KVL Consultants, Inc.

The Flood Control District of Maricopa County

DDMSW 4.8.0 Training Workshop

RIVER MECHANICS / STORM DRAINAGE HYDRAULICS

June 19, 2014

Maricopa County Department of Transportation (MCDOT)
Computer Training Room
2919 W Durango St, Phoenix Arizona 85009

Presented by:

Kenneth Lewis, P.E.

KVL Consultants Inc.

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DDMSW 4.8.0 Training Workshop

River Mechanics and Storm Drainage Hydraulics

Training Dates: June 10, 2014 (Tuesday)
June 19, 2014 (Thursday)
June 24, 2014 (Tuesday)

Location: Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Instructor: Kenneth V. Lewis, P.E.
DDMSW Developer

This training class is designed for hydraulic and hydrologic engineers interested in learning DDMSW, an application program that implements the District's Design Methodologies and Standards.

Agenda

8:30 – 9:00	**Training Overview**
	System Overview, Program Installation, General Features, Files, Tools, Administration, Help, Register Controls
9:00 – 10:00	**River Mechanics Overview**
10:00 – 10:15	**Morning Break**
10:15 – 11:00	**River Mechanics Examples**
	Scour, Sediment Yield, Riprap Sizing, Launchable Riprap, Lateral Erosion
11:00 –12:00	**Tutorial #1 – Scour Analysis**
12:00 – 1:00	**Lunch Break**
1:00 – 2:00	**Tutorial #2 – Sediment Yield Analysis**
2:00 – 2:30	**Tutorial #3 – Riprap Sizing**
2:30 – 2:45	**Afternoon Break**
2:45 – 4:30	**Storm Drainage Hydraulics Examples**
	Conveyance Facilities, Street Drainage, StormPro Backwater Module

DDMSW 4.8.0
Training Workshops
RIVER MECHANICS

Engineering Application Development and River Mechanics Branch
Engineering Division
Flood Control District of Maricopa County

June 12, 2014

This document contains step-by-step tutorials for the River Mechanics module of DDMSW. The five tutorials for the River Mechanics cover the computations of total scour for bank protection at a bend, total scour for bridge pier, sediment yield analysis for a watershed, riprap sizing for bank protection at a straight channel, and lateral erosion.

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2.0 River Mechanics

2.1 Calculate Total Scour for Bank Protection at a Bend

2.1.1 Problem Statement

To estimate the total scour depth for a channel bank protection at a mild bend (use sediment-laden equilibrium slope method for long-term scour, use *Lacey's* method for general scour including bend) with the following given conditions:

- The Cross Section *"STUDYREACHCROSSSECTION"*
  - Parameters for the Hydraulics and Geometry:
    - **Design Flow Rate (cfs):** *3200*
    - **Dominant Flow Rate (cfs) :** *800*
    - **Channel Slope** for **Design Flow (ft/ft):** *0.015*
    - **Channel Slope** for **Dominant Flow (ft/ft):** *0.015*
    - **Manning's n** for **Design Flow:** *0.035*
    - **Manning's n** for **Dominant Flow:** *0.030*
    - The geometry (station and elevation) of this cross section:

Station (X)	Elevation (Y)
100	*100*
106	*98*
156	*98*
166	*95*
191	*95*
201	*98*
251	*98*
257	*100*

    - **D50 (mm)** for Study Reach: *1.50*
    - **D84 (mm)** for Study Reach: *10.00*
    - **D16 (mm)** for Study Reach: *0.50*
    - There is a grade control structure located at *800* feet downstream of the channel location for bank protection (cross section *"STUDYREACHCROSSSECTION"*)
    - **Distance to Pivot Point (ft):** *800*

- The Cross Section *"SUPPLYREACHCROSSSECTION"*
  - Parameters for the Hydraulics and Geometry:
    - **Design Flow Rate (cfs)**: *3200*
    - **Dominant Flow Rate (cfs):** *800*

- **Channel Slope** for **Design Flow (ft/ft):** *0.01*
- **Channel Slope** for **Dominant Flow (ft/ft):** *0.01*
- **Manning's n** for **Design Flow:** *0.035*
- **Manning's n** for **Dominant Flow:** *0.030*
- The geometry (station and elevation) of this cross section:

Station (X)	Elevation (Y)
100	*100*
106	*98*
181	*98*
191	*95*
216	*95*
226	*98*
301	*98*
307	*100*

- **D50 (mm)** for Supply Reach: *2.00*
- **D84 (mm)** for Supply Reach: *12.00*
- **D16 (mm)** for Supply Reach: *1.00*

2.1.2 Step-by-Step Procedures

Step 1: Establish a New Project and Default Set-up.

Step 2: Prepare the Cross Section Hydraulics.

