CONFIDENTIAL

HYDROLOGICAL/HYDRAULIC STUDY OF NATAL ESTUARIES

DATA REPORT NO. 9
(REVISED)

MDLOTI NN 3

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

NRIO DATA REPORT D8606

Stellenbosch, South Africa
September 1986

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FOREWORD

Since the first Data Report No. 9 on the Mdloti (NN3) was written in July 1982, the hydro study of the Natal estuaries has further developed, broadening both the scope and interpretation of measurements made. Furthermore, and most importantly, simulated run-off data are now available. Therefore, it has been decided to revise the earlier data reports, bringing them in line with the current series.

LIST OF PHOTOGRAPHS

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

The Chief Director, Surveys and Mapping, Mowbray

NN3/1	23-06-77 (orthophoto)
NN3/2	30-04-37 (12h59)
NN3/3	July/August 1953 (11h39)
NN3/4	06-06-59 (11h53)
NN3/5	02-08-68 (11h14)
NN3/6	22-07-77 (11h56)
NN3/7	22-07-77 (30-04-77 river course superimposed)
NN3/8	Orthophoto (envelope of mobility, lines of measurement and lateral shift superimposed)

BRIEF NOTES MDLOTI NN3

Location

The Mdloti discharges into the Indian Ocean on the Natal North Coast at 29°39'S, 31°08'E. The head of the reach under review is a road bridge, constructed in the early 1950's, 3,2 km from the mouth (Photograph NN3/1).

Hydro Data

The M.A.R. from a catchment of 527 km^2 is 116,99 × 10^6 m^3 (20,1% of the precipitation). Of particular interest to this study is the erratic nature of the run-off. This is quantified in Table NN3/IX by (i) the high coefficients of variation for monthly run-off ranging from 98,4 to 326,6 per cent ($\overline{V}$ = 160,6%) and (ii) the mean run-off values being considerably higher than the median values. The wide spectrum of annual and monthly run-off is shown in Figures NN3/3 and 4. Figure NN3/5 shows the trends in the annual run-off for the period 1921-1975. The aforementioned Table and Figures are based upon simulated run-off data for tertiary catchments (Pitman et al., 1981). Major flood flows occurred in March 1925, June 1935 and March 1976; while lesser floods occurred in November/December 1921, March 1927, December 1942, January 1953, October 1954, February 1958 and April 1976.

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 three months previous, well above average for the next two months previous.

2) 1953 below-average run-off - likewise for four months previous, well above-average for the next two months previous.

3) 1959 below-average run-off in a well below-average hydro-year; previous two hydro-years well above average.

4) 1968 below-average run-off within a markedly dry phase.

5) 1977 below-average run-off; previous hydro-year well above average.

N.B. Simulated run-off data are not available beyond hydro-year 1975. Therefore, the comment above for the 1977 time slice is based upon local ground knowledge.

River Mouth

The Mdloti is often diverted at its mouth by a southerly-extending sand-spit and discharges into the ocean over a rocky sill. This trend is further encouraged by the position and alignment of the National Road (NR) bridge, 400 m from the mouth, completed in 1960, with its 300 m embankment across the left-bank flood plain. However, the position is variable as seen in Photograph NN3/2 for 1937 where there are well-developed northerly and southerly-extending spits. During the winter the mouth is often blocked by a sandbar (Photograph NN3/5) which was artificially breached in a central position by sugar farmers when their cane fields became flooded (Begg 1978). This practice ceased in 1982 (Begg 1984) but then the North Coast Regional Water Services Corporation found that their raw and purified water pipelines became inundated, making inspections difficult. Artificial breaching has thus continued but is done at the natural point of exit near the right bank. An example of the natural breaching of the mouth in this more southerly position may be seen in Photographs NN3/7 (mouth open) and NN3/1 (mouth closed). These photographs from the orthophoto series were taken on the 22nd July and the 23rd June 1977, respectively.

Begg (pers. comm.) estimates the mouth to be closed for 64 per cent of the year.

Land-use

(a) Agriculture

Sugar cane cultivation, often down to the river's edge has been a marked feature of the flood plain and valley sides during the period under review.

(b) Structures

The NR bridge, 400 m from the mouth, was completed in 1960. Embankments for this bridge, 300 m on the left bank and 180 m on the right bank, extend diagonally across the flood plain.

(c) Urbanization

In the 1970's La Mercy Airport was constructed fairly close upstream of the reach under review.

The aforegoing brief notes on land-use should be borne in mind when reading the following sections on siltation and lateral stability.

Siltation

The lowest 3,4 km of the Mdloti show severe siltation. On a November 1850 map in the Natal Archives, Pietermaritzburg (photo-copy inside back cover), a greater expanse of open water is depicted near the mouth compared with the available aerial photographs from 1937 onwards. The latter, in particular Photographs NN3/2-4, give evidence of the earlier larger water body on the left bank which by 1937 was largely infilled with silt and swamps. The turn of the century falls outside our detailed study period but the early map allows us to set the stage for current siltation. Figure NN3/2 shows the continuing trend of

reduction in open water areas. Photographs NN3/2-6, from 1937 to 1977 show that 21 per cent of the flood plain is occupied by fluvial silt deposits and swamps (Table NN3/I) and that avulsion occurs, these factors being indicative of siltation.

The most important physical factor causing this siltation is the highly erratic run-off. The overall gradient of the Mdloti is 1:95 (moderately steep for Natal) checking to 1:826 over the lowest 12 km. 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 sediment yield of 210 800 tons per year is derived for the Mdloti catchment. This represents a yield of 400 tons/km^2/yr, which is high. Eroding cane fields and river banks will provide a local source of silt. In the early 1970's siltation was further aggravated by earthworks associated with the construction of La Mercy Airport which is just upstream of the reach under review (Begg, 1978).

Bearing in mind that the rate of siltation in the lower reaches is not steady but is mainly the result of major hydro events (see earlier fluvial deposits on the left bank of the upper part of the reach in Photograph NN3/2), 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

Photographs NN3/2-6 show changes in siltation areas from 1937 to 1977, and areal measurements of the flood plain quantify these changes (Table NN3/I). Care must be taken in studying these changes in composition of the flood plain - river stage must be comparable and one must examine carefully which changes in cultivated and bush areas have been at the expense of the base line (1937) recent siltation areas. For the five time slices under review, the run-off was below average and in the one case

(1968) when the mouth was closed, there is no photographic evidence of the damming up of high water levels behind the bar (N.B. reduced open water area and the time slice was within a prolonged drought period). Therefore the time slices are comparable. The "recent" siltation area in 1937 comprised fluvial sand/silt plus swamp areas (20% of the flood plain). In subsequent time slices the siltation areas comprised the following:

fluvial/sand silt
swamp/marsh
increase of vegetated, cultivated 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:

1937	1953	1959	1968	1977
20	25	27	27	27
(13)	(13)	(12)	(10)	(11)

Two clear facts emerge:

(i) there has been a general reduction in open water areas over time and
(ii) there was an increase in siltation areas until 1959, after which, although some silted areas were re-worked and re-located, the total area remained constant.

(b) Aggradation/degradation over time

These changes naturally cannot be assessed from aerial photographs and successive x-sections at the same site are not available for the Mdloti. However, in December 1954 a x-section was surveyed, approximately 400 m from the mouth prior to the building of the NR bridge revealing a bed level of +1 m to M.S.L. for the two main river channels and a smaller channel. The NR bridge, built in 1960, constricts the former total channel width

by 0,7. One would thus expect the scour during major floods to be slightly deeper than the 4 m indicated by the layer of course fluvial sand shown in a x-section drawn by Orme (1974) from boreholes drilled prior to the construction of the NR bridge.

Apart from the scour and fill during major floods, there is evidence that the Mdloti is generally aggrading in its lowest reaches, although this cannot be quantified. Firstly, comparing the November 1850 map and the earliest (1937) aerial photography, former open water areas have been infilled by sediment and/or swamps. This pattern has continued from 1937-1977 (N.B. the increase of reedswamp areas which colonize deposits emerging above mean water level from 1937-1977). Secondly, channel avulsion itself is indicative of aggrading conditions.

Lateral Stability

For easy visual reference, an envelope of mobility, lines of measurement and lateral shift are superimposed on an orthophoto (Photograph NN3/8).

Lateral shift is greatest between sections 5 and 9 and at the mouth, section 12 (Figure NN3/1 and Table NN3/VIII). Sections 5-9 reflect that part of the reach where there is channel bifurcation and avulsion. Furthermore, superimposed upon this pattern has been the development of meanders upstream of the NR bridge (Photograph NN3/6). This marks the river's response to the embankments (N.B. the longer thalweg and increased sinuosity for 1977 in Table NN3/I). The change in pattern of the river course from 1937 to 1977 is highlighted in Photograph NN3/7.

The average lateral displacement from the whole reach is 61,5 m (130,3% of $\bar{R}$ width) with an average coefficient of variation of 41,5 per cent which quantifies the instability.

Overall, the Mdloti shows considerable siltation and has been laterally unstable for the period under review, 1937-1977.

Details of the classification may be found in Tables NN3/II-VI and an abstract of results is given in Table NN3/I.

REFERENCES

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ORME, A.R. (1974). Estuarine sedimentation along the Natal Coast, South Africa, Technical Report No. 5, Office of Naval Research.

PITMAN, W.V., MIDDLETON, B.J. and MIDGLEY, D.C. (1981). Surface water resources of South Africa Vol. VI, Hydrological Research Unit Report No. 9/81.

ROOSEBOOM, A. (1975). Sedimentproduksiekaart vir Suid-Afrika, Technical Report No. 61, Department of Water Affairs.

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.

