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# Flow Resistance in the Damietta Branch of the Nile River.

Mahmoud El-Gamal
*Lecturer at Irrigation and Hydraulic Engineering Department., Faculty of Engineering., El-Mansoura University., Mansoura., Egypt.*, mmelgamel@hotmail.com

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# FLOW RESISTANCE IN THE DAMIETTA BRANCH OF THE NILE RIVER

# مقاومة السريان فى مجرى فرع دمياط من نهر النيل

By Mahmoud M. El-Gamal[1]

**الملخص :** لقد تغيرت مقاومة السريان فى مجرى نهر النيل بعد انشاء السد العالي على مجرى النيل فى نهاية عام ١٩٦٤ ـ كما ظهرت فى السنوات الأخيرة مشكلة تأثير النباتات المائية على المقاومات الهيدروليكية للسريان فى مجرى النيل ـ ومعظم الدراسات السابقة عالجت هذه المسألة باقتراح تقسيم تأثير مقاومة السريان الي مقاومة نتيجة لوجود النباتات ومقاومة نتيجة لطبيعة وشكل المجرى ولكن فى هذا البحث تم تعيين معامل الخشونة (معامل ماننج ) فى مجرى فرع دمياط من نهر النيل عن طريق أخذ قياسات حقلية لخمس قطاعات ممثلة فى هذه الدراسة .

**ABSTRACT-** The problem of resistance to flow in the Nile River has changed after the closure of the Aswan High Dams across the Nile River in 1964. During recent years the necessity of determining the effect of vegetation on the hydraulic roughness of the stream of Nile River has become apparent. Many previous studies suggest the division of total resistance into vegetation resistance and form resistance without direct evidence. The study is mainly concerned with the Damietta branch of the Nile River. The results of the determination of the roughness coefficient n for five sections by field measurements are presented in this study.

## INTRDDUCTION

The problem of flow resistance in vegetated channels has received much attention but as yet there is no one solution to it. The value of Manning,s n has intermediately defined for most types of channel linings (2,4,8,9). Chow (3) presents an extensive set of design curves for a vegetated channel. Sayre and Albertson (11) determined the effect of roughness spacing on open channel flow. Rouse (10) transcribed much of the reported work (5) in open channel resistance. Kouwen, et al. (6) indicated that for wide vegetated channels, it is relatively simple to estimate the percentage of the cross-sectional area which is occupied by vegetation. Kouwen and Li (7) presented a method to determine the flow capacity of a channel lined with a particular vegetation. Aguirre and Fuentes (1) described the formulation of resistance for uniform flow in mountain rivers and tested this information against various sets of laboratory data. In the following, the Manning formula has been used for determining the flow resistance in the Nile River.

## SITE DESCRIPTION

in the vicinity of El-Mansoura University campus the length of test section is located on Fig.1. The river is approximately 180 m. Wide with an average depth of 3 m. at the river water level of (5.00) above sea level. The average flow was 100 $m^3$/sec. during the period of measured collection (July 1989). At Zefta Barrages upstream the test section was about 40 km. The length of test section was 1000 m. The river banks as well as its bottom consists mainly of silty clay. The vegetation consists mainly of floating plants and water plantain developed along the banks and filled the remainder of the stream cross-section. Approximately 90% of the bed area was covered with vegetation.

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[1] Lecturer, Department of Civil Engineering, Faculty of Engineering, El-Mansoura University, El-Mansoura, Egypt.

## MEASUREMENTS COLLECTED

Data for this research were collected at five different cross-sections (see Fig.1). The velocities were measured at predetermined points throughout each cross-section. Each cross-section was divided every 20 m. from the left bank on a line perpendicular to the center line of the river channel. Velocity was measured at a point. 25 m from the water surface in a vertical direction, then at intervals of 0.5 m downward.The magnitude of local depth and water velocities was measured with a current-meter suspended from a boot by ruled cable oriented into the flow.The resultant velocities and contours of equal magnitude of velocity in the cross-sections are plotted in Figs. 2 to 6. Values are given in m/sec. The difference of water surface level along the testing length was determined by using an accurate level measurement. This has been indicated by the measurement of the longitudinal profile. The average slope of the water surface was $8.2 \times 10^{-5}$.

## ANALYTICAL COMPUTATION

The cross-section of the river channel is considered unsymmetrical. In such a case the mean velocity for each subsection can be calculated. Then the discharge in the subsection is computed. The total discharge is therefore equal to the sum of these discharges.

