# WILDERNESS REPORT NO 2

# EVALUATION OF PROTOTYPE FLOOD CONDITIONS AND THE APPLICATION OF THE NUMERICAL MODEL TO CONDITIONS WHEN THE ESTUARY MOUTH WAS OPENED

submitted to

THE COASTAL LAKES WORKING GROUP INLAND WATER ECOSYSTEMS
and
THE NATIONAL TRANSPORT COMMISSION

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

CSIR REPORT C/SEA 8255

Stellenbosch, South Africa
December 1982

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## SCOPE

During 1978 the Coastal Engineering and Hydraulics Division (CEHD) of NRIO was asked by the Co-operative Scientific Programme (CSP) to contribute to the research study of the Touws River floodplain and Wilderness Lakes being conducted by the Coastal Lakes Working Group within the Inland Water Ecosystems Section of the National Programme for Environmental Sciences.

The model study was of interest to the National Transport Commission (NTC) because of the proposed National Road crossing the floodplain of the Serpentine.

The CEHD contribution to the study comprised the mathematical modelling of the flow in the Touws River and Wilderness Lakes system, to

(i) provide flood-levels for 1 in 5, 10, 20, 50 and 100 year predicted flood events;

(ii) investigate the influence of certain management actions such as dredging and the introduction of an artificial sluice gate; and

(iii) suggest precautionary measures to prevent flood damage of the estuary banks.

Wilderness Report No 1 describes the calibration of the numerical model against prototype flood events and the flood levels of predicted floods determined for the existing and dredged systems for conditions with the estuary mouth closed. At that stage there was a lack of sufficient prototype data for flood events with the estuary mouth open.

During 1980/81, heavy rainfall occurred in the catchment area during several occasions resulting in the estuary mouth remaining open for considerable periods of time. The estuary mouth was surveyed during the breakthrough and monitored during the flood. These flood events provided data to calibrate the numerical model against prototype open mouth conditions and to determine water levels of predicted flood events and are included in this report.

During 1981, it was decided to postpone construction of the proposed National Road. As an alternative the widening of the existing road is being investigated. Aspects of the NRIO study, relating to the flood water levels, the discharge and the possible depth of scour at the bridges crossing the Touws River estuary are outlined in correspondence in Appendix A.

The work was done by Messrs W A M Botes and M van Niekerk of the Institute's Coastal Engineering and Hydraulics Division under the supervision of Mr K S Russell, head of the Division.

F P ANDERSON
DIRECTOR

Stellenbosch
December 1982

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## 1. INTRODUCTION

This report is a continuation of an earlier contract report (CSIR, 1981), which provided a general description of the project and of the numerical model.

During 1980 no prototype data of an open-mouth condition at Wilderness were available and therefore the model simulation tests were limited to conditions in which the estuary mouth was closed.

From November 1980 to July 1981 there were several major floods during which the mouth opened. Surveying and monitoring of the estuary mouth continued during that time. The data obtained, together with the water-level and flow recordings of the lakes system were used to calibrate the numerical model for these flood conditions. It is now possible to provide the Lakes Management Board and the Lakes Working Group with particulars of predicted floods and of the influence of dredging on the system when the estuary mouth is open.

The scouring at the mouth was monitored and the rate of scouring was used as an input for the numerical model. This technique does not attempt to describe exact dynamics of the estuary mouth and is valid only for the period during which the flood event is the major factor dictating the scour at the mouth and the peak levels in the estuary. For the Touws River this period is only a few hours, after which tide, currents and wave action and the subsequent sediment transport influence the flow regime and, with decreasing river discharge, eventually result in closure of the estuary mouth.

The estimates of water-levels and flow discharges for the predicted floods have been used in calculating the scour which would occur if the existing bridge at the Touws Estuary is widened. These estimates have been made for extreme flood conditions and with the sand sill at the estuary maintained at predetermined elevations (Appendix A).

# 2. PROTOTYPE DATA

## 2.1 Survey

The Wilderness Lakes area was surveyed accurately by Ninham Shand and Partners in 1979. Figure 1b shows a layout of the lakes system with the contours and Figures 2a-2e show the cross-sections of the lakes and of the connection channels. Tables 1/1 and 1/2 list the cross-sectional areas and hydraulic radii required for the numerical computation. Table 1/3 gives the plan areas used for the computation of the storage volumes between the sections.

On 2 December 1980 a major flood occurred at Wilderness. The river mouth was skimmed mechanically and when the water-level in the estuary reached a height of 2,63 m above MSL at 11h30, the mouth was opened. The river mouth was surveyed several times by Ninham Shand and Partners on 2, 3, 4 and 8 December at three sections, that is, 10 m from the road bridge, between the bridge and the surf zone and at the surf zone. Contour plots of the surveys are given in Figures 3.1a-3.1c and the cross-sectional surveys in Figures 3.2a-3.2b. The flood was directly monitored by CEHD observers. The information is available for perusal at the Institute in Stellenbosch.

It was estimated that the mouth scoured to 0,0 m to MSL in approximately 2 hours giving an average scour rate of 0,011 m/minute in depth. This was used as the model scour rate for the calibration of the numerical model.

## 2.2 Water-level Recordings

The water-levels were recorded by the Department of Water Affairs at Wilderness, Onder-Langvlei, Bo-Langvlei and Rondevlei.

Particulars of the locations and lowered levels of the water-level recorders are given in CSIR (1981).

The prototype data for the period 27 November 1980 to 23 December 1980 are listed in Table II/1 and a graphic representation is given in Figure 4. The prototype data for the May/June 1981 flood are listed in Table II/2.

## 2.3 Touws River Flow Data

The discharge of Touws River was recorded by the Department of Water Affairs and the discharges of the period for the December 1980 flood are listed in Table II/1 and the hydrographs of the floods are shown in Figures 5a-5b together with the predicted flood hydrographs of the same magnitude. The hydrographs of the May/June 1981 flood are also shown in Figures 5a-5b and tabulated in Table II/2.

## 3. EVALUATION OF PROTOTYPE DATA

### 3.1 Water-level Recordings

Water-level histories for periods November/December 1980 and May/June 1981 are given in Figure 4 and Tables II/1 and II/2.

At the end of November 1980 a minor flood occurred which caused the water-levels in Wilderness to rise from 1,6 m to MSL to ≈ 2,0 m to MSL. About 70 hours later at 08h00 on 2 December 1980 a flood of maximum discharge of 82,4 $m^3/s$ occurred which caused a water-level rise at Wilderness of 2,6 m to MSL at which stage the mouth was opened. The maximum water-level in Onder-Langvlei was 2,1 m to MSL. After more than 20 days the levels of the upper lakes had dropped approximately 15 cm illustrating the natural sill between Onder- and Bo-Langvlei. The lowest level to which Onder-Langvlei drained was 1,25 m to MSL.

A major flood occurred on 29 May 1982 with a peak discharge of 135,5 $m^3/s$. The water-level recordings at Rondevlei and Bo-Langvlei were made available by the Department of Water Affairs and are tabulated in Table II/2. Unfortunately the recordings at Onder-Langvlei could not be retrieved.

Fortunately the river mouth was open at that stage. Nevertheless there was major flooding of low-lying areas such as in the vicinity of the Siesta Caravan Park, sagging of the road between Wilderness and Duiwe River, damage to the road at the Langvlei-Spruit and inundation of the road running along Rondevlei to the Nature Reserve Conservation Station.

### 3.2 River Discharge

#### (a) December 1980

The discharge of Touws River for the period 27 November 1980 to 23 December 1980, is tabulated in Table II/1 and a hydrograph of the event is shown in Figure 5a.

Comparison of this prototype flood with the predicted floods by Görgens (1979), (1980), leads to the following conclusions:

(i) Compared with the flood predicted by the unitgraph method the flood corresponds to approximately a 1-in-5-year flood. The prototype and predicted hydrographs are shown in Figure 5a.

(ii) Compared with a family of run hydrographs predicted for the Touws River by Görgens and Hughes (1981) the prototype flood corresponds closest to family No 3 for a 1-in-50-year flood. The comparison is shown in Figure 5b.

(b) **May 1981**

The discharge of Touws River for the period 28 May 1981 to 9 June 1981 is tabulated in Table II/2 and a hydrograph of the event is shown in Figure 5a.

A comparison of this prototype flood with the predicted floods by Görgens (1979) leads to the following conclusions:

(i) Compared with the flood predicted by the unitgraph method the flood corresponds to approximately a 1-in-10-year flood. The prototype and predicted flood hydrographs are shown in Figure 5a.

(ii) Compared with a family of run hydrographs predicted for the Touws River by Görgens (1980) the prototype flood corresponds to family No 4 for a 1-in-100-year predicted flood and a No 3 for a 1-in-50-year predicted flood. The comparison is shown in Figure 5b.

## 4. MODEL CALIBRATION

The calibration of the model with the estuary mouth closed was described in the previous report (CSIR, 1981).

During the flood of December 1980 when the estuary mouth was opened mechanically, a survey of the mouth was carried out from an hour before the opening until four days after the opening. The information obtained, together with the recorded water-levels of the lakes and the Touws River flood data, made it possible to simulate an open-mouth condition with the numerical model for the Wilderness Lakes system.

Due to the lack of a detailed description of the estuary mouth within the existing numerical model, the prototype scouring rate could not be computed by scouring formulas.

However, a prototype scouring rate of 0,011 m/minute could be determined from the survey data. When this scouring rate was applied as the model scouring rate, the water-level histories of the model compared well with the prototype data in magnitude and time, as illustrated in Figure 6 in which the prototype and model results are plotted.

The more important aspect of this simulation is the maximum levels to which the level of the water will rise during predicted flood events, and this has been computed accurately by the numerical model using the determined prototype scouring rate of 0,011 m/minute.

The model simulation is no longer valid for conditions after the flood as the techniques used no longer describe the dynamics of the estuary mouth because the influences of tide, current and wave action affect the flow regime. The model no longer reproduces accurately the situation obtaining a few days after the flood.

# 5. RESULTS

## 5.1 Results Obtained by Using the Unitgraph Predicted Floods

### 5.1.1 Original lake system

A complete series of tests was done with all combinations of initial water-levels (1,2 m, 1,4 m, 1,6 m, 1,8 m and 2,0 m to MSL), sill elevations (2,0 m, 2,5 m, 3,0 m and 3,5 m to MSL) and predicted floods (1-in-5, 10, 20, 50 and 100-year). The results are tabulated in Table III/1.

Figures 7.1 and 7.2 illustrate time histories of the water-levels in the estuary and lakes with initial water-levels of 1,6 m and 2,0 m for a sill level of 2,0 m, Figures 7.3 to 7.4 with initial water-levels of 1,6 m and 2,0 m and for a sill level of 2,5 m for predicted 1-in-5, 10, 20, 50 and 100-year flood events.

The results of all possible events are given in Figures 8.1 and 8.2.

Figures 8.1a-8.1e illustrate the water-levels at Wilderness, Onder-Langvlei and Bo-Langvlei/Rondevlei resulting from various sill heights and flood events for an initial water-level varying from 1,2 m, 1,4 m, 1,6 m, 1,8 m to 2,0 m.

Figures 8.2a-8.2d illustrate the water-levels at Wilderness, Onder-Langvlei and Bo-Langvlei/Rondevlei resulting from various initial levels and flood events for a sill height rising from 2,0 m, 2,5 m, 3,0 m to 3,5 m.

The December 1980 flood event at Wilderness indicated that a level of 2,6 m to MSL in Touws River estuary and 2,4 m in Onder-Langvlei could be considered to be approximately the limits to which the water level can rise without causing damage to low-lying properties.

Figures 8.1 and 8.2 indicate that a 1-in-100-year flood will cause inundation in the Wilderness estuary irrespective of the initial water-level in the lakes or the height of the sand sill at the river mouth.

Flooding can be prevented for floods less than 1-in-50-year if the sill is maintained at a level of 2,2 m to MSL irrespective of the initial water-level in the lakes as indicated in Figures 8.1 and 8.2.

Although the initial water-level does not affect significantly the peak levels in the estuary during floods it plays a role in the Onder-Langvlei area as illustrated in Figures 8.2a to 8.2d. This phenomenon in Wilderness is the result of the relatively small storage area of the estuary and the slow response of the water-level in Onder-Langvlei due to the length and physical properties of the Serpentine. For example, in Figure 8.2b for a sill height of 2,5 m and a 1-in-50-year flood, the peak level at Onder-Langvlei for an initial level of 1,2 m is 2,03 m and for an initial level of 2,2 m at the same sill height is 2,64 m to MSL.

### 5.1.2 Dredged system

Certain cases from the previous test series (paragraph 5.2.1) were tested with the channel between Onder-Langvlei and Bo-Langvlei dredged to 0,0 m to MSL and the Serpentine opened up to -1,0 m to MSL. The influence of the dredging to the peak levels in the estuary and the lakes for various sill heights (2,0 m, 2,5 m, 3,0 m and 3,5 m to MSL), various initial water-levels (1,2 m, 1,4 m, 1,6 m, 1,8 m, 2,0 m and 2,2 m to MSL) and predicted floods (1-in-5, 10, 20, 50 and 100-year) is illustrated in Figures 9.1a and 9.1b and the data tabulated in Table III/2.

The effect of dredging is not significant when peak levels are compared with the results of the original layout as illustrated in the figures mentioned above. The only body of water which benefits from this dredging is Onder-Langvlei where, for example, the peak water-level for a 1 in 100 year flood is reduced by 0,15 m due to this dredging.

Better circulation between Onder-Langvlei and the upper lakes is also effected by this dredging. This is illustrated in Figure 9.1a where the peak levels at Bo-Langvlei and Rondevlei increased to the same water-level as that of Onder-Langvlei.

As mentioned previously (CSIR, 1981), it must be remembered that while the inflow to the lakes improves because of dredging, the outflow will also increase. This will be of major importance following a flood during which the estuary mouth will scour. The upper lakes, that is, Bo-Langvlei and Rondevlei will then drain down to the level of the interconnection between Onder-Langvlei and Bo-Langvlei. To compensate for this a sluice gate in the Serpentine or between Onder-Langvlei and Bo-Langvlei would be essential to prevent the drying of low-lying areas in the upper lakes.

## 5.2 Results Obtained by Using the Run Hydrograph Method

**These tests were done only for the original layout.**

With reference to the techniques for the estimation and interpretation of the run hydrographs (Görgens, 1980) the unitgraph technique usually gives a higher peak than the run hydrograph with the equivalent volume. The run hydrograph method also provides for two variables, that is, the instantaneous peak rate of flow as well as the associated flood volume, which results in an almost infinite "family" of flood hydrographs for each return period. Run hydrograph No 3 was selected as being representive of the central member of each infinite family of hydrographs. (The family of hydrographs is shown in Figures A.2a-A.2e of CSIR (1981).

The results for a series of tests with various sill heights (2,0 m, 2,5 m, 3,0 m and 3,5 m to MSL), various water-levels (1,2 m, 1,4 m, 1,6 m, 1,8 m, 2,0 m and 2,2 m to MSL) and for a family of 1-in-50 and 1-in-100-year run hydrographs are illustrated in Figures 10.1a-10.2b and tabulated in Table IV.

The peak water-levels obtained by No 3 hydrograph are indicated clearly in the figures and a comparison of the results with those obtained by the unitgraph method is made in the table on the following page.

| Flood | Initial water-level | Sill height | Peak levels expressed as the % increase of the initial water-level | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Wilderness | | | Onder-Langvlei | | | Bo-Lang/Rondevlei | | |
| | | | Unit | Run | * | Unit | Run | * | Unit | Run | * |
| 1:50 | 1,6 | 2,0 | 53 % | 48 % | 5 | 41 % | 41 % | 0 | 13 % | 10 % | 3 |
| | 1,6 | 2,5 | 83 % | 76 % | 7 | 44 % | 43 % | 1 | 13 % | 11 % | 2 |
| | 1,6 | 3,0 | 110 % | 100 % | 10 | 48 % | 47 % | 1 | 13 % | 11 % | 2 |
| 1:100 | 1,6 | 2,0 | 78 % | 58 % | 20 | 56 % | 55 % | 1 | 17 % | 15 % | 2 |
| | 1,6 | 2,5 | 91 % | 84 % | 7 | 57 % | 56 % | 1 | 17 % | 15 % | 2 |
| | 1,6 | 3,0 | 126 % | 109 % | 17 | 59 % | 59 % | 0 | 18 % | 16 % | 2 |
| 1:50 | 2,0 | 2,5 | 40 % | 41 % | -1 | 27 % | 26 % | 1 | 11 % | 9 % | 2 |
| 1:100 | 2,0 | 2,5 | 43 % | 48 % | -5 | 36 % | 35 % | 1 | 15 % | 13 % | 2 |

* Difference in percentage between unit and run hydrograph

From the above comparison it can be seen that the No 3 run hydrograph gives an extremely good correlation with the unitgraphs for the same return period. At Onder-Langvlei the percentage difference water-level increase is not more than 1 per cent and at Bo-Langvlei/Rondevlei it is not more than 2 per cent. At Wilderness the difference is also within about 10 per cent for most of the cases, except for some sensitive conditions such as a long return period (1-in-100-year) and a relatively low sill level (2,0 m) where the difference is some 20 per cent.

## 6. CONCLUSIONS

(1) The numerical model was calibrated successfully for an open river-mouth condition.

(2) Except for a flood with a return period of 1 in 100 years the flooding at the estuary and the lakes can be controlled by maintaining the height of the sand sill at the estuary mouth at between 2,1 m and 2,4 m to MSL.

(3) The initial water-level in the lakes does not have much influence on the peak water-levels which can occur in the Wilderness area but contributes to the maximum levels which may occur in the upper lakes.

(4) Although the dredging of the connecting channels improves the water circulation it does not reduce the peak water-levels significantly, especially in the Wilderness area, mainly because of the length and physical properties of the Serpentine. At Onder-Langvlei the water-levels are lowered by ≈ 0,15 m.

(5) In order to prevent the low-lying areas in the upper lakes from drying due to the improvement of flow between Onder-Langvlei and Bo-Langvlei caused by dredging, installation of a sluice gate is recommended. This sluice can be either in the Serpentine (old drawbridge) or in the connecting channel between Onder-Langvlei and Bo-Langvlei. This gate should be closed only a few days after a flood when the water-level in the upper lakes has dropped to give a level of 1,5 m to MSL at the sluice gate.

(6) The maximum safe water-level at Wilderness is ≈ 2,6 m to MSL and at Onder-Langvlei ≈ 2,4 m to MSL, determined from prototype data of past flood events. With these levels as criteria a conclusive figure was calculated from the results of the various combinations of tests (Figure 11). All combinations of initial water-levels and sill heights below and

left of the flood event lines for Wilderness and Onder-Langvlei are regarded as being safe for the particular flood event.

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CSIR (1981). Wilderness Report No 1. Evaluation of prototype data and the application of a numerical model to the Wilderness Lakes and the Touws River flood plain. CSIR Report C/SEA 8113.

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GÖRGENS, A H M (1980). Run hydrographs for three Wilderness streams. Rhodes University, Hydrological Research Unit, Special Report 1/80.

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## TABLE I/1

1

WILDERNESS CROSS-SECTIONAL AREAS

| LEVEL(M) | SECTIONS | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| -1.0 | 5.00 | 2.00 | 33.00 | 1.00 | 1.00 | 1.00 | 1.00 | 373.00 | 1.00 | 1.00 | 175.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| -.5 | 26.00 | 9.00 | 50.00 | 1.00 | 1.00 | 1.00 | 1.00 | 482.00 | 1.00 | 1.00 | 330.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 0.0 | 53.00 | 19.00 | 70.00 | 13.00 | 1.00 | 10.00 | 1.00 | 599.00 | 1.00 | 1.00 | 514.00 | 1.00 | 1.00 | 13.00 | 10.00 |
| .5 | 85.00 | 33.00 | 94.00 | 32.00 | 5.00 | 15.00 | 1.00 | 722.00 | 1.00 | 1.00 | 730.00 | 1.00 | 1.00 | 31.00 | 20.00 |
| 1.0 | 123.00 | 51.00 | 122.00 | 54.00 | 12.00 | 20.00 | 7.00 | 852.00 | 5.00 | 29.00 | 976.00 | 5.00 | 1.00 | 52.00 | 30.00 |
| 1.5 | 168.00 | 74.00 | 156.00 | 82.00 | 26.00 | 25.00 | 44.00 | 990.00 | 12.00 | 79.00 | 1246.00 | 25.00 | 1.00 | 74.00 | 40.00 |
| 2.0 | 220.00 | 104.00 | 198.00 | 114.00 | 48.00 | 30.00 | 100.00 | 1135.00 | 20.00 | 137.00 | 1538.00 | 58.00 | 1.00 | 97.00 | 50.00 |
| 2.5 | 278.00 | 140.00 | 246.00 | 150.00 | 74.00 | 35.00 | 178.00 | 1286.00 | 48.00 | 201.00 | 1848.00 | 106.00 | 0.00 | 121.00 | 60.00 |
| 3.0 | 344.00 | 182.00 | 304.00 | 202.00 | 108.00 | 40.00 | 266.00 | 1440.00 | 84.00 | 270.00 | 2172.00 | 168.00 | 1.00 | 146.00 | 70.00 |
| 3.5 | 414.00 | 228.00 | 370.00 | 258.00 | 144.00 | 45.00 | 364.00 | 1600.00 | 128.00 | 344.00 | 2510.00 | 240.00 | 1.00 | 172.00 | 80.00 |
| 4.0 | 492.00 | 280.00 | 442.00 | 318.00 | 184.00 | 50.00 | 470.00 | 1760.00 | 178.00 | 424.00 | 2856.00 | 322.00 | 1.00 | 198.00 | 90.00 |
| 4.5 | 574.00 | 334.00 | 518.00 | 382.00 | 226.00 | 55.00 | 580.00 | 1924.00 | 234.00 | 508.00 | 3208.00 | 412.00 | 1.00 | 225.00 | 100.00 |
| 5.0 | 658.00 | 392.00 | 600.00 | 452.00 | 274.00 | 60.00 | 698.00 | 2090.00 | 294.00 | 594.00 | 3568.00 | 508.00 | 0.00 | 252.00 | 110.00 |

<u>TABLE I/2</u>

1

WILDERNESS HYDRAULIC RADII

SECTIONS

| LEVEL(M) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -1.0 | .15 | .23 | 1.10 | .01 | .01 | .01 | .01 | 1.78 | .01 | .01 | .63 | .01 | .01 | .01 | .01 |
| -.5 | .56 | .50 | 1.35 | .01 | .01 | .01 | .01 | 2.15 | .01 | .01 | .96 | .01 | .01 | .01 | .01 |
| 0.0 | .89 | .76 | 1.59 | .38 | .01 | .50 | .01 | 2.50 | .01 | .01 | 1.29 | .01 | .01 | .38 | .50 |
| .5 | 1.21 | 1.04 | 1.80 | .81 | .01 | .75 | .10 | 2.85 | .01 | .01 | 1.59 | .01 | .01 | .80 | 1.00 |
| 1.0 | 1.50 | 1.29 | 1.97 | 1.14 | .52 | 1.00 | .50 | 3.17 | .55 | .50 | 1.88 | .50 | .01 | 1.20 | 1.50 |
| 1.5 | 1.77 | 1.42 | 2.06 | 1.36 | .74 | 1.25 | .50 | 3.51 | .55 | .73 | 2.21 | .50 | .01 | 1.63 | 2.00 |
| 2.0 | 2.00 | 1.57 | 2.20 | 1.55 | .99 | 1.50 | .72 | 3.85 | .55 | 1.12 | 2.55 | .73 | .01 | 2.04 | 2.50 |
| 2.5 | 2.25 | 1.79 | 2.33 | 1.77 | 1.24 | 1.75 | 1.07 | 4.20 | .73 | 1.50 | 2.90 | .93 | .01 | 2.47 | 3.00 |
| 3.0 | 2.53 | 2.02 | 2.46 | 1.99 | 1.53 | 2.00 | 1.41 | 4.59 | 1.02 | 1.90 | 3.27 | 1.26 | .01 | 2.84 | 3.50 |
| 3.5 | 2.77 | 2.29 | 2.68 | 2.22 | 1.89 | 2.25 | 1.78 | 4.97 | 1.36 | 2.21 | 3.67 | 1.56 | .01 | 3.30 | 4.00 |
| 4.0 | 3.08 | 2.45 | 2.95 | 2.52 | 2.18 | 2.50 | 2.15 | 5.40 | 1.55 | 2.59 | 4.08 | 1.87 | .01 | 3.74 | 4.50 |
| 4.5 | 3.45 | 2.99 | 3.28 | 2.86 | 2.52 | 2.75 | 2.55 | 5.82 | 2.02 | 2.99 | 4.51 | 2.19 | .01 | 4.16 | 5.00 |
| 5.0 | 3.83 | 3.38 | 3.70 | 3.23 | 2.85 | 3.00 | 2.95 | 6.33 | 2.95 | 3.38 | 4.93 | 2.54 | .01 | 4.58 | 5.50 |

1

# TABLE I/3

## WILDERNESS STORAGE AREAS

SECTIONS

| LEVEL (M) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| -1.0 | 5000. | 5000. | 20000. | 5000. | 5000. | 5000. | 5000. | 796000. | 269000. | 140000. | 920000. | 1100000. | 1050000. | 5000. | 80000. |
| -.5 | 40000. | 15000. | 25000. | 6500. | 10000. | 5000. | 5000. | 835000. | 290000. | 140000. | 920000. | 1100000. | 1050000. | 10000. | 80000. |
| 0.0 | 80000. | 25000. | 30000. | 8000. | 15000. | 70000. | 10000. | 875000. | 305000. | 140000. | 920000. | 1100000. | 1050000. | 18000. | 80000. |
| .5 | 120000. | 35000. | 35000. | 9000. | 35000. | 70000. | 25000. | 945000. | 344000. | 140000. | 920000. | 1100000. | 1050000. | 50000. | 80000. |
| 1.0 | 176000. | 75000. | 45000. | 10000. | 70000. | 70000. | 100000. | 1200000. | 430000. | 140000. | 920000. | 1100000. | 1050000. | 70000. | 80000. |
| 1.5 | 218000. | 120000. | 90000. | 20000. | 110000. | 300000. | 450000. | 1450000. | 520000. | 300000. | 1100000. | 1480000. | 1350000. | 110000. | 80000. |
| 2.0 | 247000. | 155000. | 190000. | 60000. | 140000. | 360000. | 570000. | 1600000. | 640000. | 330000. | 1210000. | 1590000. | 1550000. | 140000. | 80000. |
| 2.5 | 271000. | 160000. | 240000. | 100000. | 180000. | 421000. | 792000. | 1700000. | 890000. | 379000. | 1310000. | 1660000. | 2040000. | 180000. | 80000. |
| 3.0 | 304000. | 160000. | 280000. | 161000. | 210000. | 613000. | 870000. | 1750000. | 920000. | 406000. | 1330000. | 1850000. | 2240000. | 210000. | 80000. |
| 3.5 | 304000. | 160000. | 280000. | 161000. | 210000. | 613000. | 870000. | 1750000. | 920000. | 406000. | 1330000. | 1850000. | 2240000. | 210000. | 80000. |
| 4.0 | 304000. | 160000. | 280000. | 161000. | 210000. | 613000. | 870000. | 1750000. | 920000. | 406000. | 1330000. | 1850000. | 2240000. | 210000. | 80000. |
| 4.5 | 304000. | 160000. | 280000. | 161000. | 210000. | 613000. | 870000. | 1750000. | 920000. | 406000. | 1330000. | 1850000. | 2240000. | 210000. | 80000. |
| 5.0 | 304000. | 160000. | 280000. | 161000. | 210000. | 613000. | 870000. | 1750000. | 920000. | 406000. | 1330000. | 1850000. | 2240000. | 210000. | 80000. |

TABLE II/1: PROTOTYPE DATA, 1980-11-27 TO 1980-12-23

| Date | Time | Water-levels (m) | | | | Touws flow ($m^3/s$) |
|---|---|---|---|---|---|---|
| | | Wilder-ness | Onder-Langvlei | Bo-Langvlei | Ronde-vlei | |
| 80-11-27 | 00h00 | 1,58 | 1,63 | 1,60 | 1,61 | 0,09 |
| | 12h00 | 1,60 | 1,63 | 1,60 | 1,61 | 0,09 |
| | 18h00 | 1,60 | 1,63 | 1,60 | 1,61 | 0,14 |
| 18-11-28 | 00h00 | 1,59 | 1,63 | 1,60 | 1,60 | 0,37 |
| | 06h00 | 1,59 | 1,63 | 1,60 | 1,60 | 0,80 |
| | 12h00 | 1,60 | 1,63 | 1,60 | 1,60 | 0,80 |
| | 18h00 | 1,61 | 1,63 | 1,60 | 1,60 | 0,67 |
| | 22h00 | 1,63 | 1,64 | 1,61 | 1,61 | 0,80 |
| 80-11-29 | 00h00 | 1,64 | 1,65 | 1,61 | 1,61 | 6,91 |
| | 03h00 | 1,64 | 1,66 | 1,62 | 1,61 | 13,40 |
| | 06h00 | 1,77 | 1,66 | 1,62 | 1,62 | 13,40 |
| | 09h00 | 1,91 | 1,68 | 1,62 | 1,62 | 11,05 |
| | 12h00 | 2,00 | 1,72 | 1,62 | 1,62 | 7,55 |
| | 18h00 | 2,06 | 1,76 | 1,63 | 1,62 | 4,54 |
| 80-11-30 | 00h00 | 2,03 | 1,82 | 1,63 | 1,62 | 3,07 |
| | 06h00 | 1,99 | 1,86 | 1,63 | 1,62 | 2,40 |
| | 12h00 | 1,96 | 1,88 | 1,63 | 1,63 | 1,79 |
| | 18h00 | 1,94 | 1,90 | 1,63 | 1,63 | 1,42 |
| 80-12-01 | 00h00 | 1,93 | 1,91 | 1,64 | 1,64 | 1,25 |
| | 06h00 | 1,92 | 1,92 | 1,64 | 1,64 | 1,09 |
| | 12h00 | 1,91 | 1,92 | 1,65 | 1,65 | 1,09 |
| | 18h00 | 1,91 | 1,93 | 1,66 | 1,65 | 1,09 |
| 80-12-02 | 00h00 | 1,90 | 1,93 | 1,67 | 1,65 | 1,09 |
| | 03h00 | 1,91 | 1,94 | 1,68 | 1,67 | 2,62 |
| | 06h00 | 1,92 | 1,95 | 1,69 | 1,68 | 74,32 |
| | 08h00 | 2,03 | 1,96 | 1,69 | 1,68 | 82,40 |
| | 12h00 | 2,63 | 2,02 | 1,70 | 1,71 | 49,84 |
| | 15h00 | 1,97 | | | | |
| | 18h00 | 1,49 | 2,11 | 1,71 | 1,72 | 14,19 |
| 80-12-03 | 00h00 | | 2,06 | 1,72 | 1,73 | 6,59 |
| | 06h00 | | 1,98 | 1,73 | 1,73 | 4,54 |
| | 12h00 | | 1,92 | 1,74 | 1,74 | 3,54 |
| | 18h00 | | 1,81 | 1,74 | 1,74 | 2,84 |
| 80-12-04 | 00h00 | | 1,81 | 1,74 | 1,74 | 2,19 |
| | 06h00 | | 1,76 | 1,75 | 1,75 | 1,79 |
| | 12h00 | | 1,74 | 1,74 | 1,75 | 1,60 |
| | 18h00 | | 1,70 | 1,74 | 1,75 | 1,42 |
| 80-12-05 | 00h00 | | 1,66 | 1,74 | 1,75 | 1,25 |
| | 06h00 | | 1,63 | 1,74 | 1,75 | 1,09 |
| | 12h00 | | 1,60 | 1,73 | 1,75 | 0,94 |
| | 18h00 | | 1,57 | 1,73 | 1,75 | 0,94 |

TABLE II/1 (continued)

| Date | Time | Water-levels (m) | | | | Touws flow ($m^3/s$) |
|---|---|---|---|---|---|---|
| | | Wilder-ness | Onder-Langvlei | Bo-Langvlei | Ronde-vlei | |
| 80-12-06 | 00h00 | | 1,55 | 1,73 | 1,75 | 0,80 |
| | 06h00 | | 1,53 | 1,72 | 1,75 | 0,67 |
| | 12h00 | | 1,51 | 1,72 | 1,75 | 0,67 |
| | 18h00 | 1,13 | 1,49 | 1,72 | 1,74 | 0,67 |
| 80-12-07 | 00h00 | | 1,47 | 1,71 | 1,74 | 0,55 |
| | 06h00 | 1,19 | 1,46 | 1,71 | 1,74 | 0,55 |
| | 12h00 | | 1,45 | 1,70 | 1,74 | 0,55 |
| | 18h00 | 1,22 | 1,43 | 1,70 | 1,73 | 0,55 |
| 80-12-08 | 00h00 | | 1,42 | 1,70 | 1,73 | 0,55 |
| | 06h00 | | 1,41 | 1,70 | 1,73 | 0,55 |
| | 12h00 | | 1,40 | 1,69 | 1,72 | 0,55 |
| | 18h00 | 1,20 | 1,38 | 1,69 | 1,72 | 0,55 |
| 80-12-09 | 00h00 | | 1,38 | 1,68 | 1,71 | 0,44 |
| | 06h00 | | 1,37 | 1,68 | 1,71 | 0,44 |
| | 12h00 | | 1,36 | 1,68 | 1,68 | 0,37 |
| | 18h00 | 1,11 | 1,32 | 1,67 | 1,66 | 0,37 |
| 80-12-10 | 00h00 | 1,01 | 1,31 | 1,66 | 1,66 | 0,37 |
| | 06h00 | 1,02 | 1,30 | 1,66 | 1,65 | 0,33 |
| | 12h00 | 0,98 | 1,30 | 1,66 | 1,65 | 0,33 |
| | 18h00 | 0,97 | 1,29 | 1,66 | 1,65 | 0,30 |
| 80-12-11 | 00h00 | 0,99 | 1,28 | 1,65 | 1,65 | 0,30 |
| | 06h00 | 0,99 | 1,28 | 1,65 | 1,64 | 0,30 |
| | 12h00 | 0,99 | 1,27 | 1,65 | 1,64 | 0,27 |
| | 18h00 | 0,95 | 1,27 | 1,64 | 1,64 | 0,27 |
| 80-12-12 | 00h00 | 0,93 | 1,26 | 1,64 | 1,63 | 0,27 |
| | 06h00 | 0,97 | 1,26 | 1,64 | 1,63 | 0,27 |
| | 12h00 | 1,00 | 1,26 | 1,64 | 1,63 | 0,27 |
| | 18h00 | 1,04 | 1,25 | 1,63 | 1,62 | 0,24 |
| 80-12-13 | 00h00 | 1,05 | 1,25 | 1,63 | 1,62 | 0,24 |
| | 06h00 | 1,09 | 1,25 | 1,63 | 1,62 | 0,24 |
| | 12h00 | 1,12 | 1,25 | 1,62 | 1,62 | 0,24 |
| | 18h00 | 1,14 | 1,25 | 1,62 | 1,61 | 0,24 |
| 80-12-14 | 00h00 | 1,14 | 1,25 | 1,62 | 1,61 | 0,94 |
| | 06h00 | 1,17 | 1,25 | 1,62 | 1,61 | 1,25 |
| | 12h00 | 1,21 | 1,26 | 1,62 | 1,61 | 1,09 |
| | 18h00 | 1,25 | 1,26 | 1,62 | 1,61 | 0,94 |
| 80-12-15 | 00h00 | 1,27 | 1,26 | 1,61 | 1,61 | 0,80 |
| | 06h00 | 1,29 | 1,27 | 1,61 | 1,61 | 0,67 |
| | 12h00 | 1,30 | 1,28 | 1,61 | 1,61 | 0,67 |
| | 18h00 | 1,31 | 1,28 | 1,61 | 1,61 | 0,55 |

TABLE II/1 (continued)

| Date | Time | Water-levels (m) | | | | Touws flow ($m^3/s$) |
|---|---|---|---|---|---|---|
| | | Wilder-ness | Onder-Langvlei | Bo-Langvlei | Ronde-vlei | |
| 80-12-16 | 00h00 | 1,31 | 1,29 | 1,60 | 1,61 | 0,44 |
| | 06h00 | 1,32 | 1,30 | 1,60 | 1,61 | 0,44 |
| | 12h00 | 1,32 | 1,32 | 1,60 | 1,61 | 0,44 |
| | 18h00 | 1,33 | 1,33 | 1,60 | 1,61 | 0,67 |
| 80-12-17 | 00h00 | 1,33 | 1,34 | 1,60 | 1,61 | 0,67 |
| | 06h00 | 1,36 | 1,37 | 1,60 | 1,61 | 0,80 |
| | 12h00 | 1,38 | 1,38 | 1,60 | 1,61 | 1,09 |
| | 18h00 | 1,41 | 1,38 | 1,60 | 1,61 | 1,25 |
| 80-12-18 | 00h00 | 1,43 | 1,39 | 1,60 | 1,61 | 1,09 |
| | 06h00 | 1,44 | 1,40 | 1,60 | 1,61 | 0,94 |
| | 12h00 | 1,45 | 1,41 | 1,60 | 1,61 | 0,80 |
| | 18h00 | 1,45 | 1,42 | 1,59 | 1,61 | 0,80 |
| 80-12-19 | 00h00 | 1,46 | 1,43 | 1,59 | 1,61 | 0,67 |
| | 06h00 | 1,46 | 1,44 | 1,59 | 1,60 | 0,55 |
| | 12h00 | 1,46 | 1,45 | 1,59 | 1,60 | 0,55 |
| | 18h00 | 1,47 | 1,46 | 1,59 | 1,60 | 0,44 |
| 80-12-20 | 00h00 | 1,47 | 1,46 | 1,59 | 1,60 | 0,37 |
| | 06h00 | 1,47 | 1,47 | 1,58 | 1,59 | 0,33 |
| | 12h00 | 1,45 | 1,48 | 1,58 | 1,59 | 0,30 |
| | 18h00 | 1,45 | 1,50 | 1,58 | 1,59 | 0,30 |
| 80-12-21 | 00h00 | 1,45 | 1,50 | 1,58 | 1,59 | 0,27 |
| | 06h00 | 1,46 | 1,50 | 1,58 | 1,59 | 0,27 |
| | 18h00 | 1,46 | 1,50 | 1,58 | 1,59 | 0,24 |
| 80-12-22 | 00h00 | 1,47 | 1,50 | 1,58 | 1,59 | 0,24 |
| | 12h00 | 1,47 | 1,50 | 1,58 | 1,58 | 0,24 |
| | 18h00 | 1,47 | 1,50 | 1,57 | 1,58 | 0,21 |
| 80-12-23 | 12h00 | 1,47 | 1,50 | 1,57 | 1,58 | 0,21 |