TABLE NN3/I

ABSTRACT

RIVER MDLOTI NN 3

MEASUREMENTS/CALCULATIONS FROM PHOTOGRAPHS

Date	30-4-37	July/Aug 1953	6-6-59	2-8-68	22-7-77			
Reach								
thalweg (m)	3320	3075	3245	3170	3405			
% estuarine	?	?	?	?	40			
% braided	NIL	NIL	NIL	NIL	NIL			
aerial distance(m)	2664	2652	2636	2550	2598			
sinuosity	1,25	1,16	1,23	1,24	1,31			
open water area(ha)	20,8	19,9	18,5	15,6	16,7			
$\bar{x}$ river width(m)	47,3	59,8	50,6	39,3	39,0			
Flood Plain/Valley								
% open water	13	13	12	10	11			
% sand(marine)	2	4	2	2	3			
% sand/silt(fluvial)	6	4	3	2	1			
% swamp,marsh	14	18	18	18	21			
% grass,trees,bush	14	9	10	7	9			
% cultivated	51	52	55	60	54			
% built-up				1	1			
.....								
Valley Sides (L/R)	L R	L R	L R	L R	L R	L R	L R	L R
% dune forest	8 18	8 18	8 18	6 18	6 18			
sand								
% trees	11	11	11	11	11			
% grass								
% cultivated	92 71	92 71	92 71	94 71	94 71			
% built-up								
.....								
L.B. % vegetated	25	10	2	19	17			
R.B. % vegetated	6	6	33	13	11			
Mouth								
open/closed (O/C)	O	O	O	C	O			
spit/bar:								
direction (°)	207 ± 17	210 ± 22	209	208	212			
length (m)	491 ; 464	398 ; 375	647	770	663			
width (m)	71 ± 87	87 ; 97	57	52	54			

BASIC DATA/CALCULATIONS

Lateral displacement (1937-1977) $\bar{x}$ 61,5 m (130,3 % $\bar{R}$ width)

Relative lateral stability (1937-1977) $\bar{V}$ 41,5 %

Area of catchment 527 km^2

Area of flood plain/valley 155,4 ha

Area of envelope of mobility 40,3 ha

Simulated run-off ($\times 10^6 m^3$) (1921-1975) M.A.R. 116,99 s 83,37

$\bar{V}$ 71,26 %

Major floods: March 1925, June 1935, March 1976

Lesser floods: 11-12/21, 3/27, 12/42, 1/53, 10/54, 2/58, 4/76

HUMAN INFLUENCES

Within the Reach

Cultivation:	L.V.S.	R.V.S.	Flood Plain	To Channel Edge
	93%	71%	54%	widespread

Bridges & Embankments:	Position (m from head of reach)	Date
Road	0	early 1950s
National Road	2600	1960

Canals: Nil

Urbanization/Industry: Nil

Sandbar breaching: (i) central position, until 1982 to prevent flooding of cane fields (ii) natural S. position, since 1982 to protect piped water supply systems (Begg 1984)

Others:

Upstream of the Reach

Dams: Hazelmere (1976)

Construction/~~Canalisation~~ immediately upstream of reach: for La Mercy airport (1970s)

Land-use malpractices/Silt supply: land-use malpractices + airport construction works have generated silt (Begg 1978)

STABILITY FOR PERIOD UNDER REVIEW (1937-1977)

Unstable

TABLE NN3/II — CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS — NRIO NN 3

RIVER MDLOTI, ? % ESTUARINE, REACH from 1950's Rd. Br., 3,3 km from mouth. REF. DEA U 3015

AERIAL PHOTO DATE 30-4-37 SCALE 1:10000 CATCHMENT AREA 527 km², M.A.R. 116,99 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 plains	✓ sparsely forested (0-25%)	partly cultivated
	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	8	18
✓ occasional	sand		
frequent	trees		11
	grass		
	cultivated	92	71
	built-up		

Comments * very little

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 2750 m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) 493 m	indefinite	not obviously degrading or aggrading	✓ occasionally confined	lacustrine deposits
valley area 155,4 ha	✓ fragmentary	partly entrenched	frequently confined	✓ fluvial deposits
height at head of reach ____ m to MSL	continuous	entrenched	entrenched	aeolian
valley slope 1: ____		✓ 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	207	° ± 17°
outer bar	length of spit/~~bar~~	491	m ± 464 m
silt plume (fluvial)	length stabilized	NIL	m NIL
✓ suspended sediment (marine)	width	71	m ± 87 m

Comments ____

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	*Extent*	
none	none	
indefinite	average width	493 m
fragmentary	maximum width	850 m
✓ continuous	area	155,4 ha

Areal Measurements: % Flood Plain/Valley

open water	13	swamp, marsh	14
sand (marine)	2	cultivated	51
sand, silt (fluvial)	6	built-up	
trees, bush }		----------	
grass }	14	----------	

Crops, Animal Husbandry: sugar cane

Comments ____

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

Pattern	*Measurements*		*Islands/Shoals***	*Type of Flow*	*Bar Type*
straight	*thalweg	3320 m	none	stagnant/still	none
sinuous	*aerial length	2664 m	occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity	1,25	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area	20,8 ha	✓ split	✓ irregular	✓ channel junction bars
irregular meanders	perimeter	9895 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 $\bar{x}$	47,3 m	s = 51,8 m		

Comments *whole reach

** 3 ha "dry sand" shoals near mouth

Obstructions/Constructions

Natural	*Degree*
✓ none	✓ none
logs	minor
boulders	major
vegetation	

Comments ____

Man-made NIL — *Degree of Obstruction/Constriction for Each* — *Position (from head of reach)*

road bridge/s ____
rail bridge/s ____
causeway ____
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	✓ 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 25 %	highly unstable
irregular lateral activity		✓ right bank 6 %	
✓ avulsion			

Comments ____

TABLE NN3/III — CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS — NRIO NN 3

RIVER MDLOTI, ? % ESTUARINE, REACH from 1950's Rd. Br., 3,1 km from mouth. REF. DEA U 3016

AERIAL PHOTO DATE July/Aug '53 SCALE 10000 CATCHMENT AREA 527 km², M.A.R. 116,99 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 plains	✓ sparsely forested (0-25%)	partly cultivated
	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	8	18
✓ occasional	sand		
frequent	trees		11
	grass		
	cultivated	92	71
	built-up		

Comments * very little

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 2750 m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) 493 m	indefinite	not obviously degrading or aggrading	✓ occasionally confined	lacustrine deposits
valley area 155,4 ha	✓ fragmentary	partly entrenched	frequently confined	✓ fluvial deposits
height at head of reach ____ m to MSL	continuous	entrenched	entrenched	aeolian
valley slope 1:____		✓ 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	210	° ± 22°
outer bar	length of spit/~~bar~~	398	m ± 375 m
silt plume (fluvial)	* length stabilized	230	m NIL
✓ suspended sediment (marine)	width	87	m ± 97 m

Comments * vegetation growth

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent		
none	none		
indefinite	average width	493	m
fragmentary	maximum width	850	m
✓ continuous	area	155,4	ha

Areal Measurements: % Flood Plain/Valley			
open water	13	swamp, marsh	18
sand (marine)	4	cultivated	52
sand, silt (fluvial)	4	built-up	
trees, bush }		----------	
grass }	9	----------	

Crops, Animal Husbandry: sugar cane

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	3075 m	none	stagnant/still	none
sinuous	*aerial length	2652 m	✓ occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity	1,16	frequent	uniform with rapid in reach	point bars
regular meanders	*open water area	19,9 ha	✓ split	✓ irregular	✓ channel junction bars
irregular meanders	perimeter	9762 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 $\bar{x}$	59,8 m	s = 74,1 m		

Comments *whole reach

** 1 ha "dry sand" shoal near mouth

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s	R. confined	head of reach
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	✓ 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 10 %	highly unstable
irregular lateral activity		✓ right bank 6 %	
✓ avulsion			

Comments

TABLE NN3/IV — CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS — NRIO NN 3

RIVER MDLOTI, ? % ESTUARINE, REACH from 1950's Rd. Br., 3,2 km from mouth. REF. DEA U3016

AERIAL PHOTO DATE 6-6-59 SCALE 1:10 000 CATCHMENT AREA 527 km², M.A.R. 116,99 $m^3 \times 10^6$, 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	8	18
✓ occasional	sand		
frequent	trees		11
	grass		
	cultivated	92	71
	built-up		

Comments * very little

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 2750 m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) 493 m	indefinite	not obviously degrading	✓ occasionally confined	lacustrine deposits
valley area 155,4 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	209	°
outer bar	length of spit/~~bar~~	647	m
silt plume (fluvial)	* length stabilized	350	m
✓ suspended sediment (marine)	width	57	m

Comments * vegetation growth

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent		Areal Measurements: % Flood Plain/Valley			Crops, Animal Husbandry
none	none		open water	12	swamp, marsh 18	sugar cane
indefinite	average width	493 m	sand (marine)	2	cultivated 55	
fragmentary	maximum width	850 m	sand, silt (fluvial)	3	built-up ____	
✓ continuous	area	155,4 ha	trees, bush }	____	---------- ____	
			grass }	10	---------- ____	

Comments ____

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

Pattern	Measurements		Islands/Shoals	Type of Flow	Bar Type
straight	*thalweg	3245 m	none	stagnant/still	none
sinuous	*aerial length	2636 m	occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity	1,23	** frequent	uniform with rapid in reach	point bars
regular meanders	*open water area	18,5 ha	split	✓ irregular	✓ channel junction bars
irregular meanders	perimeter	9300 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 $\bar{x}$	50,6 m	s = 70,5 m		

Comments *whole reach
** near mouth

Obstructions/Constructions

Natural	Degree
✓ none	✓ none
logs	minor
boulders	major
vegetation	

Comments ____

Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
road bridge/s	R. confined	head of reach
rail bridge/s		
causeway		
weir/dam		
fish traps		
embankment/s	200m on R.B. for new N.R. bridge	2,6 km
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 2 %	highly unstable
irregular lateral activity	channel edge	right bank 33 %	
✓ avulsion			

Comments ____

TABLE NN3/V — CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS — NRIO NN 3

RIVER MDLOTI, ? % ESTUARINE, REACH from 1950's Rd.Br., 3,2 km from mouth. REF. DEA U 301 b

AERIAL PHOTO DATE 2-8-68 SCALE 1:10 000 CATCHMENT AREA 527 km², M.A.R. 116,99 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 plains	✓ sparsely forested (0-25%)	partly cultivated
	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	6	18
✓ occasional	sand		
frequent	trees		11
	grass		
	cultivated	94	71
	built-up		

Comments * very little

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 2750 m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) 493 m	indefinite	not obviously degrading or aggrading	✓ occasionally confined	lacustrine deposits
valley area 155,4 ha	✓ fragmentary	partly entrenched	frequently confined	✓ fluvial deposits
height at head of reach ____ m to MSL	continuous	entrenched	entrenched	aeolian
valley slope 1:____		✓ 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	208	°
outer bar	length of ~~spit~~/bar	770	m
silt plume (fluvial)	* length stabilized	460	m
✓ suspended sediment (marine)	width	52	m