Let $v_1$ , $v_2$ , $v_3$ , ... $v_i$ be the magnitudes of local water velocities in the distinct subsection which was its area $\Delta A$,the mean velocity in the subsection is equal, Ref. (3)

$$V = \frac{v_1 + v_2 + \dots + v_i}{i} \qquad \dots(1)$$

the discharge in the subsection can be computed

$$d\,Q = V\,\Delta A \qquad \dots(2)$$

the total discharge is therefore

$$Q = V_1 \Delta A_1 + V_2 \Delta A_2 + \dots + V_i \Delta A_i \qquad \dots(3)$$

Let A be the total water area of the cross-section

Then it can be written :

$$A = \Delta A_1 + \Delta A_2 + \dots + \Delta A_i \qquad \dots(4)$$

The mean velocity U of the total section equals

$$U = Q \,/\, A \qquad \dots(5)$$

From the Manning equation Ref. (3)

$$U = \frac{1}{n} R^{2/3} S^{1/2} \qquad \dots(6)$$

The Manning roughness coefficient n for the cross-section can be calculated Table 1 is a summary of the calculated hydraulic data.

Table 1. Summary of Measured Hydraulic Data

| Section<br>(1) | Q<br>($m^3$/sec)<br>(2) | A<br>($m^2$)<br>(3) | U<br>(m/sec)<br>(4) | P<br>(m)<br>(5) | R<br>(m)<br>(6) | $S \times 10^{-5}$<br>(7) | n<br>(8) | UR<br>($m^2$/sec)<br>(9) |
|---|---|---|---|---|---|---|---|---|
| I | 92.638 | 377.430 | 0.245 | 194.158 | 1.943 | 8.2 | 0.0573 | 0.476 |
| II | 95.176 | 425.915 | 0.223 | 204.908 | 2.078 | | 0.0659 | 0.463 |
| III | 90.630 | 351.250 | 0.258 | 162.247 | 2.164 | | 0.0586 | 0.558 |
| IV | 85.323 | 355.500 | 0.240 | 178.420 | 1.992 | | 0.0597 | 0.478 |
| V | 90.938 | 346.962 | 0.262 | 168.830 | 2.055 | | 0.0558 | 0.538 |

## ANALYSIS OF RESULTS

Table 1 shows the results of the field study of resistance to flow in the Damietta Branch of the River Nile. Column (8) of table 1 shows the values of Manning,s roughness coefficient. From these results, it can be concluded that the values of n ranging from 0.0558 to 0.0659, are similar except that larger values, from Fig.7 shows plots of Manning,s n with UR by using the least-squares fitting for results found when the experiment was carried out. The correlation shows the n value decreases as UR increases. The decrease in the values of n is associated with the increase in vegetation bending and an increase in vegetation submergence as it increases in the UR value.

## CONCLUSIONS

The research indicates that the roughness coefficient of the Nile River has changed as a results of the closure of the Aswan High Dam. Due to the presence of vegetation, the values of Manning,s roughness coefficient n is changed and becomes larger (n = 0.0558 to 0.0659). Because determination of the appropriate roughness coefficient for a natural river is one of the more difficult works to be faced by engineers, the present study finding may assist others in making the correct value when called upon to do so.

