattered cultivation	occasional	sand			
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees		76	47
plains	moderately forested (25-75%)	mainly cultivated		grass		11	37
	heavily forested (75-100%)	✓ scattered settlement		cultivated			
	✓ riverine forest: tributaries	partly built-up		built-up		4	4
		urbanized		Comments			

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>1180</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>159</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>20,3</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u> </u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u> </u>		✓ aggrading/degrading		Comments

River Mouth

Characteristics	Measurements	Comments
✓ open/closed	right bank breakwater length <u> </u> m	
✓ natural/artificial	left bank breakwater length <u> </u> m	
canalized	rock sill level <u> </u> m to MSL	
✓ sandy	cliffs on left bank: height <u> </u> m to MSL	
rocks on right/left bank	split/bar: direction of growth <u>4</u> o	
✓ outer bar	length of split/bar <u>180</u> m	
silt plume (fluvial)	length stabilized <u>NIL</u> m	
✓ suspended sediment (marine)	width <u>78</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>29</u>	swamp, marsh <u>21</u>
indefinite	average width <u>159</u> m	sand (marine) <u>9</u>	cultivated
fragmentary	maximum width <u>330</u> m	sand, silt (fluvial) <u>39</u>	built-up <u>1</u>
✓ continuous	area <u>20,3</u> ha	trees, bush } <u>1</u>	sea
		grass	
		Comments	

Channel Description N.B. - Estimate of flow stage: LOW/~~NEAR LONG TERM MEAN/HIGH~~

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>1210</u> m	none	✓ stagnant/still	none
sinuous	*aerial length <u>1044</u> m	✓ occasional(i)	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,16</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>5,9</u> ha	split	irregular	✓ channel junction bars
irregular meanders	perimeter <u>3909</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: <u> </u>			diagonal bars
lake/s	river slope 1: <u> </u>			sand waves/large dunes
lagoon	river width $\bar{x}$ = <u>41,6</u> m	s = <u>39,6</u> m		
		Comments *whole reach		

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s <u>NR bridge</u>	R. confined	1005
logs	minor	rail bridge/s <u> </u>		
boulders	major	causeway <u> </u>		
vegetation		weir/dam <u> </u>		
Comments		fish traps <u> </u>		
		embankment/s <u> </u>		
		groynes <u> </u>		
		canals <u> </u>		
		drainage furrows <u> </u>		
		others <u> </u>		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB. RB.	slightly unstable
progression and cut-offs	rock/boulders	reeds <u>55</u> <u>16</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>9</u> <u>4</u> %	unstable
entrenched loop development	cultivation to channel edge		highly unstable
✓ irregular lateral activity			Comments
✓ avulsion			

RIVER UHLANGA, ? 57 % ESTUARINE, REACH from -, 1,2 km from mouth. REF. DWA T 402 n
 AERIAL PHOTO DATE 5-5-63 TIME 10h32 CATCHMENT AREA 38,0 km², M.A.R. 9,60 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	9	12
✓ hilly	✓ grass	scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees	76	47
plains	moderately forested (25-75%)	mainly cultivated		grass	11	37
	heavily forested (75-100%)	✓ scattered settlement		cultivated		
	✓ riverine forest: tributaries	partly built-up		built-up	4	4
		urbanized				

Comments

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>1180</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>159</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>20,3</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u> </u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u> </u>		✓ aggrading/degrading		

Comments

River Mouth

Characteristics	Measurements	Comments
* open/closed	right bank breakwater length <u> </u> m	
✓ natural/artificial	left bank breakwater length <u> </u> m	
canalized	rock sill level <u> </u> m to MSL	
sandy	cliffs on left bank: height <u> </u> m to MSL	
✓ rocks on right/left bank	spit/bar: direction of growth <u>351</u>	
✓ outer bar	length of spit/bar <u>175</u> m	
silt plume (fluvial)	length stabilized <u>NIL</u> m	
✓ suspended sediment (marine)	width <u>52</u> m	

Comments * overflow channel

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u> </u> swamp, marsh <u> </u>	
indefinite	average width <u>159</u> m	sand (marine) <u> </u> cultivated <u> </u>	
fragmentary	maximum width <u>330</u> m	sand, silt (fluvial) <u> </u> built-up <u> </u>	
✓ continuous	area <u>20,3</u> ha	trees, bush <u> </u> sea <u> </u>	
		grass <u> </u>	

Comments

Channel Description N.B. - Estimate of flow stage: LOW/~~NEAR LONG-TERM MEAN~~/HIGH (major flood 2 months previous)

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>1237</u> m	✓ none	stagnant/still	none
sinuous	*aerial length <u>1023</u> m	occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,21</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>2,9</u> ha	split	irregular	✓ channel junction bars
irregular meanders	perimeter <u>2740</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: <u> </u>			diagonal bars
lake/s	river slope 1: <u> </u>			sand waves/large dunes
lagoon	river width $\bar{x}$ = <u>28,6</u> m	s = <u>30,0</u> m		

Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s <u>NR bridge</u>	R. confined	1005
logs	minor	rail bridge/s <u> </u>		
boulders	major	causeway <u> </u>		
vegetation		weir/dam <u> </u>		
		fish traps <u> </u>		
		embankment/s <u> </u>		
		groynes <u> </u>		
		canals <u> </u>		
		drainage furrows <u> </u>		
		others <u> </u>		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB. RB.	slightly unstable
progression and cut-offs	rock/boulders	reeds <u>18</u> <u>16</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>9</u> <u>4</u> %	unstable
entrenched loop development	cultivation to channel edge	-----	highly unstable
✓ irregular lateral activity			
✓ avulsion			

Comments

RIVER UMHLANGA, 57 % ESTUARINE, REACH from -, 1,2 km from mouth. REF. DWA T402 n
 AERIAL PHOTO DATE 23-6-76 TIME 10h48 CATCHMENT AREA 38,0 km², M.A.R. 9,60 m³x10⁶, No. of DAMS NIL

(Orthophoto series)

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use
mountainous	almost none	none
✓ hilly	✓ grass	scattered cultivation
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated
plains	moderately forested (25-75%)	mainly cultivated
	heavily forested (75-100%)	✓ scattered settlement
	✓ riverine forest: tributaries	partly built-up
		urbanized

Valley Sides (Not Well-defined)

Slumping	Vegetation and Land-use	Left	Right
✓ none	coastal dune forest	9	12
occasional	sand		
frequent	trees	76	47
	grass	11	37
	cultivated		
	built-up	4	4

Comments

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>1180</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>159</u> m	indefinite	not obviously degrading	occasionally confined	lacustrine deposits
valley area <u>20,3</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u>± 4</u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u>2.95</u> approx		✓ aggrading/degrading		

Comments

River Mouth

Characteristics	Measurements
✓ open/ closed	right bank breakwater length _____ m
✓ natural/ artificial	left bank breakwater length _____ m
canalized	rock sill level _____ m to MSL
✓ sandy	cliffs on left bank: height _____ m to MSL
✓ rocks on right /left bank	spit/bar: direction of growth <u>0</u>
✓ outer bar	length of spit/bar <u>165</u> m
silt plume (fluvial)	length stabilized <u>412</u> m
✓ suspended sediment (marine)	width <u>86</u> m

Comments * overflow channel

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>16</u>	swamp, marsh <u>41</u>
indefinite	average width <u>159</u> m	sand (marine) <u>9</u>	cultivated <u>1</u>
fragmentary	maximum width <u>330</u> m	sand, silt (fluvial) <u>22</u>	built-up <u>1</u>
✓ continuous	area <u>20,3</u> ha	trees, bush } <u>10</u>	sea _____
		grass _____	

Comments

Channel Description N.B. - Estimate of flow stage: ~~LOW~~/NEAR LONG-TERM MEAN/~~HIGH~~

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>1235</u> m	✓ none	stagnant/still	none
sinuous	*aerial length <u>1048</u> m	occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,18</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>3,2</u> ha	split	✓ irregular	✓ channel junction bars
irregular meanders	perimeter <u>3500</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	**river x-sections available	shoals	✓ turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
lagoon	river width $\bar{x}$ = <u>27,4</u> m	s = <u>36,2</u> m		

Comments *whole reach

** 1968 for new NR bridge

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s <u>NR bridge</u>	R. confined	<u>1000m</u>
logs	minor	rail bridge/s _____		
boulders	major	causeway _____		
vegetation		weir/dam _____		
		fish traps _____		
		embankment/s _____		
		groynes _____		
		canals _____		
		drainage furrows _____		
		others _____		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB RB	slightly unstable
progression and cut-offs	rock/boulders	reeds <u>83</u> <u>33</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>9</u> <u>4</u> %	unstable
entrenched loop development	cultivation to	-----	highly unstable
✓ irregular lateral activity	channel edge		
✓ avulsion			

Comments

RIVER UMHLANGA, ? 57 % ESTUARINE, REACH from -, 1,2 km from mouth. REF. DWA T 402 n
 AERIAL PHOTO DATE 2-8-83 TIME 12:05 CATCHMENT AREA 38,0 km², M.A.R. 9,60 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	9	12
✓ hilly	✓ grass	scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees	76	47
plains	moderately forested (25-75%)	mainly cultivated		grass	11	37
	heavily forested (75-100%)	✓ scattered settlement		cultivated		
	✓ riverine forest: tributaries	partly built-up		built-up	4	4
		urbanized				

Comments

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>1180</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>159</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>20,3</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u> </u> m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: <u> </u>		✓ aggrading/degrading		

Comments

River Mouth

Characteristics	Measurements	
* open/closed	right bank breakwater length <u> </u> m	
✓ natural/artificial	left bank breakwater length <u> </u> m	
canalized	rock sill level <u> </u> m to MSL	
✓ sandy	cliffs on left bank: height <u> </u> m to MSL	
rocks on right/left bank	spit/bar: direction of growth <u>352</u> °	
outer bar	length of spit/bar <u>175</u> m	
silt plume (fluvial)	length stabilized <u>NIL</u> m	
✓ suspended sediment (marine)	width <u>97</u> m	

Comments * overflow channel

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>12</u>	swamp, marsh <u>41</u>
indefinite	average width <u>159</u> m	sand (marine) <u>11</u>	cultivated <u>1</u>
fragmentary	maximum width <u>330</u> m	sand, silt (fluvial) <u>20</u>	built-up <u>1</u>
✓ continuous	area <u>20,3</u> ha	trees, bush } <u>14</u>	sea
		grass	

Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR FLOOD/PEAK FLOOD/HIGH

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>1213</u> m	✓ none	✓ stagnant/still	none
sinuous	*aerial length <u>1048</u> m	occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,16</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>2,4</u> ha	split	irregular	✓ channel junction bars
irregular meanders	perimeter <u>3455</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	turbid	diamond bars
bifurcated	channel slope 1: <u> </u>			diagonal bars
lake/s	river slope 1: <u> </u>			sand waves/large dunes
lagoon	river width $\bar{x}$ = <u>29,7</u> m	s = <u>42,4</u> m		

Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Construction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s <u>NR bridge</u>	<u>R. confined</u>	<u>1000 m</u>
logs	minor	rail bridge/s <u> </u>		
boulders	major	causeway <u> </u>		
vegetation		weir/dam <u> </u>		
		fish traps <u> </u>		
		embankment/s <u> </u>		
		groynes <u> </u>		
		canals <u> </u>		
		drainage furrows <u> </u>		
		others <u> </u>		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB. RB.	slightly unstable
progression and cut-offs	rock/boulders	reeds <u>84</u> <u>34</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>9</u> <u>4</u> %	unstable
entrenched loop development	cultivation to channel edge	-----	highly unstable
✓ irregular lateral activity			
✓ avulsion			

Comments

RIVER UMHLANGA, ? NIL % ESTUARINE, REACH from -, 1,2 km from mouth.