Comments * Vegetation growth

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	*Extent*		
none	none		
indefinite	average width	493	m
fragmentary	maximum width	850	m
✓ continuous	area	155,4	ha

Areal Measurements: % Flood Plain/Valley

open water	10	swamp, marsh	18
sand (marine)	2	cultivated	60
sand, silt (fluvial)	2	built-up	1
trees, bush } grass	7	----------	----
----------	----	----------	----

Crops, Animal Husbandry: sugar cane

Comments

Channel Description

N.B. - Estimate of flow stage: LOW/~~MEAN/HIGH~~

Pattern	*Measurements*		*Islands/~~Shoals~~*	*Type of Flow*	*Bar Type*
straight	*thalweg	3170 m	none	✓ ~~stagnant~~/still	none
sinuous	*aerial length	2550 m	✓ occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity	1,24	frequent	uniform with rapid in reach	point bars
** regular meanders	*open water area	15,6 ha	split	irregular	✓ channel junction bars
irregular meanders	perimeter	10225 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 $\bar{x}$	39,3 m	s = 81,4 m		

Comments *whole reach
** forming u/s N.R. bridge

Obstructions/Constructions

Natural	*Degree*
✓ none	✓ none
logs	minor
boulders	major
vegetation	

Comments

Man-made	*Degree of Obstruction/Constriction for Each*	*Position (from head of reach)*
road bridge/s (2)	R. confined	0 & 2,6 km
rail bridge/s		
causeway		
weir/dam		
fish traps		
embankment/s	for N.R. bridge 300m L.B., 180m R.B	2,6 km
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 channel edge	left bank 19 %	highly unstable
irregular lateral activity		right bank 13 %	
✓ avulsion			

Comments

TABLE NN3/VI — CLASSIFICATION OF THE LOWER REACHES OF NATAL RIVERS — NRIO NN 3

RIVER MDLOTI, 40 % ESTUARINE, REACH from 1950's Rd. Br., 3,4 km from mouth. REF. DEA U 301 6

AERIAL PHOTO DATE 22-7-77 (orthophoto series) SCALE 1:10 000 CATCHMENT AREA 527 km², M.A.R. 116,99 $m^3 \times 10^6$, No. of DAMS* 1

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 plains	✓ sparsely forested (0-25%)	partly cultivated
	moderately forested (25-75%)	✓ mainly cultivated
	heavily forested (75-100%)	✓ scattered settlement
	** riverine forest: tributaries	partly built-up
		urbanized

Valley Sides (Well-defined)

Slumping	Vegetation and Land-use	Left	Right
none	coastal dune forest	6	18 %
✓ occasional	sand		
frequent	trees		11 %
	grass		
	cultivated	94	71 %
	built-up		

Comments * Hazelmere (1976)

** Very little

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 2750 m	none	not applicable	not applicable (no valley or free)	bedrock
bottom width (av.) 493 m	indefinite	not obviously degrading or aggrading	✓ occasionally confined	lacustrine deposits
valley area 155,4 ha	✓ fragmentary	partly entrenched	frequently confined	✓ fluvial deposits
height at head of reach ± 5 m to MSL approx.	continuous	entrenched	entrenched	aeolian
valley slope ≈1: 550		✓ 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	212	°
outer bar	length of spit/~~bar~~	663	m
silt plume (fluvial)	* length stabilized	460	m
✓ suspended sediment (marine)	width	54	m

Comments * vegetation growth

FLOOD PLAIN AND CHANNEL FEATURES

Description of Flood Plain

Presence	Extent	
none	none	
indefinite	average width	493 m
fragmentary	maximum width	850 m
✓ continuous	area	155,4 ha

Areal Measurements: % Flood Plain/Valley			
open water	11	swamp, marsh	21
sand (marine)	3	cultivated	54
sand, silt (fluvial)	1	built-up	1
trees, bush		----------	
grass	9	----------	

Crops, Animal Husbandry: sugar cane

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	3405 m	none	stagnant/still	none
sinuous	*aerial length	2598 m	✓ occasional	uniform water surface	✓ channel side bars
✓ irregular	*sinuosity	1,31	frequent	uniform with rapid in reach	✓ point bars
** regular meanders	*open water area	16,7 ha	split	✓ irregular	✓ channel junction bars
irregular meanders	perimeter	8780 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 $\bar{x}$	39,0 m	s = 61,7 m		

Comments *whole reach ** u/s N.R. bridge

*** near mouth

Obstructions/Constructions

Natural	Degree	Man-made	Degree of Obstruction/Constriction for Each	Position (from head of reach)
✓ none	✓ none	road bridge/s (2)	R. confined	0 & 2,6 km
logs	minor	rail bridge/s		
boulders	major	causeway		
vegetation		weir/dam		
		fish traps		
		embankment/s	for N.R. bridge 300m L.B., 180m R.B.	2,6 km
		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	✓ 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 17 %	highly unstable
irregular lateral activity		right bank 11 %	
✓ avulsion			

Comments

TABLE NN3/VII RIVER WIDTHS

MDLOTI NN 3

Station	Approx distance along 1977 river course from 1950s road bridge (m)	River widths (m) Date 30-4-37	Jul/Aug.'53	6-6-59	2-8-68	22-7-77	$\bar{x}$	s	V%
1	0	36	22	25	5	5	18,6	13,5	72,4
2	300	25	11	18	5	10	13,8	7,8	56,5
3	600	18	10	18	8	18	14,4	5,0	34,6
4	900	20	15	18	8	11	14,4	4,9	34,2
5	1 200	22	36	24	5	20	21,4	11,1	51,8
6	1 500	25	37	29	5	25	24,2	11,8	48,8
7	1 800	34	59 (15+10+34)	28 (5+18+5)	10 (5+5)	30	32,2	17,6	54,6
8	2 100	34	42 (10+32)	35 (10+25)	22 (10+12)	20	30,6	9,3	30,4
9	2 400	41	87 (22+65)	54 (24+30)	50 (22+28)	32 (10+22)	52,8	20,9	39,6
10	2 700	130 (90+18+22)	123 (35+88)	63 (35+28)	63 (28+35)	57 (22+35)	87,2	36,0	41,3
11	3 000	178 (150+28)	268	270	290	230 (125+105)	247,2	44,4	17,9
12	3 300	5	8	25	0	10	9,6	9,4	97,9
$\bar{x}$		47,3	59,8	50,6	39,3	39,0	47,2		
s		51,8	74,1	70,5	81,4	61,7			
V%		109,4	123,9	139,4	207,4	158,3			

TABLE NN3/VIII LATERAL STABILITY MDLOTI NN 3

Station	Approx distance along 1977 R. course from 1950s road bridge (m)	Distance from maximum observed L.B. position to mid-river (m)					Max-Min	$\bar{x}$	s	V%
		Date								
		30-4-37	Jul/Aug.'53	6-6-59	2-8-68	22-7-77				
1	0	18,0	20,0	25,0	2,5	25,0	22,5	18,1	9,2	51,1
2	300	12,5	12,0	30,0	23,0	35,0	23,0	22,5	10,3	45,7
3	600	20,0	15,0	20,0	20,0	9,0	11,0	16,8	4,9	29,0
4	900	10,0	20,0	10,0	15,0	5,5	14,5	12,1	5,5	45,9
5	1 200	64,0	60,0	35,0	38,0	10,0	54,0	41,4	21,8	52,6
6	1 500	62,0	45,0	35,0	24,0	12,5	49,5	35,7	19,1	53,4
7	1 800	81,0	81,2	91,6	47,3	80,0	44,3	76,2	16,8	22,1
8	2 100	17,0	98,6	65,7	55,5	65,0	81,6	60,4	29,2	48,4
9	2 400	32,0	135,8	104,2	118,4	140,4	108,4	106,2	43,9	41,3
10	2 700	111,4	137,3	78,9	97,6	106,0	58,4	106,2	21,3	20,0
11	3 000	144,7	144,0	135,0	150,0	136,7	15,0	142,1	6,2	4,3
12	3 300	85,0	4,0	255,0	N.R.	260,0	256,0	151,0	127,4	84,3
$\bar{x}$		54,8	64,4	73,8	53,8	73,8	61,5	65,7 64,1		41,5
s		44,0	53,4	68,8	47,7	76,7	68,0			20,6
V%		80,4	82,9	93,4	88,7	104,1	110,5			49,5