## ACKNOWLEDGEMENTS

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## APPENDIX I - REFERENCES

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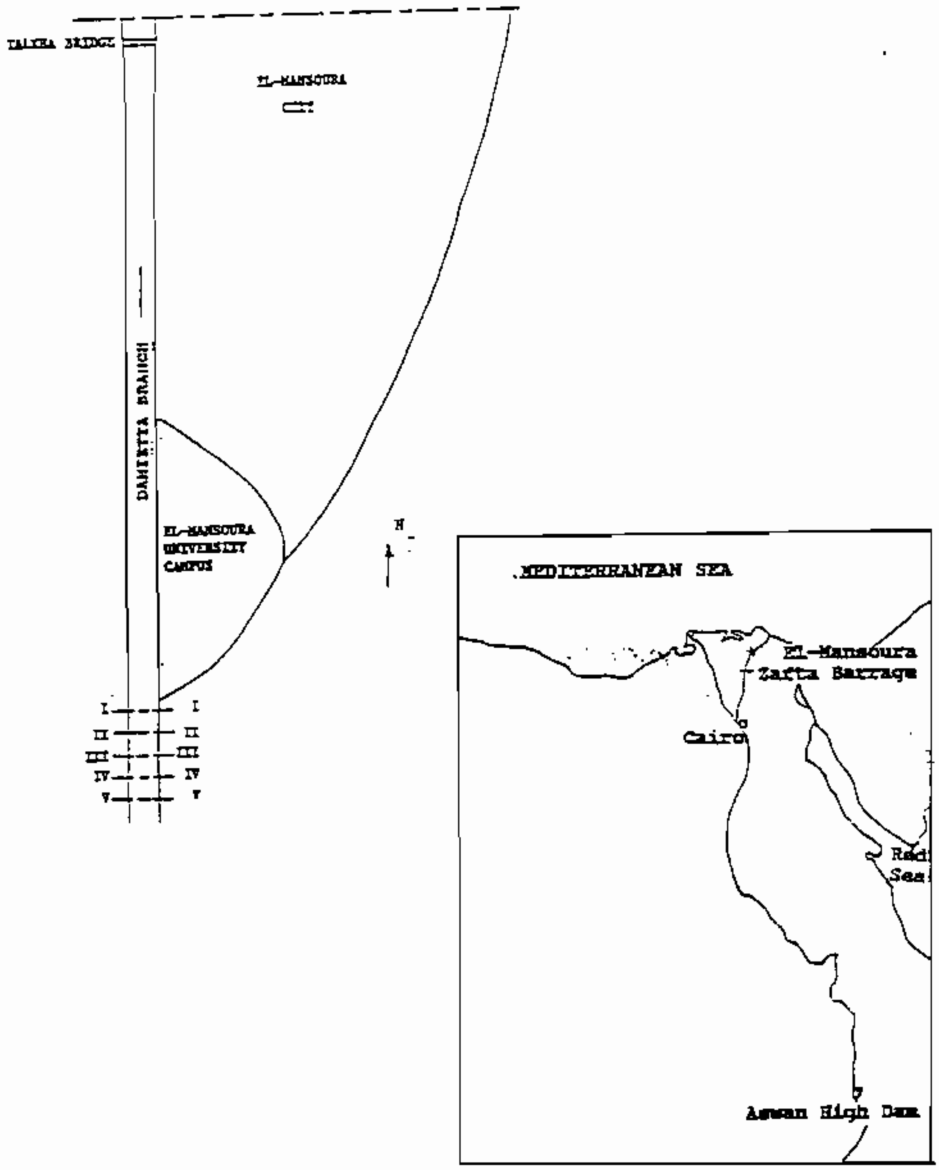
## APPENDIX II - NOTATION

The following symbols are used in this paper:

$A$ = cross-section area;
$\Delta A$ = area of subsection;
$i$ = number of subsection;
$n$ = Manning, s roughness coefficient;
$P$ = wetted perimeter of flow cross-section;
$Q$ = flow discharge in cross-section;
$dQ$ = flow discarge in subsection;
$R$ = hydraulie radius;
$S$ = longitudinal river slope;
$U$ = mean flow velocity in cross-section;
$V$ = mean flow velocity in subsection; and
$v$ = Local flow velocity.



Map of Nile River Showing Data Site

Fig. 1. Layout for experiment sections.

