

CONFIDENTIAL



**HYDROLOGICAL / HYDRAULIC STUDY
OF NATAL ESTUARIES**

**DATA REPORT NO.24
DAMBA NS 23**

SEDIMENT DYNAMICS DIVISION
COASTAL ENGINEERING AND HYDRAULICS
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY
COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

NRIO DATA REPORT D 8608

**Stellenbosch, South Africa
December 1986**

NS 23

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LIST OF PHOTOGRAPHS

N.B. Basic diapositives and orthophoto maps for this study were obtained from the following sources

- * The Chief Director, Surveys and Mapping, Mowbray
- ** The Air Survey Co. of Africa Pty (Ltd), Durban
- ***Aerial Photographic Service, Pietermaritzburg

The oblique colour aerial photograph inside the back cover was taken by F. Junor, Natal Parks Board, on 16 February 1985.

- * NS23/1 23-06-76 (orthophoto)
- * NS23/2 02-05-37 (13h20)
- * NS23/3 June/July 1955 (11h47)
- * NS23/4 05-05-63 (10h35)
- * NS23/5 23-06-69 (12h25)
- * NS23/6 06-07-76 (13h36)
- * NS23/7 02-08-83 (12h09)
- ** NS23/8 06-02-84 (15h52)
- ***NS23/9 09-07-85 (≈11h35)
- ***NS23/10 09-07-85 (02-05-37 river course superimposed)
- NS23/11 Orthophoto (envelope of mobility, lines of measurement and lateral shift superimposed)

Location

The Damba discharges into the Indian Ocean on the Natal South Coast at 30°40'S, 30°31'E. The head of the reach under review is 0,6 km from the mouth (Photograph NS23/1). This position is an arbitrary line, selected at the first point upstream of 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 and immediately upstream of the head of reach the main river course is barely discernible as it flows through swamp forest.

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 rare opportunity of studying the lowest reaches of the Damba under mouth-open conditions (February 1984) following a long, severe drought, as depicted by the August 1983 photograph 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 25 km² is 7,31 × 10⁶ m³ (28,3 % 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 NS23/XII) ranging from 53,3 to 230,7 per cent ($\bar{V} = 149,3\%$)
- (b) the wide spectrum of annual and monthly run-off shown in Figures NS23/2 and 3 and
- (c) median run-off values well below the mean (Table NS23/XII).

The aforementioned Table and Figures are based upon simulated run-off data for tertiary catchments (Pitman et al., 1981). These data also reveal high monthly run-off periods, with major flood flows occurring in March 1925, June 1935, November 1949 and March 1976, and lesser floods occurring in March 1927, October 1954, March 1955, April 1961 and April 1976 (Table NS23/XII and Figure NS23/3).

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 - likewise for two months previous, well above average six months previous
- 2) 1955 below-average run-off - likewise for previous month, above average for the next few months previous and well above average eight months previous
- 3) 1963 below-average run-off but above-average for the previous four months
- 4) 1969 almost long-term, monthly mean run-off but within a marked dry phase
- 5) 1976 slightly above-average run-off and for the previous month, major flood flows three and four months previous

- 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-average run-off, well above average five months previous.

N.B. Simulated run-off data are not available beyond hydro-year 1975. Therefore, the comments above for the 1983, 1984 and 1985 time slices are based upon local ground knowledge.

River Mouth

The Damba is diverted near its mouth by a southerly-extending spit which was artificially stabilized in 1960 to accommodate the new railway alignment. The colour photograph inside the back cover illustrates this well and it also shows the mouth in a rare "open" condition following a natural breaching, with the Damba discharging into the ocean against rocks on the right bank. Begg (pers. comm.) estimates the mouth to be closed for 95 per cent of the year and the time slices of selected aerial photography reflect this (Photographs NS23/2-9). There was probably no artificial breaching of the sandbar at the mouth until the 1980's. Begg (1984) states that the bar has been artificially breached on several occasions recently as a result of waterfront property owners (caravan park) complaining of high water levels. Whether this was the case regarding the 1984 photograph is not known but a natural breaching in this case is probable following a few months of above-average run-off.

Land-use

(a) Agriculture

There has been no cultivation on the flood plain for the period under review and only seven per cent of the upper right valley side has been cultivated.

(b) **Structures**

The earliest construction was the old railway bridge, 200 m from the mouth, which was built at the turn of the century. This structure comprised an embankment across the right bank flood plain. In 1942, the National Road (NR) bridge was built immediately upstream of the old railway bridge. A new railway bridge at the mouth, necessitating stabilization of the sand-spit, was built in 1960 while the foundations of the old railway bridge remain in situ.

(c) **Urbanization**

Residential areas have developed on the upper valley sides near the mouth since 1937. A caravan park site was established near the head of reach in 1978.

Siltation

The lowest reaches of the Damba show severe siltation throughout the period under review (Photographs NS23/2-9). An average of 49 per cent (range, 42-60%) of the flood plain is occupied by fluvial silt and swamps (Table NS23/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 Damba is 1:37 (very steep) checking to 1:185 over the lowest kilometre where the river emerges from an incised meandering course. This check in river gradient alone, 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 most of the year, favouring deposition behind a high sandbar. Man has further aggravated the position. Firstly, an embankment has been built across the right bank flood plain for the old railway bridge at the turn of the century, and siltation has occurred upstream of this embankment. Secondly, the spit at the mouth was stabilized

in 1959 to accommodate realignment of the railway line. 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) an average sediment yield of 10 000 tons per year is derived for the Damba 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 mainly from major hydro events, one should study the changes in siltation from two viewpoints:

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

(a) Changes in areas of siltation over time

Areal measurements of the flood plain from the eight time slices of aerial photography quantify the changes in siltation areas from 1937-1985 (Table NS23/I). Care must be taken in studying these changes in the composition of the flood plain. River stage should be comparable and if this is not the case, allowances must be made. (N.B. there is a maximum range of 2,15 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 (bridge embankments) have been at the expense of the 1937 base-line "recent" siltation areas. The "recent" siltation area in 1937 comprised fluvial sand/silt plus swamp areas (44% 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 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>1955</u>	<u>1963</u>	<u>1969</u>	<u>1976</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>
44	61	56	57	49	48	51	52
(15)	(12)	(18)	(11)	(18)	(15)	(11)	(13)

Two clear facts emerge:

- (i) Open water areas exhibit no particular trend. They are probably simply dependent upon mouth open/closed condition and, most importantly, antecedent run-off conditions for each time slice. The latter will affect water levels under otherwise comparable closed mouth conditions.
- (ii) There was an increase in siltation areas from 1937 to 1955, then a slight reduction. Since the 1970s the total area has remained fairly constant although small areas were re-worked and re-located.

(b) Aggradation/degradation over time

Expanded to air

These changes naturally cannot be assessed from aerial photographs directly. Some features may be inferred, however. Upstream of the old railway bridge/NR bridge the main siltation area which can be seen on all the aerial photographs is a sub-aerial delta. The 1976 orthophoto (Photograph NS23/1) shows that this "delta" has reached a level of over +5 m to M.S.L., building up over time during major flood events. The "building up" and extension towards the mouth has doubtless accelerated since the turn of the century for the reasons mentioned at the beginning of this section. The river has taken various courses through and around this "delta", such channel avulsion being indicative of aggrading conditions as mentioned previously.

Cross-sections are available for the bridge sites and, although none are successive for exactly the same site, the old railway bridge and NR bridge are comparable as they are very close. Furthermore, a "rough note" on the 1932/39 cross-sections allows us to equate the then-used road and railway datums to M.S.L. At

the turn of the century, the bed level at the old railway bridge was +1,0 m to M.S.L. By 1939 the bed level at the nearby NR bridge site was +1,44 m to M.S.L. The thalweg level on both these sections was +0,64 m to M.S.L. but whereas this level was maintained for almost 9 m river width in 1900, it was a one-only level in 1939. Two spot bed levels measured from the DWA water level station measuring point on the NR bridge on 29 February and 5 April 1984 were approximately +1,3 m and +1,4 m to M.S.L. respectively - levels which are similar to the 1939 average bed level.

About 200 m further downstream, near the mouth, a cross-section drawn for the new railway bridge (\approx 1959) shows a bed level of +0,63 m to M.S.L.

Lateral Stability

For easy visual reference, an envelope of mobility, lines of measurement and lateral shift are superimposed on an orthophoto (Photograph NS23/11).

Lateral shift is greatest at sections 1, 2 and 3 where the river has adopted various courses through the swampy conditions created on its own alluvial deposits (Figure NS23/1 and Table NS23/XI). In general, upstream of the NR bridge, the river has shifted towards the left valley side in the period 1937-1985 (Photograph NS23/10). Photograph NS23/5, taken in June 1969, shows a very straight channel between sections 1 and 2 directing the river towards the left valley side. It looks man-made but no evidence can be found to corroborate this photo interpretation. The sinuosity for the whole reach has varied during the period under review while showing a general tendency to increase, slightly.

The average displacement for the whole reach is 32,2 m (177,9% of \bar{R} width) with an average coefficient of variation of 37,7 per cent which quantifies the instability (Tables NS23/X and XI).

Overall, the Damba shows considerable siltation (the siltation position probably relatively stable since the 1960s) and has been laterally unstable for the period under review: 1937-1985.

Details of the classification may be found in Tables NS23/II-IX and an abstract of results is given in Table NS23/I.

ABBREVIATIONS/SYMBOLS/TERMS USED

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 $\frac{s}{\bar{x}}$
M.S.L.	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 - preferably where the river is confined by a bridge to facilitate the demarcation of flood plain areas.

ABSTRACT

BASIC DATA/CALCULATIONS

Lateral displacement (1937-1985) \bar{x} 32.2 m (177.9 & R width)
 Relative lateral stability (1937-1985) V 37.7 %
 Area of catchment 25 km²
 Area of flood plain/valley 8.9 ha
 Area of envelope of mobility 4.1 ha
 Simulated run-off ($\times 10^6$ m³) M.A.R. 7.31 s 4.97
 \bar{V} 67.95 %
 Major floods: March 1925, June 1935, Nov. 1949, March 1976
 Lesser floods: 3/27, 10/54, 3/55, 5/59, 4/61, 4/76

HUMAN INFLUENCES

Within the Reach
 Cultivation: L.V.S. R.V.S. Flood Plain To Channel Edge
 Nil Nil Nil Nil Nil
 Bridges & Embankments: Position (m from head of reach) Date
 Old Railway 420 1900
 National Road 405 1942
 Railway 610 1960
 Canals: Nil

Urbanization/Industry: Residential areas, upper valley sides, since 1937.
 Caravan site, head of reach, 1978.
 Sandbar breaching: Artificial breaching probably only since 1980 -
 high water levels at waterston proposition (caravan site).
 Others: Stabilization of the sand-spit at the mouth, 1959.

Upstream of the Reach

Dams: Nil
 Construction/Canalization immediately upstream of reach: Nil
 Land-use malpractices/silt supply: Marked siltation indicative of
 land-use malpractices in the catchment.