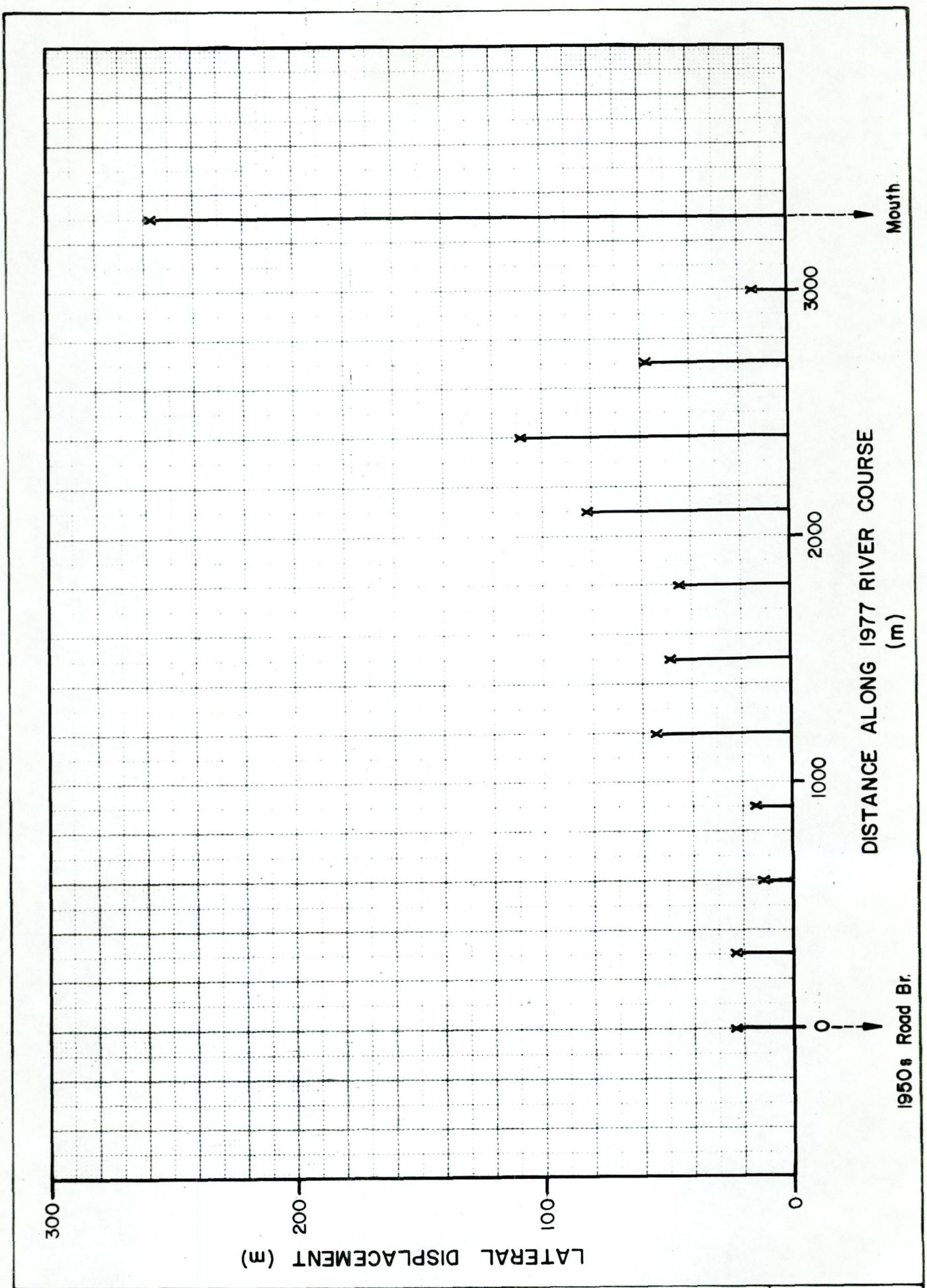
Average lateral displacement 1937-77 = 61,5 m

Average coefficient of variation 1937-77 = 41,5%

TABLE NN 3/IX SIMULATED RUN-OFF FOR MDLOTI NN 3 CATCHMENT AREA= 527.0SQ.KM.

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL	%M.A.R.
1921	2.48	92.92	90.34	23.27	3.01	2.52	2.36	2.38	2.73	2.47	2.65	2.84	229.98	196.57
1922	35.70	31.77	9.96	10.78	8.40	6.68	5.37	3.31	1.94	1.45	1.20	.96	117.53	100.46
1923	.78	.70	1.32	2.59	3.87	3.44	2.35	1.75	1.37	1.09	.94	2.16	22.36	19.11
1924	3.55	6.66	7.03	6.87	6.29	183.00	65.51	4.97	3.34	2.63	2.14	2.61	294.63	251.84
1925	3.80	3.61	2.81	1.78	1.45	2.37	2.44	1.57	1.49	1.61	1.29	1.34	25.58	21.86
1926	2.72	3.93	3.57	2.51	3.58	105.74	38.87	3.45	2.08	1.55	1.83	2.06	171.89	146.93
1927	2.26	2.40	3.06	4.53	5.36	4.71	3.39	2.30	1.53	1.05	.97	1.27	32.84	28.07
1928	1.82	2.59	3.40	3.89	3.77	33.00	14.86	3.86	7.18	18.01	9.96	21.19	123.52	105.58
1929	34.83	14.50	4.97	3.90	2.94	2.46	2.73	2.49	1.92	1.72	2.58	4.14	79.17	67.67
1930	4.97	4.78	4.61	5.63	4.77	3.73	3.46	2.56	1.65	2.22	2.68	2.24	43.31	37.02
1931	1.99	1.69	2.02	3.11	58.13	42.81	11.99	5.13	4.46	3.15	2.15	1.85	138.47	118.36
1932	2.73	3.58	4.23	3.91	2.70	2.13	2.10	2.05	1.76	1.79	1.72	1.49	30.21	25.82
1933	1.62	3.44	16.60	30.25	13.19	9.37	31.75	15.60	6.08	5.46	6.13	5.00	144.47	123.49
1934	3.19	2.34	3.61	5.72	13.06	9.05	5.60	50.76	178.40	59.42	6.36	4.88	342.39	292.66
1935	3.36	2.58	2.01	2.47	29.57	37.90	13.22	23.69	11.91	4.45	2.92	2.09	136.19	116.41
1936	2.57	69.40	26.56	3.10	4.16	4.76	4.41	3.68	2.82	2.45	2.47	2.25	128.63	109.95
1937	2.10	2.35	26.90	13.27	44.73	17.63	4.09	3.98	4.06	5.81	6.08	4.13	135.12	115.50
1938	4.18	9.51	7.53	5.25	36.67	32.23	11.00	6.04	5.73	5.00	4.43	6.29	133.87	114.43
1939	6.92	25.95	15.96	5.83	2.89	2.01	1.90	23.31	19.73	8.28	3.74	2.71	119.24	101.92
1940	2.99	39.06	21.88	6.42	2.85	2.35	3.48	3.40	2.24	1.60	1.28	1.60	89.16	76.21
1941	2.13	2.56	2.21	2.85	3.61	4.48	4.56	3.94	3.45	2.89	2.85	3.25	38.78	33.15
1942	4.34	33.67	74.14	25.22	9.69	34.68	60.40	22.60	6.56	11.25	22.61	10.63	315.79	269.93
1943	40.11	39.65	13.06	3.55	3.15	13.36	8.49	4.16	3.15	2.78	2.20	3.92	137.58	117.60
1944	6.36	6.13	3.94	2.35	3.40	59.40	23.53	4.28	3.11	2.01	1.31	1.00	116.82	99.85
1945	1.18	1.20	1.12	1.92	2.54	3.38	5.31	5.23	3.37	2.06	1.33	1.18	29.83	25.50
1946	1.57	2.54	3.66	4.24	29.35	14.19	6.12	4.72	4.08	4.06	3.50	3.08	81.11	69.33
1947	2.89	13.06	8.71	6.44	21.79	27.14	16.11	6.80	3.09	1.82	1.29	1.00	110.15	94.15
1948	2.69	5.30	5.33	4.03	4.77	5.26	5.45	4.82	3.26	2.19	1.54	1.65	46.30	39.57
1949	3.32	27.03	33.59	13.09	5.21	4.51	3.64	3.06	2.61	1.95	2.12	2.11	102.23	87.38
1950	1.62	1.16	2.56	3.98	3.32	4.58	5.76	4.23	2.68	1.92	3.64	6.12	41.58	35.54
1951	6.75	4.95	4.82	27.81	12.49	3.82	4.23	5.12	4.35	3.19	2.72	2.26	82.51	70.53
1952	1.84	2.08	3.29	85.59	65.94	16.34	3.43	2.07	1.30	.91	1.14	2.18	186.08	159.06
1953	3.16	3.90	13.36	8.33	5.62	5.61	4.38	3.32	2.74	2.16	1.91	3.57	58.06	49.63
1954	92.89	41.62	6.94	13.02	7.54	11.02	8.52	5.56	3.67	2.48	1.74	2.19	197.20	168.56
1955	3.37	4.68	4.42	2.36	3.44	33.65	15.85	5.24	3.50	2.35	2.32	3.27	84.44	72.17
1956	3.61	3.84	72.49	28.31	6.15	6.66	65.18	25.26	3.54	2.26	1.82	3.26	222.38	190.08
1957	12.46	13.74	7.63	47.33	76.35	25.55	65.33	25.37	3.84	2.48	1.66	2.34	284.09	242.83
1958	3.08	4.18	5.12	4.19	3.29	2.34	1.43	2.61	3.48	2.68	2.57	2.97	37.94	32.43
1959	3.90	4.17	3.64	2.85	2.51	3.12	4.02	3.73	2.52	1.73	1.36	1.29	34.84	29.78
1960	1.85	3.81	29.58	18.62	6.56	4.13	69.71	27.33	6.08	5.95	4.25	3.65	181.51	155.15
1961	4.11	4.54	3.67	2.69	2.33	2.84	3.18	2.60	1.75	1.20	1.81	2.23	32.95	28.17
1962	2.22	38.70	16.57	6.21	5.42	6.73	6.39	4.32	3.23	4.67	5.21	3.85	103.51	88.48
1963	3.19	3.09	2.76	39.23	17.42	4.48	3.55	2.92	2.21	2.03	1.72	1.44	84.04	71.84
1964	2.63	3.61	3.50	2.96	2.08	1.17	.67	1.07	3.57	5.65	6.08	6.14	39.13	33.45
1965	5.92	5.67	5.04	4.74	4.04	2.47	1.54	2.33	3.06	2.60	2.20	2.08	41.70	35.64
1966	2.20	3.11	3.82	5.18	5.99	21.07	11.86	5.62	3.45	2.40	1.80	1.24	67.76	57.91
1967	1.90	5.84	5.32	21.71	10.99	5.17	4.28	2.76	1.71	1.20	2.04	3.52	66.44	56.79
1968	4.17	3.91	3.06	2.06	2.11	39.44	17.84	12.22	7.83	4.19	2.79	2.47	102.07	87.25
1969	16.68	32.54	13.87	5.39	3.41	1.72	1.06	1.76	2.66	2.53	2.24	3.17	87.03	74.39
1970	4.99	5.72	6.14	5.59	13.49	57.16	22.42	42.23	17.80	5.57	19.04	11.10	211.25	180.57
1971	5.41	3.46	3.16	2.75	4.11	4.81	4.12	5.44	6.90	6.38	4.58	2.99	54.11	46.25
1972	2.33	2.56	3.04	3.66	4.22	4.61	4.28	3.08	1.95	1.38	2.22	15.11	48.45	41.41
1973	11.25	17.11	8.83	4.64	49.63	22.26	6.60	5.89	5.05	3.65	2.51	1.79	139.21	118.99
1974	1.37	1.85	3.64	30.14	26.30	8.92	3.41	2.75	2.05	1.47	1.21	3.02	86.12	73.61
1975	4.58	4.01	4.74	25.29	41.95	131.82	95.22	22.73	3.96	2.74	2.83	3.12	343.01	293.19
MEAN	7.21	12.34	11.73	11.15	13.12	20.11	14.52	8.24	7.27	4.33	3.38	3.59	116.99	
S	14.28	18.02	18.03	14.71	17.46	33.36	21.39	10.41	23.75	8.07	3.83	3.53	83.37	
V%	198.00	146.00	153.74	131.90	133.09	165.91	147.27	126.32	326.63	186.43	113.51	98.40	71.26	
MEDIAN	3.16	4.01	4.74	4.74	4.77	5.26	4.56	3.98	3.23	2.45	2.20	2.47	89.16	