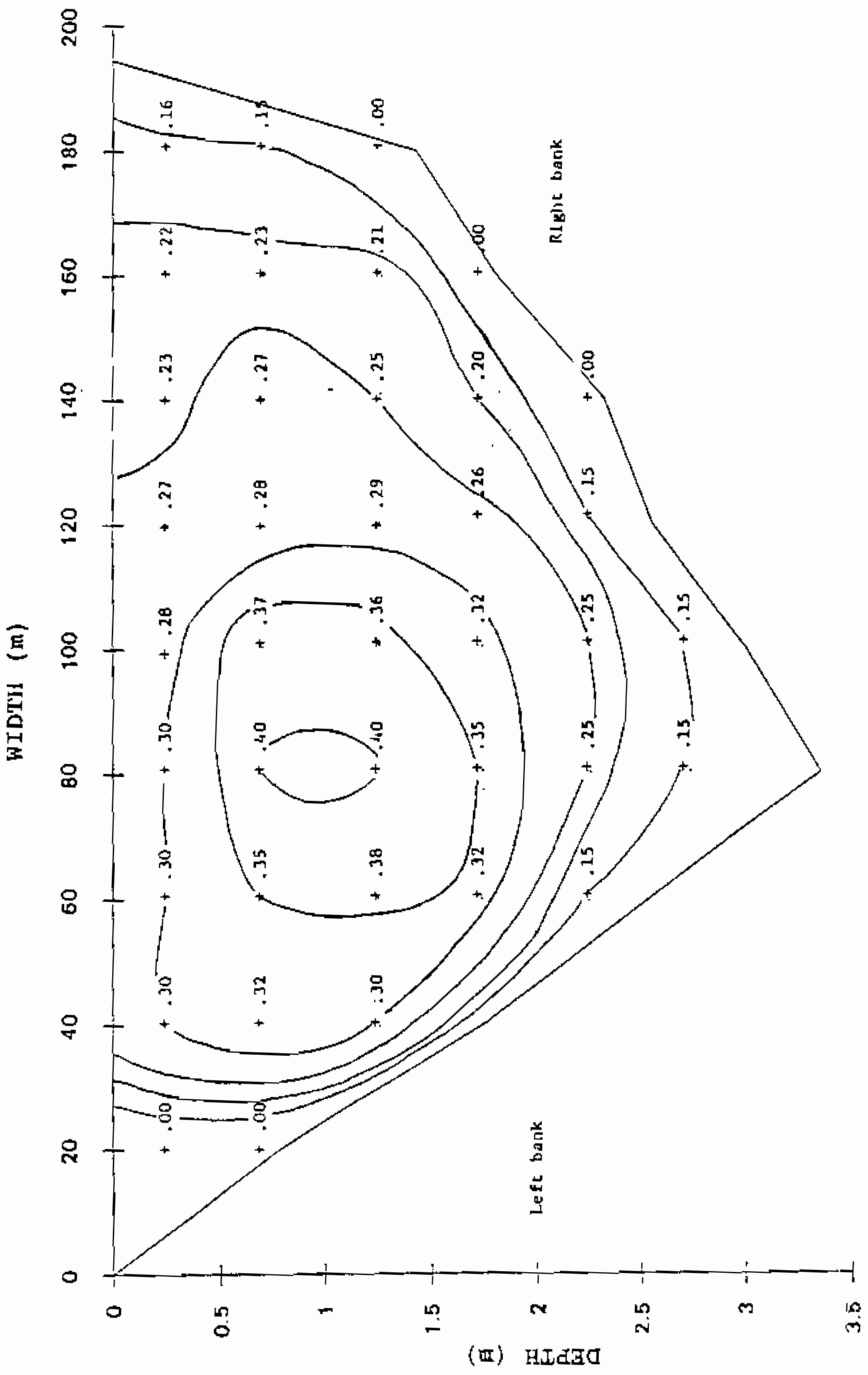


Fig. 2. Velocity distribution at cross section I.