STABILITY FOR PERIOD UNDER REVIEW (1937-1985)

Unstable

MEASUREMENTS/CALCULATIONS FROM PHOTOGRAPHS

Date	2-5-37	June/July 1955	5-5-63	23-6-69	6-7-76	2-8-83	6-2-84	9-7-85
Reach								
thalweg (m)	621	618	617	610	625	647	699	620
& estuarine	?	?	?	?	86	47	47	47
& braided	NIL	NIL	NIL	NIL	NIL	NIL	40	NIL
aerial distance (m)	504	495	513	501	502	496	549	486
sinuosity	1.23	1.25	1.20	1.22	1.25	1.30	1.27	1.28
open water area (ha)	1.3	1.1	1.6	1.0	1.6	1.3	1.0	1.2
\bar{x} river width (m)	17.4	14.3	23.5	14.4	23.6	18.6	14.6	18.6
Flood Plain/Valley								
& open water	15	12	18	11	18	15	11	13
& sand (marine)	11	14	9	9	9	9	9	9
& sand/silt (fluvial)	12		1	1	1	1	3	2
& swamp, marsh	32	60	53	54	44	41	43	43
& grass, trees, bush	30	13	15	20	22	27	27	26
& cultivated								
& built-up		1	4	5	6	7	7	7
Valley Sides (L/R)								
& dune forest	L 22	L 22	L 22	L 22	L 22	L 22	L 22	L 22
& sand	R 22	R 22	R 22	R 22	R 22	R 22	R 22	R 22
& trees	L 31	L 56	L 32	L 67	L 45	L 38	L 49	L 38
& grass	R 45	R 11	R 40	R 11	R 34	R 11	R 11	R 11
& cultivated								
& built-up	L 2	L 11	L 6	L 11	L 6	L 33	L 11	L 40
L.B. & vegetated								
R.B. & vegetated								
Mouth								
open/closed (O/C)								
spit/bar:								
direction (°)	204	206	203	202	202	203	202	202
length (m)	235	225	240	235	235	235	210	235
width (m)	62	58	43	37	38	42	42	32

STABILITY FOR PERIOD UNDER REVIEW (1937-1985)

Unstable

RIVER DAMBA, ? % ESTUARINE, REACH from -, 0,6 km from mouth. REF. DEA U 801 c
 AERIAL PHOTO DATE 2-5-37 SCALE 1:5000 CATCHMENT AREA 25 km², M.A.R. 7,31 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	22	22
✓ hilly	✓ grass	✓ scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	partly cultivated	frequent	trees	31	11
plains	moderately forested (25-75%)	mainly cultivated		grass	45	65
	heavily forested (75-100%)	✓ scattered settlement		cultivated		
	riverine forest: tributaries	partly built-up		built-up	2	2
		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>600</u> m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>146</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>8,9</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		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>204</u> °	
outer bar	length of spit/bar <u>235</u> m	
silt plume (fluvial)	length stabilized <u>NIL</u> m	
✓ suspended sediment (marine)	width <u>62</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>15</u>	swamp, marsh <u>32</u>
indefinite	average width <u>146</u> m	sand (marine) <u>11</u>	cultivated _____
fragmentary	maximum width <u>225</u> m	sand, silt (fluvial) <u>12</u>	built-up _____
✓ continuous	area <u>8,9</u> ha	trees, bush <u>13</u>	_____
		grass <u>17</u>	_____
			Comments

Channel Description N.B. - Estimate of flow stage: LOW/

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>621</u> m	✓ none	stagnant/still	none
sinuous	*aerial length <u>504</u> m	occasional	✓ uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,23</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>1,3</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>2340</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	diamond bars
bifurcated	channel slope _____			diagonal bars
lake/s	channel width \bar{x} _____ m	s = _____ m		sand waves/large dunes
lagoon	river slope _____			
	river width \bar{x} <u>17,4</u> m	s = <u>18,6</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		
logs	minor	rail bridge/s <u>(old)</u>	R. confined	<u>420</u> m
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s	<u>across R.B. flood plain</u>	<u>420</u> m
Comments		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	weak	slightly unstable
progression and cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓ unstable
entrenched loop development	cultivation to	left bank <u>42</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>17</u> %	Comments *swamp forest & coastal dune forest
✓ avulsion			

RIVER DAMBA, ? % ESTUARINE, REACH from -, 0,6 km from mouth. REF. DEA U 801c
 AERIAL PHOTO DATE 5-5-63 SCALE 1:5000 CATCHMENT AREA 25 km², M.A.R. 7,31 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	<u>11</u> <u>22</u>
✓ hilly	✓ grass	✓ scattered cultivation	occasional	sand	
undulating	✓ sparsely forested (0-25%)	partly cultivated	frequent	trees	<u>67</u> <u>28</u>
plains	moderately forested (25-75%)	mainly cultivated		grass	<u>11</u> <u>44</u>
	heavily forested (75-100%)	scattered settlement		cultivated	
	riverine forest: tributaries	✓ partly built-up urbanized		built-up	<u>11</u> <u>6</u>
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>600</u> m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>146</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>8,9</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head _____ m to MSL	✓ continuous	partly entrenched	entrenched	aeolian
valley slope 1: _____		entrenched		
		✓ aggrading		
Comments _____				

River Mouth

Characteristics	Measurements	Comments
✓ open/closed	right bank breakwater length _____ m	* wall + vegetation
✓ 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>203</u> °	
outer bar	length of spit/bar <u>240</u> m	
silt plume (fluvial)	*length stabilized <u>110</u> m	
✓ suspended sediment (marine)	width <u>43</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>18</u>	swamp, marsh <u>53</u>
indefinite	average width <u>146</u> m	sand (marine) <u>9</u>	cultivated _____
fragmentary	maximum width <u>225</u> m	sand, silt (fluvial) <u>1</u>	built-up <u>4</u>
✓ continuous	area <u>8,9</u> ha	trees, bush <u>15</u>	_____
		grass _____	_____
Comments _____			

Channel Description N.B. - Estimate of flow stage: LOW/~~MODERATE~~ FLOOD

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>617</u> m	✓ none	stagnant/still	none
sinuous	*aerial length <u>513</u> m	occasional	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>1,6</u> ha	split	✓ irregular	channel junction bars
irregular meanders	perimeter <u>2413</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	diamond bars
bifurcated	channel slope _____	s = _____ m		diagonal bars
lake/s	channel width \bar{x} _____ m	s = _____ m		sand waves/large dunes
lagoon	river slope _____	s = <u>14,1</u> m		
	river width \bar{x} <u>23,5</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 (NR)	R. confined	<u>405m</u>
logs	minor	rail bridge/s	R. confined	<u>610m</u>
boulders	major	weir/dam old rail bridge pier foundations		<u>420m</u>
vegetation		weir/dam		
		fish traps		
		embankment/s	across R.B. flood plain	<u>405, 420m</u>
		groynes		
		canals		
		drainage furrows		
		others	old sand-spit stabilized (105m)	<u>= 460-560m</u>

Lateral Channel Activity

Lateral Activity	Nature of Banks	*Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	weak	slightly unstable
progression and cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓ unstable
entrenched loop development	cultivation to	left bank <u>54</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>35</u> %	
✓ avulsion			Comments *swamp forest & coastal dune forest

RIVER DAMBA, ? % ESTUARINE, REACH from -, 0.6 km from mouth. REF. DEA U801c
 AERIAL PHOTO DATE 23-6-69 SCALE 1:5000 CATCHMENT AREA 25 km², M.A.R. 7.31 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	11 22
✓ hilly	✓ grass	✓ scattered cultivation	occasional	sand	
undulating	✓ sparsely forested (0-25%)	partly cultivated	frequent	trees	67 38
plains	moderately forested (25-75%)	mainly cultivated		grass	11 34
	heavily forested (75-100%)	scattered settlement		cultivated	
	riverine forest: tributaries	✓ partly built-up urbanized		built-up	11 6

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>600</u> m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>146</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>8.9</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		

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	split/bar: direction of growth <u>202</u> °	
outer bar	length of split/bar <u>235</u> m	
silt plume (fluvial)	*length stabilized <u>110</u> m	
suspended sediment (marine)	width <u>37</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>11</u>	swamp, marsh <u>54</u>
indefinite	average width <u>146</u> m	sand (marine) <u>9</u>	cultivated _____
fragmentary	maximum width <u>225</u> m	sand, silt (fluvial) <u>1</u>	built-up <u>5</u>
✓ continuous	area <u>8.9</u> ha	trees, bush <u>20</u>	_____
		grass _____	_____

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>610</u> m	✓ none	stagnant/still	none
sinuous	*aerial length <u>501</u> m	occasional	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>1.0</u> ha	split	✓ irregular	channel junction bars
irregular meanders	perimeter <u>1295</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	diamond bars
bifurcated	channel slope _____			diagonal bars
lake/s	channel width \bar{x} _____ m	s = _____ m		sand waves/large dunes
lagoon	river slope _____	s = <u>18.4</u> m		
	river width \bar{x} <u>14.4</u> m			

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	none	road bridge/# <u>(NR)</u>	R. confined	<u>405</u> m
logs	minor	rail bridge/# _____	R. confined	<u>610</u> m
boulders	major	weir/dam _____	_____	<u>420</u> m
vegetation		fish traps _____	_____	
		embankment/s _____	_____	<u>405 + 420</u> m
		groyne/s _____	_____	
		canals _____	_____	
		drainage furrows _____	_____	
		others <u>old sand-split stabilized (105m)</u>	_____	<u>460-560</u> m

Lateral Channel Activity

Lateral Activity	Nature of Banks	* Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	weak	slightly unstable
progression and cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓ unstable
entrenched loop development	cultivation to	left bank <u>50</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>35</u> %	

Comments * Swamp forest & coastal dune forest

RIVER DAMBA, 86 % ESTUARINE, REACH from -, 0,6 km from mouth. REF. DEA U 801c
 AERIAL PHOTO DATE 6-7-76 SCALE 1:5000 CATCHMENT AREA 25 km², M.A.R. 7,31 m³x10⁶, No. of DAMS NIL
 (Orthophoto series)

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Valley Sides (Most Well-defined)

Terrain	Vegetation	Land-use	Slumping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	11	11
✓ hilly	✓ grass	✓ scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	partly cultivated	frequent	trees	45	43
plains	moderately forested (25-75%)	mainly cultivated		grass	11	28
	heavily forested (75-100%)	scattered settlement		cultivated		7
	riverine forest: tributaries	✓ partly built-up urbanized		built-up	33	11

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>600</u> m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>146</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>89</u> ha	fragmentary	or aggrading	frequently confined	✓ fluvial deposits
height at head of reach <u>± 3</u> m to MSL.	✓ continuous	partly entrenched	entrenched	aeolian
valley slope <u>1:200 approx.</u>		✓ aggrading		

Comments

River Mouth

Characteristics	Measurements	Comments
✓ open/closed	right bank breakwater length _____ m	* wall + vegetation
✓ 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>202</u> °	
outer bar	length of spit/bar <u>235</u> m	
silt plume (fluvial)	* length stabilized <u>110</u> m	
✓ suspended sediment (marine)	width <u>38</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>18</u>	swamp, marsh <u>44</u>
indefinite	average width <u>146</u> m	sand (marine) <u>9</u>	cultivated _____
fragmentary	maximum width <u>225</u> m	sand, silt (fluvial) <u>1</u>	built-up <u>6</u>
✓ continuous	area <u>89</u> ha	trees, bush <u>14</u>	_____
		grass <u>8</u>	_____

Comments

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

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>625</u> m	✓ none	stagnant/still	none
sinuous	*aerial length <u>502</u> m	occasional	✓ uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,25</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>1,6</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>1340</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	diamond bars
bifurcated	channel slope _____	s = _____ m		diagonal bars
lake/s	channel width \bar{x} _____ m			sand waves/large dunes
lagoon	river slope _____	s = <u>17,7</u> m		
	river width \bar{x} <u>23,6</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/# (NA)	R. confined	405m
logs	minor	rail bridge/#	R. confined	610m
boulders	major	weir/dam	old rail bridge pier foundations	420m
vegetation		fish traps		
		embankment/s	across R.B. flood plain	405 + 420m
		groynes		
		canals		
		drainage furrows		
		others	old sand-spit stabilized (105m)	≈ 460-560m

Lateral Channel Activity

Lateral Activity	Nature of Banks	* Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	weak	slightly unstable
progression and cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓ unstable
entrenched loop development	cultivation to channel edge	left bank <u>46</u> %	highly unstable
irregular lateral activity		right bank <u>35</u> %	
✓ avulsion			Comments * Swamp forest + coastal dune forest

TABLE NS23/VII

CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS

NR10 NS 23

RIVER DAMBA, 47 % ESTUARINE, REACH from -, 0,6 km from mouth.

