Chapter 3

General Input Requirements

3.1 General Description of Data Input

Input data are grouped into the categories of geometry, sediment, hydrology, and special commands. A description of input records is contained in Appendix A. The alphanumerics in parentheses after each section heading in this chapter refer to the input records that control the discussed data.

3.2 Geometric Data

Geometric data includes cross sections, reach lengths and n values. In addition, the movable bed portion of each cross section and the depth of sediment material in the bed are defined. The **NC** to **H** records are used to define the model geometry. The format used for geometric data is similar to that of HEC-2.

3.2.1 Cross Sections (X1, X3, GR)

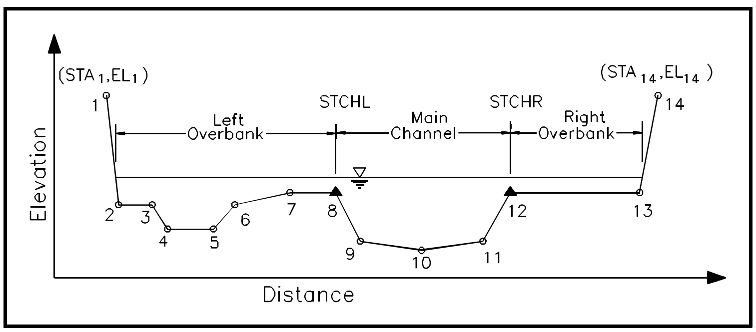

Figure 3-1
Cross Section Subsections

Cross sections are specified for the initial conditions. Calculations are made directly from coordinate points (stations, elevations), not from tables or curves of hydraulic elements. **GR** records are used to input elevation-station coordinates to provide a description of the shape of a cross section. Elevations may be positive, zero or negative. Cross section identification numbers, entered in field 1 of the **X1** record for each cross section, must be positive and should increase in the upstream direction. Corrections for skew (**X1**.8)[2] and changes in elevation (**X1.**9) can be made without re-entering coordinate points. If the water surface elevation exceeds the end elevations of a section, calculations continue by extending the end points vertically, neglecting the additional wetted perimeter.

Each cross section may be subdivided into three parts called subsections - the left overbank, main channel and right overbank as shown in Figure 3-1. Each subsection must have a reach length. It extends from the previous (downstream) section to the present cross section. This enables the simulation of channel curves where the outer part of the bend, which is represented by an overbank area, has a reach length larger than the channel or the inside overbank area. For meandering rivers, the channel length is generally greater than the overbank reach lengths.

[2] The reference (**X1**.8) means that the variable being discussed, in this case, skew, can be entered in field 8 of the **X1** record).

3.2.2 Manning's *n* Values (NC, NV, $KL, $KI)

A Manning's *n* value is required for each subsection of a cross section. It is not possible to automatically change *n* values with respect to time. Static or fixed *n* values are entered using the **NC** record. The *n* values may vary with either discharge or elevation in the main channel and overbank areas by using **NV** records. When *n* varies with discharge, the first *n* on the **NV** record should be a negative value. An **NC** record must precede the first cross section even if an **NV** record immediately follows and overrides it.

Limerinos' (1970) relationship is available for the determination of Manning's *n* based upon bed gradation. This relationship is:

$$n = \frac{0.0926R^{1/6}}{1.16 + 2.0\ \log_{10}\left(\frac{R}{d_{84}}\right)} \tag{3-1}$$

where: d_{84} = particle size in the stream bed of which 84 percent of the bed is finer, in feet
R = hydraulic radius, in feet

To compute *n* values utilizing Limerinos' relationship, the **$KL** record is placed in the hydrologic data. To return to the input *n* values, a **$KI** record must be input.

The calculation of friction loss through the reach between cross sections is made by averaging the end areas of a subsection, averaging the end hydraulic radii and applying the subsection *n* value and reach length to get a length-weighted subsection conveyance. Subsection conveyances are summed to get a total value for the cross section reach which is used to calculate friction loss.

3.2.3 Movable Bed (H, HD)

Each cross section is divided into movable and fixed-bed portions. The **H** (or **HD**) record is used to define the movable bed limits, **XSM** and **XFM**, which can extend beyond the channel bank station. Scour and deposition will cause the movable bed to fall or rise by changing the cross section elevations within the movable bed at the end of each time step.

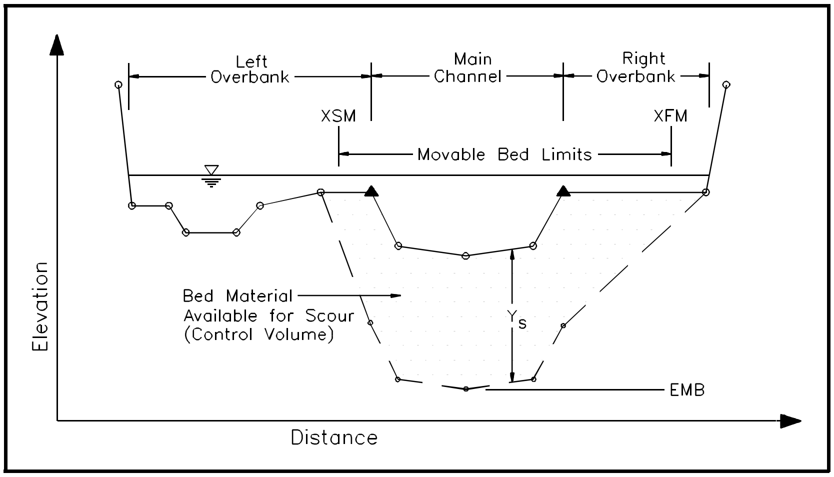

Figure 3-2
Sediment Material in the Stream Bed

The elevation of the model bottom is specified in field 2 of the **H** record. After determining the minimum channel elevation of each cross section, HEC-6 uses the model bottom elevation to compute the depth of sediment material available for scour. Optionally, the depth of sediment material, $\mathbf{Y_s}$, can be specified directly by using an **HD** record instead of an **H** record for each cross section.

3.2.4 Dredging (H, HD, $DREDGE, $NODREDGE)

The **H** (or **HD**) record is also used to specify the bottom elevation and lateral limits of the dredged channel, as well as the depth of advanced maintenance dredging. The dredged channel limits must be within the movable bed. Dredging is initiated by the **$DREDGE** record in the hydrologic data and is assumed to be active for all discharges until a **$NODREDGE** record is encountered. These "on" and "off" records can be placed anywhere in the hydrologic data. Dredging can be activated any number of times during a simulation by placing pairs of **$DREDGE**, **$NODREDGE** records in the hydrologic data.

The elevation of the channel bottom is calculated at the end of each computation interval. When the dredging option is used, if the minimum channel elevation is higher than the specified dredging elevation, the dredged channel is lowered to the specified dredging or overdredge depth, whichever is lower. Outside of the dredged channel, the points are not changed. Sediment material is assumed to be removed from the channel and from the system. An option is available to initiate dredging if the channel bottom elevation is higher than a specified minimum draft depth (**$DREDGE** record). When this occurs, the channel is dredged to an elevation such that the minimum draft is achieved.