REF. DWA T 402 n

AERIAL PHOTO DATE 6-2-84 TIME 15h52 CATCHMENT AREA 38,0 km², M.A.R. 9,60 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Valley Sides (Not Well-defined)

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	9	12
✓ hilly	✓ grass	✓ scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees	76	47
plains	moderately forested (25-75%)	mainly cultivated		grass	11	37
	heavily forested (75-100%)	✓ scattered settlement		cultivated		
	✓ riverine forest: tributaries	partly built-up		built-up	4	4
		urbanized				

Comments

Valley Characteristics

Measurements

Terraces

Relation of Channel to Valley Bottom (Vertical)

Relation of Channel to Valley Sides or Resistant Terraces (Lateral)

Surface Geology

valley length	<u>1180</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.)	<u>159</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area	<u>20,3</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach	m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1:			✓ aggrading/degrading		

Comments

River Mouth

Characteristics

Measurements

✓ open/ closed	right bank breakwater length	m
✓ natural/ artificial	left bank breakwater length	m
canalized	rock sill	level
✓ sandy	cliffs on left bank: height	m to MSL
✓ rocks on right/left bank	spit/ bar : direction of growth	0
outer bar	length of spit/ bar	<u>165</u> m
silt plume (fluvial)	length stabilized	<u>NIL</u> m
✓ suspended sediment (marine)	width	<u>90</u> m

Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence

Extent

Areal Measurements: % Flood Plain/Valley

Crops, Animal Husbandry

none	none	open water	<u>11</u>	swamp, marsh	<u>42</u>
indefinite	average width	sand (marine)	<u>8</u>	cultivated	<u>1</u>
fragmentary	maximum width	sand, silt (fluvial)	<u>20</u>	built-up	<u>1</u>
✓ continuous	area	trees, bush	<u>17</u>	sea	
		grass			

Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/HIGH

Pattern

Measurements

Islands/Shoals

Type of Flow

Bar Type

straight	*thalweg	<u>1227</u> m	✓ none	stagnant/still	none
sinuous	*aerial length	<u>1055</u> m	occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity	<u>1,16</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area	<u>2,2</u> ha	split	✓ irregular	✓ channel junction bars
irregular meanders	perimeter	<u>3210</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available		shoals	✓ turbid	diamond bars
bifurcated	channel slope 1:				diagonal bars
lake/s	river slope 1:				sand waves/large dunes
lagoon	river width $\bar{x}$ =	<u>19,9</u> m	$s = 23,6$ m		

Comments *whole reach

Obstructions/Constructions

Natural

Degree

Man-made

Degree of Obstruction/Constriction for Each

Position (from head of reach)

✓ none	✓ none	road bridge/s	<u>NR bridge</u>	<u>R. confined</u>	
logs	minor	rail bridge/s			
boulders	major	causeway			
vegetation		weir/dam			
		fish traps			
		embankment/s			
		groynes			
		canals			
		drainage furrows			
		others			

Lateral Channel Activity

Lateral Activity

Nature of Banks

Bank Vegetation

Lateral Stability

not detectable	✓ alluvium	none		stable
downstream progression	natural levees	LB. RB.		slightly unstable
progression and cut-offs	rock/boulders	reeds	<u>82</u> <u>30</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees	<u>9</u> <u>4</u> %	unstable
entrenched loop development	cultivation to			highly unstable
✓ irregular lateral activity	channel edge			
✓ avulsion				

Comments

RIVER UMHLANGA, 100 % ESTUARINE, REACH from -, 1,2 km from mouth. REF. DWAT 402 n
 AERIAL PHOTO DATE 9-7-85 TIME 11:30 CATCHMENT AREA 38,0 km², M.A.R. 9,60 m³ x 10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	9	12
✓ hilly	✓ grass	scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	✓ partly cultivated	frequent	trees	76	47
plains	moderately forested (25-75%)	mainly cultivated		grass	11	37
	heavily forested (75-100%)	✓ scattered settlement		cultivated		
	✓ riverine forest: tributaries	partly built-up		built-up	4	4
		urbanized				

Comments

Valley Characteristics

Measurements	Terraces	Relation of Channel to Valley Bottom (Vertical)	Relation of Channel to Valley Sides or Resistant Terraces (Lateral)	Surface Geology
valley length <u>1180</u> m	✓ none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>159</u> m	indefinite	✓ not obviously degrading	occasionally confined	lacustrine deposits
valley area <u>20,3</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach _____ m to MSL	continuous	partly entrenched	entrenched	aeolian
valley slope 1: _____		entrenched		
		aggrading/degrading		

Comments

River Mouth

Characteristics	Measurements
✓ open/closed	right bank breakwater length _____ m
✓ natural/artificial	left bank breakwater length _____ m
canalized	rock sill _____ level _____ m to MSL
✓ sandy	cliffs on left bank: height _____ m to MSL
rocks on right/left bank	spit/bar: direction of growth <u>0-15</u> °
✓ outer bar	length of spit/bar <u>180</u> m
silt plume (fluvial)	length stabilized <u>NIL</u> m
✓ suspended sediment (marine)	width <u>80</u> m

Comments

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>28</u>	swamp, marsh <u>39</u>
indefinite	average width <u>159</u> m	sand (marine) <u>8</u>	cultivated <u>1</u>
fragmentary	maximum width <u>330</u> m	sand, silt (fluvial) <u>6</u>	built-up <u>1</u>
✓ continuous	area <u>20,3</u> ha	trees, bush <u>17</u>	sea _____
		grass _____	

Comments

Channel Description N.B. - Estimate of flow stage: LOW/NEAR LONG-TERM MEAN/~~HIGH~~

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>1220</u> m	✓ none	✓ sluggish /still	none
sinuous	*aerial length <u>1051</u> m	occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,16</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>5,6</u> ha	split	irregular	✓ channel junction bars
irregular meanders	perimeter <u>3005</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river x-sections available	shoals	turbid	diamond bars
bifurcated	channel slope 1: _____			diagonal bars
lake/s	river slope 1: _____			sand waves/large dunes
lagoon	river width $\bar{x}$ = <u>47,4</u> m			

Comments *whole reach

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s <u>NR bridge</u>	<u>R. confined</u>	
logs	minor	rail bridge/s _____		
boulders	major	causeway _____		
vegetation		weir/dam _____		
		fish traps _____		
		embankment/s _____		
		groynes _____		
		canals _____		
		drainage furrows _____		
		others _____		

Lateral Channel Activity

Lateral Activity	Nature of Banks	Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	LB. RB.	slightly unstable
progression and cut-offs	rock/boulders	reeds <u>83</u> <u>38</u> %	moderately unstable
mainly cut-offs	protected/stabilized	trees <u>9</u> <u>4</u> %	unstable
entrenched loop development	cultivation to	-----	highly unstable
irregular lateral activity	channel edge		
✓ avulsion			

Comments

TABLE NS16/X

RIVER WIDTHS

UMHLANGA NS 16

Stn	Approx. distance along 1976 river course	River widths (m)									$\bar{x}$	s	V%
		Date											
		2-5-37	Dec 43	Jun/Jul 1955	5-5-63	23-6-76	2-8-83	6-2-84	9-7-85				
1	0	6	7	10	5	7	5	5	6	6,4	1,7	26,4	
2	200	22	5	8	25	7	5	10	5	10,9	8,0	73,8	
3	400	17 (12+5)	14 (11+5)	31 (6+25)	5	12	10	10	11	13,8	7,8	56,4	
4	600	35	43 (20+23)	60 (32+28)	20	20 (8+12)	35 (14+21)	29 (14+15)	50 (20+30)	36,5	14,1	38,5	
5	800	45	52	80	60 (20+40)	35	26	10	90	49,8	26,8	53,9	
6	1000	50 (10+40)	55 (5+5+45)	102 (30+72)	80	106	122	70	170	94,4	39,6	42,0	
7	1200 (mouth)	5	5	0	5	5	5	5	0	3,8	2,3	61,7	
$\bar{x}$		25,7	25,9	41,6	28,6	27,4	29,7	19,9	47,4	30,8			
s		18,1	23,1	39,6	30,0	36,2	42,4	23,6	63,2				
V%		70,2	89,2	95,4	104,9	132,0	142,6	118,7	133,2				