Step 3: Compute Total Scour

Step 3.1: Set up Total Scour Basic Data

Step 3.2: Calculate the Long Term Scour

Step 3.3: Calculate the General Scour

Step 3.4: Calculate the Bedform Scour

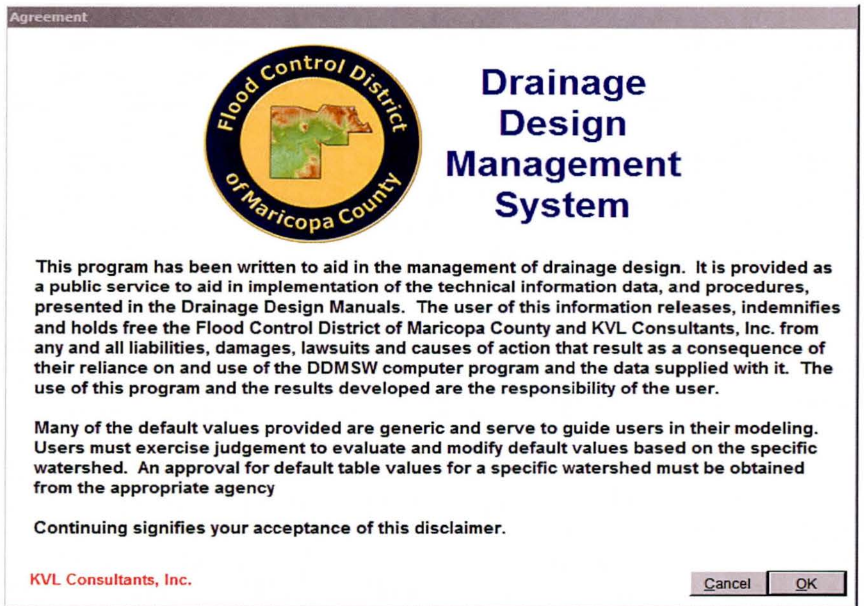
Step 3.5: Calculate the Low Flow Scour

Step 3.6: Calculate the Total Scour

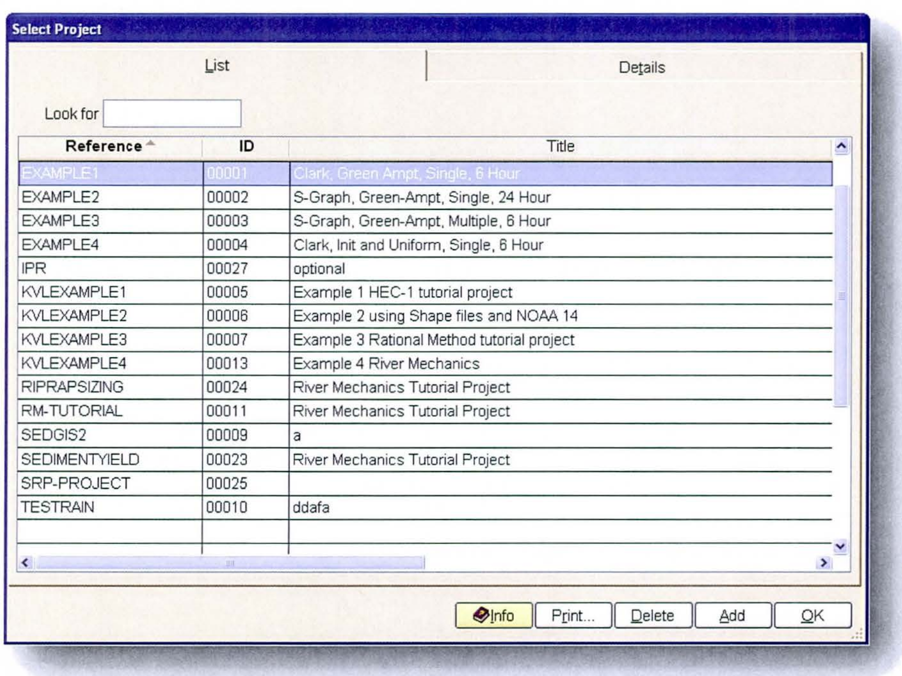
Step 4: Report the Results

(A) Step 1 - Establish a New Project and Defaults Set-up

(a) Click the **DDMSW** icon on the Desktop or Program menu to launch the **DDMSW**. Click **OK** to accept the software disclaimer as is shown in the following figure.



After the **DDMSW** is launched, the **SELECT PROJECT** window is automatically opened as is shown in the following figure.



(b) Click the **Add** button on the **SELECT PROJECT** window to start a new project (Or **File → New Project → Add**).

(c) Type *"BANKPROTECTION1"* into the **Reference** textbox. This is the name of this newly created project. The users can choose the name as long as it does not exist in the **DDMSW** database.

(d) Type into the **Title** textbox a brief descriptive title of this project ***(Optional)***.

(e) Type into the **Location** textbox the location of this project. ***(Optional)***

(f) Type into the **Agency** textbox the agency or company name. ***(Optional)***