REF. DEA U 801c

AERIAL PHOTO DATE 2-8-83 SCALE 1:5000 CATCHMENT AREA 25 km², M.A.R. 7,31 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	11	11
✓hilly	✓grass	✓scattered cultivation	occasional	sand		
undulating	✓sparsely forested (0-25%)	partly cultivated	frequent	trees	38	49
plains	moderately forested (25-75%)	mainly cultivated		grass	11	11
	heavily forested (75-100%)	scattered settlement		cultivated		7
	riverine forest: tributaries	✓partly built-up urbanized		built-up	40	22

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>600</u> m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>146</u> m	indefinite	not obviously degrading	✓occasionally confined	lacustrine deposits
valley area <u>8,9</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>		entrenched		
		✓aggrading		

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	split/bar: direction of growth <u>203</u> °
outer bar	length of split/bar <u>235</u> m
silt plume (fluvial)	* length stabilized <u>110</u> m
✓suspended sediment (marine)	width <u>42</u> m

Comments

* wall + vegetation

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>15</u>	swamp, marsh <u>41</u>
indefinite	average width <u>146</u> m	sand (marine) <u>9</u>	cultivated <u> </u>
fragmentary	maximum width <u>225</u> m	sand, silt (fluvial) <u>1</u>	built-up <u>7</u>
✓continuous	area <u>8,9</u> ha	trees, bush <u>16</u>	
		grass <u>11</u>	

Comments

Channel Description N.B. - Estimate of flow stage: LOW/Normal

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>647</u> m	✓none	stagnant/still	none
sinuous	*aerial length <u>496</u> m	occasional	✓uniform water surface	✓channel side bars
✓irregular	*sinuosity <u>1,30</u>	frequent	uniform with rapid in reach	✓point bars
regular meanders	*open water area <u>1,3</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>1391</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	diamond bars
bifurcated	channel slope			diagonal bars
lake/s	channel width \bar{x} <u> </u> m	s = <u> </u> m		sand waves/large dunes
lagoon	river slope			
	river width \bar{x} <u>18,6</u> m	s = <u>17,5</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 (NR)	R. confined	405 m
logs	minor	rail bridge/s	R. confined	610 m
boulders	major	weir/dam	old rail bridge pier foundations	420 m
vegetation		fish traps		
		embankment/s	across R.B. flood plain	405 + 420 m
		groynes		
		canals		
		drainage furrows		
		others	old sand-spit stabilized (105m)	≈ 460 - 560 m

Lateral Channel Activity

Lateral Activity	Nature of Banks	*Bank Vegetation	Lateral Stability
not detectable	✓alluvium	none	stable
downstream progression	natural levees	weak	slightly unstable
progression and cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓unstable
entrenched loop development	cultivation to	left bank <u>42</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>30</u> %	
✓avulsion			Comments *swamp forest + coastal dune forest

RIVER DAMBA, ? 47 % ESTUARINE, REACH from -, 0,7 km from mouth. REF. DEA U801c
 AERIAL PHOTO DATE 6-2-84 SCALE 1:5000 CATCHMENT AREA 25 km², M.A.R. 7,31 m³x10⁶, No. of DAMS NIL

RIVER VALLEY AND RIVER MOUTH FEATURES

General Description of the Terrain above the Valley

Valley Sides (Most Well-defined)

Terrain	Vegetation	Land-use	Sloping	Vegetation and Land-use	Left	Right
mountainous	almost none	none	✓ none	coastal dune forest	11	11
✓ hilly	✓ grass	✓ scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	partly cultivated	frequent	trees	38	49
plains	moderately forested (25-75%)	mainly cultivated		grass	11	11
	heavily forested (75-100%)	scattered settlement		cultivated		7
	riverine forest: tributaries	✓ partly built-up		built-up	40	22
		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>600</u> m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>146</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>8,9</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		

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>202</u> °			
outer bar	length of spit/bar <u>210</u> m			
silt plume (fluvial)	* length stabilized <u>110</u> m			
✓ suspended sediment (marine)	width <u>42</u> m			

Comments * wall + vegetation

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>43</u>
indefinite	average width <u>146</u> m	sand (marine) <u>9</u>	cultivated _____
fragmentary	maximum width <u>225</u> m	sand, silt (fluvial) <u>3</u>	built-up <u>7</u>
✓ continuous	area <u>8,9</u> ha	trees, bush <u>10</u>	
		grass <u>17</u>	

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>699</u> m	none	stagnant/still	none
sinuous	*aerial length <u>549</u> m	occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,27</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>1,0</u> ha	split	✓ irregular	channel junction bars
irregular meanders	perimeter <u>1460</u> m	✓ braided**	pool and riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		✓ turbid	diamond bars
bifurcated	channel slope _____			diagonal bars
lake/s	channel width \bar{x} _____ m	s = _____ m		sand waves/large dunes
lagoon	river slope _____			
	river width \bar{x} <u>14,6</u> m	s = <u>11,8</u> m		

Comments *whole reach
 ** = 40% upper reaches

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	none	road bridge/# (NR)	R. confined	405m
logs	minor	rail bridge/#	R. confined	610m
boulders	major	weir/dam	old rail bridge pier foundations	420m
vegetation		fish traps		
		embankment/s	across R.B. flood plain	405-420m
		groynes		
		canals		
		drainage furrows		
		others	old sand-spit stabilized (105m)	= 460-560m

Lateral Channel Activity

Lateral Activity	Nature of Banks	* Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	weak	slightly unstable
progression and cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	unstable
entrenched loop development	cultivation to	left bank <u>36</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>29</u> %	
✓ avulsion			Comments * swamp forest & coastal dune forest

RIVER DAMBA, ? 47 % ESTUARINE, REACH from -, 0,6 km from mouth. REF. DEA 4801c
 AERIAL PHOTO DATE 9-7-85 SCALE 1:5000 CATCHMENT AREA 25 km², M.A.R. 7,31 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	11	11
✓ hilly	✓ grass	✓ scattered cultivation	occasional	sand		
undulating	✓ sparsely forested (0-25%)	partly cultivated	frequent	trees	38	49
plains	moderately forested (25-75%)	mainly cultivated		grass	11	11
	heavily forested (75-100%)	scattered settlement		cultivated		7
	riverine forest: tributaries	✓ partly built-up urbanized		built-up	40	22
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>600</u> m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) <u>146</u> m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area <u>8,9</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		
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	✓ wall + vegetation
✓ sandy	cliffs on left bank: height _____ m to MSL	
✓ rocks on right/left bank	spit/bar: direction of growth <u>202</u> °	
outer bar	length of spit/bar <u>235</u> m	
silt plume (fluvial)	* length stabilized <u>110</u> m	
✓ suspended sediment (marine)	width <u>32</u> m	

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain	Extent	Areal Measurements: % Flood Plain/Valley	Crops, Animal Husbandry
none	none	open water <u>13</u>	swamp, marsh <u>43</u>
indefinite	average width <u>146</u> m	sand (marine) <u>9</u>	cultivated _____
fragmentary	maximum width <u>225</u> m	sand, silt (fluvial) <u>2</u>	built-up <u>7</u>
✓ continuous	area <u>8,9</u> ha	trees, bush <u>16</u>	
		grass <u>10</u>	
Comments			

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

Pattern	Measurements	Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg <u>620</u> m	✓ none	stagnant/still	none
sinuous	*aerial length <u>486</u> m	occasional	✓ uniform water surface	✓ channel side bars
✓ irregular	*sinuosity <u>1,28</u>	frequent	uniform with rapid in reach	✓ point bars
regular meanders	*open water area <u>1,2</u> ha	split	irregular	channel junction bars
irregular meanders	perimeter <u>1322</u> m	braided	pool and riffle sequence	mid-channel bars
tortuous meanders	river X-sections available		turbid	diamond bars
bifurcated	channel slope _____			diagonal bars
lake/s	channel width \bar{x} _____ m	s = _____ m		sand waves/large dunes
lagoon	river slope _____			
	river width \bar{x} <u>18,6</u> m	s = <u>17,7</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/# (NR)	R. confined	405m
logs	minor	rail bridge/#	R. confined	610m
boulders	major	weir/dam old rail bridge	pier foundations	420m
vegetation		weir/dam		
		fish traps		
		embankment/s	across R.B. flood plain	405 - 420m
		groynes		
		canals		
		drainage furrows		
		others	old sand-spit stabilized (105m)	≈ 460-560m

Lateral Channel Activity

Lateral Activity	Nature of Banks	* Bank Vegetation	Lateral Stability
not detectable	✓ alluvium	none	stable
downstream progression	natural levees	weak	slightly unstable
progression and cut-offs	rock/boulders	good	moderately unstable
mainly cut-offs	protected/stabilized	very strong	✓ unstable
entrenched loop development	cultivation to	left bank <u>36</u> %	highly unstable
irregular lateral activity	channel edge	right bank <u>25</u> %	
✓ avulsion			Comments * swamp forest & coastal dune forest

RIVER WIDTHS

TABLE NS 23/X

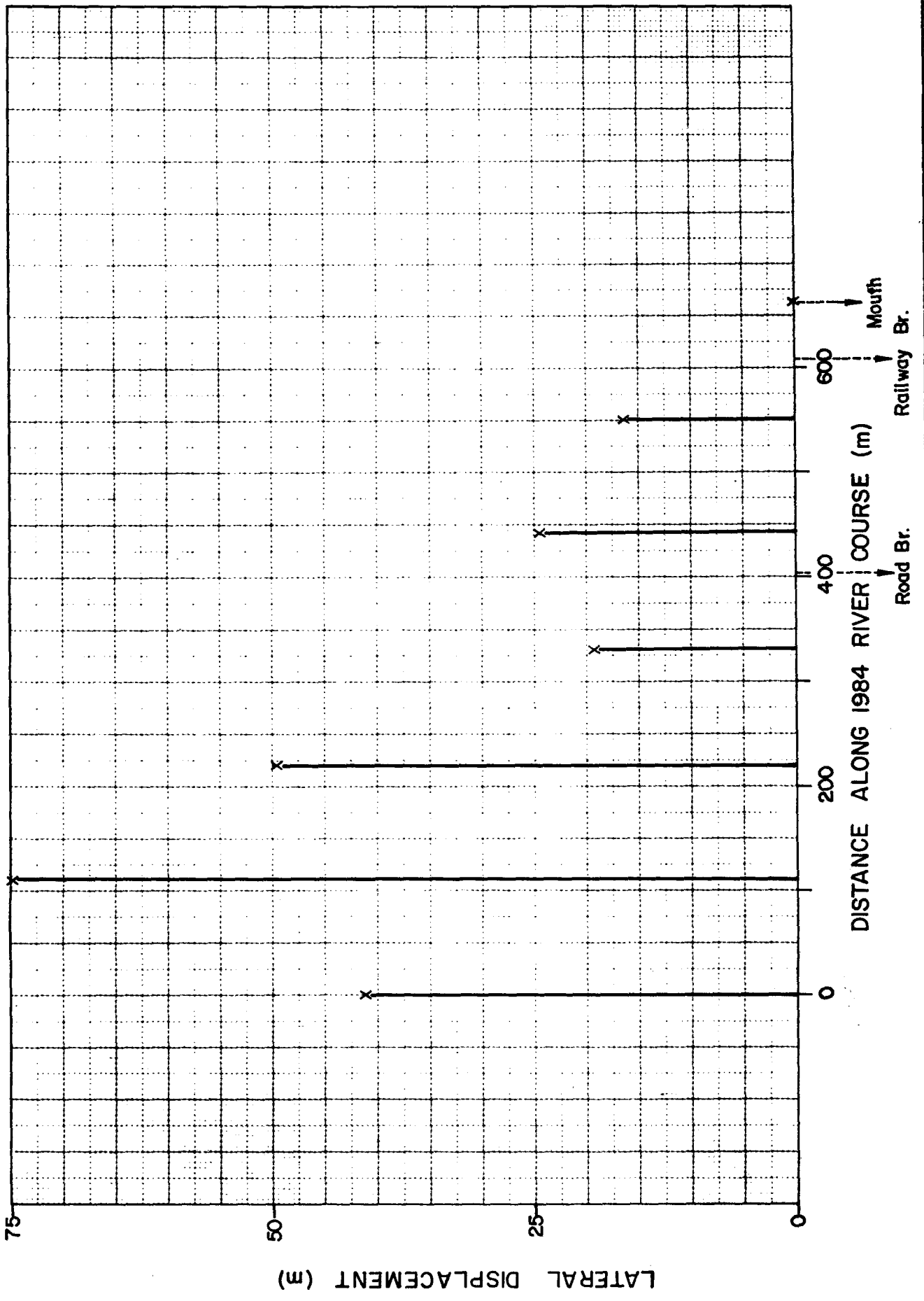
Station	Approx. distance along 1984 river course	River widths (m)										\bar{x}	s	V%
		Date												
		2.5.37	Jun/Jul 1955	5.5.63	23.6.69	6.7.76	2.8.83	6.2.84	9.7.85					
1	0	10,0 (2,5+5+2,5)	12,5 (5 x 2,5)	10,0 (2,5+5+2,5)	2,5	3,0	2,5	2,5	2,5	2,5	2,5	5,7	4,3	76,2
2	110	11,5 (2,5+9)	11,0 (3+3+2,5+2,5)	28,5 (3+5,5+10)	6,0	26,0	16,0	11,0	11,0	16,0	16,0	15,8	7,8	49,5
3	220	13,5 (2,5+11)	11,5 (2,5+3+6)	26,5 (3+5+8,5)	5,0	21,0	11,0	12,5	11,0	11,0	11,0	14,0	6,7	47,8
4	330	15,0 (2,5+12,5)	10,0 (5+5)	23,5	5,0	27,5	16,0	16,0	16,0	16,0	15,0	16,0	7,0	44,0
5	440	14,0	21,0	40,0	42,5	48,0	45,0	18,5	18,5	46,0	46,0	34,4	14,0	40,8
6	550	58,0	34,0	36,0	40,0	40,0	40,0	38,0	38,0	39,5	39,5	40,7	7,3	18,0
7	660 (mouth)	0	0	0	0	0	0	4,0	4,0	0	0	0,5	1,4	282,8
\bar{x}		17,4	14,3	23,5	14,4	23,6	18,6	14,6	14,6	18,6	18,6	18,1		
s		18,6	10,6	14,1	18,4	17,7	17,5	11,8	11,8	17,7	17,7			
V%		106,7	74,4	60,1	127,8	74,7	93,7	80,8	80,8	95,1	95,1			