3.2.5 Bridges

HEC-6 has no provision for calculating flow at bridges other than by normal backwater calculations. Piers can be simulated by adjustment of **GR** points to reflect net flow area change if general scour information is of interest at a bridge. Be sure that the top elevations of the **GR** points used for piers are above the highest anticipated water surface elevation. This is to assure that deposition does not occur on the piers. In most situations the user should ignore bridges and match water surface profiles by adjusting n values to avoid the short time intervals required for analyzing general scour at bridges with closely spaced cross sections. All bridge routine records in an HEC-2 data file must be removed before use of the file in HEC-6.

3.2.6 Ineffective Flow Area (X3)

When high ground or some other obstruction such as a levee prevents water from flowing into a subsection, the area up to that point is ineffective for conveying flow and is not used for hydraulic computations until the water surface exceeds the top elevation of the obstruction. The barrier can be a natural levee, constructed levee or some other structure. End area, wetted perimeter, n value and conveyance computations are not made in the ineffective area portions of a cross section. This is similar to the ineffective flow option in HEC-2. Sediment computations will not be made for ineffective areas.

Three methods for describing ineffective flow area are available. Method 1 confines the water within the channel limits unless the water surface elevation is higher than the elevation of either channel limit. If either (or both) channel limit elevation(s) is exceeded, that overbank area is used for hydraulic conveyance calculations (see Figure 3-3).

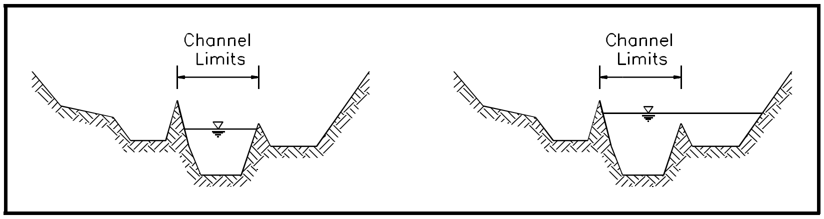

Figure 3-3
Examples of Ineffective Area, Method 1

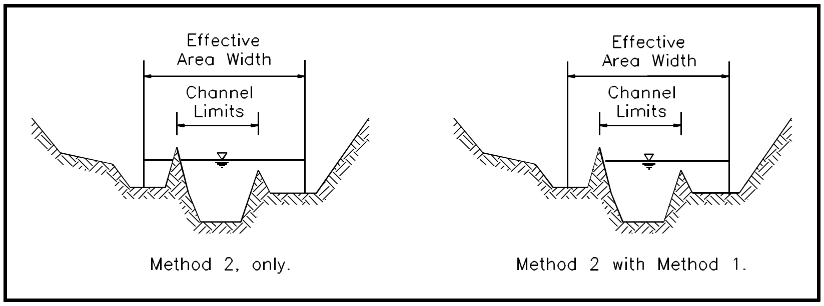

Figure 3-4
Examples of Ineffective Area, Method 2

Method 2 is used to specify an effective area width of which the left and right limits are equidistant from the centerline of the channel. This is similar to Method 2 of the encroachment option in HEC-2. Method 2 may be used in conjunction with Method 1 as shown in Figure 3-4.

Method 3 uses the exact locations (STENCL and STENCR for left and right overbanks) and elevations (ELENCL and ELENCR for left and right overbanks) of ineffective areas for each overbank area. This method is similar to Method 1 of the encroachment option in HEC-2 as demonstrated by Figure 3-5. Method 3 cannot be used together with Method 1 or 2.

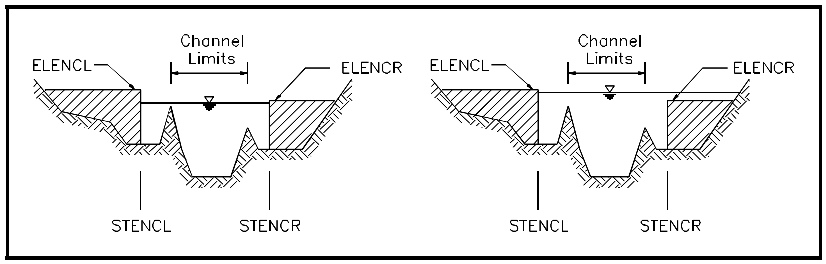

Figure 3-5
Examples of Ineffective Area, Method 3

HEC-6 automatically tests the first and last points in the movable bed to ascertain if natural levees are forming during the computations. If this occurs, HEC-6 overrides the ineffective area methods specified by input data. In fact, natural levees formed by the movable bed are always considered to establish ineffective area even if that option was not selected by input data, as illustrated in Figure 3-6.

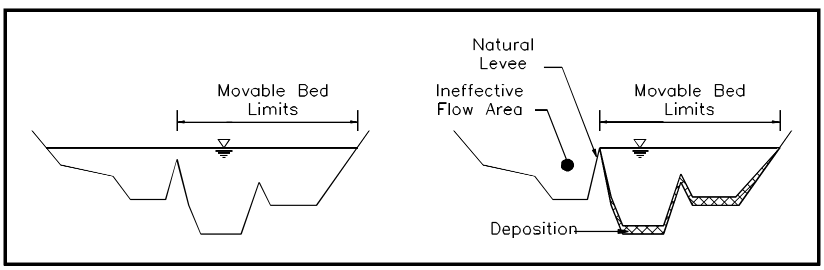

Figure 3-6
Ineffective Areas Due to Natural Levee Formation

3.2.7 Conveyance Limits (XL)

Sometimes water inundates areas that do not contribute to the water conveyance. Conveyance limits are specified by either entering a conveyance width to be centered between the channel limits or by input of two station locations that define the conveyance limits. Deposition is allowed to occur outside the conveyance limits (but within the movable bed); however, scour can occur only within the conveyance limits even if the movable bed limits are beyond the conveyance limits.

3.3 Sediment Data

Sediment data is specified on records **I** through **PF**. This data includes fluid and sediment properties, the inflowing sediment load data, and the gradation of material in the stream bed. The transport capacity relationship(s) and unit weights of deposited material are also input in this section.

The grain sizes of sediment particles commonly transported by rivers may range over several orders of magnitude. Small sizes behave much differently from large sizes. Therefore, it is necessary to classify sediment material into groups for application of different transport theories. The three basic classes considered by HEC-6 are clay, silt, and sands-boulders. The groups are identified and subdivided based on the American Geophysical Union (AGU) classification scale (Table 2-1, Vanoni 1975) as shown in Table 3-1. HEC-6 accounts for 20 different sizes of material including one size for clay, four silt sizes, five sand sizes, five gravel, two cobble sizes, and three boulder sizes. The representative size of each class is the geometric mean size, which is the square root of the class ranges multiplied together. For example, the geometric mean size for medium silt is $(0.016 \bullet 0.032)^{1/2}$ or 0.023 mm.