## TABLE II/2: PROTOTYPE DATA, 1981-05-28 TO 1981-06-09

| Date | Time | Water-levels (m) | | | | Touws flow ($m^3/s$) |
|---|---|---|---|---|---|---|
| | | Wilderness | Onder-Langvlei | Bo-Langvlei | Rondevlei | |
| 81-05-28 | 00h00 | | | 1,61 | 1,61 | 0,36 |
| | 06h00 | | | 1,61 | 1,61 | 0,36 |
| | 12h00 | 1,14 | | 1,61 | 1,61 | 0,36 |
| | 18h00 | 1,15 | | 1,61 | 1,61 | 0,42 |
| 81-05-29 | 00h00 | 1,15 | | 1,61 | 1,61 | 0,66 |
| | 06h00 | 1,15 | | 1,63 | 1,63 | 39,01 |
| | 09h00 | | | | | 135,49 |
| | 12h00 | 2,26 | | 1,92 | 1,75 | 116,93 |
| | 15h00 | | | | | 101,61 |
| | 18h00 | 1,63 | | 2,19 | 1,89 | 87,22 |
| | 21h00 | | | | | 101,61 |
| 81-05-30 | 00h00 | 1,55 | | 2,50 | 2,03 | 64,10 |
| | 06h00 | 1,17 | | 2,61 | 2,19 | 29,84 |
| | 12h00 | 1,16 | | 2,63 | 2,35 | 16,82 |
| | 18h00 | | | 2,60 | 2,47 | 17,49 |
| 81-05-31 | 00h00 | | | 2,58 | 2,53 | 12,51 |
| | 06h00 | | | 2,55 | 2,54 | 9,43 |
| | 12h00 | | | 2,53 | 2,54 | 7,42 |
| | 18h00 | | | 2,51 | 2,53 | 6,19 |
| 81-06-01 | 00h00 | | | | | |
| | 06h00 | | | 2,47 | 2,48 | 4,77 |
| | 12h00 | | | 2,45 | 2,47 | 4,24 |
| | 18h00 | | | 2,43 | 2,45 | 3,73 |
| 81-06-02 | 00h00 | | | 2,41 | 2,43 | 3,25 |
| | 06h00 | | | 2,39 | 2,41 | 3,02 |
| | 12h00 | | | 2,38 | 2,39 | 2,59 |
| | 18h00 | | | 2,36 | 2,37 | 2,16 |
| 81-06-03 | 00h00 | | | 2,34 | 2,35 | 1,96 |
| | 06h00 | | | 2,32 | 2,33 | 1,77 |
| | 12h00 | | | 2,30 | 2,32 | 1,77 |
| | 18h00 | | | 2,28 | 2,30 | 1,59 |
| 81-06-04 | 00h00 | | | 2,27 | 2,29 | 1,59 |
| | 06h00 | | | 2,25 | 2,27 | 1,59 |
| | 12h00 | | | 2,24 | 2,26 | 1,41 |
| | 18h00 | | | 2,23 | 2,25 | 1,41 |
| 81-06-05 | 00h00 | | | 2,22 | 2,23 | 1,41 |
| | 06h00 | | | 2,20 | 2,23 | 1,59 |
| | 12h00 | | | 2,19 | 2,22 | 1,59 |
| | 18h00 | | | 2,18 | 2,20 | 1,41 |

TABLE II/2 (continued)

| Date | Time | Water-levels (m) | | | | Touws flow ($m^3/s$) |
|---|---|---|---|---|---|---|
| | | Wilder-ness | Onder-Langvlei | Bo-Langvlei | Ronde-vlei | |
| 81-06-06 | 00h00 | | | 2,17 | 2,18 | 1,41 |
| | 06h00 | | | 2,15 | 2,17 | 1,24 |
| | 12h00 | | | 2,14 | 2,17 | 1,24 |
| | 18h00 | | | 2,14 | 2,17 | 1,96 |
| 81-06-07 | 00h00 | | | 2,15 | 2,17 | 5,04 |
| | 06h00 | | | 2,15 | 2,17 | 9,08 |
| | 12h00 | | | 2,14 | 2,16 | 6,19 |
| | 18h00 | | | 2,14 | 2,15 | 4,50 |
| 81-06-08 | 00h00 | | | 2,13 | 2,14 | 3,49 |
| | 06h00 | | | 2,12 | 2,13 | 3,02 |
| | 12h00 | | | 2,11 | 2,12 | 2,57 |
| | 18h00 | | | 2,10 | 2,11 | 2,36 |
| 81-06-09 | 00h00 | | | 2,09 | 2,10 | 2,16 |
| | 06h00 | | | 2,07 | 2,09 | 1,96 |
| | 12h00 | | | 2,07 | 2,08 | 1,77 |

TABLE III/1: PEAK WATER-LEVELS IN m TO MSL FOR VARIOUS SILL HEIGHTS AND INITIAL WATER-LEVELS AND PREDICTED 1 IN 5, 10, 20, 50 AND 100 YEAR FLOOD EVENTS (UNITGRAPH METHOD)

| Flood (yr) | Sill elevation (m) | Initial water-level (m) | Peak water-levels (m) | | |
|---|---|---|---|---|---|
| | | | Wilderness | Onder-Langvlei | Bo-Lang/ Rondevlei |
| 1 in 5 | 2,0 | 1,2 | 2,30 | 1,60 | 1,32 |
| " | | 1,4 | 2,26 | 1,72 | 1,51 |
| " | | 1,6 | 2,21 | 1,94 | 1,70 |
| " | | 1,8 | 2,10 | 2,09 | 1,89 |
| " | | 2,0 | 2,05 | 2,15 | 2,08 |
| " | 2,5 | 1,2 | 2,72 | 1,64 | 1,32 |
| " | | 1,4 | 2,73 | 1,81 | 1,51 |
| " | | 1,6 | 2,74 | 1,99 | 1,70 |
| " | | 1,8 | 2,74 | 2,16 | 1,90 |
| " | | 2,0 | 2,72 | 2,30 | 2,10 |
| " | | 2,2 | 2,66 | 2,44 | 2,30 |
| " | 3,0 | 1,2 | 3,02 | 1,82 | 1,33 |
| " | | 1,4 | 3,03 | 1,96 | 1,52 |
| " | | 1,6 | 3,06 | 2,11 | 1,71 |
| " | | 1,8 | 3,08 | 2,26 | 1,91 |
| " | | 2,0 | 3,12 | 2,40 | 2,12 |
| " | | 2,2 | 3,15 | 2,54 | 2,32 |
| " | 3,5 | 1,2 | | | |
| " | | 1,4 | 3,08 * | 2,55 | 2,01 |
| " | | 1,6 | 3,15 * | 2,64 | |
| " | | 1,8 | 3,22 * | 2,73 | 2,37 |
| " | | 2,0 | 3,30 * | 2,82 | |
| " | | 2,2 | 3,40 * | 2,91 | |
| 1 in 10 | 2,0 | 1,2 | 2,36 | 1,77 | 1,35 |
| " | | 1,4 | 2,30 | 1,92 | 1,54 |
| " | | 1,6 | 2,27 | 2,08 | 1,73 |
| " | | 1,8 | 2,26 | 2,21 | 1,92 |
| " | | 2,0 | 2,25 | 2,27 | 2,11 |
| " | 2,5 | 1,2 | 2,86 | 1,80 | 1,36 |
| " | | 1,4 | 2,86 | 1,96 | 1,54 |
| " | | 1,6 | 2,85 | 2,12 | 1,73 |
| " | | 1,8 | 2,83 | 2,27 | 1,93 |
| " | | 2,0 | 2,77 | 2,40 | 2,14 |
| " | | 2,2 | 2,68 | 2,52 | 2,33 |
| " | 3,0 | 1,2 | 3,17 | 1,87 | 1,36 |
| " | | 1,4 | 3,19 | 2,03 | 1,54 |
| " | | 1,6 | 3,21 | 2,19 | 1,74 |
| " | | 1,8 | 3,24 | 2,34 | 1,94 |
| " | | 2,0 | 3,26 | 2,48 | 2,15 |
| " | | 2,2 | 3,27 | 2,61 | 2,36 |
| " | 3,5 | 1,2 | | | |
| " | | 1,4 | 3,50 * | 2,84 | 2,23 |
| " | | 1,6 | 3,53 | 2,44 | 1,76 |
| " | | 1,8 | 3,55 | 2,53 | 1,98 |
| " | | 2,0 | 3,58 | 2,63 | 2,19 |
| " | | 2,2 | 3,61 | 2,74 | 2,39 |

TABLE III/1 (continued)

| Flood (yr) | Sill elevation (m) | Initial water-level (m) | Peak water-levels (m) | | |
|---|---|---|---|---|---|
| | | | Wilderness | Onder-Langvlei | Bo-Lang/ Rondevlei |
| 1 in 20 | 2,0 | 1,2 | 2,39 | 1,87 | 1,39 |
| " | | 1,4 | 2,38 | 2,02 | 1,57 |
| " | | 1,6 | 2,38 | 2,16 | 1,76 |
| " | | 1,8 | 2,38 | 2,29 | 1,96 |
| " | | 2,0 | 2,37 | 2,35 | 2,14 |
| " | 2,5 | 1,2 | 2,93 | 1,90 | 1,39 |
| " | | 1,4 | 2,91 | 2,05 | 1,57 |
| " | | 1,6 | 2,89 | 2,20 | 1,76 |
| " | | 1,8 | 2,85 | 2,34 | 1,96 |
| " | | 2,0 | 2,78 | 2,46 | 2,17 |
| " | | 2,2 | 2,68 | 2,57 | 2,36 |
| " | 3,0 | 1,2 | 3,28 | 1,96 | 1,39 |
| " | | 1,4 | 3,29 | 2,11 | 1,57 |
| " | | 1,6 | 3,31 | 2,27 | 1,76 |
| " | | 1,8 | 3,33 | 2,41 | 1,97 |
| " | | 2,0 | 3,34 | 2,53 | 2,19 |
| " | | 2,2 | 3,34 | 2,67 | 2,39 |
| " | 3,5 | 1,2 | 3,58 | 2,14 | 1,40 |
| " | | 1,4 | 3,60 | 2,27 | 1,58 |
| " | | 1,6 | 3,62 | 2,40 | 1,77 |
| " | | 1,8 | 3,64 | 2,53 | 2,00 |
| " | | 2,0 | 3,68 | 2,65 | 2,21 |
| " | | 2,2 | 3,71 | 2,77 | 2,42 |
| 1 in 50 | 2,0 | 1,2 | 2,45 | 2,00 | 1,44 |
| " | | 1,4 | 2,45 | 2,13 | 1,61 |
| " | | 1,6 | 2,45 | 2,26 | 1,80 |
| " | | 1,8 | 2,45 | 2,37 | 2,01 |
| " | | 2,0 | 2,44 | 2,43 | 2,19 |
| " | 2,5 | 1,2 | 2,96 | 2,03 | 1,44 |
| " | | 1,4 | 2,95 | 2,16 | 1,61 |
| " | | 1,6 | 2,92 | 2,30 | 1,80 |
| " | | 1,8 | 2,88 | 2,42 | 2,01 |
| " | | 2,0 | 2,80 | 2,53 | 2,22 |
| " | | 2,2 | 2,67 | 2,64 | 2,41 |
| " | 3,0 | 1,2 | 3,33 | 2,08 | 1,44 |
| " | | 1,4 | 3,34 | 2,22 | 1,61 |
| " | | 1,6 | 3,36 | 2,36 | 1,81 |
| " | | 1,8 | 3,37 | 2,49 | 2,03 |
| " | | 2,0 | 3,37 | 2,61 | 2,23 |
| " | | 2,2 | 3,37 | 2,73 | 2,43 |
| " | 3,5 | 1,2 | 3,62 | 2,22 | 1,44 |
| " | | 1,4 | 3,64 | 2,35 | 1,62 |
| " | | 1,6 | 3,67 | 2,48 | 1,82 |
| " | | 1,8 | 3,70 | 2,59 | 2,05 |
| " | | 2,0 | 3,73 | 2,71 | 2,26 |
| " | | 2,2 | 3,76 | 2,83 | 2,46 |

TABLE III/1 (continued)

| Flood (yr) | Sill elevation (m) | Initial water-level (m) | Peak water-levels (m) | | |
|---|---|---|---|---|---|
| | | | Wilderness | Onder-Langvlei | Bo-Lang/ Rondevlei |
| 1 in 100 | 2,0 | 1,2 | 2,83 | 2,27 | 1,49 |
| " | | 1,4 | 2,84 | 2,39 | 1,65 |
| " | | 1,6 | 2,85 | 2,49 | 1,87 |
| " | | 1,8 | 2,86 | 2,58 | 2,09 |
| " | | 2,0 | 2,86 | 2,64 | 2,28 |
| " | 2,5 | 1,2 | 3,13 | 2,29 | 1,49 |
| " | | 1,4 | 3,10 | 2,40 | 1,65 |
| " | | 1,6 | 3,05 | 2,51 | 1,87 |
| " | | 1,8 | 2,98 | 2,61 | 2,09 |
| " | | 2,0 | 2,86 | 2,71 | 2,30 |
| " | | 2,2 | 2,83 | 2,81 | 2,49 |
| " | 3,0 | 1,2 | 3,62 | 2,33 | 1,49 |
| " | | 1,4 | 3,62 | 2,44 | 1,65 |
| " | | 1,6 | 3,62 | 2,55 | 1,88 |
| " | | 1,8 | 3,61 | 2,66 | 2,10 |
| " | | 2,0 | 3,58 | 2,77 | 2,31 |
| " | | 2,2 | 3,53 | 2,88 | 2,51 |
| " | 3,5 | 1,2 | 3,98 | 2,40 | 1,49 |
| " | | 1,4 | 4,00 | 2,52 | 1,66 |
| " | | 1,6 | 4,02 | 2,63 | 1,89 |
| " | | 1,8 | 4,04 | 2,74 | 2,12 |
| " | | 2,0 | 4,07 | 2,85 | 2,33 |
| " | | 2,2 | 4,08 | 2,96 | 2,54 |

* Peak water-level less than level of sill (no breakthrough)

TABLE III/2: PEAK WATER-LEVELS IN m TO MSL FOR VARIOUS SILL HEIGHTS AND INITIAL WATER-LEVELS FOR THE ORIGINAL AND DREDGED SYSTEM (UNITGRAPH METHOD)

| Sill elevation (m) | Initial water-level (m) | Peak water-levels (m) | | | | | | Flood (yr) |
|---|---|---|---|---|---|---|---|---|
| | | Wilderness | | Onder-Langvlei | | Bo-Lang/Rondevlei | | |
| | | Orig. | Dred. | Orig. | Dred. | Orig. | Dred. | |
| 2,0 | 1,2 | 2,30 | 2,26 | 1,60 | 1,62 | 1,32 | 1,45 | 1 in 5 |
| | 1,4 | 2,26 | 2,24 | 1,77 | 1,76 | 1,51 | 1,62 | " |
| | 1,6 | 2,21 | 2,19 | 1,94 | 1,90 | 1,70 | 1,78 | " |
| | 1,8 | 2,10 | 2,09 | 2,09 | 2,04 | 1,89 | 1,96 | " |
| | 2,0 | 2,05 | 2,02 | 2,15 | 2,12 | 2,08 | 2,10 | " |
| 2,0 | 1,2 | 2,36 | 2,33 | 1,77 | 1,75 | 1,35 | 1,53 | 1 in 10 |
| | 1,4 | 2,30 | 2,29 | 1,92 | 1,87 | 1,54 | 1,69 | " |
| | 1,6 | 2,27 | 2,25 | 2,08 | 2,00 | 1,73 | 1,85 | " |
| | 1,8 | 2,26 | 2,23 | 2,21 | 2,13 | 1,92 | 2,02 | " |
| | 2,0 | 2,25 | 2,21 | 2,27 | 2,21 | 2,11 | 2,16 | " |
| 2,0 | 1,2 | 2,83 | - | 2,27 | - | 1,49 | - | 1 in 100 |
| | 1,4 | 2,84 | 2,84 | 2,39 | 2,24 | 1,65 | 1,92 | " |
| | 1,6 | 2,85 | 2,84 | 2,49 | 2,34 | 1,87 | 2,07 | " |
| | 1,8 | 2,86 | 2,84 | 2,58 | 2,44 | 2,09 | 2,24 | " |
| | 2,0 | 2,86 | 2,84 | 2,64 | 2,52 | 2,28 | 2,38 | " |
| 2,5 | 1,2 | 2,72 | 2,65 | 1,64 | 1,67 | 1,32 | 1,47 | 1 in 5 |
| | 1,4 | 2,73 | 2,67 | 1,81 | 1,81 | 1,51 | 1,63 | " |
| | 1,6 | 2,74 | 2,69 | 1,99 | 1,95 | 1,70 | 1,80 | " |
| | 1,8 | 2,74 | 2,71 | 2,16 | 2,11 | 1,90 | 1,98 | " |
| | 2,0 | 2,72 | 2,71 | 2,30 | 2,25 | 2,10 | 2,16 | " |
| | 2,2 | 2,66 | 2,66 | 2,44 | 2,40 | 2,30 | 2,34 | " |
| 2,5 | 1,2 | 2,86 | 2,80 | 1,80 | 1,78 | 1,36 | 1,54 | 1 in 10 |
| | 1,4 | 2,86 | 2,81 | 1,96 | 1,91 | 1,54 | 1,70 | " |
| | 1,6 | 2,85 | 2,81 | 2,12 | 2,05 | 1,73 | 1,86 | " |
| | 1,8 | 2,83 | 2,81 | 2,27 | 2,19 | 1,93 | 2,04 | " |
| | 2,0 | 2,77 | 2,76 | 2,40 | 2,33 | 2,14 | 2,22 | " |
| | 2,2 | 2,68 | 2,67 | 2,52 | 2,46 | 2,33 | 2,39 | " |
| 2,5 | 1,2 | 2,93 | 2,88 | 1,90 | 1,86 | 1,39 | 1,60 | 1 in 20 |
| | 1,4 | 2,91 | 2,88 | 2,05 | 1,98 | 1,57 | 1,74 | " |
| | 1,6 | 2,89 | 2,87 | 2,20 | 2,12 | 1,76 | 1,90 | " |
| | 1,8 | 2,85 | 2,84 | 2,34 | 2,25 | 1,96 | 2,08 | " |
| | 2,0 | 2,78 | 2,77 | 2,46 | 2,38 | 2,17 | 2,26 | " |
| | 2,2 | 2,68 | 2,66 | 2,57 | 2,50 | 2,36 | 2,43 | " |
| 2,5 | 1,2 | 2,96 | 2,92 | 2,03 | 1,95 | 1,44 | 1,68 | 1 in 50 |
| | 1,4 | 2,95 | 2,92 | 2,16 | 2,07 | 1,61 | 1,81 | " |
| | 1,6 | 2,92 | 2,90 | 2,30 | 2,19 | 1,80 | 1,96 | " |
| | 1,8 | 2,88 | 2,86 | 2,42 | 2,32 | 2,01 | 2,13 | " |
| | 2,0 | 2,80 | 2,78 | 2,53 | 2,44 | 2,22 | 2,31 | " |
| | 2,2 | 2,67 | 2,66 | 2,64 | 2,56 | 2,41 | 2,47 | " |

TABLE III/2 (continued)

| Sill elevation (m) | Initial water-level (m) | Peak water-levels (m) | | | | | | Flood (yr) |
|---|---|---|---|---|---|---|---|---|
| | | Wilderness | | Onder-Langvlei | | Bo-Lang/ Rondevlei | | |
| | | Orig. | Dred. | Orig. | Dred. | Orig. | Dred. | |
| 2,5 | 1,2 | 3,13 | - | 2,29 | - | 1,49 | - | 1 in 100 |
| | 1,4 | 3,10 | 3,10 | 2,40 | 2,26 | 1,65 | 1,92 | " |
| | 1,6 | 3,05 | 3,05 | 2,51 | 2,37 | 1,87 | 2,08 | " |
| | 1,8 | 2,98 | 2,96 | 2,61 | 2,47 | 2,09 | 2,25 | " |
| | 2,0 | 2,86 | 2,85 | 2,71 | 2,58 | 2,30 | 2,41 | " |
| | 2,2 | 2,83 | 2,82 | 2,81 | 2,70 | 2,49 | 2,58 | " |
| 2,0 | 1,6 | 2,21 | 2,19 | 1,94 | 1,90 | 1,70 | 1,78 | 1 in 5 |
| | | 2,27 | 2,25 | 2,08 | 2,00 | 1,73 | 1,85 | 1 in 10 |
| | | 2,38 | 2,36 | 2,16 | 2,07 | 1,76 | 1,89 | 1 in 20 |
| | | 2,45 | 2,42 | 2,26 | 2,16 | 1,80 | 1,95 | 1 in 50 |
| | | 2,85 | 2,84 | 2,49 | 2,34 | 1,87 | 2,07 | 1 in 100 |
| 2,5 | 1,6 | 2,74 | 2,69 | 1,99 | 1,95 | 1,70 | 1,80 | 1 in 5 |
| | | 2,85 | 2,81 | 2,12 | 2,05 | 1,73 | 1,86 | 1 in 10 |
| | | 2,89 | 2,87 | 2,20 | 2,12 | 1,76 | 1,90 | 1 in 20 |
| | | 2,92 | 2,90 | 2,30 | 2,19 | 1,80 | 1,96 | 1 in 50 |
| | | 3,05 | 3,05 | 2,51 | 2,37 | 1,87 | 2,08 | 1 in 100 |
| 3,0 | 1,6 | 2,21 | 2,19 | 1,94 | 1,90 | 1,70 | 1,78 | 1 in 5 |
| | | 3,21 | 3,17 | 2,19 | 2,13 | 1,74 | 1,88 | 1 in 10 |
| | | 3,31 | 3,27 | 2,27 | 2,18 | 1,76 | 1,92 | 1 in 20 |
| | | 3,36 | 3,32 | 2,36 | 2,26 | 1,81 | 1,98 | 1 in 50 |
| | | 3,62 | 3,62 | 2,55 | 2,41 | 1,88 | 2,09 | 1 in 100 |
| 3,5 | 1,6 | 3,15* | 3,06* | 2,64 | 2,31* | - | - | 1 in 5 |
| | | 3,53 | 3,47* | 2,44 | - | 1,76 | - | 1 in 10 |
| | | 3,62 | 3,60 | 2,40 | 2,31 | 1,77 | 1,97 | 1 in 20 |
| | | 3,67 | 3,66 | 2,48 | 2,36 | 1,82 | 2,02 | 1 in 50 |
| | | 4,02 | 4,04 | 2,63 | 2,48 | 1,89 | 2,11 | 1 in 100 |

* Peak water-level less than height of sill (no breakthrough)

TABLE IV: PEAK WATER-LEVELS IN m TO MSL FOR VARIOUS SILL HEIGHTS, INITIAL WATER-LEVELS AND A FAMILY OF 1 IN 50 AND 1 IN 100 YEAR RUN HYDROGRAPHS

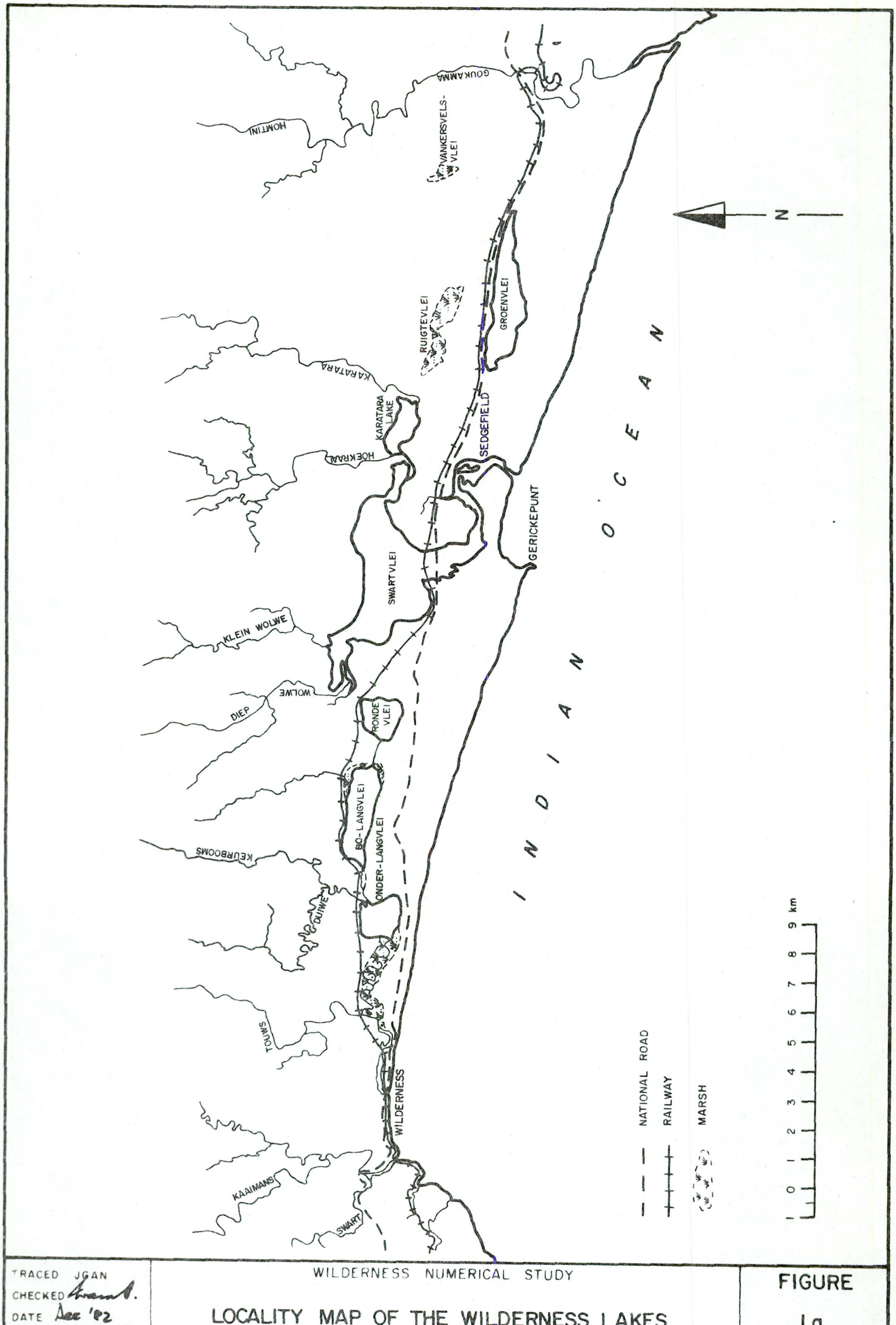
| Sill height (m to MSL) | Initial water-level (m) | Run hydrograph No | Peak water-levels (m) | | | Flood (yr) |
|---|---|---|---|---|---|---|
| | | | Wilderness | Onder-Langvlei | Bo-Lang/ Rondevlei | |
| 2,5 | 1,2 | 1 | 2,66 | 1,47 | 1,26 | 1 in 50 |
| | | 2 | 2,88 | 1,79 | 1,36 | " |
| | | 3 | 2,82 | 2,02 | 1,41 | " |
| | | 4 | 2,68 | 2,07 | 1,44 | " |
| | | 5 | 2,54 | 1,99 | 1,45 | " |
| | 1,4 | 1 | 2,69 | 1,66 | 1,45 | " |
| | | 2 | 2,89 | 1,95 | 1,53 | " |
| | | 3 | 2,82 | 2,15 | 1,58 | " |
| | | 4 | 2,68 | 2,18 | 1,61 | " |
| | | 5 | 2,55 | 2,10 | 1,62 | " |
| | 1,6 | 1 | 2,73 | 1,85 | 1,65 | " |
| | | 2 | 2,90 | 2,12 | 1,71 | " |
| | | 3 | 2,82 | 2,28 | 1,77 | " |
| | | 4 | 2,68 | 2,28 | 1,80 | " |
| | | 5 | 2,55 | 2,20 | 1,80 | " |
| | 1,8 | 1 | 2,78 | 2,05 | 1,84 | " |
| | | 2 | 2,91 | 2,27 | 1,91 | " |
| | | 3 | 2,81 | 2,40 | 1,97 | " |
| | | 4 | 2,68 | 2,37 | 2,00 | " |
| | | 5 | 2,55 | 2,30 | 1,99 | " |
| | 2,0 | 1 | 2,83 | 2,23 | 2,05 | " |
| | | 2 | 2,92 | 2,42 | 2,12 | " |
| | | 3 | 2,81 | 2,51 | 2,18 | " |
| | | 4 | 2,67 | 2,46 | 2,20 | " |
| | | 5 | 2,54 | 2,38 | 2,18 | " |
| | 2,2 | 1 | 2,89 | 2,40 | 2,25 | " |
| | | 2 | 2,94 | 2,56 | 2,32 | " |
| | | 3 | 2,79 | 2,62 | 2,37 | " |
| | | 4 | 2,65 | 2,55 | 2,38 | " |
| | | 5 | 2,54 | 2,46 | 2,35 | " |
| 2,0 | 1,6 | 1 | 2,51 | 1,83 | 1,64 | " |
| | | 2 | 2,55 | 2,09 | 1,71 | " |
| | | 3 | 2,37 | 2,26 | 1,76 | " |
| | | 4 | 2,19 | 2,25 | 1,79 | " |
| | | 5 | 2,05 | 1,99 | 1,78 | " |
| 2,5 | 1,6 | 1 | 2,73 | 1,85 | 1,65 | " |
| | | 2 | 2,90 | 2,12 | 1,71 | " |
| | | 3 | 2,82 | 2,28 | 1,77 | " |
| | | 4 | 2,68 | 2,28 | 1,80 | " |
| | | 5 | 2,55 | 2,02 | 1,80 | " |

TABLE IV (continued)

| Sill height (m to MSL) | Initial water-level (m) | Run hydrograph No | Peak water-levels (m) Wilderness | Onder-Langvlei | Bo-Lang/ Rondevlei | Flood (yr) |
|---|---|---|---|---|---|---|
| 3,0 | 1,6 | 1 | 2,84 | 2,17 | 1,70 | 1 in 50 |
| | | 2 | 3,19 | 2,18 | 1,72 | " |
| | | 3 | 3.20 | 2,35 | 1,78 | " |
| | | 4 | 3,12 | 2,40 | 1,81 | " |
| | | 5 | 3,03 | 2,59 | 1,88 | " |
| 3,5 | 1,6 | 1 | 2,84 | 2,17 | 1,76 | " |
| | | 2 | 3,47 | 2,74 | 1,86 | " |
| | | 3 | 3,61 | 2,54 | 1,81 | " |
| | | 4 | 3,56 | 2,68 | 1,88 | " |
| | | 5 | 3,32 | 3,10 | 2,41 | " |
| 2,5 | 1,2 | 1 | 2,80 | 1,49 | 1,27 | 1 in 100 |
| | | 2 | 3,09 | 1,97 | 1,38 | " |
| | | 3 | 2,97 | 2,28 | 1,47 | " |
| | | 4 | 2,73 | 2,33 | 1,52 | " |
| | | 5 | 2,55 | 2,12 | 1,55 | " |
| | 1,4 | 1 | 2,84 | 1,68 | 1,46 | " |
| | | 2 | 3,09 | 2,12 | 1,56 | " |
| | | 3 | 2,96 | 2,39 | 1,64 | " |
| | | 4 | 2,72 | 2,41 | 1,69 | " |
| | | 5 | 2,55 | 2,20 | 1,70 | " |
| | 1,6 | 1 | 2,88 | 1,87 | 1,66 | " |
| | | 2 | 3,10 | 2,27 | 1,75 | " |
| | | 3 | 2,95 | 2,50 | 1,84 | " |
| | | 4 | 2,72 | 2,49 | 1,90 | " |
| | | 5 | 2,55 | 2,28 | 1,87 | " |
| | 1,8 | 1 | 2,92 | 2,07 | 1,85 | " |
| | | 2 | 3,11 | 2,41 | 1,95 | " |
| | | 3 | 2,94 | 2,60 | 2,06 | " |
| | | 4 | 2,71 | 2,56 | 2,11 | " |
| | | 5 | 2,54 | 2,36 | 2,07 | " |
| | 2,0 | 1 | 2,98 | 2,25 | 2,05 | " |
| | | 2 | 3,12 | 2,54 | 2,16 | " |
| | | 3 | 2,93 | 2,70 | 2,26 | " |
| | | 4 | 2,69 | 2,62 | 2,30 | " |
| | | 5 | 2,54 | 2,42 | 2,25 | " |
| 2,5 | 2,2 | 1 | 3,03 | 2,42 | 2,26 | " |
| | | 2 | 3,12 | 2,68 | 2,36 | " |
| | | 3 | 2,90 | 2,80 | 2,46 | " |
| | | 4 | 2,67 | 2,68 | 2,48 | " |
| | | 5 | 2,53 | 2,49 | 2,40 | " |

TABLE IV (continued)

| Sill height (m to MSL) | Initial water-level (m) | Run hydrograph No | Peak water-levels (m) | | | Flood (yr) |
|---|---|---|---|---|---|---|
| | | | Wilderness | Onder-Langvlei | Bo-Lang/ Rondevlei | |
| 2,0 | 1,6 | 1 | 2,67 | 1,85 | 1,65 | 1 in 100 |
| | | 2 | 2,76 | 2,25 | 1,74 | " |
| | | 3 | 2,52 | 2,48 | 1,84 | " |
| | | 4 | 2,24 | 2,47 | 1,90 | " |
| | | 5 | 2,04 | 2,09 | 1,85 | " |
| 2,5 | 1,6 | 1 | 2,88 | 1,87 | 1,66 | " |
| | | 2 | 3,10 | 2,27 | 1,75 | " |
| | | 3 | 2,95 | 2,50 | 1,84 | " |
| | | 4 | 2,72 | 2,49 | 1,90 | " |
| | | 5 | 2,55 | 2,28 | 1,87 | " |
| 3,0 | 1,6 | 1 | 3,02 | 1,95 | 1,67 | " |
| | | 2 | 3,39 | 2,32 | 1,75 | " |
| | | 3 | 3,34 | 2,54 | 1,85 | " |
| | | 4 | 3,17 | 2,55 | 1,91 | " |
| | | 5 | 3,04 | 2,65 | 1,96 | " |
| 3,5 | 1,6 | 1 | 3,02 | 2,24 | | " |
| | | 2 | 3,67 | 2,42 | 1,77 | " |
| | | 3 | 3,75 | 2,64 | 1,87 | " |
| | | 4 | 3,64 | 2,75 | 1,96 | " |
| | | 5 | 3,52 | 3,13 | 2,23 | " |



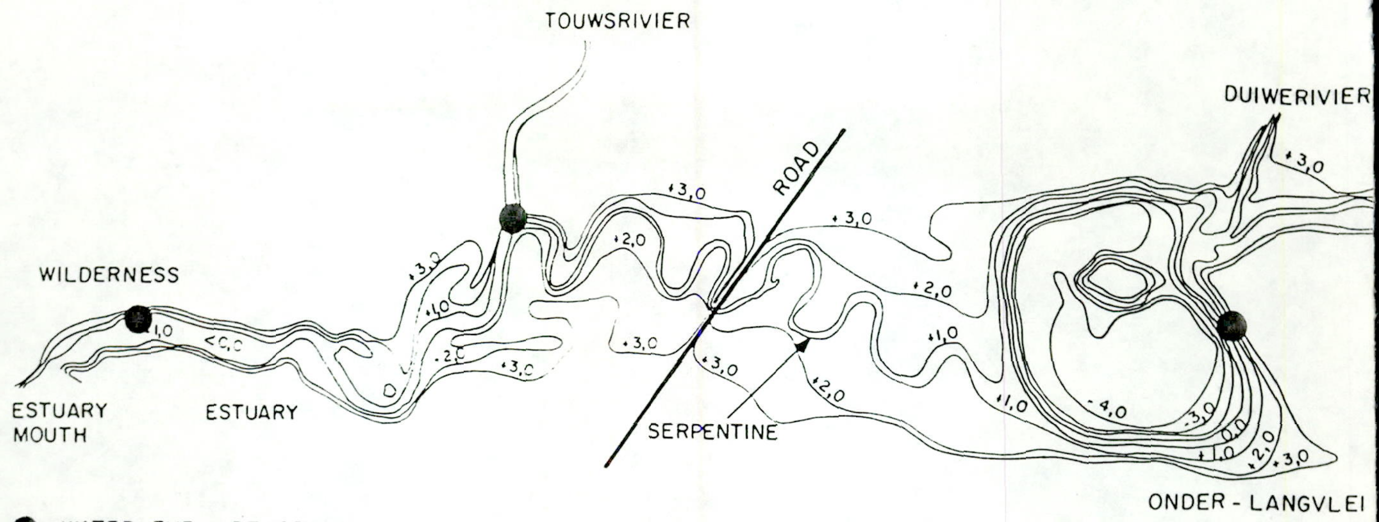

TRACED JGAN
CHECKED
DATE Dec '82
REF C/SEA 8255

WILDERNESS NUMERICAL STUDY

LOCALITY MAP OF THE WILDERNESS LAKES

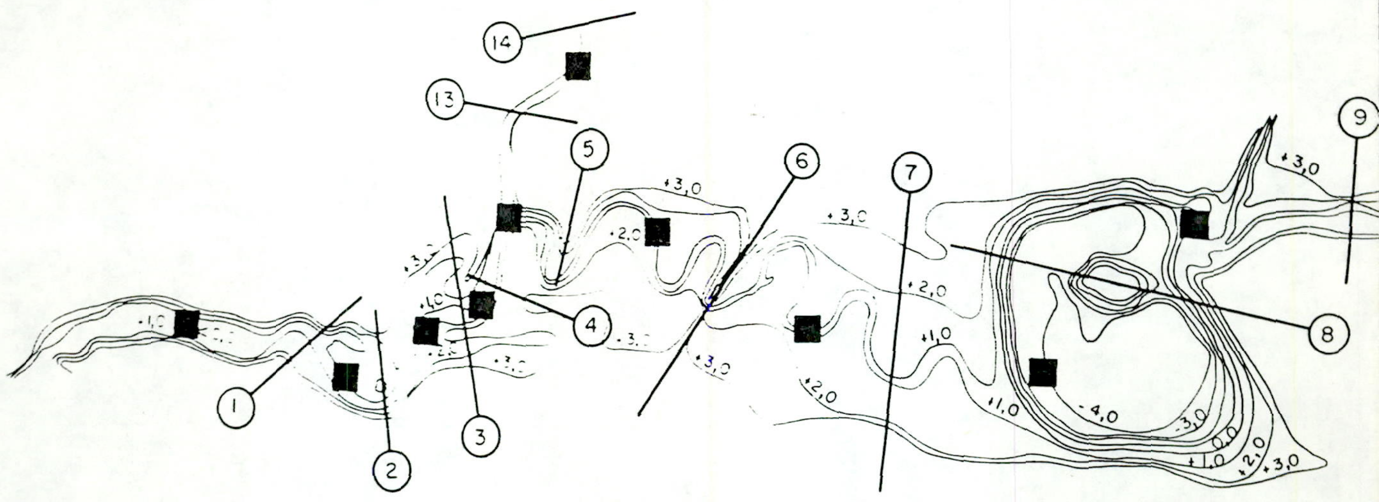
FIGURE 1a

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




● WATERLEVEL RECORDERS

1) CONTOURS OF THE WILDERNESS LAKES (LEVELS TO MSL)