Station	Approx. distance along 1984 river course	Distance from maximum observed L.B. position to mid-river (m)										Max-Min	\bar{x}	s	V%
		Date													
		02-05-37	Jun/Jul 1955	05-05-63	23-06-69	06-07-76	02-08-83	06-02-84	09-07-85						
1	0	<u>58,2</u>	74,1	60,9	72,5	98,0	<u>99,0</u>	97,0	98,0	40,8	82,2	17,7	21,5		
2	110	<u>80,6</u>	67,3	56,7	25,0	13,0	15,0	<u>6,0</u>	8,0	74,6	34,0	29,6	87,2		
3	220	<u>60,1</u>	50,5	41,1	15,0	<u>10,5</u>	15,0	12,5	12,5	49,6	27,2	20,1	74,0		
4	330	<u>31,7</u>	29,3	25,0	<u>12,5</u>	15,0	25,0	27,5	22,5	19,2	23,6	6,7	28,5		
5	440	15,0	<u>10,5</u>	30,0	21,3	27,5	<u>35,0</u>	17,0	28,0	24,5	23,0	8,4	36,6		
6	550	29,0	34,0	<u>37,5</u>	32,0	<u>21,0</u>	35,0	35,0	31,0	16,5	31,8	5,1	16,1		
7	660 (mouth)	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	2,0	N.R.	0	2,0	0	0		
\bar{x}		45,8	44,3	41,9	29,7	30,8	37,3	28,1	33,3	32,2	32,0		37,7		
s		24,5	24,2	14,3	22,1	33,4	31,5	32,5	32,9	24,8	36,4		31,6		
V%		53,5	54,7	34,2	74,4	108,6	84,4	115,4	98,7	77,0			83,9		

Average lateral displacement 1937-1985 = 32,2 m (i.e. 177,9%R)
 Average coefficient of variation 1937 - 1985 = 37,7%

TABLE NS 23/XII SIMULATED RUN-OFF FOR DAMBA NS 23 CATCHMENT AREA = 25.050 KM. \$M.A.R.													
YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1921	.22	.40	4.79	1.89	.32	.21	.16	.19	.24	.22	.20	.21	9.05
1922	.87	1.32	.69	.41	1.67	.95	.41	.24	.14	.14	.15	.12	7.12
1923	.12	.13	.16	.22	.32	.31	.21	.14	.10	.08	.08	.11	1.98
1924	.14	.20	.36	2.67	1.32	10.91	4.00	.36	.21	.16	.13	.11	20.56
1925	.14	.16	.14	.13	.15	.34	.38	.25	.21	.19	.14	.14	2.37
1926	.25	.30	.26	.19	.20	5.13	2.05	.30	.18	.12	.12	.14	9.21
1927	.18	.20	.23	.28	.36	.37	.26	.17	.12	.08	.09	.10	2.43
1928	.15	.22	.24	.23	.21	.37	.51	.45	3.92	2.86	.94	.55	10.64
1929	.70	.65	.47	.49	.46	.31	.22	.17	.15	.16	.16	.25	4.20
1930	.39	.42	.44	.50	.42	.43	.44	.29	.16	4.40	1.93	.45	10.26
1931	.36	.31	.28	.40	.40	.47	.39	.33	.29	.22	.15	.12	3.62
1932	.18	.38	.52	.40	.23	.18	.19	.16	.11	.09	.09	.08	2.61
1933	.09	.23	1.19	2.88	1.23	.44	.38	.33	.24	.24	.25	.20	7.69
1934	.16	.25	2.46	1.16	.38	.35	.35	.41	7.82	3.06	.55	.40	17.35
1935	.29	.20	.12	.12	.28	.44	.37	.42	.49	.35	.22	.17	3.46
1936	.21	4.33	1.77	.37	2.78	.71	.57	.18	.12	.10	.13	.15	8.95
1937	.17	.20	.27	.39	.38	1.20	.32	.35	.25	.21	.20	.15	6.57
1938	.19	.28	.36	.38	1.61	.95	.44	.30	.22	.19	.20	.34	5.46
1939	.54	.62	2.78	1.15	.20	.14	.14	.34	.51	.41	.26	.18	7.25
1940	.14	.86	.70	.41	.24	.20	.21	.16	.10	.09	.08	.11	3.30
1941	.15	.19	.19	.32	.39	.45	.48	.24	.15	.15	.15	.19	3.27
1942	.30	.53	1.84	.97	.41	1.22	3.53	1.54	.51	.42	.50	.48	12.25
1943	1.24	2.42	1.13	.46	.34	.34	.32	.22	.16	.15	.12	.22	7.14
1944	.46	.46	.26	.15	.18	.37	.39	.28	.20	.14	.11	.09	3.09
1945	.09	.16	.12	.11	.16	.24	.26	.20	.13	.09	.07	.06	1.75
1946	.09	.17	.22	.21	.23	1.32	.88	.50	.55	.57	.42	.28	5.43
1947	.22	2.95	2.02	.79	.61	.23	.61	.47	.28	.17	.12	.09	8.95
1948	.26	.37	.28	.20	.17	.23	.28	.24	.16	.11	.09	.10	2.49
1949	.27	8.29	3.17	.51	.48	.41	.33	.31	.27	.23	.33	.40	15.00
1950	.36	.34	3.18	4.08	1.39	.53	.46	.29	.17	.11	.15	.28	11.35
1951	.51	.49	.41	.95	.70	.47	.54	.62	.50	.34	.23	.17	5.92
1952	.18	.18	.23	.35	.61	.49	.27	.16	.11	.08	.13	.24	3.01
1953	.35	.46	.53	.47	.35	.32	.27	.23	.22	.18	.15	.20	3.72
1954	5.54	2.27	.37	1.26	.83	1.91	.98	.37	.24	.18	.13	.17	14.25
1955	.27	.35	.35	.21	.26	5.32	2.25	.50	.35	.27	.25	.27	10.65
1956	.35	.47	2.95	1.30	.42	.55	1.97	.99	.34	.20	.15	.25	9.95
1957	1.23	.87	.45	.39	1.74	.95	3.73	1.56	.30	.19	.36	.13	11.67
1958	.18	.34	.41	.36	.33	.25	.17	6.04	2.42	.42	.19	.32	11.60
1959	.31	.31	.26	.19	.17	.34	.37	.37	.40	.19	.14	.15	2.92
1960	.20	.29	.47	.53	.40	.43	5.32	2.15	.40	.30	.23	.20	10.91
1961	.21	.26	.26	.26	.34	1.09	.71	.35	.21	.14	.14	.15	4.12
1962	.19	.35	.37	2.62	1.18	4.39	1.78	.29	.19	.29	.36	.28	12.29
1963	.30	.38	1.95	2.88	1.12	.35	.26	.20	.22	.27	.22	.19	8.35
1964	2.63	1.30	.50	.48	.46	.32	.18	.15	.23	.31	.35	.45	7.35
1965	1.38	1.19	.63	.51	.47	.30	.19	.25	.30	.25	.19	.17	5.82
1966	.15	.17	.19	.22	.33	.47	1.34	.76	.31	.23	.19	.14	4.49
1967	.16	.31	.34	.27	.23	.24	.23	.17	.12	.08	.12	.20	2.47
1968	.44	.63	.70	.52	.32	.17	.09	.11	.44	.33	.26	.25	3.25
1969	.44	.63	.70	.52	.32	.17	.09	.11	.44	.33	.26	.25	3.25
1970	1.03	.82	.63	.48	.39	.38	.37	.46	.44	.39	.55	.60	6.54
1971	.54	.49	.54	.53	1.31	.75	.22	.22	.22	.23	.25	.16	5.52
1972	.13	.31	.43	.35	.26	.22	.22	.19	.12	.09	.12	.21	2.66
1973	.28	.34	.38	.39	.43	.43	.37	.46	.51	.38	.25	.17	4.39
1974	.15	.19	.37	1.34	1.17	.66	.38	.23	.15	.10	.08	.12	4.94
1975	.19	.19	.27	.43	3.78	11.69	6.54	1.55	.63	.49	.40	.37	26.53
MEAN	.47	.74	.81	.72	.65	1.14	.88	.52	.50	.39	.25	.22	7.31
S	.81	1.29	.99	.83	.68	2.27	1.33	.86	1.16	.76	.28	.12	4.97
V%	171.56	173.40	121.43	115.49	105.22	199.08	150.95	163.61	230.62	194.12	110.79	55.28	67.95
MEDIAN	.22	.34	.38	.40	.39	.43	.37	.30	.22	.19	.15	.18	5.82