TABLE NS16/XI

LATERAL STABILITY

uMHLANGA NS 16

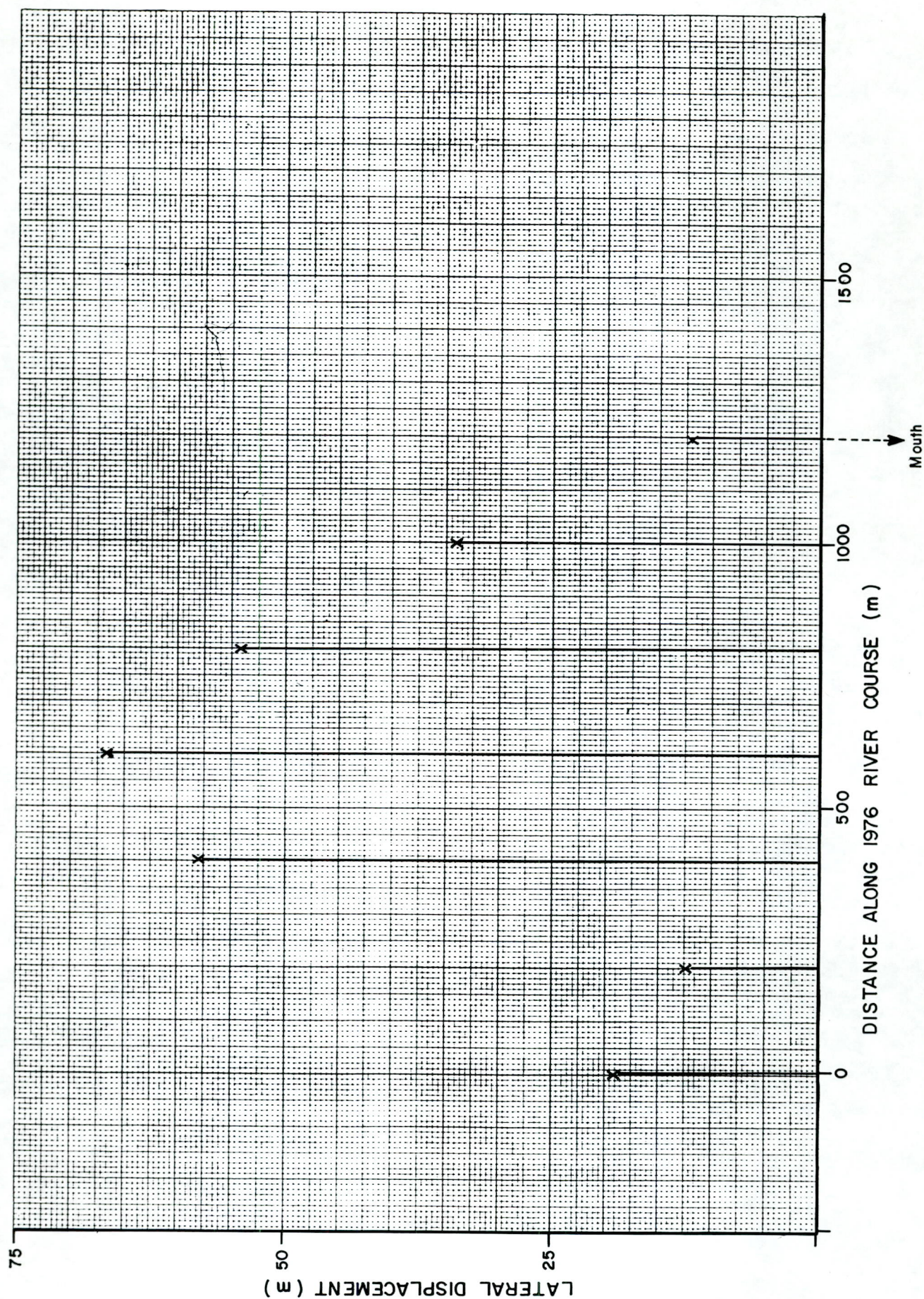
Stn	Approx. distance along 1976 river course	Distance from maximum observed L.B. position to mid-river (m)								Max-Min	$\bar{x}$	s	V%
		Date											
		2-5-37	Dec 43	Jun/Jul 1955	5-5-63	23-6-76	2-8-83	6-2-84	9-7-85				
1	0	6	6	5	6	20	15	24	11	19	11,6	7,3	62,9
2	200	11	6	14	14	18	14	15	8	12	12,5	3,9	31,4
3	400	40,1	24,8	55,2	83	55	54	55	48	58,2	51,9	16,4	31,7
4	600	45,4	62	54,8	100	33	66,4	59,6	61	67	60,3	19,3	32,1
5	800	57	56	40	54,7	70	16	20	47	54	45,1	18,8	41,7
6	1000	125	125	101,1	130	120	105	134	100	34	117,5	13,5	11,5
7	1200 (mouth)	3	15	N.R.	22	8	10	8	N.R.	12	11,0	6,6	60,3
$\bar{x}$		41,1	42,1	45,0	58,5	51,0	40,1	45,1	45,8	36,6	44,3		
s		42,6	43,0	34,4	47,5	40,7	36,3	43,9	34,1		46,1		38,8
V%		103,8	102,1	76,5	81,1	79,8	90,6	97,4	74,4				

Average lateral displacement 1937 - 1985 = 36,6 m (i.e. 118,8% $\bar{R}$ width)

Average coefficient of variation 1937 - 1985 = 38,8%

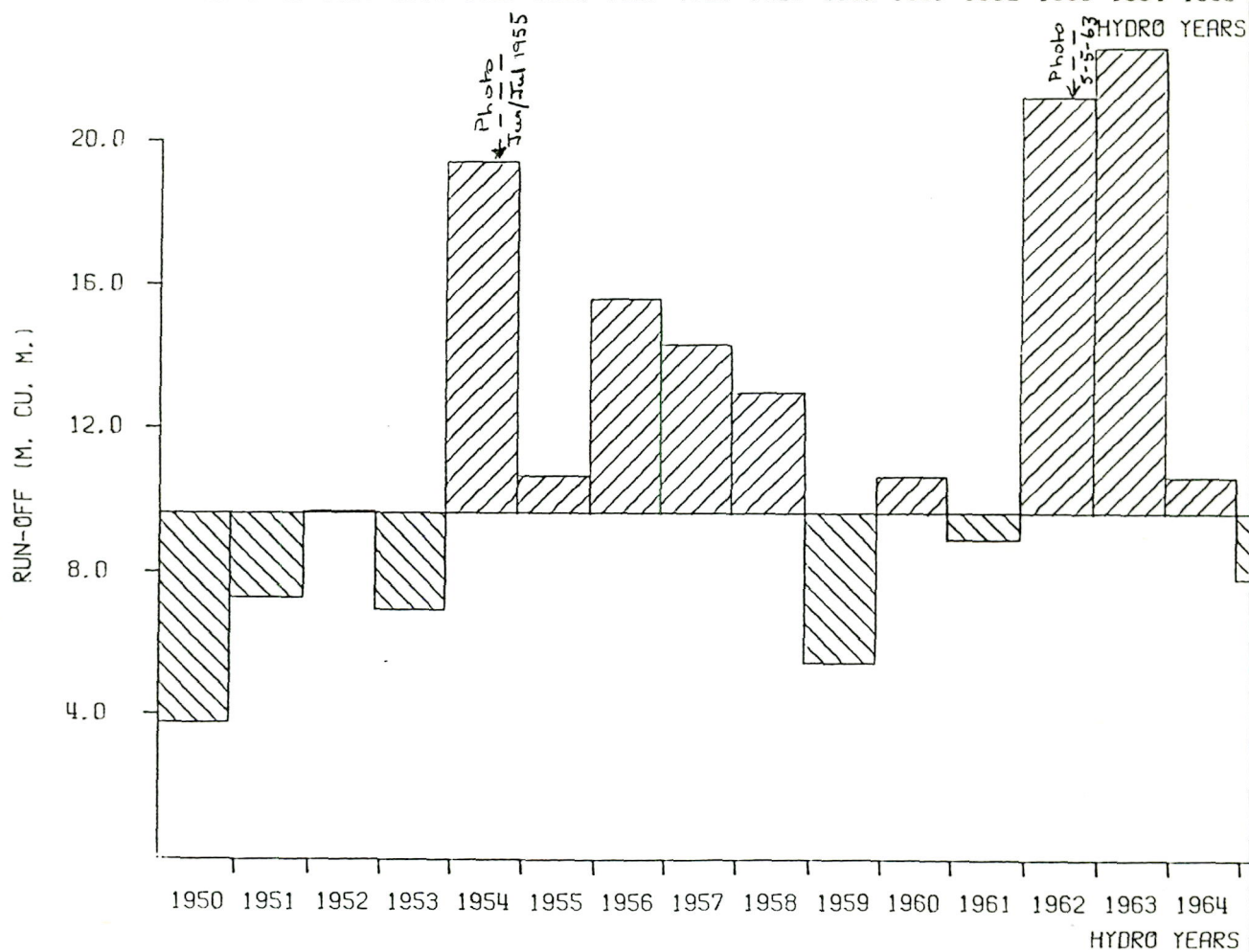
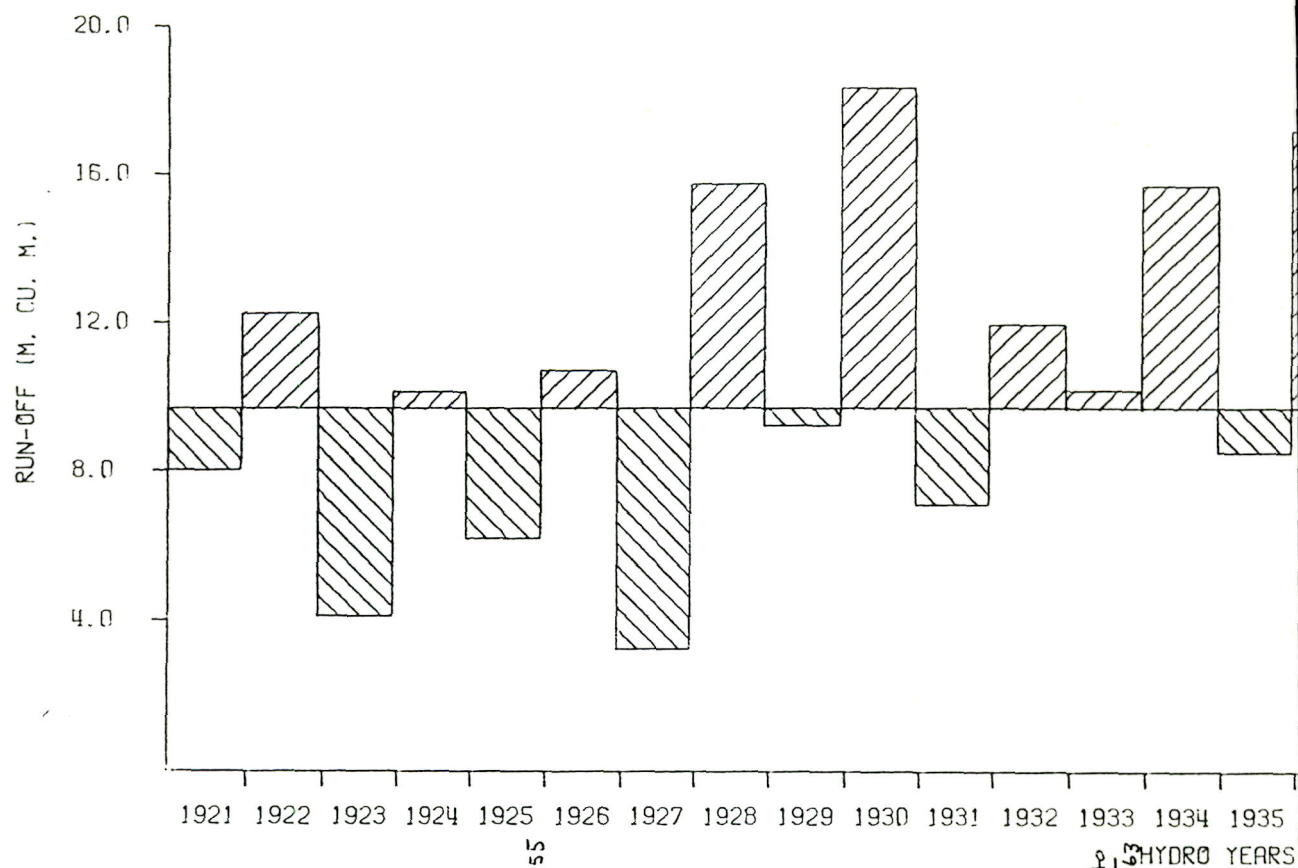
TABLE NS 16/XII SIMULATED RUN-OFF FOR UHHLANGA NS 16 CATCHMENT AREA= 38.05Q.KM.