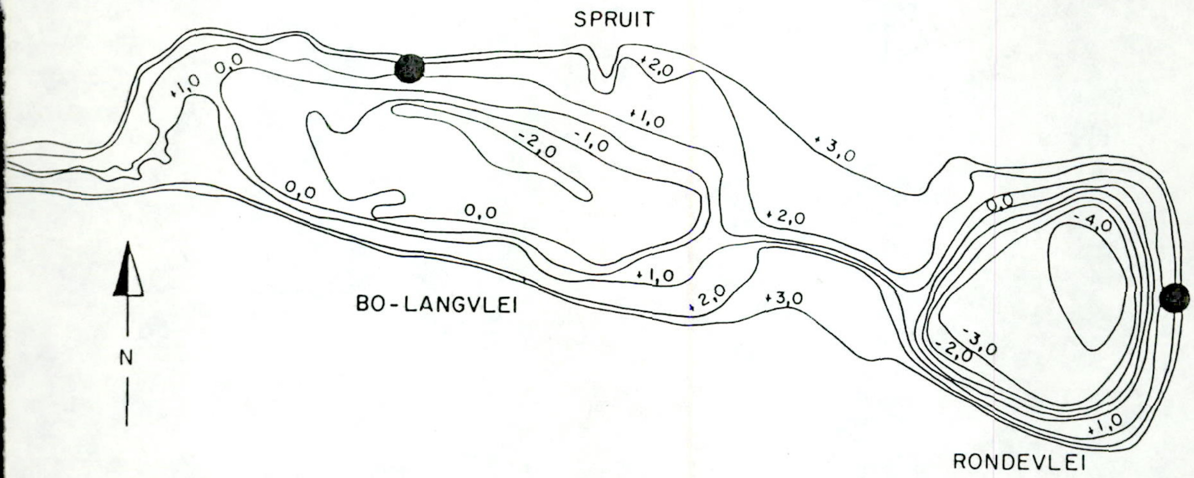

○ CALCULATION OF FLOW

■ CALCULATION OF WATERLEVEL

2) POSITIONS OF CROSS-SECTIONS, WHERE FLOW AND WATERLEVELS ARE CALCULATED

| | | |
|---|---|---|
| TRACED JGAN<br>CHECKED<br>DATE Dec '82<br>REF C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>LAYOUT OF THE WILDERNESS LAKES AND POSITIONS OF CROSS-SECTIONS | FIGURE 1b |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY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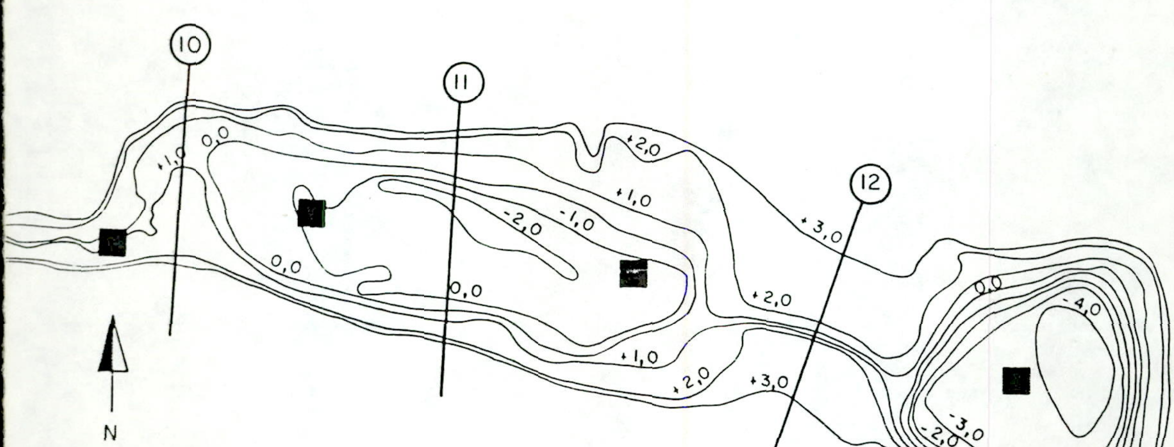
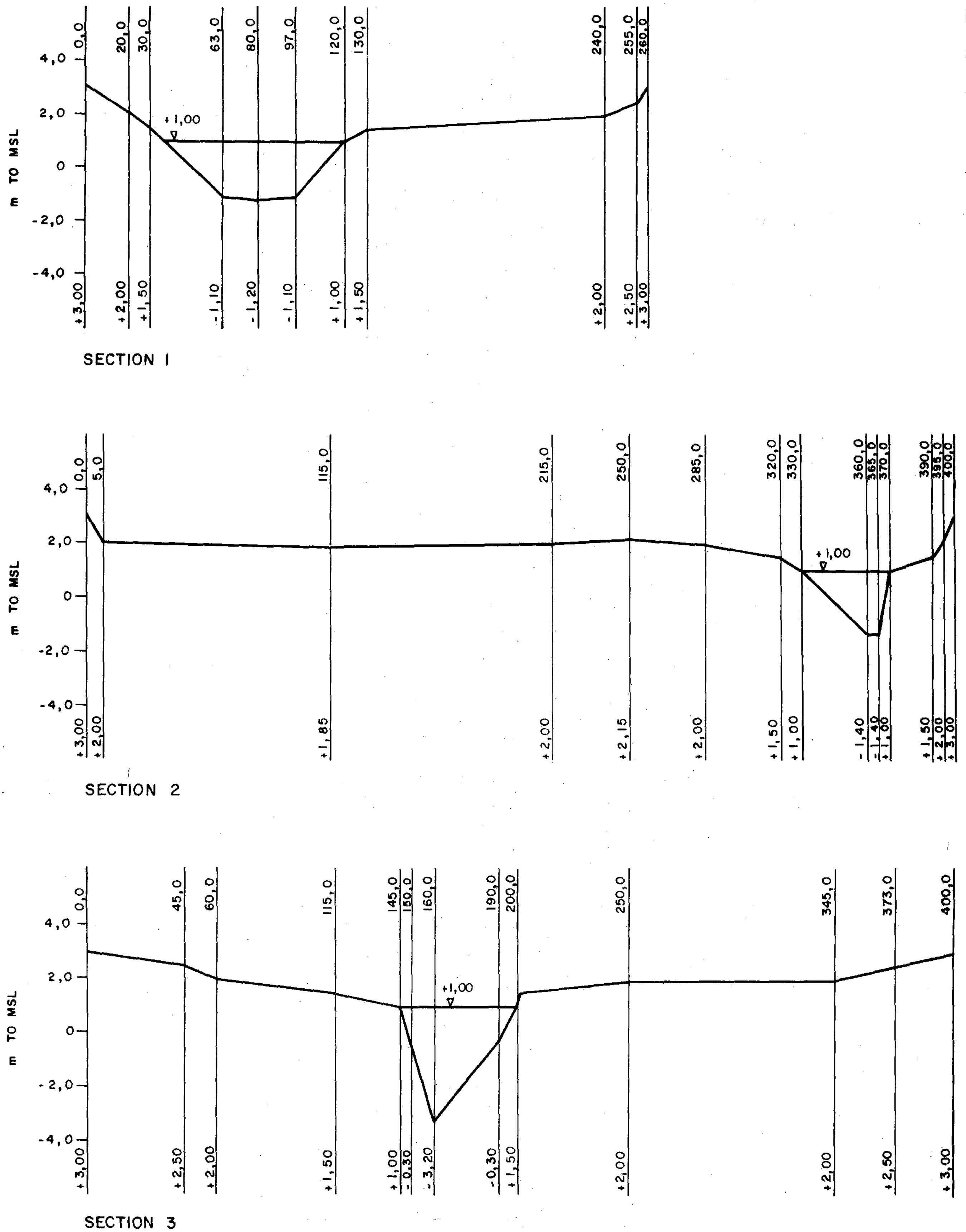
+1,0 0,0
+1,0
-1,0
-2,0
+3,0
0,0
0,0
+2,0
0,0
-4,0
+1,0
BO-LANGVLEI
2,0
+3,0
N
-3,0
-2,0
+1,0
RONDEVLEI


10
11
+2,0
+1,0 0,0
+1,0
12
-2,0
-1,0
+3,0
0,0
0,0
+2,0
0,0
-4,0
+1,0
+2,0
+3,0
N
-3,0
-2,0
+1,0



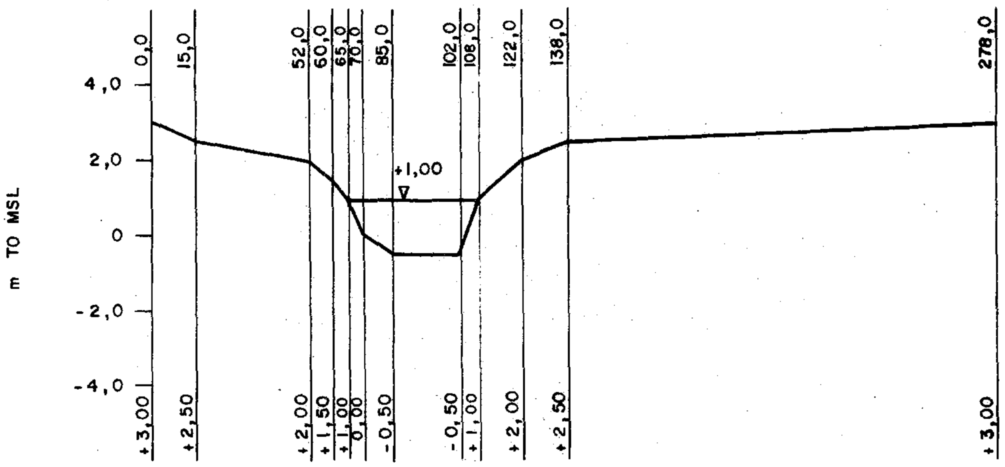

TRACED JGAN
CHECKED *[signature]*
DATE *Dec '82*
REF *C/SEA 8255*

WILDERNESS NUMERICAL STUDY

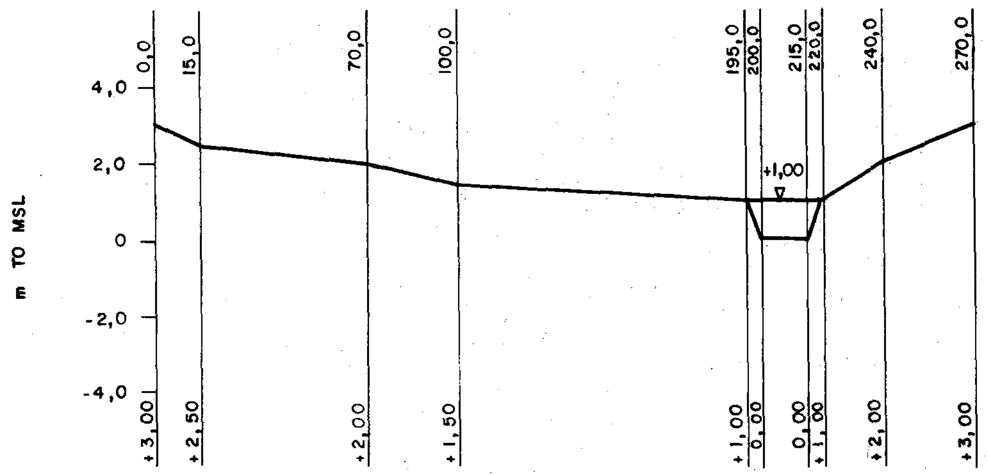
**CROSS-SECTIONAL SURVEYS**

**FIGURE 2. a**

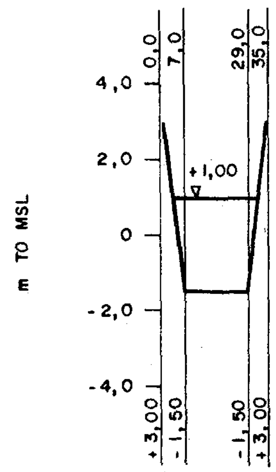
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




SECTION 4



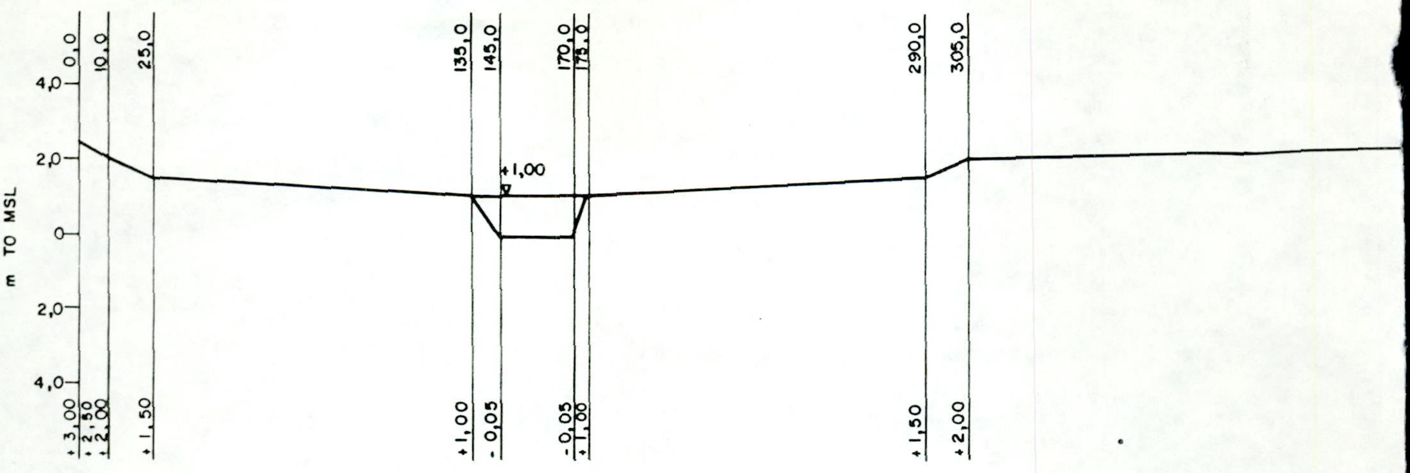

SECTION 5



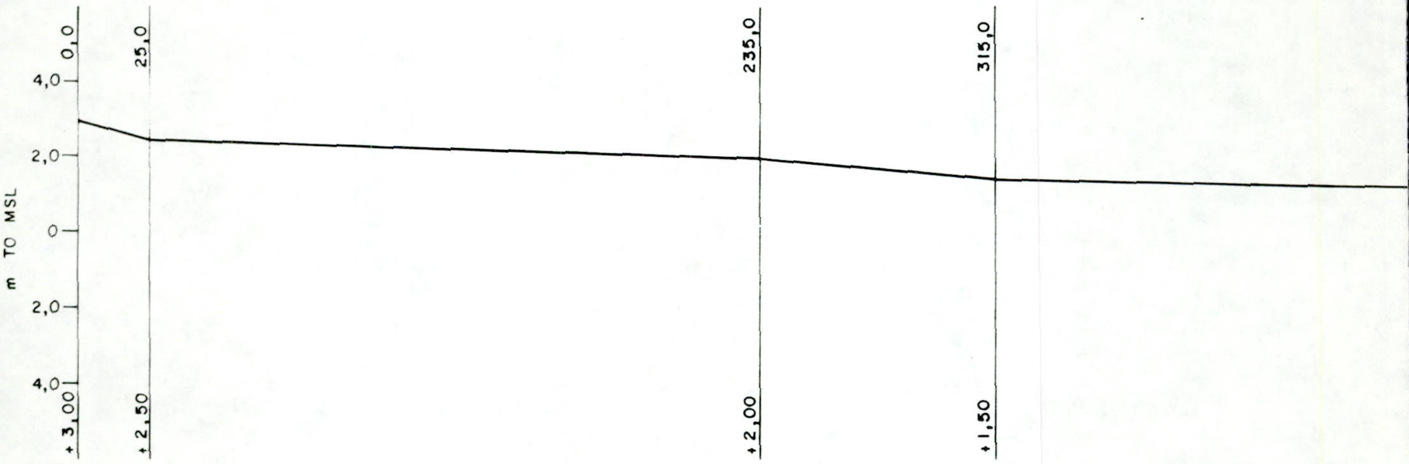

SECTION 6 (BRIDGE)

| | | |
|---|---|---|
| TRACED JGAN<br>CHECKED<br>DATE Dec '82<br>REF C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>**CROSS-SECTIONAL SURVEYS** | **FIGURE**<br>**2. b** |

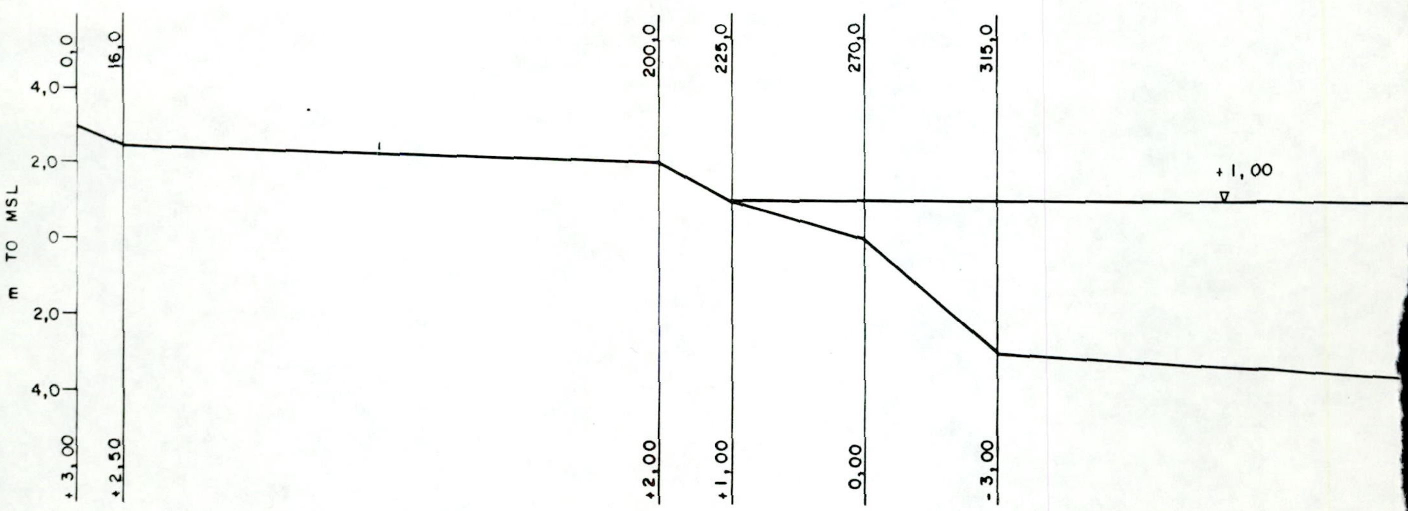
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




SECTION 6.1




SECTION 7




SECTION 8

TRACED

CHECKED

DATE Dec' 82

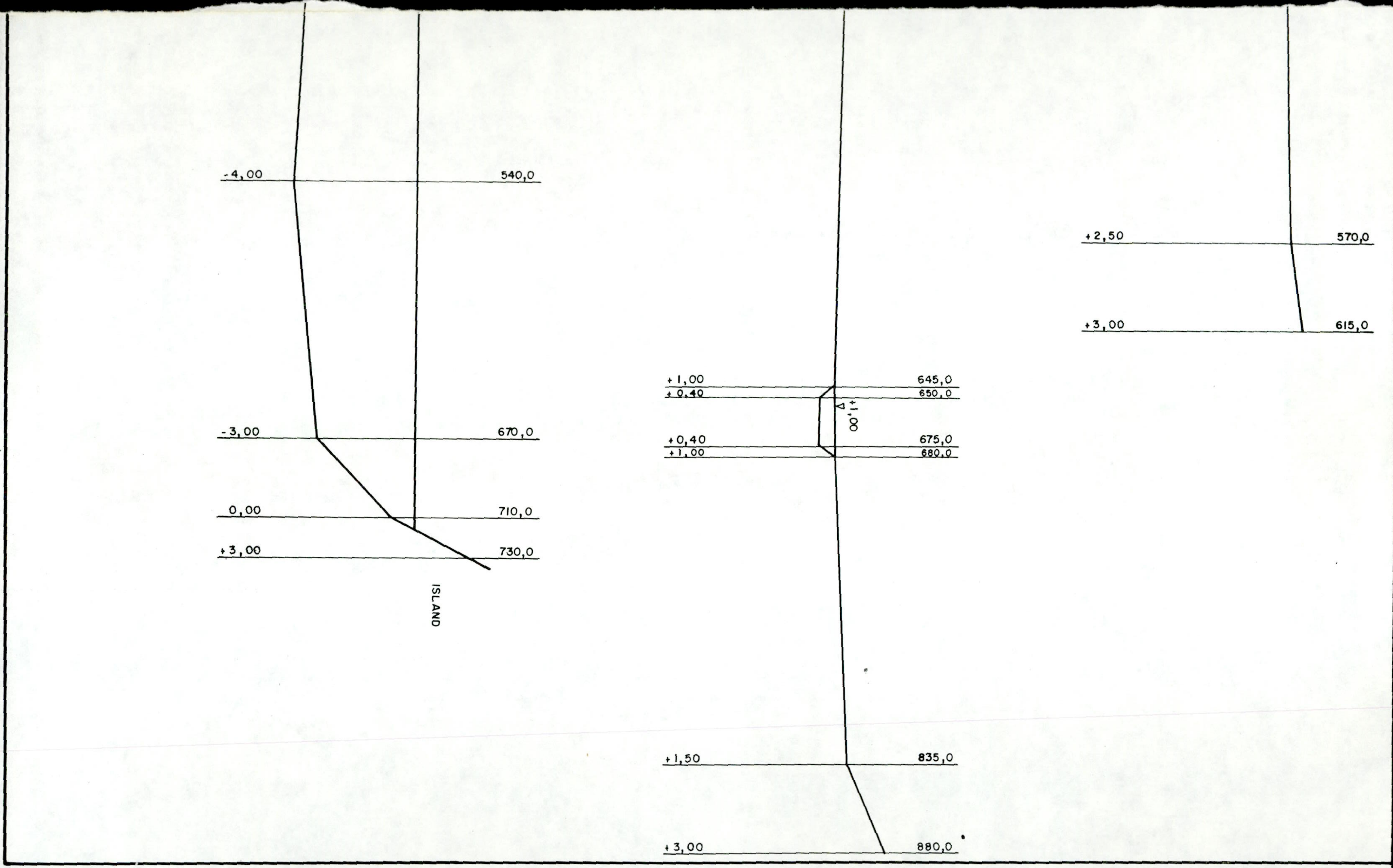
REF C/SEA 8255

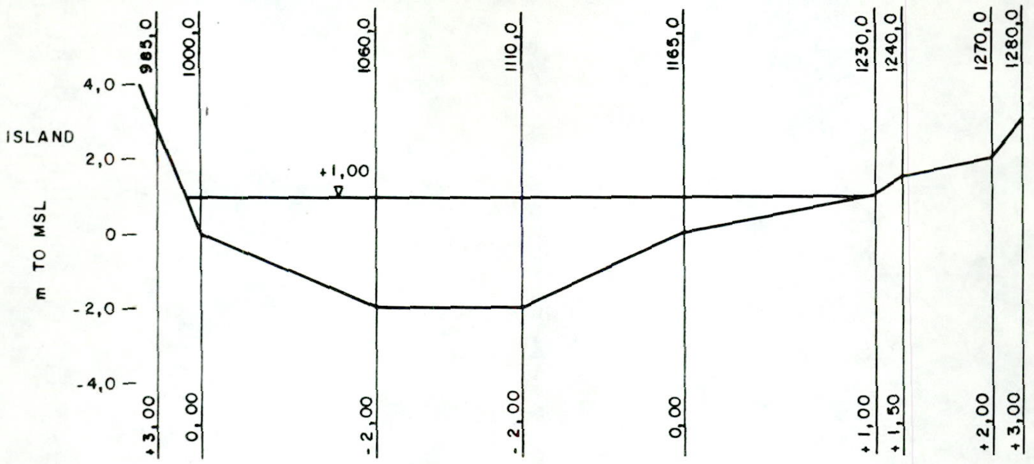
WILDERNESS NUMERICAL STUDY

**CROSS-SECTIONAL SURVEYS**

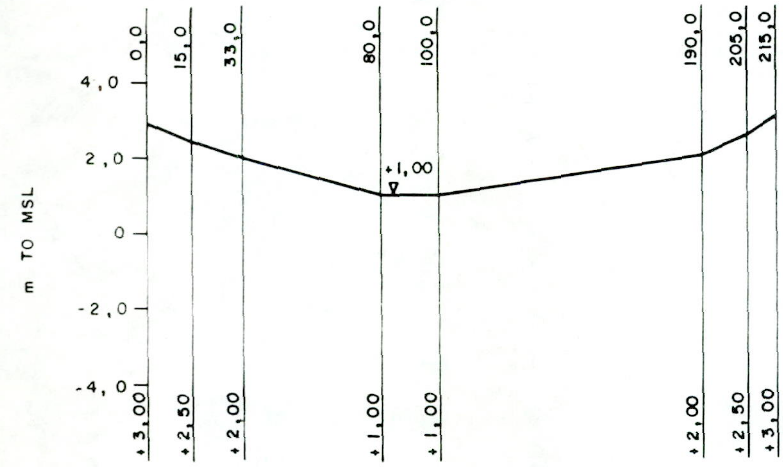
**FIGURE 2.c**

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY

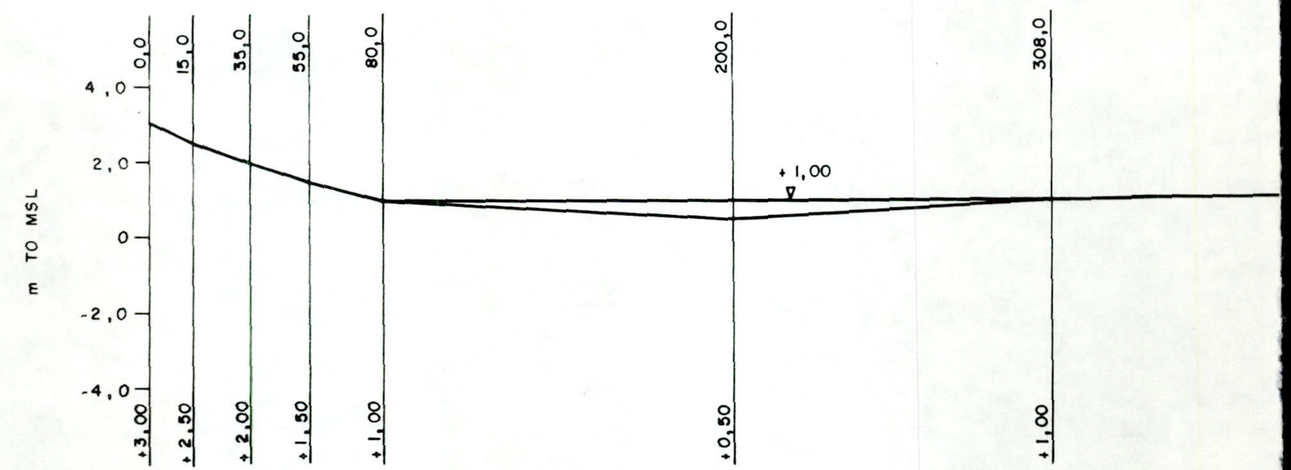

-4,00
540,0
-3,00
670,0
0,00
710,0
+3,00
730,0
ISLAND
+1,00
645,0
+0,40
650,0
+1,00
+0,40
675,0
+1,00
680,0
+1,50
835,0
+3,00
880,0
+2,50
570,0
+3,00
615,0




SECTION 8 CONTINUE



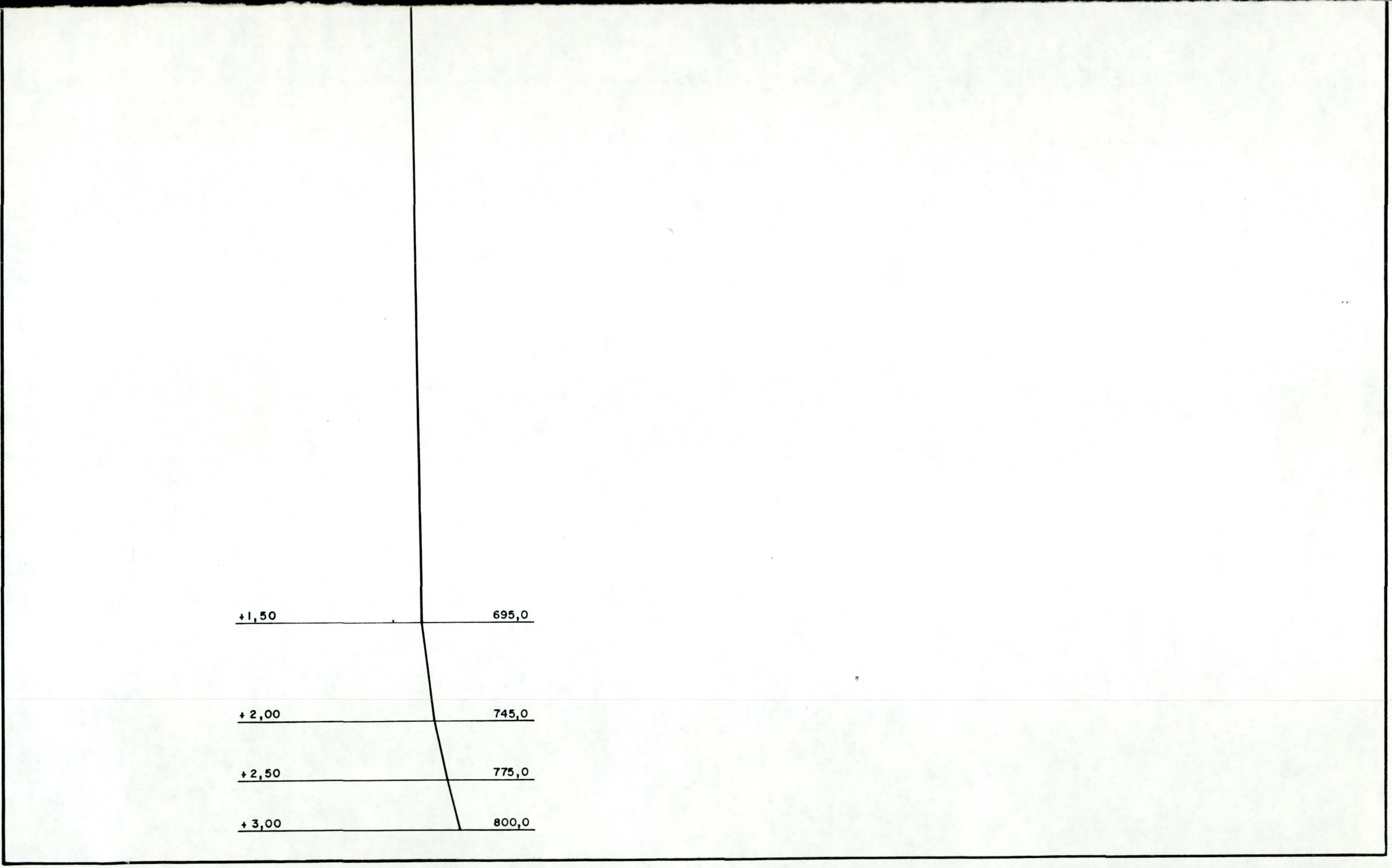

SECTION 9

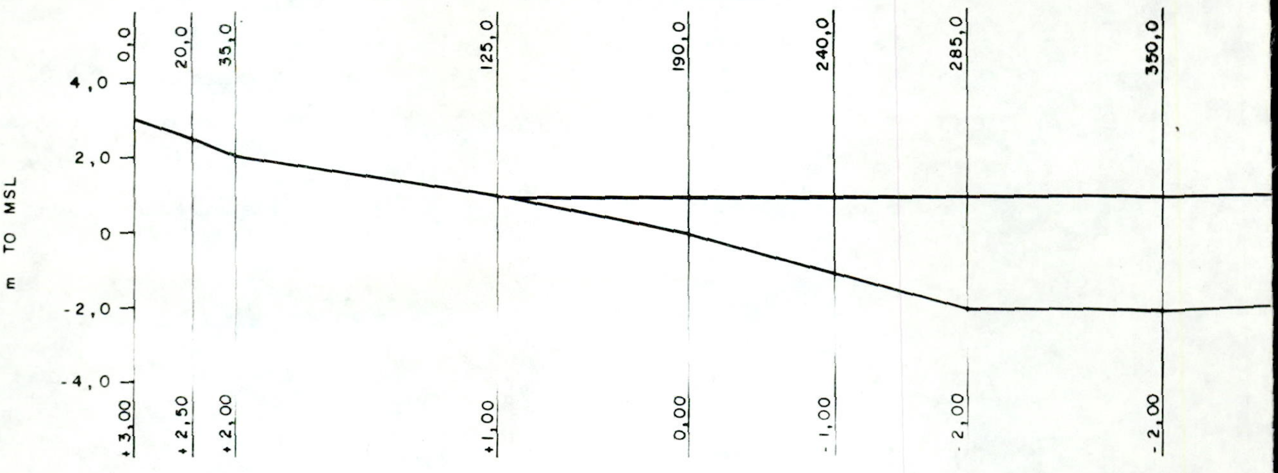



SECTION 10

| | | |
|---|---|---|
| TRACED JGAN<br>CHECKED [signature]<br>DATE Aec '82<br>REF C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br><br>**CROSS-SECTIONAL SURVEYS** | **FIGURE**<br>**2. d** |

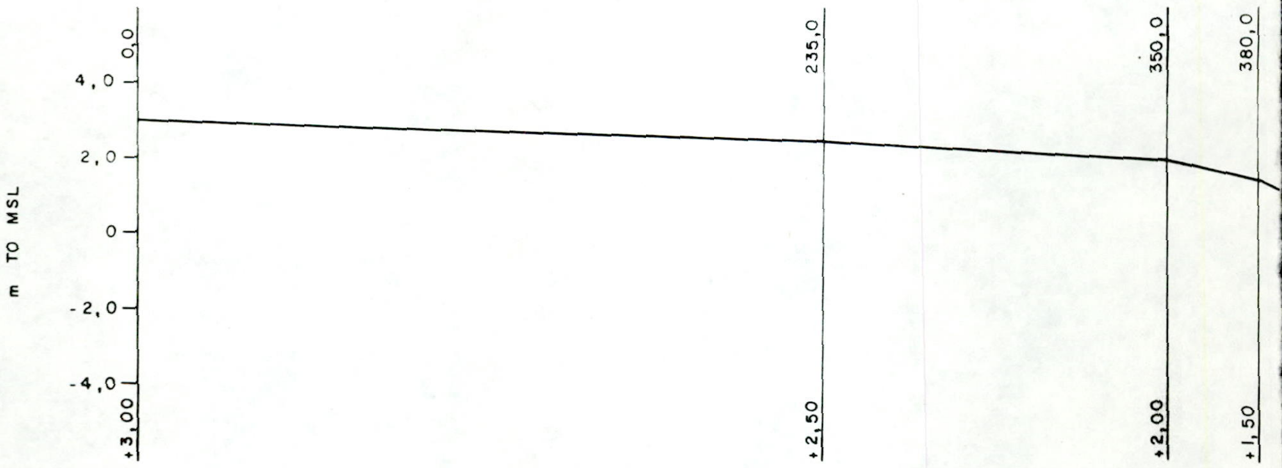
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY


+1,50
695,0
+2,00
745,0
+2,50
775,0
+3,00
800,0




SECTION 11


SECTION 11 CONTINUE




SECTION 12

| | | |
|---|---|---|
| TRACED JGAN<br>CHECKED AA<br>DATE: Dec' 82<br>REF. C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br><br>**CROSS-SECTIONAL SURVEYS** | **FIGURE**<br><br>**2. e** |