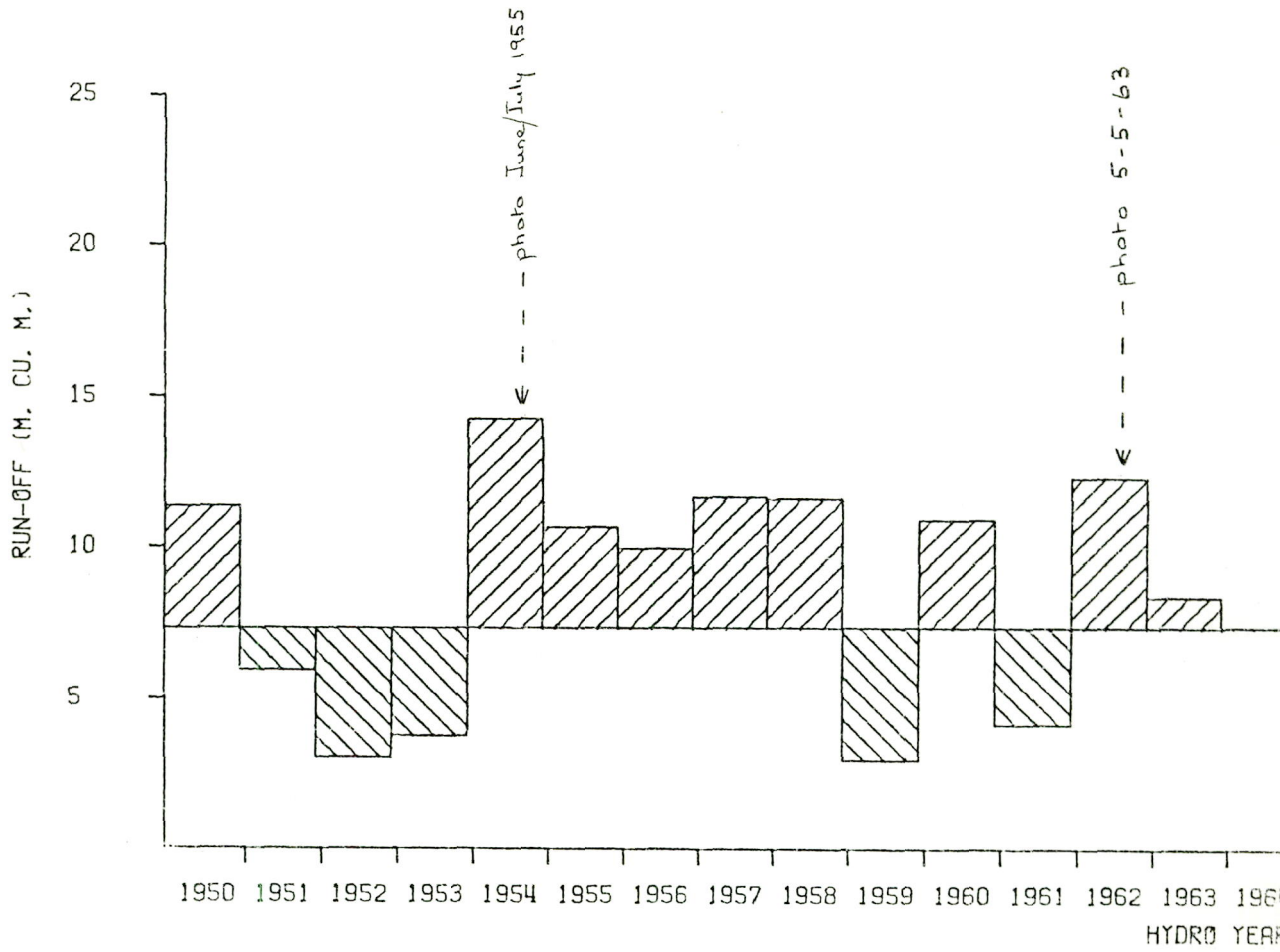
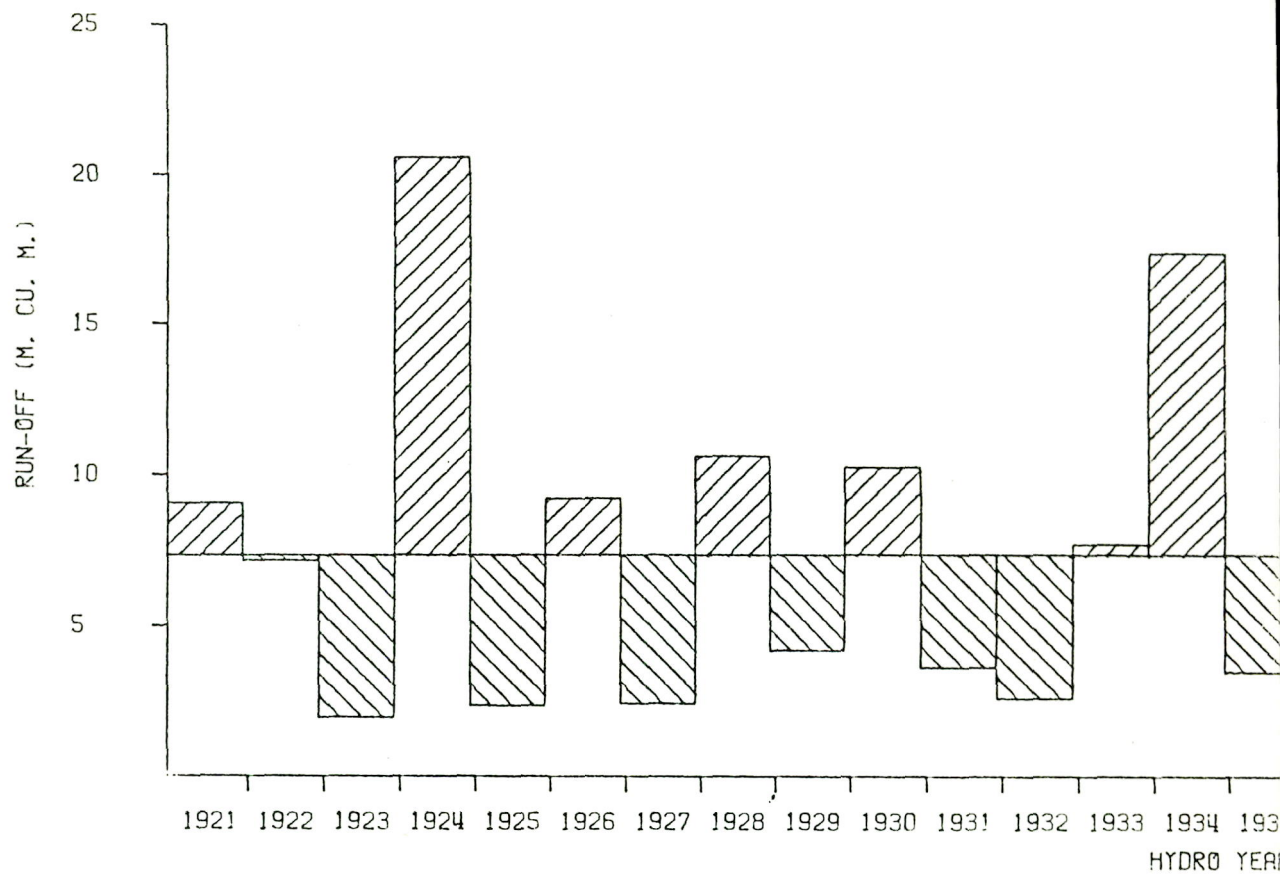
MEAN ANNUAL RUN-OFF = 7.31 MILLION CUBIC METRES. COMPILED FROM HRU REPORT NO. 9/81 DATA



TRACED: MM
 CHECKED:
 DATE:
 REF:

NATAL ESTUARIES: DAMBA
THALWEG DISPLACEMENT
 (1937 - 1985)

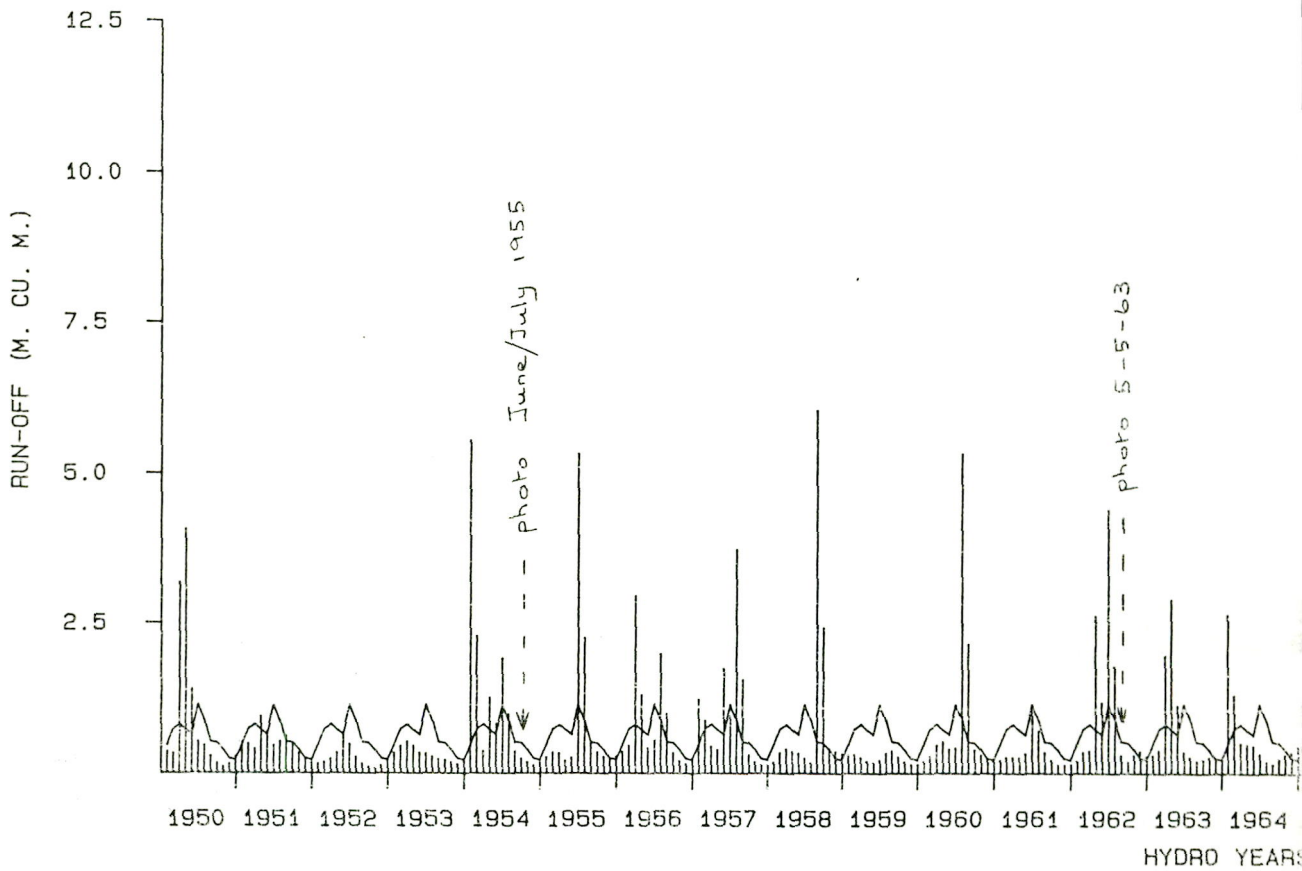
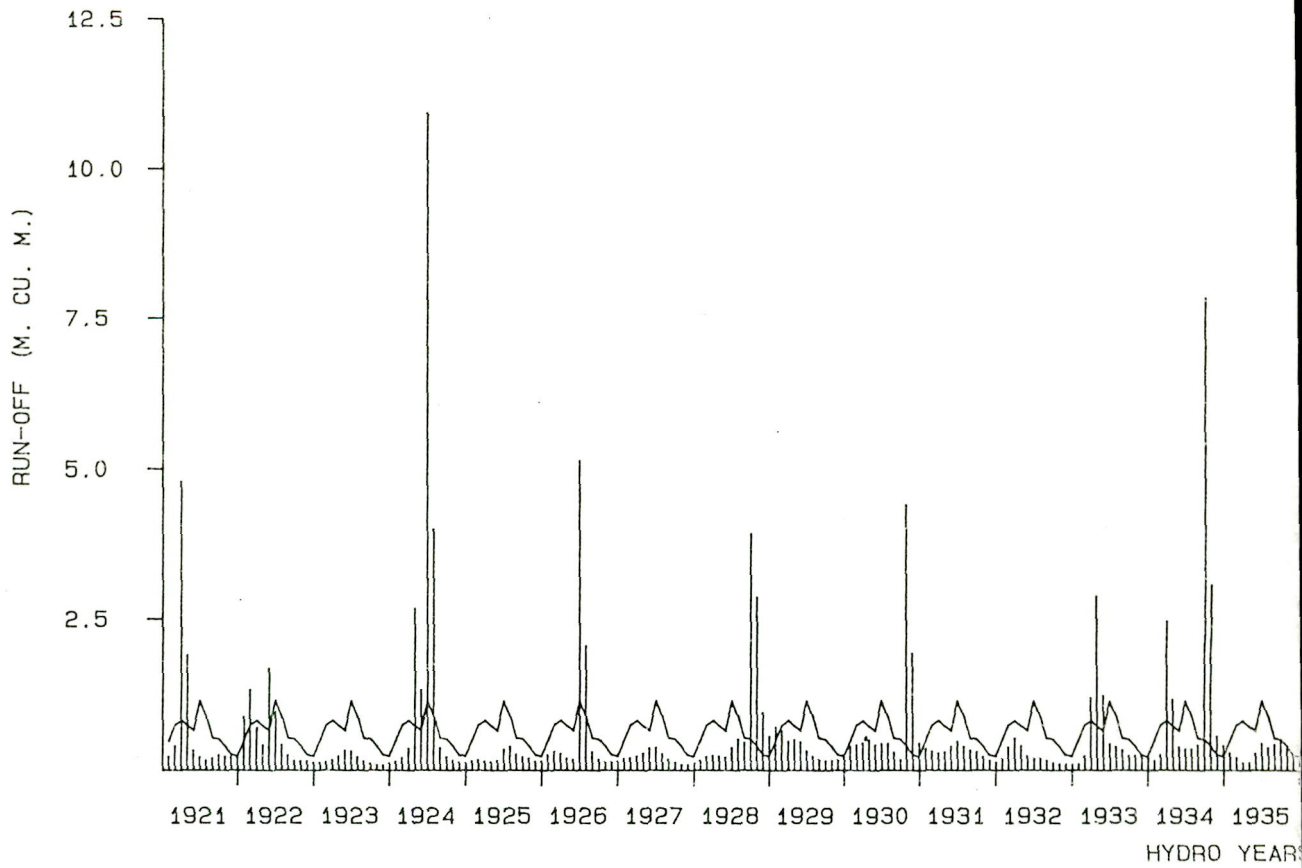
FIGURE
 NS 23 / 1