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	\$M.A.R.
1921	.32	.49	3.19	1.40	.41	.29	.23	.37	.43	.32	.25	.28	7.97	83.04
1922	2.41	2.22	.80	.44	2.85	1.50	.52	.25	.15	.33	.42	.34	12.23	127.35
1923	.35	.46	.72	.76	.61	.35	.21	.16	.11	.09	.10	.16	4.08	42.55
1924	.25	.36	.50	.64	.62	4.60	1.90	.37	.20	.20	.16	.25	10.09	105.05
1925	.46	.50	.36	.26	.31	1.75	.91	.32	.39	.40	.27	.25	6.19	64.43
1926	.47	.60	.49	.30	.22	5.50	2.23	.31	.15	.10	.13	.18	10.67	111.15
1927	.28	.28	.32	.48	.53	.40	.23	.16	.15	.11	.13	.15	3.23	33.62
1928	.23	.31	.26	.28	.28	.51	.77	.66	5.86	3.82	1.19	1.51	15.69	163.47
1929	2.42	2.43	.99	.86	.61	.28	.15	.37	.20	.26	.29	.56	9.17	95.51
1930	.83	.77	.74	.78	.74	1.93	1.03	.37	.19	7.33	2.98	.57	18.26	190.19
1931	.61	.58	.42	.32	.47	1.04	.72	.52	.46	.34	.26	1.34	7.09	73.86
1932	1.86	3.76	3.09	1.03	.31	.39	.45	.33	.22	.18	.14	.14	11.92	124.14
1933	.18	2.22	1.83	2.43	1.15	.48	.42	.35	.23	.32	.32	.22	10.11	105.27
1934	.17	.29	3.53	1.53	.41	.43	.52	1.99	3.95	1.67	.65	.50	15.64	162.92
1935	.36	.31	.20	.20	2.57	1.54	.58	.85	.73	.48	.31	.32	8.44	87.92
1936	.52	7.52	2.93	1.09	2.37	1.17	.44	.24	1.14	.19	.26	.24	17.10	178.16
1937	.32	.38	1.36	1.13	1.11	.65	1.75	1.00	.45	.43	.42	.30	9.28	96.67
1938	.26	.36	.80	.70	1.84	1.11	.54	.36	.26	.24	.26	.52	7.25	75.56
1939	.77	.67	1.26	.70	.20	.17	.19	1.84	1.09	.42	.24	.23	7.84	81.68
1940	.26	.49	.55	.34	.16	.16	.18	.14	.11	.12	.18	.27	2.97	30.94
1941	.44	.49	.39	2.37	1.17	.58	.62	.55	.39	.23	.25	.34	7.82	81.46
1942	.53	4.89	4.47	1.35	.38	2.17	2.43	1.09	.50	.38	.52	.55	19.25	200.55
1943	1.18	.95	.98	.67	.47	.37	.31	.25	.22	.22	.17	.49	6.29	65.51
1944	1.66	.92	.32	.18	.31	.58	.52	.31	.19	.16	.13	.12	5.39	56.16
1945	2.54	1.23	.26	.15	.23	.37	.47	.39	.24	.15	.10	.10	6.24	64.95
1946	.21	1.13	.84	.53	.48	1.87	1.19	1.20	2.49	1.23	.46	.31	11.95	124.44
1947	.27	3.43	1.74	.73	.96	2.28	1.19	.46	.24	.14	.12	.18	11.70	121.85
1948	1.90	1.09	.40	.22	.31	.53	.53	.38	.23	.15	.13	.18	6.06	63.10
1949	.39	2.47	1.25	.99	.72	.44	.56	.88	.70	.50	.62	.64	10.15	105.75
1950	.51	.43	.53	.60	.43	.33	.24	.15	.12	.12	.12	.17	3.73	38.89
1951	1.12	.72	.53	1.87	1.02	.38	.28	.34	.31	.24	.18	.27	7.25	75.48
1952	.33	.35	.40	2.19	3.92	1.43	.29	.17	.10	.08	.13	.27	9.66	100.61
1953	.50	2.13	1.19	.48	.35	.47	.43	.33	.30	.23	.18	.33	6.93	72.16
1954	7.89	3.13	.40	3.21	1.62	1.23	.73	.32	.22	.19	.34	.32	19.39	201.96
1955	.54	.66	.54	.26	.24	3.05	2.80	1.03	.45	.35	.13	.39	10.64	110.79
1956	1.21	2.50	3.98	1.51	.42	.56	2.80	1.32	.37	.23	.18	.49	15.59	162.40
1957	2.24	1.74	.72	.57	2.89	1.54	2.46	1.15	.30	.23	.23	.23	14.32	149.14
1958	.38	.72	.69	.48	.37	.28	.22	6.07	2.51	.45	.39	.41	12.97	135.11
1959	.55	.58	.46	.39	.38	.53	.67	.66	.48	.29	.21	.24	5.44	56.64
1960	.34	.51	.69	.60	.36	.76	3.72	1.63	.43	.55	.56	.51	10.64	110.83
1961	.56	1.46	.85	.50	.41	2.70	1.29	.38	.23	.15	.16	.21	8.87	92.43
1962	.52	.69	.50	2.26	1.06	9.42	3.59	.42	.33	1.12	.84	.48	21.21	220.90
1963	.81	.86	5.10	5.88	1.96	.56	.43	.32	4.01	1.86	.47	.34	22.59	235.33
1964	4.23	1.91	.44	.35	.34	.21	.11	.14	.47	.73	.73	.95	10.63	110.68
1965	2.20	1.42	.73	.65	.53	.28	.19	.35	.49	.42	.29	.28	7.81	81.33
1966	.30	.38	.43	.60	.61	.28	2.73	1.26	.40	.38	.23	.23	8.47	88.21
1967	.25	.46	.51	.35	.23	.32	.41	.31	.17	.12	.19	.40	3.72	38.75
1968	.58	.58	.47	.30	.33	.62	.65	1.61	.94	.41	.31	.31	7.09	73.80
1969	.55	.77	.71	.44	.25	.15	.08	.11	.26	.32	.42	.56	4.61	47.98
1970	5.63	3.13	1.45	.89	.56	.37	.32	.53	.54	.53	2.16	1.19	17.27	179.88
1971	2.44	1.33	.62	.37	.48	.26	.26	.15	.16	.19	.19	.17	6.83	71.13
1972	.16	.43	.60	.43	.24	.16	.14	.11	.07	.06	.11	.29	2.79	29.11
1973	.37	.28	.18	.10	.16	.22	.29	.59	.71	.49	.29	.20	3.88	40.47
1974	.18	.27	1.02	.76	.45	.34	.23	.15	.12	.09	.07	.39	4.08	42.48
1975	.58	.39	.43	.54	.62	3.11	1.54	.67	.50	.36	.29	.23	9.25	96.38
1976	.38	.40	.24	.14	.13	.10	.07	.06	.09	.09	.09	.13	1.91	19.89
MEAN	1.03	1.25	1.06	.89	.77	1.14	.87	.65	.64	.55	.38	.38	9.60	
S	1.40	1.34	1.12	.95	.80	1.57	.92	.87	1.08	1.09	.48	.28	4.98	
V8	135.87	107.66	105.64	107.33	103.70	137.46	106.25	133.78	168.27	198.64	128.01	74.79	51.92	
MEDIAN	.51	.67	.62	.60	.45	.53	.52	.37	.30	.26	.25	.29	8.47	
MEAN ANNUAL RUN-OFF=			9.60	MILLION	CUBIC METRES.		COMPILED FROM HRU REPORT NO.12/81	DATA						



NATAL ESTUARIES : uMHLANGA
 THALWEG DISPLACEMENT (1937-1985)

FIGURE
 NS 16/1



TRACED : COMPLET

CHECKED :

DATE :

REF. :