MEAN ANNUAL RUN-OFF= 116.99 MILLION CUBIC METRES. COMPILED FROM HRU REPORT NO.9/81 DATA



TRACED: MM CHECKED: DATE: REF	NATAL ESTUARIES: MDLOTI THALWEG DISPLACEMENT: 1937 -77	FIGURE NN 3/1

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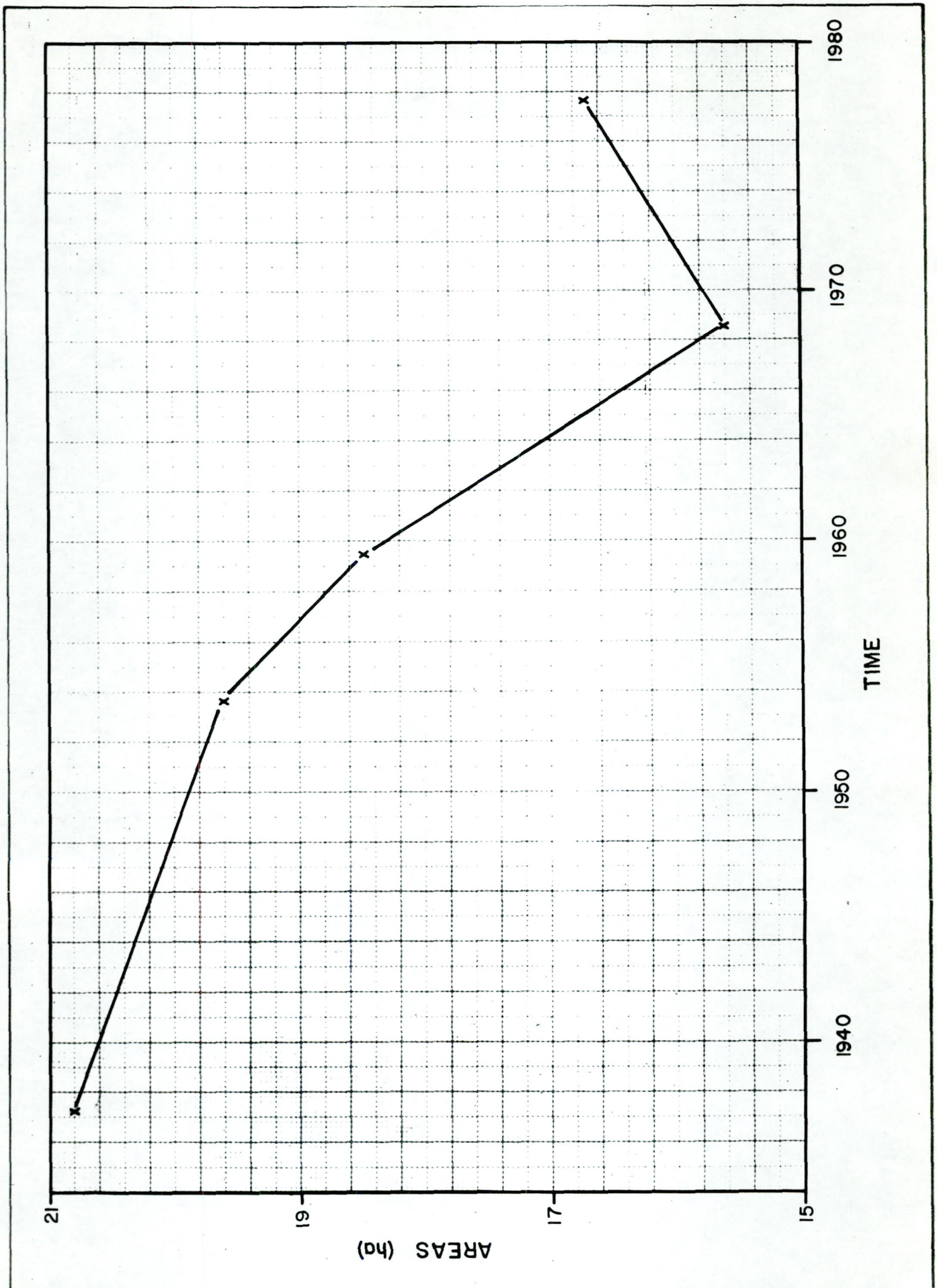

TRACE : MM CHECKED: DATE: REF.:	NATAL ESTUARIES: MDLOTI OPEN WATER AREAS: 1937 – 77	FIGURE NN 3/2

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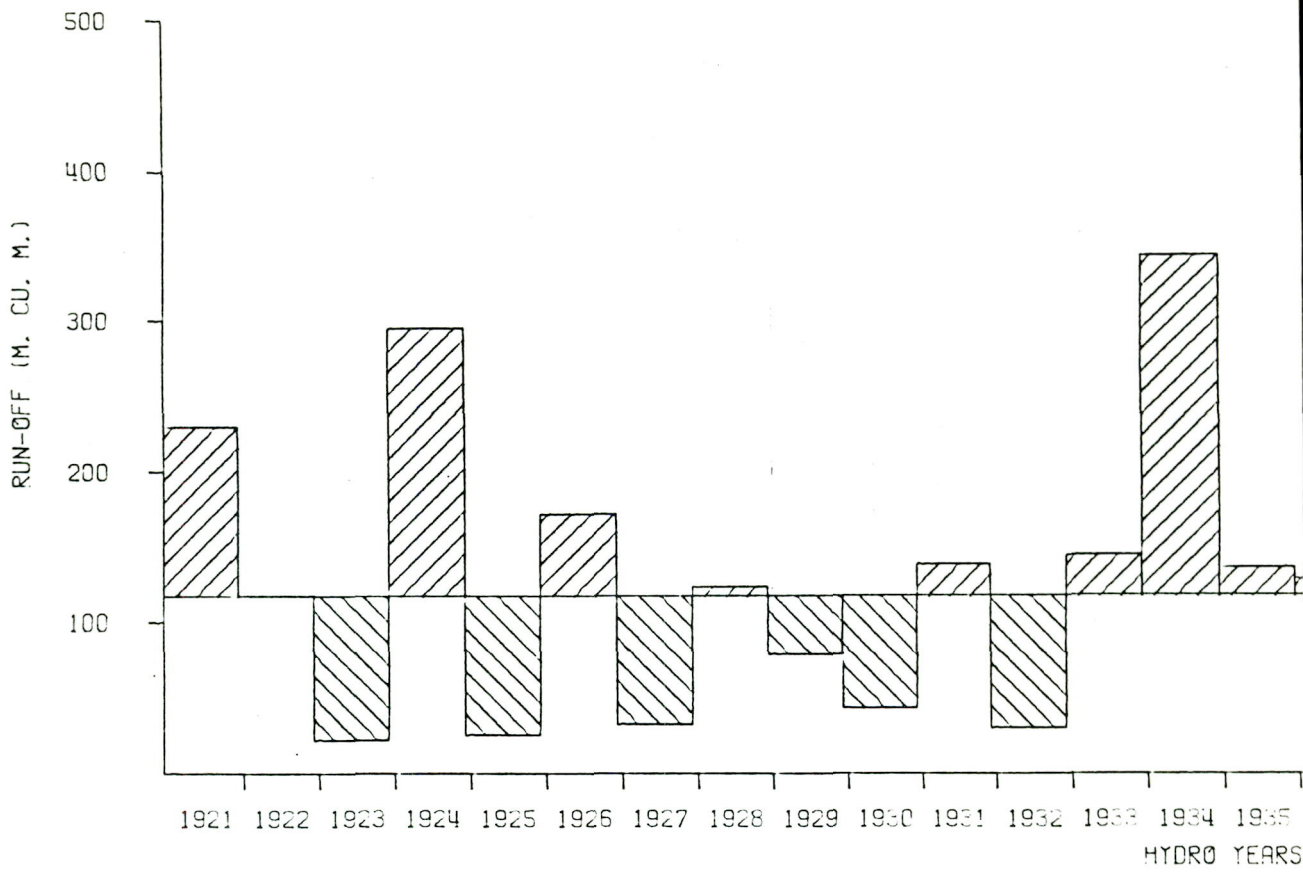