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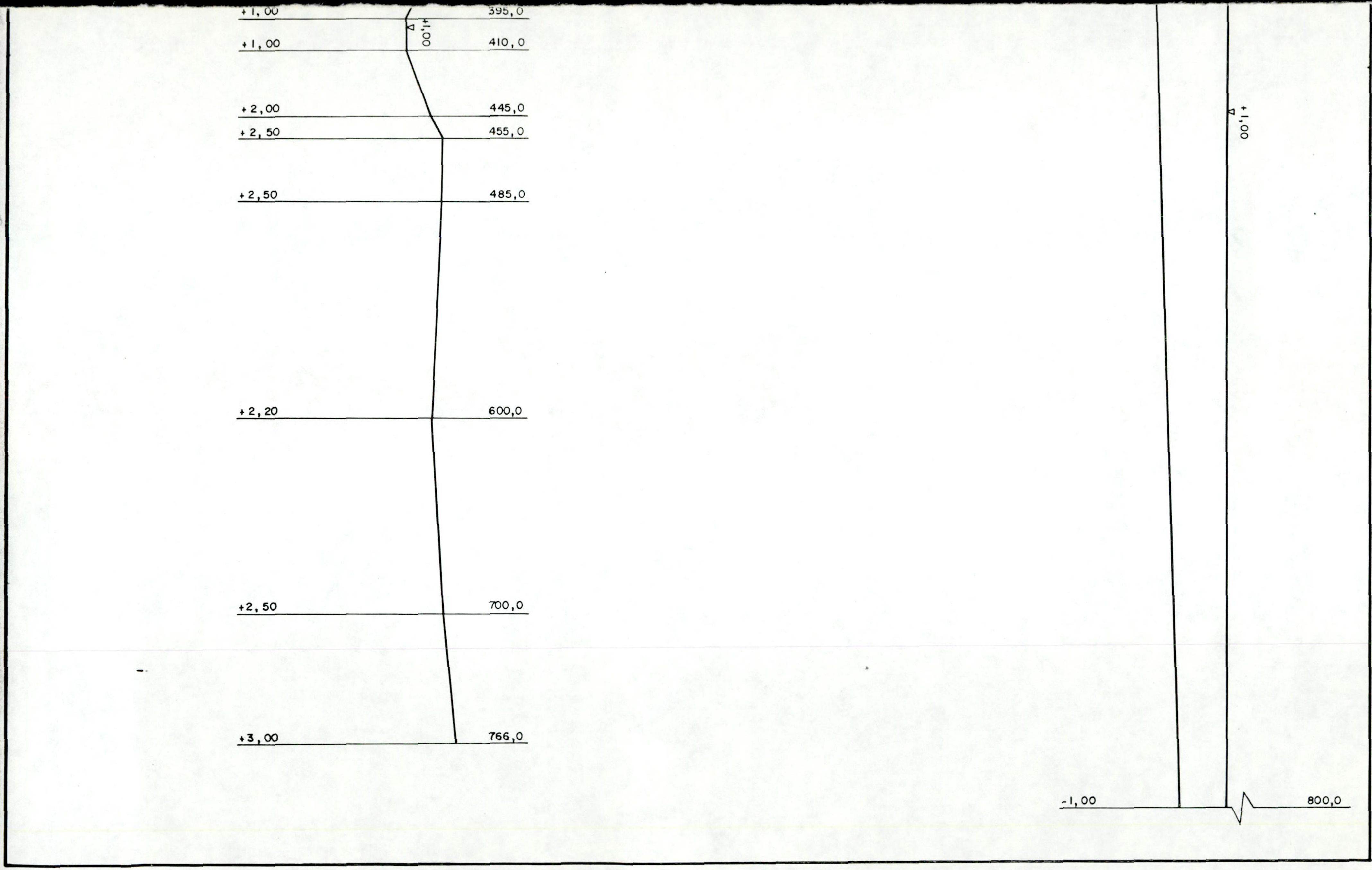
+1,00
395,0
+1,00
410,0
+1,00
+2,00
445,0
+2,50
455,0
+2,50
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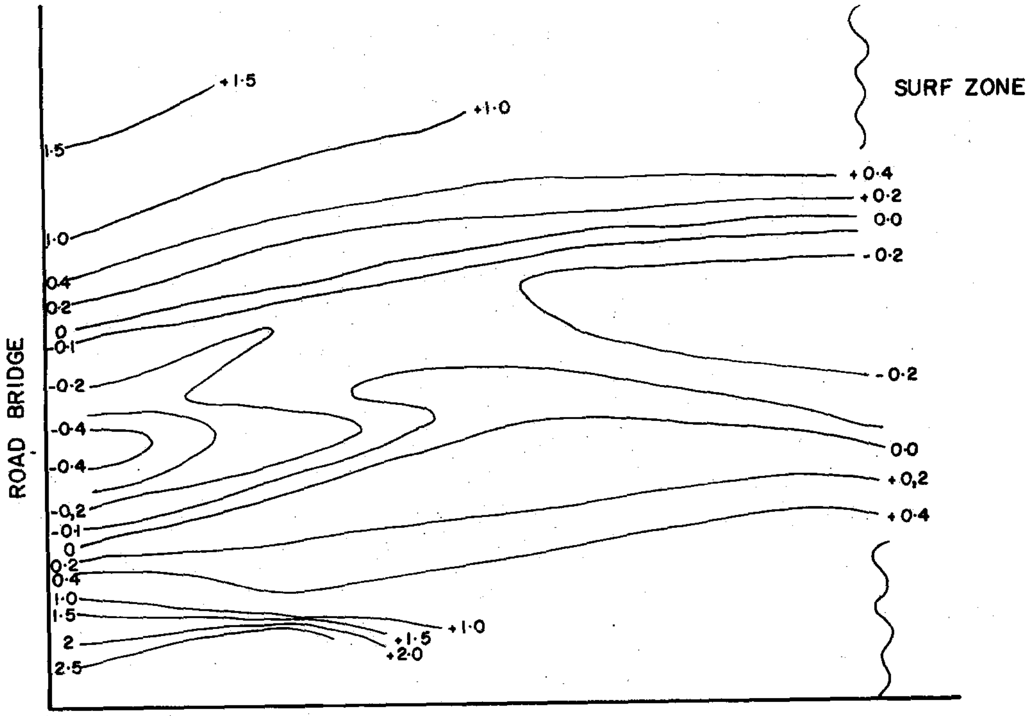
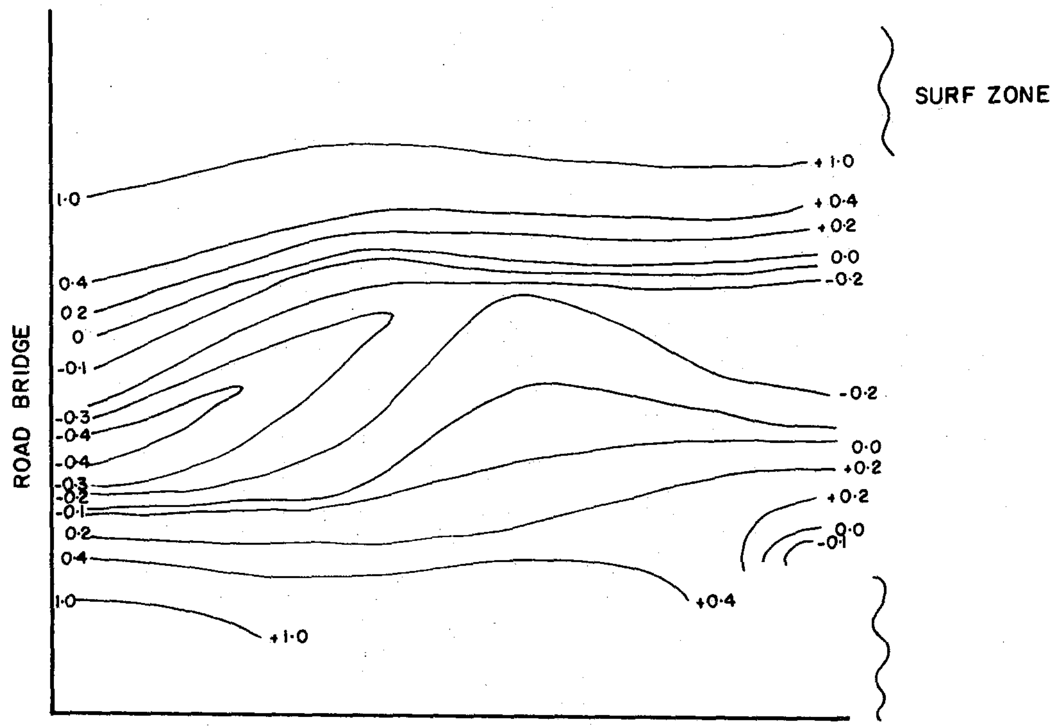
600,0
+2,50
700,0
+3,00
766,0
+1,00
-1,00
800,0




1980 - 12 - 03 AT 09 H 30
(22 HOURS AFTER BREAKTHROUGH)

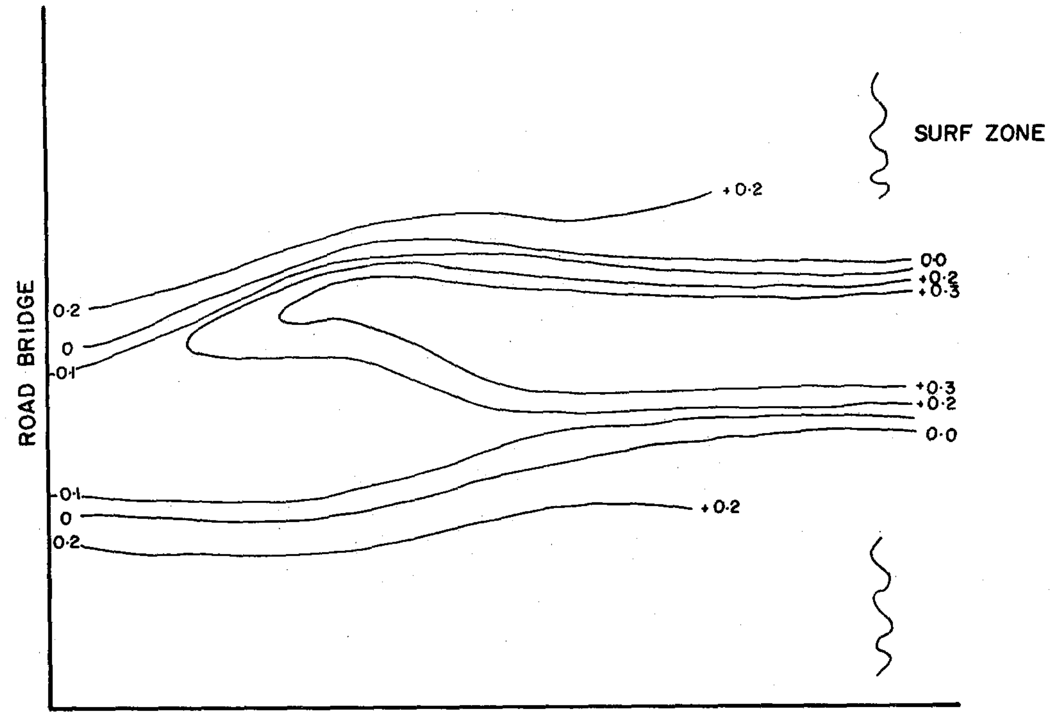



1980 - 12 - 03 16 H 15
(29 HOURS AFTER BREAKTHROUGH)

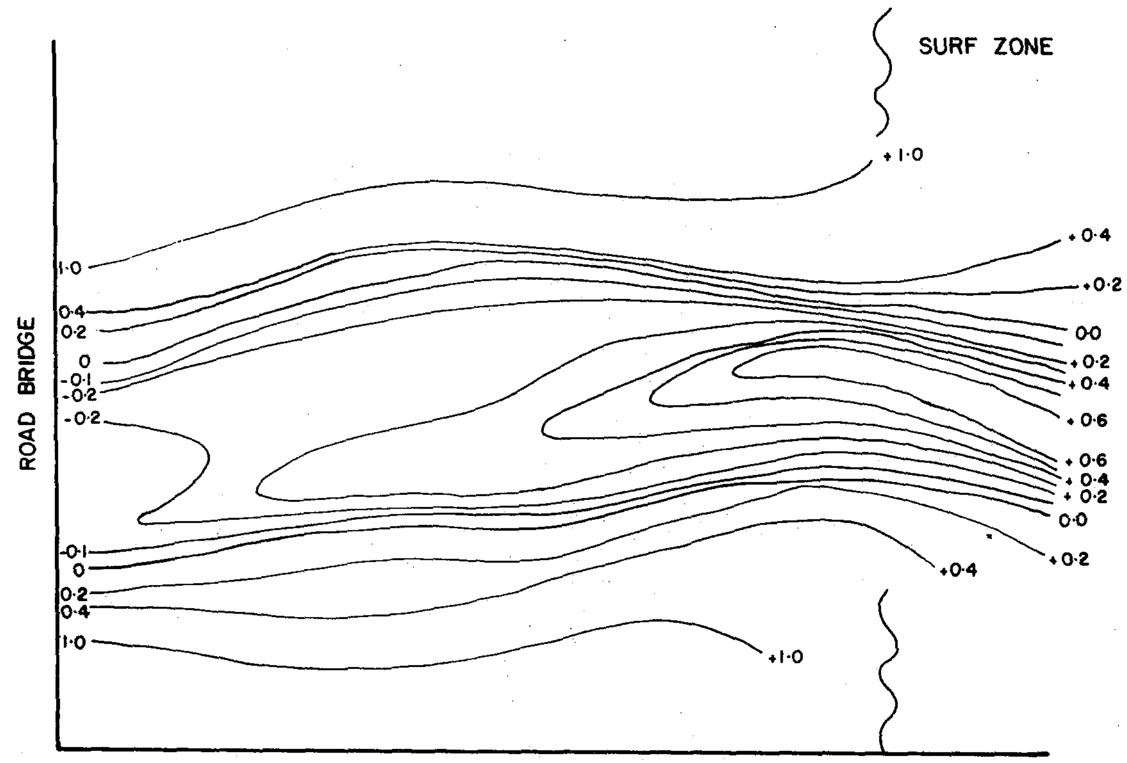
SCALE: 1 IN 1145

| | | |
|---|---|---|
| TRACED L de J<br>CHECKED: [signature]<br>DATE: Dec '82<br>REF: C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>**CONTOUR MAPS OF THE ESTUARY MOUTH AT WILDERNESS (DEC. 1980)** | FIGURE<br>3·1a |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




1980-12-03 18 H 30
(31 HOURS AFTER BREAKTHROUGH)




1980-12-03 8 H 30
(45 HOURS AFTER BREAKTHROUGH)

| | | |
|---|---|---|
| TRACED J. de J<br>CHECKED [signature]<br>DATE Dec '82<br>REF C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>**CONTOUR MAPS OF THE ESTUARY MOUTH AT WILDERNESS (DEC.1980)** | **FIGURE**<br>**3.1b** |

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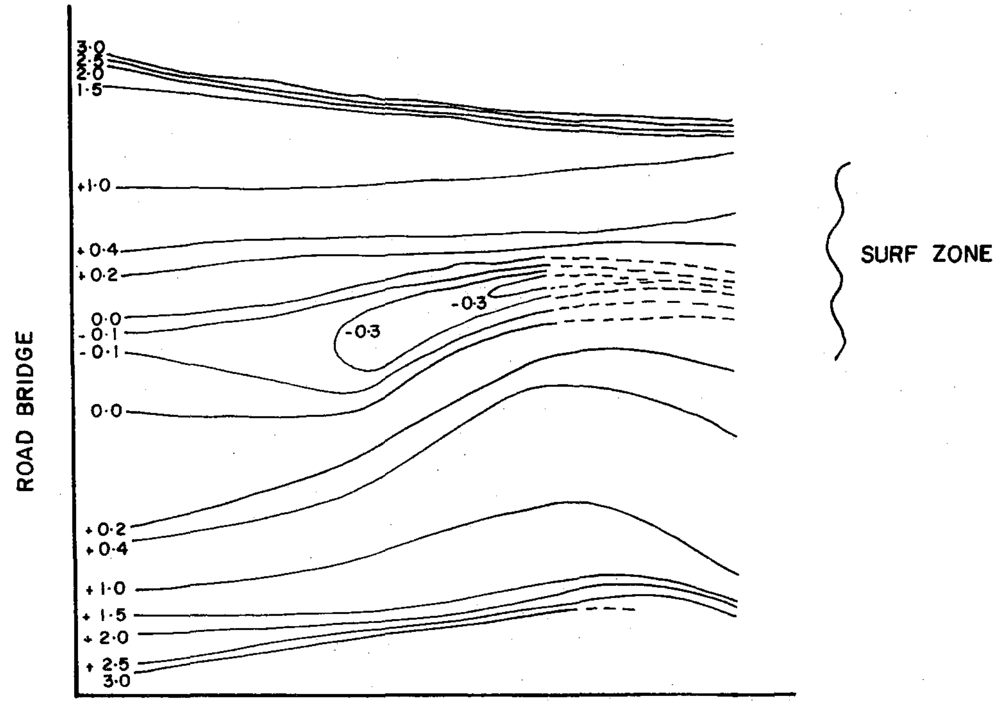



1980-12-08 11H30
(6 DAYS AFTER BREAKTHROUGH)

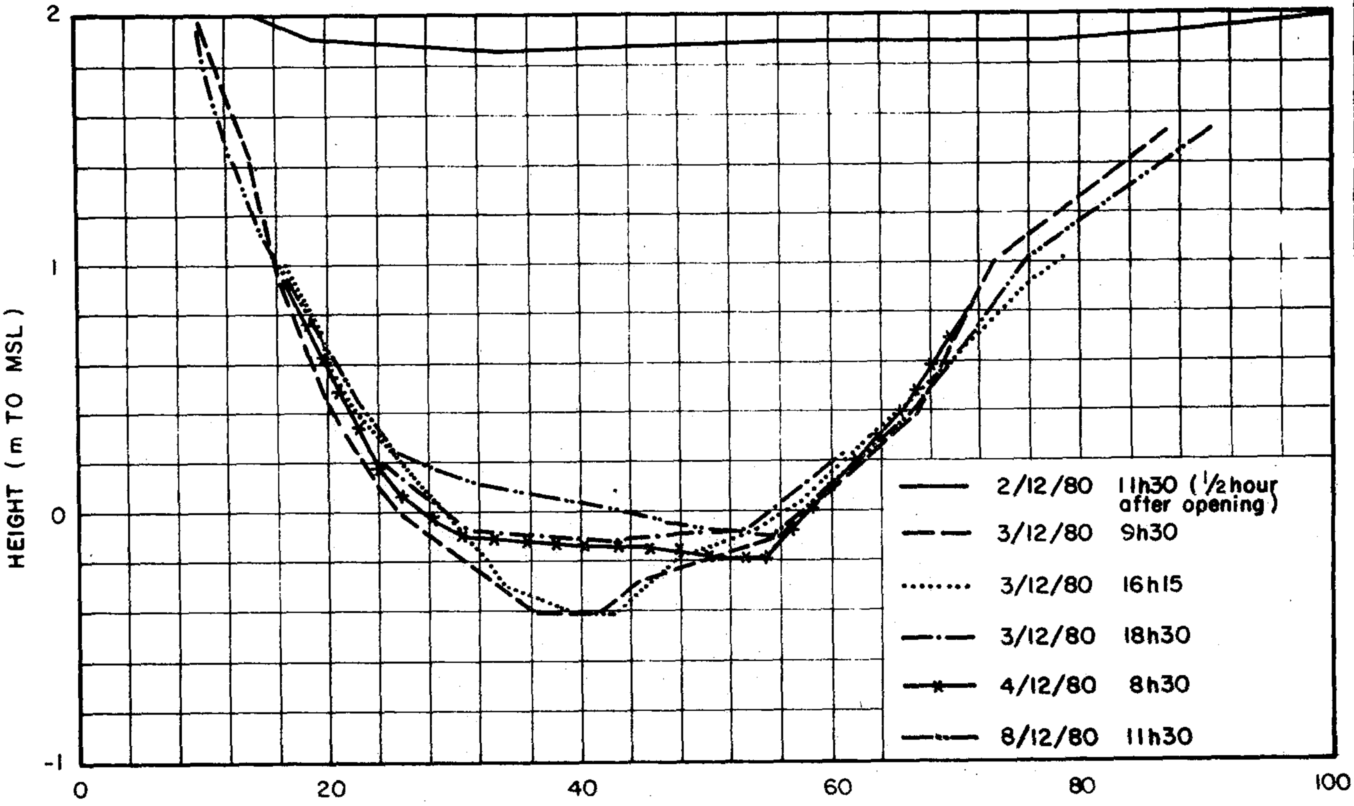
TRACED L de J
CHECKED
DATE Dec '82
REF C/SEA 8255

WILDERNESS NUMERICAL STUDY

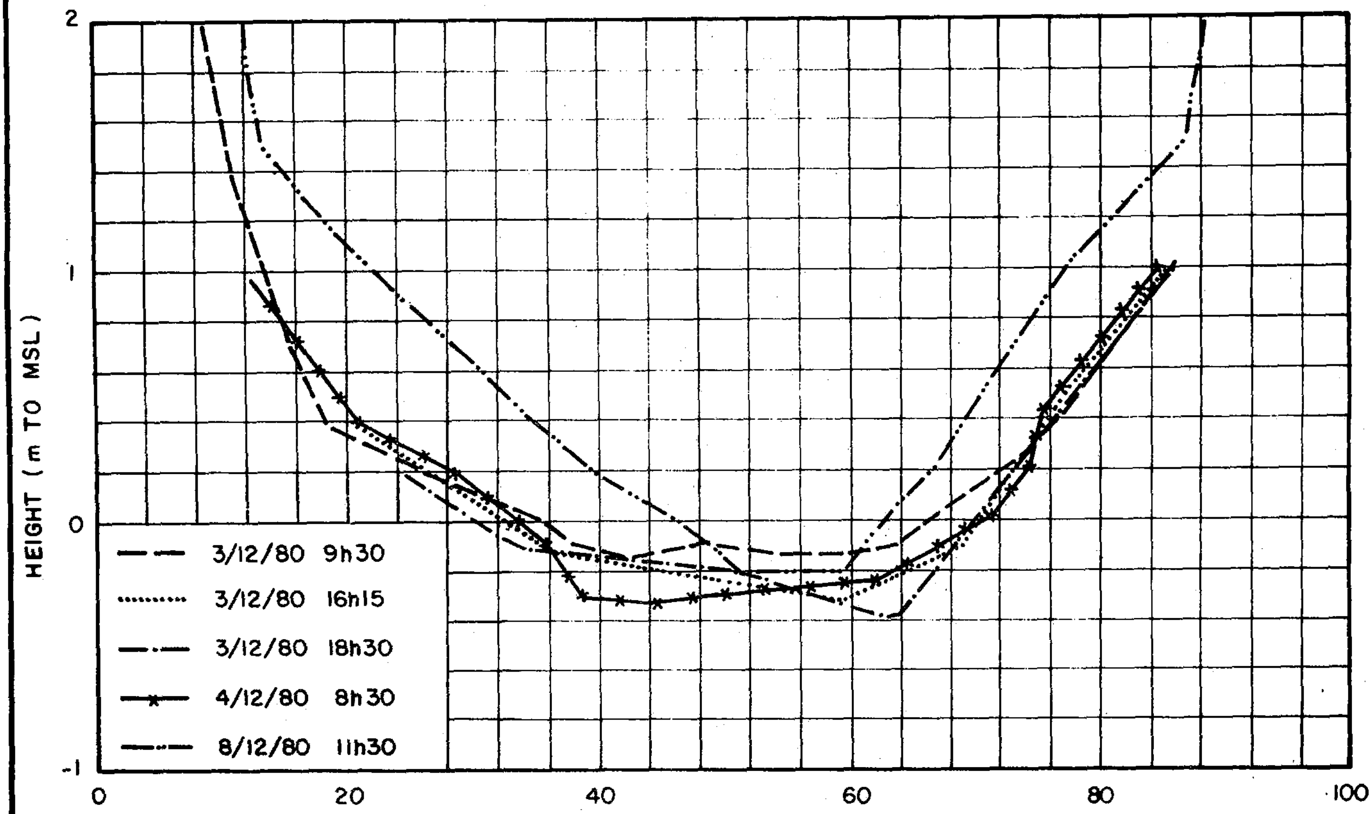
CONTOUR MAPS OF THE ESTUARY MOUTH AT WILDERNESS (DEC. 1980)

FIGURE 3.1c

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



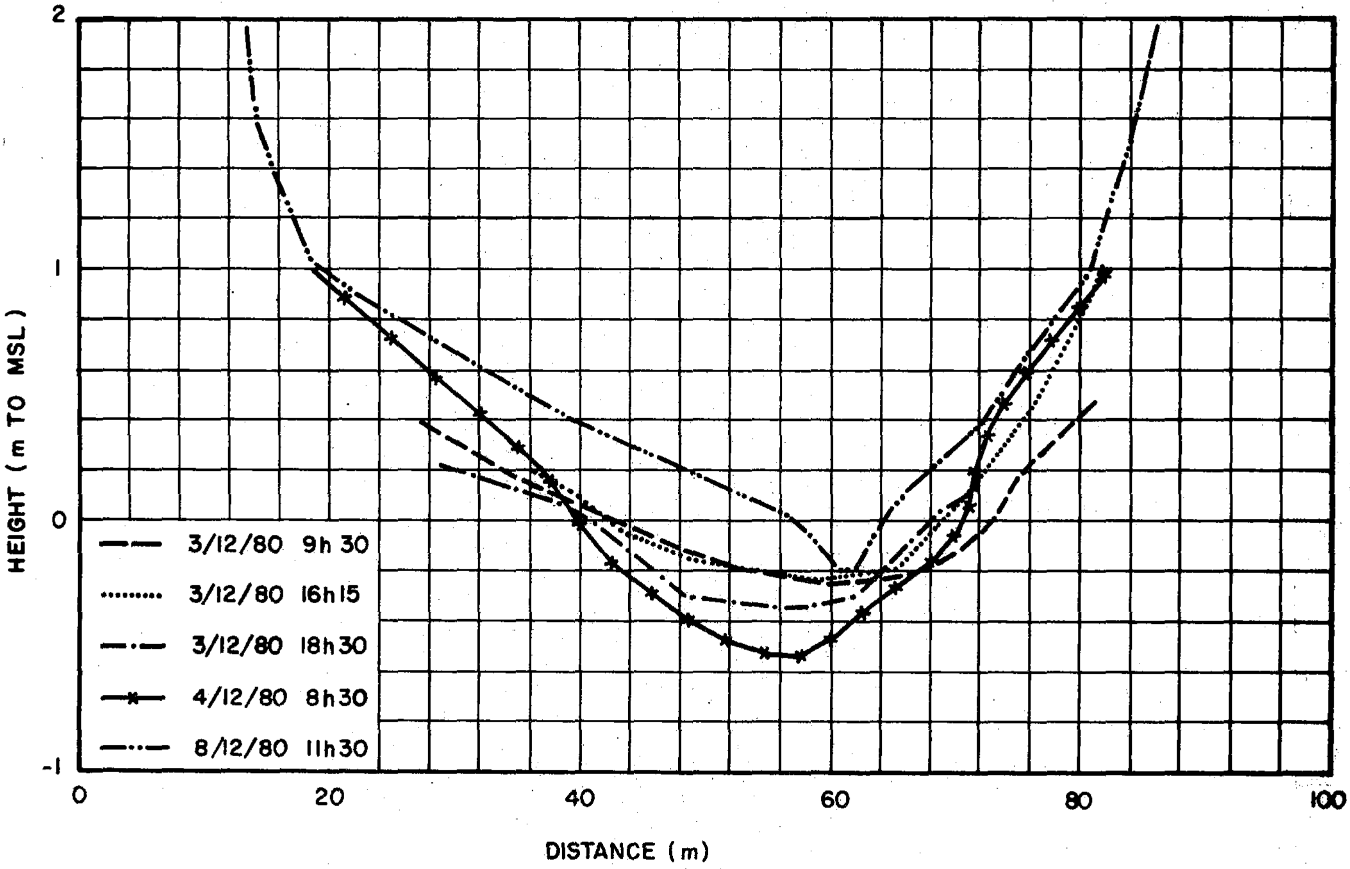

10 m SEAWARD OF THE ROAD BRIDGE




50 m SEAWARD OF THE ROAD BRIDGE

| | | |
|---|---|---|
| TRACED<br>CHECKED<br>DATE Dec '82<br>REF C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>**CROSS-SECTIONAL SURVEYS OF THE ESTUARY MOUTH AT WILDERNESS (DEC. 1980)** | FIGURE<br>3.2a |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




100m SEAWARD OF THE ROAD BRIDGE

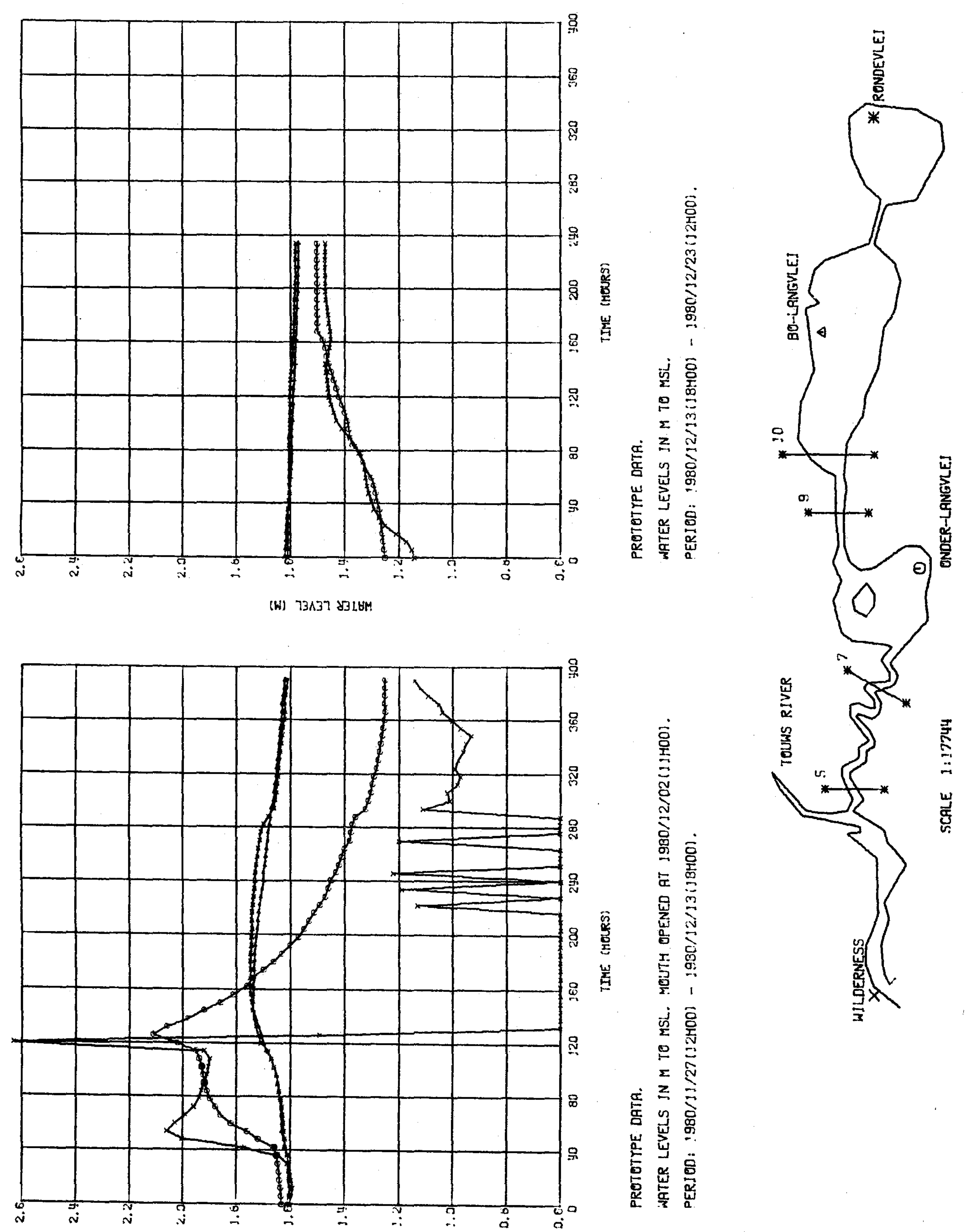
TRACED L de J
CHECKED
DATE Dec '82
REF C/SEA 8255

WILDERNESS NUMERICAL STUDY

CROSS-SECTIONAL SURVEYS OF THE ESTUARY MOUTH AT WILDERNESS (DEC. 1980)

FIGURE 3.2b

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 31/04/03.<br>REF. C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>PROTOTYPE DATA.<br>1980/11/27(12H00) - 1980/12/23(12H00). | FIGURE<br>4 |

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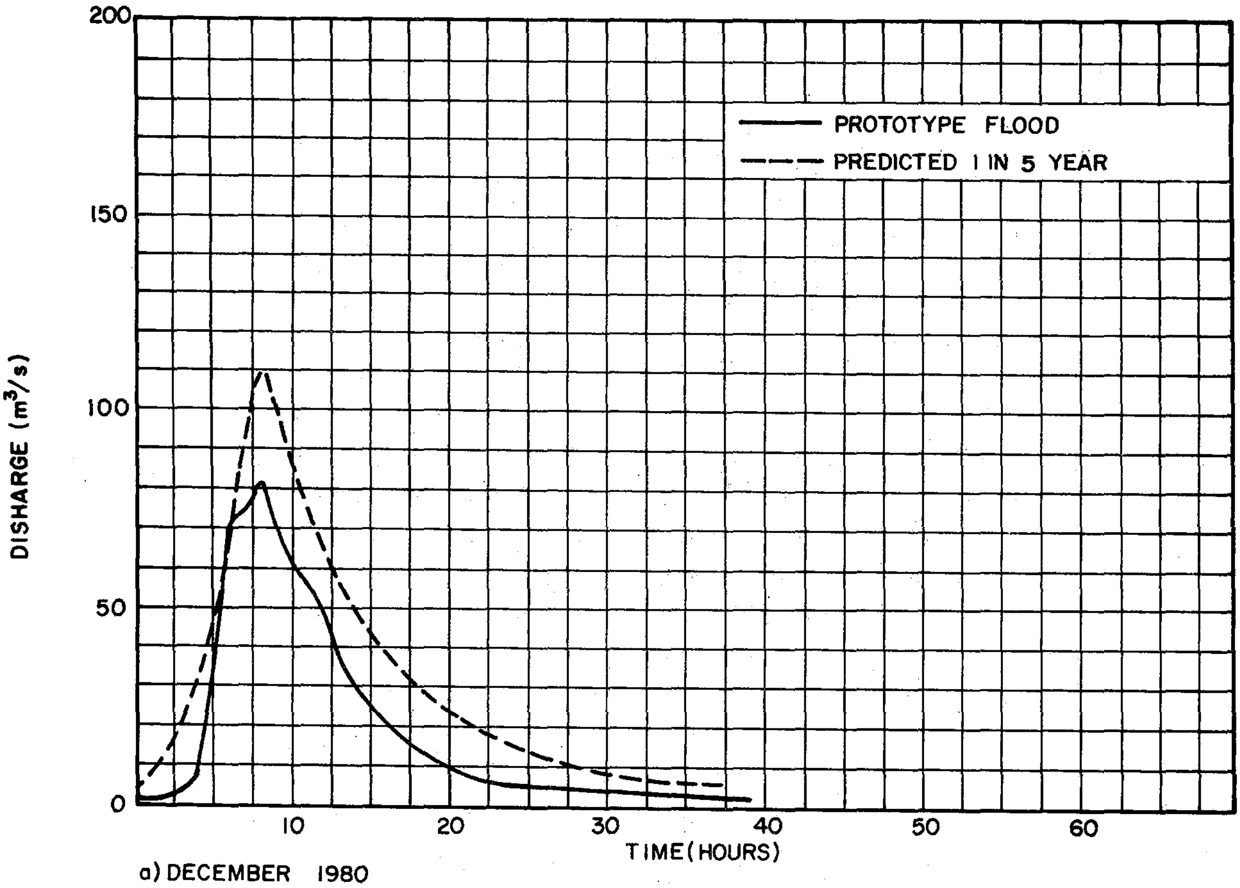
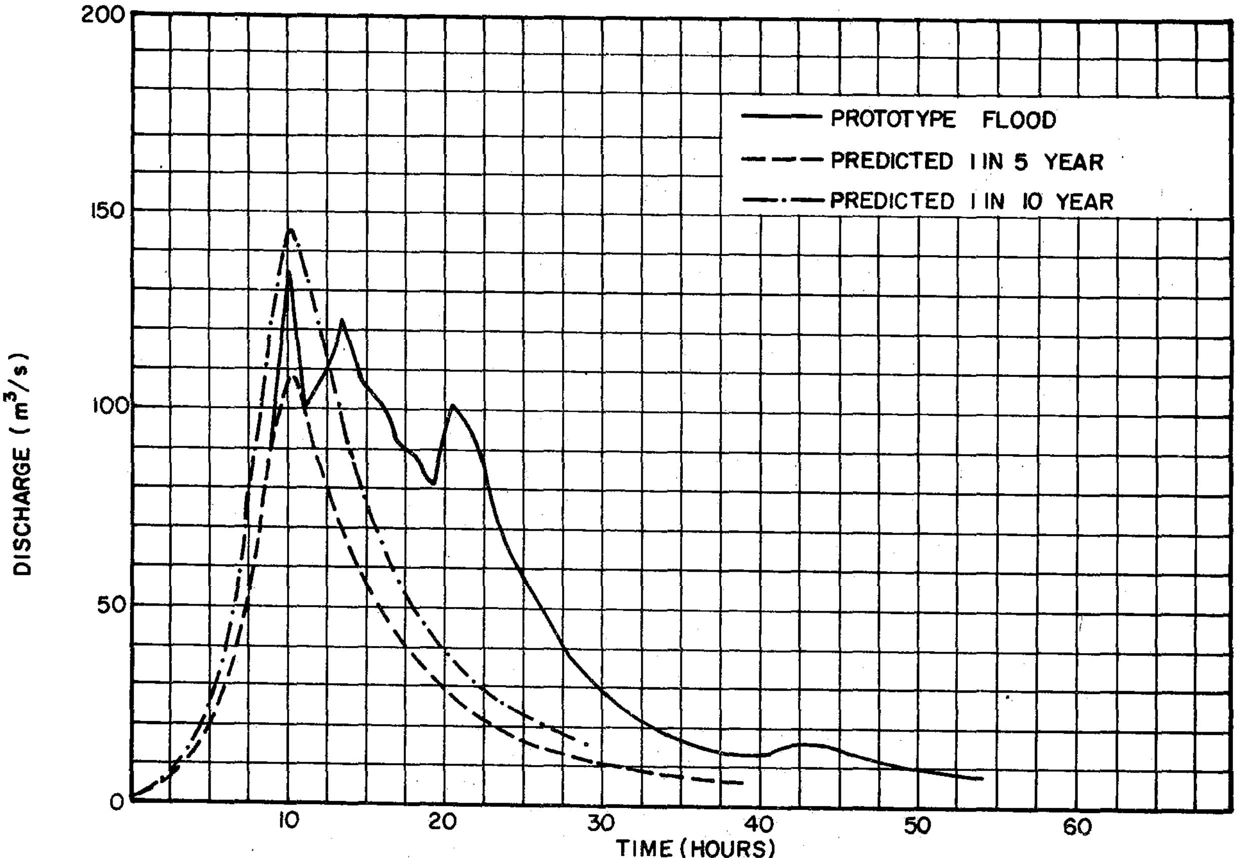



a) DECEMBER 1980




b) MAY 1981

| | | |
|---|---|---|
| TRACED : L de J<br>CHECKED : [signature]<br>DATE : Dec '82<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>**COMPARISON BETWEEN OBSERVED AND PREDICTED FLOOD HYDROGRAPHS (UNIT) FOR TOUWS RIVER** | **FIGURE**<br>**5 a** |