Table 3-1
Grain Size Classification of Sediment Material

Class Size Number Used in HEC-6	Sediment Material	Grain Diameter (mm)
	Clay	
1	Clay	0.002 - 0.004
	Silt	
1	Very Fine Silt	0.004 - 0.008
2	Fine Silt	0.008 - 0.016
3	Medium Silt	0.016 - 0.032
4	Coarse Silt	0.032 - 0.0625
	Sands - Boulders	
1	Very Fine Sand (VFS)	0.0625 - 0.125
2	Fine Sand (FS)	0.125 - 0.250
3	Medium Sand (MS)	0.25 - 0.50
4	Coarse Sand (CS)	0.5 - 1.0
5	Very Coarse Sand (VCS)	1 - 2
6	Very Fine Gravel (VFG)	2 - 4
7	Fine Gravel (FG)	4 - 8
8	Medium Gravel (MG)	8 - 16
9	Coarse Gravel (CG)	16 - 32
10	Very Coarse Gravel (VCG)	32 - 64
11	Small Cobbles (SC)	64 - 128
12	Large Cobbles (LC)	128 - 256
13	Small Boulders (SB)	256 - 512
14	Medium Boulders (MB)	512 - 1024
15	Large Boulders (LB)	1024 - 2048

3.3.1 Inflowing Sediment Load (LQ, LT, LF)

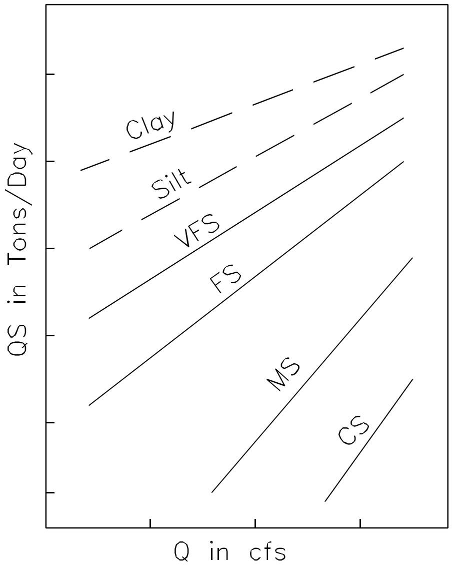

Figure 3-7
Water-Sediment Inflow Relationship

The aggradation or degradation of a stream bed profile depends upon the amount and size of sediment inflow relative to the transport capacity of the stream (see Section 2.3.1). The inflowing sediment supplies entering the upstream boundaries of the geometric model and at local inflow points are called inflowing sediment loads and are expressed in tons/day. The sediment load should include both bed and suspended load (total load) and is expressed as a log-log function of water discharge in cfs vs. sediment load in tons/day as depicted in Figure 3-7.

Data is entered on the **LT** and **LF** records as a table of sediment load by grain size class for a range of water discharges. The discharges entered on the **LQ** record should encompass the full range found in the computational hydrograph. A complete sediment load table is required for every inflow into the network. This includes the inflow to each stream segment as well as all local inflows.

In most projects, the sediment load table, once set, does not need to be modified. However, the option exists to modify or replace a sediment load table at any time during the simulation. This option is provide by the **$SED** option. See Appendix A for a description of this option.

If the inflowing sediment load is essentially of one grain size, that size should be located in Table 3-1, identified by its classification, and assigned the number of its grain size class. For instance, if the representative size is 0.035 mm, its classification is medium sand and its sand size number is 3. This number is then input for variables IGS and LGS on the **I4** record. But if the inflowing load is composed of a range of grain sizes, it is desirable to further subdivide sand and perhaps silts and clays into the classifications shown in Table 3-1. Use as many of these classifications as needed to describe the situation. It is not necessary to start with the smallest size nor is it necessary to go to the coarsest size, but once a range of sizes is selected, all grain sizes within that range must be included. The AGU classifications in Table 3-1 are stored internally in HEC-6 and cannot be modified.

3.3.2 Sediment Material in the Stream Bed (PF)

Transport theory for sand relates the total moving sand and coarser load to the gradation of sediment particles on the bed surface. Armor calculations require the gradation of material beneath the bed surface and knowledge about the depth to bedrock or some other material that might prevent degradation.

The gradation of sediment material in the stream bed (the subsurface gradation) is specified as a function of percent finer vs. grain size on the **PF** records. Cross section numbers are used in field 1 of the **PF** records to identify the subsurface gradation location within the geometric data set. Subsurface gradations are linearly interpolated for those cross sections for which **PF** records have not been specified.

The gradation of sediment particles on the stream bed (the bed surface gradation) and the distribution of sizes in the inflowing load are intimately related. One must complement the other in sediment transport theory. The significant depth for sediment transport calculations is two grain diameters and is difficult to sample. Therefore, in using HEC-6, it is customary to specify inflowing sediment load and the subsurface gradation and let HEC-6 calculate the bed surface gradation.

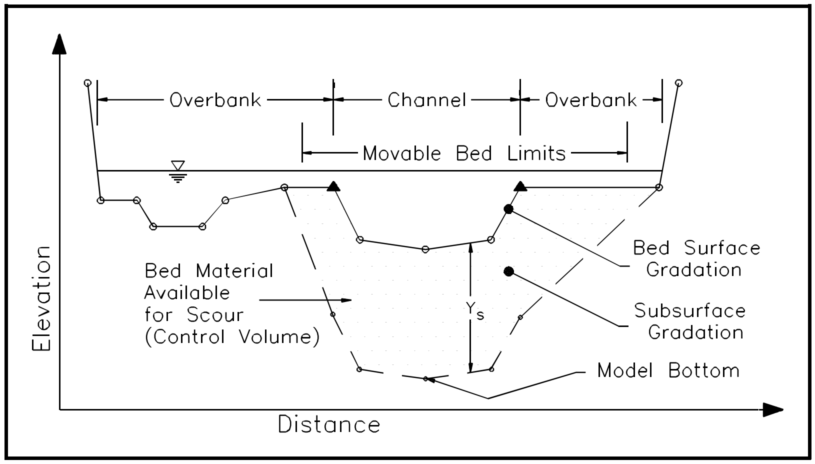

Figure 3-8
Bed Sediment Control Volume

3.3.3 Sediment Properties (I1, I2, I3, I4)

Five basic properties are considered: grain size, specific gravity, grain shape factor, unit weight of deposits and fall velocity. The grain size classifications shown in Table 3-1 are predefined in HEC-6. The specific gravity of bed material has a default value of 2.65 and the grain shape factor has a default value of 0.667. These values can be altered by providing the new values on the **I2**-**I4** records. The fall velocity method is input on the **I1** record.