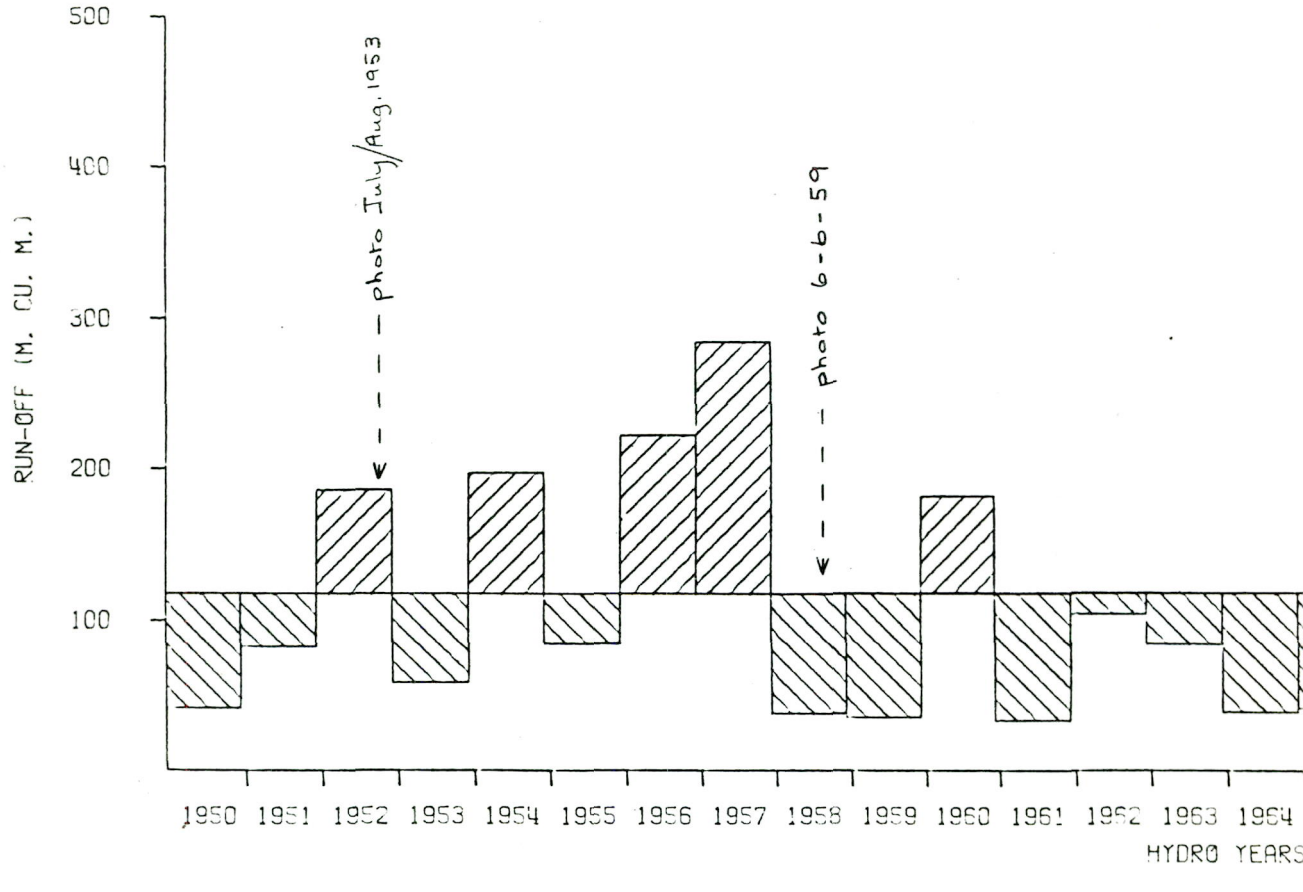

TRACED : TEMPLOT CHECKED: DATE : REF. :	NATAL ESTUARIES : MDLOTI SIMULATED ANNUAL RUN-OFF 1921-1975	FIGURE NN 3/3

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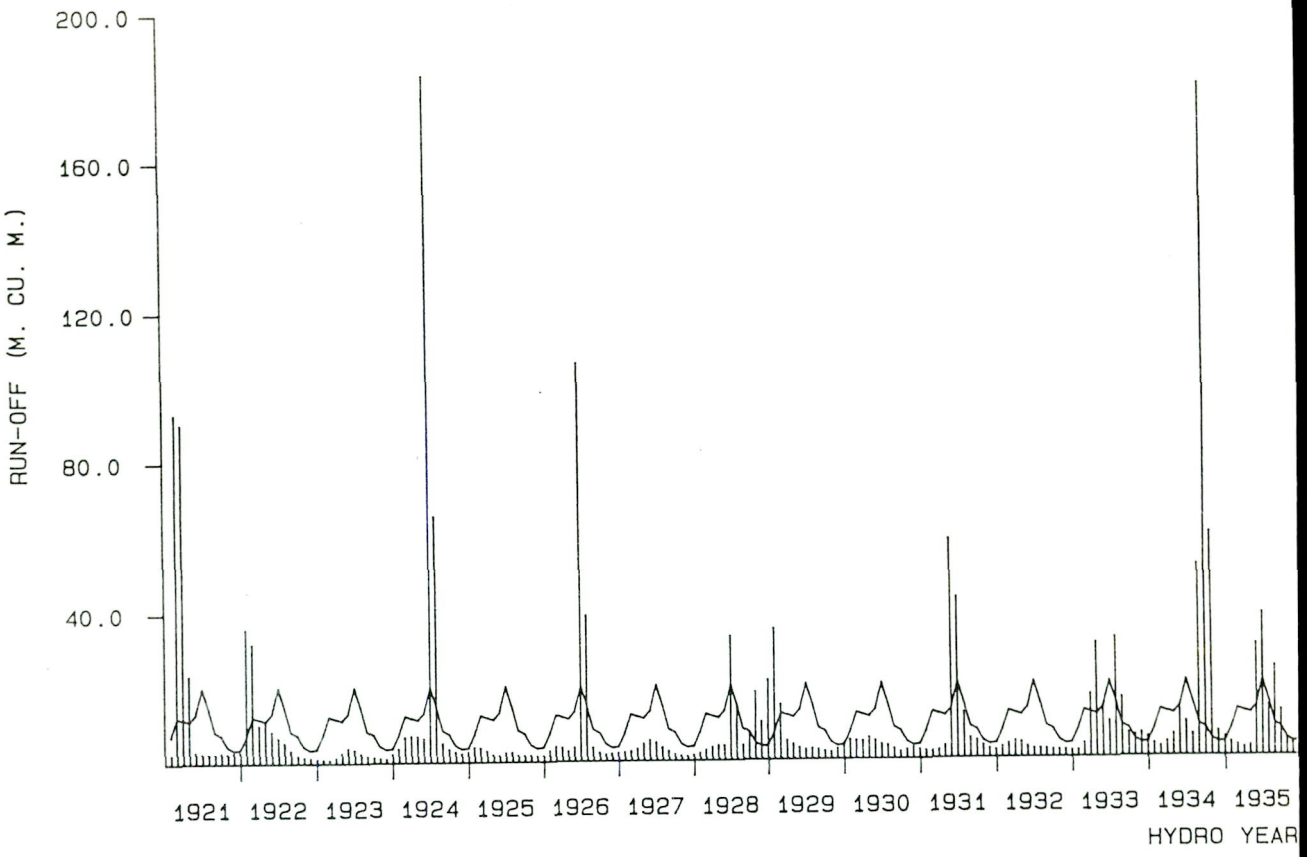