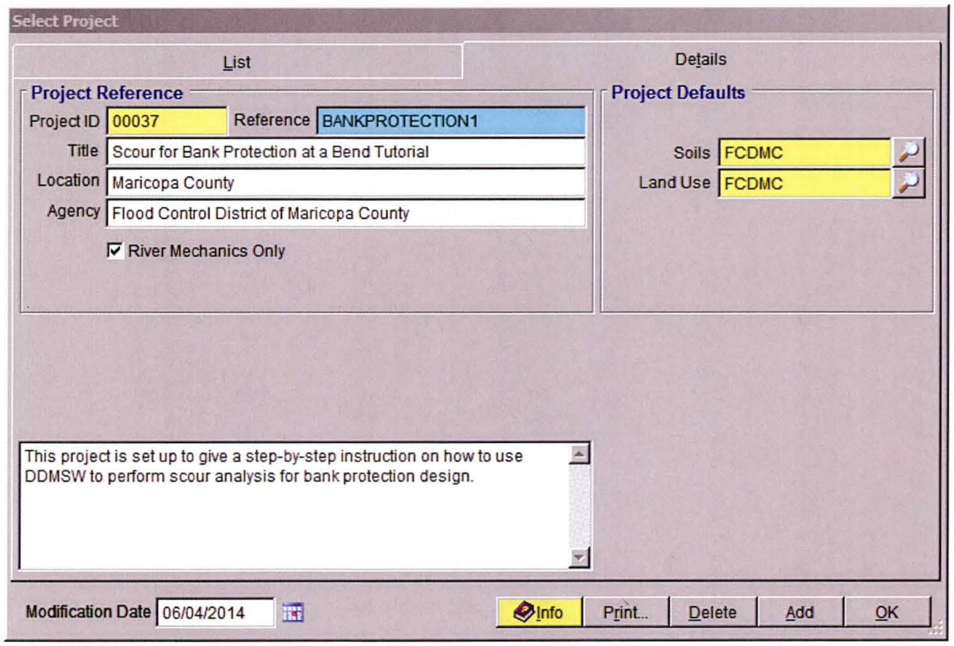
(g) Check **River Mechanics Only** checkbox for this project.

(h) Type a detailed description of this project into the comment area under the **Project Reference** frame. ***(Optional)***

(i) Click the **Save** button to save the entered data.

(j) Click the **OK** button on the **SELECT PROJECT** window to close the window, the following figure shows what the window looks like.

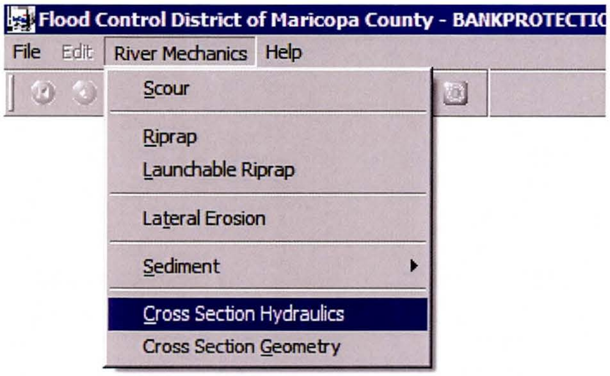
(k) Click the **OK** button on the pop-up message box.



Note: the **Project ID** *00037* in the above figure is the database records unique read-only identifier of the project, which is automatically generated by the program when a new project is created. When the users create a new project, the **Project ID** of this new project will not be the same as the **Project ID** shown in the above figure.

(B) Step 2 - Prepare the Cross Section Hydraulics

(a) From the menu bar of the main application window, click **River Mechanics ➔ Cross Section Hydraulics** to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window.



(b) Click the **Add** button on the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window to activate all the necessary data entry fields.

(c) Select the *"Calculate Data"* for the **Source** (*"Enter Data"* can also be selected for the **Source** if the hydraulic results for a cross-section are available.)

(d) Type *"STUDYREACHCROSSSECTION"* into the **Cross Section ID** textbox.

(e) By default, both the **Design** and **Dominant** textboxes in the **Entire Cross Section** frame are checked. If not, please check these two checkboxes.

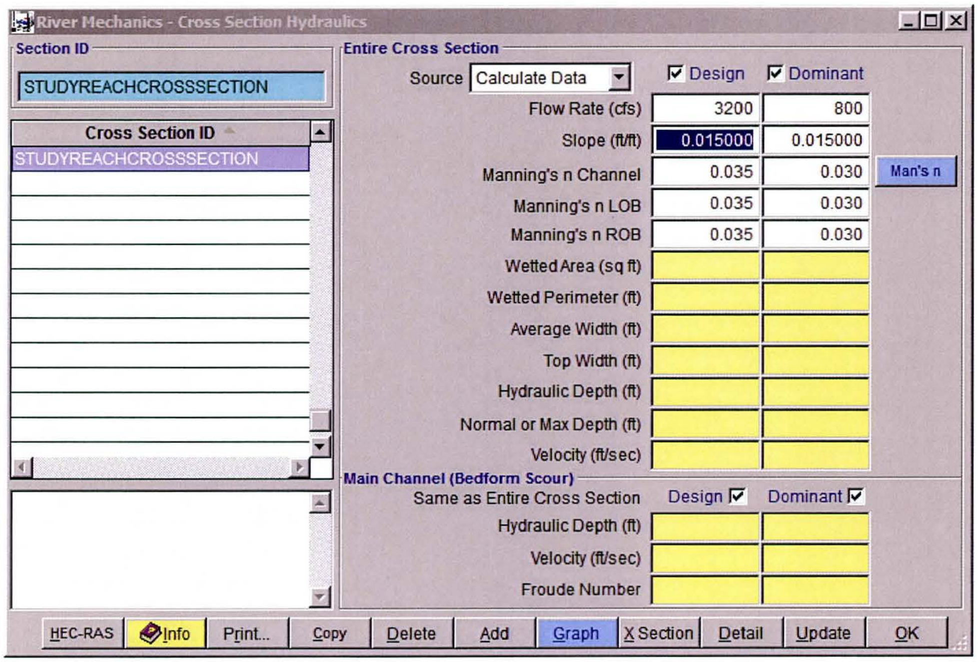
(f) Type in *"3200"* and *"800"* into the **Flow Rate (cfs)** textboxes for **Design** and **Dominant**, respectively.