3.3.4 Sediment Transport

3.3.4.1 Clay and Silt Transport (I2, I3)

Two methods for clay and silt transport are available in HEC-6. They are only applicable for flows with suspended sediment concentrations less than 300 mg/ℓ (Krone 1962). The first method (MTCL and MTSL = 1 in **I2** and **I3** records, respectively) allows the deposition of clays and silts but does not allow scour. The second method (MTCL and MTSL = 2) allows for both deposition and scour as described in Section 2.3.8. When this method is used, two additional **I2** records are required to provide information regarding critical shear stress thresholds for deposition and shear stress thresholds and erosion rates for both particle and mass erosion. Further details concerning these additional **I2** records are given in the **Special I2** record description in Appendix A.

3.3.4.2 Sand and Gravel Transport (I1, J, K)

There are several sand and gravel transport relationships available in HEC-6. The **I4** record is used to specify which of the following to use.

a. Toffaleti's (1966) transport function
b. Madden's (1963) modification of Laursen's (1958) relationship
c. Yang's (1973) stream power for sands
d. DuBoys' transport function (Vanoni 1975)

e. Ackers-White (1973) transport function
f. Colby (1964) transport function
g. Toffaleti (1966) and Schoklitsch (1930) combination
h. Meyer-Peter and Müller (1948)
i. Toffaleti and Meyer-Peter and Müller combination
j. Madden's (1985, unpublished) modification of Laursen's (1958) relationship
k. Copeland's (1990) modification of Laursen's relationship (Copeland and Thomas 1989)
l. User specification of transport coefficients based upon observed data

For the options involving two sediment transport relationships, the transport potential for each sediment size is computed using both methods and the largest transport potential is utilized.

If there is enough field data to develop a functional relationship between hydraulic parameters and sediment transport by grain size, the user-developed relationship using the **J** and **K** records should be considered. The functional relationship for each size class, **i**, is:

$$GP_i = \left[\frac{EFD \cdot SLO - C_i}{A_i}\right]^{B_i} \cdot EFW \cdot STO \qquad \textbf{(3-2)}$$

where:

EFD	=	effective depth
EFW	=	effective width
SLO	=	energy slope
STO	=	roughness correction factor, see Equation 3-3
A, B, C	=	sediment transport coefficients developed using data
GP	=	sediment transport potential

Often the transport potential is affected by variations in flow resistance. To account for this, the **K** record is used to define a factor, **STO**, which is multiplied by **GP** to determine the sediment transport potential. **STO** is defined by:

$$STO = 10^{-6} \cdot D \cdot n^{E} \qquad \textbf{(3-3)}$$

where:

D,E	=	sediment transport coefficients developed using data
n	=	Manning's roughness coefficient
STO	=	multiplying factor of GP

3.4 Hydrologic Data

Hydrologic data is specified on records **Q** through **W**. The hydrologic data includes water discharges, temperatures, downstream water surface elevations and flow duration.

Having specified the initial geometry (size, shape, and slope of the channel) and the sediment relationships for the stream, the final step in sediment calculations is to simulate the response of these data to hydrologic inputs and, perhaps, reservoir operation rules. A continuous simulation is needed for a water discharge hydrograph since both sediment transport and hydraulics of flow are nonlinear functions of water discharge. The lack of coincidence between main stem and tributary flood hydrographs makes it essential to enter flow from tributaries at their correct locations along the main stem.

3.4.1 Flow Duration (W)

HEC-6 treats a continuous hydrograph as a sequence of discrete steady flows, each having a specified duration, **ΔT**, as illustrated in Figure 3-9. This is done to reduce the number of time steps used to simulate a given time period, and thus reduce execution time. A discharge hydrograph blocked out in this manner is referred to as a "computational hydrograph". One **ΔT** value is entered on each **W** record (each set of **Q** through **W** records in the hydrologic data represents a time step or increment of the computational hydrograph.)

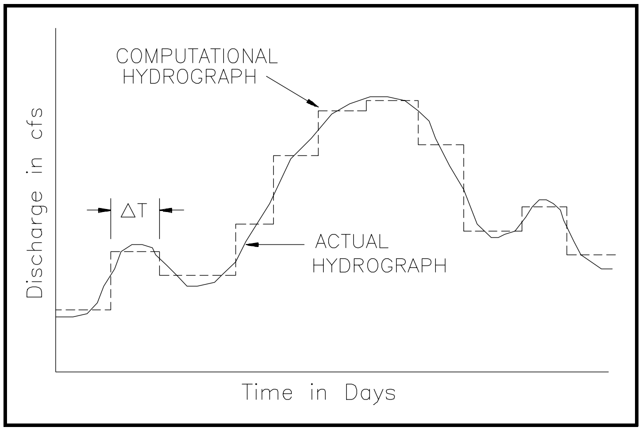

Figure 3-9
A Computational Hydrograph

3.4.2 Boundary Conditions

In a river system there are three types of boundaries: upstream, downstream, and internal. The upstream and downstream boundaries are at the cross sections that are most upstream and most downstream, respectively, on a stream segment. There are three types of internal boundaries: a local inflow point, a tributary junction point, and an hydraulic control point.

There are also three boundary conditions that can be prescribed by HEC-6: water discharge, sediment discharge, and water surface elevation (stage). The water and sediment discharges must be defined at each upstream boundary and at each local inflow point. Stage must be prescribed at the downstream boundary of the primary stream segment; and it can be prescribed at hydraulic control points.

3.4.2.1 Upstream Boundary Conditions

Water Discharge (Q, T)

The water discharge entering the river network at the upstream end of each stream segment is entered on the **Q** record. Each value on the **Q** record represents a discrete steady flow from the computational hydrograph for the each stream segment or local inflow.

The temperature of the inflowing water is set by inserting a **T** record in the Q, **Q**, and **W** data. A water temperature (**T**) record is **required** for the first time step. The temperature is assumed to be the same for subsequent discharges until another **T** record is encountered. The water temperature of a stream segment downstream of a junction point is determined by discharge weighting of the tributary/local inflow and main stem temperatures. The water temperature is essential for the calculation of particle fall velocities. New fall velocities are calculated each time a new **T** record is read.

Sediment Discharge

The sediment discharge data is entered as a sediment load table vs. discharge on **LQ**, **LT** and **LF** records. This is outlined in Section 3.3.1.

3.4.2.2 Downstream Boundary Conditions ($RATING, RC, R, S)

A water surface elevation must be specified at the downstream boundary of the model for every time step. HEC-6 provides three options for prescribing this downstream boundary condition: (1) a rating curve, (2) **R** records, or (3) a combination of a rating curve and **R** records.

The first option involves the use of a rating curve which can be specified using a **$RATING** record followed by a set of **RC** records containing the water surface elevation data as a function of discharge (See Table 3-2). The rating curve need only be specified once at the start of the hydrologic data and a water surface elevation will be determined by interpolation using the discharge given on the **Q** record for each time step. The rating curve may be temporarily modified using the **S** record or replaced by entering a new set of **$RATING** and **RC** records before any Q record in the hydrologic data.