NATAL ESTUARIES : UMHLANGA

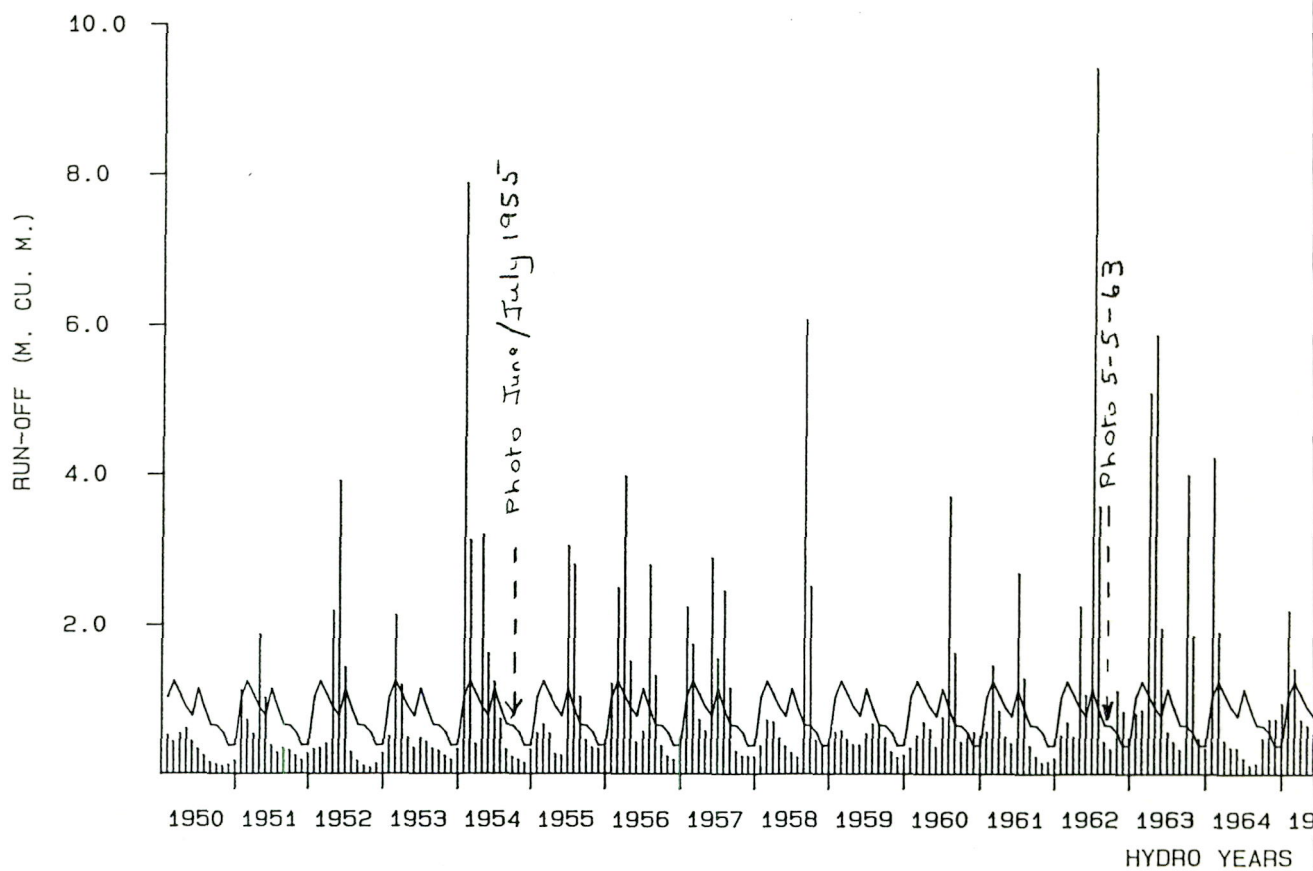
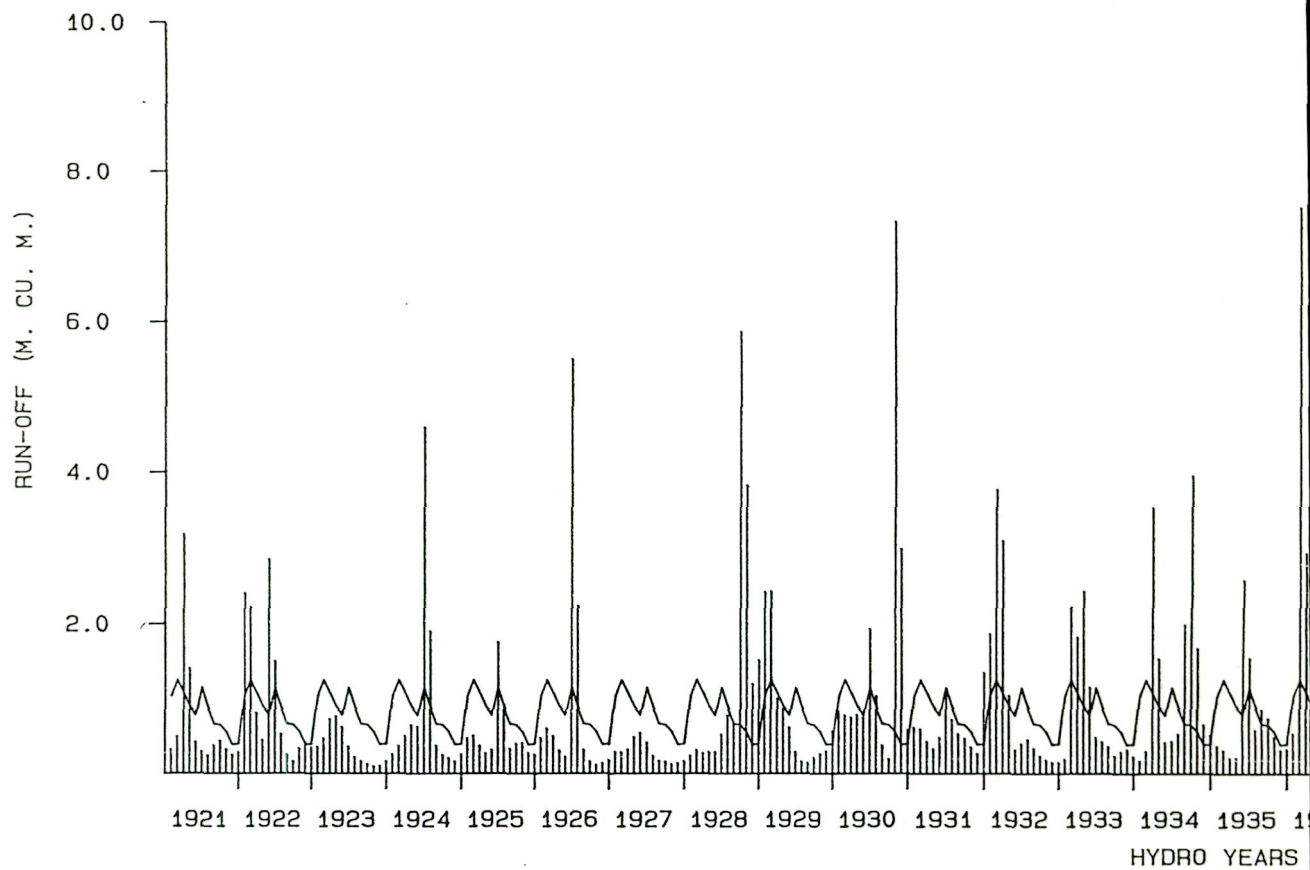
SIMULATED ANNUAL RUN-OFF

1921-1976

FIGURE

NS16/2

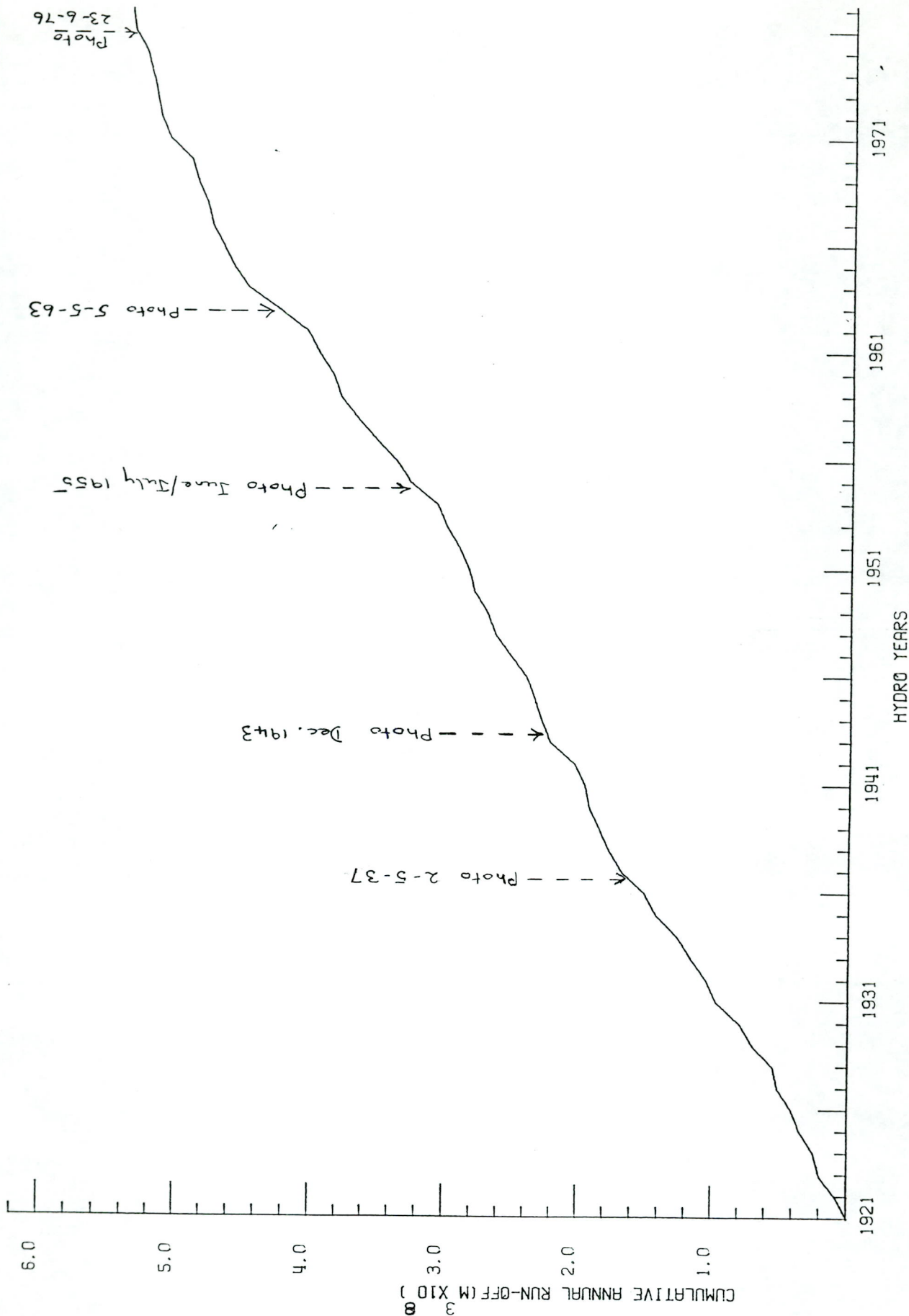
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



TRACED : COMPLIT
CHECKED:
DATE :
REF. :