TRACED : COMPILOT
 CHECKED:
 DATE :
 REF. :

NATAL ESTUARIES : DAMBA
 SIMULATED ANNUAL RUN-OFF
 1921-1975

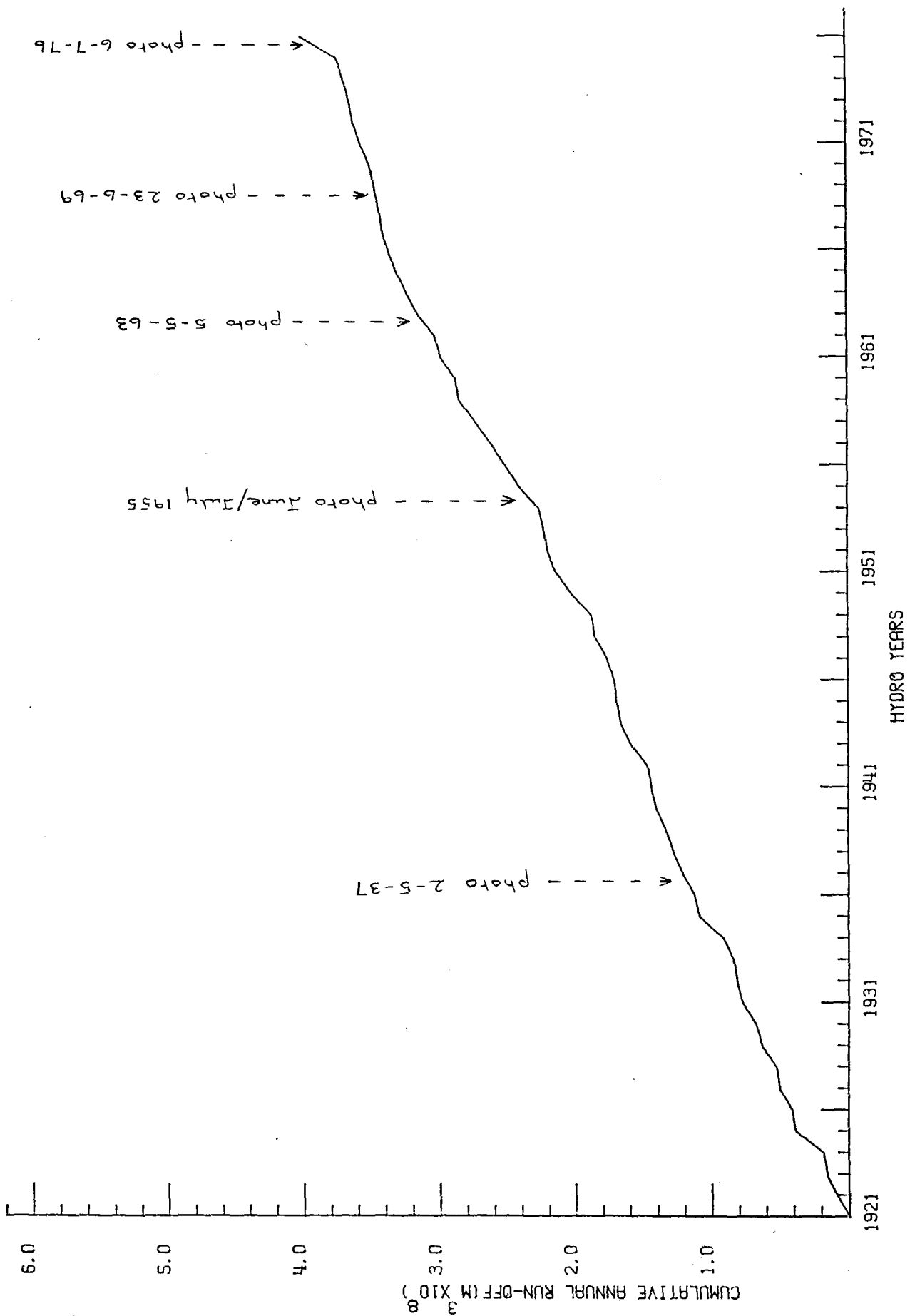
FIGURE
 NS 23/2



TRACED : COMPLIT
 CHECKED:
 DATE :
 REF. :

NATAL ESTUARIES : DAMBA
 SIMULATED MONTHLY RUN-OFF
 1921-1975

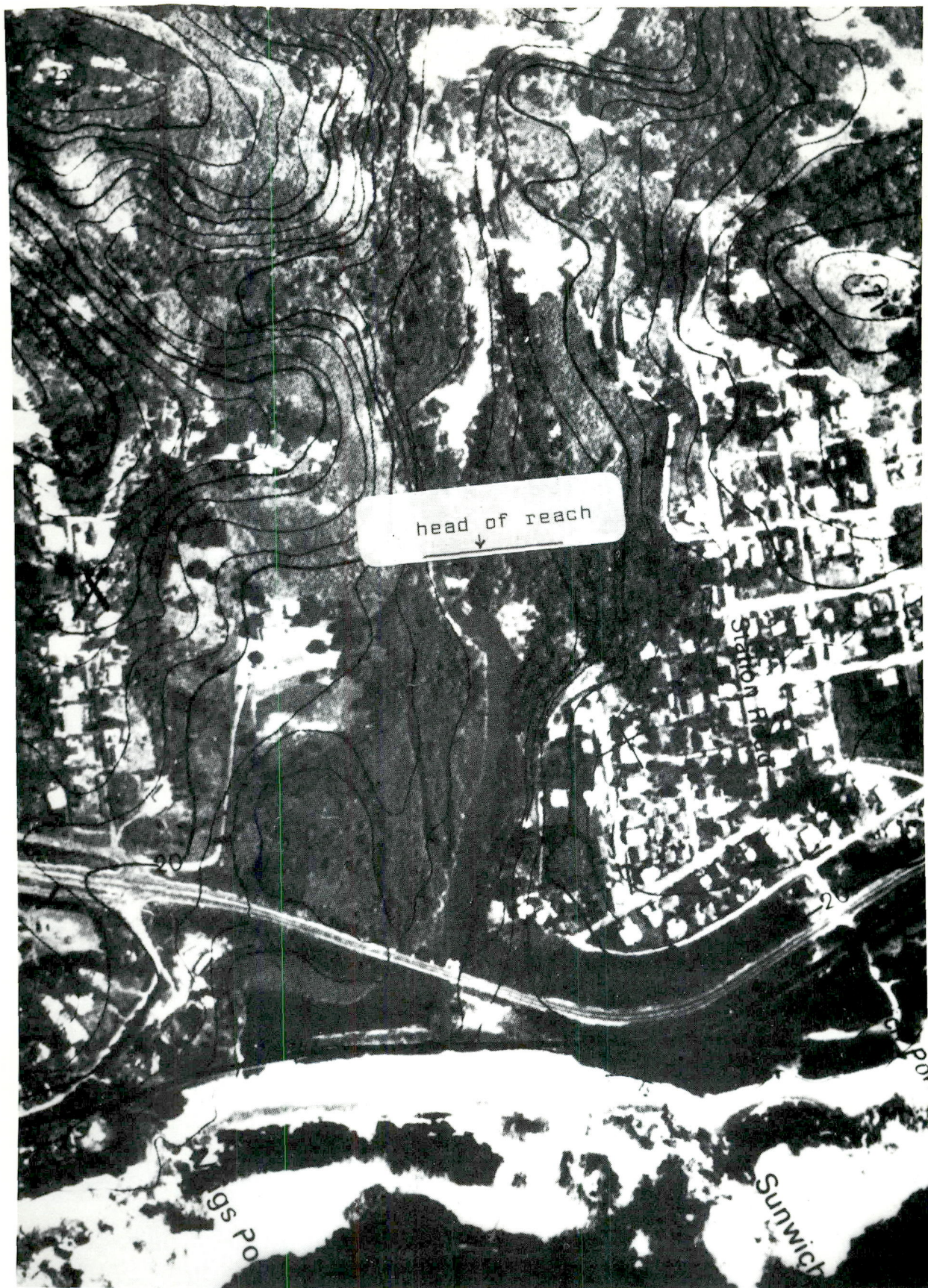
FIGURE
 NS 23/3



TRACED : COMPILOT
 CHECKED:
 DATE :
 REF. :

NATAL ESTUARIES: DAMBA
 CUMULATIVE ANNUAL RUN-OFF

FIGURE
 NS 23/4



SCALE: 1:5000 approx

TRACED
CHECKED
DATE
REF

NATAL ESTUARIES: DAMBA

23-6-76 (ORTHO PHOTO)