In the second option, **R** records can be used **instead** of a rating curve to define the water surface elevation. This option is often used with reservoirs where the water surface elevations are a function of time and not flow. To use this method, an **R** record is required for the first time step. The elevation entered in Field 1 of this record will be used for each succeeding time step until another **R** record is found with a non-zero value in Field 1 to change it. In this way, you only insert **R** records to change the water surface to a new value.

Option 3 is a combination of the first two options. This option makes it possible to use the rating curve most of the time to determine the downstream water surface elevation while still allowing the user to specify the elevation exactly at given time steps. In this option, the **R** record's non-zero Field 1 value for the downstream water surface elevation will override the rating curve for that time step. On the next time step, HEC-6 will go back to using the rating curve unless another **R** record is found with a non-zero value in Field 1.

3.4.2.3 Internal Boundary Conditions (QT, X5, R)

The **QT** record defines the location of a local inflow or tributary junction. The methods for prescribing the inflowing water and sediment discharge data are discussed in Section 3.4.2.1 (these are upstream boundary conditions). The water surface elevation of the downstream boundary of a tributary cannot be prescribed by the user; HEC-6 assigns the water surface of the cross section downstream of the junction to the downstream boundary of the tributary (this is a downstream boundary).

An **X5** record in the geometry data creates an internal boundary (or hydraulic control point) at which the water surface may be specified. The specified water surface at this internal boundary is called an internal boundary condition. Two options are available to specify the water surface at this internal boundary. A rule-curve type of option can be specified to establish a constant operating elevation of a navigation pool within the geometric data. This is accomplished by specifying a water surface elevation and a head loss on the **X5** record. When the tailwater elevation plus the head loss term is higher than the specified water surface elevation, the pool rises. This option was originally developed for hinged pool operations which usually had constant head losses for all discharges. The second option allows users to specify a rating curve at an internal boundary by using a combination of **X5** and **R** records. This is helpful in modeling weirs and drop structures.

3.4.2.4 Transmissive Boundary Condition ($B)

If a **$B** record is encountered in the hydrologic data, a transmissive boundary condition is defined at every downstream boundary in the system. This transmissive boundary condition will allow sediment reaching that boundary to pass without changing that cross section. This is useful for situations where the conditions at the downstream boundary are anomalous (such as at a bridge, weir, drop structure, etc.) and may cause upstream computations to be in error if incorporated into the sediment transport/bed change computations.

3.4.3 Example Hydrology Input

An example set of hydrologic data for several time steps is shown in Table 3-2.

The **$HYD** record indicates that the hydrologic data follows. The **$RATING** and **RC** records are used to input a discharge-elevation relationship. Every time step must have Q, **Q** and **W** (or **X**) records. The Q records contain user comments and also control the output level for each time step. The A in Column 5 and the B in Column 6 of the Q record for event number 1 will produce A-level output of the water surface profile computations and B-level output of the sediment transport computations.

The **Q** record contains the water discharge and its duration, in days, is on the **W** record. Because long time steps may cause computational oscillations, it may be desirable to divide long time steps into smaller increments. In time step 3, an **X** record is used to divide a long 10 day time step into 20 half day increments.

A water temperature (**T**) record is **always** required for the first time step. In this example, no **T** record is given in time step 2; therefore, the second time step will use the same temperature as time step 1 (60°F). The **T** record in time step number 3 changes the temperature (70°F).

Table 3-2
Example of Hydrologic Input for HEC-6

```
$HYD
  field1|field 2|field 3|field 4|field 5|field 6|field 7|...
$RATING
RC    3    100      0      0    520    525    528
Q   AB  Time Step 1, A/B Level Output
Q    100
T     60
W      1
Q       Time Step 2 - No Output
Q    200
W      2
Q    A  Time Step 3 - 10 days at 20 increments
Q    200
R    527
T     70
X           .5     10
  field1|field 2|field 3|field 4|field 5|field 6|field 7|...
$RATING
RC    3    100      0      0    520    525    528
Q   BB  TIME STEP NO. 4
Q    200
W      1
$$END
```

The water surface elevation in Field 1 on the **R** record in time step number 3 sets the stage for the downstream boundary to 527 ft. This value overrides the Stage-Discharge Rating curve entered before time step 1. The rating curve (**$RATING** and **RC** records) just before event number 4 is used to determine the starting water surface for time step number 4 and overrides elevation 527 from the **R** record in time step 3.

A **$$END** record marks the end the hydrologic data as well as the entire HEC-6 input file.

3.5 Special Command Records (EJ, $TRIB, $LOCAL, $HYD, $$END)

A command record structure was developed to enhance the flexibility of HEC-6. The **EJ**, **$HYD**, and **$$END** records are used to delineate the geometric, sediment and hydrologic data. These commands are **required** for all data sets. The **EJ** record identifies the end of geometric input. The **$HYD** record identifies the beginning of the hydrologic data. The **$$END** record identifies the end of the input. If tributaries or local inflow/outflow points are being modeled, **$TRIB** and **$LOCAL** records, respectively, are required. The **$TRIB** and **$LOCAL** records are used to distinguish tributary and local data from data for the primary stream segment in the geometric and sediment data sets.

3.6 Network Model

A network system in which sediment transport in tributaries is calculated can be simulated with HEC-6. This section describes the required data sequence.

The network option is designed so that individual segments of the stream network can be analyzed independently to calibrate and confirm the model. With only minor changes, the user will be able to link the data sets together and perform the final analysis on the entire stream network.

Correct methodology for labeling model segments is essential. HEC-6 saves information from the first title record in each geometric model as a label and prints it out as an identifier of the segment. Therefore, the stream's name and data model/test/run number code should be included on the **T1** record. The date of the data set is also useful information.

The following are presented to define the terms used in this section.

Control Point: The downstream boundary of the main stem and the junction point of each tributary.

Local Inflow/Outflow Point: Points along any river segment at which water and sediment enters or exits that segment.

River Segment: A part of a river system which has an upstream water and sediment inflow point and has a downstream termination at a control point. Sediment transport is calculated along a segment.

Tributary: A river segment other than the main stem in which sediment transport is calculated.

Main Stem: The primary river segment with its outflow at the downstream end of the model.

3.6.1 Numbering Stream Segments

Stream segments and control points should not be numbered arbitrarily. To illustrate the numbering procedure, Figure 3-10 is used as an example and depicts a stream network. Each river segment's upstream-most inflow point is designated by $\mathbf{I}_k$ where k is the segment number. Local inflow/outflow points are marked with large arrows and labelled by $L_{i,j}$ where j is the sequence number (going upstream) of local inflow/outflow points along segment i. Control points are designated by a circled number. The numbering of segments, inflow/outflow points, and control points should follow these steps:

Step 1 - Sketch out the stream network system.