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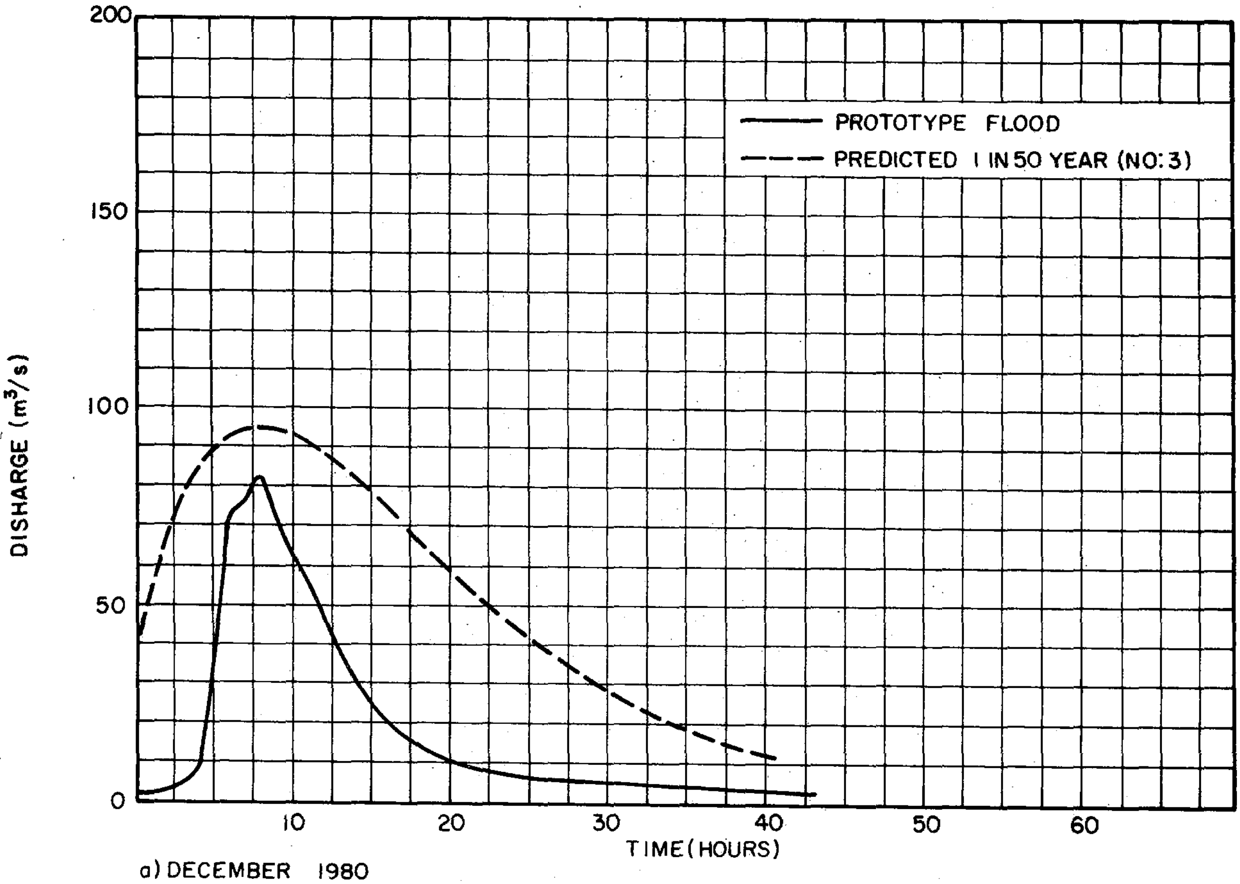
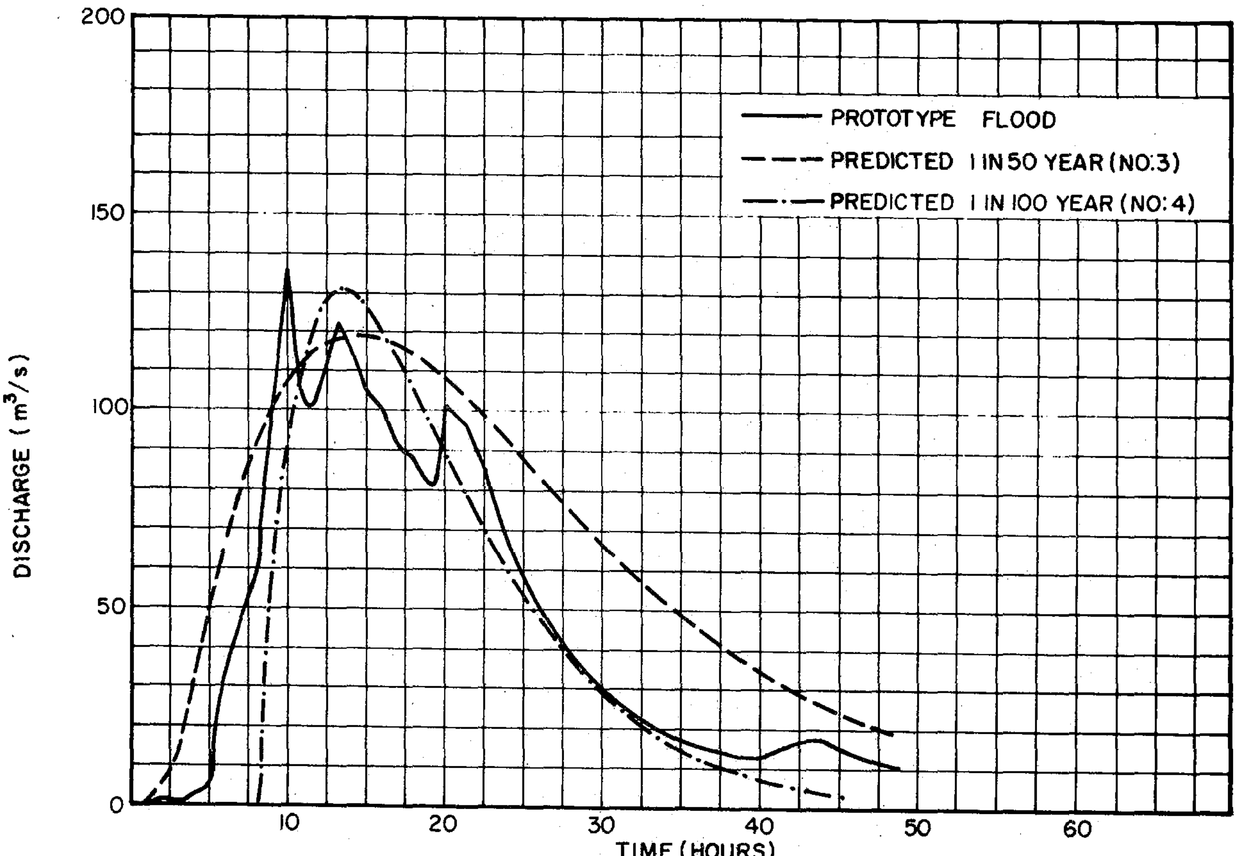



a) DECEMBER 1980




b) MAY 1981

| | | |
|---|---|---|
| TRACED: L de J<br>CHECKED: [signature]<br>DATE: Dec '82<br>REF.: C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>**COMPARISON BETWEEN OBSERVED AND PREDICTED FLOOD HYDROGRAPHS (RUNHYDROGRAPHS) FOR TOUWS RIVER** | **FIGURE 5b** |

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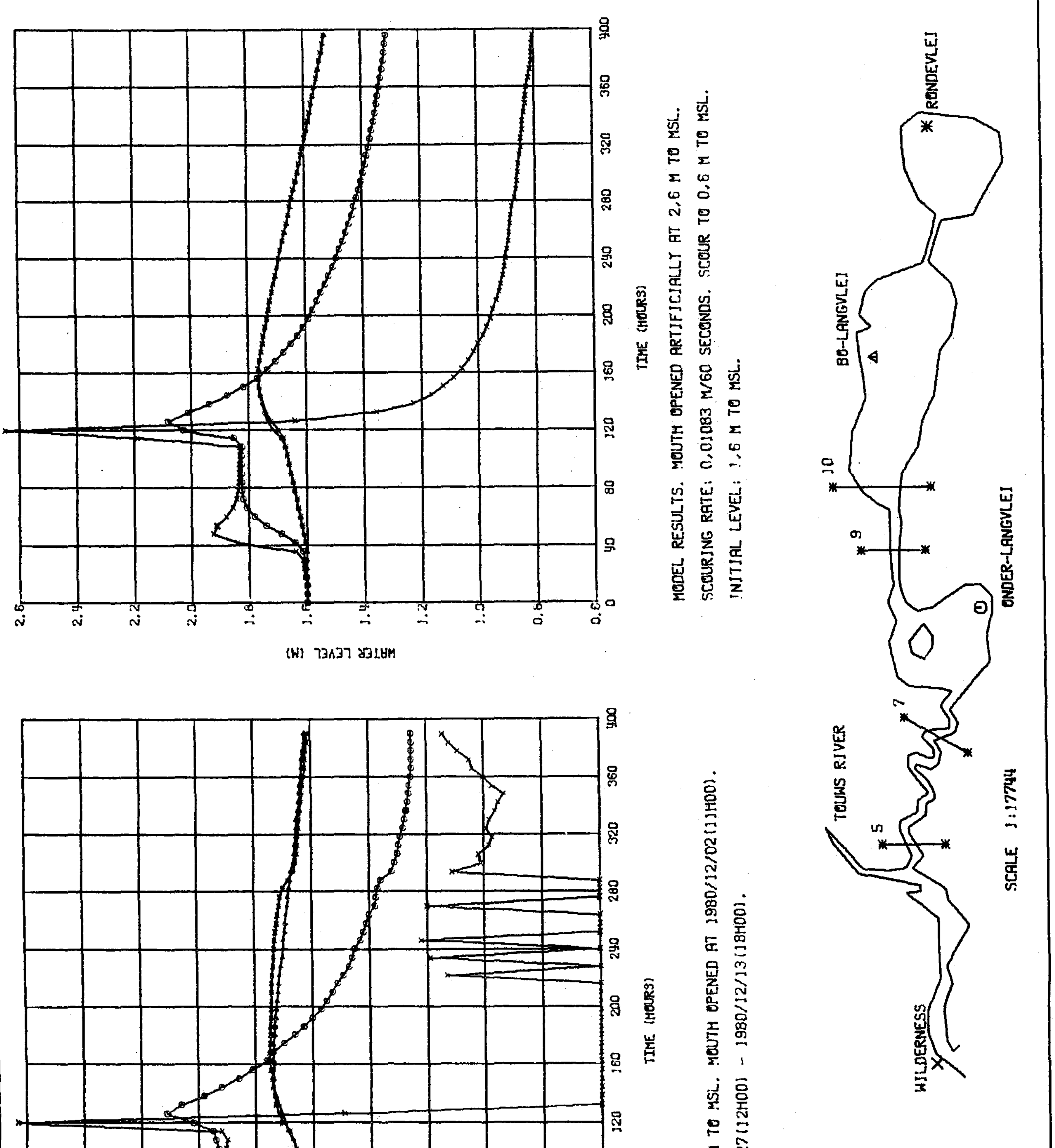


| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 31/04/03.<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>MODEL CALIBRATION. PROTOTYPE DATA -<br>1980/11/27(12H00) - 1980/12/13(18H00). | FIGURE<br>6 |

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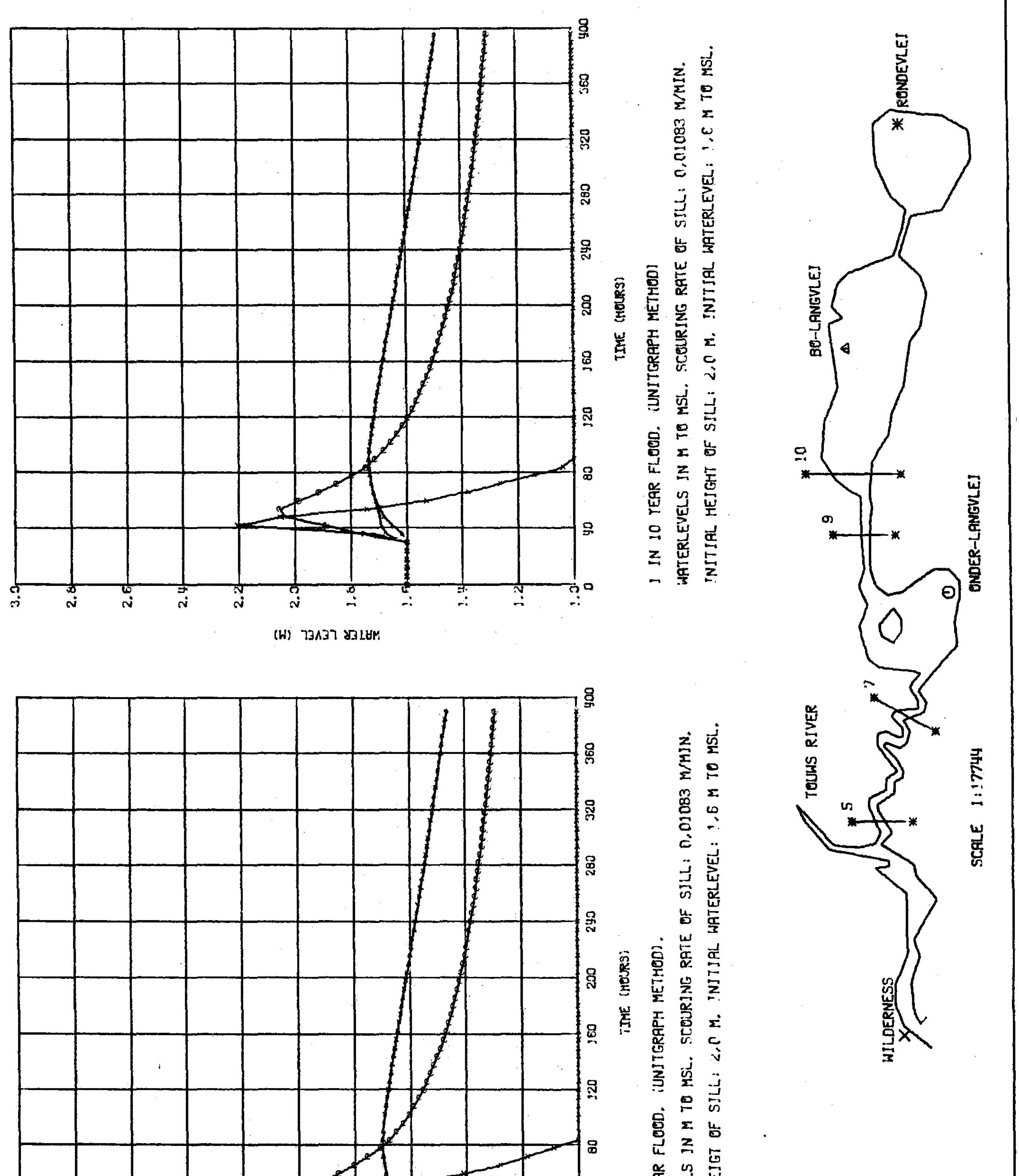
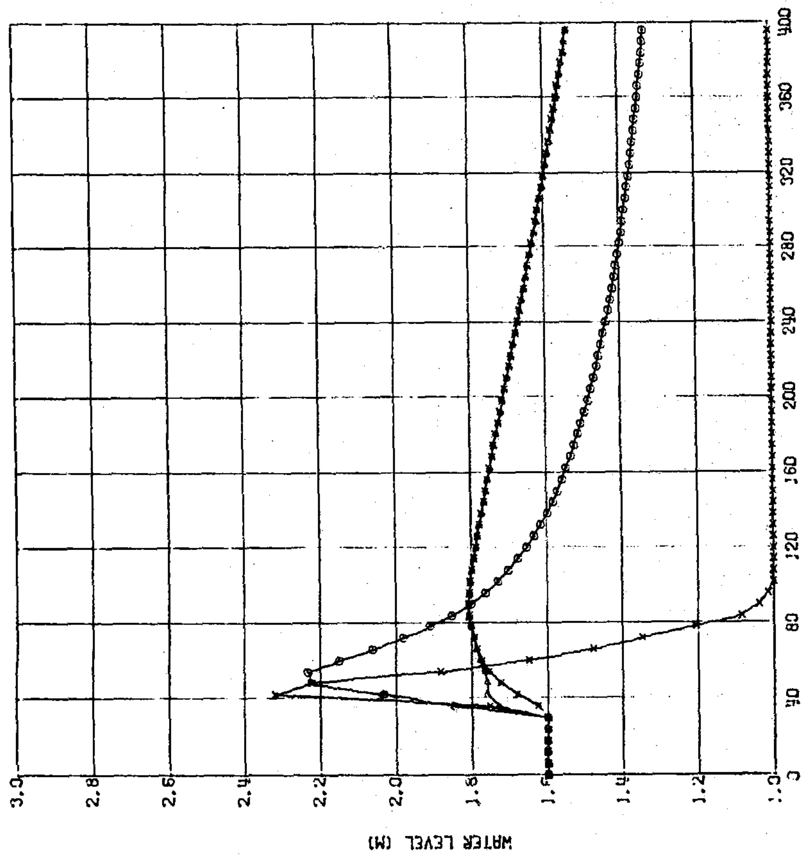
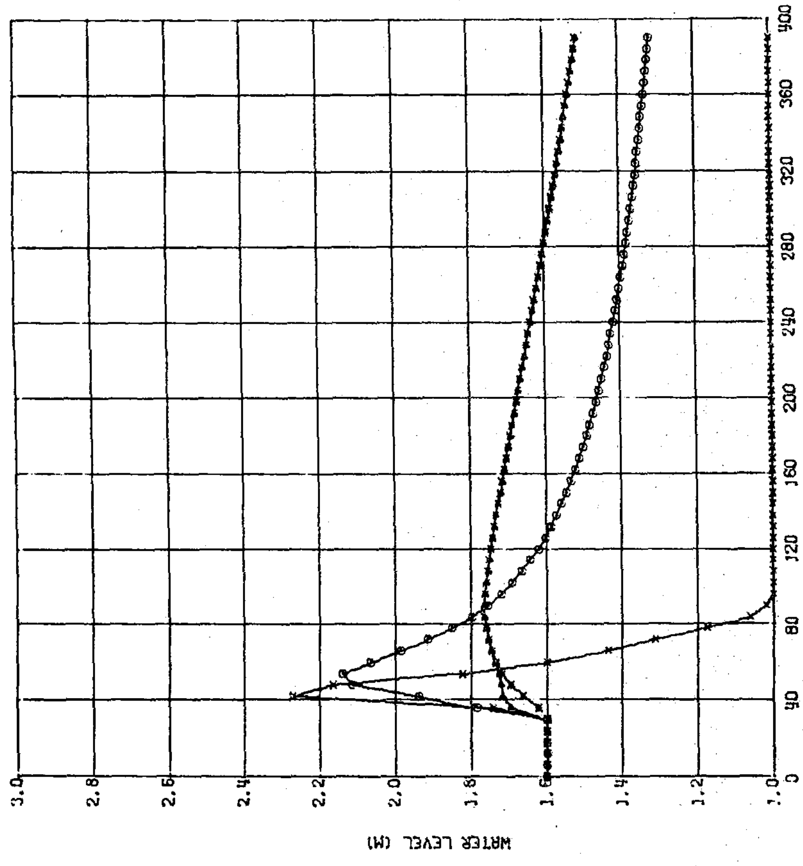



| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 31/11/05.<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 5 AND 1 IN 10 YEAR FLOODS<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.1a |

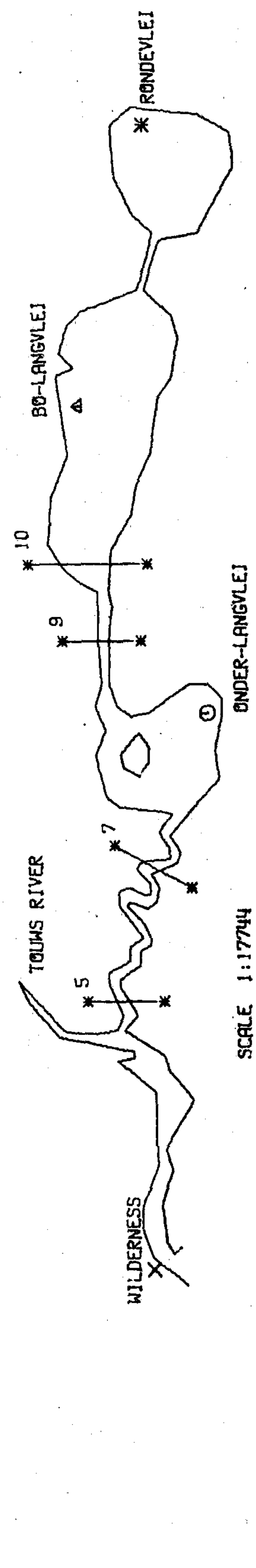
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




1 IN 50 YEAR FLOOD. (UNITGRAPH METHOD)
WATERLEVELS IN M TO MSL. SCOURING RATE OF SILL: 0.01083 M/MIN.
INITIAL HEIGHT OF SILL: 2.0 M. INITIAL WATERLEVEL: 1.6 M TO MSL.




1 IN 20 YEAR FLOOD. (UNITGRAPH METHOD).
WATERLEVELS IN M TO MSL. SCOURING RATE OF SILL: 0.01083 M/MIN.
INITIAL HEIGT OF SILL: 2.0 M. INITIAL WATERLEVEL: 1.6 M TO MSL.




TRACED : COMPLOT
CHECKED : WAMB
DATE : 31/11/05.
REF. C/SEA 8255

WILDERNESS NUMERICAL STUDY

SIMULATED 1 IN 20 AND 1 IN 50 YEAR FLOOD
SCOURING SILL. (PROTOTYPE SCOURING RATE)

FIGURE 7.1b

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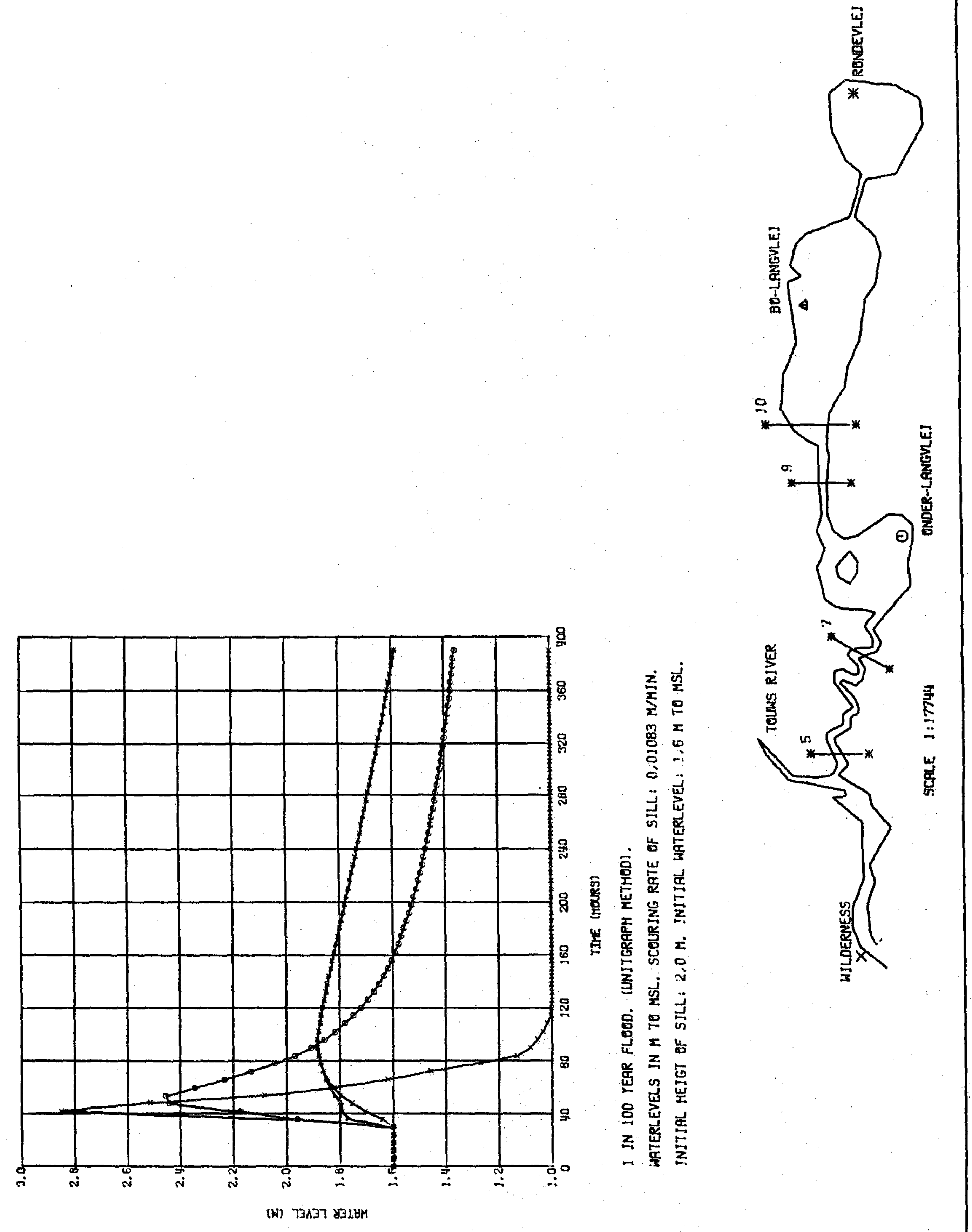
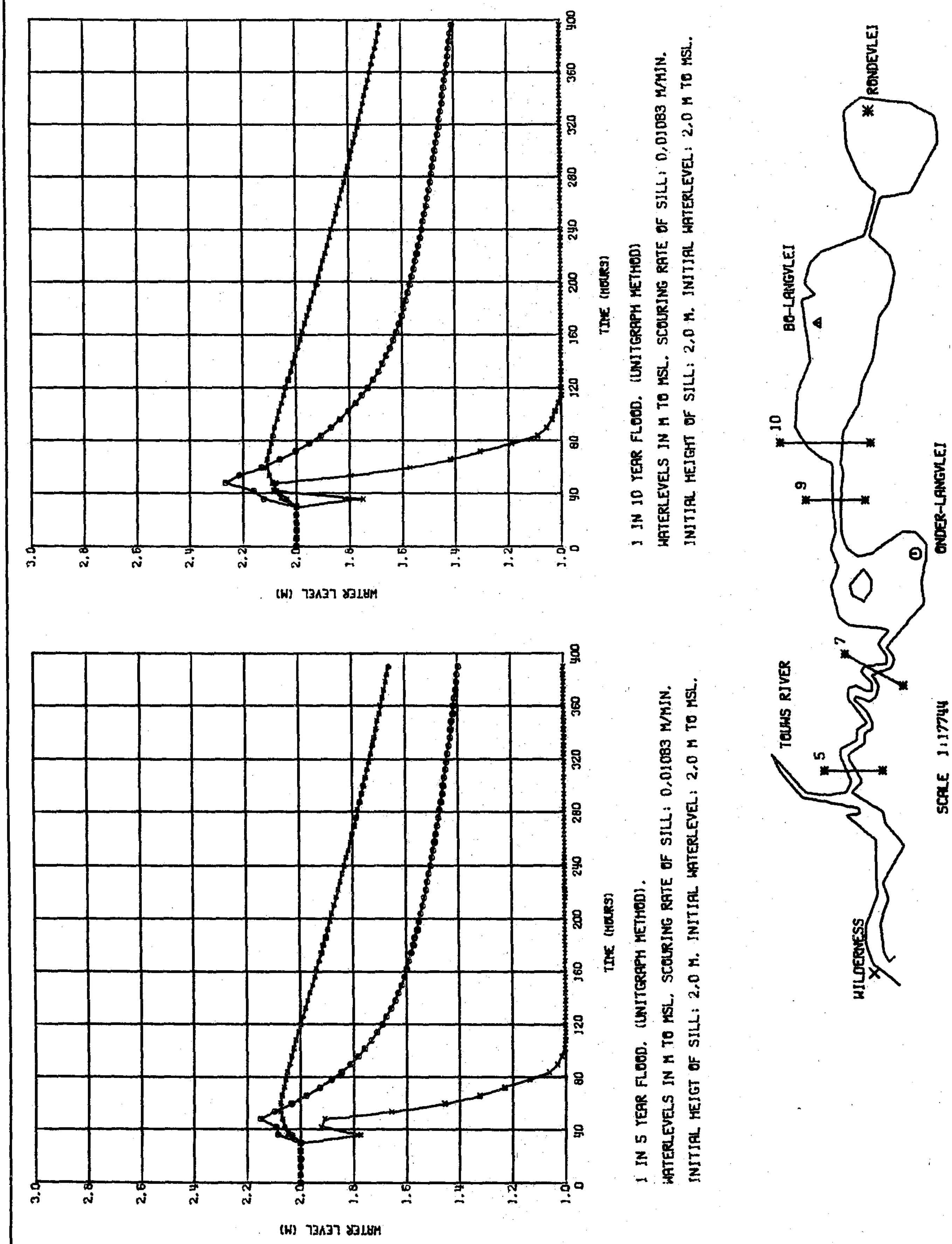


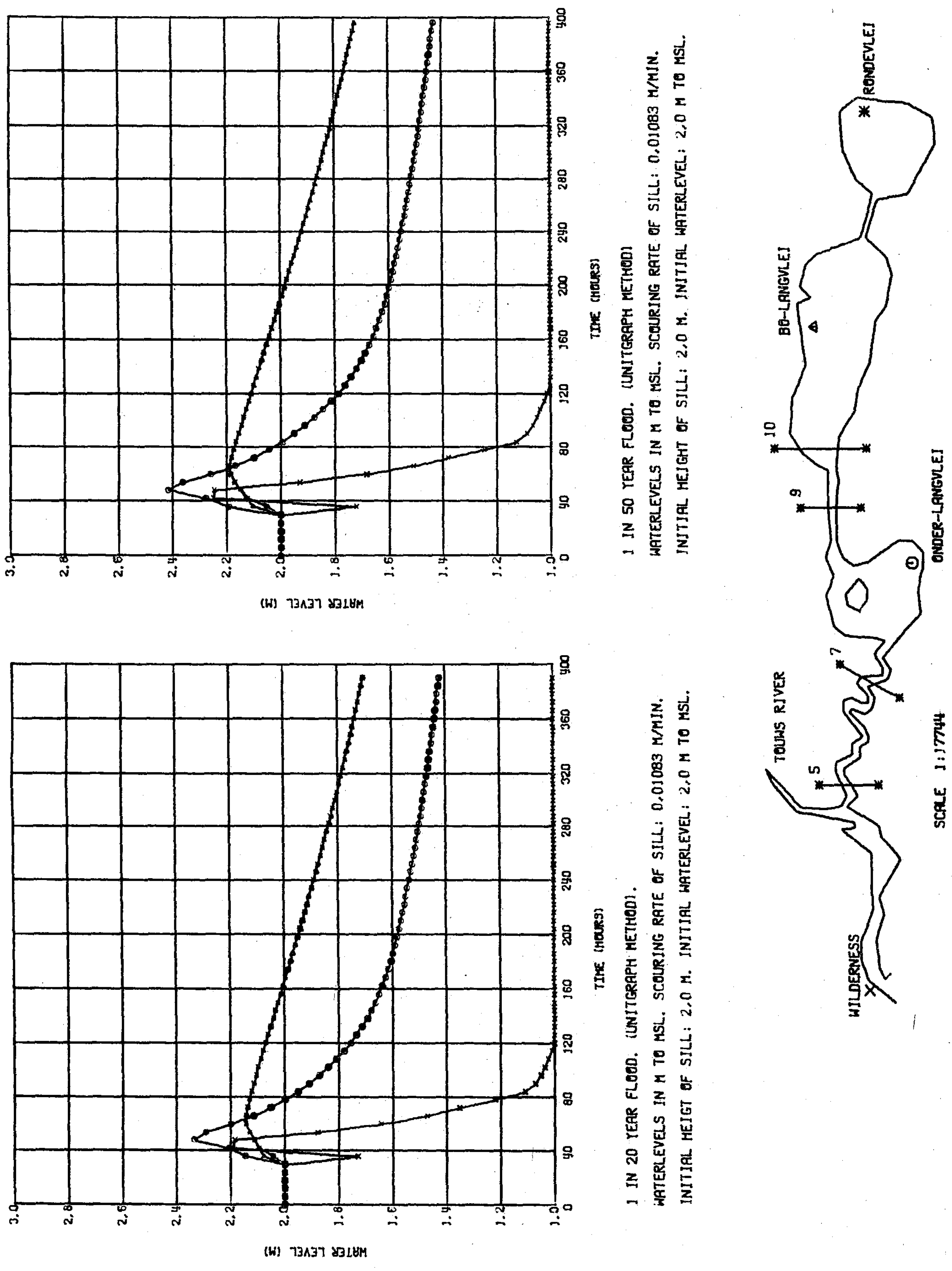

| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 31/11/06.<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 100 YEAR FLOOD (UNIT)<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.1c |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



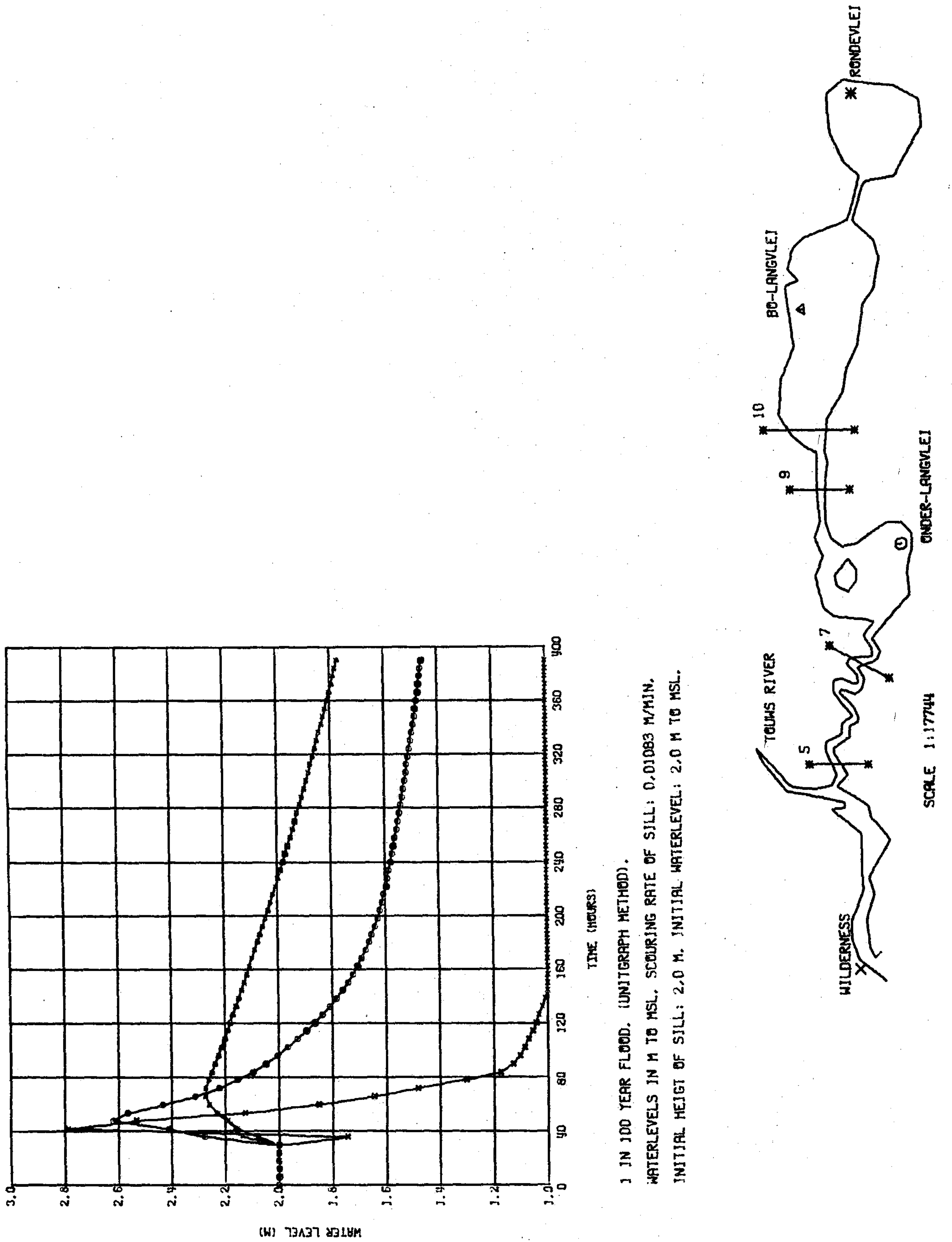

| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 81/11/24.<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 5 AND 1 IN 10 YEAR FLOOD<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.2a |
|---|---|---|