PHOTOGRAPH

NS 23/1

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1 5000 approx

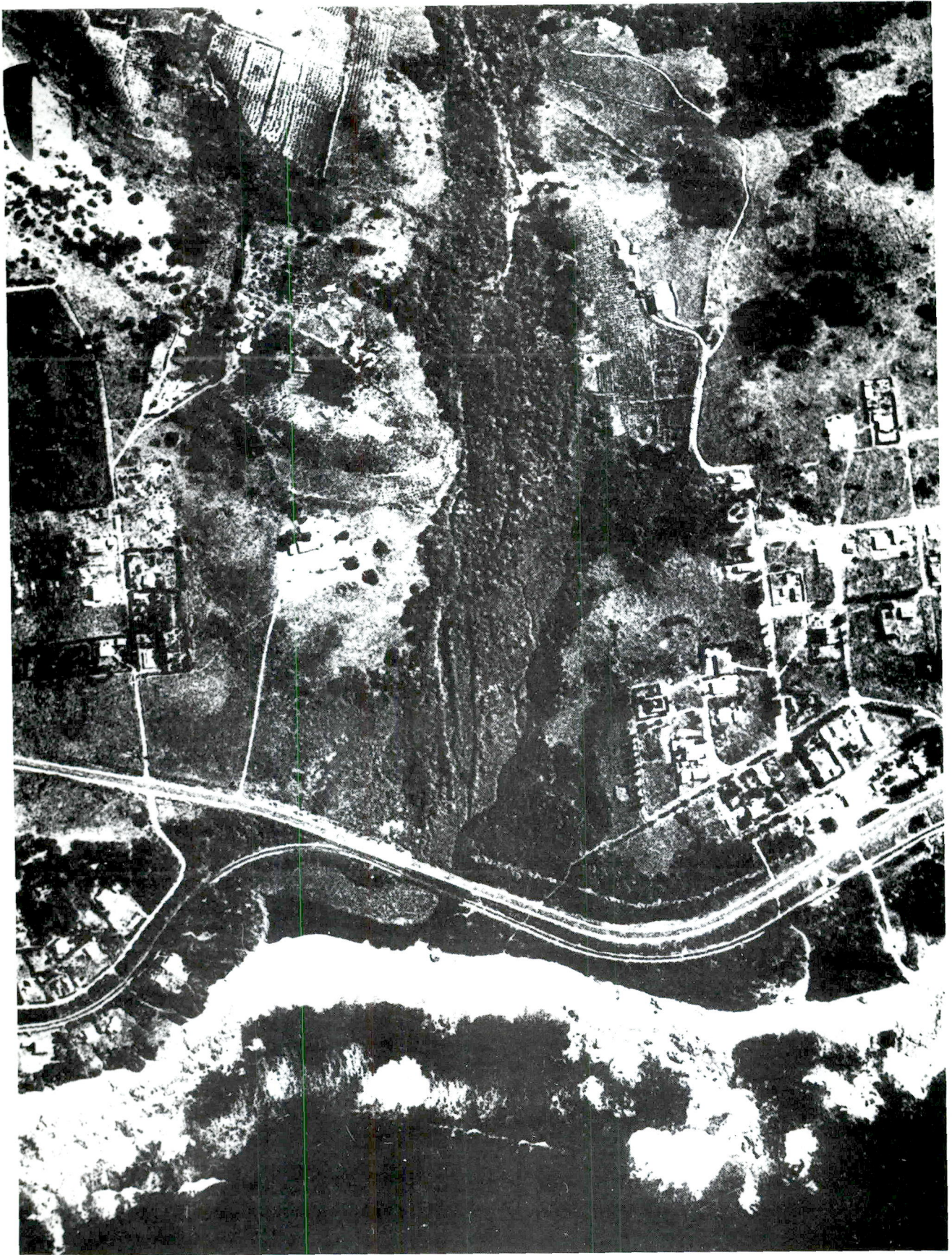
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CHECKED:
DATE
REF.

NATAL ESTUARIES:DAMBA

2-5-37 (13h20)

PHOTOGRAPH

NS23/2



SCALE: 1 5000 approx

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DATE
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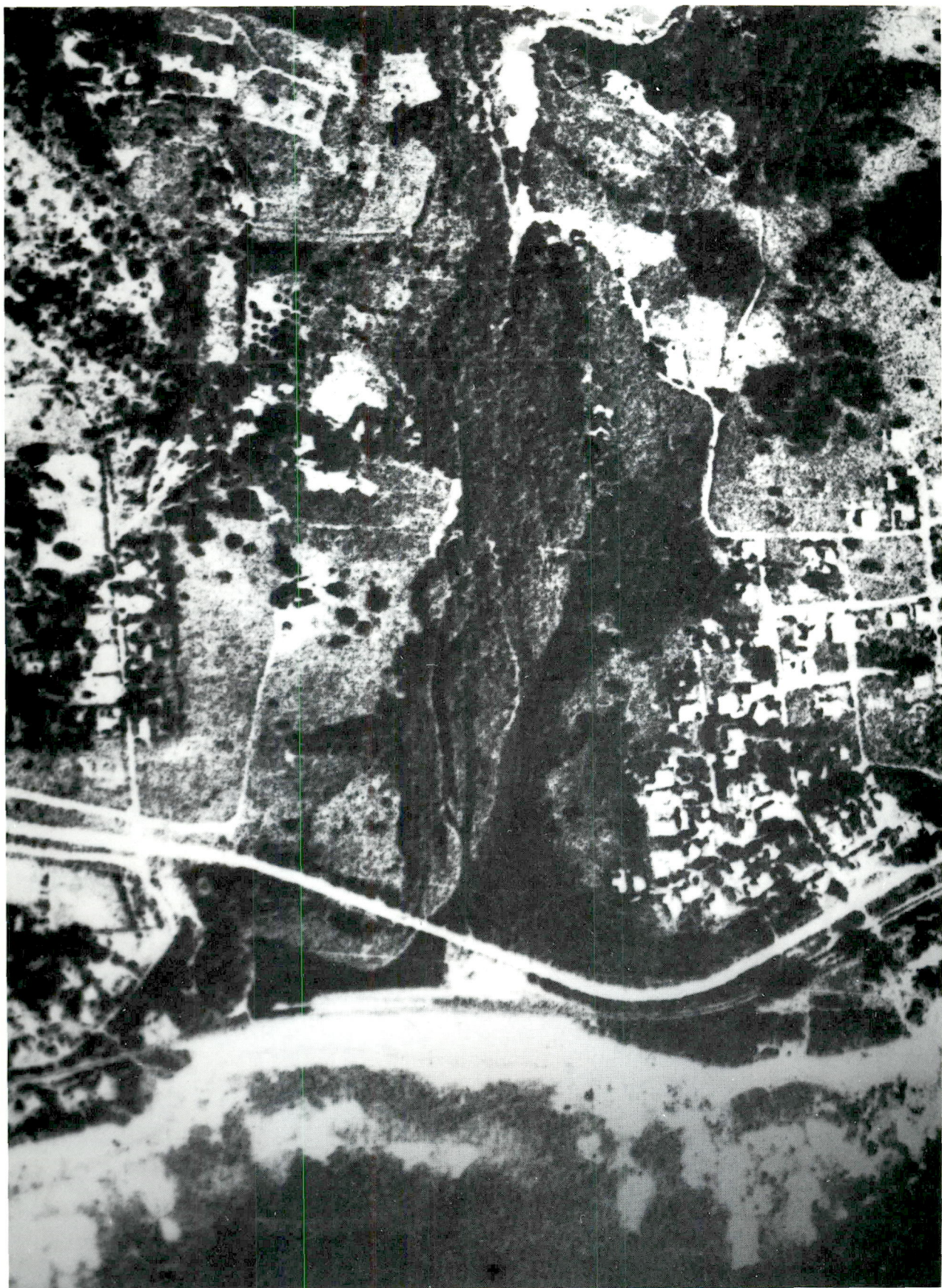
NATAL ESTUARIES: DAMBA

JUNE / JULY 1955 (11h47)

PHOTOGRAPH

NS 23/3

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SCALE: 1 5000 approx

TRACED
CHECKED:
DATE
REF

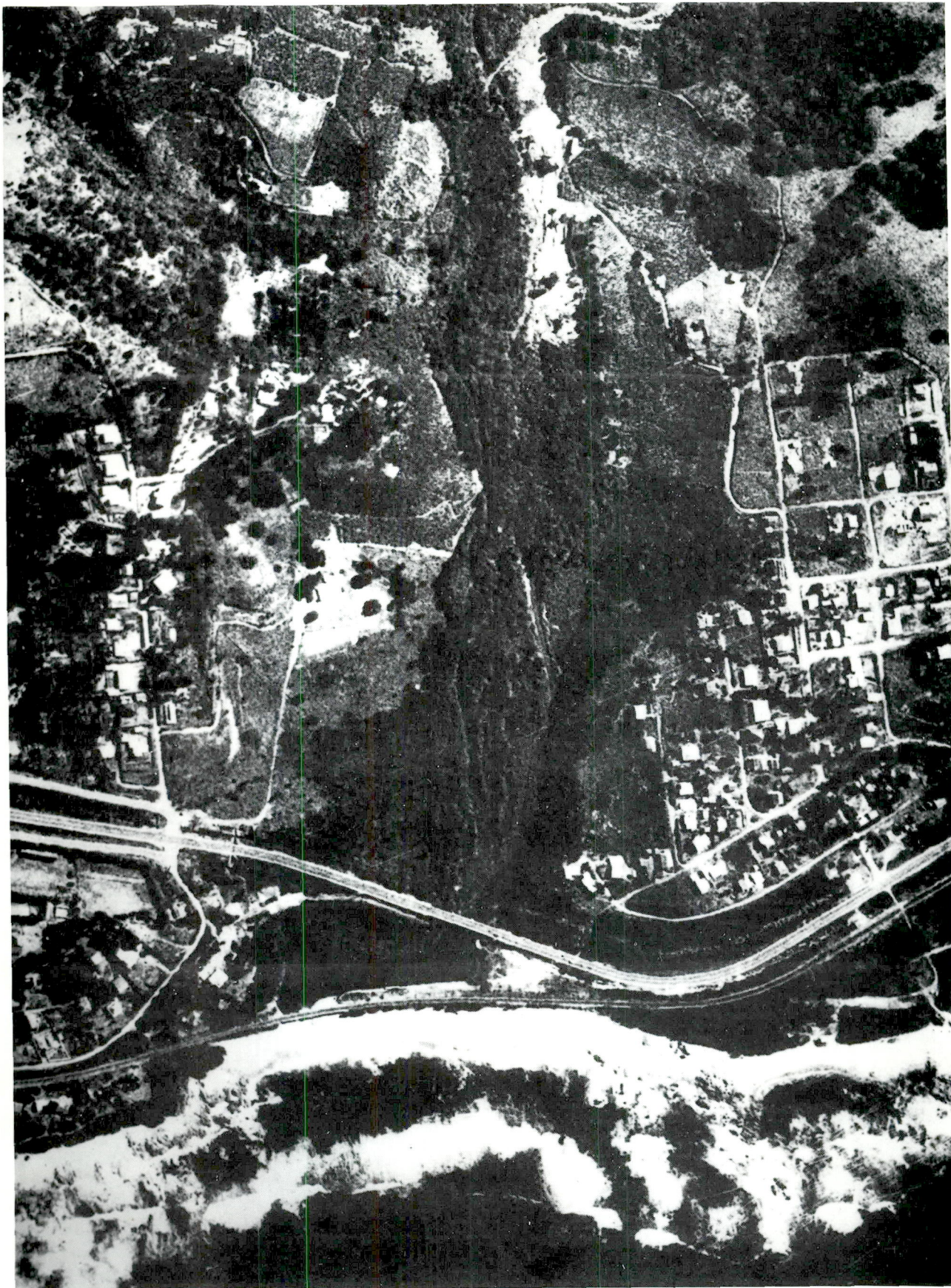
NATAL ESTUARIES: DAMBA

5-5-63 (10h35)

PHOTOGRAPH

NS 23/4

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1:5000 approx

TRACED
CHECKED.
DATE
REF

NATAL ESTUARIES:DAMBA

23-6-69 (12h25)

PHOTOGRAPH

NS 23/5

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SCALE: 1 5000 approx

TRACED
CHECKED
DATE
REF

NATAL ESTUARIES : DAMBA

6-7-76 (13h36)

PHOTOGRAPH

NS 23/6



SCALE: 1:5000 approx

TRACED
CHECKED
DATE
REF.

NATAL ESTUARIES:DAMBA

2-8-83 (12h09)

PHOTOGRAPH

NS 23/7

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SCALE: 1 5000 approx

TRACED
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DATE
REF.