Step 2 - Number the control points 1, 2, and 3 along the main stem at the junctions with tributaries. With the main stem as segment 1, number segments 2 and 3. Number the main stem's upstream inflow point with I_1 and for segment 2, I_2 and for segment 3, I_3. Label the main stem's local inflow/outflow points, $L_{1,1}$ and $L_{1,2}$.

Step 3 - Starting from the downstream-most tributary (at control point 2) of the main stem, continue numbering control points 4 and 5. Number segments 4 and 5 coming off the control points and place inflow points I_4 and I_5. Label $L_{4,1}$ for the local inflow entering segment 4.

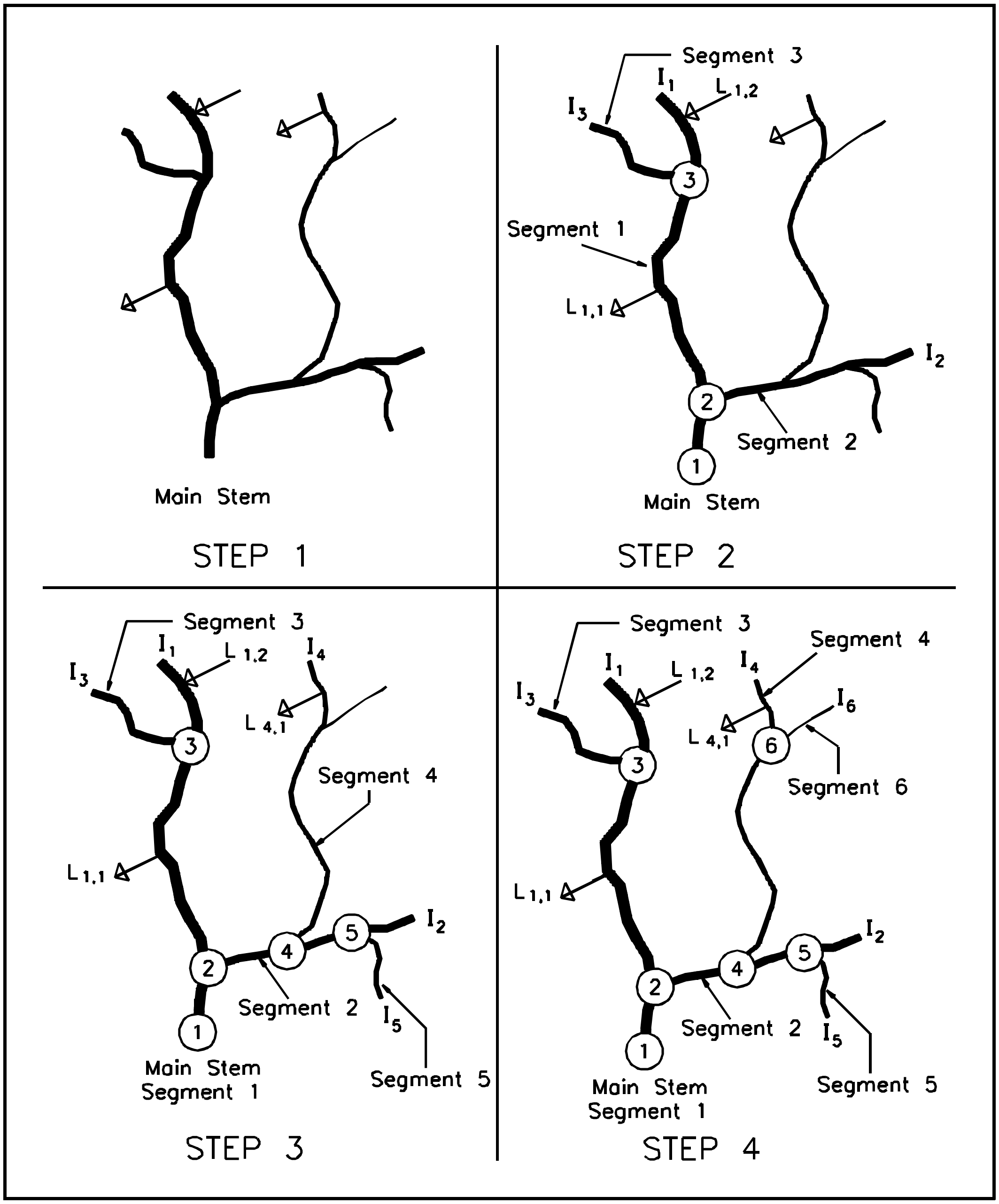

Figure 3-10
Example of Stream Network Numbering System

Step 4 - Starting from the downstream-most tributary of segment 2 (at control point 4), continue along segment 4, numbering control point 6, segment 6 and inflow point I_6. Since there are no tributaries on segment 6, check for tributaries on segment 5 (next upstream tributary of segment 4). Since there are no tributaries on segment 5 and all tributaries from control point 2 are accounted for, go to step 5.

Step 5 - Check the next upstream segment off the main stem, segment 3, for tributaries. If there were tributaries, the procedure would have continued as in steps 3 and 4 with the next control point being 7. Since there are no more tributaries, the numbering is complete.

3.6.2 Cross Section Data Sets of Main Stem and Tributaries

HEC-6 identifies segments by the order in which cross section sets are assembled in forming the geometric model. When HEC-6 reads the main stem geometry and, eventually, reaches the first **EJ** record in the geometric data set, it will read one more record. If that record is a **$TRIB** record, HEC-6 will begin reading data for a segment in a stream network. This process is repeated until all geometric data sets representing river segments are read. The **CP** record following the **$TRIB** record identifies the control point number associated with the geometry information for each tributary segment data set. Table 3-3 illustrates these requirements for the network shown in Figure 3-10.

Table 3-3
Sequence of Geometry Data for a River Network

Record	Comments
T1	MAIN STEM GEOMETRY COMES FIRST, THEN TRIBUTARIES.
T2	EXAMPLE ILLUSTRATES GEOMETRIC SEQUENCE OF FIGURE 3-10
T3	THIS RECORD TO **EJ** RECORD CONTAINS GEOMETRIC INFO.
——	Main stem geometry, incl. **QT** records for $L_{1,1}$, $L_{1,2}$ and segments 2 & 3.
EJ	End of main stem (Segment 1)
$TRIB	Warns HEC-6 that geometry for a tributary segment follows.
CP 2	This stream segment enters the network at control point 2.
T1	SEGMENT 2 - THE FIRST TRIBUTARY UPSTREAM OF CONTROL POINT 1.
T2	AMERICAN RIVER
T3	SEDIMENTATION STUDY OF SACRAMENTO RIVER DELTA
——	Geometry of Segment 2, contains **QT** records for segment 4 and 5.
EJ	End of Segment 2.
$TRIB	Indicates that data for additional tributary segments follow.
CP 3	This stream segment enters the network at control point 3.
T1	SEGMENT 3 - SECOND TRIBUTARY - UPSTREAM ON SACRAMENTO RIVER
T2	DRY CREAK
T3	SEDIMENTATION STUDY OF SACRAMENTO RIVER DELTA
——	Geometry of Segment 3.
EJ	End of Segment 3.
$TRIB	Indicates that data for additional tributary segments follow.
CP 4	This stream segment enters the network at control point 4.
T1	SEGMENT 4 - FIRST TRIBUTARY ON SEGMENT 2
T2	ARDEN CREEK
T3	SEDIMENTATION STUDY OF SACRAMENTO RIVER DELTA AND ENDS AT **I4**.
——	Geometry of Segment 4, contains **QT** records for Segment 6 and $L_{4,1}$.
EJ	End of Segment 4.
T4	Sediment data follows.