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



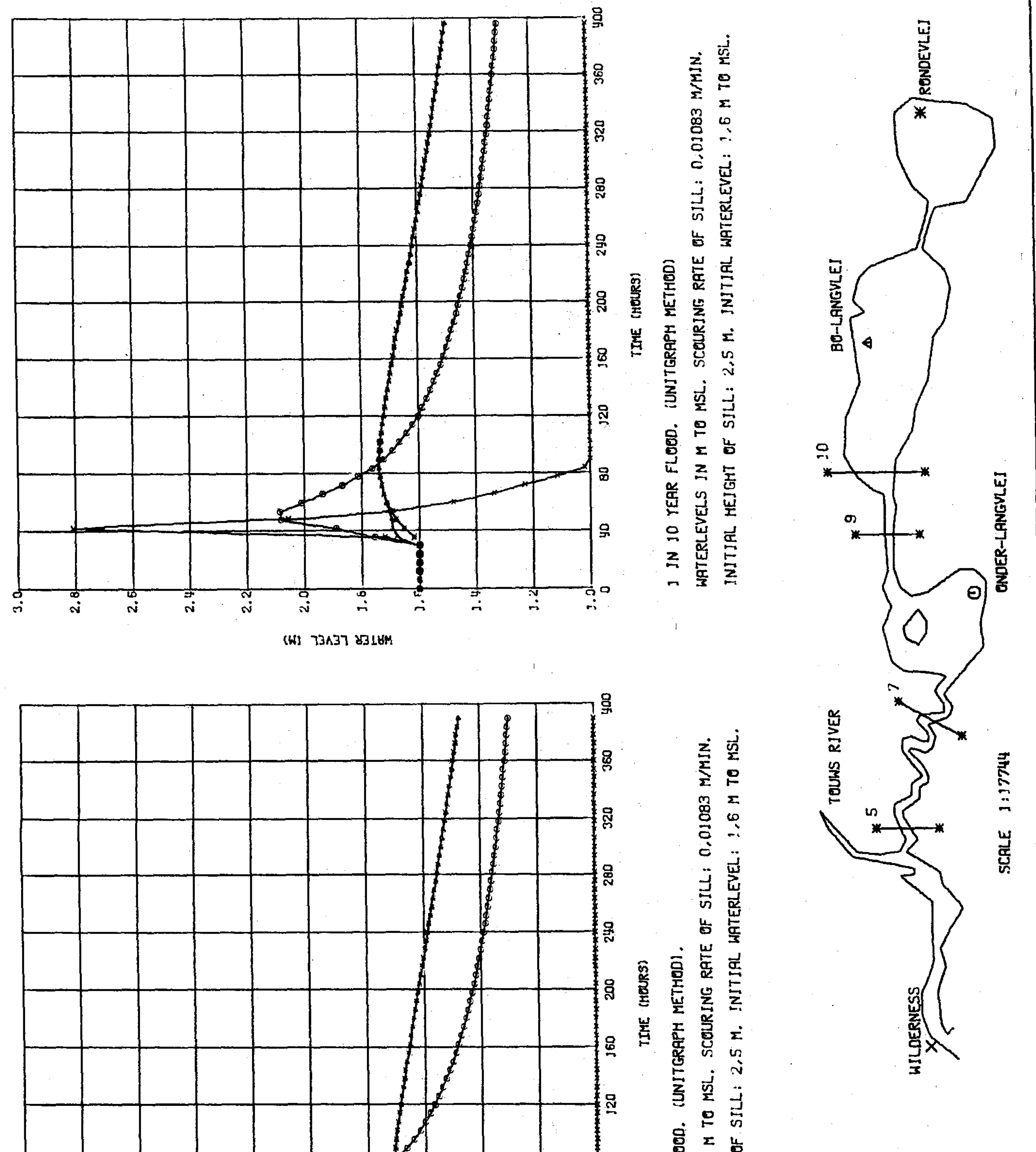

| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 81/11/24.<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 20 AND 1 IN 50 YEAR FLOOD<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.2b |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY



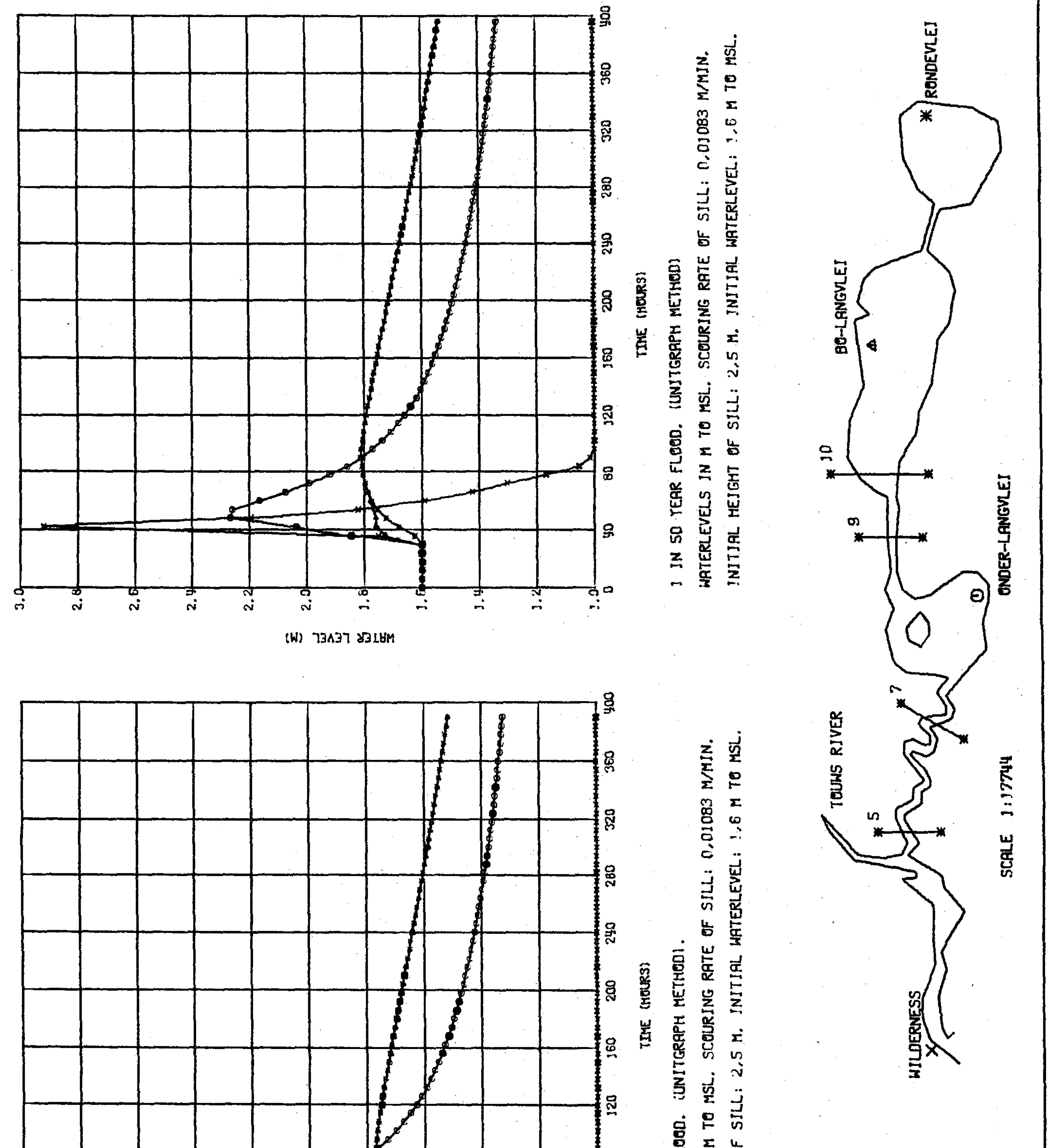

| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 81/11/24.<br>REF. C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 100 YEAR FLOOD (UNIT)<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.2c |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 31/11/30.<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 5 AND 1 IN 10 YEAR FLOOD<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.3a |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




| | | |
|---|---|---|
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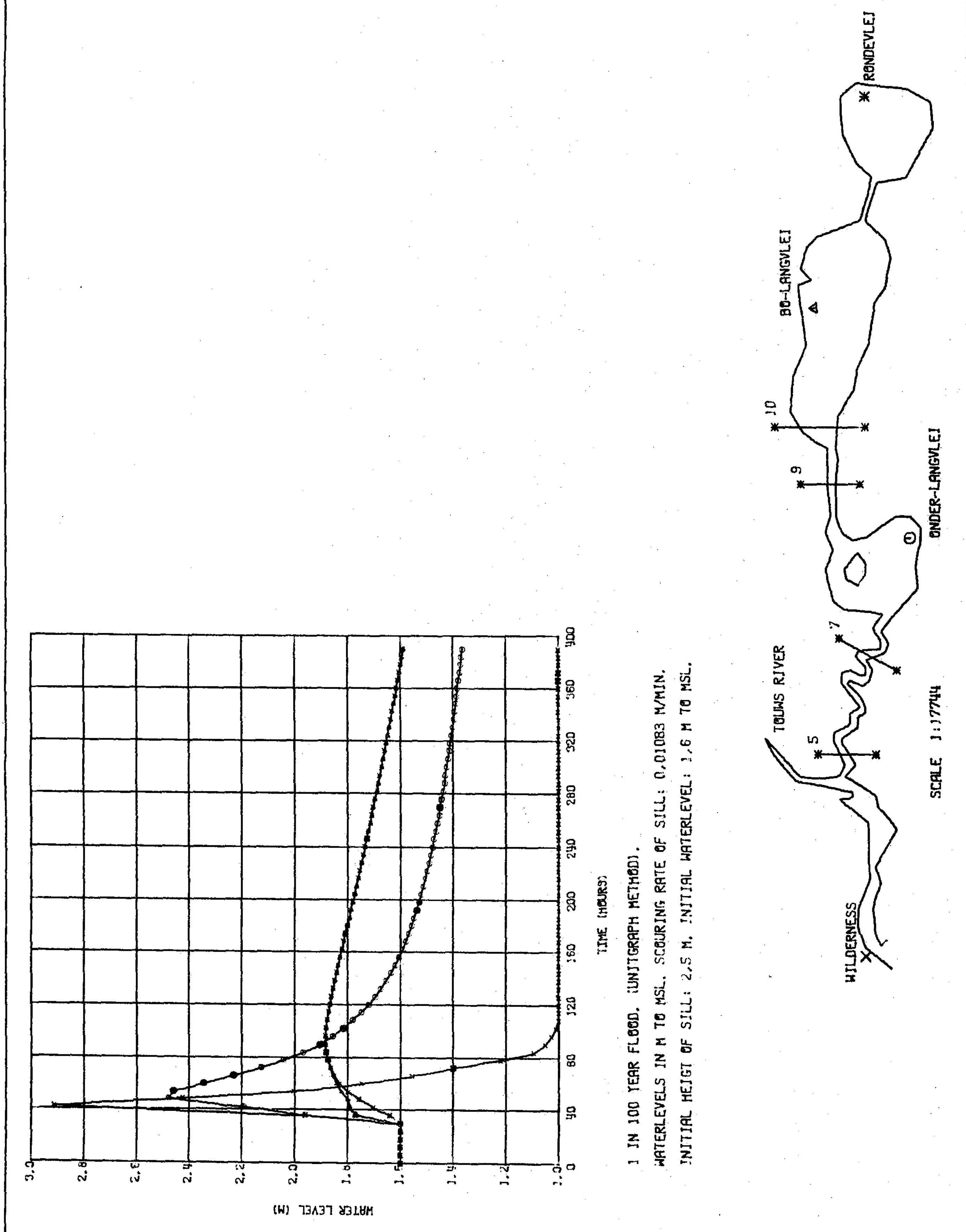
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




TRACED : COMPLOT
CHECKED : WAMB
DATE : 31/12/09.
REF. C/SEA 8255

WILDERNESS NUMERICAL STUDY

SIMULATED 1 IN 100 YEAR FLOOD (UNIT)
SCOURING SILL. (PROTOTYPE SCOURING RATE)

FIGURE 7.3c

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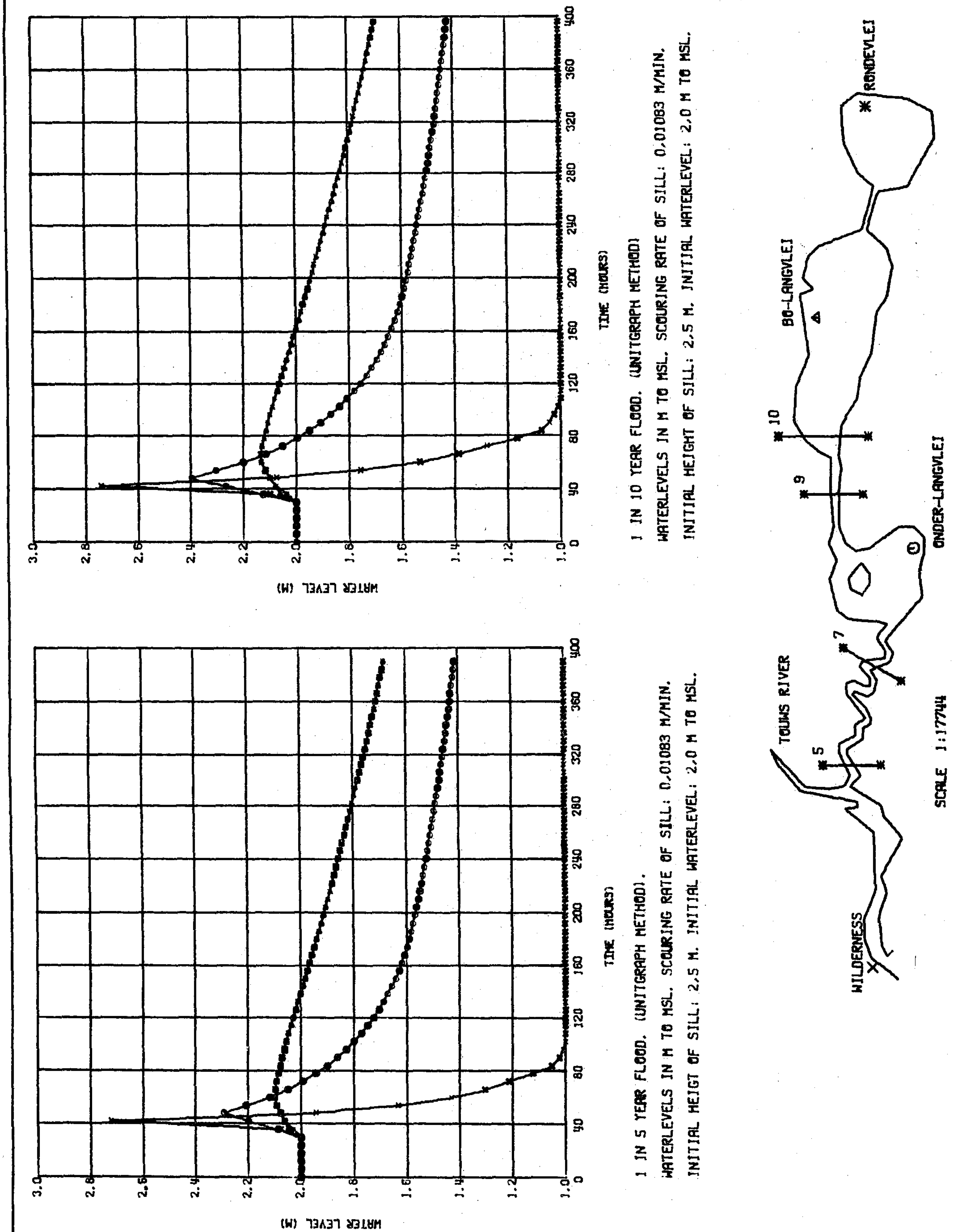
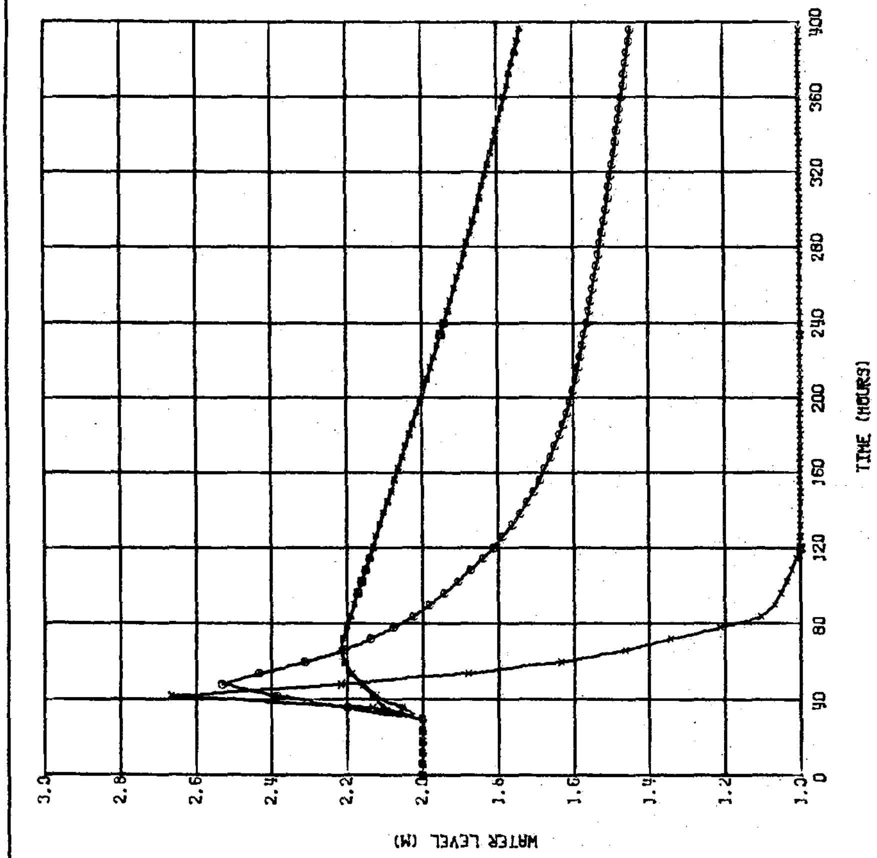
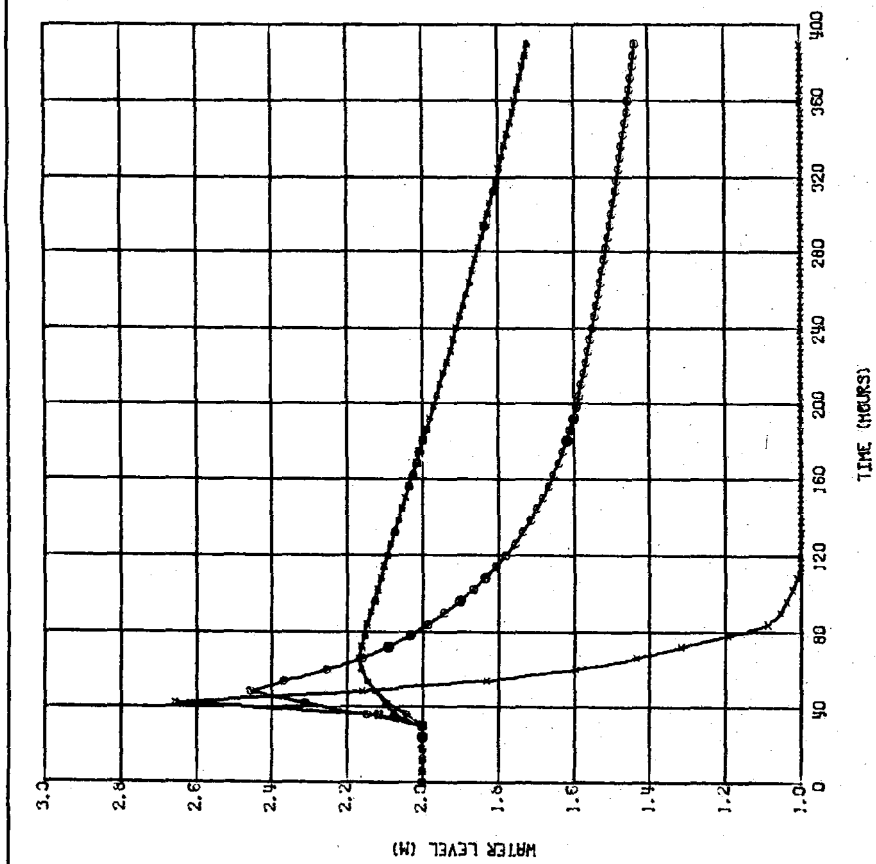



| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 32/01/29.<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 5 AND 1 IN 10 YEAR FLOOD<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.4a |

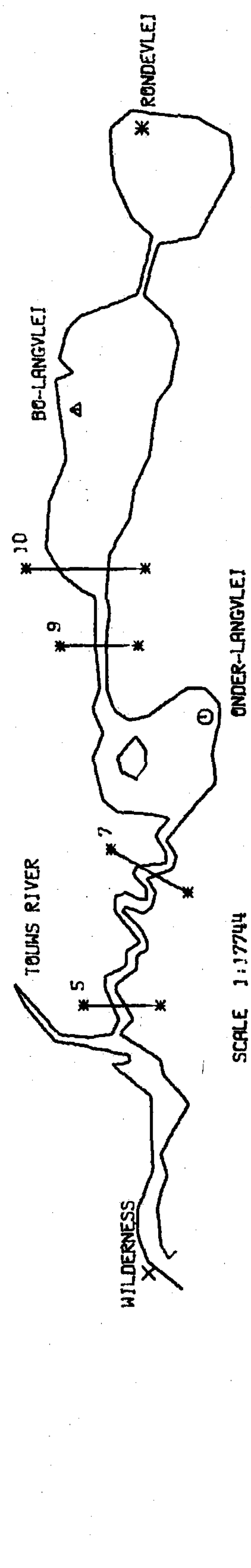
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




1 IN 50 YEAR FLOOD. (UNITGRAPH METHOD)
WATERLEVELS IN M TO MSL. SCOURING RATE OF SILL: 0,01083 M/MIN.
INITIAL HEIGHT OF SILL: 2,5 M. INITIAL WATERLEVEL: 2,0 M TO MSL.

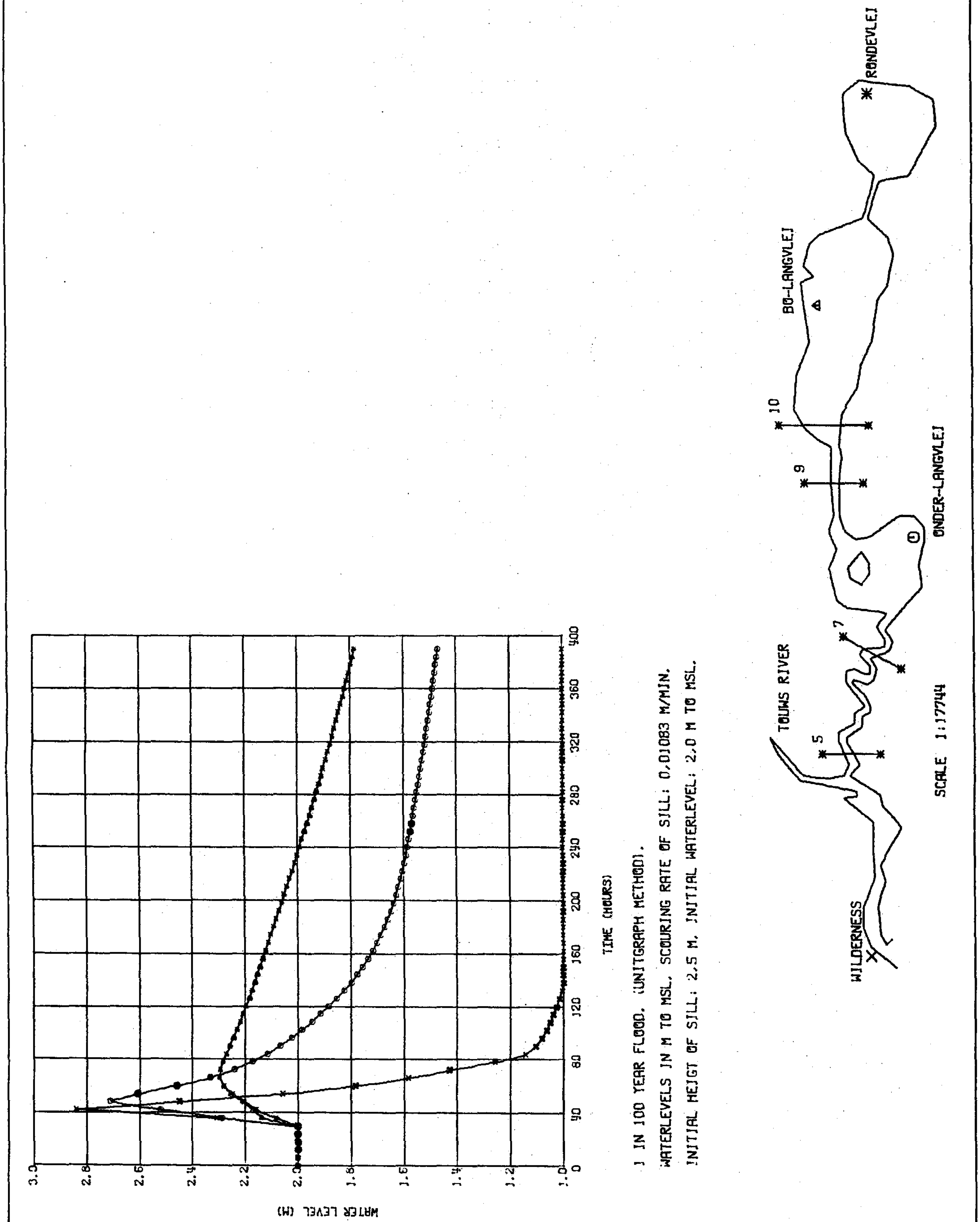



1 IN 20 YEAR FLOOD. (UNITGRAPH METHOD).
WATERLEVELS IN M TO MSL. SCOURING RATE OF SILL: 0,01083 M/MIN.
INITIAL HEIGT OF SILL: 2,5 M. INITIAL WATERLEVEL: 2,0 M TO MSL.



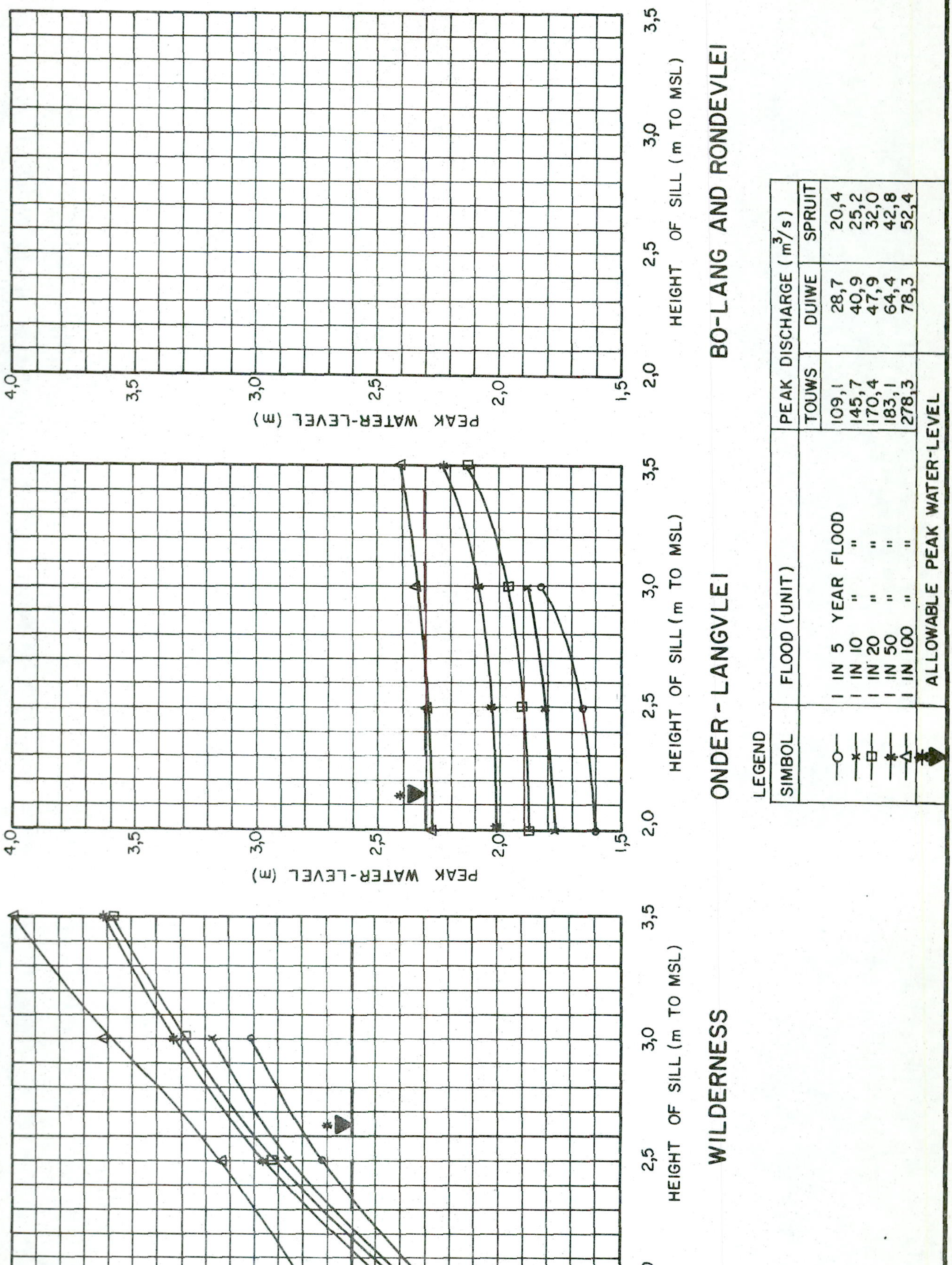

| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 31/12/14.<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 20 AND 1 IN 50 YEAR FLOOD<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.4b |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




| | | |
|---|---|---|
| TRACED : COMPLOT<br>CHECKED : WAMB<br>DATE : 82/01/29.<br>REF. C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>SIMULATED 1 IN 100 YEAR FLOOD (UNIT)<br>SCOURING SILL. (PROTOTYPE SCOURING RATE) | FIGURE<br>7.4c |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY

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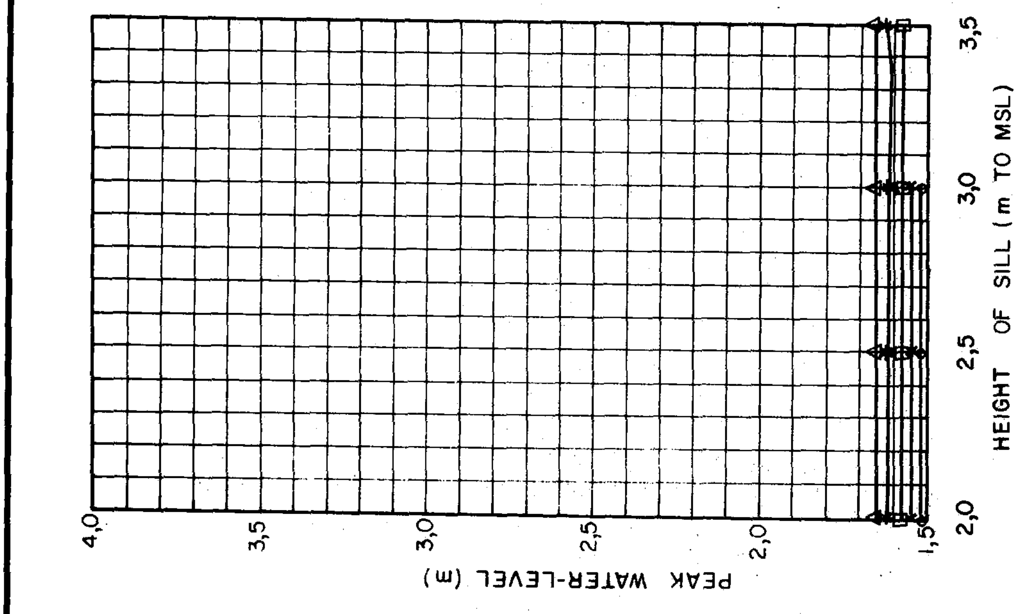
CHECKED : [signature]
DATE : Dec '82
REF. : C/SEA 8255

WILDERNESS NUMERICAL STUDY

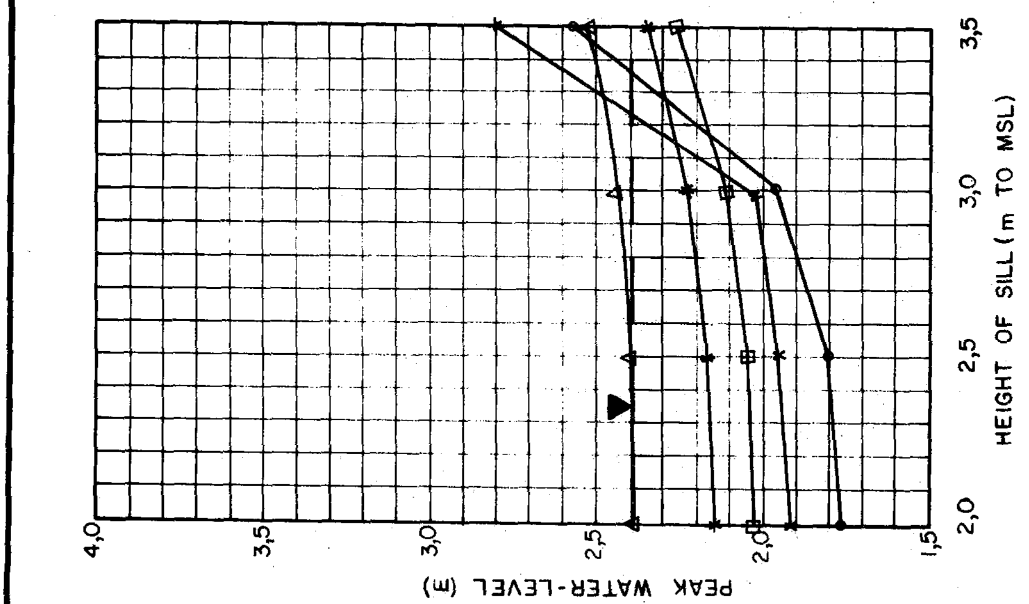
## PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHTS AND PREDICTED FLOODS AND AN INITIAL WATER-LEVEL OF 1,2 m TO MSL

FIGURE 8.1a

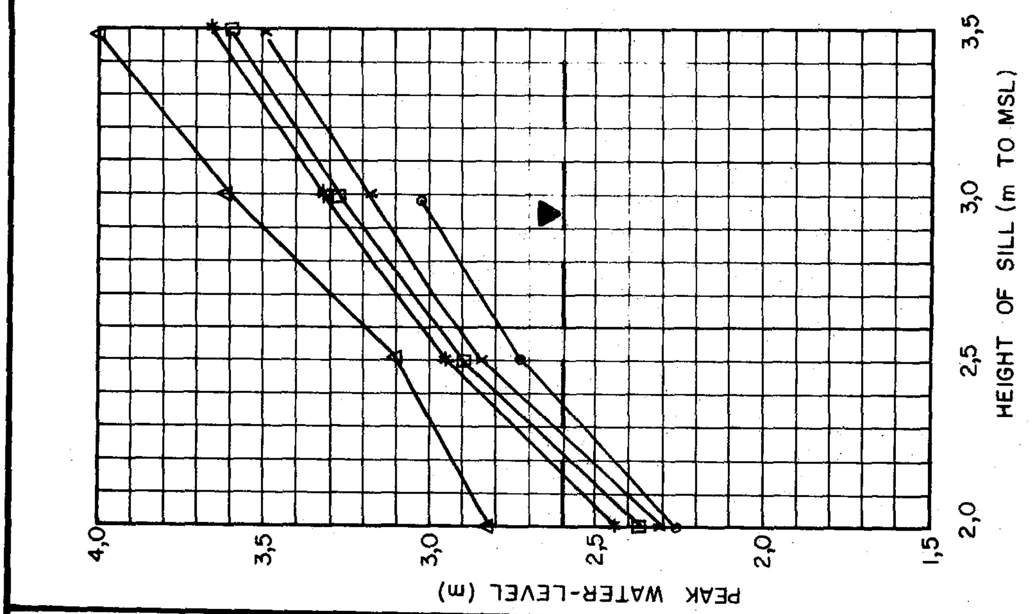
NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




BO-LANG AND RONDEVLEI




ONDER-LANGVLEI




WILDERNESS

LEGEND

| SIMBOL | FLOOD (UNIT) | PEAK DISCHARGE ($m^3/s$) TOUWS | DUIWE | SPRUIT |
|---|---|---|---|---|
| —o— | 1 IN 5 YEAR FLOOD | 109,1 | 28,7 | 20,4 |
| —*— | 1 IN 10 " " | 145,7 | 40,9 | 25,2 |
| —□— | 1 IN 20 " " | 170,4 | 47,9 | 32,0 |
| —×— | 1 IN 50 " " | 183,1 | 64,4 | 42,8 |
| —△— | 1 IN 100 " " | 278,3 | 78,3 | 52,4 |
| ▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

TRACED: L. de J.
CHECKED: [signature]
DATE: C/SEA 8255
REF.: Dec '82

WILDERNESS NUMERICAL STUDY

**PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHTS AND PREDICTED FLOODS AND AN INITIAL WATER-LEVEL OF 1,4 m TO MSL**

FIGURE 8.1b

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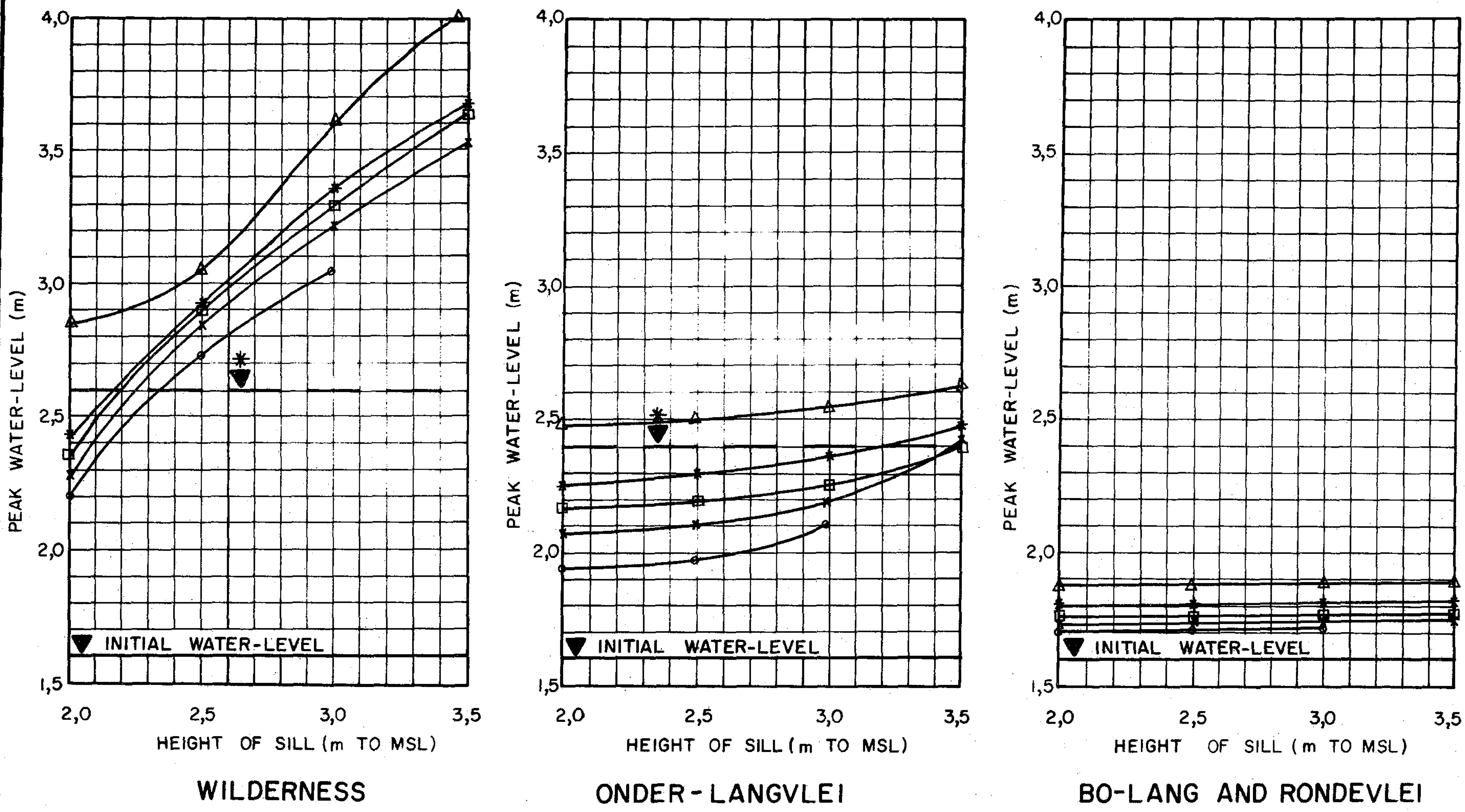