NATAL ESTUARIES : UMHLANGA
SIMULATED MONTHLY RUN-OFF
1921-1976

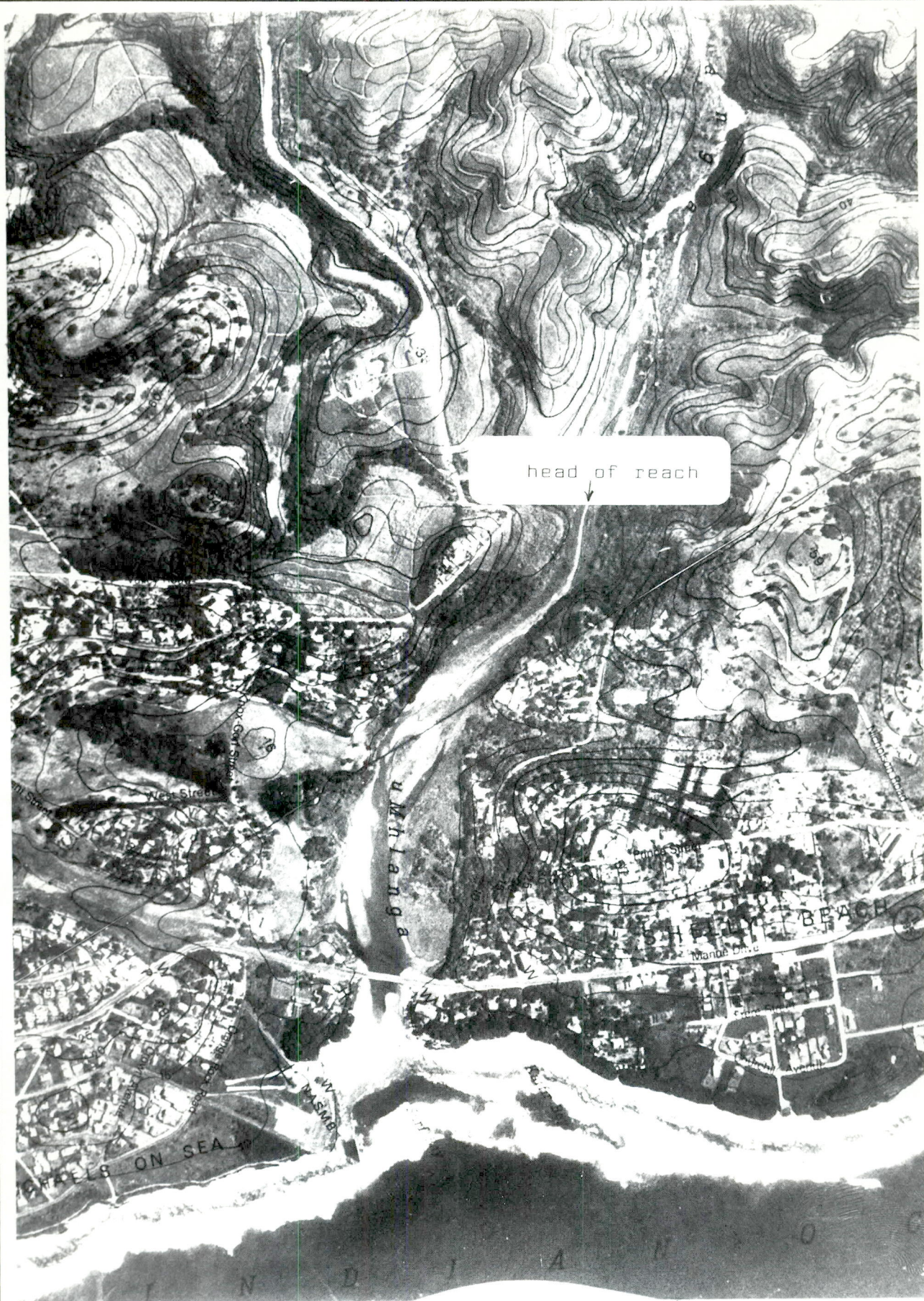
FIGURE
NS 16/3



TRACED : COMLOT
 CHECKED :
 DATE :
 REF. :

NATAL ESTUARIES: UMHLANGA
 CUMULATIVE ANNUAL RUN-OFF

FIGURE
 NS 16/4



SCALE 1:10 000 approx

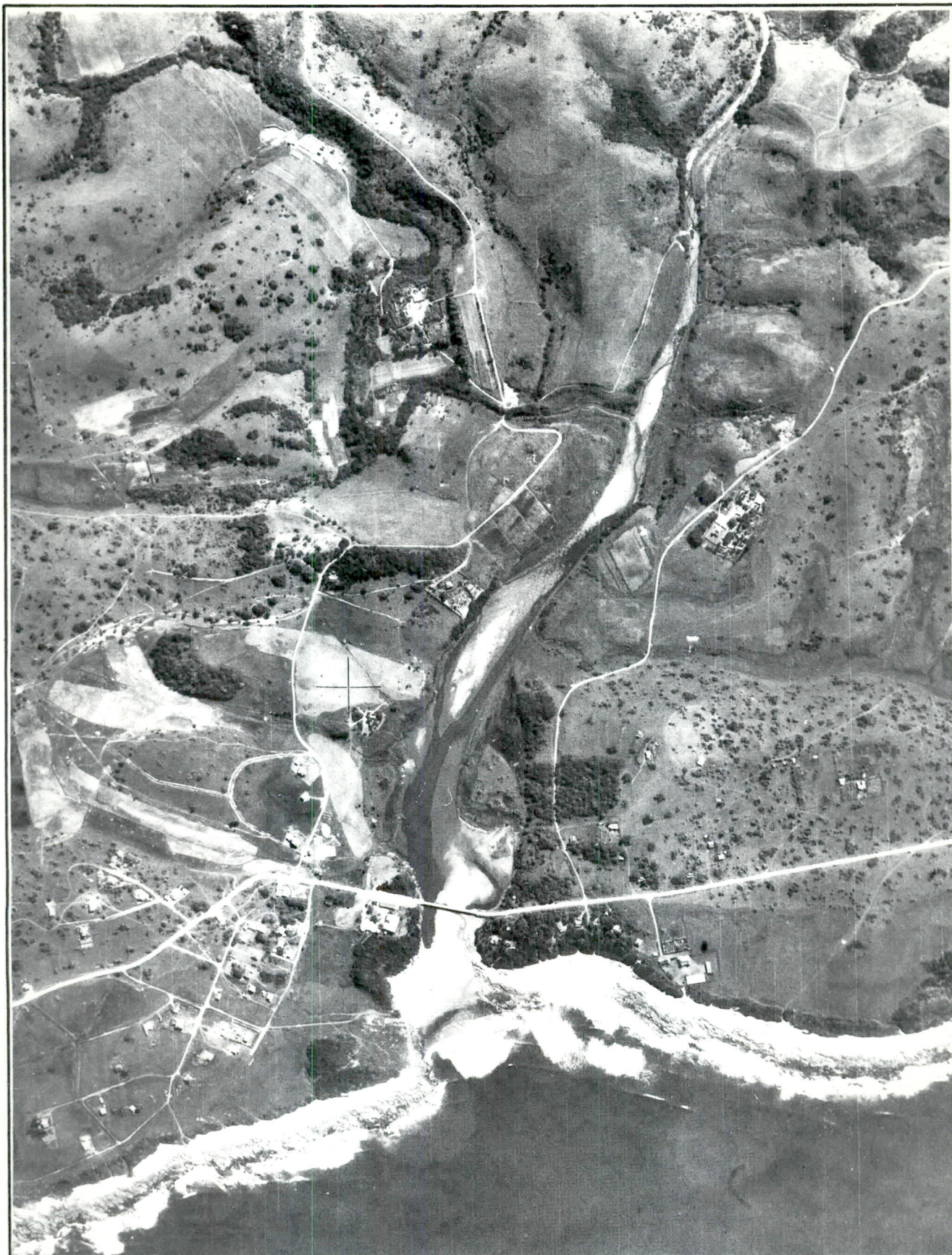


NATAL ESTUARIES: uMHLABA

23-06-76 (ORTHOPHOTO)

PHOTOGRAPH

NS 16/1



SCALE 1 : 10 000 approx



NATAL ESTUARIES : uMHLANGA

02-05-37 (13h14)

PHOTOGRAPH

NS 16/2



SCALE 1 : 10 000 approx



NATAL ESTUARIES : uMHLANGA

DECEMBER 1943 (10h17)

PHOTOGRAPH

NS 16/3



SCALE: 1 : 10 000 approx



NATAL ESTUARIES : uMHLANGA

JUNE / JULY 1955 (13h 09)

PHOTOGRAPH

NS 16/4



SCALE 1 : 10 000 approx

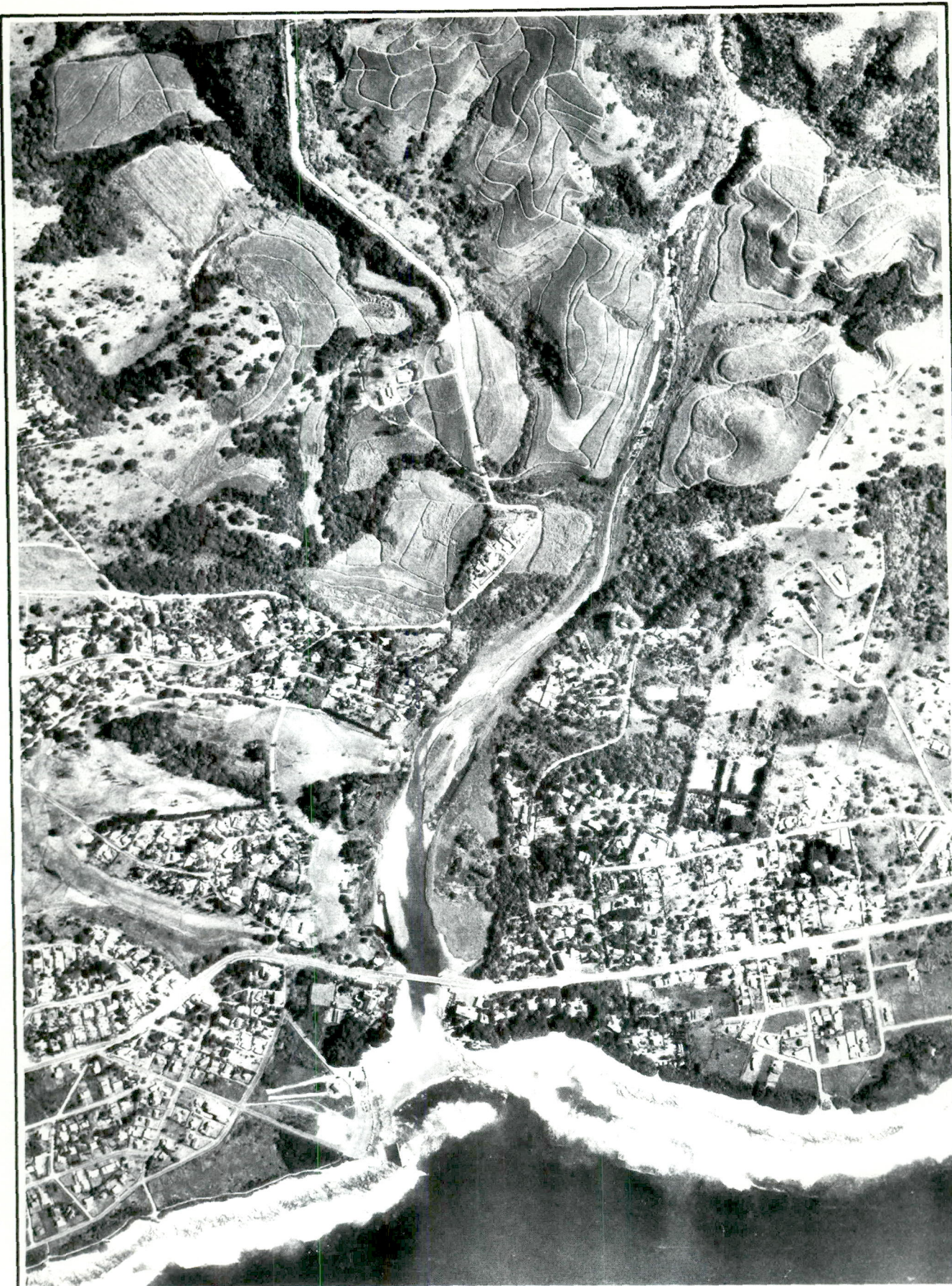


NATAL ESTUARIES: uMHLANGA

05-05-63 (10h32)