(g) Type in *"0.015"* and *"0.015"* into the **Slope (ft/ft)** textboxes for **Design** and **Dominant**, respectively.

(h) Type in *"0.035"* and *"0.030"* into the **Manning's n Channel** textboxes for **Design** and **Dominant,** respectively. Use the same values (*"0.035"* and *"0.030"*) for the **Manning's n LOB** and **Manning's n ROB** textboxes.

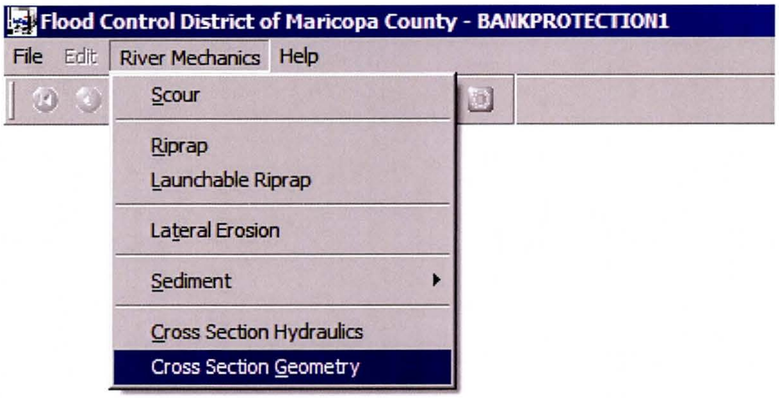
(i) Check **Same as Entire Cross Section** checkboxes for both **Design** and **Dominant** in the **Main Channel (Bedform Scour)** frame (Note: These boxes are checked if the bedform scour computation is based on the entire cross-section hydraulics).

(j) After the data entry, click the **Save** button and the window looks like what is shown in the following figure.

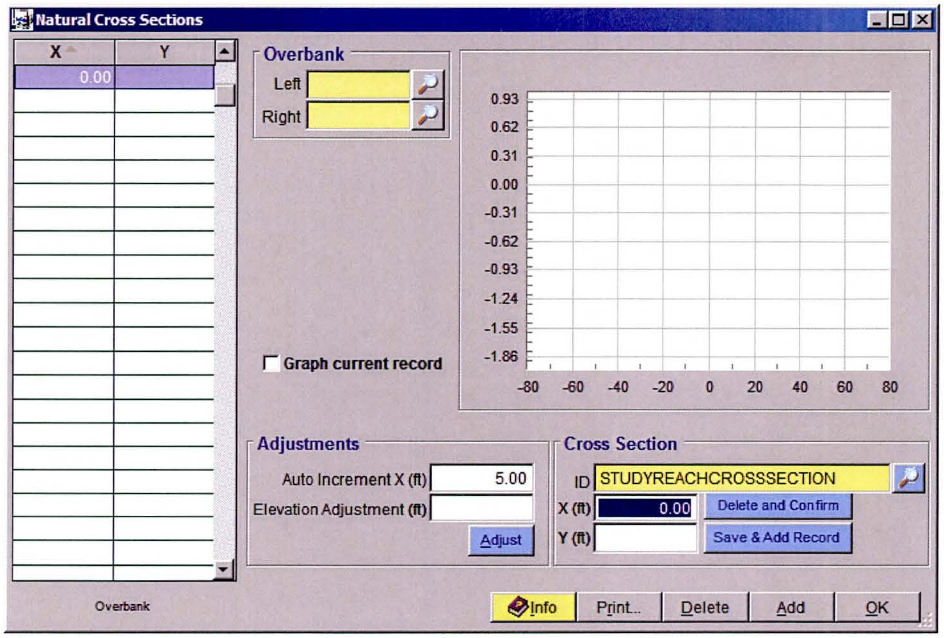


(k) Click the **OK** button to close the window.

(l) From the menu bar of the main application window, click **River Mechanics ➔ Cross Section Geometry** as is shown in the following figure and the **RIVER MECHANICS – CROSS SECTION GEOMETRY** window opens.



(m) Click the "Magnifying Glass" on the right side of the **ID** textbox in the **Cross Section** frame to open the **SELECT CROSS SECTION ID** window. Highlight **Cross Section ID** *"STUDYREACHCROSSSECTION"* and click **OK** to close the window.