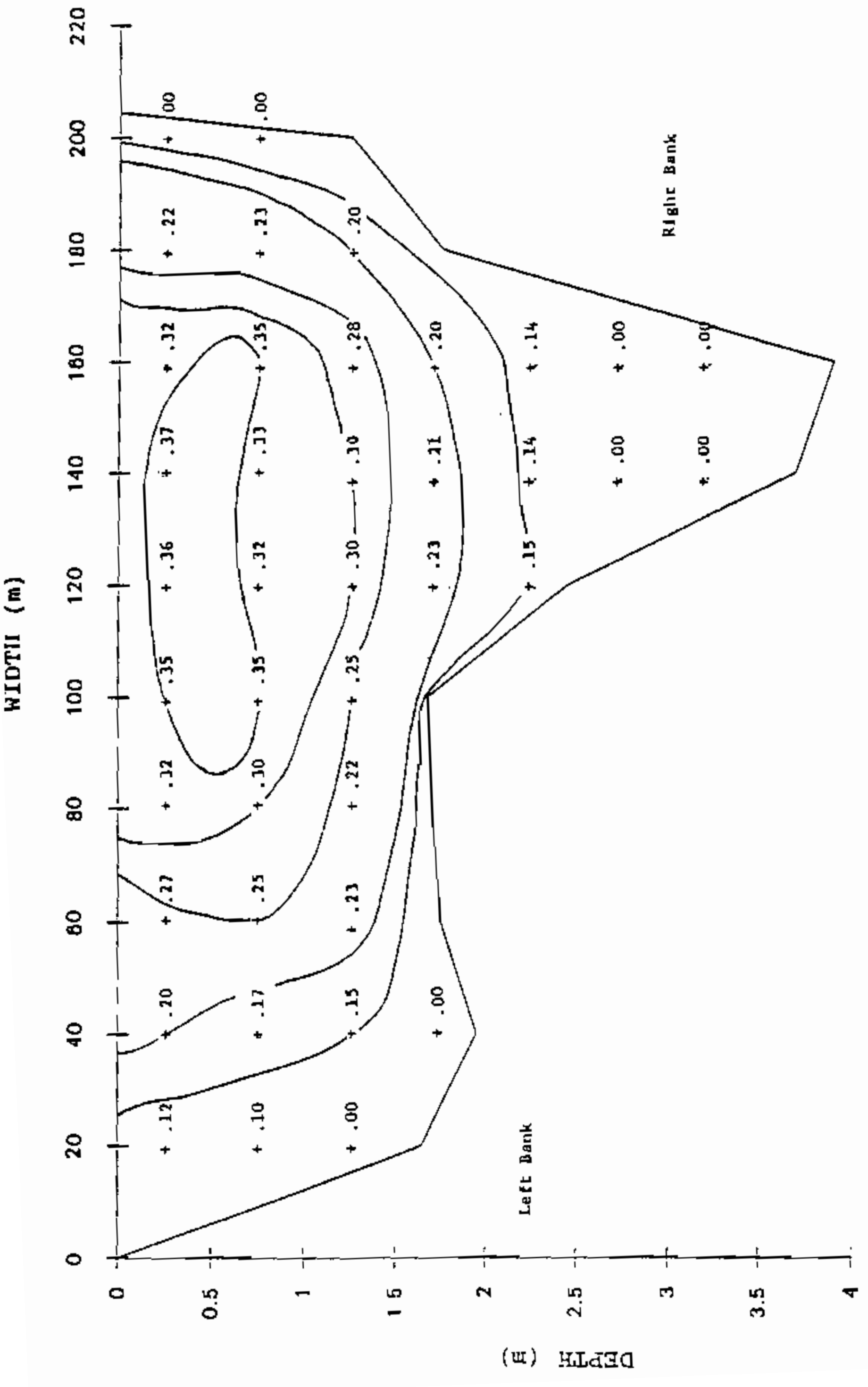


Fig. 3. Velocity distribution at cross section II.