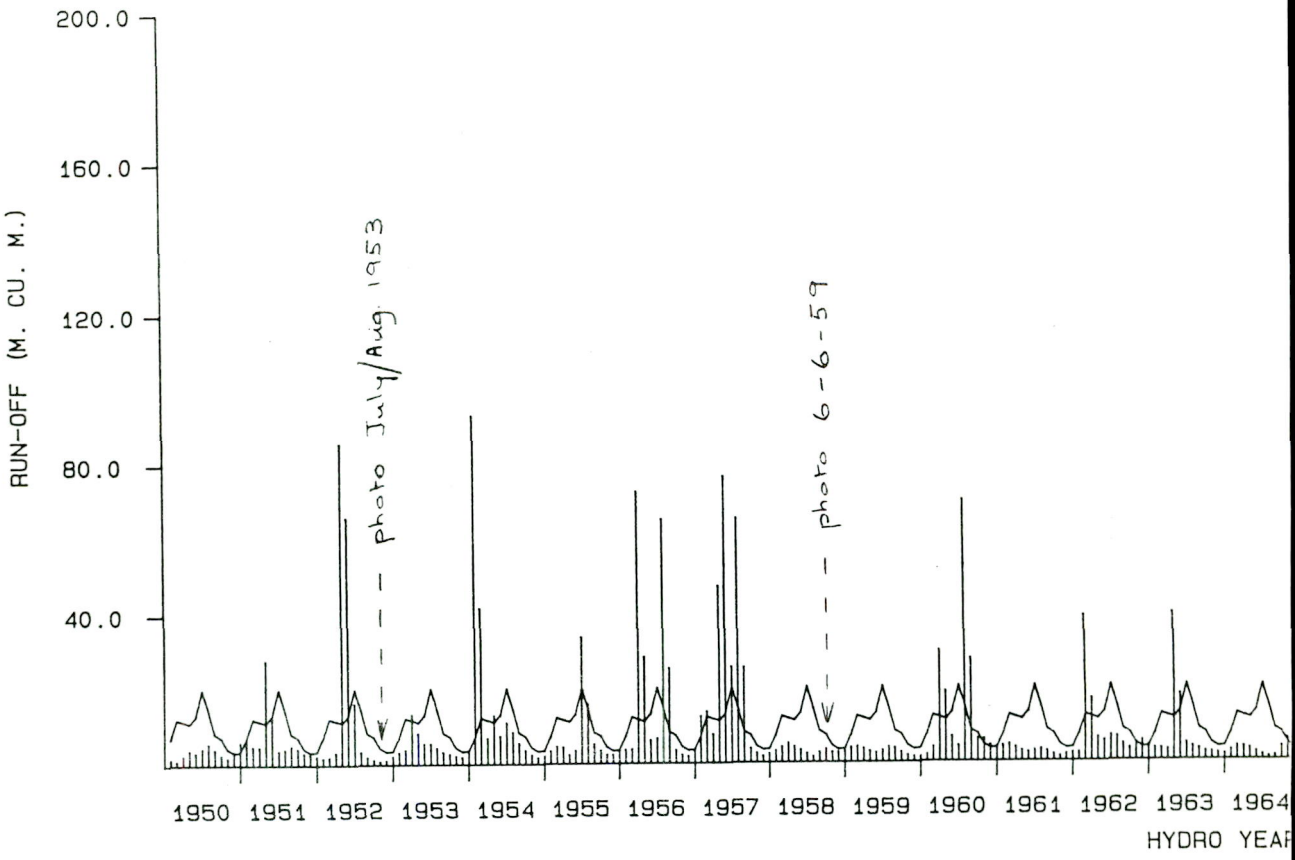

TRACED : COMPLOT CHECKED: DATE : REF. :	NATAL ESTUARIES : MDLOTI SIMULATED MONTHLY RUN-OFF 1921-1975	FIGURE NN3/4

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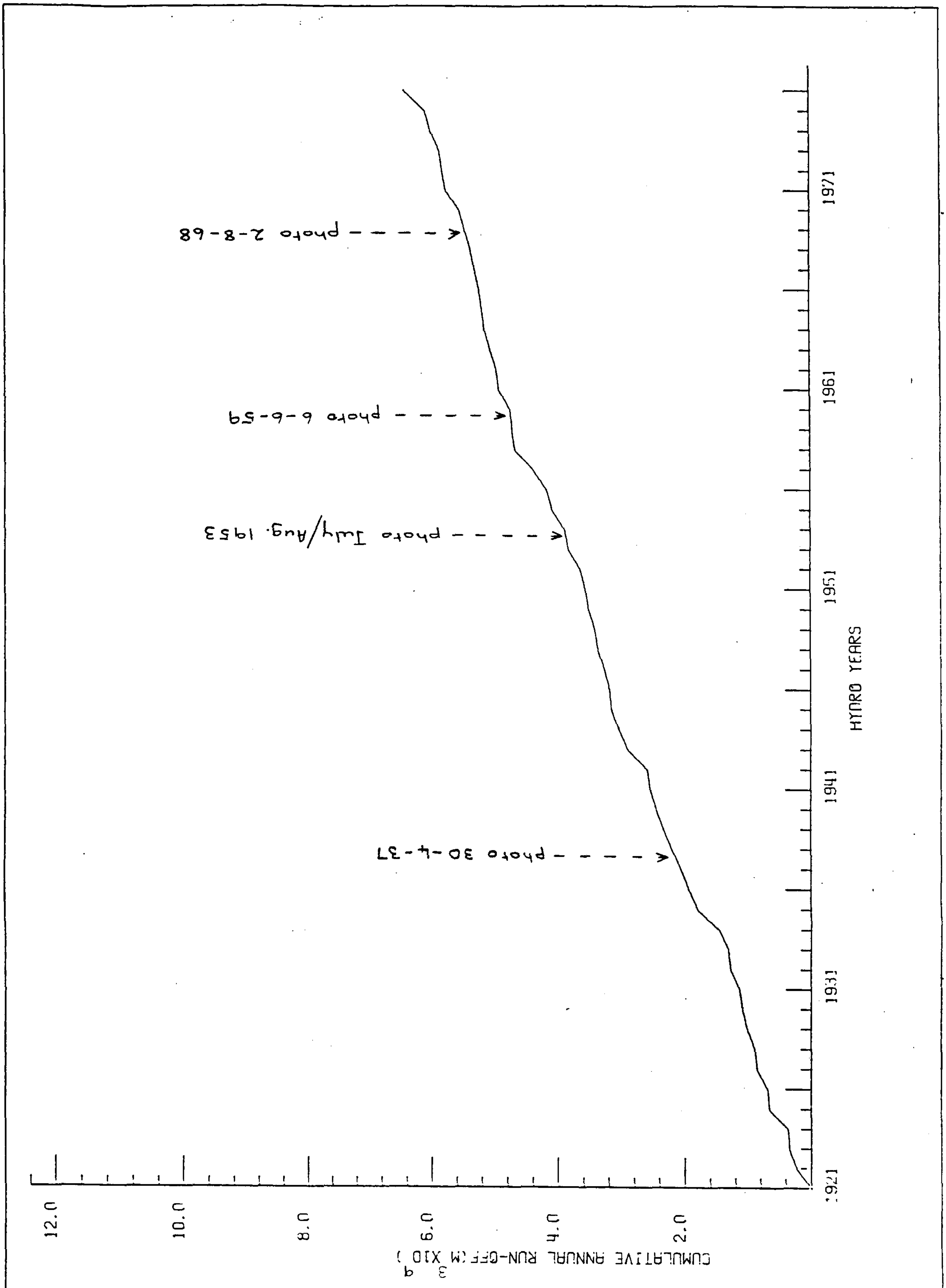

TRACED : TEMPLOT
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DATE :
REF. :

NATAL ESTUARIES: MDLOTI

CUMULATIVE ANNUAL RUN-OFF

FIGURE
NN3/5

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23-6-11

SCALE 1 : 12 900 approx

TRACED JGAN CHECKED DATE REF	NATAL ESTUARIES: MDLOTI 23-6-77 (ORTHOPHOTO) 13h25	PHOTOGRAPH NN3 / 1

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SCALE 1: 12 900 approx

TRACED JGAN CHECKED DATE REF	NATAL ESTUARIES: MDLOTI 30-4-37 (12h59)	PHOTOGRAPH NN3 / 2

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SCALE 1 : 12 900 approx

TRACED JGAN CHECKED DATE REF	NATAL ESTUARIES: MDLOTI JULY/AUGUST 1953 (11h39)	PHOTOGRAPH NN3 / 3

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SCALE 1: 12 900 approx

TRACED JGAN CHECKED DATE REF	NATAL ESTUARIES: MDLOTI 6-6-59 (11h53)	PHOTOGRAPH NN3/4

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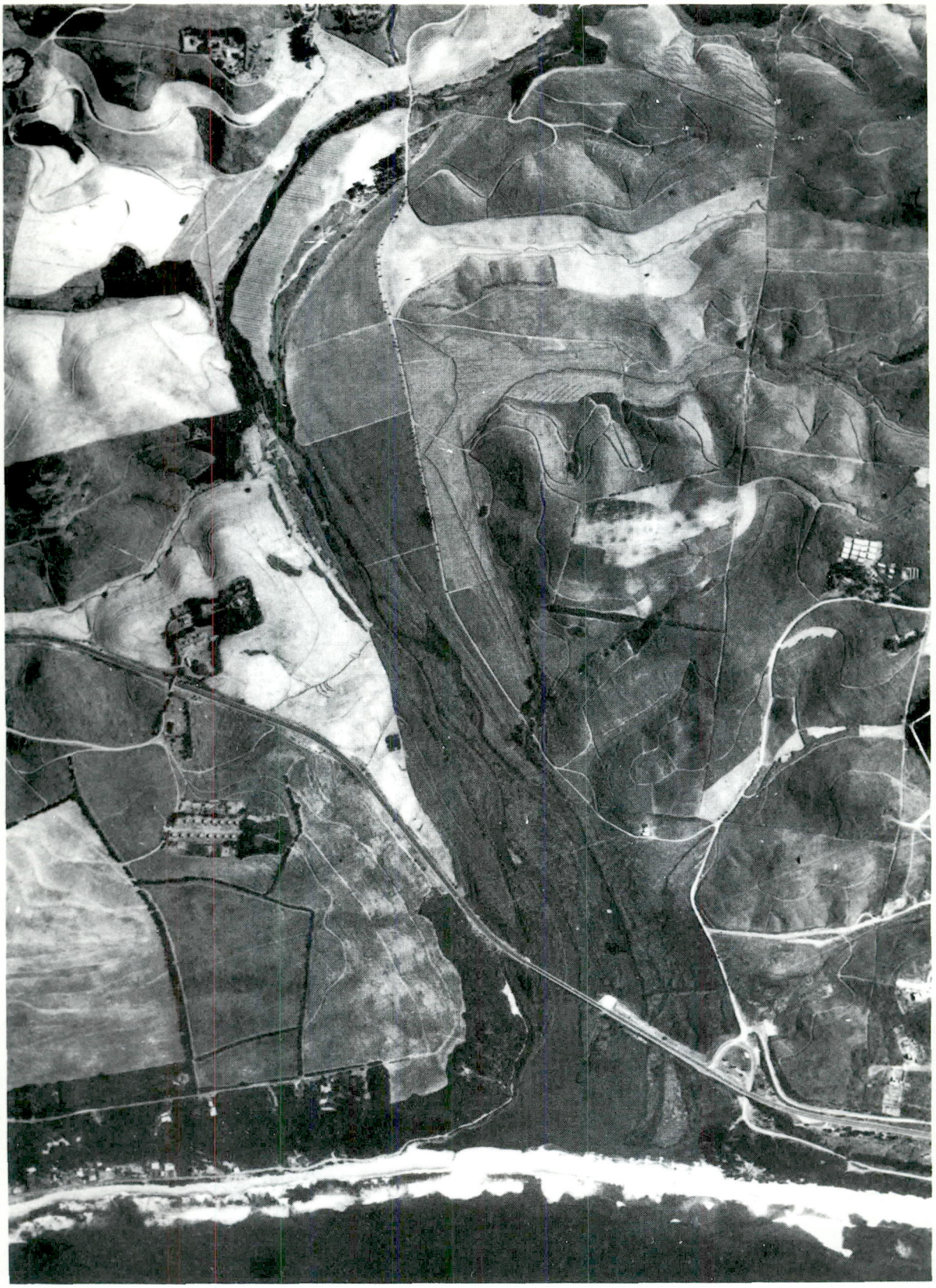

SCALE 1 : 12 900 approx

TRACED JGAN CHECKED DATE REF	NATAL ESTUARIES: MDLOTI 2-8-68 (11h14)	PHOTOGRAPH NN3/5

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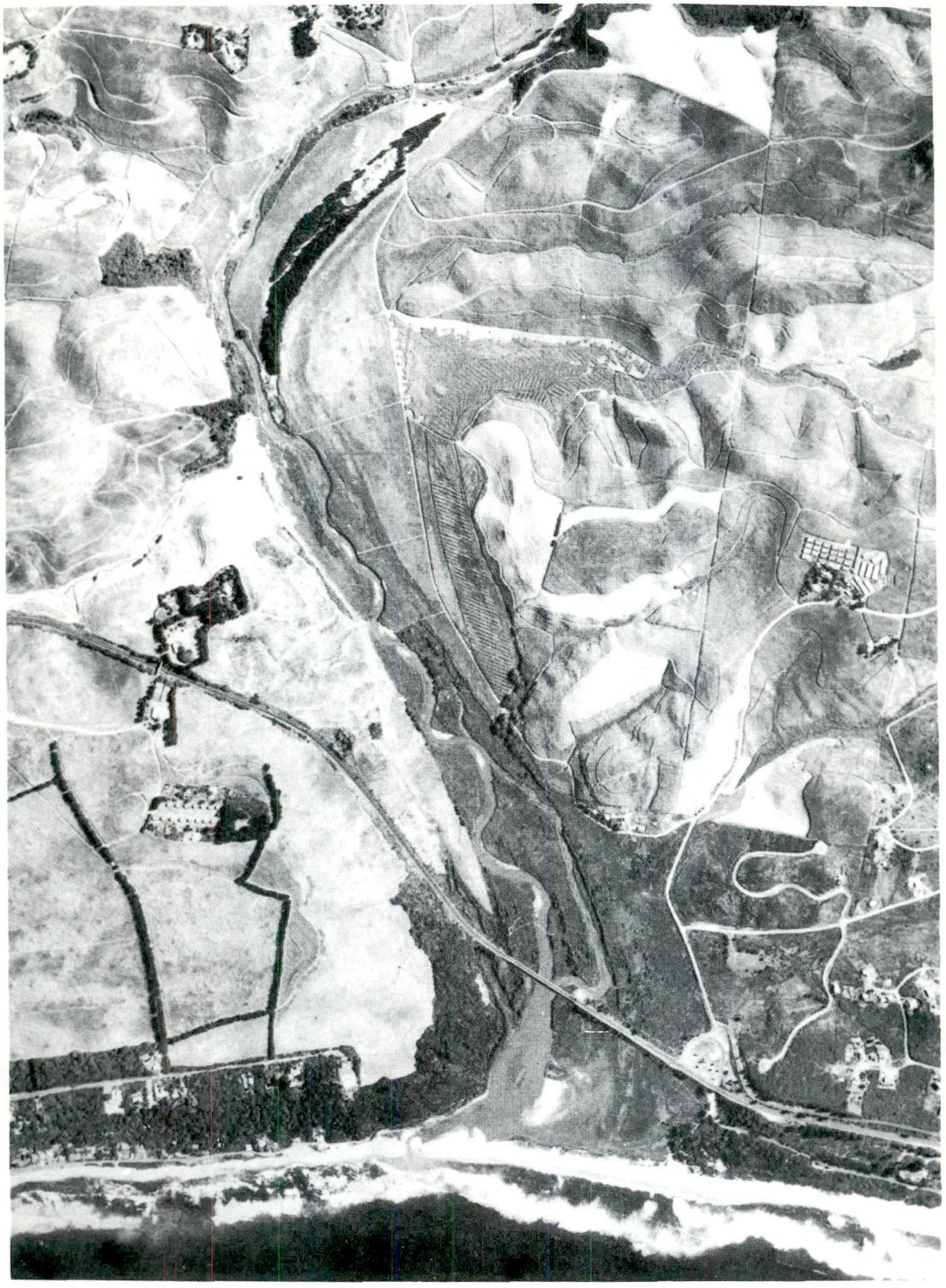