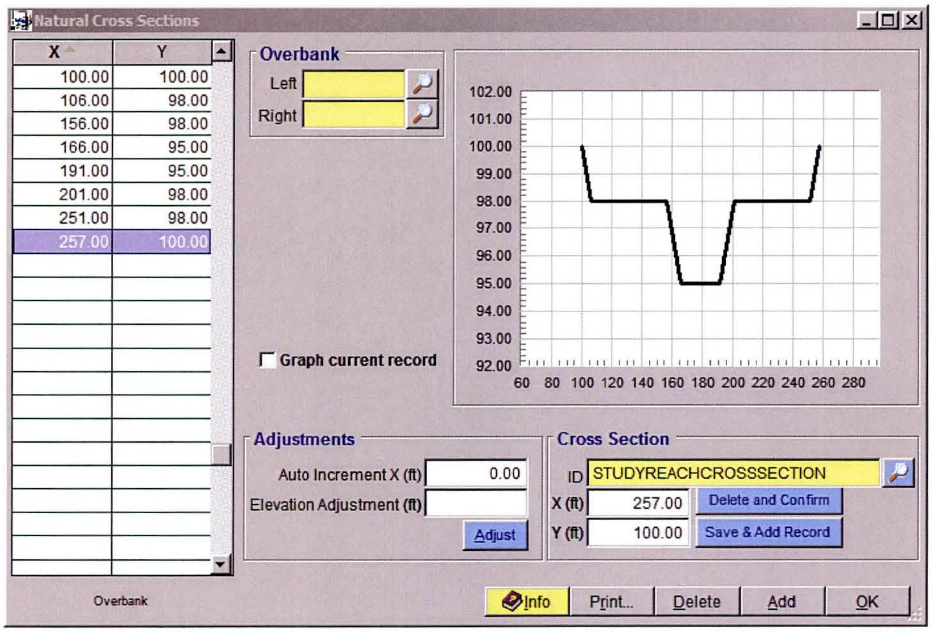


(n) Click the **Add** button on the **NATURAL CROSS SECTIONS -- ADD** window and type *"100"* and *"100"* into the **X (ft)** and **Y (ft)** textboxes, respectively. Click the **Save & Add Record** button.

(o) Repeat the above step for the rest of pairs of **X** and **Y** values provided below.

X	Y
106	*98*
156	*98*
166	*95*
191	*95*
201	*98*
251	*98*
257	*100*

After all the **X** and **Y** values are entered, the **NATURAL CROSS SECTIONS** window will look like the following figure.



Cross-section data can be imported into **DDMSW**. However, the XY data must be prepared based on **DDMSW** XY data format before the cross-section is imported. To know the **DDMSW** XY data format, export the data of an existing cross-section (**File ➔ Export Data ➔** *select "Crosssections" under "Hydraulics"* **Section ➔** *check a radio button for format such as* **XLS** *for* **Excel ➔ Export ➔** *use default file name or define a file name* **➔ Save ➔ OK**).

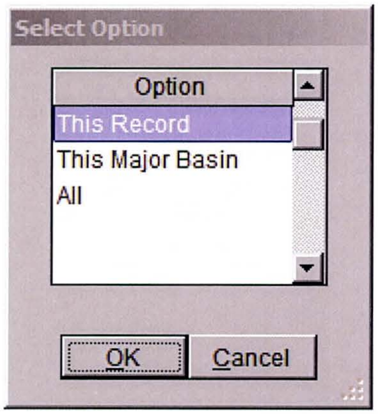
(p) To define the **Left Bank Station,** select *"156.00"* on the XY grid table and click the "Magnifying Glass" on the right side of the **Left Bank Station** textbox.

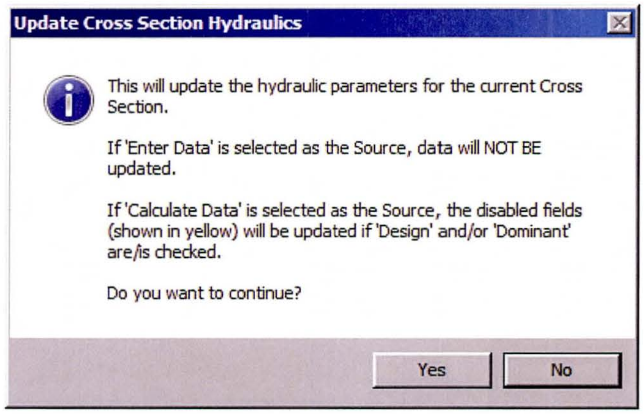
(q) To define the **Right Bank Station**, select *"201.00"* on the XY grid table and click the "Magnifying Glass" on the right side of the Right Bank Station textbox.

(r) Click **OK** to close the **NATURAL CROSS SECTIONS** window.