LEGEND

| SIMBOL | FLOOD (UNIT) | PEAK DISCHARGE ($m^3/s$) | | |
|---|---|---|---|---|
| | | TOUWS | DUIWE | SPRUIT |
| —○— | 1 IN 5 YEAR FLOOD | 109,1 | 28,7 | 20,4 |
| —×— | 1 IN 10 " " | 145,7 | 40,9 | 25,2 |
| —□— | 1 IN 20 " " | 170,4 | 47,9 | 32,0 |
| —*— | 1 IN 50 " " | 183,1 | 64,4 | 42,8 |
| —△— | 1 IN 100 " " | 278,3 | 78,3 | 52,4 |
| * ▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

TRACED L de J
CHECKED [signature]
DATE : Dec '82
REF C/SEA 8255

WILDERNESS NUMERICAL STUDY

# PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHTS AND PREDICTED FLOODS AND AN INITIAL WATER-LEVEL OF 1,6 m TO MSL

FIGURE 8.1c

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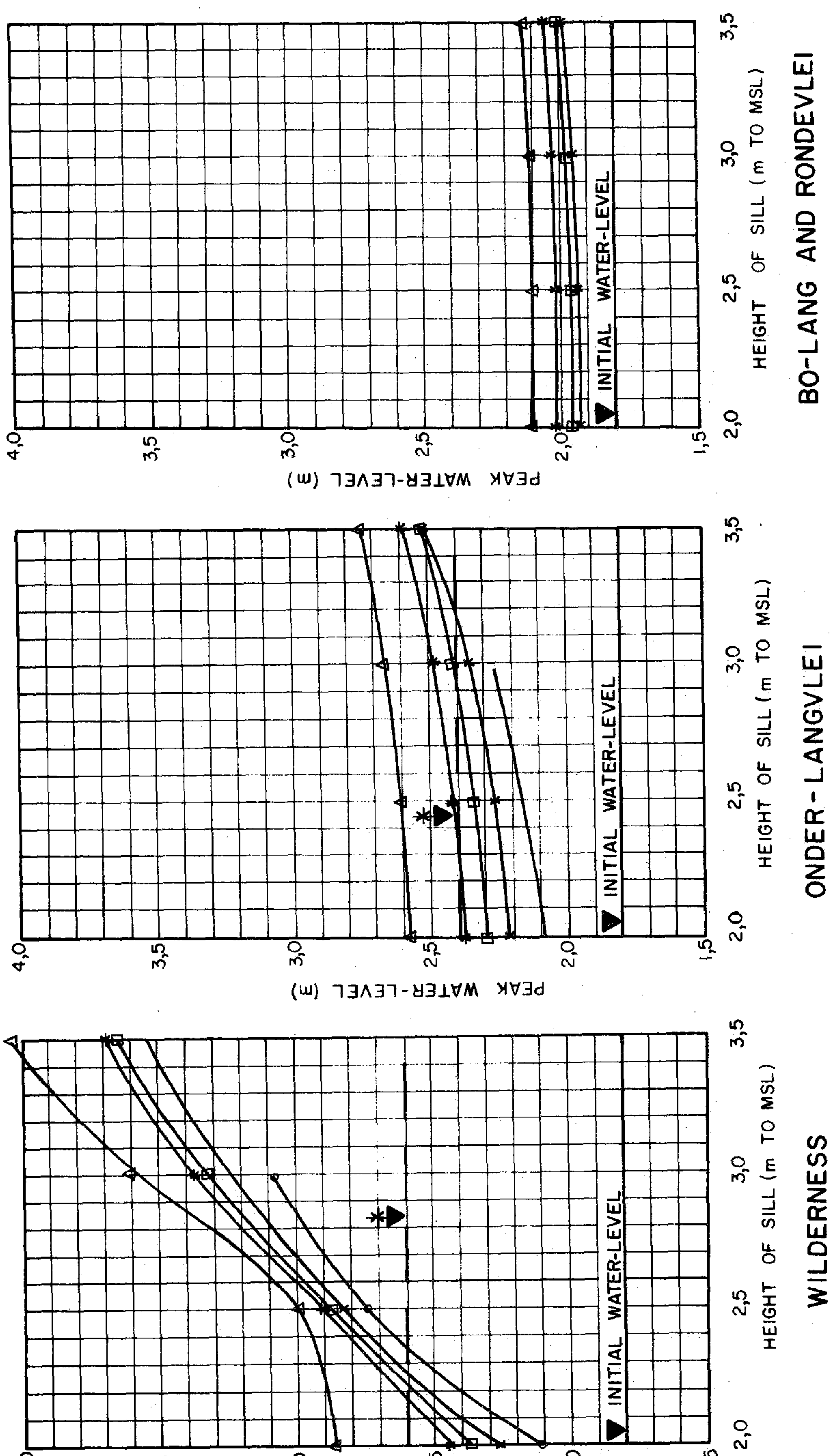


LEGEND

| SIMBOL | FLOOD (UNIT) | PEAK DISCHARGE (m³/s) TOUWS | DUIWE | SPRUIT |
|---|---|---|---|---|
| —o— | 1 IN 5 YEAR FLOOD | 109,1 | 28,7 | 20,4 |
| —*— | 1 IN 10 " " | 145,7 | 40,9 | 25,2 |
| —□— | 1 IN 20 " " | 170,4 | 47,9 | 32,0 |
| —+— | 1 IN 50 " " | 183,1 | 64,4 | 42,8 |
| △ | 1 IN 100 " " | 278,3 | 78,3 | 52,4 |
| ✱▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

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CHECKED : AA.
DATE : Dec '82
REF : C/SEA 8255

WILDERNESS NUMERICAL STUDY

**PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHTS AND PREDICTED FLOODS AND AN INITIAL WATER-LEVEL OF 1,8 m TO MSL**

FIGURE 8.1d

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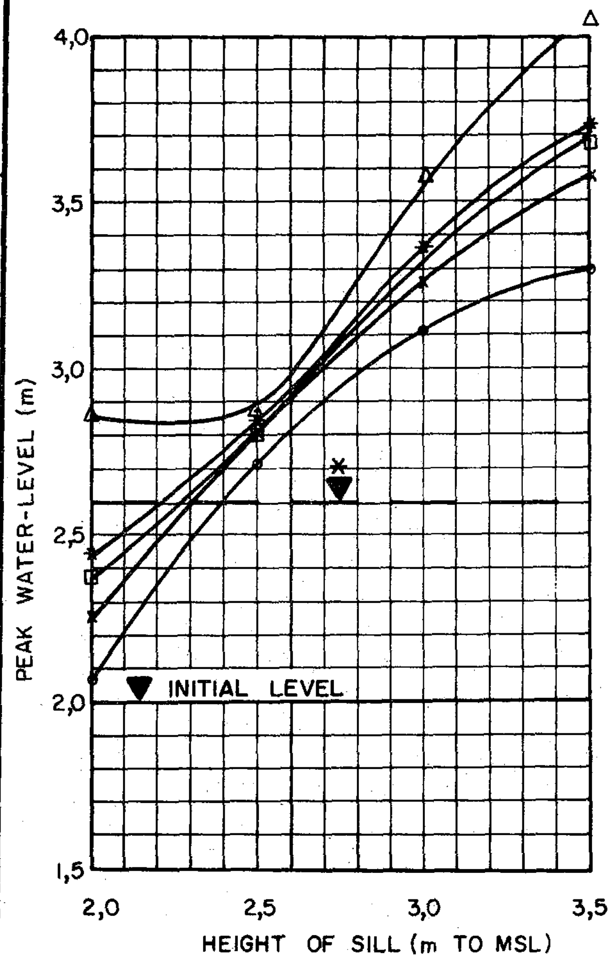
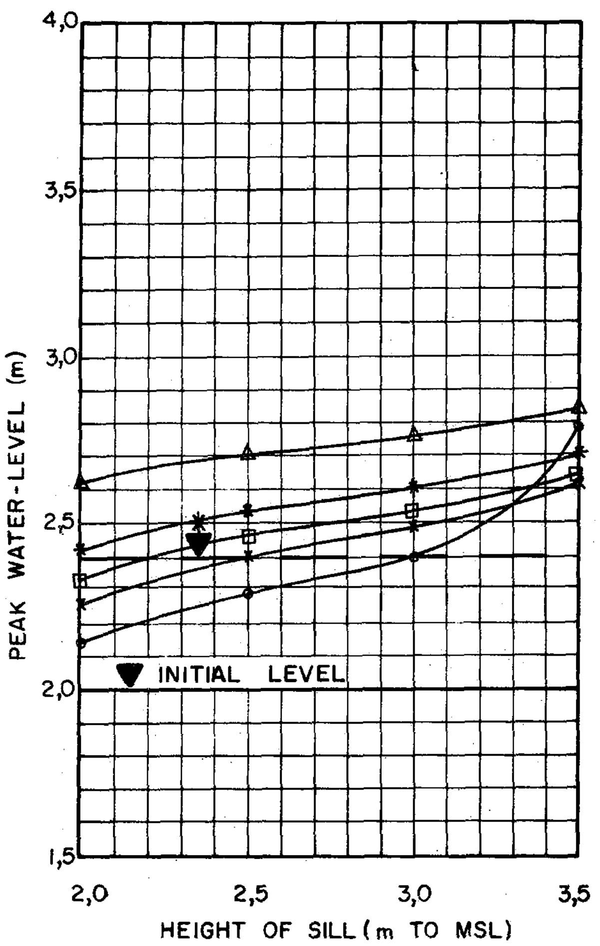
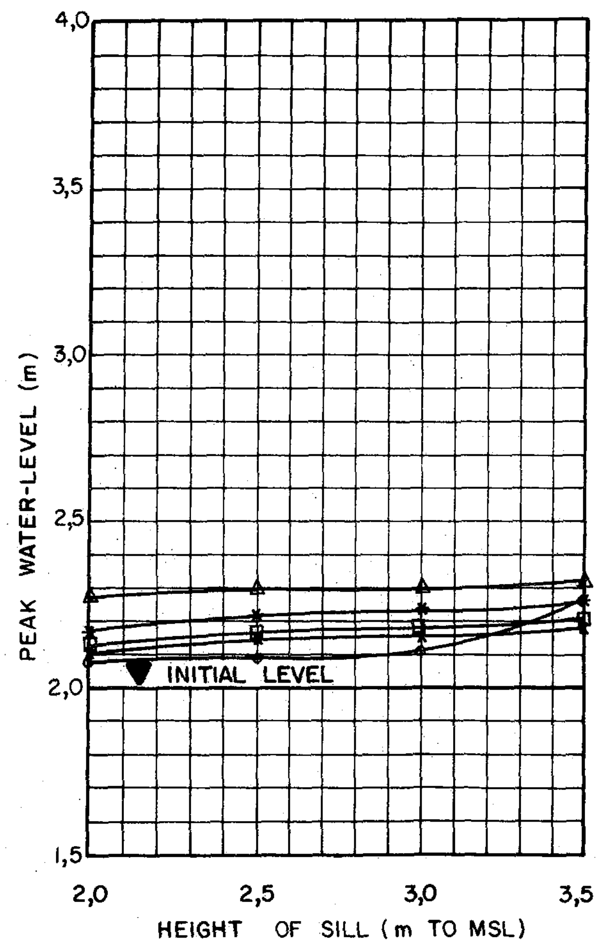



WILDERNESS




ONDER-LANGVLEI




BO-LANG AND RONDEVLEI

LEGEND

| SIMBOL | FLOOD (UNIT) | PEAK DISCHARGE ($m^3/s$) | | |
|---|---|---|---|---|
| | | TOUWS | DUIWE | SPRUIT |
| —o— | 1 IN 5 YEAR FLOOD | 109,1 | 28,7 | 20,4 |
| —x— | 1 IN 10 " " | 145,7 | 40,9 | 25,2 |
| —□— | 1 IN 20 " " | 170,4 | 47,9 | 32,0 |
| —*— | 1 IN 50 " " | 183,1 | 64,4 | 42,8 |
| —△— | 1 IN 100 " " | 278,3 | 78,3 | 52,4 |
| * ▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

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DATE : Dec '82
REF. : C/SEA 8255

WILDERNESS NUMERICAL STUDY

# PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHTS AND PREDICTED FLOODS AND AN INITIAL WATER-LEVEL OF 2,0 m TO MSL

FIGURE 8.1e

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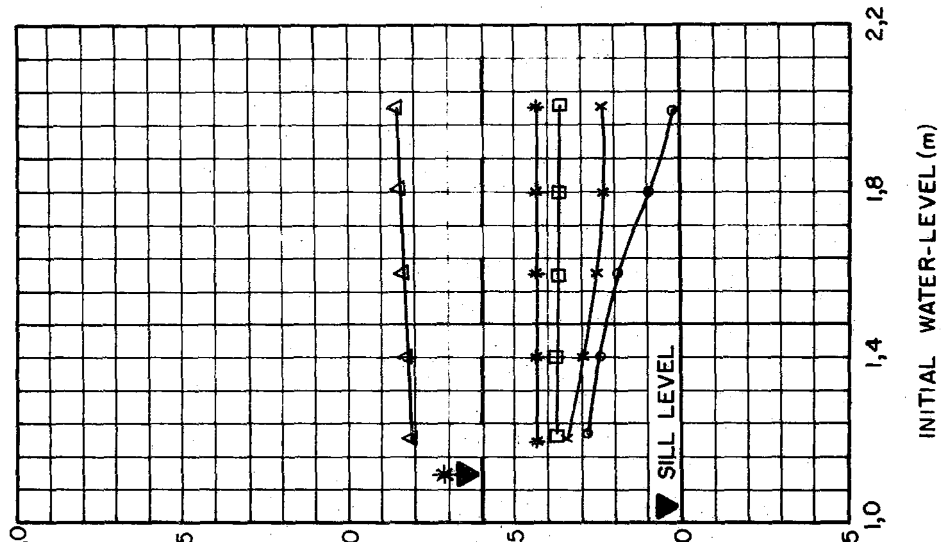
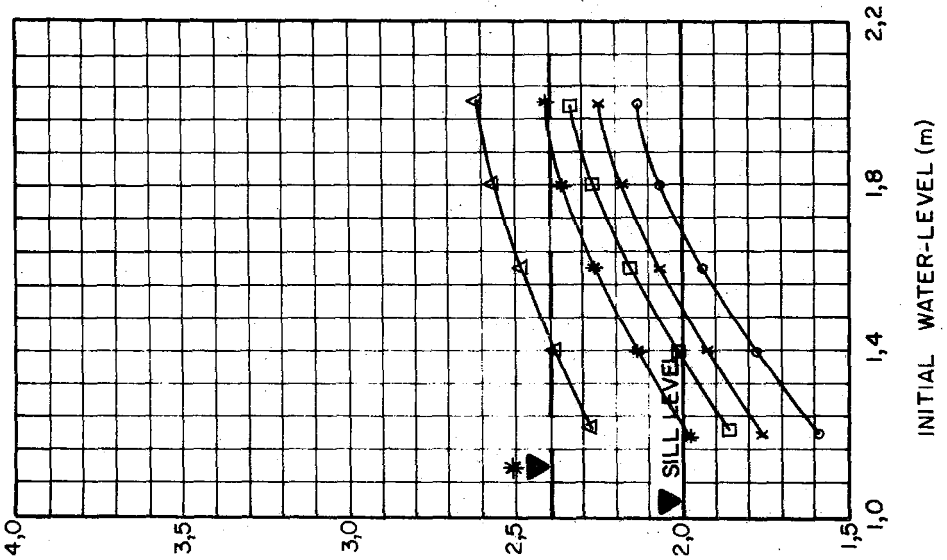
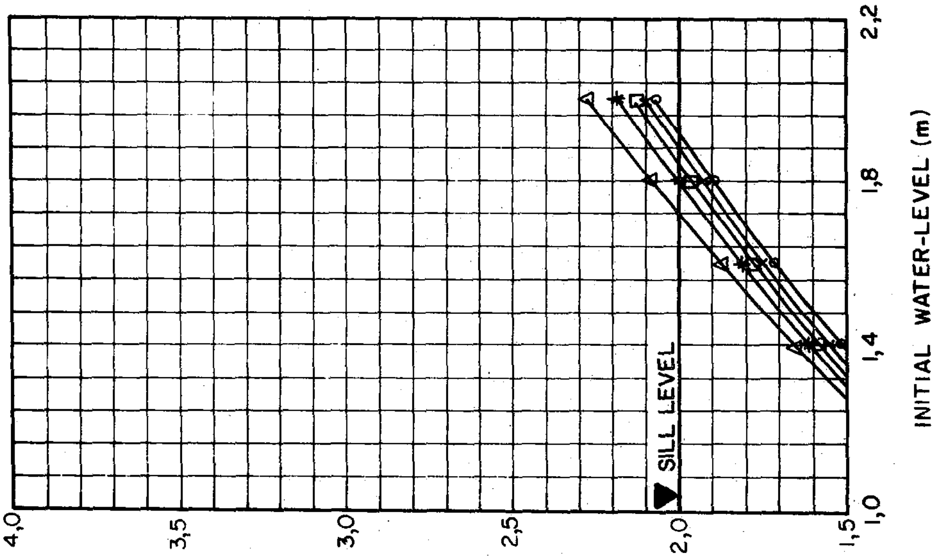



WILDERNESS




ONDER-LANGVLEI



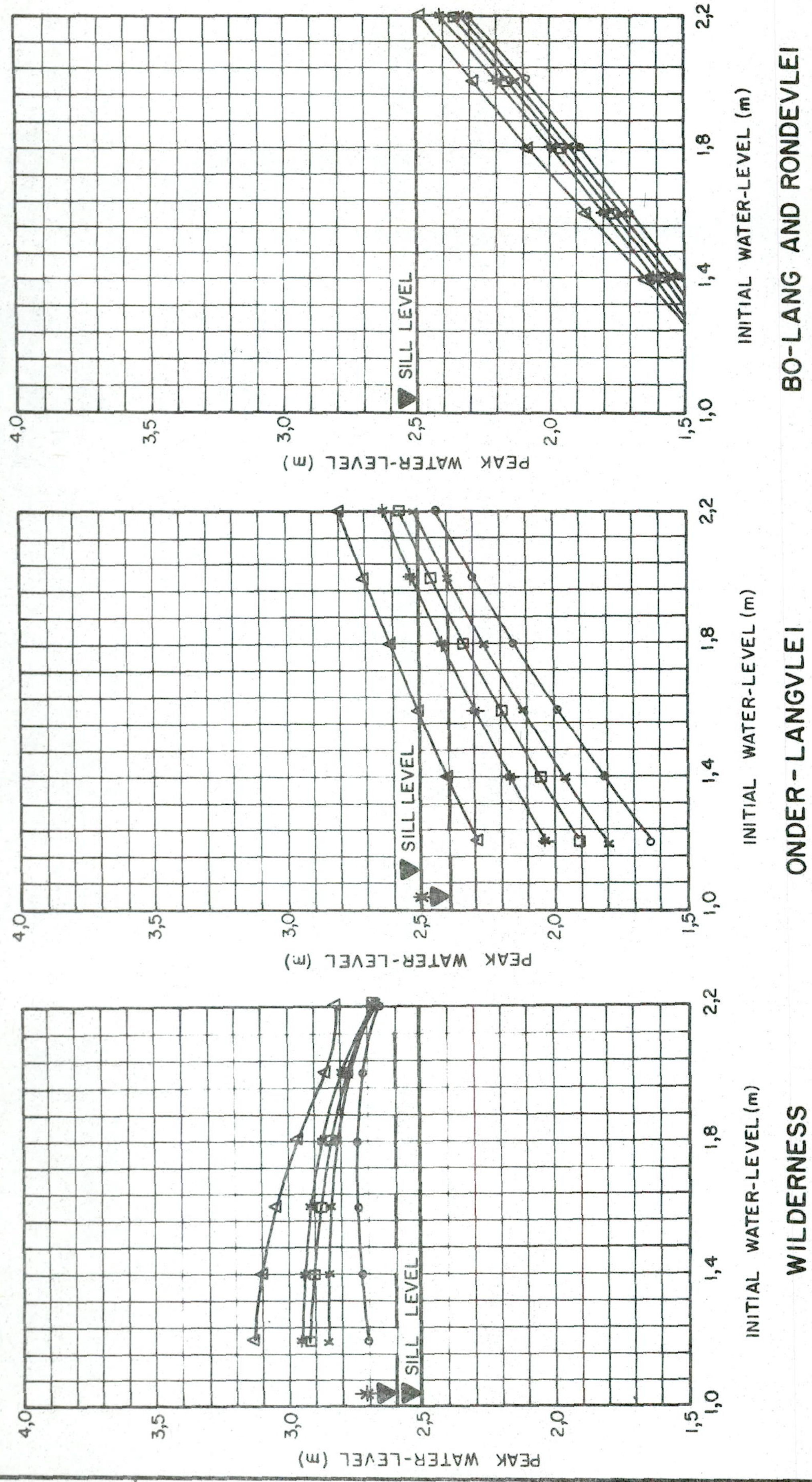

BO-LANG AND RONDEVLEI

LEGEND

| SIMBOL | FLOOD (UNIT) | PEAK DISCHARGE ( $m^3/s$ ) | | |
|---|---|---|---|---|
| | | TOUWS | DUIWE | SPRUIT |
| –○– | 1 IN 5 YEAR FLOOD | 109,1 | 28,7 | 20,4 |
| –*– | 1 IN 10 " " | 145,7 | 40,9 | 25,2 |
| –□– | 1 IN 20 " " | 170,4 | 47,9 | 32,0 |
| –×– | 1 IN 50 " " | 183,1 | 64,4 | 42,8 |
| –△– | 1 IN 100 " " | 278,3 | 78,3 | 52,4 |
| ▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

| | | |
|---|---|---|
| TRACED L de J<br>CHECKED [signature]<br>DATE Dec '82<br>REF C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>**PEAK WATER-LEVEL AT THE LAKES FOR A SILL HEIGHT OF 2,0 m TO MSL** | FIGURE<br>**8.2a** |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




LEGEND

| SIMBOL | FLOOD (UNIT) | PEAK DISCHARGE ($m^3/s$) TOUWS | DUIWE | SPRUIT |
|---|---|---|---|---|
| —o— | 1 IN 5 YEAR FLOOD | 109,1 | 28,7 | 20,4 |
| —x— | 1 IN 10 " " | 145,7 | 40,9 | 25,2 |
| —□— | 1 IN 20 " " | 170,4 | 47,9 | 32,0 |
| —✱— | 1 IN 50 " " | 183,1 | 64,4 | 42,8 |
| —△— | 1 IN 100 " " | 278,3 | 78,3 | 52,4 |
| ▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

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DATE Dec' 82
REF C/SEA 8255

WILDERNESS NUMERICAL STUDY

## PEAK WATER-LEVEL AT THE LAKES FOR A SILL HEIGHT OF 2,5 m TO MSL

FIGURE 8.2b

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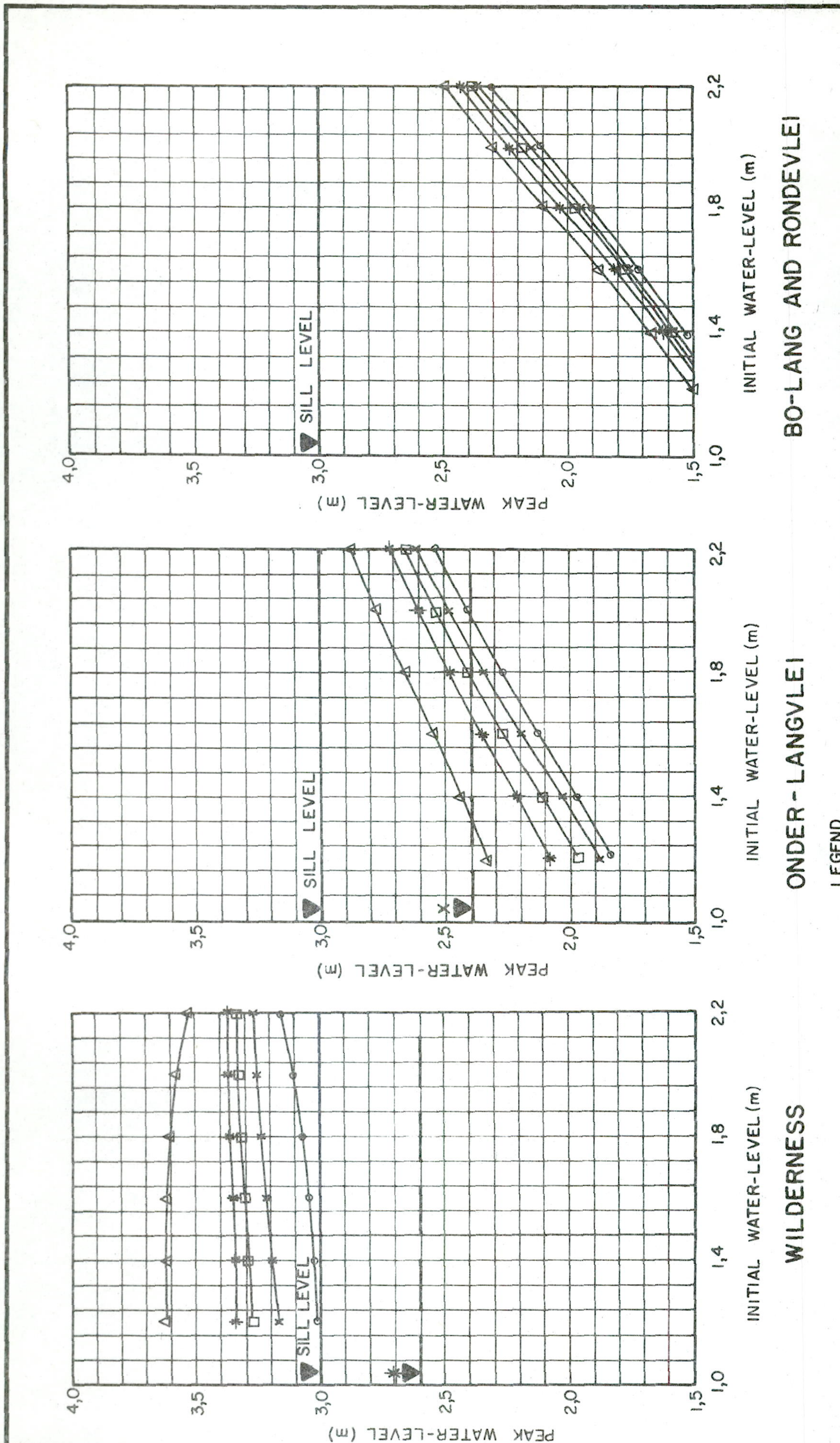


LEGEND

| SIMBOL | FLOOD (UNIT) | PEAK DISCHARGE ( $m^3/s$ ) | | |
|---|---|---|---|---|
| | | TOUWS | DUIWE | SPRUIT |
| ○ | 1 IN 5 YEAR FLOOD | 109,1 | 28,7 | 20,4 |
| × | 1 IN 10 " " | 145,7 | 40,9 | 25,2 |
| □ | 1 IN 20 " " | 170,4 | 47,9 | 32,0 |
| * | 1 IN 50 " " | 183,1 | 64,4 | 42,8 |
| △ | 1 IN 100 " " | 278,3 | 78,3 | 52,4 |
| ▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

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DATE : Dec '82
REF : C/SEA 8255

WILDERNESS NUMERICAL STUDY

PEAK WATER-LEVEL AT THE LAKES FOR A SILL HEIGHT OF 3,0 m TO MSL

FIGURE 8.2 c

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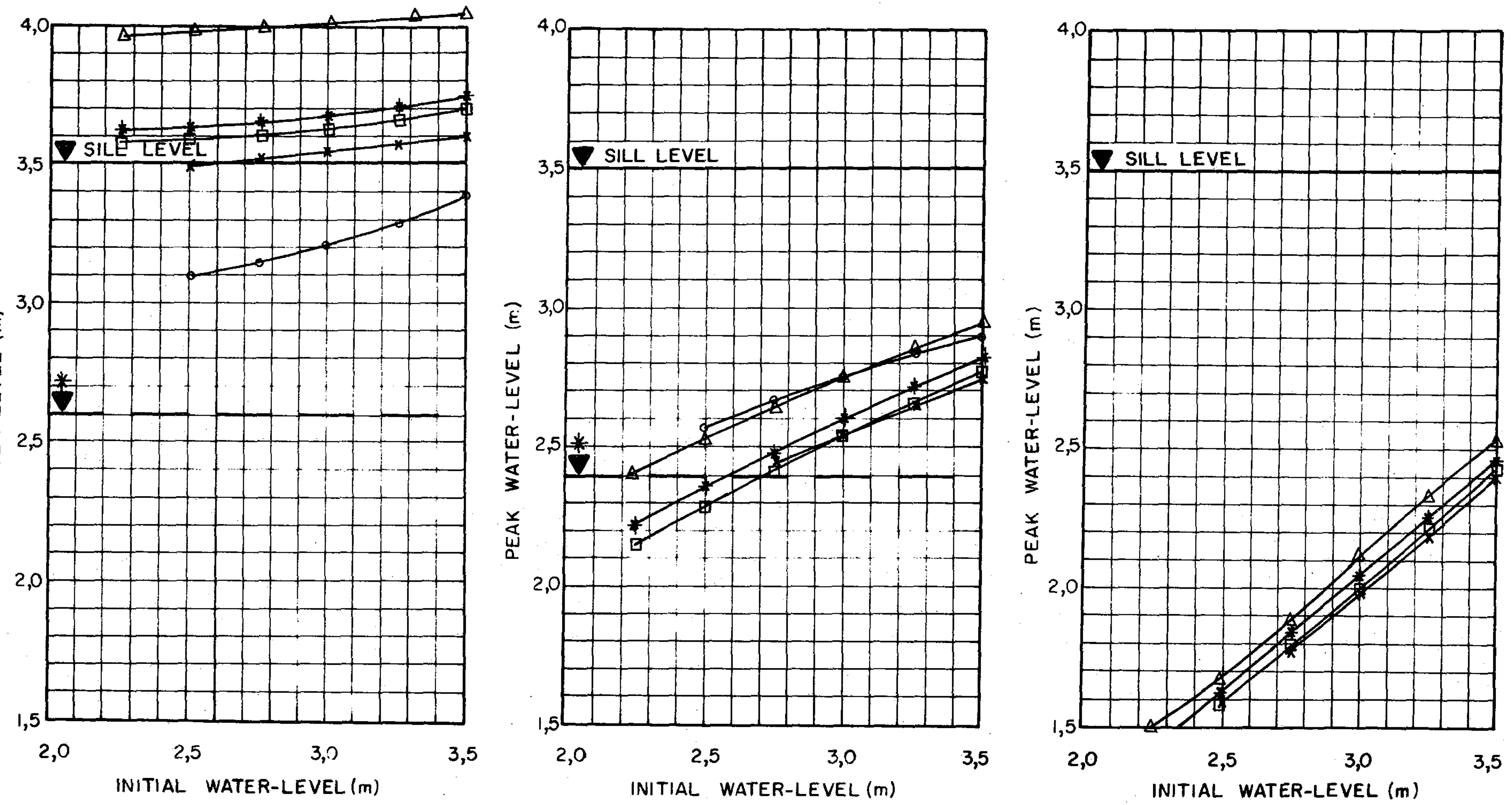


WILDERNESS    ONDER-LANGVLEI    BO-LANG AND RONDEVLEI

LEGEND

| SIMBOL | FLOOD (UNIT) | PEAK DISCHARGE ($m^3/s$) | | |
|---|---|---|---|---|
| | | TOUWS | DUIWE | SPRUIT |
| —o— | 1 IN 5 YEAR FLOOD | 109,1 | 28,7 | 20,4 |
| —×— | 1 IN 10 " " | 145,7 | 40,9 | 25,2 |
| —□— | 1 IN 20 " " | 170,4 | 47,9 | 32,0 |
| —✱— | 1 IN 50 " " | 183,1 | 64,4 | 42,8 |
| —△— | 1 IN 100 " " | 278,3 | 78,3 | 52,4 |
| ✱▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

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DATE: Dec '82
REF: C/SEA 8255

WILDERNESS NUMERICAL STUDY

## PEAK WATER-LEVEL AT THE LAKES FOR A SILL HEIGHT OF 3,5 m TO MSL

FIGURE 8.2d

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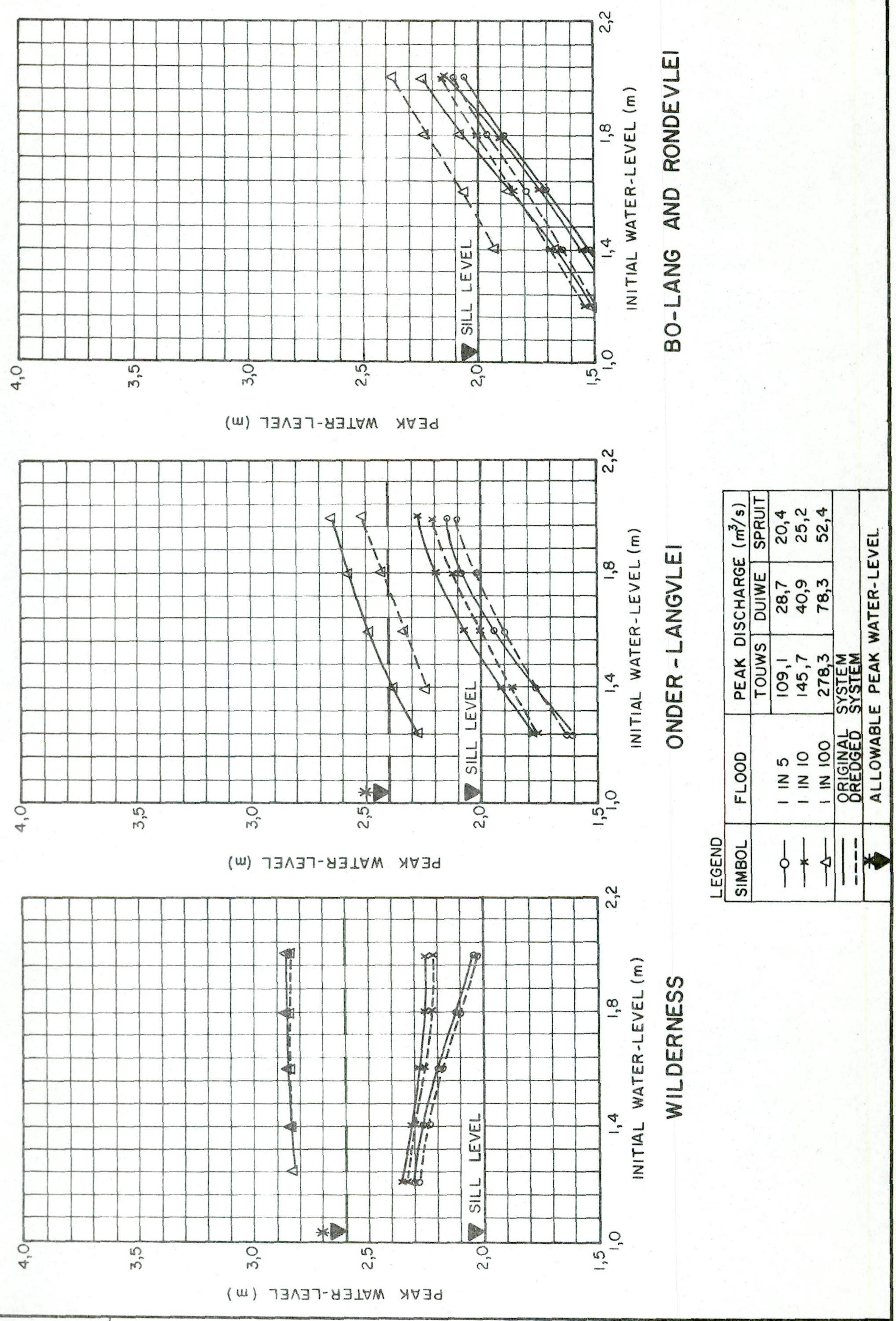


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|---|---|---|
| TRACED L de J<br>CHECKED [signature]<br>DATE Dec '82<br>REF C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>PEAK WATER-LEVELS FOR INITIAL WATER-LEVELS PREDICTED FLOODS AND A SILL HEIGHT OF 2,0m TO MSL FOR THE ORIGINAL AND DREDGED SYSTEM | FIGURE<br>9.1a |