Figure 3-11 shows how to position cross sections at a control point. The location of the junction (control) point is specified by inserting a **QT** record just prior to the **X1** record for the next cross section upstream from the control point location (e.g., 0.78 in Figure 3-11). The control point number must be coded on that **QT** record. It is not necessary to treat the control point reach any differently than other reaches. HEC-6 will mix flow, temperature and sediment concentrations as though this were a normal river reach. There is no accounting of momentum losses due to impinging flows.

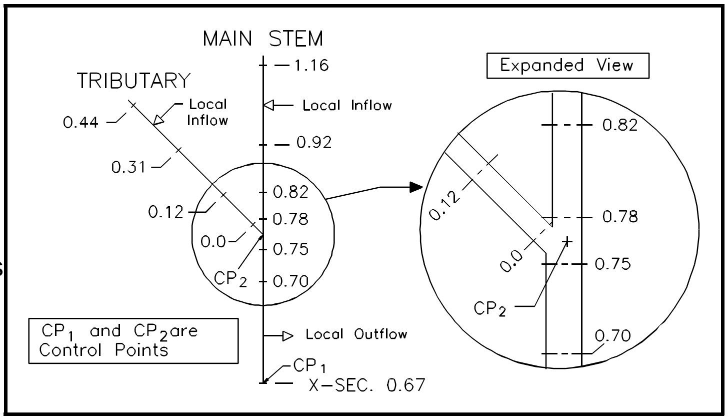

Figure 3-11
Locating Cross Sections for Stream Networks

3.6.3 Sediment Data

The main stem sediment data follows the geometric data in the data file. The main stem data specifies the fluid and sediment properties, number of grain size classes and unit weight of deposits for the **entire** network. If sediment properties in **I1** through **I5** records are present in the tributary data sets, they will be skipped by HEC-6. Information for local inflows and/or diversions on a segment are input as a part of that segment's sediment data. These are identified with a **$LOCAL** record followed by inflow/outflow sediment discharge tables.

After the main stem sediment data set is entered, it is followed by a **$TRIB** record and then the first tributary sediment data set. It is not necessary to enter a control point number since the sediment data must be in the same sequence as the geometric sets described earlier. This is illustrated in Table 3-4 which is for the network shown in Figure 3-10.

Table 3-4
Sequence of Sediment Data for a River Network

Record	Comments
——	Previous geometric records.
T4-T8	**T4-T8** records are used for comments on main stem.
——	Rest of sediment data of main stem are entered.
$LOCAL	Indicates information on local inflow points follows.
LQL	Provide sediment load data for local inflow on **LQL**, **LTL** and **LFL** records.
LTL	Since there are two local inflow/diversion points in
LFL	segment 1 ($L_{1,1}$ and $L_{1,2}$), two complete sets of these records are
LQL	required; enter the data for $L_{1,1}$ first followed by that for $L_{1,2}$.
LTL	
LFL	
$TRIB	Sediment data for segment 2 begins here.
T4-T8	**T4-T8** records are used for comments on segment 2.
——	Enter the **LQ**-**LF** and **PF** records for segment 2 here.
$TRIB	Sediment data for segment 3 begins here.
T4-T8	**T4-T8** records are used for comments on segment 3.
——	Enter the **LQ**-**LF** and **PF** records for segment 3 here.
$TRIB	Sediment data for segment 4 begins here.
T4-T8	**T4-T8** records are used for comments on segment 4.
——	Enter the **LQ**-**LF** and **PF** records for segment 4 here.
$LOCAL	Indicates information on local inflow/diversion points follows.
LQL	
LTL	These records are for the local inflow/diversion point $L_{4,1}$.
LFL	
$TRIB	Sediment data for segment 5 begins here.
——	Enter sediment data for the remaining segments in similar fashion.
$HYD	Start of hydrology.

3.6.4 Hydrologic Data

The Hydrologic data set depicted in Table 3-5 is for the stream network shown in Figure 3-10. In general the water discharge and temperatures (**Q** and **T** records) are entered in the order of the control point numbers. If the control point's segment contains local inflow/outflow points, their discharges and temperatures are entered in the fields after the control point information. The information for the next control point is then entered. An example of this procedure follows.

The information in field 1 of the **Q** (Q_1) and **T** (T_1) records refers to segment 1 (see Figure 3-10). Information on these records is for the water exiting segment 1 at control point 1. An example is given in Table 3-5. Information in fields 2 ($Q_1L_{1,1}$ and $T_1L_{1,1}$) and 3 ($Q_1L_{1,2}$ and $T_1 L_{1,2}$) are for the local inflow points $L_{1,1}$ and $L_{1,2}$, respectively, which are on segment 1. Field 4 (Q_2 and T_2) contains the information on the water entering control point 2 from segment 2. Segment 3 information is entered in field 5 (Q_3 and T_3) and is for water entering control point 3 from segment 3. This procedure is continued for each control point and segment. The flow duration (**W** record) data remains constant for the entire stream network computation for that time step. Since HEC-6 does not "route" the water, it is necessary to process the hydrologic data for each segment and produce a single duration which best simulates the hydraulic and sediment processes of the whole system.

Table 3-5
Hydrologic Data Input for Stream Networks

$HYD									
Q	THIS ILLUSTRATES THE HYDROLOGIC DATA SEQUENCE.								
Q	Q_1	$Q_1L_{1,1}$	$Q_1L_{1,2}$	Q_2	Q_3	Q_4	$Q_4L_{4,1}$	Q_5	Q_6
T	T_1	$T_1L_{1,1}$	$T_1L_{1,2}$	T_2	T_3	T_4	$T_4L_{4,1}$	T_5	T_6
W	W_1								
Q	Next Time Step								
———	Continue with sets of Q to **W** records for all discharges								
$$END	End of model data input								

3.6.5 Summary of Data Input Sequence

The first data set in the data input is the geometric data. The main stem geometry is followed by a **$TRIB** command record, a **CP** record and then the geometric model for the first tributary, i.e., the stream segment joining the main stem at control point number 2. If more than one junction (control) point is present, each tributary data set must follow sequentially with a **$TRIB** command record followed by a **CP** record.