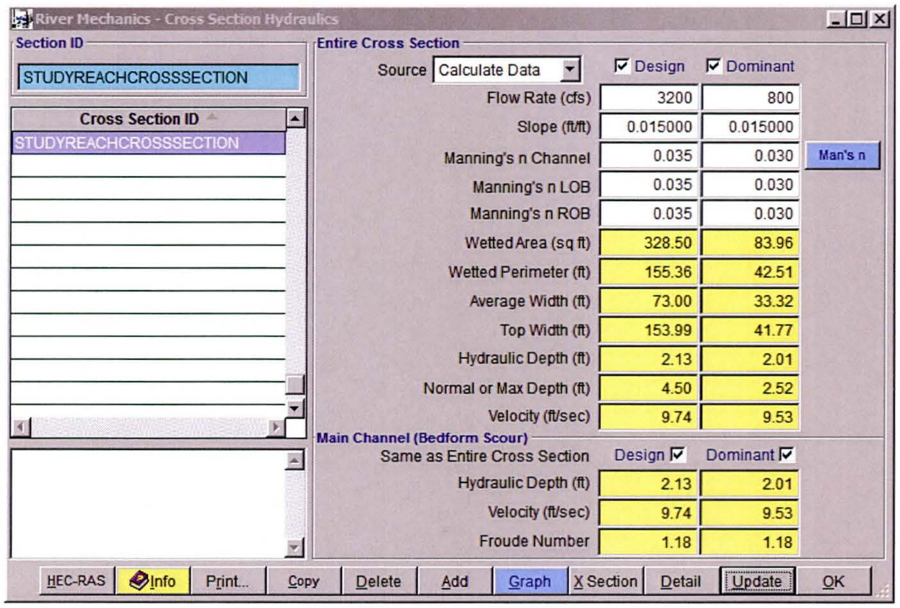
(s) Go back to the main application window, and click **River Mechanics ➔ Cross Section Hydraulics** from the menu bar to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window. Click the **Update** button to update the hydraulic parameter listed on the form by performing a hydraulic analysis using the geometric data provided. The textboxes with yellow highlights will be populated with results from the analysis.

(t) Highlight *"This Record"*, click the **OK** button to close the **SELECT OPTION** window. Click **Yes** to continue.





After the update, the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window looks like what is shown in the following figure.



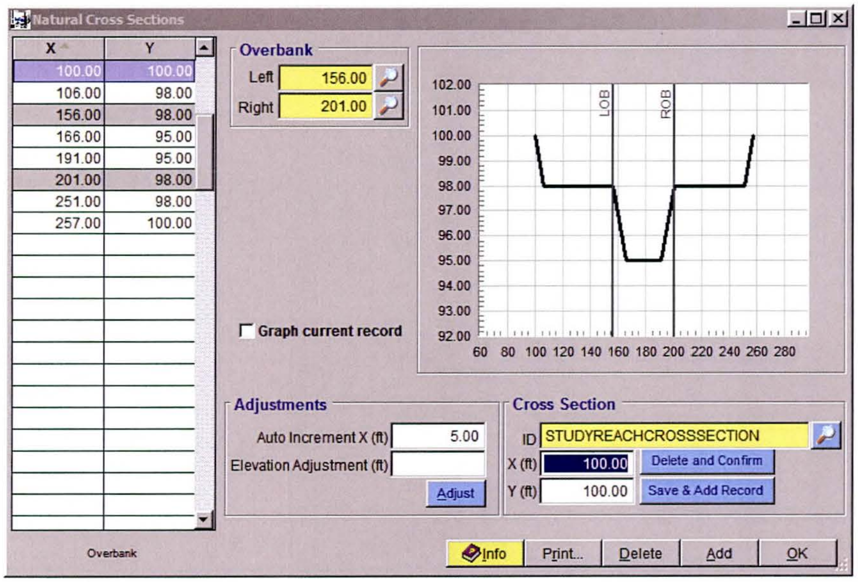
Repeat the whole procedure listed in Step 2 using the following parameters and values to create another cross section, *"SUPPLYREACHCROSSSECTION"*.

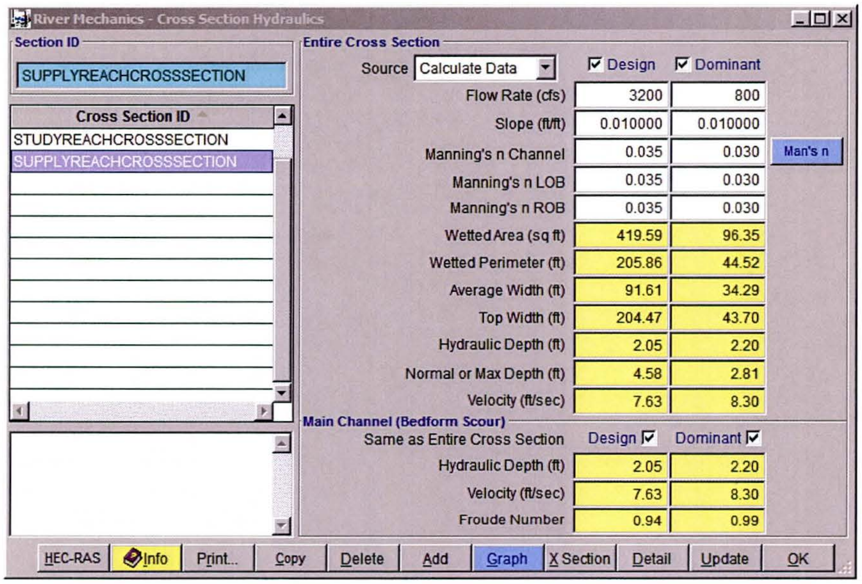
- **Cross Section ID:** *SUPPLYREACHCROSSSECTION*
- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rate (cfs):** *800*
- **Design Slope (ft/ft):** *0.010*
- **Dominant Slope (ft/ft):** *0.010*
- **Design Manning's n** (**Channel, LOB,** and **ROB**): *0.035*
- **Dominant Manning's n** (**Channel, LOB,** and **ROB**): *0.030*
- The geometry (station and elevation) of this cross section:

Station (X)	Elevation (Y)
100	*100*
106	*98*
181	*98*
191	*95*
216	*95*
226	*98*
301	*98*
307	*100*

- **Left Bank Station:** *181.00*
- **Right Bank Station:** *226.00*

After this step is finished, the **NATURAL CROSS SECTIONS** window looks like what is shown in the following figures.