PHOTOGRAPH

NS 16/5



SCALE: 1 : 10 000 approx

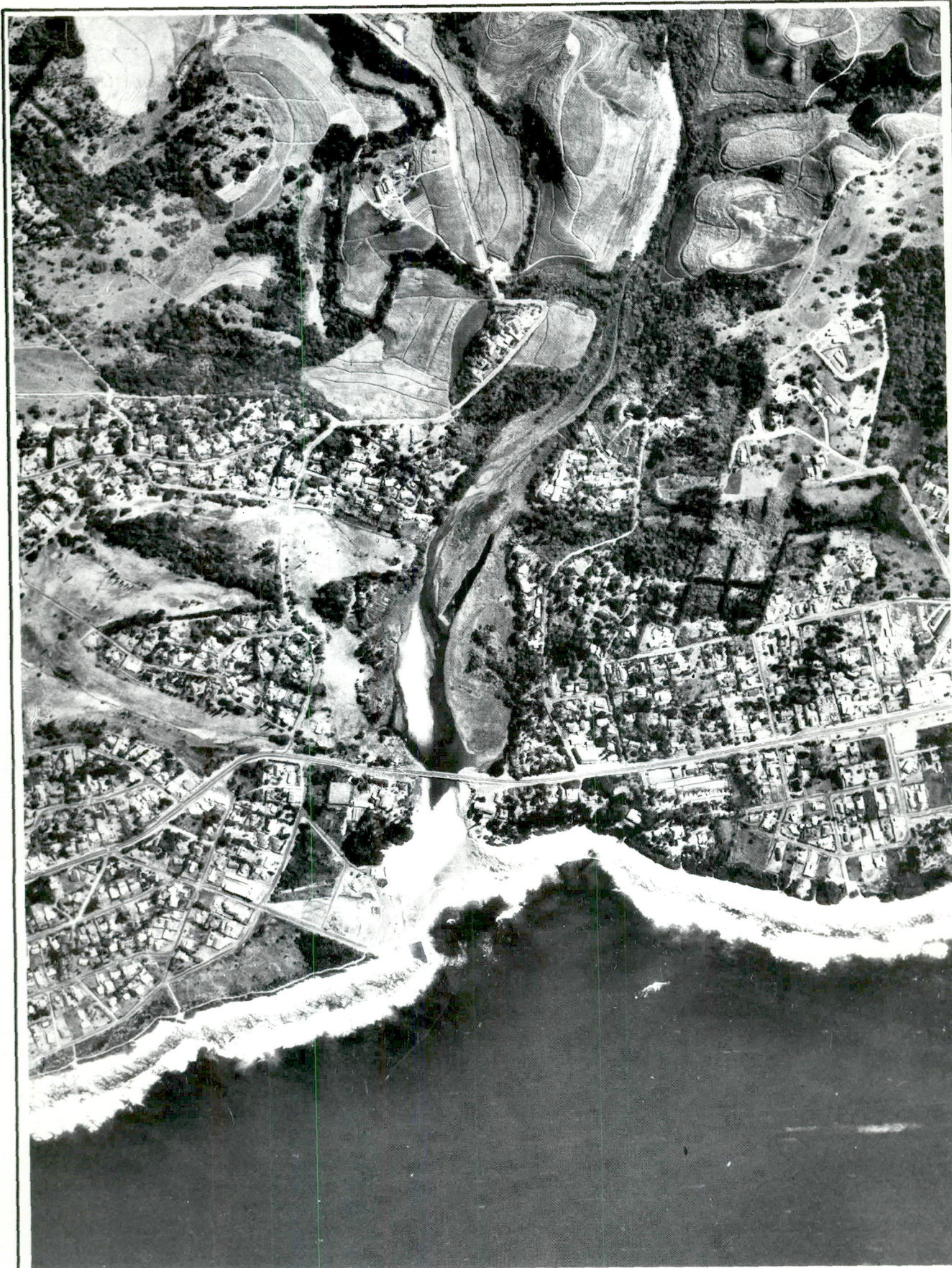


NATAL ESTUARIES: uMHLANGA

23-06-76 (10h48)

PHOTOGRAPH

NS 16/6



SCALE: 1:10 000 approx



NATAL ESTUARIES: uMHLANGA

02-08-83 (12h05)

PHOTOGRAPH

NS 16/7



SCALE: 1 : 10 000 approx



NATAL ESTUARIES: uMHLANGA

06-02-84 (15h52)

PHOTOGRAPH

NS 16/8



SCALE: 1 : 10 000 approx



NATAL ESTUARIES : uMHLANGA

09-07-85 (11h30)

PHOTOGRAPH

NS 16/9



SCALE 1 : 10 000 approx



NATAL ESTUARIES : uMHLANGA

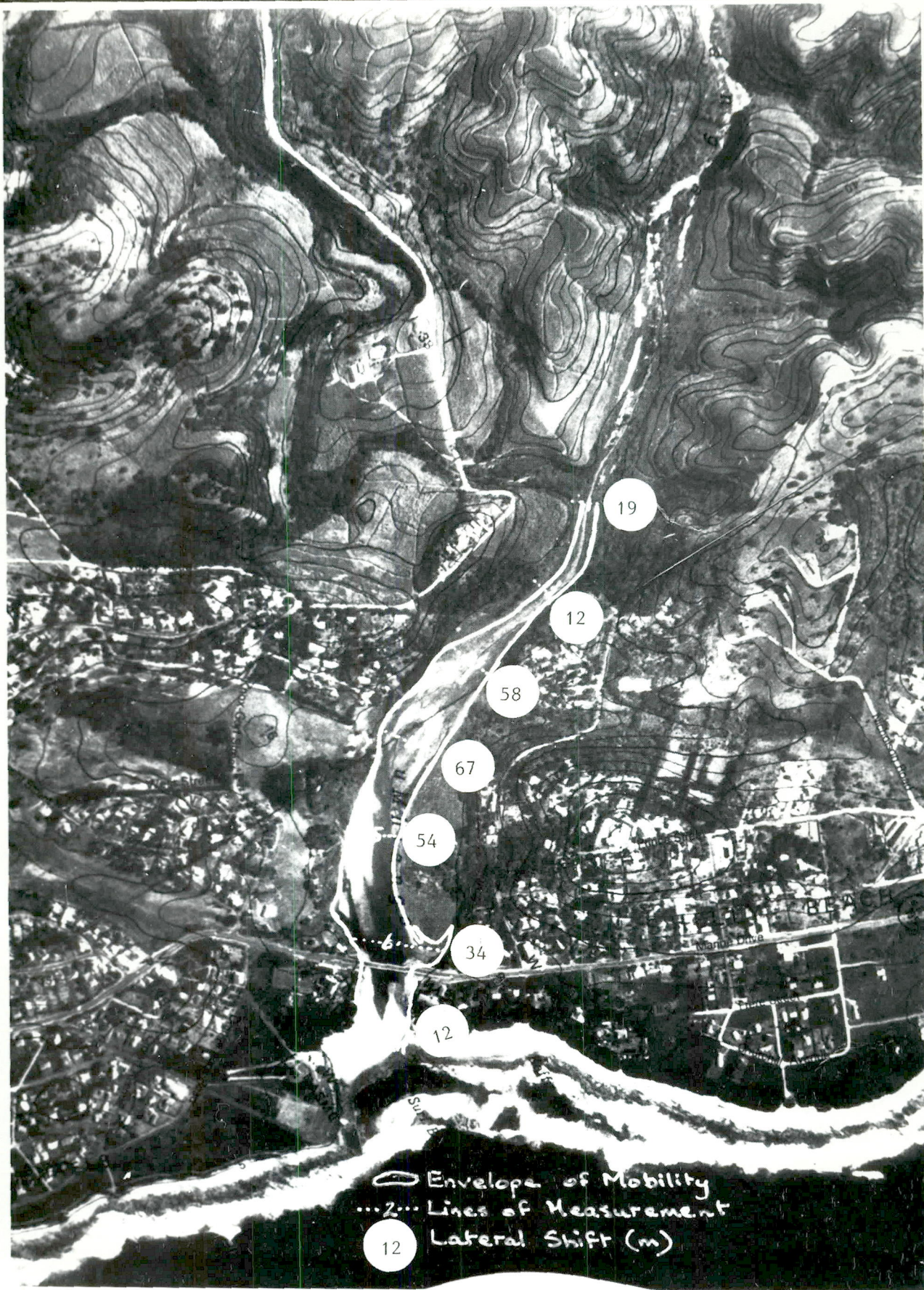
09-07-85

(02-05-37 RIVER COURSE SUPERIMPOSED)

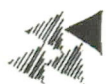
PHOTOGRAPH

NS 16/10

CSIR - DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE AND TECHNOLOGY



SCALE 1:10 000 approx



NATAL ESTUARIES; uMHLANGA

ORTHOPHOTO (ENVELOPE OF MOBILITY, LINES OF
 MEASUREMENT AND LATERAL SHIFT SUPERIMPOSED)

PHOTOGRAPH

NS 16/11



SCALE: 1 : 5 000 approx



NATAL ESTUARIES: uMHLANGA

25-03-78 (12h32)

PHOTOGRAPH

NS 16/12

APPENDIX

APPENDIXSources of Data

06-12-86 Oblique aerial photography (author)
02-10-87 Vertical aerial photography
08-05-88 (Aerial Photographic Service,
02-01-89 Pietermaritzburg)

Post-1987 flood field visit (author)

Local ground knowledge: personal communication with the Town Clerk (Mr R R Turner) and the Borough Engineer (Mr J Woodman) of Uvongo.