SCALE: 1 : 12 900 approx.

TRACED : CHECKED : DATE: REF. :	NATAL ESTUARIES : MDLOTI 22-7-77 (11h 56)	PHOTOGRAPH NN3/6

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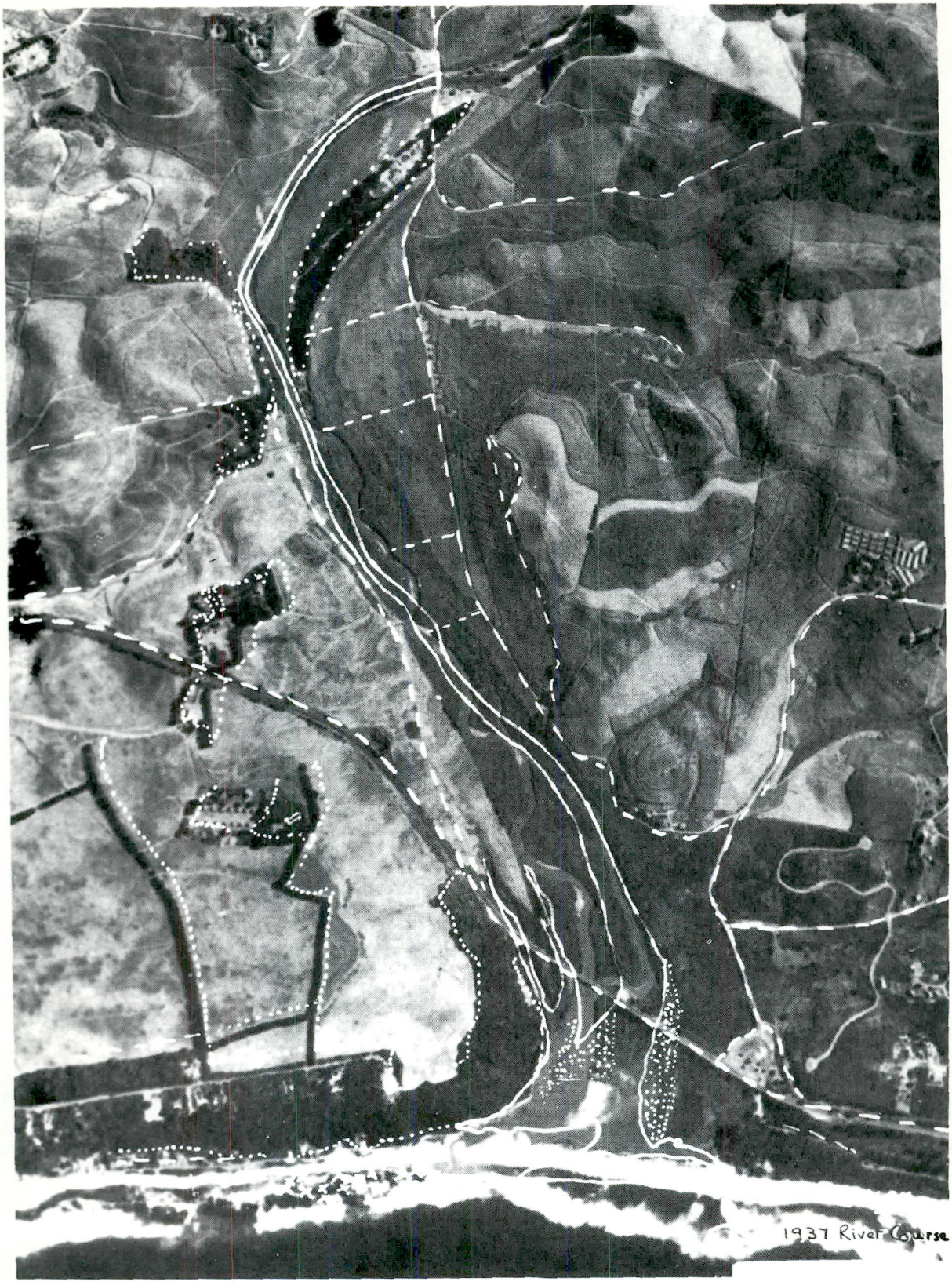

SCALE 1 12 900 approx.

TRACED CHECKED DATE REF	NATAL ESTUARIES : MDLOTI 22-7-77 (30-4-37 RIVER COURSE SUPERIMPOSED)	PHOTOGRAPH NN3 / 7

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SCALE: 1 : 12 900 approx.

TRACED: JGAN CHECKED: DATE: REF. :	NATAL ESTUARIES : MDLOTI ORTHOPHOTO (ENVELOPE OF MOBILITY, LINES OF MEASUREMENT AND LATERAL SHIFT SUPERIMPOSED)	PHOTOGRAPH NN3 / 8

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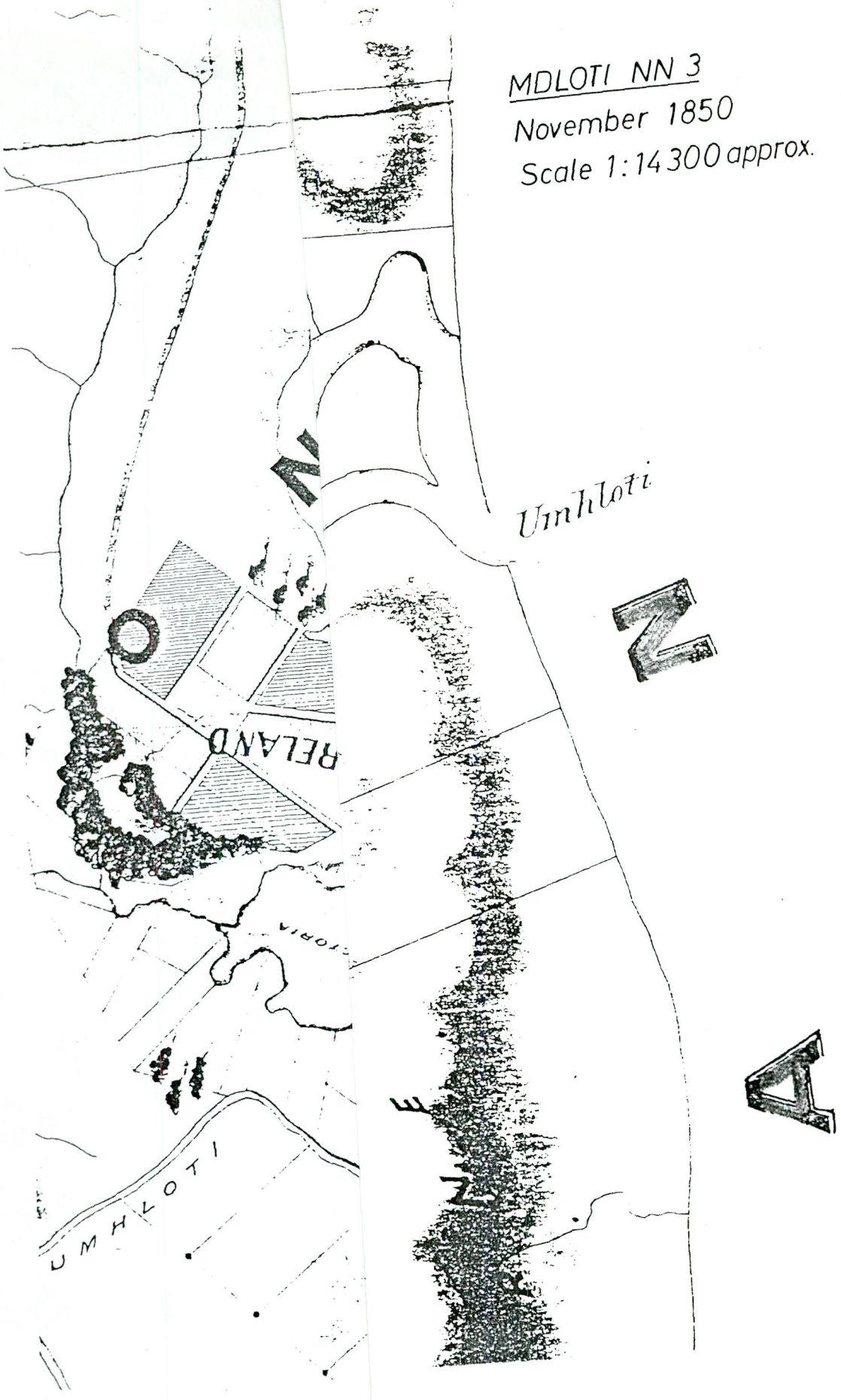
MDLOTI NN 3
November 1850
Scale 1:14300 approx.
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