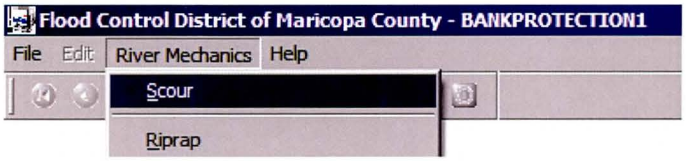


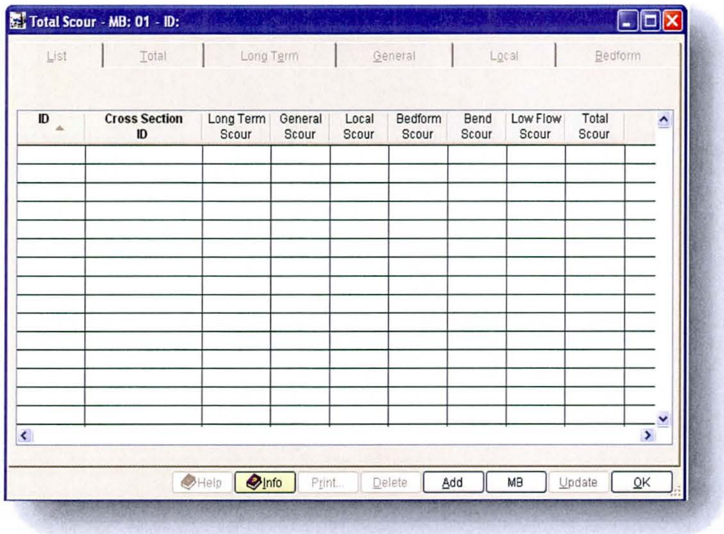


(C) Step 3 - Compute Total Scour

(C.1) Set up Total Scour Basic Data

(a) From the menu bar of main application window, click **RIVER MECHANICS** ➔ **SCOUR,** to open the **TOTAL SCOUR – MB: 01** window.





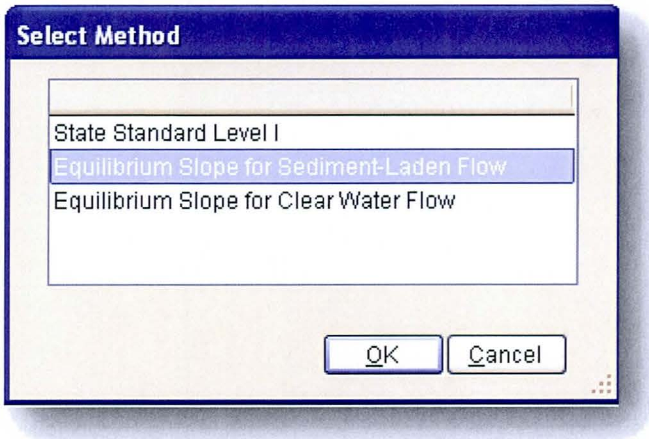
(b) Click the **Add** button on the **TOTAL SCOUR – MB: 01 – ID:** window to activate the necessary data entry fields.

(c) Type *"AZRIVER"* into the **ID** textbox.

(d) Check the checkboxes **Long Term**, **General**, **Bedform**, and **Low Flow** (Note: Do not check **Local Scour**)

(e) Click the browse button in the **Method** column across **Long Term** check box on the **Total** tab to launch **SELECT METHOD** window and to select the method to use for Long-Term scour analysis.

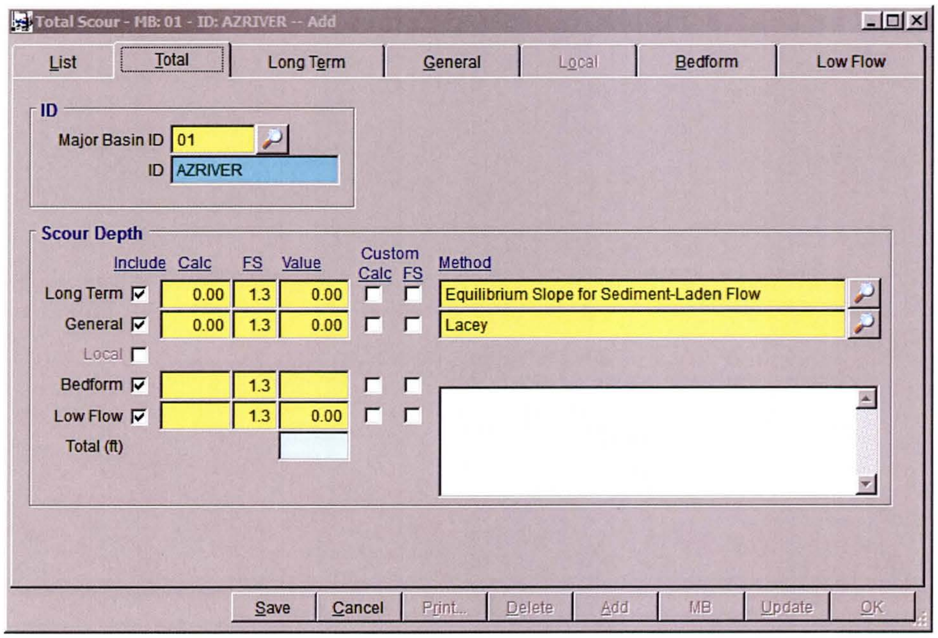
(f) Select the *"Equilibrium Slope for Sediment-Laden Flow"* from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window.