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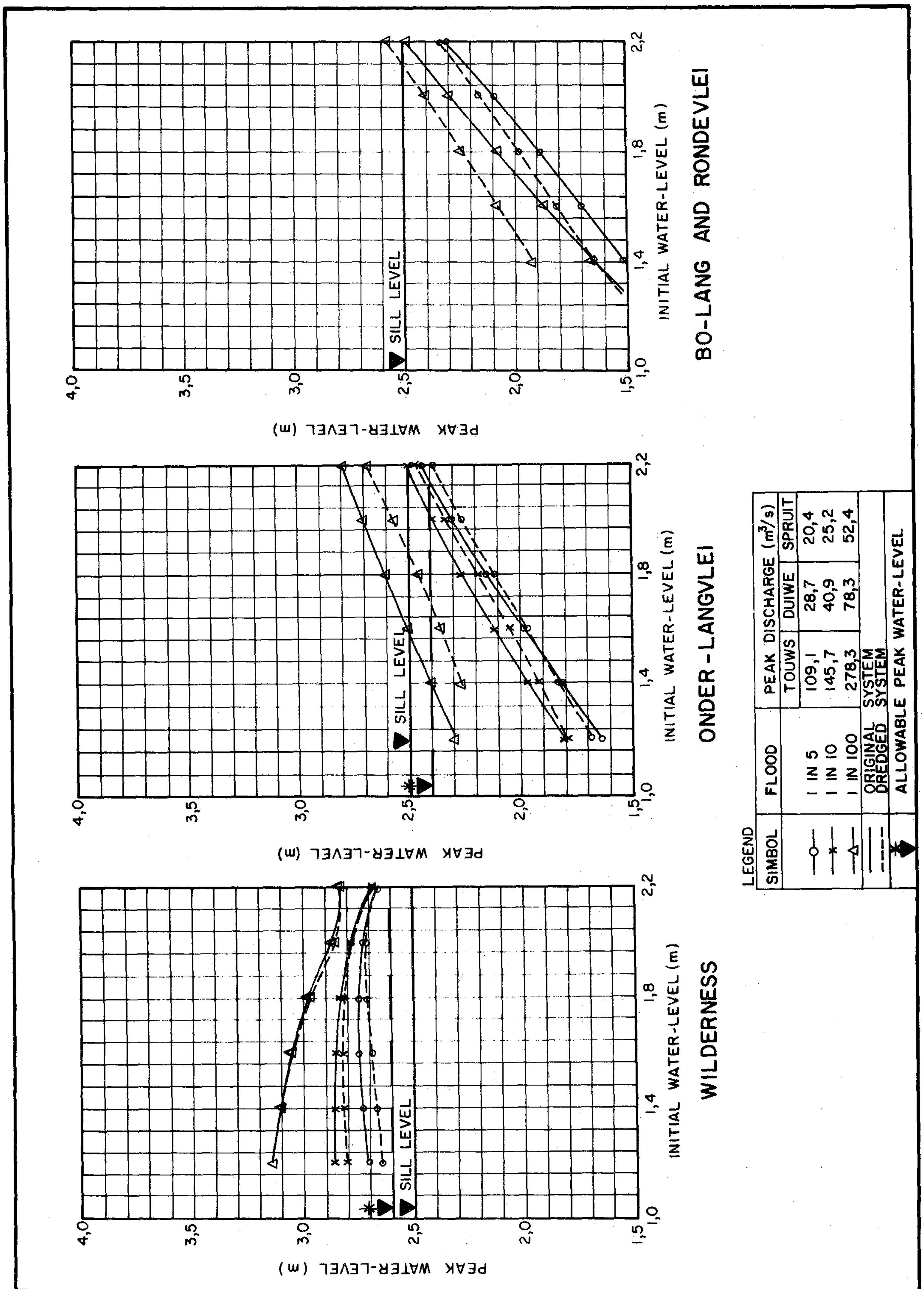


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REF: C/SEA 8255

WILDERNESS NUMERICAL STUDY

**PEAK WATER-LEVELS FOR INITIAL WATER-LEVELS PREDICTED FLOODS AND A SILL HEIGHT OF 2,5m TO MSL FOR THE ORIGINAL AND DREDGED SYSTEM**

FIGURE 9.1b

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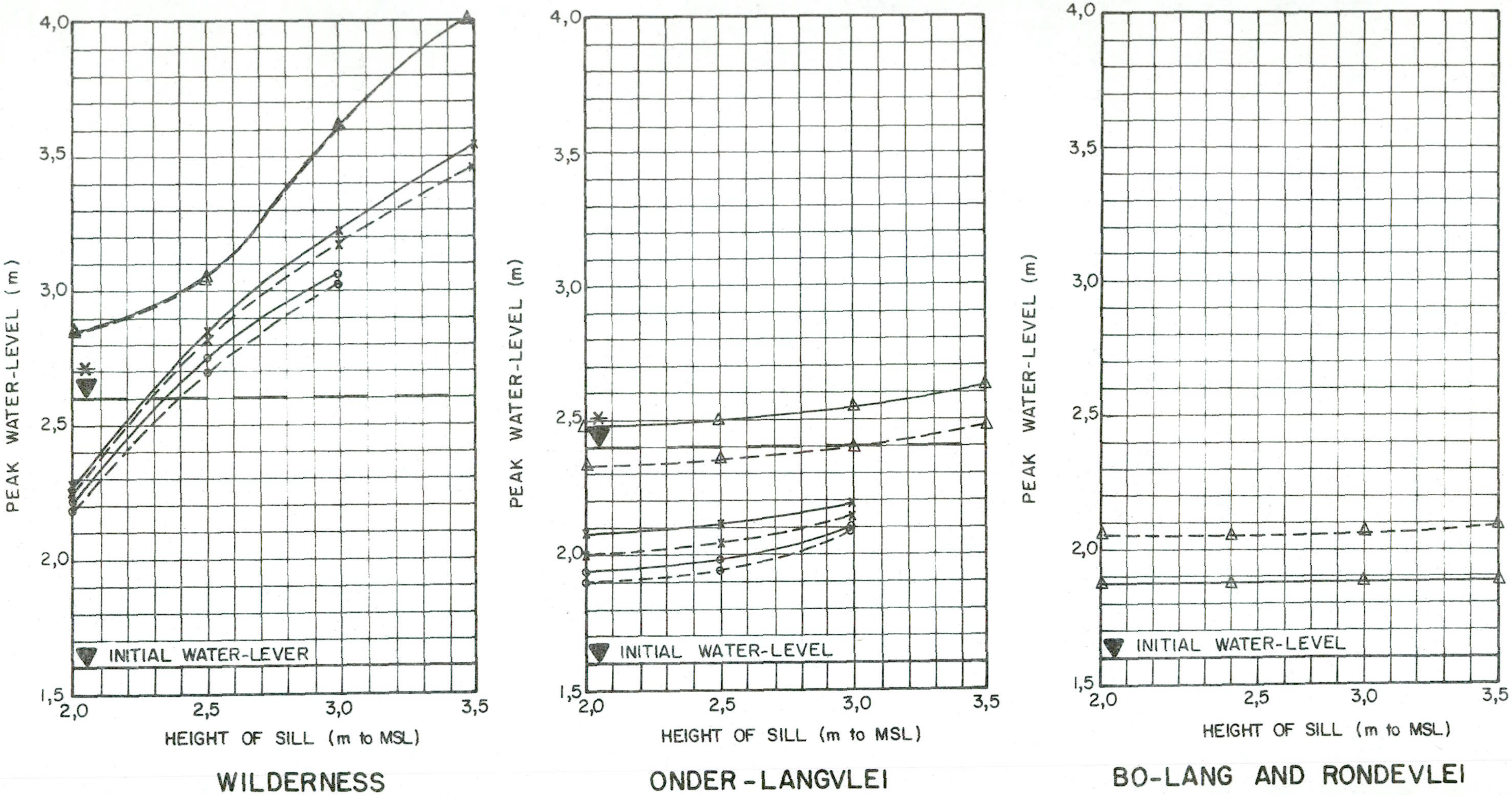


LEGEND

| SIMBOL | FLOOD | PEAK DISCHARGE ($m^3/s$) | | |
|---|---|---|---|---|
| | | TOUWS | DUIWE | SPRUIT |
| —o— | 1 IN 5 | 109,1 | 28,7 | 20,4 |
| —x— | 1 IN 10 | 145,7 | 40,9 | 25,2 |
| —△— | 1 IN 100 | 278,3 | 78,3 | 52,4 |
| ——— | ORIGINAL SYSTEM | | | |
| - - - - | DREDGED SYSTEM | | | |
| ▼ | ALLOWABLE PEAK WATER-LEVEL | | | |

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DATE Dec '82
REF. C/SEA 8255

WILDERNESS NUMERICAL STUDY

PEAK WATER-LEVELS FOR INITIAL WATER-LEVELS PREDICTED FLOODS AND A SILL HEIGHT OF 1,6m TO MSL FOR THE ORIGINAL AND DREDGED SYSTEM

FIGURE 9.1c

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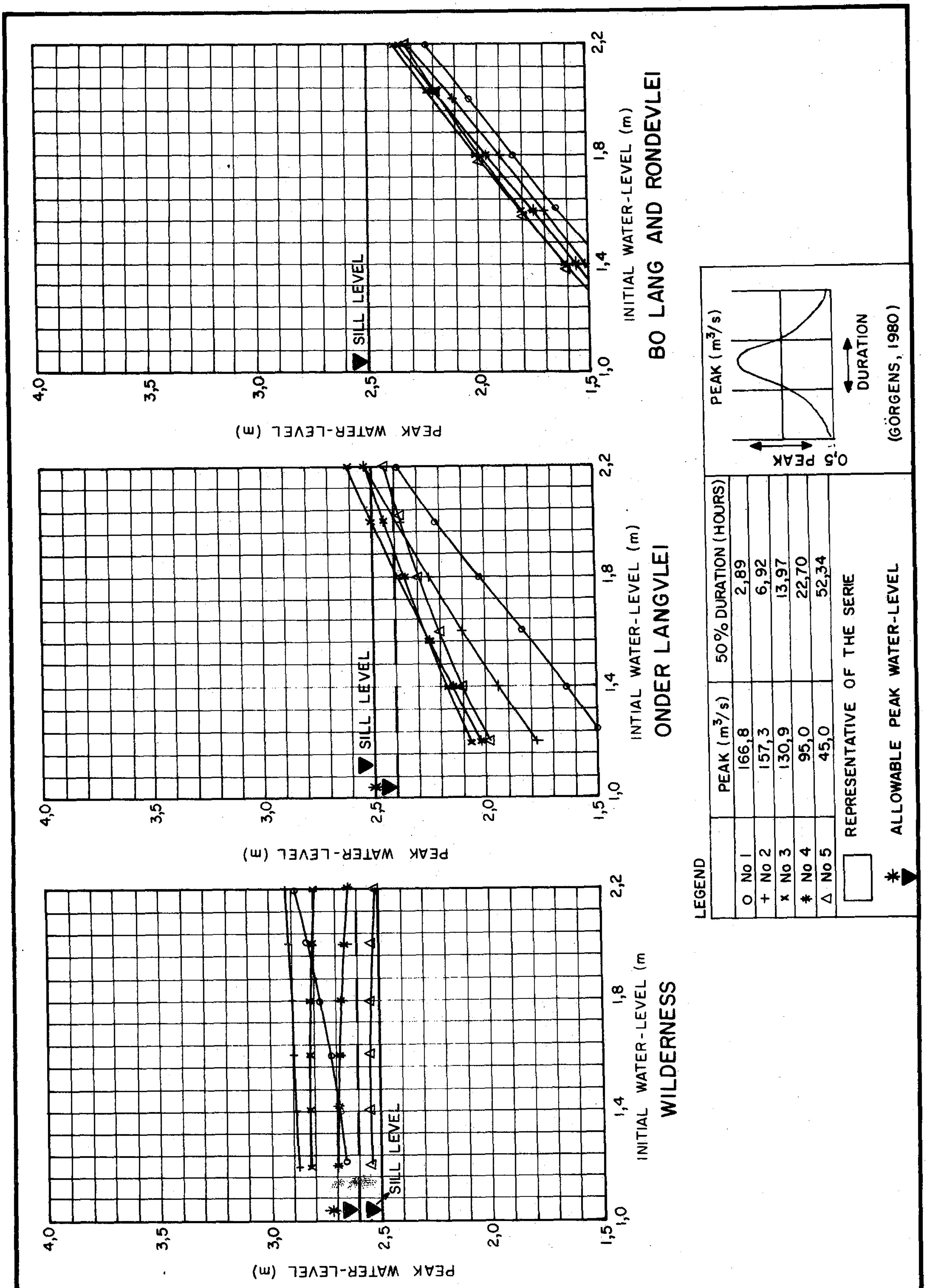


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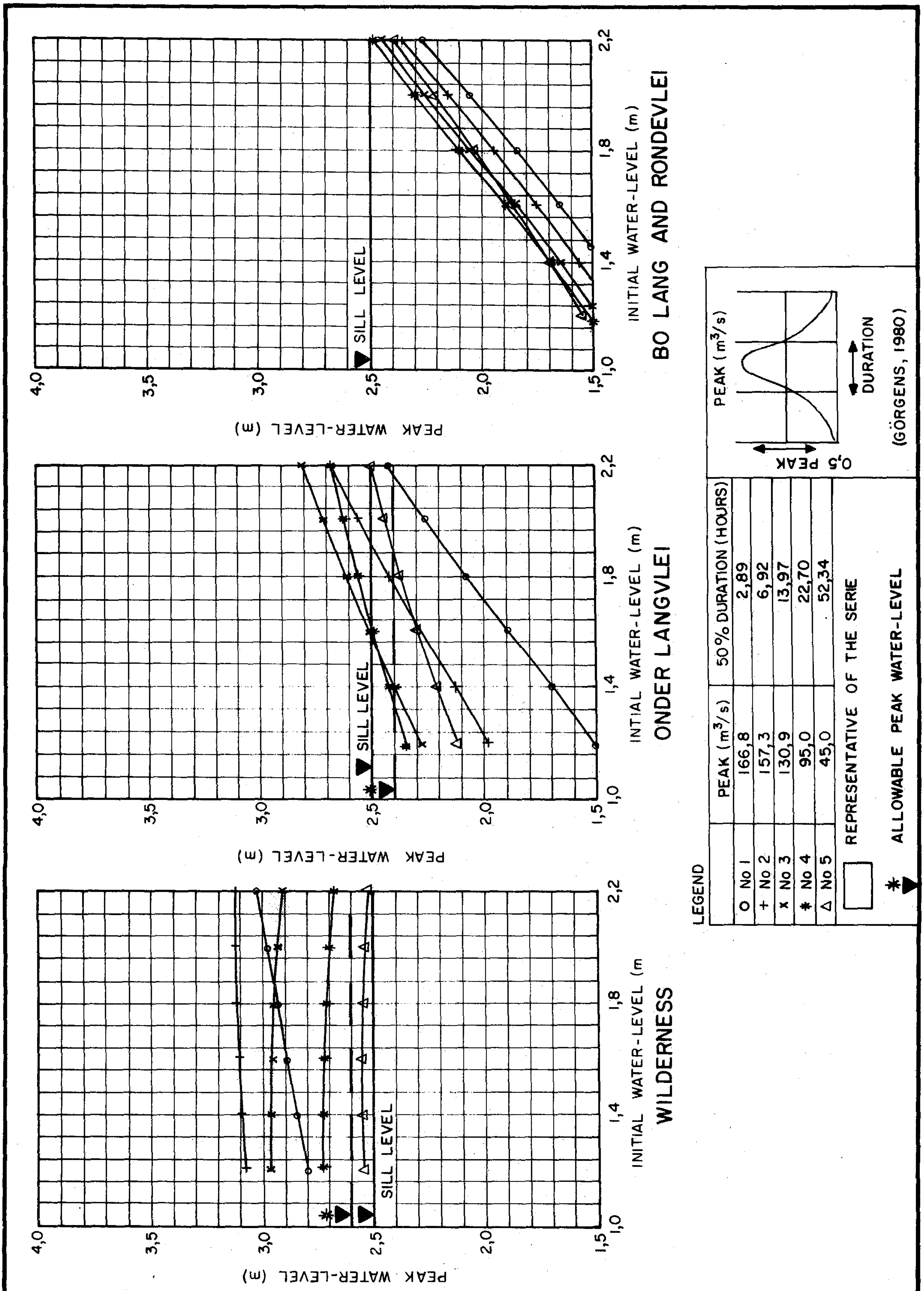
DATE : Dec '82
REF. : C/SEA 8255

WILDERNESS NUMERICAL STUDY

**PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHS AND FOR A SERIE OF 1 IN 50 YEAR RUNHYDROGRAPHS AND A SILL HEIGHT OF 2,5 m TO MSL**

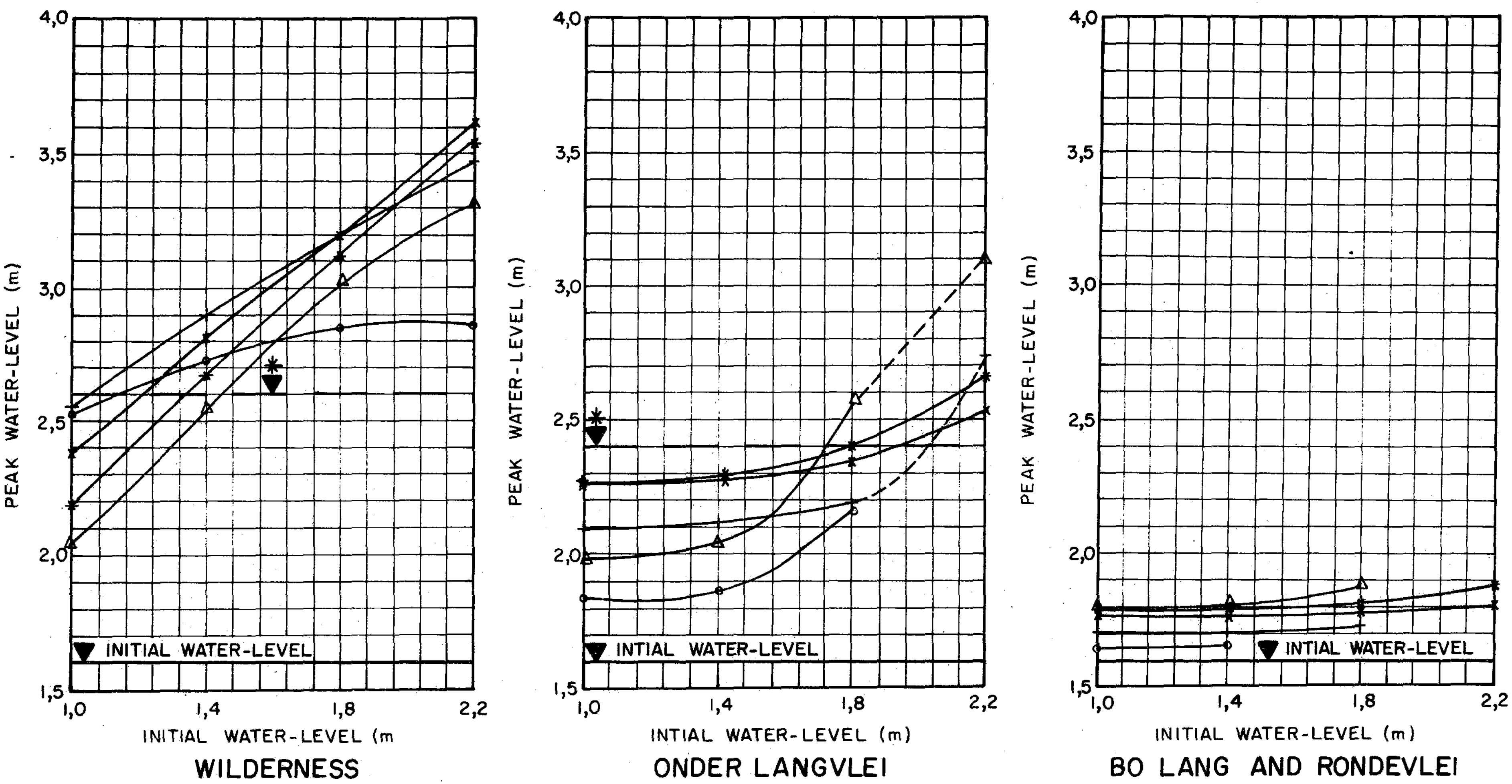
**FIGURE 10.1a**

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




| | | |
|---|---|---|
| TRACED: L de J<br>CHECKED: [signature]<br>DATE: Dec '82<br>REF: C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHS AND FOR A SERIE OF 1 IN 100 YEAR RUNHYDROGRAPHS AND A SILL LEVEL OF 2,5 m TO MSL | FIGURE<br>10.1b |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY

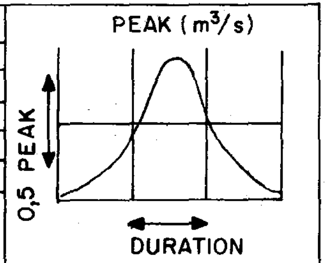



LEGEND

| | PEAK ($m^3/s$) | 50% DURATION (HOURS) |
|---|---|---|
| O No 1 | 166,8 | 2,89 |
| + No 2 | 157,3 | 6,92 |
| x No 3 | 130,9 | 13,97 |
| * No 4 | 95,0 | 22,70 |
| Δ No 5 | 45,0 | 52,34 |

▭ REPRESENTATIVE OF THE SERIE

*▼ ALLOWABLE PEAK WATER-LEVEL




(GÖRGENS, 1980)

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DATE : Dec '82
REF : C/SEA 8255

WILDERNESS NUMERICAL STUDY

**PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHS AND FOR A SERIE OF 1 IN 50 YEAR RUNHYDROGRAPHS FOR AN INITIAL LEVEL OF 1,6 m TO MSL**

FIGURE 10.2D

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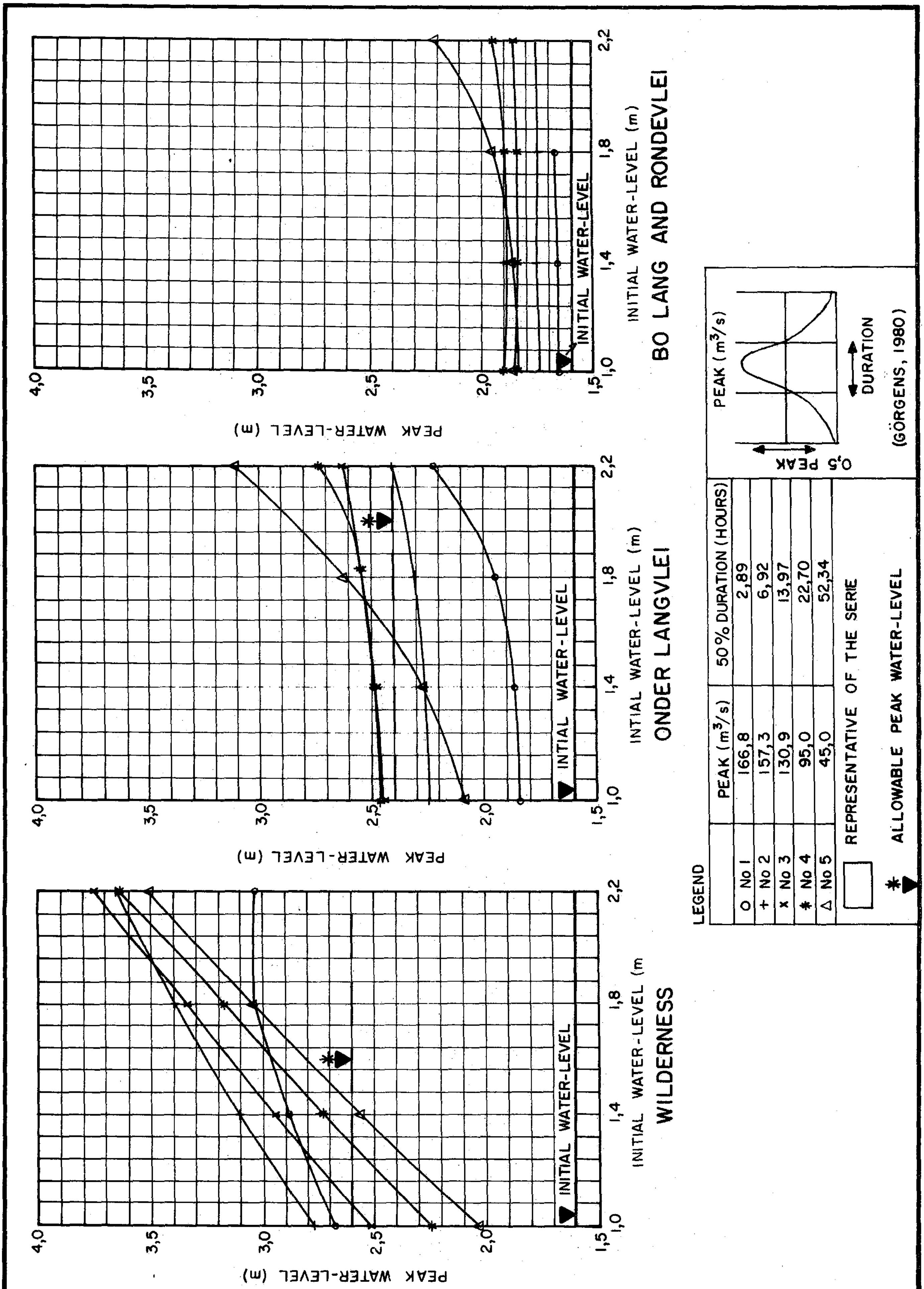


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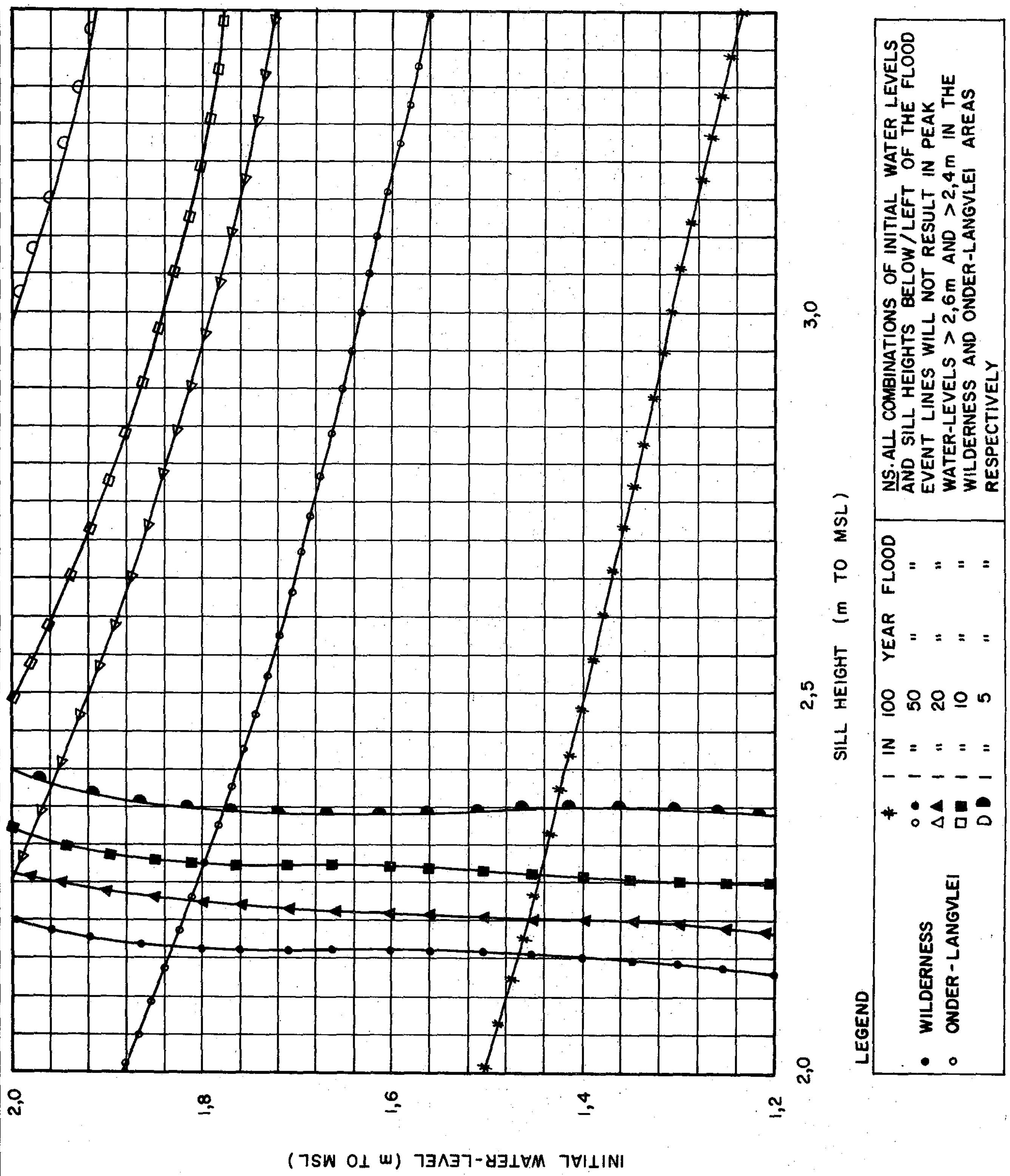
DATE : Dec '82
REF : C/SEA 8255

WILDERNESS NUMERICAL STUDY

**PEAK WATER-LEVELS FOR VARIOUS SILL HEIGHS AND FOR A SERIE OF 1 IN 100 YEAR RUNHYDROGRAPHS FOR AN INITIAL LEVEL OF 1,6 m TO MSL**

FIGURE 10.2b

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY




| | | |
|---|---|---|
| TRACED : L. de J<br>CHECKED : [signature]<br>DATE : Dec' 82<br>REF. : C/SEA 8255 | WILDERNESS NUMERICAL STUDY<br>ALLOWABLE INITIAL LEVELS AND SILL HEIGHTS FOR PROBABLE FLOOD EVENTS WHICH WILL CAUSE INUNDATION OF WILDERNESS AND ONDER-LANGVLEI | FIGURE<br>11 |

NATIONAL RESEARCH INSTITUTE FOR OCEANOLOGY

# APPENDIX A

Correspondence concerning the widening of the existing road bridge at the Touws River mouth.

Departement van Vervoer • Department of Transport

Forumgebou, Posbus 415, Pretoria 0001
Forum Building, P.O. Box 415, Pretoria 0001

Verwysing / Reference N12/4/1-02-070-03

Navrae / Enquiries P Serton  Bylyn / Ext. 1256

The Director
National Institute for Oceanology
P O Box 320
STELLENBOSCH
7600

1982-02-17

Sir

ESTUARY OF THE TOUW RIVER

As you may be well aware the National Transport Commission decided some time ago to leave the construction of a full freeway along the Garden Route for some 15 to 20 years and instead improve the existing main road through the Wilderness.

This decision requires doubling the road and hence the structures through the Wilderness municipal area. The Prime Minister expressed some concern regarding the effect on the siltation of the Touw-lagoon of such an extention the existing piers and requested us to have an expert opinion available to forstall any local criticism that may be leveled at these plans.

It would therefore be appreciated if you could produce a short report from your current knowledge of the lagoon, on the causes of the present siltation and the likely effect of doubling the road bridge on the existing conditions.

The firm of Scott and de Waal, P O Box 4090 Cape Town, telephone 021-229547, can give you details of the carriageway spacing and possible pier configurations if you so require.

Yours faithfully

for A.B. Eksteen
DIRECTOR GENERAL : TRANSPORT

OK/919 N12/4/1-02-070-03

Director-General
Department of Transport
P O Box 415
PRETORIA
0001

1982.02.24

Attention: Mr P Serton

Dear Sir

ESTUARY OF THE TOUWS RIVER

In reply to your letter of the 17th February 1982 concerning the effect of the widening of the bridge over the Touws River, I have contacted Mr Wüst, of Scott and De Waal, to obtain details of the carriageway spacing and possible bridge configuration. Mr Wüst informs me that they have recently submitted a proposed cross-section of the bridge for your consideration and that he can only supply these details when it has received your approval.

He will contact us again as soon as further details are available. We will then produce the short report which you have requested on the causes of the present siltation and the likely effect of doubling the road bridge on the existing conditions. In the meantime, we have supplied him with a copy of the report which we have prepared on the Wilderness Lakes to inform him of the flood levels under various flow conditions.

Yours faithfully

K S RUSSELL
HEAD: COASTAL ENGINEERING AND HYDRAULICS DIVISION

/ml

OA/N/91

Scott and de Waal
Nedbank Centre
Strand Street
CAPE TOWN
8001

ATTENTION: Mr I Wüst

1982.06.29

Dear Sir

PROPOSED WIDENING OF THE NATIONAL ROAD AT WILDERNESS

Enclosed please find the information about the influence of the proposed widening of the National Road at Wilderness as discussed on 23rd June, 1982 at this Institute.

a) The influence of the proposed widening of the bridge at the Touws River mouth on the water exchange of the lakes system

The wider bridge will not adversely influence the hydraulic behaviour or decrease the exchange of water of the lakesssystem.

b) Scouring at the piers of the proposed extension

The maximum scour which can be expected at a bridge can be determined by means of the following scouring formula:

$$Q = Cb_{eff}d^{3/2}$$

Where Q = flow in cumec
C = flow coefficient (C = 0,85)
$b_{eff}$ = effective span of the bridge (m)
d = mean water depth (m) after scouring has taken place.
(Refer to CSIR Report C/SEA 8103/1).

A study of the December 1980 flood indicates that the flow is concentrated mainly in the westernmost four spans of the existing road bridge at an angle as indicated in the Figure overleaf. In this figure the effective spans to be used in the scouring formula of the existing and proposed structures are indicated by A and $A_1$ respectively.
(A = 26 m and $A_1$ = 18 m).

...Figure 1 ...

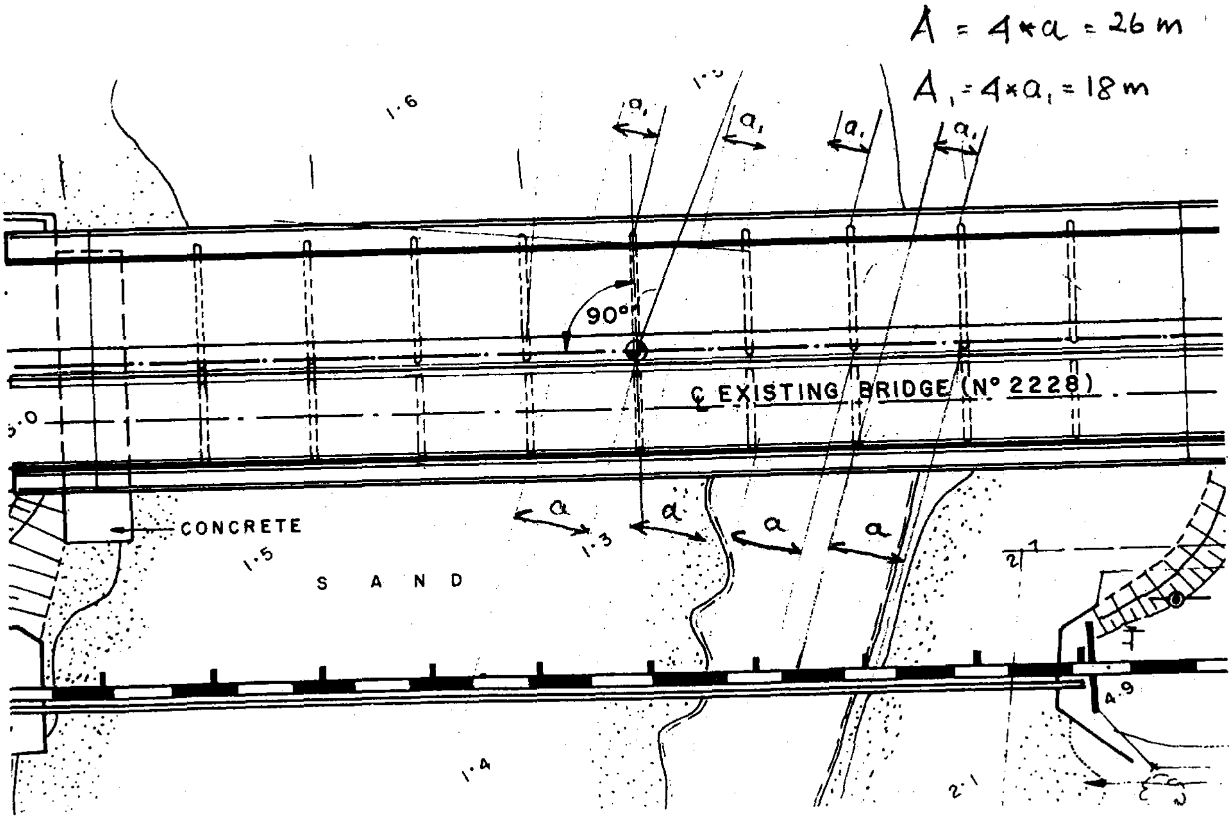



Figure 1.

The predicted floods, maximum levels at Wilderness for a 2,0 m sand sill at the mouth, maximum discharges and the corresponding estimated maximum scour for the existing and proposed bridge structures based on the December 1980 flood information are tabulated below. The indicated width of the river mouth on the figure is based on only two prototype flood events. In order to demonstrate the influence of an extreme condition for scouring the effective span of the bridge was assumed to be half of the recorded width (i.e. A = 13 m and $A_1$ = 9 m) and the results also listed below.

| PREDICTED FLOOD | MAXIMUM LEVEL AT WILDERNESS (M) | MAXIMUM FLOW ($M^3/S$) | DEPTH OF SCOUR TO MSL | | | |
|---|---|---|---|---|---|---|
| | | | EXISTING | | PROPOSED | |
| | | | A=26m | A=13m * | $A_1$ = 18m | $A_1$ = 9 m* |
| 1 in 5 yr | 2,45 | 90,2 | -0,55 | -2,05 | -1,26 | -3,18 |
| 1 in 10 yr | 2,53 | 115,3 | -1,01 | -2,77 | -1,84 | -4,10 |
| 1 in 20 yr | 2,60 | 138,9 | -1,41 | -3,41 | -2,35 | -4,91 |
| 1 in 50 yr | 2,65 | 156,59 | -1,64 | -3,85 | -2,71 | -5,48 |
| 1 in 100 yr | 2,90 | 255,13 | -3,11 | -6,11 | -4,53 | -8,36 |

**The above results indicate the sensitivity of the predicted scour to changes in the total effective span and especially in the approach angle. Nevertheless, the results shown for A = 26 m and $A_1$ = 18 m should be taken as the best estimate of the expected scour whereas the other two columns indicate possible extreme scour depths.**

**The ...**

The scouring at the existing structure with an effective width of 26 m corresponds to scouring measured in the prototype for a 1 in 10 year flood. The location where the maximum scour occurred during recorded floods is at the abutment of the western bank of the river although it could shift to one of the piers should the flow be diverted towards the east by, for example, the position of the breach in the berm.

A copy of The Wilderness Report No. 2 which is in a draft form will be forwarded to you after completion.

c) The influence of a wider bridge over Swartvlei

As discussed on 23rd June 1982, the widening of this bridge will have no adverse effect on the hydraulic behaviour of the estuary.

d) Hydrographical survey of Knysna

Included are three hydrographical survey plans of the eastern part of the Knysna lagoon.

Do not hesitate to ask for more information regarding this matter should the need arise.

Yours sincerely

D H SWART
COASTAL ENGINEERING AND HYDRAULICS DIVISION

WAMB/ml