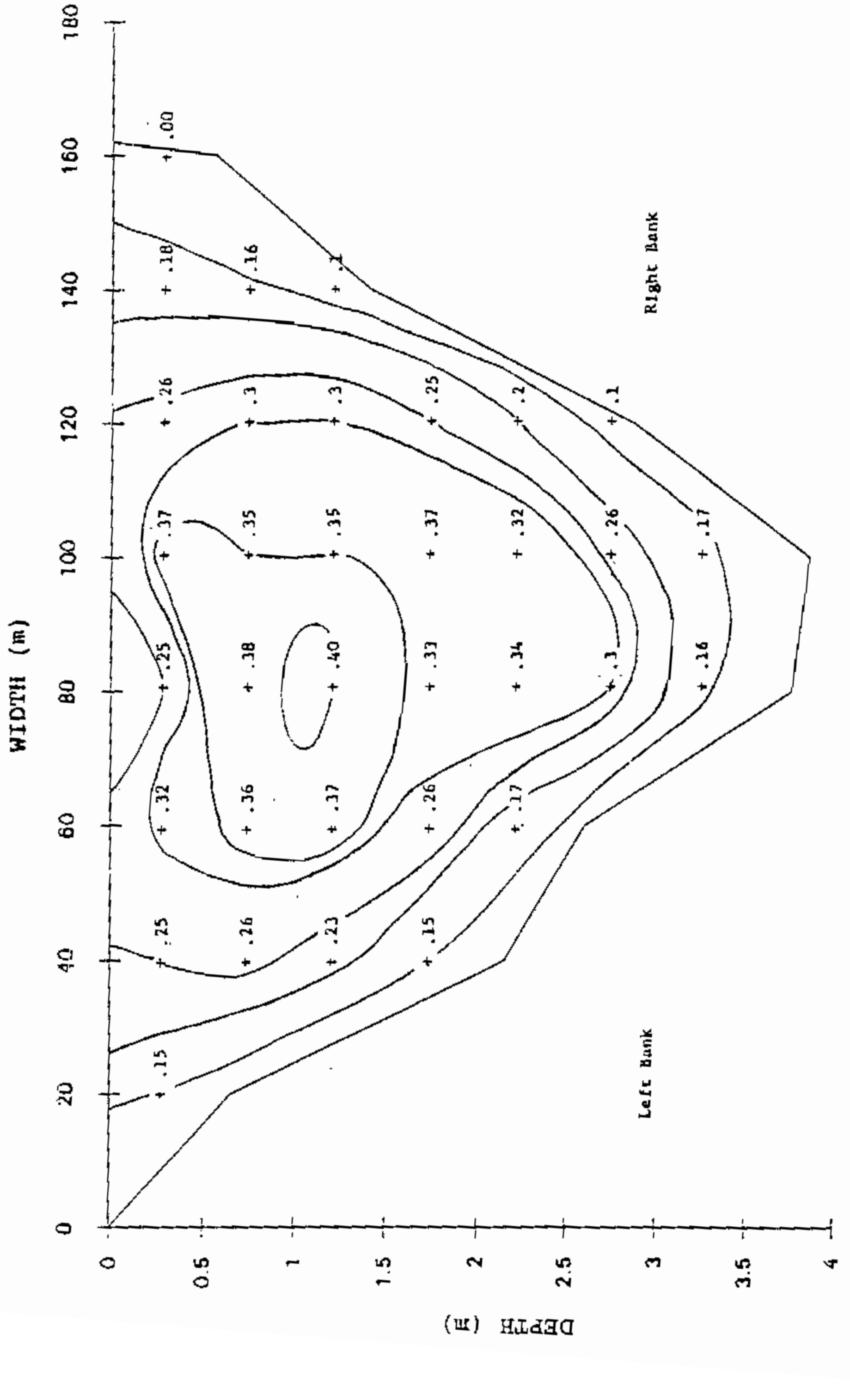


Fig. 4. Velocity distribution at cross section III.

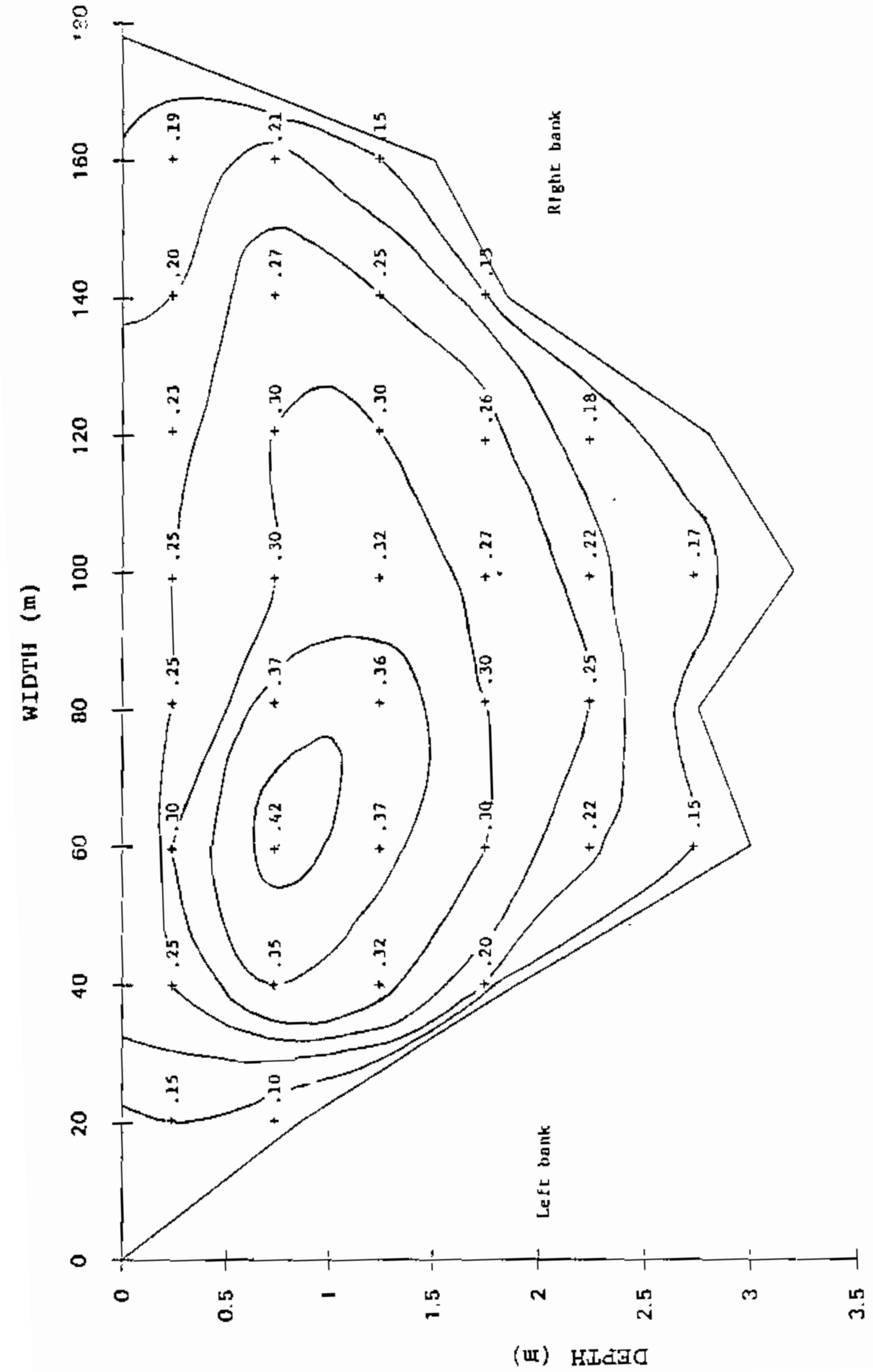


Fig. 5. Velocity distribution at cross section IV.

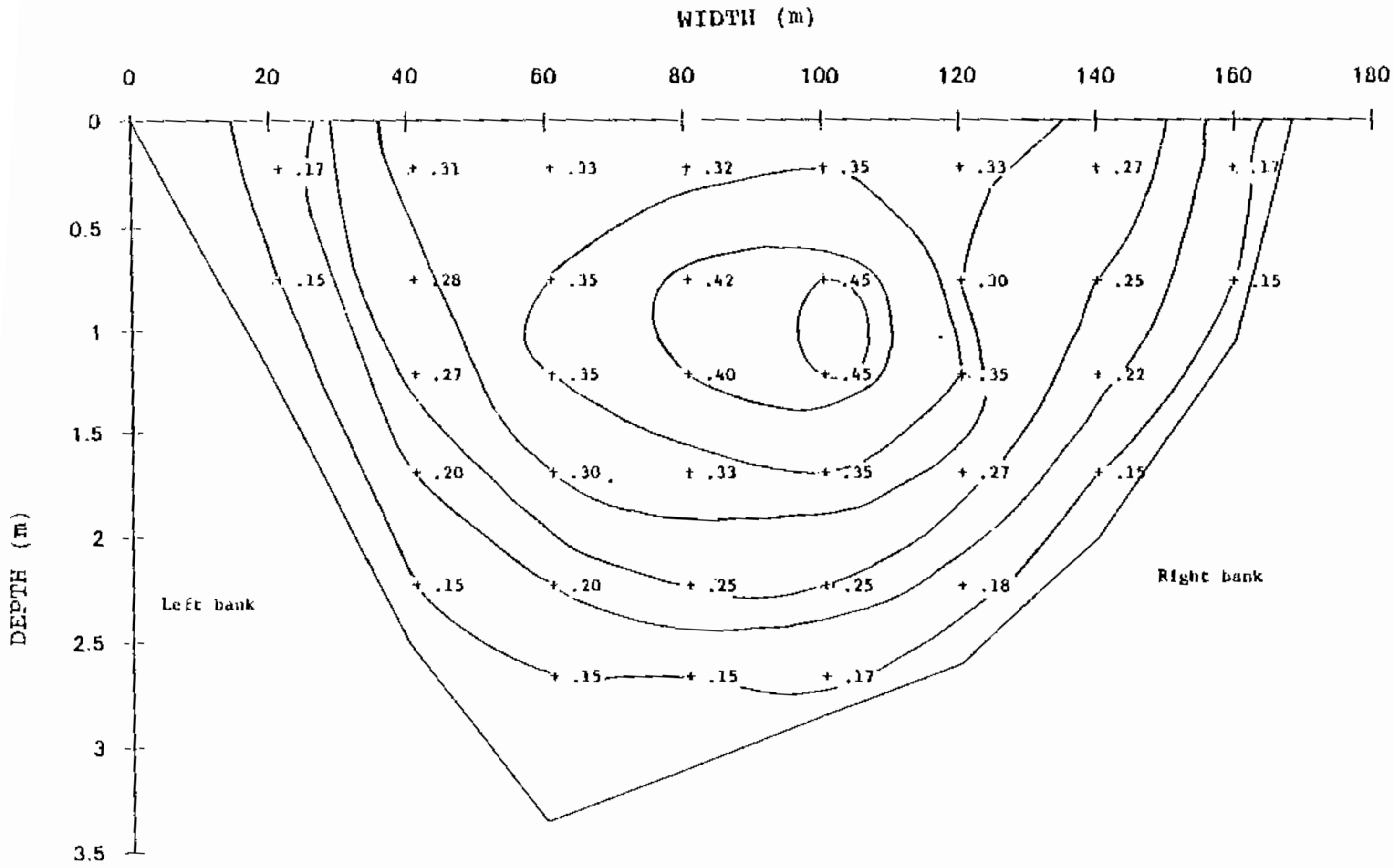


Fig. 6. Velocity distribution at cross section V.

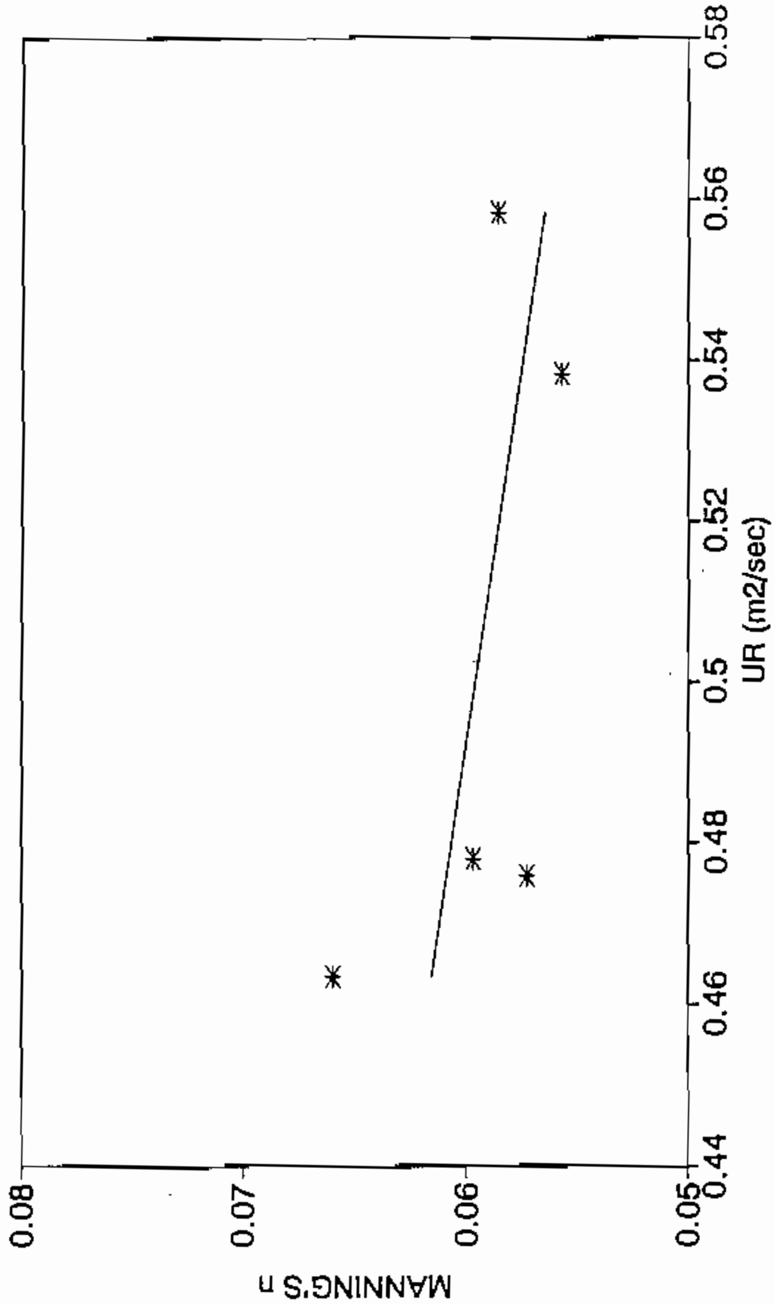


FIG.7- VARIATION OF MANNING'S n COEFF. WITH PRODUCT UxR