After all geometric data have been read, HEC-6 reads sediment data. Sediment data, one set for each stream segment, must be arranged in the sequence of the control point numbers. A **$TRIB** command record precedes the sediment data for each tributary.

Hydrologic data follows the sediment data, but a different concept is utilized for entering hydrologic data than was used in the geometric and sediment data sets. No **$TRIB** command records are required. Instead, the main stem flow, local inflows and tributary junction flows are all entered on the same **Q** record. The starting water surface elevation is read or calculated for the downstream boundary (control point 1), water temperatures are read for each water discharge, and the flow duration is read.

3.6.6 Calculation Sequence of Network Systems

3.6.6.1 Hydraulic Computations for Network Systems

Water surface profiles are calculated for the main stem first and the elevation at each control point is saved. Each time the water discharge changes, the water discharges are mixed and new water temperatures are calculated for the main stem and tributaries. Upon reaching the upstream end of stream segment number 1, computations return to control point number 2, its starting water surface elevation is retrieved from storage, and the hydraulic computations are made for stream segment number 2. Like the main stem, a tributary can have local inflows/diversions and tributary junctions. These are handled like the main stem, as presented above. Hydraulic computations are continued for segment 3 in a similar fashion until all stream segments have been analyzed; then sediment movement computations begin.

3.6.6.2 Sediment Computations

Although data input and hydraulic computations proceed through network segments in the same order in which the data was read, sediment computations are made in the reverse order. It is necessary for HEC-6 to process the most remote tributary first (highest segment number) to determine its sediment contribution to the next stream segment. After all sediment computations for the tributary are completed and results are printed, computations proceed to the next lower numbered segment. After the main stem calculations, HEC-6 cycles back to read the next discharge. The process is repeated until all water discharges have been analyzed.

3.7 Input Requirements for Other Options

3.7.1 Fixed-Bed Calculations

HEC-6 is capable of being executed as a "fixed bed" model similar to HEC-2. The minimum records required are: **T1-T3**, **NC**, **X1**, **GR**, **H**, **EJ**, **$HYD**, Q, **Q**, **R**, **T**, **W** and **$$END**. The **H** record can be left blank. Optional records are **NV**, **X3**, **X5**, **$RATING** and **RC**. Note that **T4** through **PF** records are not required; if these records are present, a fixed-bed run is achieved by moving the **$HYD** through **$$END** records to just after the **EJ** record of the geometry data set. Fixed-bed runs are used to identify and correct any errors in the geometric data and analyze the hydraulic behavior of the model for a full range of flows. Calibration and confirmation of the hydraulics are performed similar to procedures used for HEC-2 (HEC 1990).

3.7.2 Multiple Fixed-Bed Calculations

If there are no tributaries or local inflow/outflow points, up to ten profiles may be computed in one run. Table 3-6 contains an example of a time step using five discharges from 100 to 10,000 cfs with starting water surface elevations ranging from 510 to 518 ft. Multiple profile runs are preferred over single runs because the printout is more compact for the same number of discharges making it easier to make comparisons. If a **$RATING** record set has been entered, the **R** record is not needed.

Table 3-6
Example of Hydrologic Data Set for Multiple Fixed-Bed Calculations

$HYD					
*	A 5 DISCHARGES FROM LOW TO HIGH				
Q	100.	500.	1000.	5000.	10000.
R	510.	512.	513.	516.	518.
T	70.	70.	70.	70.	70.
W	1.	1.	1.	1.	1.
$$END					

3.7.3 Cross Section Shape Due to Deposition ($GR)

By default, HEC-6 adjusts the elevation of each cross section coordinate within the wet portion of the movable bed a constant amount for deposition or erosion as illustrated in Figure 3-12. A nonuniform deposition option is provided by the use of a **$GR** record in the hydrologic data. This nonuniform deposition is a function of water depth which, over time, will ultimately result in a horizontal deposition surface. Bed elevation adjustments for erosion remain uniform.

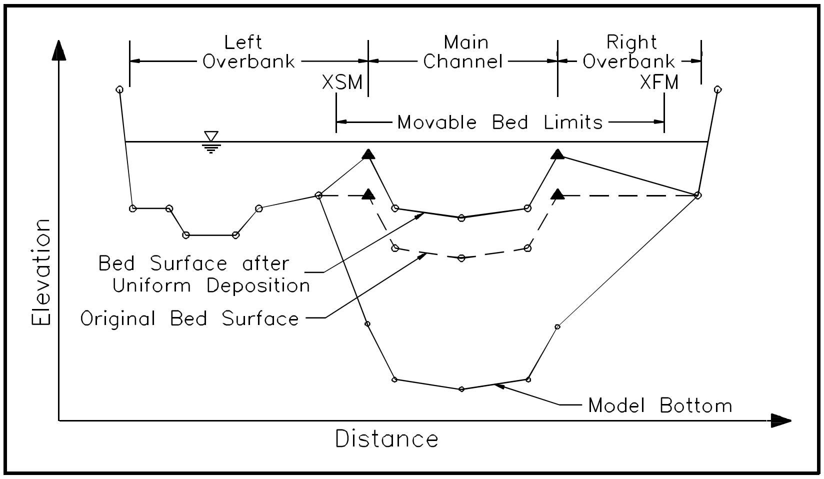

Figure 3-12
Uniform Deposition

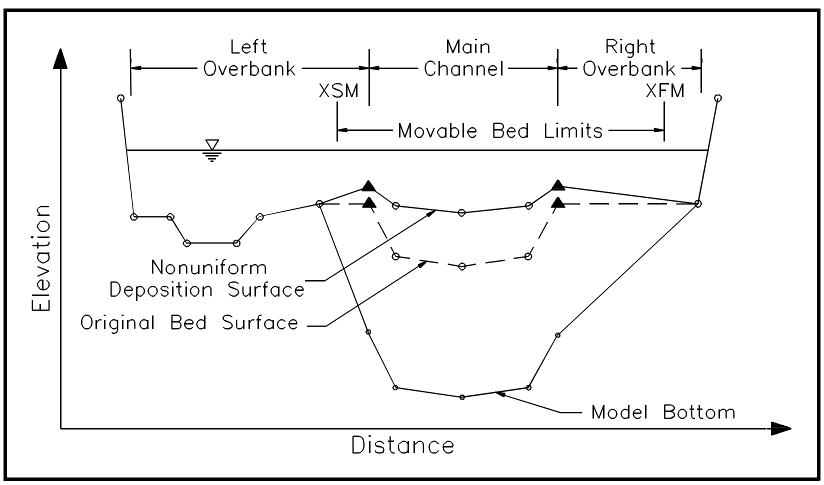

Figure 3-13
Nonuniform Deposition

3.7.4 Cumulative Volume Computations ($VOL)

An option is available in HEC-6 to compute the cumulative volume of sediment material passing each cross section. This option is initiated with the **$VOL** record. HEC-6 will also calculate the storage volume for a table of elevations for each cross section. The **VR** and **VR** records are use to define the table of elevations.