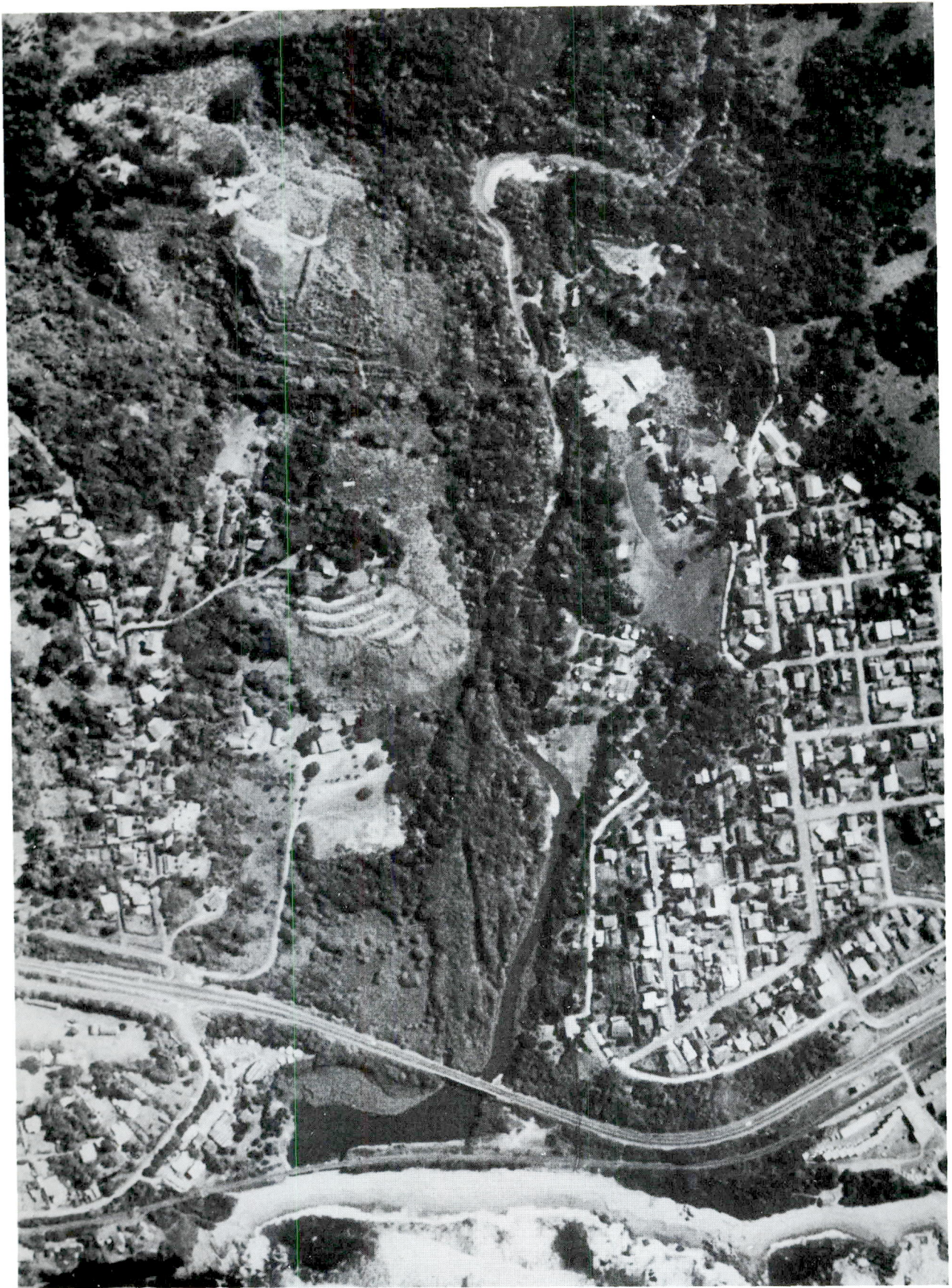
NATAL ESTUARIES:DAMBA

6-2-84 (15h52)

PHOTOGRAPH

NS23/8

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1 5000 approx

TRACED
CHECKED
DATE
REF

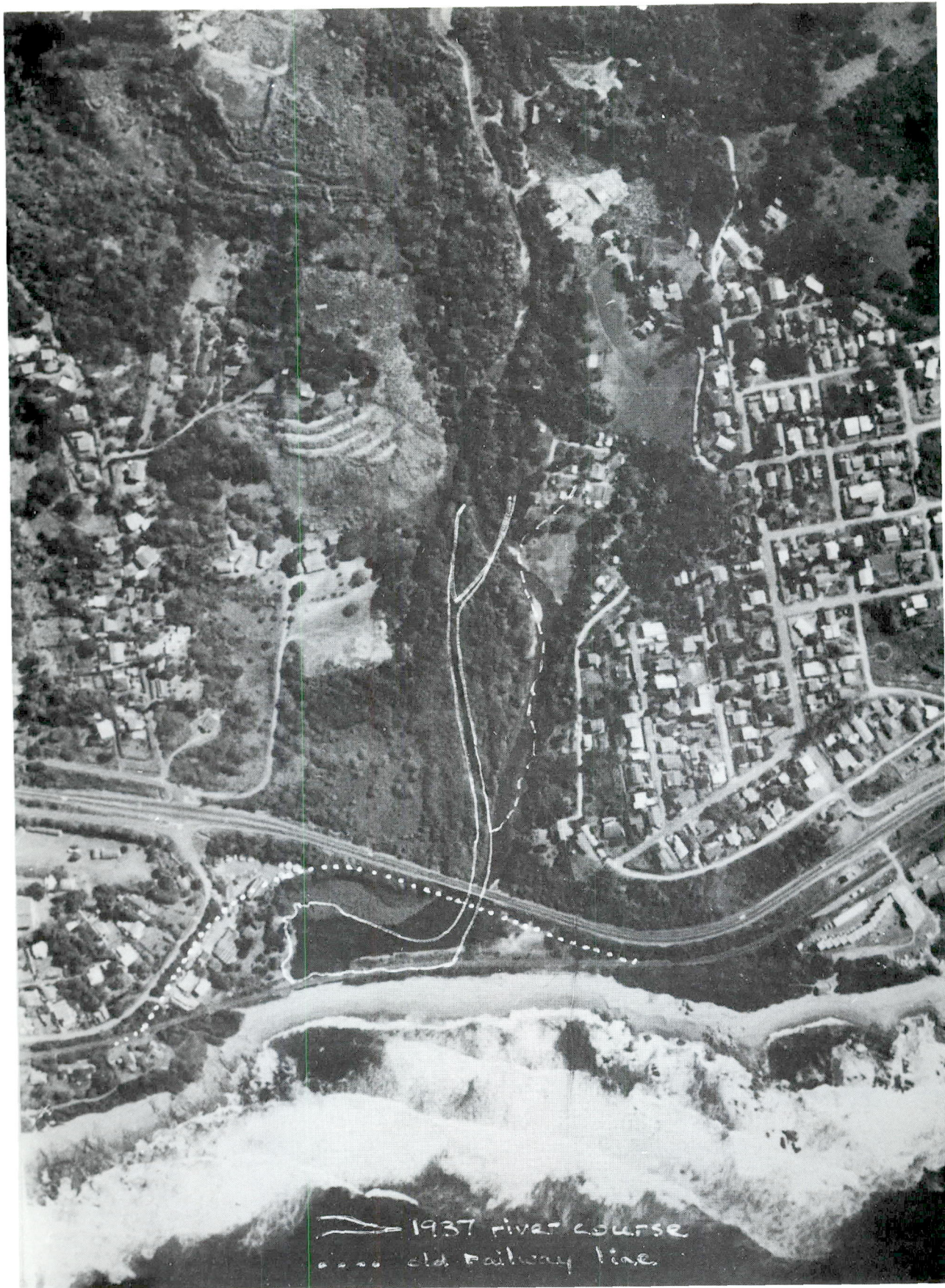
NATAL ESTUARIES:DAMBA

9-7-85 (=11h35)

PHOTOGRAPH

NS 23/9

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



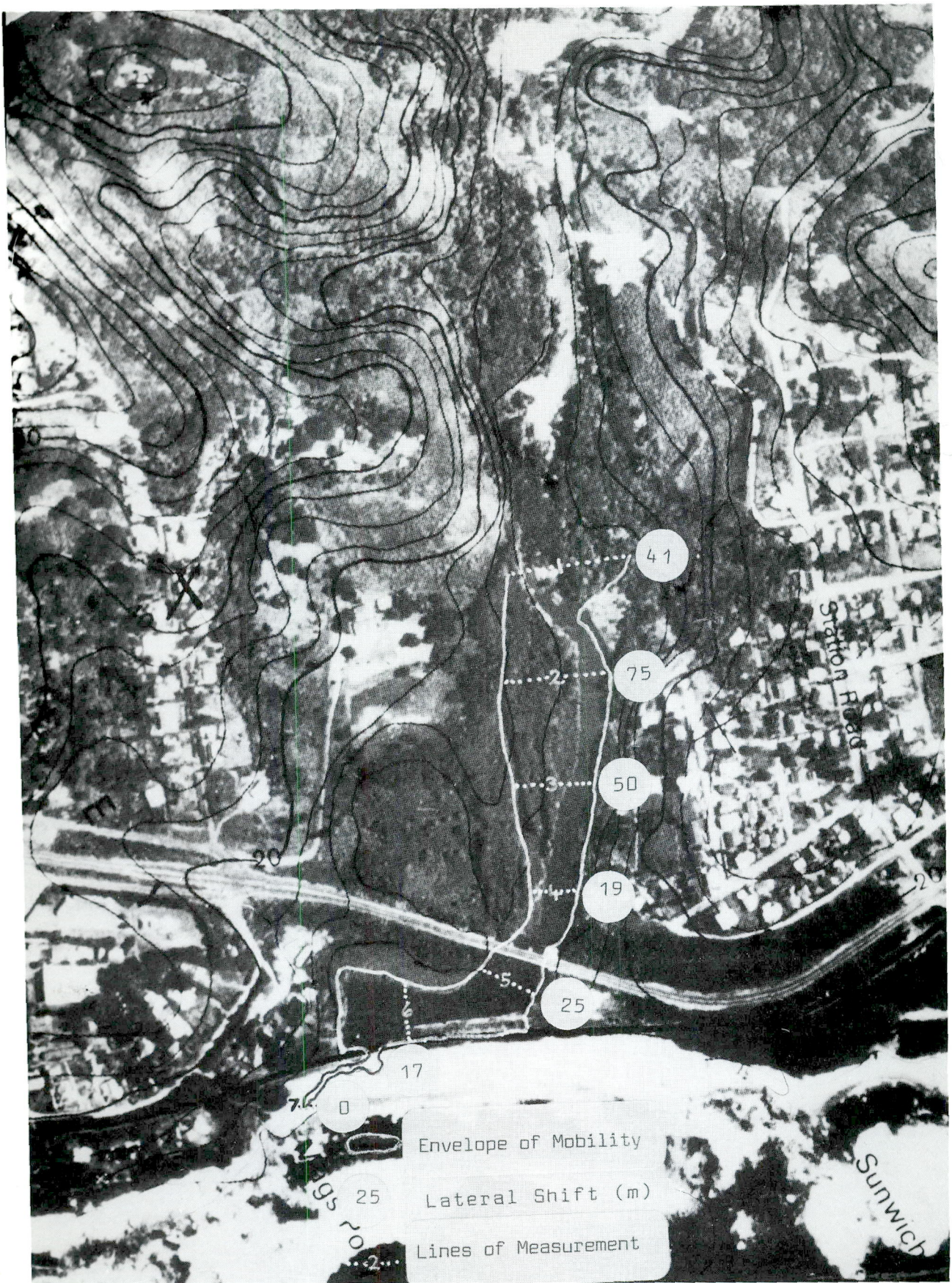
SCALE: 1 5000 approx

TRACED
CHECKED
DATE
REF

NATAL ESTUARIES: DAMBA
9-7-85
(2-5-37 RIVER COURSE SUPERIMPOSED)

PHOTOGRAPH
NS 23/10

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



SCALE: 1 5000 approx

TRACED CHECKED DATE REF	NATAL ESTUARIES: DAMBA ORTHOPHOTO (ENVELOPE OF MOBILITY, LINES OF MEASUREMENT AND LATERAL SHIFT SUPERIMPOSED)	PHOTOGRAPH NS 23/11
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY		