Krishnappan (52)

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PREDICTION OF SEDIMENT SORTING USING MOBED:
USERS MANUAL UPDATE II

by

B.G. Krishnappan

Environmental Hydraulics Section
Hydraulics Division
National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario, Canada
L7R 4A6
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TABLE OF CONTENTS

ABSTRACT

A sediment sorting algorithm has been added to model MOBED to extend the model to predict the effects of armouring in degrading stream beds. Details of the algorithm and the changes that have to be made to the source code and input data arrangements are described in this update. Test data sets and sample model outputs are also included.

RESUME

On a ajouté au modèle d'écoulement MOBED un algorithme de sélection des sédiments afin d'accroître sa capacité à prévoir les effets du recouvrement du fond par les sédiments sur la détérioration des lits. Cette mise à jour fournit des précisions sur l'algorithme et les modifications à apporter au code des sources et à l'arrangement des données d'entrée. Des groupes de données d'essai et des exemples de résultats figurent également dans ce document.

MANAGEMENT PERSPECTIVE

River flow transports sediment both in suspension and by bottom movement. The interactions of sediment movement and the water flows are very complex especially when neither the sediment supply nor the water flow is steady.

The MOBED model mimics the real world very well and this update improves it.

Because river flow moves the smaller sediment first, there tends to be a residue of larger sediment left in place which armours the bed against further movement.

This update to the model gives a new routine which incorporates the sorting and armouring effect which should bring the model even closer to reality. All river engineers should include MOBED in their "lexicon" of tools.

T. Milne Dick
Chief
Hydraulics Division

PERSPECTIVE DE GESTION

Les cours d'eau transportent des sédiments en suspension et des dépôts de fond. L'étude des interactions entre le déplacement des sédiments et les débits est très complexe, surtout si on considère que ni l'accumulation de sédiments ni le débit n'est un phénomène stable.

Le modèle MOBED reproduit adéquatement les conditions véritables de la nature, et cette mise à jour permet de l'améliorer davantage.

Etant donné que les cours d'eau entraînent d'abord les petites particules, il se produit une accumulation des plus gros sédiments dans le fond. Ces sédiments tendent à recouvrir le lit d'une couche qui empêche tout déplacement ultérieur.

Cette mise à jour du modèle crée un nouveau parcours qui permet de faire un choix dans la sélection et la protection des effets afin de rapprocher le modèle des conditions naturelles. MOBED devrait faire partie du «lexique» des outils de génie hydraulique.

Le chef,
T. Milne Dick
Division de l'hydraulique

1.0 INTRODUCTION

The model MOBED described in the original Users Manual (1) and the Users Manual Update I (2) assumes that the hydraulic sorting of bed sediment is negligible and considers the sediment size characteristics in terms of only two representative sizes, namely D_{50} and D_{65}. It also assumes that these two sizes remain constant throughout the river reach being modelled. Such an assumption is justifiable in applications in which the river flow is in equilibrium with sediment supply and all fractions of the sediment bed are transported by the flow. For reaches of river where the equilibrium condition is upset by man-made or natural causes, and where a degradation of the river is anticipated, the hydraulic sorting and consequently the armouring of the river bed may become an important factor which should be considered in predicting the ultimate response of a river to changes imposed on its regime. Therefore, it was decided to incorporate a sediment sorting algorithm into MOBED. With this algorithm, the model is now able to predict the size distribution of bed sediment as a function of time and distance along the river in addition to predicting the usual water and bed level changes and other hydraulic and sediment transport characteristics. In this update, a brief description of the sediment sorting algorithm is given together with a description of all the changes that were made to the source code and to the arrangement of input data.

2.0 SEDIMENT SORTING ALGORITHM

The initial size distribution of the bed sediment at a number of cross-sections within the study reach has to be specified to the model. The size distribution is expressed in terms of weight-percentage of sediment in different size ranges. Ten different size ranges were selected starting with a sediment size of 0.062 mm and ending with 64.00 mm. The selected size ranges are similar to the ones used in the model HEC-6 (3) and they are shown schematically in Fig. 1. The

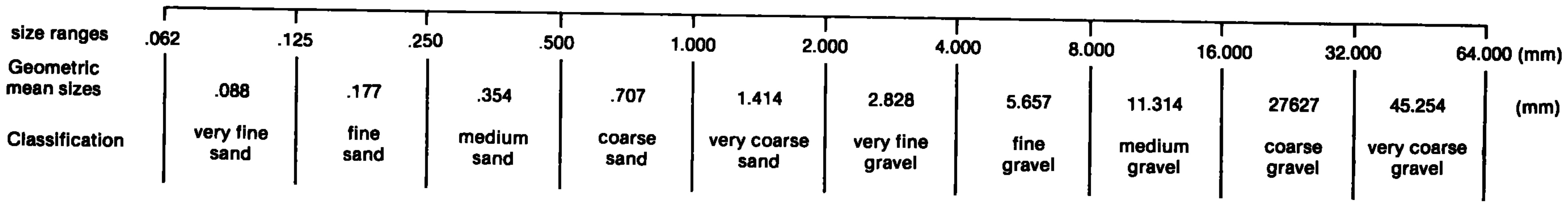


Fig. 1: Size ranges adopted for MOBED model

percentages of sediment in all of the ten size ranges have to be specified to the model. If a particular fraction is not present, then a zero value has to be specified.

Given the initial distribution of the bed sediment, the model then computes the distribution of the bed sediment after every time step as follows:

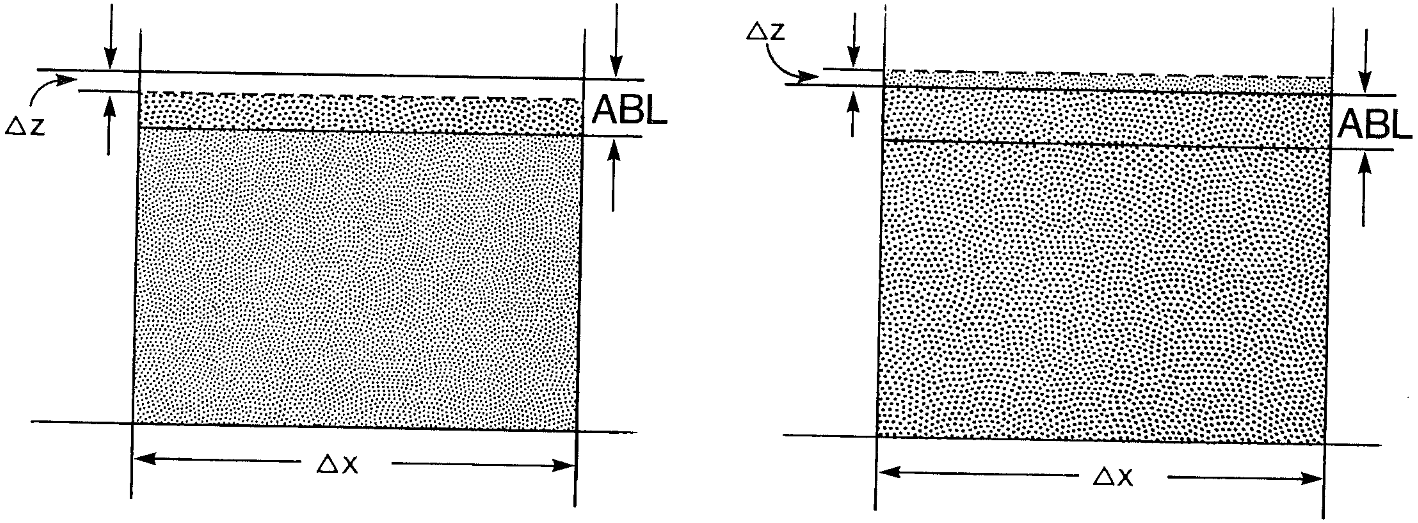
First, the shear velocity of the flow is compared with the critical shear velocity evaluated from the shields diagram for the finest size fraction of the sediment material.

If the flow-shear velocity is less than the critical shear velocity, i.e., if the flow is not able to transport even the finest fraction of the sediment, then the size distribution of the sediment bed is assumed to remain unaltered.

Secondly, the shear velocity of the flow is compared with the critical shear velocity for the coarsest size fraction. If the flow-shear velocity is greater than the critical shear velocity of the coarsest fraction, i.e, if the flow is able to transport all fractions of the bed sediment, then also the size distribution is assumed to remain unaltered. In other words, it is assumed that when all fractions of the sediment material are moving, the hydraulic sorting is considered to be negligible. Hydraulic sorting is assumed to be present only when the flow shear velocity lies in the range of critical shear velocities bounded by those of the finest and of the coarsest size fractions respectively. The size distribution of the bed sediment undergoing hydraulic sorting is computed by considering an active bed layer and the probability of a sand particle of certain size to stay when subjected to a particular bed shear stress. The derivation of the relationships for both degrading and aggrading beds is given below.

2.1 Degrading Bed

Let the thickness of the active bed layer be ABL and let ΔZ be the amount of bed degradation during one time step (see Fig. 2).



Degrading bed

Aggrading bed

Fig. 2 Schematic representation sediment sorting in active bed layer in degrading and aggrading beds.

Weight of a fraction, say i, remaining in the active bed layer is composed of two parts. Part one is the weight of the fraction in the layer (ABL - ΔZ):

$$[(ABL - \Delta Z)\ \Delta X\ Pp\ \rho_s g\ r_i] \tag{1}$$

where ΔX is the length of a control element of the stream bed, P is the wetted perimeter, p denotes the volume of sediment in unit volume of bedlayer, ρ_s is the density of sediment, g is the acceleration due to gravity and r_i is the fraction of sediment in size range i.

Part two is the component left behind when the flow degrades the bed by the amount ΔZ. This part is given by:

$$[\Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i]\ q_i \tag{2}$$

where q_i is the probability that a particle belonging to size range, i, will not be transported by the flow that existed during the time interval Δt.

Therefore, the weight of fraction, i, in the active bed layer is:

$$[(ABL - \Delta Z)\ \Delta X\ Pp\ \rho_s g\ r_i] + [\Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i]\ q_i \tag{3}$$

The total weight of all fractions in the active bed layer is:

$$\sum_{i=1}^{10} [(ABL - \Delta Z)\ \Delta X\ Pp\ \rho_s g\ r_i + \Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i\ q_i] \tag{4}$$

$$= (ABL - \Delta Z)\ \Delta X\ Pp\ \rho_s g + \sum_{i=1}^{10} \Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i q_i \tag{5}$$

The percentage weight of fraction, i, is:

$$\frac{(ABL - \Delta Z)\ \Delta X\ Pp\ \rho_s g\ r_i + [\Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i]\ q_i}{(ABL - \Delta Z)\ \Delta X\ Pp\ \rho_s g + \sum_{i=1}^{10} \Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i\ q_i} \tag{6}$$

$$= \frac{(ABL - \Delta Z)\ r_i + \Delta Z\ r_i\ q_i}{(ABL - \Delta Z) + \sum_{i=1}^{10} \Delta Z \cdot r_i q_i} \times 100 \tag{7}$$

2.2 Aggrading Bed

As in the previous case, the weight of a fraction, say, i, consists of the weight in the deposited layer as well as the weight in the active bed layer. The weight in the deposited layer is:

$$[\Delta Z\ \Delta X\ P\ p\ \rho_s g\ r_i]\ q_i \tag{8}$$

The weight in the active bed layer is:

$$[ABL\ \Delta X\ Pp\ \rho_s g\ r_i] \tag{9}$$

The total weight of fraction i is:

$$[\Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i\ q_i + ABL\ \Delta X\ Pp\ \rho_s g\ r_i] \tag{10}$$

The total weight of all fractions in both the deposited and active bed layer is

$$\sum_{i=1}^{10} (\Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i\ q_i + ABL\ \Delta X\ Pp\ \rho_s g\ r_i) \tag{11}$$

$$= ABL\ \Delta Xp\ P\rho_s g + \sum_{i=1}^{10} \Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i q_i \tag{12}$$

The percentage weight of fraction i, therefore, is:

$$\frac{\Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i\ q_i + ABL\ \Delta X\ Pp\ \rho_s g\ r_i}{ABL\ \Delta X\ Pp\ \rho_s g + \sum_{i=1}^{10} \Delta Z\ \Delta X\ Pp\ \rho_s g\ r_i\ q_i} \times 100 \qquad (13)$$

$$= \frac{\Delta Z\ r_i q_i + ABL\ r_i}{ABL + \sum_{i=1}^{10} \Delta Z\ r_i q_i} \times 100 \qquad (14)$$

To use Equations (7) and (14) and to predict the percentage weight distribution of the sorted sediment after one time step, the quantities q_i and ABL have to be known. In the present model, the quantity q_i is evaluated using the Gessler's (4) expression which is

$$q_i = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{X_{u_i}} \exp\left(-\frac{1}{2} X_o^2\right) dX_o \qquad (15)$$

where $$x_{u_i} = \left(\frac{\tau_{x_i}}{\bar{\tau}} - 1\right)/0.57 \qquad (16)$$

τ_{x_i} is the critical shear stress for initiation of motion of fraction, i, as determined from Shield's diagram and $\bar{\tau}$ is the average bed shear stress. The thickness of active bed layer, ABL, is assumed to be related to D_{65}

$$ABL = 2\ D_{65} \qquad (17)$$

The above assumption was tested using the laboratory data of Little and Mayer (5), and a satisfactory agreement between model prediction and the laboratory measurement was observed.

In a recent paper on the development of equilibrium armour layers, Shen and Lu (6) evaluated q_i using Equation (15) but with a different expression for x_{u_i}. Shen and Lu expressed x_{u_i} as:

$$x_{u_i} = \frac{\xi \dfrac{\tau_{c_i}}{\bar{\tau}} - 1}{(CV)_\tau} \tag{18}$$

where ξ is a hiding factor and $(CV)_\tau$ is the coefficient of variation of bottom shear stress fluctuations. Note that in Gessler's expression $(CV)_\tau$ is taken as a constant equal to 0.57. Shen and Lu treated the hiding factor as a function of the grain size, the apparent roughness of the bed surface and the thickness of laminar sublayer. They treated the coefficient of variation $(CV)_\tau$ as a function of the standard deviation of the initial distribution of the bed sediment. They also used a slightly different Shield's diagram to estimate the critical shear stress for the initiation of sediment motion. They did all this to match their predicted armour layer distributions exactly with the measured distribution of Little and Mayer (5). However, it has been established by Kellerhals and Church (7) and Ettema (8) that the measured distributions of Little and Mayer do not reflect the true distribution of the armour coat because of the sampling technique used. They argued that the hot-wax method used by Little and Mayer biases the measured distribution towards the larger sizes. Therefore, the method of Shen and Lu which was formulated on the basis of a biased distribution may not be valid to predict the true armour coat distribution. In a recent paper, Odgaard (9) has proposed that the grain size distribution of the armoured bed follows the normal distribution with mean 1.0 and standard deviation 0.57 when the grain size is normalized as follows:

$$\frac{\theta}{S}\left(\frac{\rho_s - S}{\rho}\right)\frac{D}{R} \tag{19}$$

where θ is the Shield's parameter, S is the slope of uniform flow, ρ is the density of the fluid, D is the diameter of the particle and R is the hydraulic radius. The method of Odgaard was derived for the fully developed armour layers.

2.3 Calibration of the Proposed Method

As pointed out earlier the thickness of the active bed layer ABL was determined by running the model for the data of Little and Mayer (5). The value of ABL is selected so that the final computed distribution is somewhat finer than the measured distributions. Three runs were selected (runs Nos. 2.1, 3.1 and 6.1). The model was run until the equilibrium armour layers were developed. The size distribution resulting from the model is compared with the measured distribution as shown in Figs. 3, 4 and 5. A deliberate attempt has been made to ensure that the predicted distributions do not match the measured distribution and the deviation is such that the predicted distribution is finer than the measured distribution. The predicted distributions are then analyzed according to the method of Odgaard (9) and the results are shown in Fig. 6. The open symbols represent the predicted values, while the solid symbols denote the measured values. The solid line is the one proposed by Odgaard. It can be seen from Fig. 6 that the predicted values agree with the curve closer near the finer end of the distribution.

In the light of the uncertainty in the measurement, it was felt that any further refinement to the prediction method is not warranted. Improved experimental techniques to measure the grain size distributions of armour layers are urgently needed to improve our predictive capability.

After computing the percentage of sediment in each size range using Eqns. 7 and 14, the model then computes D_{35} and D_{65} by

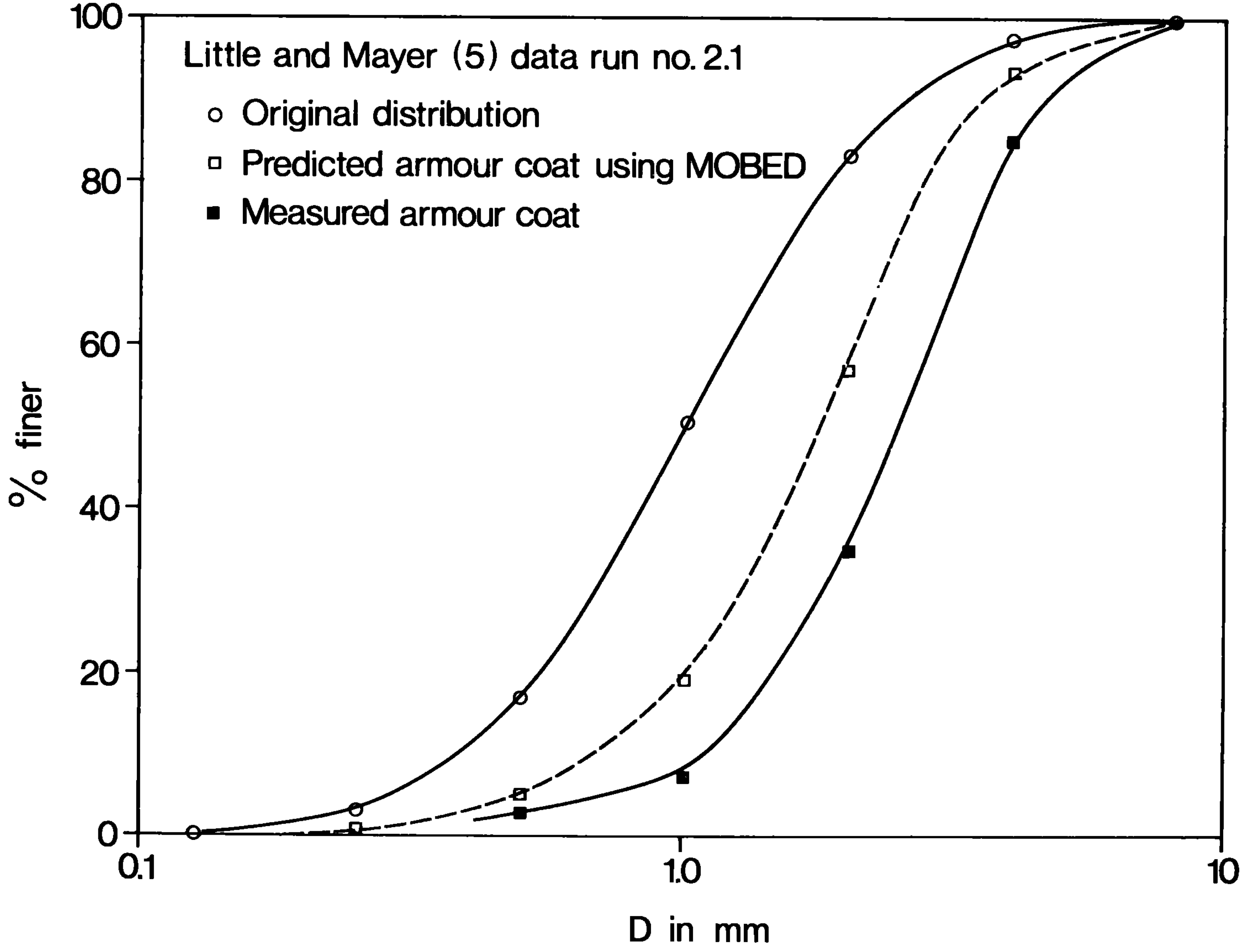


Fig. 3 Measured and Predicted distributions of armour coat

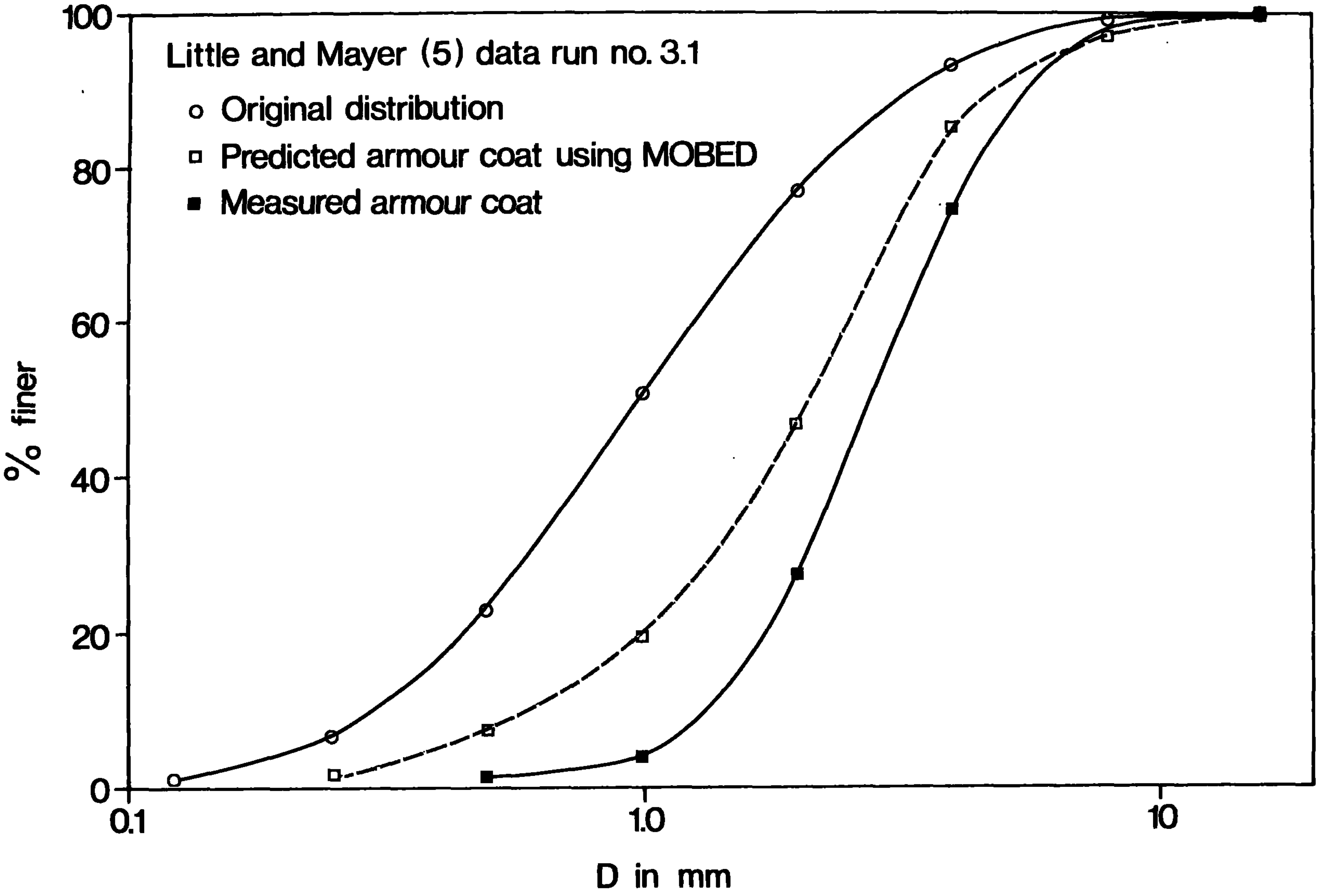


Fig. 4 Measured and Predicted distributions of armour coat

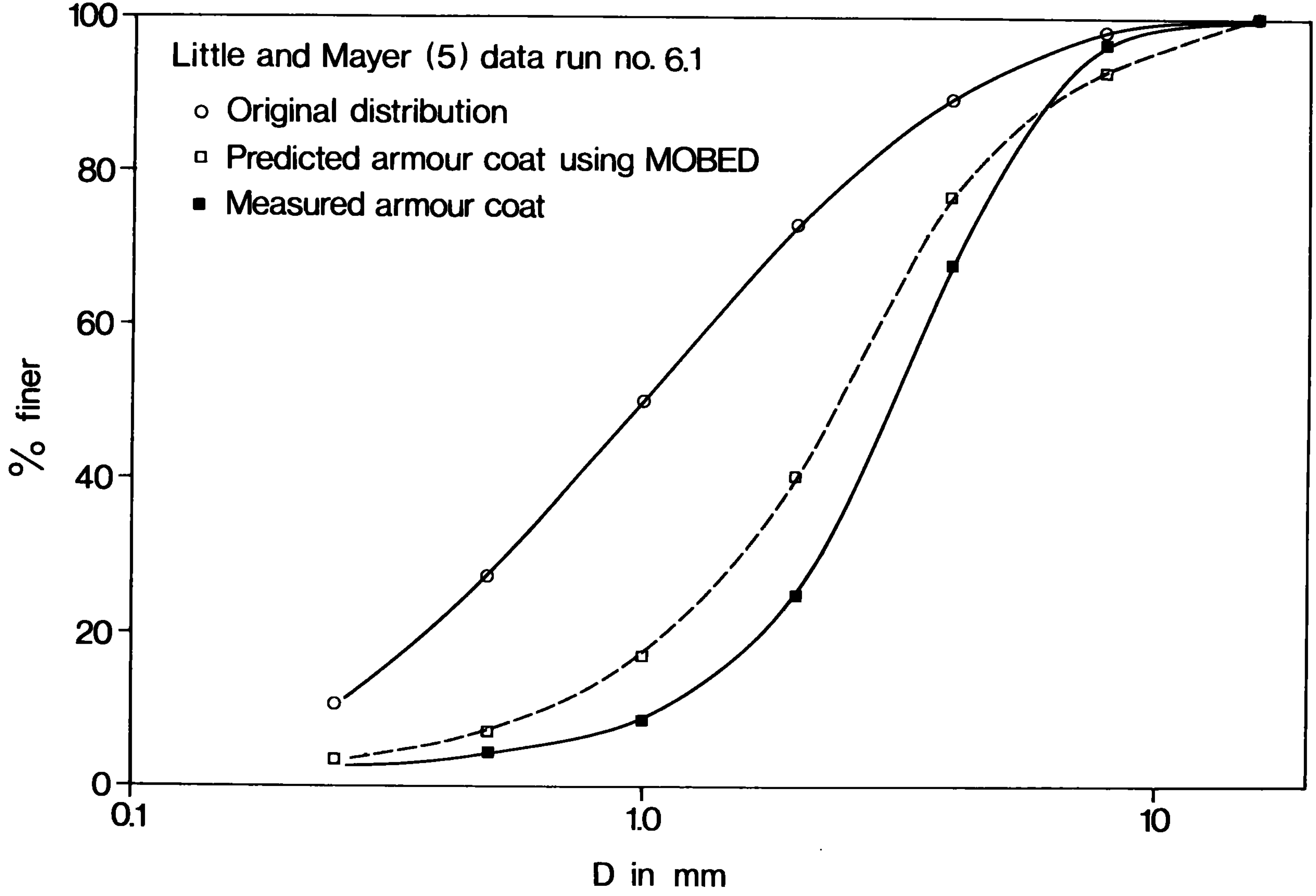


Fig. 5 Measured and Predicted distributions of armour coat

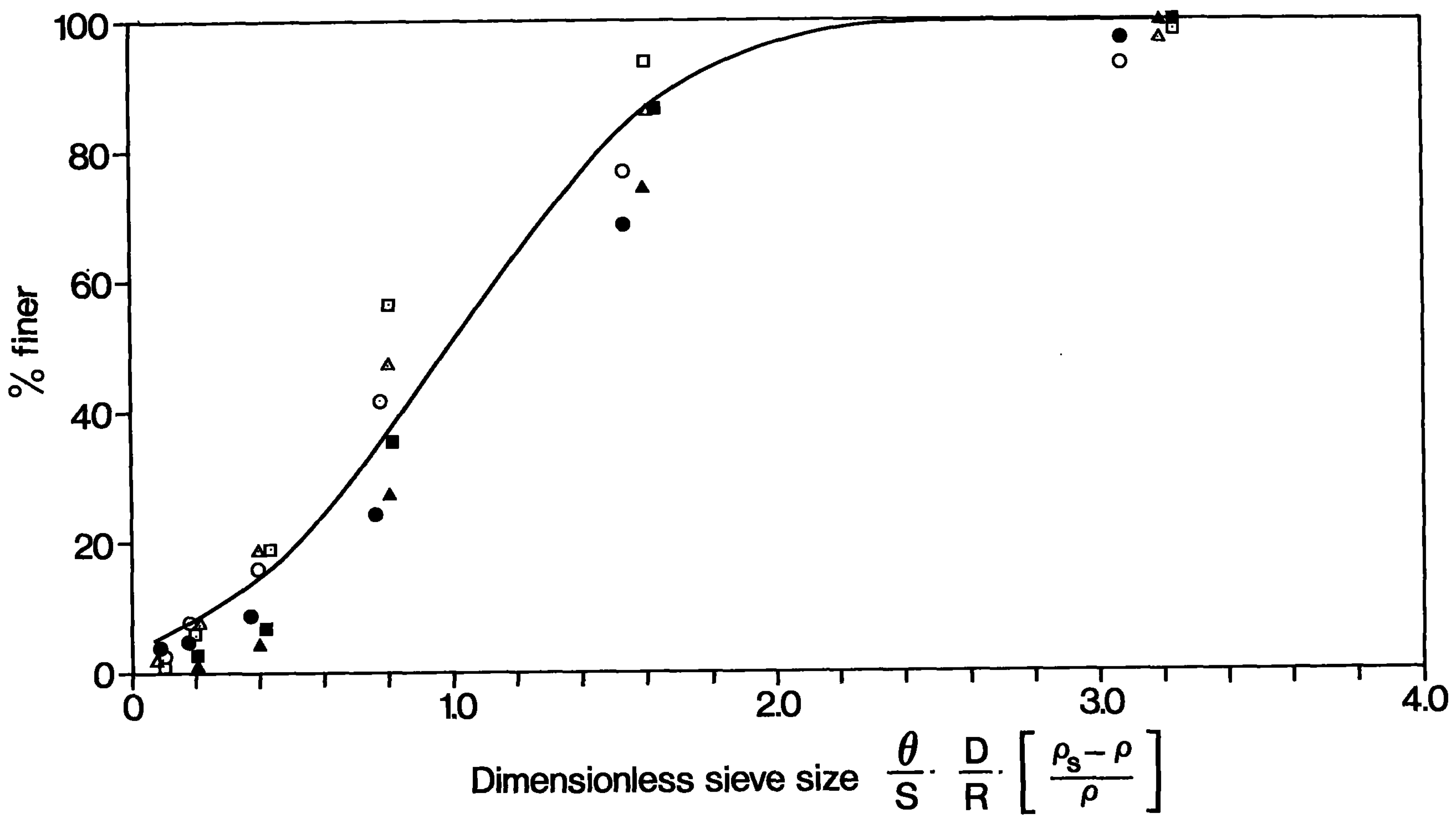


Fig. 6 Comparison with Odgaard's curves

constructing the cumulative distribution curve and linear interpolation as follows:

Let P_1, P_2,...P_{10} be the weight percentages of the bed sediment. Then the cumulative distribution is computed as shown in the table below.

Size in mm	Percentage Finer
0.125	P_1
0.250	P_1+P_2
0.500	$P_1+P_2+P_3$
1.000	$P_1+P_2+P_3+P_4$
2.000	$P_1+P_2+P_3+P_4+P_5$
4.000	$P_1+P_2+P_3+P_4+P_5+P_6$
8.000	$P_1+P_2+P_3+P_4+P_5+P_6+P_7$
16.000	$P_1+P_2+P_3+P_4+P_5+P_6+P_7+P_8$
32.000	$P_1+P_2+P_3+P_4+P_5+P_6+P_7+P_8+P_9$
64.000	$P_1+P_2+P_3+P_4+P_5+P_6+P_7+P_8+P_9+P_{10}$

The grain sizes for which the percentage finer values are 35 and 65, i.e., D_{35} and D_{65} are determined by interpolation. Referring to Fig. 7, the values of D_{35} and D_{65} are determined from the following two relations.

$$\frac{\log D'_u - \log D'_\ell}{\log D_{35} - \log D'_\ell} = \frac{P'_u - P'_\ell}{35 - P'_\ell} \tag{20}$$

$$\frac{\log D''_u - \log D''_\ell}{\log D_{65} - \log D''_\ell} = \frac{P''_u - P''_\ell}{65 - P''_\ell} \tag{21}$$

where D'_u and D'_ℓ are the grain size values that encompass D_{35}. P'_u and P'_ℓ are corresponding percentage finer values. Similarly, D''_u and D''_ℓ are

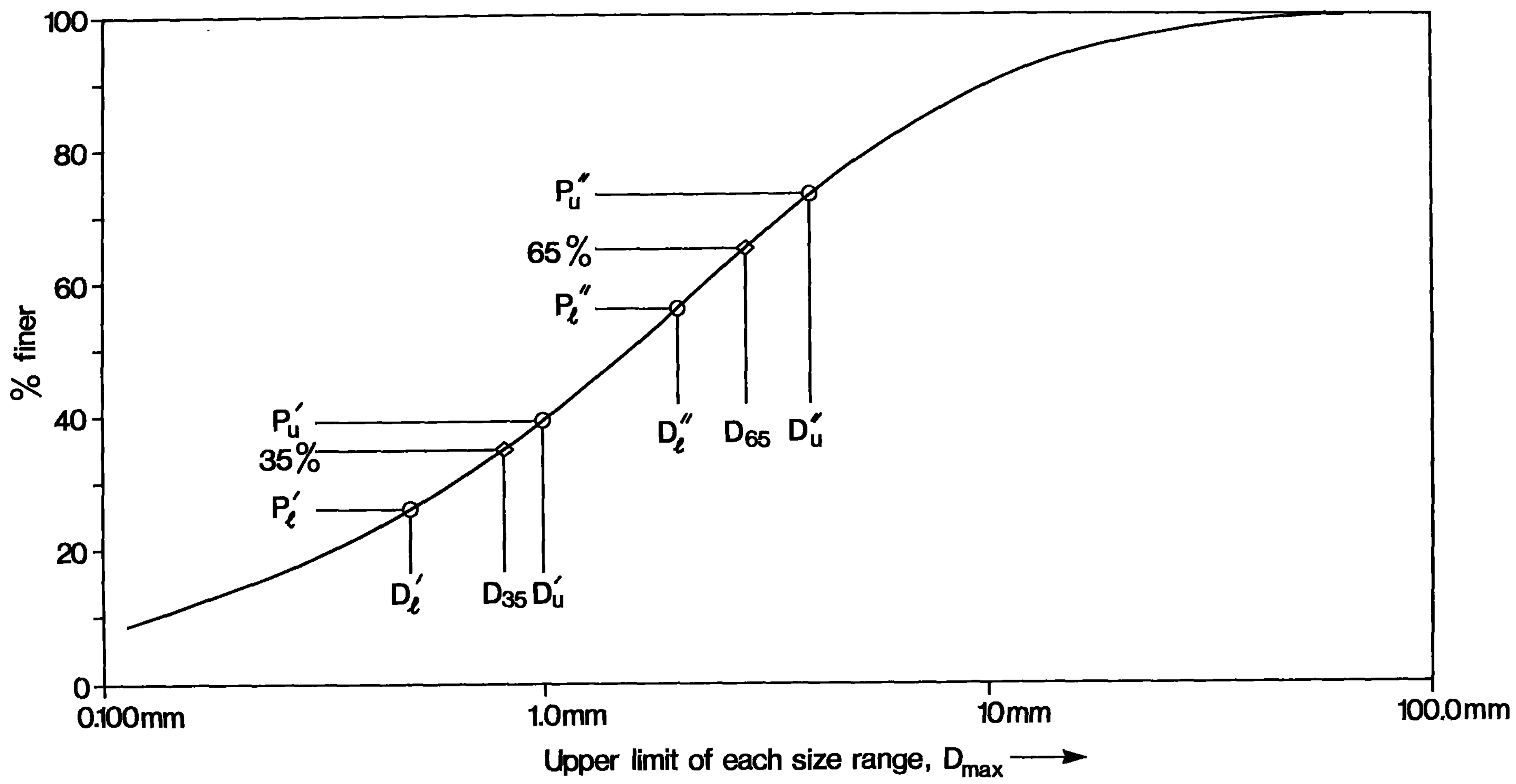


Fig. 7 Evaluation of D_{35} + D_{65}

the grain sizes that encompass D_{65}, and P_u'' and P_ℓ'' are the corresponding percentage finer values.

The values of D_{35} and D_{65} are then used to compute the sediment transport rate and the friction factor of the mobile boundary flow in the model. As the armour layer develops, the values of D_{35} and D_{65} increase which in turn affects both the sediment transport rate and the friction factor. For the same flow condition, the sediment transport rate will decrease as D_{35} increases and the skin friction will increase as D_{65} increases. Therefore, the effect of armouring is felt in the sediment transport rate and the friction factor via the values of D_{35} and D_{65} respectively.

2.4 Changes to Source Code

Since the grain size distribution is treated as a function of distance along the river reach, the grain size parameters D_{35} and D_{65} have to become subscripted variables. Similarly since the friction parameters CONST, EM and EN depend on the grain size distribution, these parameters have to be also subscripted variables. These changes were introduced into the source code. A listing of the revised code is given in Appendix I.

2.5 Changes to Data Files

The grain size distribution information is specified to the model along with the geometric information in TAPE1. The grain size distribution is specified at the same stations for which the geometry data are specified. The model then assigns the grain size distribution data to the grid station in the same way as it assigns the geometry data to the grid stations. The revised arrangement of tape 1 is shown schematically in Fig. 8. The format of the data of tape 1 is shown in Table 1.

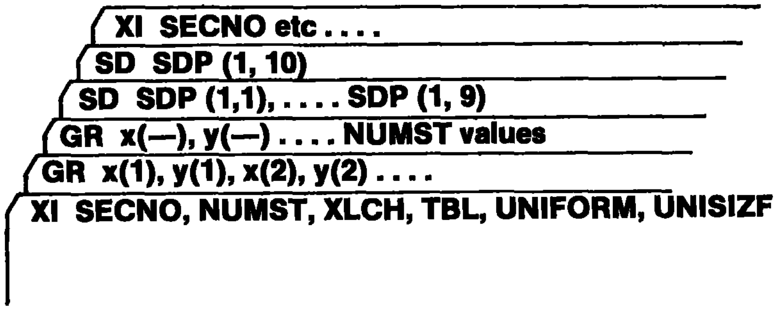


Fig. 8: GEOMETRIC DATA ARRANGEMENT (TAPE 1)

TABLE 1

MOBED Geometric Data (TAPE1)

Group	Format	Columns		Variable Name
X1	F8.0	1-8	Card identification parameter	X1
	F8.3	9-16	An identification number for for the station	SECNO
	I4	17-20	Number of points to define the shape of the cross-section	NUMST
	4X	21-24	Gap	
	F8.3	25-32	Distance in metres or ft between adjacent stations. Zero for the first station.	XLCH
	F8.3	33-40	Thickness of bedlayer in metres or in ft.	TBL
	I3	41-43	Control parameter which specifies whether the sediment is uniform or not	UNIFORM
	F8.3	44-51	A factor which when multiplied by the upper limit of the size range for which a value of 1.0 is specified gives the size of uniform sediment	UNISIZF
GR	F8.0	1-8	Card identification parameter	GR
	9F8.3	9-16	Lateral distance in metres or ft. of a point on the perimeter of the cross-section	X(1)
		17-24	Elevation of the same point in metres or in ft.	Y(1)
		25-32	Lateral distance of the second point	X(2)

TABLE 1. MOBED Geometric Data (TAPE1) (continued) Table 1.2

Group	Format	Columns		Variable Name
		33-40	Elevation of the 2nd point	Y(2)
		41-48	Lateral distance of the 3rd point	X(3)
		49-56	Elevation of the 3rd point	Y(3)
		57-64	Lateral distance of the 4th point	X(4)
		73-80	Lateral distance of the 5th point	X(5)
GR	F8.0	1-8	Card identification parameter	
	9f8.3	9-16	Elevation of the 5th point	Y(5)
		17-24	Lateral distance of the 6th point	X(6)
		25-32	Elevation of the 6th point	Y(6)
		33-40	Lateral distance of 7th point	X(7)
		41-48	Elevation of 7th point	Y(7)
		49-56	Lateral distance of 8th point	X(8)
		57-64	Elevation of 8th point	Y(8)
		65-72	Lateral distance of 9th point	X(9)
		73-80	Elevation of 9th point	Y(9)
			(This group contains coordinates of NUMST points)	
SD	F8.0	1-8	Card identification parameter	SD
	9F8.3	9-16	Fraction of sediment by weight in size range #1	SDP(1,1)
		17-24	Fraction of sediment by weight in size range #2	SDP(1,2)
		25-32	Fraction of sediment by weight in size range #3	SDP(1,3)
		33-40	Fraction of sediment by weight in size range #4	SDP(1,4)
		41-48	Fraction of sediment by weight in size range #5	SDP(1,5)

TABLE 1. MOBED Geometric Data (TAPE1) (continued) Table 1.3

Group	Format	Columns		Variable Name
		49-56	Fraction of sediment by weight in size range #6	SDP(1,6)
		57-64	Fraction of sediment by weight in size range #7	SDP(1,7)
		65-72	Fraction of sediment by weight in size range #8	SDP(1,8)
		73-80	Fraction of sediment by weight in size range #9	SDP(1,9)
		9-16	Fraction of sediment by weight in size range #10	SDP(1,10)

This completes the geometric data specification to Station #1. The data for other stations are continued in a similar fashion. Note that the data specification is from upstream station to downstream station.

The structure of the input data file, TAPE8, is also affected by inclusion of the sediment sorting algorithm. The arrangement of data in TAPE8 is shown schematically in Fig. 9. The format is shown in Table 2. Note that additional data groups are added to the original TAPE8 arrangement. The values of D_{35} and D_{65} specified under data group 8 of the previous TAPE8 are dropped and data groups 17 and 18 are added to provide space for storing $(D_{35}(I), I = 1,N)$ and $(D_{65}(I), I = 1,N)$ for the last time step in a batch simulation in which the total simulation period is covered by a series of shorter duration simulations. Initially, the data groups 17 and 18 contain zero values. Data groups 15 and 16 are added to provide space for storing the bed layer thickness, BL and the active bed layer thickness at the end of the simulation period. At the start of simulation, data groups 15 and 11 also contain zero values. Data group 19 is to provide space for storing the percentage of sediment in different size ranges for each grid station. Zero values are specified at the very start of the simulation period.

2.6 Miscellaneous Changes

A control parameter was introduced into the model so that the model can be run for uniform size sediment. The name of the control parameter is UNIFORM. When the bed sediment is uniform, a value of unity is specified to this parameter, otherwise, a value of zero is specified. When running the model for uniform size sediments an additional parameter called UNISIZF is introduced to calculate the actual size of the sediment from the size range. When specifying grain size distribution for a uniform sediment, a value of 1.0 will be specified to a size range and the actual size of the sediment will be computed as:

$$\text{Actual sediment size} = \text{UNISIZF} \times \text{upper limit of the size range} \qquad (22)$$

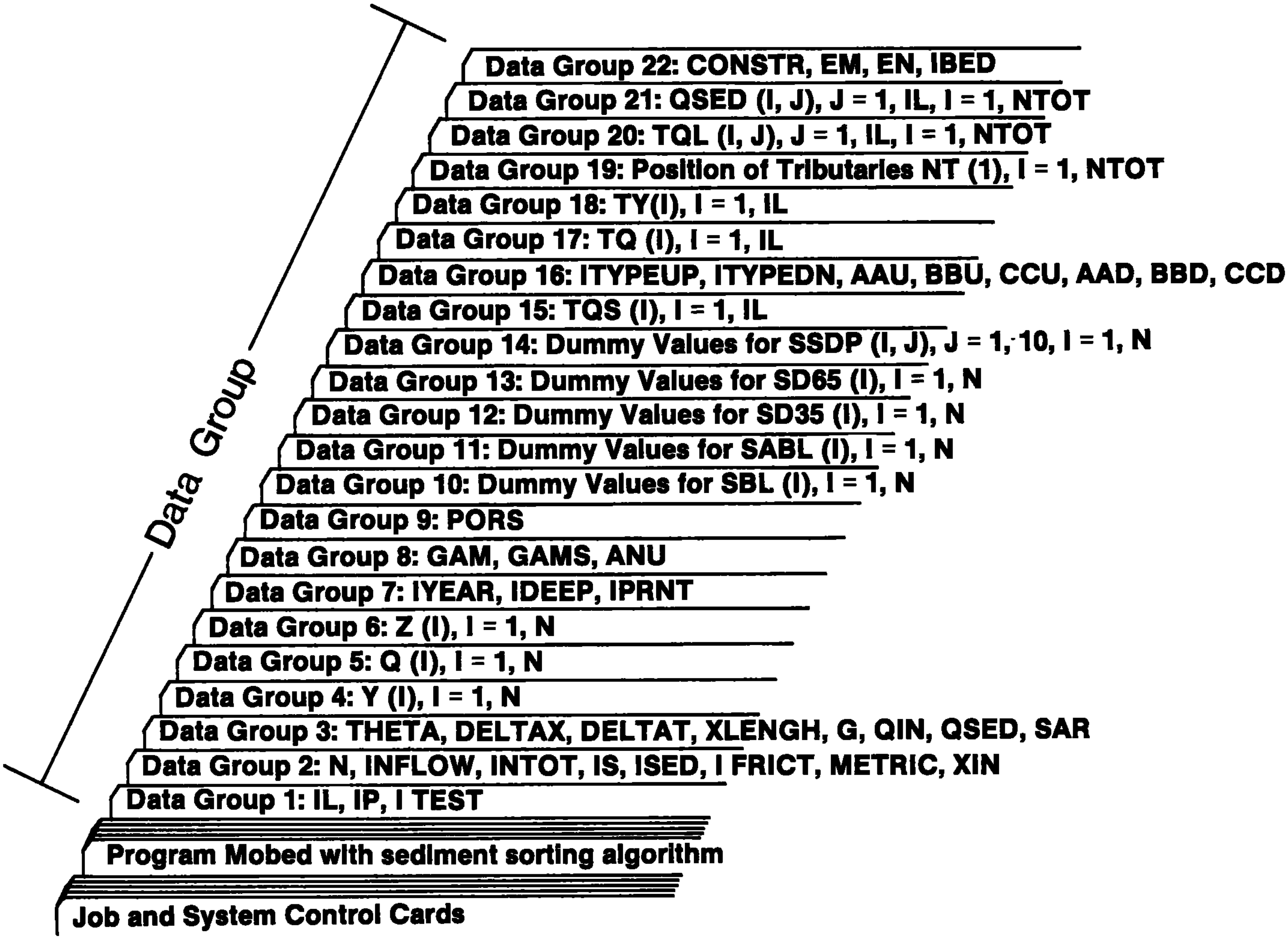


Fig. 9: IMPUT DATA ARRANGEMENT FOR MOBED (TAPE 8)

TABLE 2

MOBED INPUT DATA (TAPE8)

Group	Format	Columns		Variable Name
1	3I5	1-5	Number of time steps for which the model predictions have to be carried out	IL
		6-10	An integer parameter to set the time counters at the start of the model predictions	IP
		11-15	A control parameter to print out intermediate results of a number of computations. ITest=1 will cause the printout. ITEST=0 will bypass the printout.	ITEST
2	6I5, 2F10.4	1-5	Number of grid points along the river reach (maximum=61).	N
		6-10	Control parameter for tributary INFLOW=1, indicates presence of tributary inflows in this reach	INFLOW
		11-15	Total number of tributaries present in the model reach	NTOT
		16-20	An integer between 1 and N, to indicate the position of a storage basin in terms of the grid positions. IS=0 indicates absence of storage basins	IS
		21-25	A control parameter to indicate the nature of river reach. If ISED=0, the reach is rigid boundary. IF ISED=1, the reach is loose boundary	ISED

TABLE 2. MOBED INPUT Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
		26-30	A control parameter to choose the friction factor relation. IF IFRIC=1, then the relations of kishi and kuroki are used.	IFRICT
		31-40	A conversion factor to convert the geometric data specified in TAPE1 from British units to metric units. If data are specified in British units then METRIC=.3048. If data are in metric units then METRIC=1.0	METRIC
		41-50	Location of the first cross-section for which the geometric data are specified. The location is specified in terms of distance in metres measured from the upstream boundary	XIN
3	6F9.3	1-9	A weighting coefficient. A value of 0.67 is recommended	THETA
		10-18	Distance in metres between grid points	DELTAX
		19-27	Time increments, in seconds	DELTAT
		28-36	Total distance of reach (m)	XLENGH
		37-45	Acceleration due to gravity (m/s^2)	G
		46-54	Water surface area of storage basin, in m^2	SAR

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
4	8F10.3 (Upstream to Downstream)	1-10	Initial flow depth (m)	Y(1)
		11-20	Initial flow depth (m)	Y(2)
		21-30	Initial flow depth (m)	Y(3)
		31-40	Initial flow depth (m)	Y(4)
		41-50	Initial flow depth (m)	Y(5)
		51-60	Initial flow depth (m)	Y(6)
		61-70	Initial flow depth (m)	Y(7)
		71-80	Initial flow depth (m)	Y(8)
	N such values have to be specified			
5	8F10.4 (Upstream to Downstream)	1-10	Initial flow rate (m^3/s)	Q(1)
		11-20	Initial flow rate (m^3/s)	Q(2)
		21-30	Initial flow rate (m^3/s)	Q(3)
		31-40	Initial flow rate (m^3/s)	Q(4)
		41-50	Initial flow rate (m^3/s)	Q(1)
		51-60	Initial flow rate (m^3/s)	Q(5)
		61-70	Initial flow rate (m^3/s)	Q(7)
		71-80	Initial flow rate (m^3/s)	Q(8)
	N such values have to be specified			
6	8F10.6	1-10	The bottom elevation (m)	Z(1)
		11-20	The bottom elevation (m)	Z(2)
		21-30	The bottom elevation (m)	Z(3)
		31-40	The bottom elevation (m)	Z(4)
		41-50	The bottom elevation (m)	Z(5)
		51-60	The bottom elevation (m)	Z(6)
		61-70	The bottom elevation (m)	Z(7)
		71-80	The bottom elevation (m)	Z(8)
	N such values have to be specified			

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
7	I4,I5, I2	1-4	An identifier for the geometric data	IYEAR
		5-9	Maximum flow depth expected in ft.	IDEEP
		10-11	Control parameter to print out all the geometric properties of the river reach. If IPRNT=1, the calculated geometric properties such as the flow cross-sectional area wetted perimeter and top width for all the cross-sections are printed out	
8	3E10.4	1-10	Specific weight of water (kg/m^3)	GAM
		11-20	Submerged specific weight of sediment (1650 kg/m^3)	GAMS
		21-30	Kinematic viscosity (10^{-6}m^2/s)	ANU
9	F5.2	1-5	Volume of sediment in unit volume of bed layer	PORS
10	8F10.6 (upstream to downstream)	1-10	Dummy Bedlayer thickness (m)	SBL(1)
		11-20	Dummy Bedlayer thickness (m)	SBL(2)
		21-30	Dummy Bedlayer thickness (m)	SBL(3)
		31-40	Dummy Bedlayer thickness (m)	SBL(4)
		41-50	Dummy Bedlayer thickness (m)	SBL(5)
		51-60	Dummy Bedlayer thickness (m)	SBL(6)
		61-70	Dummy Bedlayer thickness (m)	SBL(7)
		71-80	Dummy Bedlayer thickness (m)	SBL(8)

N such values have to be specified. The model will update the SBL values with actual bed layer thickness when it rewrites TAPE8 at the end of the first simulation in a batch mode. When preparing initial TAPE8, please specify zero values for SBL.

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
11	8F10.6	1-10	Dummy value for active bed layer thickness (m)	SABL(1)
	(upstream	11-20	Dummy value for active bed layer thickness (m)	SABL(2)
	to	21-30	Dummy value for active bed layer thickness (m)	SABL(3)
	downstream)	31-40	Dummy value for active bed layer thickness (m)	SABL(4)
		41-50	Dummy value for active bed layer thickness (m)	SABL(5)
		51-60	Dummy value for active bed layer thickness (m)	SABL(6)
		61-70	Dummy value for active bed layer thickness	SABL(7)
		71-80	Dummy value for active bed layer thickness (m)	SABL(8)

N such values have to be specified. The model will update the SABL values with actual bed layer thickness values when it rewrites TAPE8 at the end of the first simulation. Therefore, when preparing initial TAPE8, please specify zero values for SABL.

Group	Format	Columns		Variable Name
12	8F10.6	1-10	Dummy value for D_{35} (m)	SD35(1)
		11-20	Dummy value for D_{35} (m)	SD35(2)
		21-30	Dummy value for D_{35} (m)	SD35(3)
		31-40	Dummy value for D_{35} (m)	SD35(4)
		41-50	Dummy value for D_{35} (m)	SD35(5)
		51-60	Dummy value for D_{35} (m)	SD35(6)

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
		61-70	Dummy value for D_{35} (m)	SD35(7)
		71-80	Dummy value for D_{35} (m)	SD35(8)
			N such values have to be specified. The model will update the SD35 values with the actual D_{35} values when it rewrites TAPE8 at the end of the first batch simulation. Therefore, when preparing initial TAPE8, please specify zero values for SD35.	
13	8F10.6	1-10	Dummy value for D_{65} (m)	SD65(1)
		11-20	Dummy value for D_{65} (m)	SD65(2)
		21-30	Dummy value for D_{65} (m)	SD65(3)
		31-40	Dummy value for D_{65} (m)	SD65(4)
		41-50	Dummy value for D_{65} (m)	SD65(5)
		51-60	Dummy value for D_{65} (m)	SD65(6)
		61-70	Dummy value for D_{65} (m)	SD65(7)
		71-80	Dummy value for D_{65} (m)	SD65(8)
			N such values need to be specified. The model will update the SD65 values with the actual values of D_{65} when it rewrites TAPE8 at the end of the first batch simulation. Therefore, when preparing initial TAPE8, please specify zero values for SD65.	
14	8F10.6	1-10	Dummy values for percent by weight of particles in size range 1	SSDP(I,1)
		11-20	Dummy values for percent by weight of particles in size range 2	SSDP(I,2)
		21-30	Dummy values for percent by weight of particles in size range 3	SSDP(I 3)
		31-40	Dummy values for percent by weight of particles in size range 4	SSDP(I,4)
		41-50	Dummy values for percent by weight of particles in size range 5	SSDP(I,5)

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
		51-60	Dummy values for percent by weight of particles in size range 2	SSDP(I,6)
		61-70	Dummy values for percent by weight of particles in size range 2	SSDP(I,7)
		71-80	Dummy values for percent by weight of particles in size range 2	SSDP(I,8)
	N such values need to be specified. The model will update the SSDP values with the actual grain size distribution values when it rewrites TAPE8 at the end of the first batch simulation. Therefore, when preparing initial TAPE8, please specify zero values for these parameters.			
15	8F10.6	1-10	Sediment transport rate at upstream boundary in kg/s.	TQS(1)
		11-20	Sediment transport rate at upstream boundary in kg/s.	TQS(2)
		21-30	Sediment transport rate at upstream boundary in kg/s.	TQS(3)
		31-40	Sediment transport rate at upstream boundary in kg/s.	TQS(4)
		41-50	Sediment transport rate at upstream boundary in kg/s.	TQS(5)
		51-60	Sediment transport rate at upstream boundary in kg/s.	TQS(6)
		61-70	Sediment transport rate at upstream boundary in kg/s.	TQS(7)
		71-80	Sediment transport rate at upstream boundary in kg/s.	TQS(8)
	(This group contains I1 such values)			

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
16	2I,	1-3	Type of upstream boundary condition	ITYPEUP
	6F5.0	4-6	Type of downstream boundary condition	ITYPEDN
		11-15	Parameter of upstream stage-discharge relationship	AAU
		16-20	Parameter of upstream stage-discharge relationship	BBU
		21-25	Parameter of upstream stage-discharge relationship	CCU
		26-30	Parameter of downstream stage-discharge relationship	AAD
		31-35	Parameter of downstream stage-discharge relationship	BBD
		36-40	Parameter of downstream stage-discharge relationship	CCD
17	8F10.4	1-10	Flow rate as a function of time at the upstream or downstream boundary	TQ(1)
		11-20	Flow rate as a function of time at the upstream or downstream boundary	TQ(2)
		21-30	Flow rate as a function of time at the upstream or downstream boundary	TQ(3)
		31-40	Flow rate as a function of time at the upstream or downstream boundary	TQ(4)
		41-50	Flow rate as a function of time at the upstream or downstream boundary	TQ(5)

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
		51-60	Flow rate as a function of time at the upstream or downstream boundary	TQ(6)
		61-70	Flow rate as a function of time at the upstream or downstream boundary	TQ(7)
		71-80	Flow rate as a function of time at the upstream or downstream boundary	TQ(8)
	(this group contains IL such values)			
18	8F10.4	1-10	Flow depth as a function of time at the downstream or upstream boundary	TY(1)
		11-20	Flow depth as a function of time at the downstream or upstream boundary	TY(2)
		21-30	Flow depth as a function of time at the downstream or upstream boundary	TY(3)
		31-40	Flow depth as a function of time at the downstream or upstream boundary	TY(4)
		41-50	Flow depth as a function of time at the downstream or upstream boundary	TY(5)
		51-60	Flow depth as a function of time at the downstream or upstream boundary	TY(6)

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
		61-70	Flow depth as a function of time at the downstream or upstream boundary	TY(7)
		71-80	Flow depth as a function of time at the downstream or upstream boundary	TY(8)
	(This group contains IL such values)			
19	6I5	1-5	Position of 1st Tributary	NT(1)
		6-10	Position of 2nd Tributary	NT(2)
		11-15	Position of 3rd Tributary	NT(3)
		16-20	Position of 4th Tributary	NT(4)
		21-25	Position of 5th Tributary	NT(5)
		26-30	Position of 6th Tributary	NT(6)
20	8F10.4	1-10	Tributary inflow rate of the first tributary	TQL(1,1)
		11-20	Tributary inflow rate of the first tributary	TQL(1,2)
		21-30	Tributary inflow rate of the first tributary	TQL(1,3)
		31-40	Tributary inflow rate of the first tributary	TQL(1,4)
		41-50	Tributary inflow rate of the first tributary	TQL(1,5)
		51-60	Tributary inflow rate of the first tributary	TQL(1,6)
		61-70	Tributary inflow rate of the first tributary	TQL(1,7)

TABLE 2. MOBED Input Data (TAPE8) (continued)

Group	Format	Columns		Variable Name
		71-80	Tributary inflow rate of the first tributary	TQL(1,8)
	This group contains IL such values for each tributary specified.			
21	8F10.4	1-10	Lateral sediment inflow rate at first tributary	QSED(1,1)
		11-20	Lateral sediment inflow rate at first tributary	QSED(1,2)
		21-30	Lateral sediment inflow rate at first tributary	QSED(1,3)
		31-40	Lateral sediment inflow rate at first tributary	QSED(1,4)
		41-50	Lateral sediment inflow rate at first tributary	QSED(1,5)
		51-60	Lateral sediment inflow rate at first tributary	QSED(1,6)
		61-70	Lateral sediment inflow rate at first tributary	QSED(1,7)
		71-80	Lateral sediment inflow rate at first tributary	QSED(1,8)
	This group contains IL such values for each tributary specified.			
22	F20.5,	1-10	Friction parameter	CONSTR
	F210.3,	11-20	Friction parameter	EM
	I5	21-30	Friction parameter	EN
		31-35	Parameter defining the nature of bed form	IBED

The parameters, UNIFORM, UNISIZE are specified to the model through TAPE1. (See Fig. 8 and Table 1.)

In this version of MOBED, the ratio between the suspended load and the total sediment load is computed and is printed out as an additional model output. As pointed out earlier, the sediment transport rate calculations are carried out using D_{35} value for the sediment and not the individual fraction of sediment in each size range. For calculating the ratio between the suspended load and total load, a critical shear velocity for initiation of suspension proposed by van Rijn (10) was adopted. According to this method, the critical shear velocity U_{*cr} for sediment suspension is given by:

$$\frac{U_{*cr}}{w} = \frac{4}{D_*} \quad \text{for} \quad 1 < D_* \leq 10$$

$$\frac{U_{*cr}}{w} = 0.4 \text{ for } D_* > 10 \qquad (23)$$

where w is the fall velocity of sediment. D_* is a dimensionless grain size given by

$$D_* = D_{35} \left[\left(\frac{\rho_s}{\rho} - 1 \right) \frac{g}{\nu^2} \right] \qquad (24)$$

In the above expression, ν stands for the kinematic viscosity of fluid.

The fall velocity of particles w is evaluated from the following relation

$$w = C \, [D_*^{3}]^{n} \sqrt{\left(\frac{\rho_s - \rho}{\rho} \right) g \, D_{35}} \qquad (25)$$

where C and n are given as follows:

$$\left.\begin{aligned} c &= .056 \\ n &= 0.50 \end{aligned}\right\} \quad \text{if } 0 < D_*^3 \leq 100$$

$$\left.\begin{aligned} c &= .1585 \\ n &= 0.20 \end{aligned}\right\} \quad \text{if } 100 \leq D_*^3 \leq 5 \times 10^5$$

$$\left.\begin{aligned} c &= 1.825 \\ n &= 0.00 \end{aligned}\right\} \quad \text{if } D_*^3 > 5 \times 10^5$$

The method of Einstein (11) was employed to compute the ratio between the suspended sediment load and the bed load transport. According to this method the ratio is given as:

$$A = \frac{q_{ss}}{q_{sb}} = \frac{1}{\kappa} \frac{1}{23.2} \frac{h}{D_{65}} \left(\frac{\eta_a}{1 - \eta_a}\right)^Z \Big[\ln\left(\frac{A_s}{2.72} \frac{h}{2.5D_{65}}\right)$$

$$\int_{\eta_a}^{1} \left(\frac{1 - \eta}{\eta}\right) d\eta + \int_{\eta_a}^{1} \left(\frac{1 - \eta}{\eta}\right)^Z \ln\eta \, d\eta\Big] \qquad (26)$$

where q_{ss} is the suspended sediment transport and q_{sb} is the bed load transport rate. η_a, Z, A_s are defined as follows:

$$\eta_a = \frac{2\,D_{65}}{h} \qquad (27)$$

$$Z = \frac{1}{\kappa} \frac{w}{U_*} \qquad (28)$$

$$A_s = e^{\kappa B_s} \qquad (29)$$

where $$B_s = (2.50\ x + 5.50)e^{-0.217x^2} + 8.5\ (1.0 - e^{-0.217x^2}) \tag{30}$$

in which $$x = \ln\ (2.5\ U_* D_{65}/\nu) \tag{31}$$

Knowing the ratio between q_{ss} and q_{sb}, the ratio between q_{ss} and q_{st} can be computed as

$$\frac{q_{ss}}{q_{st}} = \{1 - (\frac{1}{1 + A})\} \tag{32}$$

(q_{st} is the total sediment transport rate.)

A new subroutine called TRIBUT is introduced in this version of MOBED. This subroutine allows the model to treat up to six tributaries in the study reach. The tributary inflow hydrographs are read into the model through the input data file TAPE8 (see Table 2 and Fig. 9). The lateral sediment inputs from the tributaries are also considered. They are also read into the model through TAPE8.

3.0 TEST DATA FILES AND MODEL OUTPUTS

Data files, tape 8 and tape 1 prepared for one of the runs of Little and Mayor are shown in Appendices II and III respectively as examples of these files and could serve as a set of test data for model implementation. The model output that was generated using the test data is shown in Appendix IV. The model output consists of percentages of sediment by weight in different size ranges, the values of D_{35}, D_{65}, the total bed depth, active bed layer thickness, the type of bed forms present at each node, the friction parameters at each node and the ratio between the suspended sediment load and the total load at each grid node, in addition to the usual output of flow parameters.

4.0 SUMMARY

A sediment sorting algorithm incorporated into MOBED is described in this report. Some of the additional changes that were introduced to the model are also described. A set of sample test data and the model output generated using the test data are presented.

5.0 ACKNOWLEDGMENTS

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REFERENCES

1. Krishnappan, B.G. "Users Manual: Unsteady, non-uniform, mobile boundary flow model - MOBED", Hydraulics Division, NWRI, Burlington, Ontario, Feb. 1981.
2. Krishnappan, B.G. "MOBED Users Manual update I", Hydraulics Division, NWRI, Burlington, Ontario, Aug. 1983.
3. HEC-6 Scour and Deposition in Rivers and Reservoirs: Users Manual, U.S. Army Corps of Engineers, the Hydrologic Engineering Center, California, March 1977.
4. Gessler, J. "Beginning and ceasing of sediment motion", Proceedings of the Institute of River Mechanics, Colorado State University, Fort Collins, Colorado, 15-26 June 1970.
5. Little, W.C. and Mayer, P.G. "The Role of Sediment Gradation on Channel Armouring", School of Engineering, Georgia Institute of Technology, Atlanta, Georgia, May 1972.
6. Shen, H.W. and Lu, J.Y., "Development and Prediction of Bed Armouring, Journal of Hydraulic Engineering, ASCE, Vol. 109, No. 4, April 1983.
7. Kellerhals, R., and Church, M. Discussion of "stability of channel beds by armouring", Journal of the Hydraulics Division, ASCE, Vol. 103, No. HY7, 1977, pp. 826-827.
8. Ettema, R., "Sampling armour-layer sediments", Journal of Hydraulic Engineering, Vol. 110, No. 7, July 1984, pp. 992-996.
9. Odgaard, A.J. "Grain-size distribution of river bed armour layers", Journal of Hydraulic Engineering, Vol. 110, No. 10, Oct. 1984.

APPENDIX I

Listing of MOBED with Armouring Routine

```
          73/171   OPT=1                                  FTN 4.8+536          86/12/.

C
C         * * * * * * * * * * * * * * * * * * * *
C         *                                     *
C         *                                     *
C         *           MODEL  MOBED              *
C         *  (WITH SEDIMENT SORTING ALGORITHM)  *
C         *                                     *
C         *                                     *
C         * * * * * * * * * * * * * * * * * * * *
C
C
C         MODEL MOBED WAS DEVELOPED AT THE HYDRAULICS  DIVISION OF
C         THE NATIONAL WATER RESEARCH INSTITUTE IN BURLIGTON, ONTARO,
C         CANADA.
C
C
C         THE MODEL SOLVES THE ST. VENANT EQUATICNS AND A SEDIMENT MASS
C         BALANCE EQUATION.   THEREFORE IT IS SUITABLE FOR PREDICTING
C         WATER AND BED LEVEL VARIATIONS UNDER UNSTEADY FLOW CONDITIONS
C
C
C
C
C         THE CODE FOR THE MODEL WAS DEVELOPED USING A CDC CYBER 371 MODEL
C         COMPUTER.   SOME VARIABLE NAMES AND PROGRAM STATEMENTS MAY NOT BE
C         SUITABLE FOR OTHER COMPUTER INSTALLATICNS; BUT,WITH SLIGHT
C         MODIFICATIONS THIS CODE CAN BE IMPLEMENTED IN OTHER COMPUTERS.
C             E.G.   SOME VARIABLE NAMES NEED TO BE SHORTENED FOR
C                    SOME I.B.M. APPLICATIONS
C         THE PROGRAM STATEMENT IS USED TO SET UP THE INPUT AND
C         OUTPUT FILES AS WELL AS SCRATCH FILES.
C             I.E.   WRITE (6,   SPECIFIES TO WRITE CN FILE TAPE6
C                    UNITS 60 AND 61 ARE THE STANDARD I/O
C                    UNIT 4 IS A BINARY SCRATH FILE USED BY MOBED
C                    FOF TEMPORARY STORAGE.
C
C         *************************************************************
C
C         CHAPTER  0000  **** DIMENSIONS AND COMMON BLOCKS ****
C
C         *************************************************************
C
C
C
          PROGRAM MOBED (INPUT,OUTPUT,TAPE1,TAPE60=INPUT,TAPE61=OUTPUT,TAPE4
         $,TAPE8,TAPE6)
          COMMON/A/  Y(61),BW(61),II,TQS(200)
          COMMON/B/  GAM,GAMS,D35(61),D65(61),ANU,G,ABL(61),SDP(61,10),BL(61)
         $,SDPI(61,10)
          COMMON /E/  DELTAX,DELTAT,N
          COMMON/C/  ITYPEUP,ITYPEDN,K1,AAU,BBU,CCU,AAD,BBD,CCD
          COMMON/D/  TQ(200),TY(200),E(61),F(61),DELY(61),Q(61)
          DIMENSION  Z(61),B(61),A(61),P(61),R(61),DERB(61),DERP(61),
         $QL1(61),C(61),AYX(61),A1(61),B1(61),C1(61),D1(61),E1(61),A2(61),
         $B2(61),C2(61),D2(61),E2(61),L(61),M(61),K(61),DELQ(61),D(61)
         $,T(61),QL2(61),CONST(61),EM(61),EN(61),TA(61)
          DIMENSION  QS1(61),QS2(61),QST1(61),QST2(61),ZZ(61),DELZ(61),
         $CAV1(61),CAV2(61),Y1(61),Y2(61),SBL(61),UNISIZF(61)
          DIMENSION  AVY(61),SABL(61),SD35(61),SD65(61),SSDP(61,10),FR(61)
          DIMENSION  CAV(61),QST(61),RANGE(61),RNEW(61)
          DIMENSION  P1(61),P2(61),BT1(61),BT2(61),AR1(61),AR2(61),ASFL(61)
          INTEGER H,UNIFORM(61),IBED(61)
          DIMENSION  TQL(6,200),NT(6),QSED(6,200)
          REAL LANG,L,M,K,METRIC
          DATA TQ(1),TY(1) /999999.,999999./
          WRITE (61,1120)
C
C
C          ********************************************
C
C          CHAPTER  AAAA  **** INPUT PARAMETERS ****
C
C          ********************************************
C
C
C
```

```
C                    SECTION A1
C                    **********
C
C     THE FOLLOWING IS THE LIST OF SYMBOLS USED IN THIS PROGRAM.
C
C
C     N              IS THE NUMBER OF GRID POINTS ALONG THE RIVER REACH.
C
C     INFLOW         IS A CONTROL PARAMETER FOR TRIBUTARY.
C
C     INFLOW=1       INDICATES PRESENCE OF A TRIBUTARY INFLOW IN
C                    THIS REACH.
C
C     INFLOW=0       INDICATES ABSENCE OF TRIBUTARY.
C
C     NTOT           SPECIFIES THE NUMBER OF TRIBUTARIES.
C                    POSITION OF THE TRIBUTARY.
C
C
C
C     IS             IS AN INTEGER BETWEEN 1 TO N TO INDICATE THE
C                    POSITION OF THE STORAGE BASIN IN TERMS OF THE
C                    GRID LENGTHS.
C
C     IS=0           SIGNIFIES ABSENCE OF STORAGE BASIN.
C
C     ISED           IS A CONTROL PARAMETER TO INDICATE WHETHER THE
C                    REACH IS RIGID BOUNDARY OR A LOOSE BOUNDARY.
C
C     ISED=0         SIGNIFIES THAT THE REACH IS A RIGID BOUNDARY.
C
C     ISED=1         SIGNIFIES THAT THE REACH IS A LOOSE BOUNDARY.
C
C                     NOTE: FOR RIGID BOUNDARY RIVER FLOWS THE EARLIER
C                           VERSION OF MOBED (USERS MANUAL UPDATEI,1983)
C                           IS EASIER TO USE.  IF FLOW REVERSALS ARE
C                           EXPECTED AS IN TIDAL RIVERS THEN THIS VERION
C                           IS MORE APPROPRIATE.
C     THETA          IS A WEIGHTING COEFFICIENT BETWEEN 0.5 AND 1.00.
C
C     DELTAX         IS THE LENGTH BETWEEN GRID POINTS (IN METERS).
C
C     DELTAT         IS THE TIME INCREMENTS IN SECONDS.
C
C     XLENGH         IS THE TOTAL LENGTH OF THE RIVER REACH MODELLED
C                    (IN METERS).
C
C     G              IS THE ACCELERATION DUE TO GRAVITY (IN M/SEC**2).
C
C     QIN            IS THE TRIBUTARY FLOW RATE PER UNIT LENGTH (IN M**3/M*SEC).
C                     THE TRIBUTARY INFLOW IS TREATED AS A LINE SOURCE
C                     OF LENGTH DELTAX.  THEREFORE, QIN IS EQUAL TO THE
C                     TOTAL TRIBUTARY INFLOW DIVIDED BY DELTAX.
C
C     QSED           IS THE SEDIMENT INFLOW RATE PER UNIT LENGTH(IN M**3/M*SEC).
C                     THE LATERAL INFLOW OF SEDIMENT,LIKE THE TRIBUTARY
C                     INFLOW, IS TREATED AS A LINE SOURCE OF LENGTH
C                     DELTAX.  THEREFORE, QSED IS EQUAL TO THE TOTAL
C                     LATERAL SEDIMENT INFLOW RATE DIVIDED BY DELTAX
C
C     SAR            IS THE WATER SURFACE AREA OF STORAGE BASIN.
C
C     METRIC         IF GEOMETRICAL DATA ARE IN BRITISH UNITS THEN
C                    METRIC=0.3048.   OTHERWISE METRIC=1.0
C
C     XIN            DISTANCE-IN-METRES BETWEEN THE FIRST GRID STATION
C                    AND THE FIRST CROSS SECTION WHERE GEOMETRICAL DATA
C                    ARE SPECIFIED.
C
C     TQS              UPSTREAM BOUNDARY VALUES OF SEDIMENT TRANSPORT RATE
C
C
C     IFRICT           CONTROL PARAMETER TO SELECT FRICTIONAL RELATIONS
C
C     IFRICT=1         THE FRICTIONAL RELATIONS OF KISHI-KUROKI ARE USED
C
C     IFRICT.NE.1      THE FRICTIONAL RELATIONS SUCH AS MANNINGS OR CHEZYS
```

```
C                       (OR ANY OTHER FRICTION FACTOR) CAN BE SPECIFIED.
C                       IN SUCH CASES TAPE8 SHOLLD HAVE VALUES FOR CONSTR,
C                       EM,EN,IBED.    SEE USERS MANUAL UPDATE(1983) TO
C                       EVALUATE THESE PARAMETERS.
C
C     ITEST             CONTROL PARAMETER FOR WRITING OUT CALCULATED VALUES
C                       ITEST=1 FOR TEST MODE 0 FOR NON-TEST MODE
C
C
C     IL                NUMBER OF TIME INCREMENTS (DELTAT) FOR WHICH THE
C                       FLOW COMPUTATIONS ARE TO BE CARRIED OUT
C
C
C     IP                CONTROL PARAMETER TO SET STARTING DAY ON OUTPUT
C
      READ (60,485) IL,IP,ITEST
      READ (60,490) N,INFLOW,NTCT,IS,ISED,IFRICT,METRIC,XIN
      READ (60,500) THETA,DELTAX,DELTAT,XLENGH,G,SAR
C
C
C                     SECTION A2
C                     **********
C
C     Y         IS THE FLOW DEPTH IN METERS.
C
C     Q         IS THE FLOW RATE IN (M**3/S)
C
C
C     Z         IS THE BOTTOM ELEVATION (IN METERS FORM DATUM)
C
C
C     * READ IN INITIAL CONDITIONS *
C
C
      READ (60,510) (Y(I),I=1,N)
      READ (60,520) (Q(I),I=1,N)
      READ (60,1050) (Z(I),I=1,N)
C
C
C                     SECTION A3
C                     **********
C
C
C
C     QST             IS SEDIMENT TRANSPORT RATE (IN M**3/SEC).
C
C     CAV             IS THE VOLUMETRIC CONCENTRATION OF SEDIMENT.
C
C
C     IYEAR   IS THE YEAR THE DATA COLLECTED (I.E. 1985).
C
C     IDEEP   IS THE MAXIMUM DEPTH TO BE CONSIDERED (E.G.10) IN FEET.
C        NOTE: IDEEP IS THE ONLY QUANTITY THAT IS EXPRESSED IN BRITISH
C              UNITS IN TAPE6.
C
C     IPRNT   IS A CONTROL PARAMETER, FOR LISTING OF AREAS,WETTED-PERIMETER,
C             AND TOP WIDTHS. SET IPRNT = 1 TO 9 IF LISTING DESIRED.
C
C     RANGE   IS AN ARRAY CONTAINS THE STATION NUMBERS WHERE ACTUAL
C             MEASUREMENTS WERE TAKEN.
C
C     UNIFORM IS THE CONTROL PARAMETER ARRAY TO SPECIFY THE NATURE OF
C                 THE SEDIMENT DISTRIBUTION
C             UNIFORM = 1   ( UNIFORM SEDIMENT)
C                     = 0 ( NON-UNIFORM SEDIMENT)
C
C    UNISIZF            UNIFORM SEDIMENT SIZE EXPRESSED AS UNISIZF
C                       TIMES THE UPPER LIMIT OF SIZE RANGE (SEE USER
C                            MANUAL UPDATE 11)
C
C
      READ (60,530) IYEAR,IDEEP,IPRNT
C
C
      CALL PROFILE (METRIC,IDEEP,RANGE,NUM,IPRNT,IYEAR,XIN,UNIFORM,UNISI
     $ZF)
      CALL KLIST (RANGE,NUM,N,RNEW,IPRNT,DELTAX)
C
```

```
C
C                       SECTION A4
C                       **********
C
C
C       GAM             IS THE SPECIFIC WEIGHT OF WATER (1000KG/M**3).
C
C       GAMS            IS SUBMERGED SPECIFIC WEIGHT OF SEDIMENT
C                       (1650 KG/M**3).
C
C       D35             IS AN ARRAY OF GRAIN SIZE OF SEDIMENT (IN METERS).
C
C       D65             IS AN ARRAY OF GRAINSIZE OF SEDIMENT RESPONSIBLE FOR ROUGHNESS
C
C       ANU             IS THE KINEMATIC VISCOSITY OF WATER
C                       (1.0**-6 M**2/SEC).
C
C       PORS            IS THE RATIO OF VOLUME OF SEDIMENT TO VOLUME OF BED
C                            LAYER.
C
C
C       TQS             IS THE SEDIMENT INPUT RATE AT THE UPSTREAM SECTION
C                       AS A FUNCTION OF TIME
C
C
        READ (60,540) GAM,GAMS,ANU
C
C
        READ (60,550) PORS
     00 READ (60,560) (SBL(I),I=1,N)
        READ (60,560) (SABL(I),I=1,N)
        READ (60,560) (SD35(I),I=1,N)
        READ (60,560) (SD65(I),I=1,N)
        DO 85 I=1,N
   85     READ (60,560) (SSDP(I,J),J=1,10)
C
        READ (60,560) (TQS(I),I=1,IL)
C
C                       SECTION A5
C                       **********
C
C
C       ITYPEUP AND ITYPEDN SPECIFY THE TYPE OF BOUNDARY CONDITIONS AT
C       THE UPSTREAM AND DOWNSTREAM SECTIONS RESPECTIVELY.
C       IF THEY TAKE A VALUE OF :
C         1     Y IS GIVEN BY A FUNCTION OF T
C         2     Q IS GIVEN BY A FUNCTION OF T
C         3     Q IS GIVEN BY A FUNCTION OF Y  (I.E. STAGE-DISCHARGE RELATIONSHIP)
C
C
C       AAU,BBU,CCU
C       AAD,BBD,CCD,        ARE CONSTANTS APPEARING IN THE STAGE-DISCHARGE IN THE
C                           FORM Q = A*(Y**B)+C. SET TO ZEROES IF STAGE DISCHARGE
C                           RELATIONS ARE NOT CHOSEN AS BOUNDARY CONDITIONS.
C
C
C
        READ (60,570) ITYPEUP,ITYPEDN,AAU,BBU,CCU,AAD,BBD,CCD
C
C
C                       SECTION A6
C                       **********
C
C
C                 SPECIFICATION OF UPSTREAM AND DOWNSTREAM BOUNDARY CONDITIONS.
C
C
C       TQ              IS THE FLOW RATE AS A FUNCTION OF TIME
C
C       TY              IS THE FLOW DEPTH AS A FUNCTION OF TIME
C
C
        IF(((ITYPEUP.EQ.2).AND.(ITYPEDN.EQ.1)).OR.((ITYPEUP.EQ.1).AND.
     $(ITYPEDN.EQ.2))) GO TO 70
        IF(((ITYPEUP.EQ.3).AND.(ITYPEDN.EQ.1)).OR.((ITYPEUP.EQ.1).AND.
     $(ITYPEDN.EQ.3))) GO TO 80
        IF ((ITYPEUP.EQ.3).AND.(ITYPEDN.EQ.3)) GO TO 90
```

```
          READ (60,520)  (TQ(I),I=1,IL)
          GO TO 90
       70 READ (60,520)  (TQ(I),I=1,IL)
       80 READ (60,520)  (TY(I),I=1,IL)
    C
       90 IF(INFLOW.NE.0) READ(60,511)   (NT(I),I=1,NTOT)
          IF(INFLOW.NE.0) READ(60,520)   ((TQL(I,J),J=1,IL),I=1,NTOT)
          IF(INFLOW.NE.0) READ(60,520)   ((CSED(I,J),J=1,IL),I=1,NTOT)
            IF ((ISED.NE.1).OR.(IFRICT.NE.1)) READ(60,580) CONSTR,(EM(I),
         $  EN(I),IBED(I),I=1,N)
    C
    C
    C     *****************************************************
    C
    C
    C     CHAPTER  8888  **** PRINT OUT ALL THE PARAMETERS ****
    C
    C
    C     *****************************************************
    C
    C
    C
          WRITE (61,590)
          IF (ITEST.EQ.1) WRITE (61,600)
          WRITE  (61,610) N
          WRITE  (61,620) INFLOW
          WRITE(61,630) NTOT
          WRITE  (61,650) IS
          WRITE  (61,660) ISED
          WRITE  (61,670) THETA
          WRITE  (61,680) DELTAX
          WRITE  (61,690) DELTAT
          WRITE  (61,700) XLENGH
          WRITE  (61,710) G
          WRITE  (61,740) SAR
          WRITE  (61,770) ANJ
          WRITE  (61,780) ITYPEUP
          WRITE  (61,790) ITYPEDN
          WRITE  (61,800)
          WRITE  (61,810)
          IF (TQ(1).EQ.999939.) GO TO 94
          WRITE  (61,815)
          WRITE  (61,510)  (TQ(I),I=1,IL)
          WRITE  (61,810)
       94 IF (TY(1).EQ.999939.) GO TO 95
          WRITE  (61,816)
          WRITE  (61,510)  (TY(I),I=1,IL)
    C
    C
    C     ***********************************************
    C
    C
    C
    C     CHAPTER  CCCC  **** START OF MAIN LOOP ****
    C
    C     ***********************************************
    C
    C
    C
       95 IAGAIN = 0
          II = 1
          IF (ISED.NE.1) GO TO 110
          DO 100 I=1,N
             Y1(I) = Y(I)
      100 CONTINUE
      110 IF (II.GE.IL) STOP
          IF (ITEST.NE.1) GO TO 115
             IF (IAGAIN.EQ.0) WRITE (61,515)
             IF (IAGAIN.EQ.1) WRITE (61,516)
             WRITE (61,810)
             WRITE(61,510) (Y(I),I=1,N)
      115 REWIND 4
    C*
    C*
    C
    C
    C               COMPUTATIONS OF GEOMETRIC PROPERTIES OF THE STREAM USING
    C               SUBROUTINE -- GEOMET.
    C
    C
    C
```

```
C     A              IS FLOW CROSS SECTIONAL AREA (IN M**2).
C
C     P              IS THE WETTED PERIMETER (IN METERS).
C
C     R              IS HYDRAULIC RADIUS (IN METERS).
C
C     B              IS TOP WIDTH  (IN METERS).
C
C     Q              IS FLOW RATE (IN M**3/SEC).
C
C     AYX            IS THE RATE OF CHANGE OF ≠A≠ W.R.T. X - DIRECTION
C                    WHEN DEPTH IS HELD CONSTANT.
C
C     AVY            IS THE AVERAGE DEPTH IN THE REACH.
C
C     FR             IS THE FROUDE NUMBER.
C
C
      CALL GEOMET (A,P,R,B,DERB,DERP,Q,AYX,AVY,FR,IDEEP,RNEW,
     $            SABL,SD35,SD65,SSDP,UNIFORM,SBL,UNISIZF)
C
C
C               COMPUTATION OF FRICTIONAL PARAMETERS FOR THE FLOW USING
C               SUBROUTINE -- FRICT.
C
C
C     CONST, EM, AND EN ARE FRICTION PARAMETERS.
C
C
C     ASF            IS THE AVERAGE CHANGE SLOPE OF THE REACH.
C
C     C              IS THE FRICTION COEFFICIENT.
C
C     IBED           IS A PARAMETRIC ARRAY REPRESENTING THE BED FORM
C                    CHARACTERISTICS.
C
C
C
C
      CALL FRICT (Y,Z,Q,A,R,CONST,EM,EN,ASF,BSLOPE,IBED,IFRICT,ISED,
     $ASFL)
C
      IF (ISED.NE.1) GO TO 230
      IF (IFRICT.NE.1) GO TO 120
      GO TO 130
  120 CONTINUE
      DO 125 I =1,N
  125   CONST(I) = CONSTR
  130 IF (IAGAIN.EQ.1) GO TO 250
      IF (II.LE.2) GO TO 150
      DO 140 I=1,N
         P1(I) = P2(I)
         BT1(I) = BT2(I)
         AR1(I) = AR2(I)
         CAV1(I) = CAV2(I)
  140 QST1(I) = QST2(I)
      GO TO 170
  150 IF (II.GE.2) GO TO 170
C
C
C               COMPUTATION OF THE SEDIMENT TRANSPORT RATE AND THE AVERAGE
C               SEDIMENTS CONCENTRATIONS USING  SUBROUTINE -- SEDI.
C
C
C     CAV            IS THE AVERAGE VOLUMETRIC SEDIMENT CONCENTRATION.
C
C     QST            IS THE TOTAL SEDIMENT TRANSPORT RATE (IN M**3/SEC).
C
C
      CALL SEDI (Q,A,AVY,R,FR,ASF,QST,CAV,C,TA)
      DO 160 I=1,N
         P1(I) = P(I)
         BT1(I) = B(I)
         AR1(I) = A(I)
         CAV1(I) = CAV(I)
  160 QST1(I) = QST(I)
      GO TO 250
```

```
 170  CALL SEDI  (Q,A,AVY,R,FR,ASF,QST,CAV,C,TA)
      DO 180 I=1,N
         P2(I) = P(I)
         BT2(I) = B(I)
         AR2(I) = A(I)
         CAV2(I) = CAV(I)
 180  QST2(I) = QST(I)
C
C     *** *********************************************
C
C
C     CHAPTER  DDDD  **** LATERAL SEDIMENT INFLOW   ****
C
C
C     *** *********************************************
C
      IF(INFLOW.EQ.1) GO TO 194
      DO 193 I=1,N
      QS1(I)=0.00
      QS2(I)=0.00
  193 CONTINUE
      GO TO 195
  194 DO 191 KK=1,NTOT
      LL=NT(KK)
      DO 190 I=1,N
      IF(I.EQ.NT(KK))  GO TO 192
      QS1(I)=0.00
      QS2(I)=0.00
      GO TO 190
  192 QS1(I)=QSED(LL,II)
      QS2(I)=QSED(LL,II+1)
  190 CONTINUE
  191 CONTINUE
  195 CONTINUE
C
C
C
C
C      **************************************************************
C
C
C      CHAPTER  EEEE  **** FLOW DEPTH AND BED ELEVATION CORRECTION ****
C
C
C      **************************************************************
C
C
C
C
       N1 = N-1
       DO 200 I=2,N1
          DELZ(I) = (DELTAT/(4.0*PORS))*(QS1(I)+QS2(I)+0.5*QS1(I-1)+0.5*
     $    QS2(I-1)+0.5*QS1(I+1)+0.5*QS2(I+1))-(DELTAT/(4.0*PORS*DELTAX))*
     $    (QST1(I+1)-QST1(I-1)+QST2(I+1)-QST2(I-1))-(1.0/(4.0*PORS))*(2.0
     $    *AR2(I)*CAV2(I)-2.0*AR1(I)*CAV1(I)+AR2(I-1)*CAV2(I-1)-AR1(I-1)*
     $    CAV1(I-1)+AR2(I+1)*CAV2(I+1)-AR1(I+1)*CAV1(I+1))
  200  CONTINUE
       DELZ(1) =  (DELTAT/(4.0*PORS))*(QS1(1)+QS1(2)+QS2(1)+QS2(2))-
     $(DELTAT/(2.0*PORS*DELTAX))*(QST1(2)-QST1(1)+QST2(2)-QST2(1))-(1.0/
     $(2.0*PORS))*(AR2(1)*CAV2(1)-AR1(1)*CAV1(1)+AR2(2)*CAV2(2)-AR1(2)*
     $CAV1(2))
       DELZ(N) =  (DELTAT/(4.*PORS))*(QS1(N)+QS1(N1)+QS2(N)+QS2(N1))-
     $(DELTAT/(2.0*PORS*DELTAX))*(QST1(N)-QST1(N1)+QST2(N)-QST2(N1))-(1.
     $0/(2.0*PORS))*(AR2(N)*CAV2(N)-AR1(N)*CAV1(N)+AR2(N1)*CAV2(N1)-AR1
     $(N1)*CAV1(N1))
       DO 210 I=1,N
          DELZ(I) = 2.0*DELZ(I)/(BT2(I)+BT1(I))
          CALL NEWBED(I,DELZ(I),ASFL,Q,A,R,CONST,EM,EN,UNIFORM)
          CALL BED(I,UNIFORM,UNISIZF)
  210  CONTINUE
       IF (ITEST.NE.1) GO TO 215
       WRITE (61,825)
       WRITE (61,826)
       WRITE (61,830)  (QST1(I),QST2(I),CAV1(I),CAV2(I),I=1,N)
       WRITE (61,835)
       WRITE (61,836)
       WRITE (61,840)  (DELZ(I),I=1,N)
  215  DO 220 I=1,N
```

```
            ZZ(I) = Z(I)+DELZ(I)
            Y(I) = Z(I)+Y2(I)-ZZ(I)
C
C       STOP 001 CHECK FOR -VE FLOW DEPTHS
C
            IF (Y(I).GE.0.0) GO TO 220
            WRITE (61,850)
            WRITE (61,860)
            STOP 001
C
C
  220   Z(I) = ZZ(I)
        IAGAIN = 1
        GO TO 110
  230   CONTINUE
        DO 235 I = 1,N
  235    CONST(I) = CONSTR
        DO 240 I=1,N
  240   C(I) = (Q(I)/A(I))/SQRT(G*R(I)*ASF)
        GO TO 270
C
C
  250   CONTINUE
        CALL SEDI (Q,A,AVY,R,FR,ASF,QST,CAV,C,TA)
        DO 260 I=1,N
            Y2(I) = Y(I)
            P2(I) = P(I)
            BT2(I) = B(I)
            AP2(I) = A(I)
            CAV2(I) = CAV(I)
            QST2(I) = QST(I)
  260   CONTINUE
C
C
C       ****************************************
C
C
C       CHAPTER  FFFF  **** LATERAL INFLOW ****
C
C
C       ****************************************
C
C
  270 IF(INFLOW.EQ.1)  GO TO 280
      DO 275 I=1,N
      QL1(I)=0.00
      QL2(I)=0.00
  275 CONTINUE
      GO TO 300
  280 CALL TRIBUT(II,TQL,NT,NTCT,QL1,QL2)
  300 CONTINUE
C
C
C       **************************************************
C
C
C       CHAPTER  GGGG  **** DOUBLE SWEEP COEFFICINETS ****
C
C       **************************************************
C
C
  310   H = N-1
C
C                       DOUBLE SWEEP COEFFICIENTS
C
        DO 320 I=1,H
            A1(I) = (B(I)+B(I+1))/(2.*DELTAT)-(2.*THETA/DELTAX)*((Q(I+1)-Q
     $      (I))/(B(I+1)+B(I))*DERB(I+1))+THETA*((QL1(I+1)+QL1(I))/(B(I+1)+
     $      B(I))*DERB(I+1))
            B1(I) = 2.*THETA/DELTAX
            C1(I) = (B(I)+B(I+1))/(2.*DELTAT)-(2.*THETA/DELTAX)*((Q(I+1)-Q
     $      (I))/(B(I+1)+B(I))*DERB(I))+THETA*((QL1(I)+QL1(I+1))/(B(I+1)+B
     $      (I))*DERB(I))
            C1(I) = -C1(I)
            D1(I) = -2.*THETA/DELTAX
            D1(I) = -D1(I)
            E1(I) = (2./DELTAX)*(Q(I+1)-Q(I))-(QL1(I+1)+QL1(I))-THETA*(QL2
```

```
     $    (I+1)+QL2(I))*1.0
  320 E1(I) = -E1(I)
      DO 330 I=1,H
C
C
          A2(I) = -(THETA/DELTAX)*Q(I+1)*B(I+1)*(Q(I+1)-Q(I))/(A(I+1)*A(I
     $    +1))+(G*THETA/(2.0*DELTAX))*((Y(I+1)-Y(I))*B(I+1)+A(I+1)+A(I))+
     $    (THETA/(2.0*DELTAX))*(((2.0*B(I+1)*E(I+1)*Q(I+1)*Q(I+1)/A(I+1)*
     $    *3)-(DERB(I+1)*Q(I+1)*Q(I+1)/A(I+1)**2))*(Y(I+1)-Y(I))-(B(I+1)*
     $    Q(I+1)*Q(I+1)/A(I+1)**2)-(B(I)*Q(I)*Q(I)/A(I)**2))-(G*THETA/(2.
     $    0*DELTAX))*(B(I+1)*(Z(I)-Z(I+1)))+(G*THETA/2.0)*CONST(I)*(R(I+1
     $    )/D65(I))**EM(I)*FR(I+1)**EN(I)*(B(I+1)*(EM(I)-3.0*EN(I))-(A(I+
     $    1)*DERP(I+1)*(EM(I)-EN(I))/P(I+1))+E(I+1))+(THETA/2.0)*(2.0*Q(I
     $    +1)*Q(I+1)*B(I+1)*AYX(I+1)/A(I+1)**3)
C
C
          B2(I) = 1.0/(2.0*DELTAT)+(THETA/DELTAX)*(Q(I+1)/A(I+1)+Q(I)/A(I
     $    )+(Q(I+1)-Q(I))/A(I+1))+(THETA/(2.0*DELTAX))*2.0*Q(I+1)*B(I+1)*
     $    (Y(I)-Y(I+1))/(A(I+1)*A(I+1))+((G*THETA/2.0)*CONST(I)*(R(I+1)/D
     $    65(I))**EM(I)*FR(I+1)**EN(I)*2.0*EN(I)*A(I+1)/Q(I+1))-((THETA/2
     $    .0)*2.0*Q(I+1)*AYX(I+1)/(A(I+1)*A(I+1)))
C
C
          C2(I) = -(THETA/DELTAX)*Q(I)*B(I)*(Q(I+1)-Q(I))/(A(I)*A(I))+(G*
     $    THETA/(2.0*DELTAX))*(B(I)*(Y(I+1)-Y(I))-A(I+1)-A(I))+(THETA/(2.
     $    0*DELTAX))*((Y(I+1)-Y(I))*(2.0*B(I)*B(I)*Q(I)*Q(I)/(A(I)*A(I)*A
     $    (I))-Q(I)*Q(I)*DERB(I)/(A(I)*A(I)))+B(I+1)*Q(I+1)*Q(I+1)/(A(I+1
     $    )*A(I+1))+B(I)*Q(I)*Q(I)/(A(I)*A(I)))-(G*THETA/(2.0*DELTAX))*(B
     $    (I)*(Z(I)-Z(I+1)))+(G*THETA/2.0)*CONST(I)*(R(I)/D65(I))**EM(I)*
     $    FR(I)**EN(I)*(B(I)*(EM(I)-3.0*EN(I))-A(I)*DERP(I)*(EM(I)-EN(I))
     $    /P(I)+B(I))+(THETA/2.0)*2.0*Q(I)*Q(I)*B(I)*AYX(I)/(A(I)*A(I)*A(
     $    I))
          C2(I) = -C2(I)
C
C
          D2(I) = (1.0/(2.0*DELTAT))+(THETA/DELTAX)*((Q(I+1)-Q(I))/A(I)-Q
     $    (I)/A(I)-Q(I+1)/A(I+1))+(THETA/(2.0*DELTAX))*2.0*Q(I)*B(I)*(Y(I
     $    )-Y(I+1))/(A(I)*A(I))+(G*THETA/2.0)*CONST(I)*(R(I)/D65(I))**EM(
     $    I)*FR(I)**EN(I)*2.0*EN(I)*A(I)/Q(I)-(THETA/2.0)*2.0*Q(I)*AYX(I)
     $    /(A(I)*A(I))
          D2(I) = -D2(I)
C
C
          E2(I) = (1.0/DELTAX)*(Q(I+1)/A(I+1)+Q(I)/A(I))*(Q(I+1)-Q(I))+(G
     $    /(2.0*DELTAX))*(A(I+1)+A(I))*(Y(I+1)-Y(I))-(1.0/(2.0*DELTAX))*
     $    (B(I+1)*Q(I+1)*Q(I+1)/(A(I+1)*A(I+1))+B(I)*Q(I)*Q(I)/(A(I)*A(I)
     $    ))*(Y(I+1)-Y(I))-(G/(2.0*DELTAX))*(A(I+1)+A(I))*(Z(I)-Z(I+1))+
     $    (G/2.0)*CONST(I)*(R(I+1)/D65(I))**EM(I)*FR(I+1)**EN(I)*A(I+1)+
     $    (G/2.0)*CONST(I)*(R(I)/D65(I))**EM(I)*FR(I)**EN(I)*A(I)-0.50*Q
     $    (I+1)*Q(I+1)*AYX(I+1)/(A(I+1)*A(I+1))-0.50*Q(I)*Q(I)*AYX(I)/(A(
     $    I)*A(I))
          E2(I) = -E2(I)
  330 CONTINUE
C
      IF (ITEST.NE.1) GO TO 340
C
      WRITE (61,865)
      WRITE (61,866)
      WRITE (61,870) (A1(I),B1(I),C1(I),D1(I),E1(I),I=1,H)
      WRITE (61,867)
      WRITE (61,866)
      WRITE (61,870) (A2(I),B2(I),C2(I),D2(I),E2(I),I=1,H)
C
  340 CONTINUE
C
C
C     ***********************************************************
C
C
C     CHAPTER  HHHH  **** UPSTREAM BOUNDARY CONDITIONS ****
C
C
C     ***********************************************************
C
C
      K1 = II
C
```

```
      CALL USTREAM
C
C
C     ********************************************
C
C
C     CHAPTER  IIII  **** STORAGE ADJUSTMENTS ****
C
C
C     ********************************************
C
C
C
      DO 350 I=2,N
         J = I-1
         E(I) = (A1(J)*(C2(J)+D2(J)*E(J))-A2(J)*(C1(J)+D1(J)*E(J)))/(B2
     $   (J)*(C1(J)+D1(J)*E(J))-B1(J)*(C2(J)+D2(J)*E(J)))
         F(I) = ((E2(J)+D2(J)*F(J))*(C1(J)+D1(J)*E(J))-(E1(J)+D1(J)*F(J)
     $   )*(C2(J)+D2(J)*E(J)))/(B2(J)*(C1(J)+D1(J)*E(J))-B1(J)*(C2(J)+D2
     $   (J)*E(J)))
         IF (I.NE.IS) GO TO 350
         E(I) = E(J)-SAR/DELTAT
         F(I) = G(J)-Q(J+1)+F(J)+E(J)*(Y(J+1)-Y(J))
 350  CONTINUE
      IF (ITEST.NE.1) GO TO 355
      WRITE (61,875)
      WRITE (61,876)
      WRITE (61,880) (E(I),F(I),I=2,N)
 355  DO 360 I=1,H
         L(I) = A1(I)/(C1(I)+D1(I)*E(I))
         M(I) = B1(I)/(C1(I)+D1(I)*E(I))
         K(I) = (E1(I)+D1(I)*F(I))/(C1(I)+D1(I)*E(I))
         IF (I.NE.IS) GO TO 360
         L(I) = 1.0
         M(I) = 0.0
         K(I) = 0.0-(Y(I+1)-Y(I))
 360  CONTINUE
C TEMP
      TOTALS = 0.0
      IF (ITEST.NE.1) GO TO 365
      WRITE (61,885)
      WRITE (61,886)
      WRITE (61,890) (L(I),M(I),K(I),I=1,H)
C
C
C     ********************************
C
C
C     CHAPTER  JJJJ  **** OUTPUT ****
C
C
C     ********************************
C
C
C
C                         DOWNSTREAM BOUNDARY CONDITIONS
C
C
C
 365  DO 370 I=1,N
         T(I) = I*DELTAT-DELTAT
C TEMP
         TOTALS = TOTALS + QST(I)
 370  D(I) = I*DELTAX-DELTAX
      TIME = (II+IP)*DELTAT-DELTAT
      MDAYS = TIME/(3600.0*24.0)
      DAYS = MDAYS
      REM1 = AMOD(TIME,86400.0)
      IHR = REM1/3600.0
      HR = IHR
      REM2 = AMOD(REM1,3600.0)
      MIN = REM2/60.0
      AMIN = MIN
      REM3 = AMOD(REM2,60.0)
      SEC = REM3
 380  WRITE (61,950) DAYS,HR,AMIN,SEC
      WRITE (61,960)
      WRITE (61,970) (D(I),Q(I),Y(I),QST(I),FR(I),Z(I),B(I),A(I),C(I),R
     $(I),I=1,N)
      IF (ISED.NE.1) GO TO 440
```

```
      WRITE (61,980) ASF
      WRITE (61,990) BSLOPE
C TEMP
      WRITE (61,745) TOTALS/N
      WRITE (61,750)
      WRITE (61,760) (D(I),(SDP(I,J)*100,J=1,10),D35(I),D65(I),BL
     $(I),ABL(I),I=1,N)
      WRITE (61,1000)
       DO 435 I=1,N
       GO TO (390,400,410,420,430), IBED(I)
 390   WRITE (61,1010) D(I),CONST(I),EM(I),EN(I),TA(I)
       GO TO 435
 400   WRITE (61,1020) D(I),CONST(I),EM(I),EN(I),TA(I)
       GO TO 435
 410   WRITE (61,1030) D(I),CONST(I),EM(I),EN(I),TA(I)
       GO TO 435
 420   WRITE (61,1040) D(I),CONST(I),EM(I),EN(I),TA(I)
       GO TO 435
 430   WRITE (61,1050) D(I),CONST(I),EM(I),EN(I),TA(I)
 435   CONTINUE
 440   CONTINUE
C
C.....REMOVE COMMENTS FOR PLOT FILE (TAPE6) AT DAY ** OF EACH RUN
C     D,Z AND AD ARE THE DISTANCE DOWNSTREAM,BED AND WATER LEVELS RESP.
C
C     IF (DAYS.NE.**) GO TO 449
C     REWIND 6
C     DO 445 I=1,N
C       AD(I)=Y(I)+Z(I)
C445    WRITE (6,446) (D(I),Z(I),AD(I))
C446  FORMAT (3F12.6)
C     ENDFILE 6
C
C
C
C
 449  IF (II.EQ.(IL-1)) GO TO 450
      GO TO 460
 450  REWIND 8
      WRITE(8,485) IL,IP,ITEST
      WRITE (8,490) N,INFLOW,IN,INT,IS,ISED,IFRICT,METRIC,XIN
      WRITE (8,500) THETA,DELTAX,DELTAT,XLENGH,G,QIN,QSED,SAR
      WRITE (8,510) (Y(I),I=1,N)
      WRITE (8,520) (Q(I),I=1,N)
      WRITE (8,1060) (Z(I),I=1,N)
      WRITE (8,530) IYEAR,IDEEP,IPRNT
      WRITE (8,540) GAM,GAMS,ANU
      WRITE (8,550) PORS
      WRITE (8,560) (BL(I),I=1,N)
      WRITE (8,560) (ABL(I),I=1,N)
      WRITE (8,560) (D35(I),I=1,N)
      WRITE (8,560) (D65(I),I=1,N)
      DO 457 I = 1,N
 457   WRITE (8,560) (SDP(I,J),J=1,10)
C
      WRITE (8,560) (TQS(I),I=1,IL)
      WRITE (8,570) ITYPEUP,ITYPEDN,AAU,BBU,CCU,AAD,BBD,CCD
      IF(((ITYPEUP.EQ.2).AND.(ITYPEDN.EQ.1)).OR.((ITYPEUP.EQ.1).AND.
     $(ITYPEDN.EQ.2))) GO TO 452
      IF(((ITYPEUP.EQ.3).AND.(ITYPEDN.EQ.1)).OR.((ITYPEUP.EQ.1).AND.
     $(ITYPEDN.EQ.3))) GO TO 454
      IF ((ITYPEUP.EQ.3).AND.(ITYPEDN.EQ.3)) GO TO 456
      WRITE (8,520) (TQ(I),I=1,IL)
      GO TO 456
 452  WRITE (8,520) (TQ(I),I=1,IL)
 454  WRITE (8,520) (TY(I),I=1,IL)
 456  IF(INFLOW.NE.0) WRITE(8,511)  (NT(I),I=1,NTOT)
      IF(INFLOW.NE.0) WRITE(8,520)  ((TQL(I,J),J=1,IL),I=1,NTOT)
      IF(INFLOW.NE.0) WRITE(8,520)  ((QSED(I,J),J=1,IL),I=1,NTOT)
 000  IF ((ISED.NE.1).OR.(IFRICT.NE.1)) WRITE (8,580) CONSTR,(EM(I),EN(
     $I),IBED(I),I=1,N)
 460  CONTINUE
C
C     .*****************************************************************
C
C
C
C     CHAPTER  KKKK  **** DOWNSTREAM BOUNDARY CONDITIONS ****
```

```
C
C
C     **************************************************************
C
C
      CALL DSTREAM
      DELQ(N) = E(N)*DELY(N)+F(N)
      Y(N) = Y(N)+DELY(N)
      IF (Y(N).GE.0.0) GO TO 465
      WRITE (61,1130)
      STOP 016
 465  Q(N) = Q(N)+DELQ(N)
C
C
C     ***************************************************************
C
C
C     CHAPTER  LLLL  **** NEW FLOW DEPTH AND DISCHARGE ****
C
C
C     ***************************************************************
C
C
      DO 470 I=1,H
         J = N-I
         DELY(J) = L(J)*DELY(J+1)+M(J)*DELQ(J+1)-K(J)
         Y(J) = Y(J)+DELY(J)
         IF (Y(J).GE.0.0) GO TO 469
         WRITE (61,1065)
         STOP 010
 469     DELQ(J) = E(J)*DELY(J)+F(J)
 470  Q(J) = Q(J)+DELQ(J)
      DO 481 I=1,N
      IF(IFRICT.EQ.1) GO TO 481
      IF(Q(I).GT.0.00) GO TO 481
      CONST(I)=-CONSTR
  481 CONTINUE
      IF (ITEST.NE.1) GO TO 475
      WRITE (61,868)
      WRITE (61,869)
      WRITE (61,870) (DELY(I),DELQ(I),K(I),F(I),Q(I),I=1,H)
C
 475  DO 480 I=1,N
         IF (II.EQ.1) GO TO 480
         Y1(I) = Y2(I)
 480  Y2(I) = Y(I)
      II = II+1
      IAGAIN = 0
C
      GO TO 110
C
C
C
C
C     ************************************************************
C
C
C     CHAPTER  MMMM  **** FORMATS FOR OUTPUT ****
C
C
C     ************************************************************
C
C
 485  FORMAT (3I5)
 490  FORMAT (6I5,2F10.4)
 500  FORMAT (6F9.3)
 510  FORMAT (8F10.3)
 511  FORMAT(6I10)
 515  FORMAT (1H0,≠NEW FLOW DEPTHS≠)
 516  FORMAT (1H0,≠CORRECTED FLOW DEPTHS≠)
 520  FORMAT (8F10.4)
 530  FORMAT (I4,I5,I2)
 540  FORMAT (3E10.4)
 550  FORMAT (F5.2)
 560  FORMAT (8F10.6)
 570  FORMAT (2I3,4X,6F10.6)
 580  FORMAT (F20.5,2F10.3,I5)
```

```
  590   FORMAT (1H1)
  600   FORMAT (1H0,≠** TEST MODE ASSUMED **≠)
  610   FORMAT (1H0,≠NUMBER OF GRID POINTS ALONG THE RIVER REACH N=≠,I5)
  620   FORMAT (1H0,≠CONTROL PARAMETER FOR TRIBUTORY PRESENCE INFLOW=≠,I5)
  630   FORMAT (1H0,≠NUMBER OF TRIBUTARIES=≠,I5)
  650   FORMAT (1H0,≠CONTROL PARAMETER FOR STORAGE BASIN IS=≠,I5)
  660   FORMAT (1H0,≠CONTROL PARAMETER SIGNIFYING THE NATURE OF FLOW ≠,
       $≠BOUNDARY ISED=≠,I5)
  670   FORMAT (1H0,≠WEIGHTING COEFFICIENT THETA=≠,F8.3)
  680   FORMAT (1H0,≠DISTANCE IN METERS BETWEEN GRID POINTS DELTAX=≠,F8.2)
  690   FORMAT (1H0,≠TIME INCREMENTS IN SECONDS DELTAT=≠,F9.1)
  700   FORMAT (1H0,≠TOTAL LENGTH OF RIVER REACH MODELLED XLENGTH=≠,F10.2)
  710   FORMAT (1H0,≠ACCELERATION DUE TO GRAVITY G=≠,F8.4)
  740   FORMAT (1H0,≠WATER SURFACE AREA OF STORAGE BASIN SAR=≠,F8.4)
C TEMP
  745   FORMAT (1H0,≠AVERAGE SEDIMENT TRANSPORT RATE = ≠,F16.10)
  750   FORMAT (1H1,≠ NEW SEDIMENT CHARACTERISTICS≠,//,5X,≠RANGE≠,19X,
       $≠PERCENTAGES OF GRAINSIZES 1 THRU 10 RESPECTIVELY≠,22X,≠D35≠,7X,
       $≠D65≠,3X,≠BED DEPTH≠,3X,≠ABL≠,/)
  760   FORMAT (F11.2,2X,10F8.3,1X,2F10.6,F9.3,F9.5)
  770   FORMAT (1H0,≠THE VALUE OF KINEMATIC VISCOSITY IS=≠,F10.6)
  780   FORMAT (1H0,≠UPSTREAM BOUNDARY TYPE=≠,I5)
  790   FORMAT (1H0,≠DOWNSTREAM BOUNDARY TYPE=≠,I5)
  800   FORMAT (1H0,≠BOUNDARY VALUES≠)
  810   FORMAT (1H0)
  815   FORMAT (3X,≠UPSTREAM≠,/,3X,≠--------≠)
  816   FORMAT (3X,≠DOWNSTREAM≠,/,3X,≠----------≠)
  820   FORMAT (1H0)
  825   FORMAT (//1H ,11X,≠QST1≠,11X,≠QST2≠,11X,≠CAV1≠,11X,≠CAV2≠,5X,
       $≠(I=1,N)≠)
  826   FORMAT (1H ,11X,≠----≠,11X,≠----≠,11X,≠----≠,11X,≠----≠)
  830   FORMAT (/100(/1H ,4F15.2)/)
  835   FORMAT (//1H ,5X,≠(DELZ(I),I=1,N)≠)
  836   FORMAT (1H ,5X,15(≠-≠))
  840   FORMAT (/100(/1H ,10F10.3))
  850   FORMAT (1H0,≠THE CORRECTED FLOW DEPTH GOES NEGATIVE.≠,/,
       $≠ POSSIBLE CAUSE: UNREALISTIC VALUE FOR BED LEVEL CHANGE (DELZ).≠)
  860   FORMAT (1H ,≠REMEDY:REDUCE DELTAT AND RERUN.≠)
  865   FORMAT (//1H ,16X,≠A1≠,18X,≠B1≠,18X,≠C1≠,18X,≠D1≠,18X,≠E1≠,5X,
       $≠(I=1,N-1)≠)
  866   FORMAT (1H ,16X,≠--≠,18X,≠--≠,18X,≠--≠,18X,≠--≠,18X,≠--≠)
  867   FORMAT (//1H ,16X,≠A2≠,18X,≠B2≠,18X,≠C2≠,18X,≠D2≠,18X,≠E2≠,5X,
       $≠(I=1,N-1)≠)
  868   FORMAT (//1H ,15X,≠DELY≠,16X,≠DELQ≠,18X,≠K≠,18X,≠F≠,18X,≠Q≠,5X,
       $≠(I=1,N-1)≠)
  869   FORMAT (1H ,15X,≠----≠,16X,≠----≠,18X,≠-≠,18X,≠-≠,18X,≠-≠)
  870   FORMAT (/100(/1H ,5F20.5))
  875   FORMAT (//1H ,8X,≠E≠,12X,≠F≠,5X,≠(I=2,N)≠)
  876   FORMAT (1H ,8X,≠-≠,12X,≠-≠)
  880   FORMAT (/100(/1H ,2F12.3))
  885   FORMAT (//1H ,9X,≠L≠,11X,≠M≠,11X,≠K≠,5X,≠(I=1,N-1)≠)
  886   FORMAT (1H ,9X,≠-≠,11X,≠-≠,11X,≠-≠)
  890   FORMAT (/100(/1H ,3F12.3))
  900   FORMAT (1H1,1X,≠UPSTREAM BOUNDARY CONDITIONS≠)
  910   FORMAT (1H0,1X,≠TIME≠,6X,≠FLOW RATE≠)
  920   FORMAT (1H ,F9.0,4X,F10.4)
  930   FORMAT (1H0,1X,≠DOWNSTREAM BOUNDARY CONDITIONS≠)
  940   FORMAT (1H0,1X,≠TIME≠,6X,≠FLOW DEPTH≠)
  950   FORMAT (1H1,1X,≠SOLUTION AT TIME T=≠,F9.2,≠DAYS≠,F9.2,≠HOURS≠,
       $F9.2,≠MINUTES≠,F9.2,≠SECONDS≠)
  960   FORMAT (1H0,1X,≠DISTANCE≠,2X,≠FLOW RATE≠,2X,≠FLOW DEPTH≠,2X,
       $≠SEDIMENT RATE≠,2X,≠FROUDE N≠,2X,≠BOTTOM ELEVATION≠,2X,≠TOP WIDTH≠,
       $2X,≠FLOW AREA≠,2X,≠FRICTION FACTOR≠,2X,≠HYDRAULIC RADIUS≠)
  970   FORMAT (1H ,1X,F8.2,2X,F10.4,1X,F10.4,F14.10,2X,F10.4,4X,F10.6,
       $4X,F10.4,2X,F10.4,4X,F10.4,8X,F10.4)
  980   FORMAT (1H0,≠AVERAGE ENERGY SLOPE OF THE REACH=≠,F8.5)
  990   FORMAT (1H0,≠AVERAGE SLOPE OF BED=≠,F8.5)
 1000   FORMAT (//,5X,≠RANGE≠,25X,≠BED STATE≠,44X,≠FRICTION PARAMETERS≠,
       $5X,≠RATIO CSS/QST≠,/,86X,≠CONST≠,6X,≠M≠,10X,≠N≠)
 1010   FORMAT (F11.2,9X,≠THE BED IS COVERED WITH DUNES OF TYPE 1≠,20X,
       $F12.4,3F10.4)
 1020   FORMAT (F11.2,9X,≠THE BED IS COVERED WITH DUNES OF TYPE 2≠,20X,
       $F12.4,3F10.4)
 1030   FORMAT (F11.2,6X,≠THE BED IS IN A TRANSITION STATE FROM DUNE 1 ≠,
       $≠TO FLAT BED≠,7X,F12.4,3F10.4)
 1040   FORMAT (F11.2,27X,≠THE BED IS FLAT≠,27X,F12.4,3F10.4)
 1050   FORMAT (F12.2,18X,≠THE BED IS COVERED WITH ANTIDUNES≠,18X,F11.4,
```

```
      $3F10.4)
 1050 FORMAT (6F10.6)
 1065 FORMAT (1H0,≠CALCULATED FLOW DEPTH IS NEGATIVE≠,/,≠ REMEDY: ≠,
      $           ≠REDUCE DELTAT AND RERUN≠)
 1120 FORMAT (1H1,51X,13(≠*≠),/,62X,≠* REPORT *≠,/,62X,10(≠*≠),
      $       ////,50X,13(≠* ≠),2(/,50X,≠*≠,35X,≠*≠),/,50X,≠*≠,12X,
      $       ≠MODEL MOBED≠,12X,≠*≠,/,50X,≠*≠,1X,≠( WITH SEDIMENT ≠,
      $       ≠CHARACTERISTICS )≠,1X,≠*≠,2(/,50X,≠*≠,35X,≠*≠),/,50X,
      $       13(≠* ≠))
 1130 FORMAT(1H1,≠ Y(N) IS NEGATIVE ≠)
      END
```

```
          SUBROUTINE BED(N,UNIFORM,UNISIZF)
C
C     SUBROUTINE TO CALCULATE D35 AND D65 FROM THE GIVEN SEDIMENT SIZE
C     DISTRIBUTION
C
          COMMON/B/ GAM,GAMS,D35(61),D65(61),ANU,G,ABL(61),SDP(61,10),BL(61)
         $,SDPI(61,10)
          COMMON/X/ A(61),P(61),W(61),DEPTH(61)
          DIMENSION SPOT(2),PU(2),PL(2),DU(2),DL(2),D(10),UNISIZF(61)
          INTEGER UNIFORM(61)
          DATA (D(I),I=1,10) /0.000125,0.000250,0.000500,0.00100,0.0020,
         $                    0.004,0.008,0.016,0.032,0.064/
          DATA SPOT(1),SPOT(2) /0.35,0.65/
          DATA (DU(I),I=1,2) /2*0.0/
          DATA (DL(I),I=1,2) /2*0.0/
C
          IF (UNIFORM(N).EQ.1) GO TO 30
           PU(1) = 0.0
           PU(2) = 0.0
          DO 20 L = 1,2
           TEMP = 0.0
            DO 10 K=1,10
             TEMP = TEMP + SDP(N,K)
             IF ((TEMP.LT.SPOT(L)).OR.(PU(L).NE.0.0)) GO TO 10
             PU(L) = TEMP
             PL(L) = TEMP - SDP(N,K)
C
C    STOP 003 CHECK FOR ZERO DENOMINATOR FOR D65,D35 CALCULATION
C
             IF(PU(L).EQ.PL(L)) GO TO 50
             DU(L) = D(K)
             DL(L) = D(K-1)
   10        CONTINUE
            IF ((DU(L).LT.0.0).OR.(DL(L).LT.0.0)) GO TO 50
   20       CONTINUE
            D35(N) = 10**((0.35-PL(1))/(PU(1)-PL(1))*(ALOG10(DU(1))-ALOG10(
         $           DL(1)))+ALOG10(DL(1)))
            D65(N) = 10**((0.65-PL(2))/(PU(2)-PL(2))*(ALOG10(DU(2))-ALOG10(
         $           DL(2)))+ALOG10(DL(2)))
            GO TO 45
   30       CONTINUE
            DO 35 I =1,10
             D35(N) = D(I)*UNISIZF(N)
             IF (SDP(N,I).GT.0.1) GO TO 40
   35        CONTINUE
   40       D65(N) = D35(N)
   45       CONTINUE
            RETURN
   50       WRITE (61,120) PL(L),PU(L),DL(L),DU(L)
            STOP 003
  120       FORMAT (1H0,≠CALCULATION OF D35 OR D65 WOULD HAVE RESULTED≠,
         $          ≠ IN DIVISION BY ZERO IN SUBROUTINE BED OR LOG OF ≠,
         $          ≠NEGATIVE NUMBER≠,/,≠ PL = ≠,F10.5,≠ PU = ≠,F10.5,
         $          ≠ DL = ≠,F10.5,≠ DU = ≠,F10.5)
            END
```

```
ROUTINE NEWBED      73/171   CPT=1                              FTN 4.8+538         86/12/

            SUBROUTINE NEWBED(I,DELTAZ,ASFL,Q,A,R,CONST,EM,EN,UNIFORM)
C
C     SUBROUTINE TO RECALCULATE THE NEW PERCENTAGES OF EACH BED SIZE
C                   AND THE ADJUSTED ACTIVE BED LAYER DEPTH
C
          COMMON/A/  Y(61),BW(61),II,TQS(200)
          COMMON/B/  GAM,GAMS,D35(61),D65(61),ANU,G,ABL(61),SDP(61,10),BL(61)
         $,SDPI(61,10)
          DIMENSION  A(61),R(61)
          DIMENSION  VCR(10),QP(10),D(10),ASFL(61),Q(61),CONST(61),EM(61),
         $EN(61)
          INTEGER UNIFORM(61)
          DATA  (VCR(I),I=1,10)  /0.0120,0.0124,0.0146,0.0195,0.0306,0.0467,
         $                           0.0685,0.0973,0.1377,0.1947/
          DATA  (D(I),I=1,10)  /0.000094,0.000188,0.000375,0.00075,0.0015,
         $                       0.003,0.006,0.012,0.024,0.048/
C
          IF(UNIFORM(I).EQ.1)  GO TO 100
              FR=(Q(I)/A(I))**2/(G*R(I))
              ASL=CONST(I)*(R(I)/D65(I))**EM(I)*FR**EN(I)
           VS  =  SQRT(G*Y(I)*ASL)
           M = 1
           DO  10  J = 1,10
            K  =  10  -  (J-1)
            IF  (VS.LT.VCR(K))  M=K
   10       CONTINUE
           IF  (M.EQ.1)  GO TO  70
           M1  =  M  -  1
           SUM  =0.0
           DO  20  J  =  1,M1
   20       SUM  =  SUM  +  SDP(I,J)
C
           PC  =  1.0  -  SUM
           IF  (PC.LE.0.000001)  GO  TO  65
           ABL(I)  =2.0*D65(I)
           CV  =  0.57
           SUM1=  0.0
          SUM2=0.0
           DO  30  J=1,10
            XU  =  ((VCR(J)/VS)**2-1.)/CV
            QP(J)  =  ERF(XU/SQRT(2.0))/2.0  +  0.5
  000       SUM1=  SUM1+  QP(J)*SDP(I,J)
          SUM2=SUM2+(1.0-QP(J))*SDP(I,J)
   30       CONTINUE
          IF(DELTAZ.LT.0.0)  GO  TO  95
           DIN  =  ABL(I)+DELTAZ*SUM1
           IF  (DIN.EQ.0.0)  GO  TO  80
           DO  40  J  =  1,10
            SDP(I,J)  =  (ABL(I)*SDP(I,J)+DELTAZ*QP(J)*SDP(I,J))/DIN
   40       CONTINUE
          GO TO  70
     95  CONTINUE
          DELTAB=ABS(DELTAZ)
          IF(ABL(I).LT.DELTAB)  ABL(I)=DELTAB
          DIN  =DELTAB*SUM1+ABL(I)-DELTAB
          DO 96  J=1,10
          SDP(I,J)=(DELTAB*QP(J)*SDP(I,J)+(ABL(I)-DELTAB)*SDP(I,J))/DIN
     96  CONTINUE
          GO TO  70
     65  DO 66  J=1,10
          SDP(I,J)=SDPI(I,J)
     66  CONTINUE
     70  BL(I)=BL(I)+DELTAZ
           IF  (BL(I).LE.0.0)  GO TO  90
  100      RETURN
   80      WRITE  (61,120)
           STOP  004
   90      DELTAZ  =  0.0
           BL(I)   =  0.0
           RETURN
  120      FORMAT  (1H0,≠DENOMINATOR  ZERO  IN  SUBROUTINE  NEWBED≠)
           END
```

```
ROUTINE USTREAM    73/171  OPT=1                              FTN 4.8+538         86/12/

          SUBROUTINE USTREAM
C
C   SUBROUTINE TO ESTABLISH UPSTREAM BOUNDARY DOUBLE
C   SWEEP COEFFICIENTS
C
          COMMON/A/  Y(61),BH(61),II,TQS(200)
          COMMON/C/  ITYPEUP,ITYPEDN,K1,AAU,BBU,CCU,AAD,BBD,CCD
          COMMON/D/  TQ(200),TY(200),E(61),F(61),DELY(61),Q(61)
          COMMON /E/  DELTAX,DELTAT,N
C
          GO TO (100,110,120), ITYPEUP
  100     E(1) = 100000.00
          F(1) = -E(1)*(TY(K1+1)-TY(K1))
          RETURN
C
  110     E(1) = 0.0
          F(1) = TQ(K1+1)-TQ(K1)
          RETURN
C
  120     F(1) = AAU*Y(1)**BBU-Q(1)
          E(1) = AAU*BBU*Y(1)**(BBU-1)
          RETURN
          END

VERITY  DETAILS    DIAGNOSIS OF PROBLEM
  I               AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED
```

```
ROUTINE DSTREAM    73/171  OPT=1                               FTN 4.8+538          86/12/

            SUBROUTINE DSTREAM
      C
      C   SUBROUTINE TO ESTABLISH DOWNSTREAM BOUNDARY
      C   VALUES OF DELY(N)
      C
            COMMON/A/  Y(51),BM(61),II,TQS(200)
            COMMON/C/  ITYPEUP,ITYPEDN,K1,AAU,BBU,CCU,AAD,BBD,CCD
            COMMON/D/  TQ(200),TY(200),E(61),F(61),DELY(61),Q(61)
            COMMON /E/  DELTAX,DELTAT,N
      C
            GO TO (100,110,120), ITYPEDN
      C
       100  DELY(N) =  TY(K1+1)-TY(K1)
            RETURN
       110  DELY(N) =  ((TQ(K1+1)-TQ(K1))-F(N))/E(N)
            RETURN
      C
       120  S=Y(N)-0.800
            IF(S.GT.0.1775) GO TO 10
            DELY(N)=(Q(N)+F(N)-3.0585*S**3.0889)/(9.4474*S**2.0889-E(N))
            GO TO 20
        10  DELY(N)=(Q(N)+F(N)-.754*S**2.27905)/(1.7184*S**1.27905-E(N))
        20  CONTINUE
            RETURN
            END


VERITY  DETAILS    DIAGNOSIS OF PROBLEM

 I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTE
```

```
ROUTINE TRIBUT     73/171   OPT=1                              FTN 4.8+538         86/12/

            SUBROUTINE TRIBUT(N,II,TQL,NT,NTOT,QL1,QL2)
      C
      C     THIS SUBROUTINE COMPUTES TRIBUTARY-PARAMETERS
      C
      C
            DIMENSION TQL(6,200),NT(6),QL1(61),QL2(61)
            DO 10 I=1,N
            QL1(I)=0.00
            QL2(I)=0.00
         10 CONTINUE
            DO 20 I=1,NTOT
            NI=NT(I)
            QL1(NI)=TQL(I,II)
            QL2(NI)=TQL(I,II+1)-TQL(I,II)
         20 CONTINUE
            RETURN
            END
```

```
      SUBROUTINE GEOMET (A,P,R,B,DERB,DERP,Q,AYX,AVY,FR,IDEEP,RNEW,
     $                   SABL,SD35,SD65,SSDP,UNIFORM,SBL,UNISIZF)
C
C   SUBROUTINE TO ESTABLISH THE GEOMETRIC CHARACTERISTICS
C   OF THE RIVER SECTION
C
      DIMENSION AR(61),TW(61),WP(61),D(61)
      COMMON/A/Y(61),BW(61),II,TQS(200)
      COMMON/B/ GAM,GAMS,D35(61),D65(61),ANU,G,ABL(61),SDP(61,10),BL(61)
     $,SDPI(61,10)
      COMMON/E/ DELTAX,DELTAT,N
      DIMENSION A(61),P(61),R(61),B(61),DERB(61),DERP(61),Q(61),
     $AYX(61),AVY(61),FR(61)
      DIMENSION AY(61),SABL(61),SD35(61),SD65(61),TSDP(10),SSDP(61,10)
      DIMENSION RNEW(61),ELEV(61),SBL(61),UNISIZF(61)
      INTEGER H,UNIFORM(61),TUNIF
      G = 9.81
      IEND = IDEEP+1
      FEET = 1./(.0254*12.)
C
      YAV = 0.0
      DO 100 I=1,N
         YAV = YAV+Y(I)
 100  CONTINUE
      YAV = YAV/N
C
      I1AV = IFIX((YAV*FEET)+1.00001)
      I2AV = I1AV+1
      RNO = 999999.0
C
C
      DO 150 I=1,N
 110     IF (RNEW(I).EQ.RNO) GO TO 130
C
         DO 120 JI=1,IEND
            READ (4) RNO,ELEV(JI),D(JI),AR(JI),WP(JI),TW(JI)
 120     CONTINUE
         READ (4) TBL,TABL,TD35,TD65,(TSDP(KK),KK = 1,10),TUNIF,TUNIS
         IF (RNEW(I).EQ.RNO) GO TO 130
         GO TO 110
C
 130     CONTINUE
         IF (II.NE.1) GO TO 137
         BL(I) = TBL
         ABL(I) = TABL
         D35(I) = TD35
         D65(I) = TD65
         DO 135 KK = 1,10
         SDPI(I,KK)=TSDP(KK)
 135      SDP(I,KK) = TSDP(KK)
         UNIFORM(I) = TUNIF
         UNISIZF(I)=TUNIS
 137     CONTINUE
         CALL SEEK (AV,AR(I1AV),AR(I2AV),YAV,D(I1AV),D(I2AV))
C
         J = IFIX((Y(I)*FEET)+1.00001)
         K = J+1
C
C     STOP 005 FLOW DEPTH EXCEEDING MAX DEPTH CHECK
C
         IF (K.LE.IDEEP) GO TO 140
         WRITE (61,170)
         WRITE (61,180)
         STOP 005
C
 140     CALL SEEK (A(I),AR(J),AR(K),Y(I),D(J),D(K))
         CALL SEEK (P(I),WP(J),WP(K),Y(I),D(J),D(K))
         CALL SEEK (B(I),TW(J),TW(K),Y(I),D(J),D(K))
C
         DERB(I) = (TW(K)-TW(J))/(D(K)-D(J))
         DERP(I) = DERB(I)
         AY(I) = AV
C
         R(I) = A(I)/P(I)
         AVY(I) = A(I)/B(I)
         FR(I) = (Q(I)*Q(I)/(A(I)*A(I)))/(G*R(I))
C
```

```
              IF((SBL(I).EQ.0.0).OR.(II.NE.1)) GO TO 150
              BL(I) = SBL(I)
              ABL(I) = SABL(I)
              D35(I) = SD35(I)
              D65(I) = SD65(I)
              DO 145 KK = 1,10
 145            SDP(I,KK) = SSDP(I,KK)
 150      CONTINUE
          H = N-1
          DO 160 I=1,H
              AYX(I) = (AY(I+1)-AY(I))/DELTAX
 160      CONTINUE
          AYX(N) = AYX(H)
          RETURN
C
 170      FORMAT (1H0,≠THE CALCULATED FLOW DEPTH EXCEEDS THE ≠,
         $≠MAXIMUM CHANNEL DEPTHS SPECIFIED.≠)
 180      FORMAT (1H ,≠REMEDY:INCREASE THE VALUE OF IDEEP*≠)
          END
```

```
ROUTINE SEEK        73/171  OPT=1                          FTN 4.8+538         86/12/

             SUBROUTINE SEEK (Z,A1,A2,Y,D1,D2)
      C
             Z = A1+((A2-A1)/(D2-D1))*(Y-D1)
      C
             RETURN
             END
```

```
ROUTINE FRICT      73/171   OPT=1                         FTN 4.8+538          86/12/0

            SUBROUTINE FRICT (Y,Z,Q,A,R,CONST,EM,EN,ASF,BSLOPE,IBED,IFRICT,
           $ISED,ASFL)
      C
      C  SUBROUTINE TO ESTABLISH THE FRICTIONAL PARAMETERS NAMELY
      C  CONST , M , AND N FOR MOBILE BOUNDARY FLOWS
      C
            COMMON/B/  GAM,GAMS,D35(61),D65(61),ANU,G,ABL(61),SDP(61,10),BL(61)
           $,SDPI(61,10)
            COMMON/E/  DELTAX,DELTAT,N
            DIMENSION  Y(61),Z(61),Q(61),A(61),R(61),EL(61),X(61),CONST(61),
           $ EM(61),EN(61),ASFL(61)
            INTEGER IBED(61)
      C
            DO 100 I=1,N
               EL(I) = Z(I)+Y(I)+(Q(I)*Q(I)/(A(I)*A(I)))/(2.0*G)
               X(I) = DELTAX*(I-1)
        100 CONTINUE
      C        COMPUTATION OF LOCAL ENERGY SLOPES
      C
            N1=N-1
            DO 10 I=2,N1
            EDIF=(EL(I-1)-EL(I+1))
            IF((Q(I).GT.0.0).AND.(EDIF.LT.0.0)) GO TO 220
            IF((Q(I).LT.0.0).AND.(EDIF.GT.0.0)) GO TO 220
            ASFL(I)=ABS(EDIF)/(2.0*DELTAX)
       10   CONTINUE
            ASFL(1)=ASFL(2)
            ASFL(N)=ASFL(N1)
            SUM1 = 0.00
            SUM2 = 0.00
            SUM3 = 0.00
            SUM4 = 0.00
            SUM5 = 0.00
            DO 110 I=1,N
               SUM1 = SUM1+1.0
               SUM2 = SUM2+X(I)
               SUM3 = SUM3+X(I)*X(I)
               SUM4 = SUM4+EL(I)
               SUM5 = SUM5+EL(I)*X(I)
       110  CONTINUE
            S0 = SUM1
            S1 = SUM2
            S2 = SUM3
            T0 = SUM4
            T1 = SUM5
            A1 = (S0*T1-S1*T0)/(S0*S2-S1*S1)
            A0 = (S2*T0-S1*T1)/(S0*S2-S1*S1)
            ASF = ABS(A1)
      C
      C
            SUM4 = 0.00
            SUM5 = 0.00
            DO 120 I=1,N
               SUM4 = SUM4+Z(I)
               SUM5 = SUM5+Z(I)*X(I)
       120  CONTINUE
            T0 = SUM4
            T1 = SUM5
            A1 = (S0*T1-S1*T0)/(S0*S2-S1*S1)
            A0 = (S2*T0-S1*T1)/(S0*S2-S1*S1)
            BSLOPE = ABS(A1)
            IF ((ISED.NE.1).OR.(IFRICT.NE.1)) RETURN
            SUM = 0.00
            DO 130 I=1,N
               SUM = SUM+R(I)
        130 CONTINUE
      C
            DO 190 I =1,N
            IF(D65(I).EQ.0.0) GO TO 200
            AVR = SUM/N
            AYD = GAM*AVR*ASF/(GAMS*D65(I))
            AL1 = 0.02*(AVR/D65(I))**0.50
            AL2 = 0.02*(AVR/D65(I))**0.56
            AL3 = 0.07*(AVR/D65(I))**0.40
            IF(AL3.LT.AL2)AL3 = AL2
            AL1L = AL1-0.000001
            AL1H = AL1+0.000001
```

```
C
C  TRANSFERING CCNTROL TO SET FROPER FRICTION PARAMETERS
C
C TEMP
C       CONST(I) =  0.0340
C       EM(I)    =  0.0
C       EN(I)    =  3.0
C       IBED(I)  =  1
C       GO TO 190
C
        IF (AYD.LT.AL1L) GO TO 140
        IF ((AYD.GT.AL1L).AND.(AYD.LT.AL1H)) GC TO 150
        IF ((AYD.GT.AL1).AND.(AYD.LT.AL2)) GO TO 160
        IF ((AYD.GT.AL2).AND.(AYD.LT.AL3)) GO TO 170
        IF (AYD.GT.AL3) GO TO 180
  140   CONST(I)=(GAM/GAMS)**2/191.0
        EM(I)= 1.0
        EN(I)= 3.00
        IBED(I)= 1
        IF(Q(I).LT.0.0)    CONST(I)=-CONST(I)
        GO TO 190
  150   CONST(I)= 1.0/91.0
        EM(I)= 0.00
        EN(I)= 1.0
        IBED(I)= 2
        IF(Q(I).LT.0.0)    CONST(I)=-CONST(I)
        GO TO 190
  160   CONST(I)= 1.0/(53.43*(GAM/GAMS)**0.857)
        EM(I)= -0.429
        EN(I)= 0.143
        IBED(I)= 3
        IF(Q(I).LT.0.0)    CONST(I)=-CONST(I)
        GO TO 190
  170   CONST(I)= 1.0/47.5
        EM(I)= -0.333
        EN(I)= 1.00
        IBED(I)= 4
        IF(Q(I).LT.0.0)    CONST(I)=-CONST(I)
        GO TO 190
  180   CONST(I)=(GAM/GAMS)**2/482.00
        EM(I)= 0.20
        EN(I)= 3.00
        IBED(I)= 5
        IF(Q(I).LT.0.0)    CONST(I)=-CONST(I)
  190   CONTINUE
        FETURN
  200   WRITE (61,210)
        STOP 007
  210   FORMAT (1H1,≠ ** D65 = 0 ZERO DIVISION IF FRICT≠)
 220    WRITE(61,230)
        STOP 020
 230    FORMAT(1H1,≠***** ENERGY SLOPE IS NEGATIVE IN FRICT***≠)
        END
```

```
          SUBROUTINE SEDI (Q,A,AVY,R,FR,ASF,QST,CAV,C,TA)
C
C      SUBROUTINE TO CALCULATE THE SEDIMENT TRANSPORT
C      RATES AND AVERAGE CONCENTRATION OF SEDIMENT
C
          COMMON/A/  Y(61),B4(61),II,TQS(200)
          COMMON/B/  GAM,GAMS,D35(61),D65(61),ANU,G,ABL(61),SDP(61,10),BL(61)
         $,SDPI(61,10)
          COMMON /E/  DELTAX,DELTAT,N
          DIMENSION  Q(61),A(61),AVY(61),C(61),CAV(61),QST(61)
          DIMENSION  R(61),FR(61),ZETA(26),Y1(26),Y2(26),TA(61)
          REAL  NP,LHS
C
C
C                            SEDIMENT CONSTANTS
C
          DO 150 I=1,N
C
          DGR  =  D35(I)*(G*GAMS/(ANU*ANU*GAM))**(1.0/3.0)
          IF(DGR.LT.1.0)DGR  =  1.0
          IF  (DGR.GE.1.0.AND.DGR.LE.60.0)  GO  TO  100
          RN  =  0.0
          RA  =  .17
          RM  =  1.5
          RC  =  0.025
          GO  TO  110
  100     RN  =  1.-.56*ALOG10(DGR)
          RA  =  .23/SQRT(DGR)+.14
          RM  =  9.66/DGR+1.34
          RCC  =  2.86*ALOG10(DGR)-(ALOG10(DGR))**2-3.53
          RC  =  10.0**(RCC)
  110     CONTINUE
C
C         STOP 006 CHECK FOR -VE HYDRAULIC RADIUS VALUES
C
             IF  (R(I).GT.0.0)  GO  TO  120
             WRITE  (61,160)
             WRITE  (61,170)  R(I)
             STOP  006
C
  120        CONTINUE
C
C       CALCULATION OF FALL VELOCITY W
C
             LCHECK  =  0
             DGR3  =  DGR**3
             IF(DGR3.LE.500000.0)  GO  TO  121
             CT  =  1.625
             NP  =  0.0
             GO  TO  125
  121        CONTINUE
             IF(DGR3.LE.100.0)  GO  TO  122
             CT  =  0.1565
             NP  =  0.2
             GO  TO  125
  122        CT  =  0.056
             NP  =  0.5
  125        W  =  CT*DGR3**NP*SQRT(GAMS/GAM*G*D35(I))
C
C
C               CALCULATION OF CRITICAL SHEARVELOCITY FOR INITIATION OF SUSPENSION
C
C
          IF(DGR.GT.10.0)  GO  TO  90
          UCRS=4.0*W/DGR
          GO  TO  80
   90     UCRS=0.4*W
   80     CONTINUE
C
C
C
C        CALCULATION OF GRAIN ROUGHNESS SHEAR VELOCITY
C
             T1  =  0.40
             VSP  =  SQRT(G*ASF*Y(I))
  126        LCHECK  =  LCHECK  +  1
             IF(LCHECK.GE.5))  GO  TO  155
```

```
          TEMP1 = VSP*2.5*D65(I)/ANU
          IF (TEMP1.LT.0.0) GO TO 157
          X = ALOG(TEMP1)
          BS = (2.5*X+5.5)*EXP(-0.217*X**2)+8.5*(1.0-EXP(-0.217*X**2))
          AS = EXP(T1*BS)
          HP = VSF**2/G/ASF
          TEMP1 = AS/2.72*HP/2.5/D65(I)
          IF (TEMP1.LT.0.0) GO TO 158
          RHS = 1.0/T1*ALOG(TEMP1)
          LHS = Q(I)/A(I)/VSP
          T2 = ABS(LHS - RHS)
          IF(T2.LT.0.001) GO TO 127
          T3 = (LHS + RHS)/2.0
          VSP = Q(I)/A(I)/T3
          GO TO 126
 127      CONTINUE
C
          C(I) = (Q(I)/A(I))/SQRT(G*R(I)*ASF)
          IF (AVY(I).LT.0.0) GO TO 156
          FGR = (C(I)/A(I))*(SQRT(32.0)*ALOG10(10.0*AVY(I)/D35(I)))**
     $    (FN-1.0)/(C(I)**RN*SQRT(G*D35(I)*(GAMS/GAM)))
          IF (FGR.LE.RA) GO TO 130
          GO TO 140
 130      FGR = RA
  140     ZX = RC*((FGR-RA)/RA)**RM
          XX = ZX*((GAMS/GAM)+1)*D35(I)*C(I)**RN/AVY(I)
          QST(I) = ZX*D35(I)*(Q(I)/A(I))*C(I)**RN
          QST(I) = QST(I)*A(I)/AVY(I)
C
C    CALCULATION OF RATIO QSS/QST
C
          NL = 25
          NP1 = NL + 1
          NM1 = NL - 1
          VS=SQRT(G*ASF*Y(I))
          IF(VS.LT.UCRS)  GO TO 145
          Z = W/VSP/T1
          ZA = 2.0*D65(I)/Y(I)
          H = (1.0-ZA)/NL
          ZETA(1) = ZA
          DO 141 J = 2,NP1
          ZETA(J) = ZETA(J-1) + H
          IF (ZETA(J).LT.0.0) GO TO 159
 141      CONTINUE
          DO 142 J = 1,NP1
          Y1(J) = ((1.0-ZETA(J))/ZETA(J))**Z
 142      Y2(J) = Y1(J) * ALOG(ZETA(J))
          SUM1 = 0.0
          SUM2 = 0.0
          DO 143 J = 2,NM1,2
          SUM1 = SUM1 + Y1(J)*4.0
 143      SUM2 = SUM2 + Y2(J)*4.0
          DO 144 J = 3,NL,2
           SUM1 = SUM1 + Y1(J)*2.0
 144       SUM2 = SUM2 + Y2(J)*2.0
          TINT1 = (SUM1+Y1(1)+Y1(NP1))*H/3.0
          TINT2 = (SUM2+Y2(1)+Y2(NP1))*H/3.0
          TEMP1 = AS*Y(I)/2.72/2.5/D65(I)
          IF (TEMP1.LT.0.0) GO TO 154
          TA(I) = Y(I)/D65(I)/T1/23.2*(ZA/(1.0-ZA))**Z*(ALOG(TEMP1)
     $        *TINT1+TINT2)
          TA(I)=(1.0-(1.0/(1.0+TA(I))))
          GO TO 146
  145     TA(I)=0.00
  146     CAV(I) = QST(I)/Q(I)*TA(I)
 150  CONTINUE
C
C       SPECIFICATION OF THE UPSTREAM BOUNDARY CONDITION FOR
C       SEDIMENT TRANSPORT RATE
      QST(1) = TGS(II)/2650.0
      CAV(1) = QST(1)/Q(1)
      RETURN
C
 154  WRITE (61,200)
      STOP 017
 155  WRITE (61,180) LHS,RHS
      STOP 011
```

```
ROUTINE SEDI        73/171  OPT=1                            FTN 4.8+538         86/12/

        156   WRITE (61,190)
              STOP 012
        157   WRITE (61,200)
              STOP 013
        158   WRITE (61,200)
              STOP 014
        159   WRITE (61,200)
              STOP 015
       C
        160   FORMAT (1H0,≠THE CALCULATED HYDRAULIC RADIUS IS NEGATIVE≠,/,
             $≠ POSSIBLE CAUSE: CORRECTED FLOW DEPTH GOES NEGATIVE.≠,7,
             $≠ REMEDY: REDUCE DELTAT AND RERUN.≠)
        170   FORMAT (1H ,5HR(I)=,2X,E20.5)
        180   FORMAT (1H1,≠ LOOP CHECK IN SEDI HIT 50≠,/,≠ LHS = ≠,F15.6,
             $            5X,≠RHS = ≠,F15.6)
        190   FORMAT (1H1,≠ AVY(I) WAS NEGATIVE IN SEDI CANNOT TAKE LOG≠)
        200   FORMAT (1H1,≠ NEGATIVE ALOG ARGUMENT IN SEDI, CHECK STOP≠)
              END
```

```
      SUBROUTINE PROFILE (METRIC,IDEEP,RANGE,NUM,IPRNT,IYEAR,XIN,UNIFOR
     $M,UNISIZF)
C
C  SUBROUTINE TO COMPUTE THE GEOMETRIC CHARACTERISTICS OF
C  THE RIVER REACH FOR EACH GRID LOCATION
C
      COMMON/Z/X(500),Y(500),XU(500),YU(500)
      COMMON/X/A(61),P(61),W(61),DEPTH(61)
      COMMON/B/ GAM,GAMS,D35(61),D65(61),ANU,G,ABL(61),SDP(61,10),BL(61)
     $,SDPI(61,10)
      DIMENSION ELEV(61),RANGE(61),UNISIZF(61)
      INTEGER UNIFORM(61)
      REAL LOWEST,METRIC
      DATA A(1),DEPTH(1)/0.0001866,0/
C
C
        DATA P(1),W(1)/0.673,0.60/
C
C
      NUM = 0
      SUM = 0.00
C
C
 100  CONTINUE
C     THE CROSS SECTIONAL DATA ARE SPECIFIED IN A FORMAT
C     SIMILAR TO HEC-2
C
C     SECNO         AN IDENTIFICATION NUMBER FOR THE SECTION
C
C     NUMST         NUMBER OF POINTS TO DEFINE THE SHAPE OF THE SECTION
C
C     XLCH          DISTANCE BETWEEN ADJACENT SECTIONS (IN METERS OR FEET)
C
C     ABL           ACTIVE BED LAYER
C
C     UNIFORM       BED CONTROL PARAMETER ( SEE MAIN PROGRAM )
C
C      UNISIZF       (SEE MAIN PROGRAM)                                   OR FT
C
C     Y             VERTICAL CO-ORDINATE OF A POINT ON THE PERIMETER (IN METERS
C
C     X             HORIZONTAL CO-ORDINATE OF THE SAME POINT (IN METERS OR FEET
C
      READ (1,170) SECNO,NUMST,XLCH,TBL,UNIFORM(NUM+1),UNISIZF(NUM+1)
      IF (EOF(1)) 150,110
C
 110  CONTINUE
      LAST = NUMST
      TBL=TBL*METRIC
C
C
      NUM = NUM+1
      SUM = SUM+XLCH
      RANGE(NUM) = SUM*METRIC+XIN
      READ (1,180) (X(I),Y(I),I=1,LAST)
C
      LOWEST = 99999.
      DO 120 I=1,LAST
         IF(Y(I).LT.LOWEST)LOWEST = Y(I)
 120  CONTINUE
C
      IM = IDEEP+1
      ELEV(1) = LOWEST
      DO 130 I=2,IM
C
         ELEV(I) = LOWEST+FLOAT(I-1)*0.3048/METRIC
         CALL COMPARE (LAST,ELEV(I),IEND)
C
         CALL CROSS (I,IEND,ELEV(I),METRIC)
C
 130  CONTINUE
      IF (IPRNT.NE.0) WRITE (61,190)
      ELEV(1) = ELEV(1)*METRIC
      DO 140 I=1,IM
C
         WRITE (4) RANGE(NUM),ELEV(I),DEPTH(I),A(I),P(I),W(I)
         IF (IPRNT.NE.0) WRITE (61,200) RANGE(NUM),ELEV(I),DEPTH(I),A(I)
```

```
          $     ,P(I),W(I)
     140   CONTINUE
           TABL = 0.0
           READ (1,180) (SDP(NUM,I),I=1,10)
           WRITE (61,210) RANGE(NUM),TBL
           WRITE (51,220) (SDP(NUM,I)*100.0,I=1,10)
           CALL BED(NUM,UNIFORM,UNISIZF)
           WRITE (61,230) D35(NUM),D65(NUM)
           WRITE (4) TBL,TABL,D35(NUM),D65(NUM),(SDP(NUM,I),I=1,10),
          $UNIFORM(NUM),UNISIZF(NUM)
    C
           GO TO 100
    C
     150   RETURN
    C
     160   FORMAT (1H1)
     170   FORMAT (6X,F8.3,I4,4X,2F8.3,I3,F8.3)
     180   FORMAT (9X,9F6.3)
     190   FORMAT (1H1,8X,≠RANGE≠,5X,≠ELEVATION≠,5X,≠DEPTH≠,15X,≠AREA≠,10X,
          $≠WETTED PERIMETER≠,7X,≠TOP WIDTH≠)
     200   FORMAT (5X,F9.2,2F12.3,3F20.2)
     210   FORMAT (1H1,///,≠ SEDIMENT CHARACTERISTICS AT RANGE ≠,F9.2,//,
          $          ≠ DEPTH OF BED LAYER INITIALLY = ≠,F10.3)
     220   FORMAT (//,≠ PERCENTAGE OF GRAINSIZES 1 THRU 10 RESPECTIVELY≠,
          $          //,10F10.3)
     230   FORMAT (/,25X,≠D35 = ≠,F10.6,10X,≠D65 = ≠,F10.6)
           END
```

```
      SUBROUTINE COMPARE (LAST,ELEV,IEND)
C
C  THIS SUBROUTINE COMPARES EACH ELEMENT IN Y WITH ELEV
C  IF THE POINT IS UNDERWATER OR A BOUNDARY POINT WHICH MUST
C  BE INTERPOLATED IT IS RECORDED IN THE ARRAYS XU AND YU
C  WHERE XU IS A DISTANCE ALONG THE CROSSECTION AND YU IS THE ELEVATION
C  OF INTEREST
C
      COMMON/Z/X(500),Y(500),XU(500),YU(500)
      LOGICAL ABOVE
C
      ABOVE = .TRUE.
      J = 1
C
      DO 140 I=1,LAST
C     IF(Y(I).EQ.0.0)GO TO 60
         IF (Y(I)-ELEV) 100,100,130
C
 100     IF (ABOVE) 110,120
 110     ABOVE = .FALSE.
         IF (I.EQ.1) GO TO 120
         M = I-1
         N = I
         CALL FORMULA (N,M,ELEV,J)
         J = J+1
C
 120     YU(J) = Y(I)
         XU(J) = X(I)
         J = J+1
         GO TO 140
C
 130     IF (ABOVE) GO TO 140
         ABOVE = .TRUE.
         M = I
         N = I-1
         CALL FORMULA (N,M,ELEV,J)
         J = J+1
C
         GO TO 140
C 60  Y(I)=Y(I-1)
C     X(I)=X(I-1)
 140  CONTINUE
C
      IEND = J-1
      RETURN
      END
```

```
ROUTINE FORMULA    73/171  OPT=1                        FTN 4.8+538         86/12/(

            SUBROUTINE FORMULA (N,M,ELEV,J)
      C
      C  THIS SUBROUTINE INTERPOLATES TO FIND THE VALUE OF X MID-STATION
      C  WHERE Y EQUALS ELEV
      C
            COMMON/Z/X(500),Y(500),XU(500),YU(500)
      C
            XU(J) = X(N)-(((ELEV-Y(N))/(Y(M)-Y(N)))*(X(N)-X(M)))
            YU(J) = ELEV
      C
            RETURN
            END
```

```
ROUTINE CROSS       73/171  OPT=1                         FTN 4.8+538         86/12/

              SUBROUTINE CROSS (J,IEND,H,METRIC)
        C
        C   THIS SUBROUTINE CALCULATES THE CROSS-SECTIONAL AREA UNDER WATER,
        C   THE WETTED-PERIMETER, AND THE WIDTH
        C
              COMMON/Z/X(500),Y(500),XU(500),YU(500)
              COMMON/X/A(61),P(61),W(61),DEPTH(61)
              REAL METRIC
        C
        C
              HH = H*METRIC
        C
              A(J) = 0.
              P(J) = 0.
              W(J) = 0.
        C
              IF (IEND.LE.1) GO TO 110
              IEND = IEND-1
        C
              DO 100 I=1,IEND
                 IF (YU(I).EQ.H.AND.YU(I+1).EQ.H) GO TO 100
        C
                 X1 = (XU(I+1)-XU(I))*METRIC
                 Y1 = (YU(I+1)-YU(I))*METRIC
                 YYU = (YU(I)+YU(I+1))*METRIC
        C
                 A(J) = A(J)+X1*(HH-(YYU/2.))
                 P(J) = P(J)+SQRT(X1**2+Y1**2)
                 W(J) = W(J)+X1
        C
         100  CONTINUE
         110  DEPTH(J) = FLOAT(J-1)*0.3048
              H = H*METRIC
              RETURN
              END
```

```
      SUBROUTINE KLIST (R,ILAST,N,NEWR,IPRNT,DELTAX)
C
C  THIS SUBROUTINE ASSIGNS THE CORRECT AREAS TOP-WIDTHS
C  WETTED PERIMETERS TO EACH GRID POINT
C
      DIMENSION R(61),NEWR(61)
      REAL NEWR
      DO 120 L=1,N
         XD = (L-1)*DELTAX
         AMIN = 99999.0
         DO 110  J=1,ILAST
            DIFF = XD-R(J)
            IF (ABS(DIFF).LT.AMIN) GO TO 100
            GO TO 110
 100        AMIN = DIFF
            K = J
 110     CONTINUE
         NEWR(L) = R(K)
 120  CONTINUE
C
C
      IF (IPRNT.NE.0) WRITE (61,130) (NEWR(J),J=1,N)
      RETURN
C
 130  FORMAT (1H1,≠RANGE NUMBERS ASSIGNED≠,61(/1H ,F10.2))
      END
```

APPENDIX II

A Sample of Input Data in TAPE8

```
   62    0    0
   26    0    0    0    1    1    1.0000    1.0000
     .667     .500  600.000   12.500    9.810    0.000
      .056      .056      .056      .056      .056      .056      .056      .056
      .056      .056      .056      .056      .056      .056      .056      .056
      .056      .056      .056      .056      .056      .056      .056      .056
      .056      .056
     .0127     .0127     .0127     .0127     .0127     .0127     .0127     .0127
     .0127     .0127     .0127     .0127     .0127     .0127     .0127     .0127
     .0127     .0127     .0127     .0127     .0127     .0127     .0127     .0127
     .0127     .0127
  1.025000  1.024000  1.023000  1.022000  1.021000  1.020000  1.019000  1.018000
  1.017000  1.016000  1.015000  1.014000  1.013000  1.012000  1.011000  1.010000
  1.009000  1.008000  1.007000  1.006000  1.005000  1.004000  1.003000  1.002000
  1.001000  1.000000
1984    4 1
 .1000E+04 .1650E+04 .1000E-05
  .40
  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
  0.000000  0.000000
  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
  0.000000  0.000000
   .000000   .000000   .000000   .000000   .000000   .000000   .000000   .000000
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  0.000000  0.000000
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0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
2  1      0.000000  0.000000  0.000000  0.000000  0.000000  0.000000
   .0130     .0130     .0130     .0130     .0130     .0130     .0130     .0130
   .0130     .0130     .0130     .0130     .0130     .0130     .0130     .0130
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   .0130     .0130     .0130     .0130     .0130     .0130     .0130     .0130
   .0130     .0130     .0130     .0130     .0130     .0130     .0130     .0130
   .0130     .0130     .0130     .0130     .0130     .0130     .0130     .0130
   .0130     .0130     .0130     .0130     .0130     .0130     .0130     .0130
   .0130     .0130     .0130     .0130     .0130     .0130
   .0560     .0560     .0560     .0560     .0560     .0560     .0560     .0560
   .0560     .0560     .0560     .0560     .0560     .0560     .0560     .0560
   .0560     .0560     .0560     .0560     .0560     .0560     .0560     .0560
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   .0560     .0560     .0560     .0560     .0560     .0560     .0560     .0560
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.0000    .0000    .0000    .0000    .0000    .0000
```

APPENDIX III

A Sample of Input Data in TAPE1

```
X1          1.000  13.000     1.0    1.00  0
GR          0.000   0.600   0.000   0.400   0.000   0.200   0.000   0.000   0.100
GR          0.000   0.200   0.000   0.300   0.000   0.400   0.000   0.500   0.000
GR          0.600   0.000   0.600   0.200   0.600   0.400   0.600   0.600
SD          0.000   0.075   0.105   0.210   0.250   0.190   0.150   0.020   0.000
SD          0.000
```

APPENDIX IV

Sample Output

```
**********
* REPORT *
**********


* * * * * * * * * * * * * * * * * * *
*                                   *
*                                   *
*            MODEL MOBED            *
* ( WITH SEDIMENT CHARACTERISTICS ) *
*                                   *
*                                   *
* * * * * * * * * * * * * * * * * * *
```

```
RANGE     ELEVATION     DEPTH              AREA        WETTED PERIMETER      TOP WIDTH
 2.00       0.000       0.000               .00               .67               .60
 2.00        .305        .305               .18              1.21               .60
 2.00        .610        .610               .37              1.80               .60
 2.00        .914        .914               .55              1.80               .60
 2.00       1.219       1.219               .73              1.80               .60


SEDIMENT CHARACTERISTICS AT RANGE       2.00

DEPTH OF BED LAYER INITIALLY =      1.000

PERCENTAGE OF GRAINSIZES 1 THRU 10 RESPECTIVELY

    0.000      7.500    10.500    21.000    25.000    19.000    15.000     2.000     0.000     0.000

                         D35 =     .000876          D65 =     .002074


RANGE NUMBERS ASSIGNED
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
      2.00
```

```
NUMBER OF GRID POINTS ALONG THE RIVER REACH N=   26

CONTROL PARAMETER FOR TRIBUTORY PRESENCE INFLOW=    0

NUMBER OF TRIBUTARIES=    0

CONTROL PARAMETER FOR STORAGE BASIN IS=    0

CONTROL PARAMETER SIGNIFYING THE NATURE OF FLOW BOUNDARY ISED=    1

WEIGHTING COEFFICIENT THETA=    .667

DISTANCE IN METERS BETWEEN GRID POINTS DELTAX=     .50

TIME INCREMENTS IN SECONDS DELTAT=    600.0

TOTAL LENGTH OF RIVER REACH MODELLED XLENGTH=     12.50

ACCELERATION DUE TO GRAVITY G=  9.8100

WATER SURFACE AREA OF STORAGE BASIN SAR=  0.0000

THE VALUE OF KINEMATIC VISCOSITY IS=   .000001

UPSTREAM BOUNDARY TYPE=    2

DOWNSTREAM BOUNDARY TYPE=    1

BOUNDARY VALUES

  UPSTREAM
  --------
    .013      .013      .013      .013      .013      .013      .013      .013

  DOWNSTREAM
  ----------
    .056      .056      .056      .056      .056      .056      .056      .056
```

```
SOLUTION AT TIME T=     0.00DAYS     0.00HOURS     0.00MINUTES     0.00SECONDS

DISTANCE  FLOW RATE  FLOW DEPTH  SEDIMENT RATE  FROUDE N  BOTTOM ELEVATION  TOP WIDTH  FLOW AREA  FRICTION FACTOR  HYDRAULIC RADIUS
   0.00     .0127      .0560     0.0000000000     .3299       1.025000         .6000      .0338        12.8437             .0437
    .50     .0127      .0560      .0000002369     .3299       1.024000         .6000      .0338        12.8437             .0437
   1.00     .0127      .0560      .0000002369     .3299       1.023000         .6000      .0338        12.8437             .0437
   1.50     .0127      .0560      .0000002369     .3299       1.022000         .6000      .0338        12.8437             .0437
   2.00     .0127      .0560      .0000002369     .3299       1.021000         .6000      .0338        12.8437             .0437
   2.50     .0127      .0560      .0000002369     .3299       1.020000         .6000      .0338        12.8437             .0437
   3.00     .0127      .0560      .0000002369     .3299       1.019000         .6000      .0338        12.8437             .0437
   3.50     .0127      .0560      .0000002369     .3299       1.018000         .6000      .0338        12.8437             .0437
   4.00     .0127      .0560      .0000002369     .3299       1.017000         .6000      .0338        12.8437             .0437
   4.50     .0127      .0560      .0000002369     .3299       1.016000         .6000      .0338        12.8437             .0437
   5.00     .0127      .0560      .0000002369     .3299       1.015000         .6000      .0338        12.8437             .0437
   5.50     .0127      .0560      .0000002369     .3299       1.014000         .6000      .0338        12.8437             .0437
   6.00     .0127      .0560      .0000002369     .3299       1.013000         .6000      .0338        12.8437             .0437
   6.50     .0127      .0560      .0000002369     .3299       1.012000         .6000      .0338        12.8437             .0437
   7.00     .0127      .0560      .0000002369     .3299       1.011000         .6000      .0338        12.8437             .0437
   7.50     .0127      .0560      .0000002369     .3299       1.010000         .6000      .0338        12.8437             .0437
   8.00     .0127      .0560      .0000002369     .3299       1.009000         .6000      .0338        12.8437             .0437
   8.50     .0127      .0560      .0000002369     .3299       1.008000         .6000      .0338        12.8437             .0437
   9.00     .0127      .0560      .0000002369     .3299       1.007000         .6000      .0338        12.8437             .0437
   9.50     .0127      .0560      .0000002369     .3299       1.006000         .6000      .0338        12.8437             .0437
  10.00     .0127      .0560      .0000002369     .3299       1.005000         .6000      .0338        12.8437             .0437
  10.50     .0127      .0560      .0000002369     .3299       1.004000         .6000      .0338        12.8437             .0437
  11.00     .0127      .0560      .0000002369     .3299       1.003000         .6000      .0338        12.8437             .0437
  11.50     .0127      .0560      .0000002369     .3299       1.002000         .6000      .0338        12.8437             .0437
  12.00     .0127      .0560      .0000002369     .3299       1.001000         .6000      .0338        12.8437             .0437
  12.50     .0127      .0560      .0000002369     .3299       1.000000         .6000      .0338        12.8437             .0437

AVERAGE ENERGY SLOPE OF THE REACH=  .00200

AVERAGE SLOPE OF BED=  .00200

AVERAGE SEDIMENT TRANSPORT RATE =      .0000002276
```

```
NEW SEDIMENT CHARACTERISTICS
 RANGE                        PERCENTAGES OF GRAINSIZES 1 THRU 10 RESPECTIVELY                             D35       D65    BED DEPTH    ABL
  0.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
   .50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  1.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  1.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  2.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  2.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  3.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  3.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  4.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  4.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  5.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  5.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  6.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  6.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  7.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  7.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  8.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  8.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  9.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
  9.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
 10.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
 10.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
 11.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
 11.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
 12.00    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000
 12.50    0.000   7.500  10.500  21.000  25.000  19.000  15.000   2.000   0.000   0.000   .000876   .002074    1.000   0.00000

 RANGE                    BED STATE                                    FRICTION PARAMETERS      RATIO QSS/QST
                                                                   CONST       M          N
  0.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
   .50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  1.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  1.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  2.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  2.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  3.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  3.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  4.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  4.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  5.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  5.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  6.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  6.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  7.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  7.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  8.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  8.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  9.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
  9.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
 10.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
 10.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
 11.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
 11.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
 12.00       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
 12.50       THE BED IS COVERED WITH DUNES OF TYPE 1               .0019    1.0000     3.0000      0.0000
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 SOLUTION AT TIME T=      0.00DAYS      0.00HOURS     10.00MINUTES      0.00SECONDS

 DISTANCE  FLOW RATE  FLOW DEPTH  SEDIMENT RATE    FROUDE N  BOTTOM ELEVATION  TOP WIDTH   FLOW AREA  FRICTION FACTOR  HYDRAULIC RADIUS
     0.00      .0127       .0542  0.0000000000        .3620        1.023228       .6000       .0327         14.1519             .0425
      .50      .0127       .0533   .0000002561        .3793        1.023115       .6000       .0322         14.4847             .0419
     1.00      .0127       .0525   .0000004649        .3976        1.023004       .6000       .0316         14.6304             .0413
     1.50      .0127       .0525   .0000004633        .3972        1.022004       .6000       .0317         14.8233             .0414
     2.00      .0127       .0525   .0000004614        .3968        1.021005       .6000       .0317         14.8151             .0414
     2.50      .0127       .0526   .0000004593        .3962        1.020006       .6000       .0317         14.8055             .0414
     3.00      .0127       .0526   .0000004567        .3957        1.019007       .6000       .0317         14.7945             .0414
     3.50      .0127       .0526   .0000004536        .3950        1.018008       .6000       .0317         14.7817             .0414
     4.00      .0127       .0527   .0000004501        .3942        1.017010       .6000       .0318         14.7670             .0415
     4.50      .0127       .0527   .0000004459        .3933        1.016011       .6000       .0318         14.7498             .0415
     5.00      .0127       .0528   .0000004411        .3922        1.015013       .6000       .0318         14.7300             .0416
     5.50      .0127       .0529   .0000004355        .3910        1.014015       .6000       .0319         14.7071             .0416
     6.00      .0127       .0529   .0000004290        .3896        1.013018       .6000       .0319         14.6805             .0416
     6.50      .0127       .0530   .0000004214        .3879        1.012020       .6000       .0320         14.6497             .0417
     7.00      .0127       .0531   .0000004127        .3861        1.011023       .6000       .0320         14.6140             .0418
     7.50      .0127       .0532   .0000004028        .3839        1.010027       .6000       .0321         14.5727             .0418
     8.00      .0127       .0533   .0000003913        .3814        1.009031       .6000       .0322         14.5250             .0419
     8.50      .0127       .0535   .0000003782        .3785        1.008035       .6000       .0322         14.4697             .0420
     9.00      .0127       .0537   .0000003633        .3751        1.007039       .6000       .0324         14.4059             .0422
     9.50      .0127       .0539   .0000003465        .3713        1.006045       .6000       .0325         14.3322             .0423
    10.00      .0127       .0541   .0000003275        .3669        1.005050       .6000       .0326         14.2472             .0424
    10.50      .0127       .0544   .0000003062        .3613        1.004056       .6000       .0328         14.1493             .0426
    11.00      .0127       .0547   .0000002827        .3562        1.003061       .6000       .0330         14.0366             .0428
    11.50      .0127       .0550   .0000002567        .3496        1.002067       .6000       .0332         13.9072             .0431
    12.00      .0127       .0554   .0000002285        .3422        1.001073       .6000       .0334         13.7569             .0434
    12.50      .0127       .0559   .0000001984        .3338        1.000075       .6000       .0337         13.5886             .0437

AVERAGE ENERGY SLOPE OF THE REACH=  .00181

AVERAGE SLOPE OF BED=  .00185

AVERAGE SEDIMENT TRANSPORT RATE =      .0000003671
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NEW SEDIMENT CHARACTERISTICS
                              PERCENTAGES OF GRAINSIZES 1 THRU 10 RESPECTIVELY                         D35      D65    BED DEPTH   ABL
 RANGE
  0.00    0.000   5.840   8.230  16.910  23.274  23.673  19.467   2.596   0.000   0.000   .001127  .002739    .998    .00415
   .50    0.000   6.779   9.513  19.223  24.255  21.034  16.933   2.251   0.000   0.000   .000982  .002376    .999    .00415
  1.00    0.000   7.497  10.496  20.994  24.997  19.007  15.007   2.001   0.000   0.000   .000877  .002075   1.000    .00415
  1.50    0.000   7.497  10.496  20.992  24.997  19.009  15.008   2.001   0.000   0.000   .000877  .002076   1.000    .00415
  2.00    0.000   7.496  10.495  20.991  24.996  19.010  15.010   2.001   0.000   0.000   .000877  .002076   1.000    .00415
  2.50    0.000   7.496  10.494  20.989  24.996  19.012  15.012   2.002   0.000   0.000   .000877  .002076   1.000    .00415
  3.00    0.000   7.495  10.493  20.987  24.995  19.014  15.014   2.002   0.000   0.000   .000877  .002077   1.000    .00415
  3.50    0.000   7.494  10.492  20.985  24.994  19.017  15.016   2.002   0.000   0.000   .000877  .002077   1.000    .00415
  4.00    0.000   7.493  10.490  20.983  24.993  19.020  15.019   2.002   0.000   0.000   .000877  .002077   1.000    .00415
  4.50    0.000   7.492  10.489  20.980  24.992  19.023  15.022   2.003   0.000   0.000   .000877  .002078   1.000    .00415
  5.00    0.000   7.490  10.487  20.976  24.991  19.027  15.025   2.003   0.000   0.000   .000878  .002078   1.000    .00415
  5.50    0.000   7.489  10.485  20.973  24.990  19.031  15.029   2.004   0.000   0.000   .000878  .002079   1.000    .00415
  6.00    0.000   7.487  10.482  20.968  24.988  19.037  15.033   2.004   0.000   0.000   .000878  .002080   1.000    .00415
  6.50    0.000   7.485  10.479  20.963  24.987  19.042  15.038   2.005   0.000   0.000   .000878  .002081   1.000    .00415
  7.00    0.000   7.483  10.476  20.956  24.985  19.049  15.044   2.006   0.000   0.000   .000879  .002082   1.000    .00415
  7.50    0.000   7.480  10.473  20.951  24.984  19.056  15.050   2.007   0.000   0.000   .000879  .002083   1.000    .00415
  8.00    0.000   7.477  10.468  20.944  24.982  19.065  15.056   2.008   0.000   0.000   .000879  .002084   1.000    .00415
  8.50    0.000   7.473  10.464  20.936  24.981  19.074  15.064   2.009   0.000   0.000   .000880  .002085   1.000    .00415
  9.00    0.000   7.470  10.459  20.927  24.981  19.084  15.071   2.010   0.000   0.000   .000880  .002086   1.000    .00415
  9.50    0.000   7.465  10.453  20.917  24.981  19.095  15.080   2.011   0.000   0.000   .000881  .002088   1.000    .00415
 10.00    0.000   7.461  10.446  20.906  24.982  19.106  15.088   2.012   0.000   0.000   .000881  .002089   1.000    .00415
 10.50    0.000   7.455  10.439  20.894  24.984  19.118  15.096   2.013   0.000   0.000   .000882  .002091   1.000    .00415
 11.00    0.000   7.450  10.432  20.882  24.989  19.129  15.104   2.014   0.000   0.000   .000883  .002092   1.000    .00415
 11.50    0.000   7.444  10.424  20.870  24.996  19.139  15.111   2.015   0.000   0.000   .000883  .002094   1.000    .00415
 12.00    0.000   7.439  10.417  20.859  25.006  19.147  15.117   2.016   0.000   0.000   .000884  .002095   1.000    .00415
 12.50    0.000   7.435  10.412  20.853  25.020  19.148  15.117   2.016   0.000   0.000   .000884  .002095   1.000    .00415

 RANGE                    BED STATE                                              FRICTION PARAMETERS      RATIO QSS/QST
                                                                               CONST       M         N
  0.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
   .50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  1.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  1.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  2.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  2.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  3.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  3.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  4.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  4.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  5.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  5.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  6.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  6.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  7.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  7.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  8.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  8.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  9.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
  9.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
 10.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
 10.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
 11.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
 11.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
 12.00       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
 12.50       THE BED IS COVERED WITH DUNES OF TYPE 1                           .0019    1.0000    3.0000    0.0000
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SOLUTION AT TIME T=      0.00DAYS      0.00HOURS     20.00MINUTES      0.00SECONDS

DISTANCE  FLOW RATE  FLOW DEPTH  SEDIMENT RATE    FROUDE N  BOTTOM ELEVATION   TOP WIDTH   FLOW AREA   FRICTION FACTOR   HYDRAULIC RADIUS
    0.00       .0127      .0569  0.0000000000        .3153        1.022159         .6000       .0343        12.9076               .0444
     .50       .0127      .0562   .0000000316        .3260        1.022110         .6000       .0339        13.1257               .0439
    1.00       .0127      .0547   .0000002419        .3534        1.022536         .6000       .0329        13.6665               .0428
    1.50       .0127      .0542   .0000003340        .3622        1.022011         .6000       .0327        13.8355               .0425
    2.00       .0127      .0542   .0000003330        .3621        1.021013         .6000       .0327        13.8332               .0425
    2.50       .0127      .0542   .0000003319        .3619        1.020015         .6000       .0327        13.8304               .0425
    3.00       .0127      .0542   .0000003307        .3618        1.019017         .6000       .0327        13.8271               .0425
    3.50       .0127      .0542   .0000003292        .3616        1.018020         .6000       .0327        13.8231               .0425
    4.00       .0127      .0542   .0000003276        .3613        1.017024         .6000       .0327        13.8183               .0425
    4.50       .0127      .0542   .0000003257        .3610        1.016027         .6000       .0327        13.8126               .0425
    5.00       .0127      .0542   .0000003234        .3607        1.015032         .6000       .0327        13.8056               .0425
    5.50       .0127      .0542   .0000003208        .3602        1.014037         .6000       .0327        13.7972               .0425
    6.00       .0127      .0542   .0000003177        .3597        1.013043         .6000       .0327        13.7871               .0426
    6.50       .0127      .0543   .0000003141        .3590        1.012050         .6000       .0327        13.7748               .0426
    7.00       .0127      .0543   .0000003098        .3583        1.011055         .6000       .0327        13.7599               .0426
    7.50       .0127      .0544   .0000003048        .3573        1.010067         .6000       .0328        13.7418               .0426
    8.00       .0127      .0544   .0000002989        .3562        1.009077         .6000       .0328        13.7200               .0427
    8.50       .0127      .0545   .0000002919        .3548        1.008088         .6000       .0328        13.6937               .0427
    9.00       .0127      .0546   .0000002838        .3532        1.007100         .6000       .0329        13.6622               .0428
    9.50       .0127      .0547   .0000002744        .3512        1.006114         .6000       .0329        13.6244               .0428
   10.00       .0127      .0548   .0000002637        .3483        1.005128         .6000       .0330        13.5797               .0429
   10.50       .0127      .0549   .0000002514        .3462        1.004143         .6000       .0331        13.5269               .0430
   11.00       .0127      .0551   .0000002377        .3431        1.003158         .6000       .0332        13.4655               .0431
   11.50       .0127      .0553   .0000002226        .3395        1.002173         .6000       .0333        13.3945               .0433
   12.00       .0127      .0555   .0000002063        .3354        1.001187         .6000       .0335        13.3136               .0434
   12.50       .0127      .0558   .0000001891        .3307        1.000193         .6000       .0336        13.2204               .0436

AVERAGE ENERGY SLOPE OF THE REACH=  .00193

AVERAGE SLOPE OF BED=  .00190

AVERAGE SEDIMENT TRANSPORT RATE =       .0000002691
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NEW SEDIMENT CHARACTERISTICS

 RANGE                        PERCENTAGES OF GRAINSIZES 1 THRU 10 RESPECTIVELY                              D35       D65    BED DEPTH   ABL

   0.00    0.000   5.104   7.236  15.306  23.846  25.110  20.544   2.752   0.000   0.000   .001238   .002904    .997   .00548
    .50    0.000   5.951   8.393  17.337  24.520  22.894  18.442   2.453   0.000   0.000   .001096   .002610    .998   .00475
   1.00    0.000   7.095   9.358  20.049  24.850  20.060  15.371   2.110   0.000   0.000   .000930   .002222   1.000   .00415
   1.50    0.000   7.492  10.489  20.940  24.995  19.023  15.020   2.003   0.000   0.000   .000877   .002076   1.000   .00415
   2.00    0.000   7.490  10.487  20.977  24.994  19.026  15.023   2.003   0.000   0.000   .000878   .002078   1.000   .00415
   2.50    0.000   7.489  10.484  20.972  24.993  19.031  15.027   2.004   0.000   0.000   .000878   .002079   1.000   .00415
   3.00    0.000   7.487  10.482  20.968  24.992  19.036  15.031   2.004   0.000   0.000   .000878   .002080   1.000   .00415
   3.50    0.000   7.484  10.479  20.962  24.991  19.042  15.037   2.005   0.000   0.000   .000878   .002080   1.000   .00415
   4.00    0.000   7.482  10.475  20.956  24.989  19.045  15.043   2.006   0.000   0.000   .000879   .002082   1.000   .00415
   4.50    0.000   7.479  10.471  20.949  24.988  19.058  15.050   2.007   0.000   0.000   .000879   .002083   1.000   .00416
   5.00    0.000   7.475  10.466  20.940  24.986  19.067  15.059   2.008   0.000   0.000   .000879   .002084   1.000   .00416
   5.50    0.000   7.471  10.461  20.931  24.984  19.075  15.067   2.009   0.000   0.000   .000880   .002086   1.000   .00416
   6.00    0.000   7.466  10.454  20.919  24.982  19.091  15.077   2.010   0.000   0.000   .000881   .002087   1.000   .00416
   6.50    0.000   7.461  10.447  20.906  24.980  19.105  15.089   2.012   0.000   0.000   .000881   .002089   1.000   .00416
   7.00    0.000   7.455  10.438  20.891  24.978  19.121  15.103   2.014   0.000   0.000   .000882   .002092   1.000   .00416
   7.50    0.000   7.447  10.428  20.875  24.976  19.140  15.118   2.016   0.000   0.000   .000883   .002094   1.000   .00417
   8.00    0.000   7.439  10.417  20.855  24.975  19.161  15.134   2.018   0.000   0.000   .000884   .002097   1.000   .00417
   8.50    0.000   7.430  10.405  20.834  24.974  19.184  15.153   2.020   0.000   0.000   .000885   .002100   1.000   .00417
   9.00    0.000   7.420  10.391  20.810  24.975  19.209  15.172   2.023   0.000   0.000   .000886   .002104   1.000   .00417
   9.50    0.000   7.408  10.375  20.784  24.977  19.236  15.193   2.025   0.000   0.000   .000888   .002108   1.000   .00418
  10.00    0.000   7.396  10.359  20.756  24.981  19.265  15.215   2.029   0.000   0.000   .000889   .002112   1.000   .00418
  10.50    0.000   7.383  10.341  20.726  24.989  19.294  15.237   2.032   0.000   0.000   .000891   .002115   1.000   .00418
  11.00    0.000   7.369  10.322  20.696  25.000  19.321  15.258   2.034   0.000   0.000   .000893   .002119   1.000   .00418
  11.50    0.000   7.355  10.303  20.666  25.017  19.347  15.276   2.037   0.000   0.000   .000895   .002123   1.000   .00419
  12.00    0.000   7.341  10.285  20.638  25.039  19.367  15.291   2.039   0.000   0.000   .000896   .002125   1.000   .00419
  12.50    0.000   7.333  10.274  20.624  25.066  19.370  15.293   2.039   0.000   0.000   .000897   .002126   1.000   .00419


 RANGE                  BED STATE                                          FRICTION PARAMETERS     RATIO QSS/QST
                                                                         CONST      M         N

   0.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
    .50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   1.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   1.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   2.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   2.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   3.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   3.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   4.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   4.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   5.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   5.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   6.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   6.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   7.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   7.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   8.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   8.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   9.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
   9.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
  10.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
  10.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
  11.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
  11.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
  12.00       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
  12.50       THE BED IS COVERED WITH DUNES OF TYPE 1                    .0019   1.0000    3.0000     0.0000
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