Sequence of Events after 1985

- (1) March 1986: artificial breaching of the sandbar by Junior Lifeguards in a position just north of mid-cove.
- (2) Nov/Dec 1986: heavy rains and minor flood flows during which the uMhlanga flowed straight out to sea in a mid-cove position; after which the mouth migrated to the right (southern bank), impinging on the bank near the lifesavers' hut. During high tides the sea covered most of the "beach area" towards the right bank.
- (3) 06-12-86: oblique aerial photograph (inside back cover) shows a sand groyne under construction on the right bank. This groyne followed the normal flood path to mid-cove and was built up with material from the left bank (northern) side of the bar which had been lowered in an attempt to encourage flow to the left bank (Turner, pers. comm.). The sand groyne was soon washed away.
- (4) January to early September 1987: flow persisted to the right bank (southern) side; erosion of the major dune area behind the beach became a major cause of concern.

- (5) 29-09-87: major flood flows (Photograph NS16/1A).
- (6) Oct/Nov 1987: continued erosion of areas near the lifesavers' hut and the dune.
- (7) December 1987: gabion protection for the lifesavers' hut and dune areas; a groyne (built of sandbags) constructed in approximately the same position as the "sand wall groyne" referred to in paragraph 3 above.
- (8) 08-05-88: the groyne was covered by beach sand (Photograph NS16/2A). This covering was partly natural and partly artificial (Woodman, pers. comm.). Sand-spit/beach width was approximately 80 m.
- (9) 02-01-89: sand-spit/beach width was 150 m approximately (Photograph NS16/3A).
- (10) March 1990: Sand-spit/beach elevation is building up towards the right bank (southern) side (Woodman, pers. comm.).

Normality/Abnormality of the 1986-1989 Mouth Morphometry

- (1) It is unlikely that the artificial breaching of the bar in March 1986 caused the subsequent beach erosion and mouth positions. At the worst, it possibly accelerated the natural course of events. The early 1980s were very dry, with a partial breaking of the drought by February 1984 and February 1985 minor flood flows. Therefore at the time of the good rains and river flows of late 1986, there was only a limited supply of sand in the littoral zone and the surf zone was further landward, there being no protection of a well-defined outer bar.
- (2) During the 1986/1987 rainy season, the fairly strong seasonal flood flows would be followed by the mouth migrating to the right bank AND by subsequent storm swells driving straight into the cove, attacking and lowering the beach area.

- (3) The major flood flows at the end of September 1987 further aggravated the position. It is very interesting to note that the high water line of the March 1963 flood (p 6 of the main text) is almost identical with high water line conditions of the September 1987 flood (Figure NS16/1A): only 10-15 m width of beach remaining in each case.
- (4) Strong river flow conditions persisted for most of October 1987. Concurrently, and persisting during November and December 1987, strong erosive marine attack occurred straight into the cove, there being no well-developed outer bar to provide some protection. This directed the river mouth towards the right bank, as usual, but caused the whole process to operate further landward. Therefore, erosion of the dune area was more severe for a longer period.
- (5) The "normal" post-flood spit-building process from the left bank was precluded by (a) prolonged above-average river flows and (b) the lowering of the bar on the left bank (northern side) and building of the sandbag groyne in December 1987. The latter, while serving its purpose in aiding the protection of the right bank and dune areas from combined river and sea attack, would initially have delayed natural sand-spit/beach replenishment.
- (6) By May 1988, normal beach replenishment processes were well underway, beach widths being fully restored by January 1989.

In conclusion, therefore, it would appear that the changes in beach morphometry from 1986 to 1989 were a natural and predictable response to lesser and major flood flows following a dry phase. Such high water line, erosive conditions are not truly abnormal (cold comfort to a town council and the public wishing to sustain the conditions of a relatively stable, attractive beach which they can usually enjoy for many years at a time!).

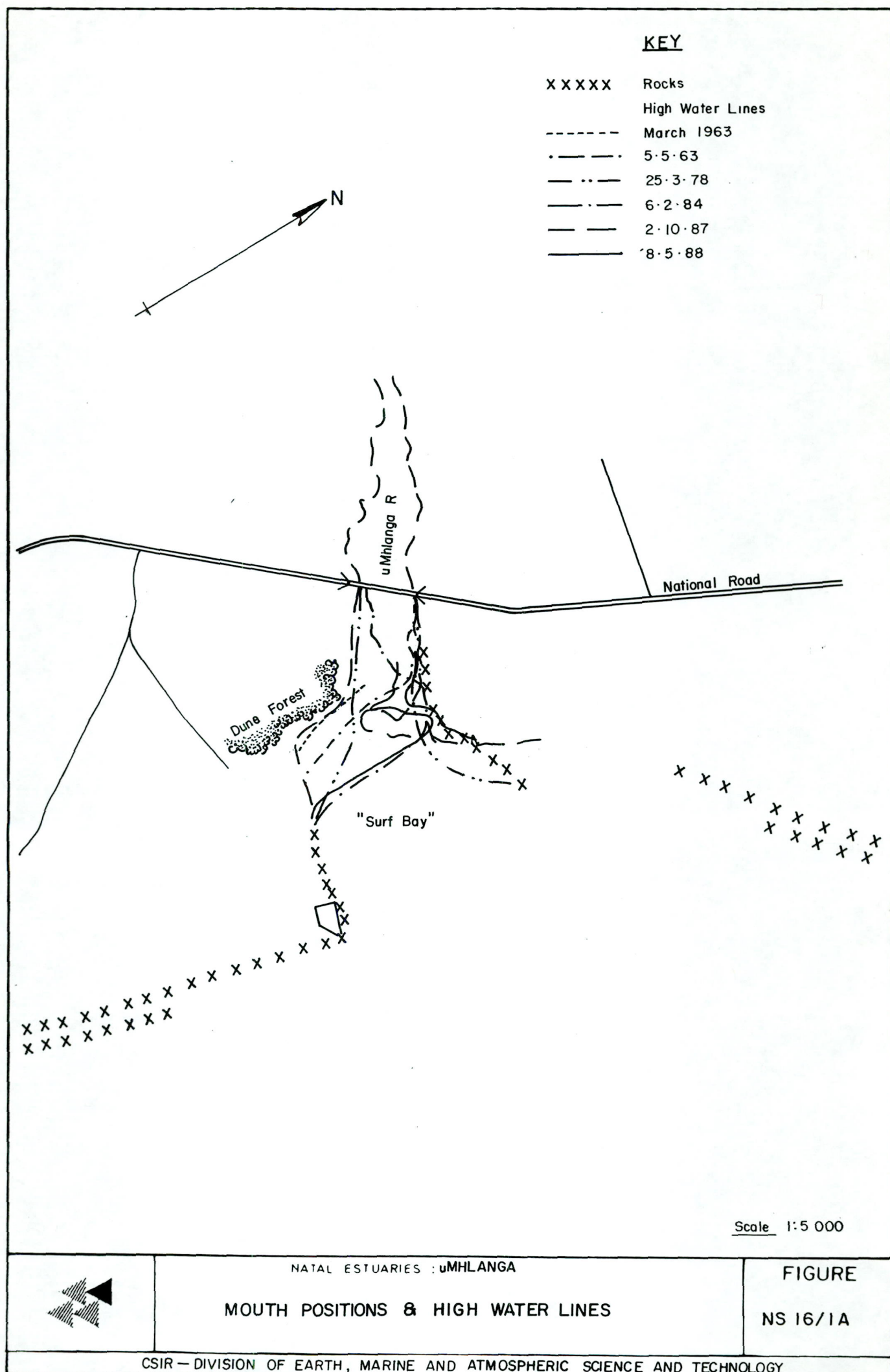
Recent River Bed Levels

A river cross-section at the National Road Bridge was surveyed by L van der Merwe (CSIR) on 20-04-89. This survey reveals an average river bed level of +0,28 m to M.S.L. over a channel width of 66,5 m and a thalweg elevation of +0,15 m to M.S.L. Both levels are marginally lower than those for 1968 (p 9), indicating a slight degradation following the scour and fill process during recent floods. Present levels are not, however, as low as they were in 1930.

Recommendations

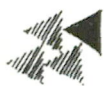
- (1) There should be a minimum of human interference to the natural processes involved in the morphometry of the sand-spit/beach area.
- (2) The local authority should continue its general policy of not breaching the sandbar artificially. This will ensure, under normal seasonal conditions, the optimum flushing out of the system at the optimum position for breaching.
- (3) Should artificial breaching be deemed necessary, it should take place towards the left bank (northern side) in the position of the "normal overflow channel". The stage (i.e. the lagoon water level) prior to breaching should be at least +2,5 m to M.S.L. at the NR bridge.
- (4) The normal physical processes should be understood and appreciated; due attention being given to wet/dry phases and the effects of both seasonal and episodic floods within these phases. Protective measures for property and/or dunes should be carried out locally only with due attention to the design and nature of materials used. The mid-cove beach area is best left to function naturally in order to expedite beach replenishment.

- (5) It would be advantageous if future planned beach surveys were to incorporate a section on the same site as the one surveyed during the period 1972 to 1975 (CSIR, C/SEA 75/4 & 23). Beach elevations could be compared and management policies would be facilitated.
- (6) Cross-sections should be surveyed at the NR bridge at the end of each wet and dry season and after any future major hydro event. Long-term net aggradation/degradation can then be verified.
- (7) Water levels (preferably daily) should be taken from the NR bridge. This would verify the level at which natural breaching of the sandbar occurs and facilitate management policy, should artificial breaching be deemed necessary.





SCALE: 1:5 000 approx



NATAL ESTUARIES: uMHLANGA

02-10-87 (11h50)

PHOTOGRAPH

NS 16/1A



SCALE: 1 : 5 000 approx.



NATAL ESTUARIES: UMHLANGA

08-05-88

PHOTOGRAPH

NS 16/2A



SCALE 1 : 5 000 approx



NATAL ESTUARIES : uMHLANGA

02-01-89 (12h00)

PHOTOGRAPH

NS 16/3A