(g) Click the browse button in the method column across **General** check box on the **Total** tab to launch **SELECT METHOD** window and to select the method to use for General scour analysis.

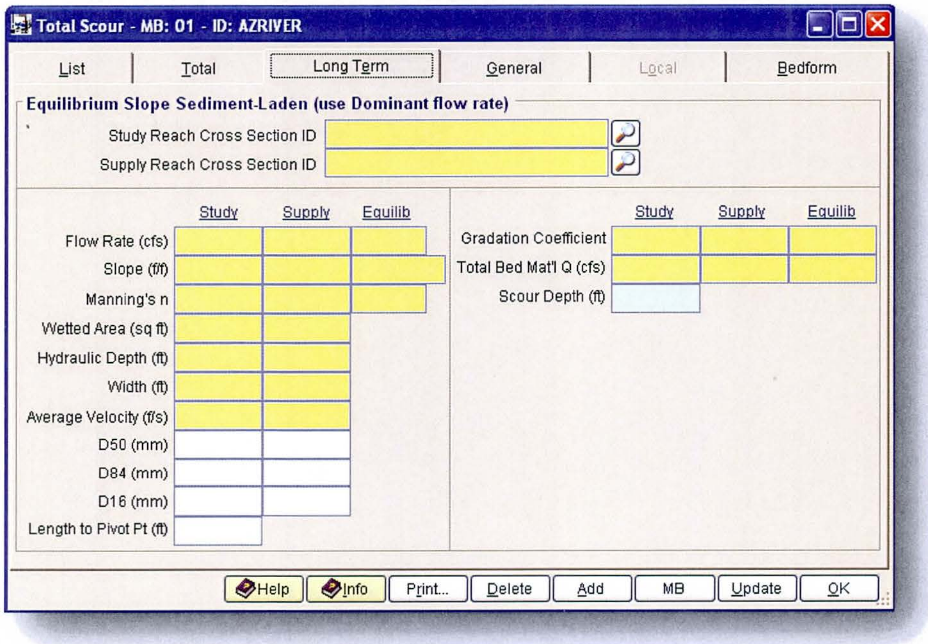
(h) Select the *"Lacey"* method from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window.

(i) Click the **Save** button to save the entered data. The window will look like what is shown in the following figure.



(C.2) Calculate the Long Term Scour

(a) Select the **Long Term** tab as shown in the following figure.



(b) Click browse button beside the **Study Reach Cross Section ID** to select the cross section ID *"STUDYREACHCROSSSECTION"*, and click **OK** to close the selection window.

(c) Click browse button beside the **Supply Reach Cross Section ID** to select the cross section **ID** *"SUPPLYREACHCROSSSECTION"*, and click **OK** to close the selection window.

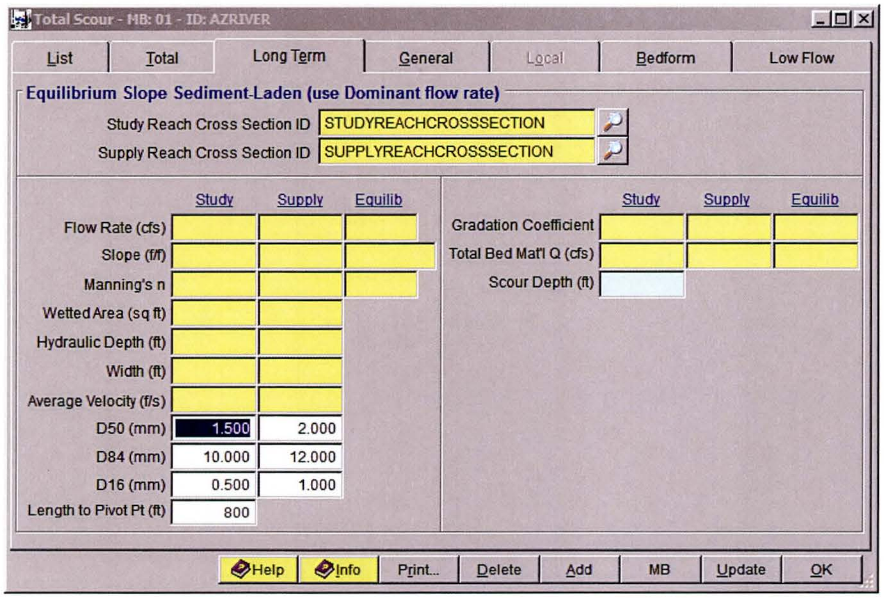
(d) Enter the **D50 (mm)** values *"1.5"* and *"2.0"* for **Study** and **Supply**, respectively.

(e) Enter the **D84 (mm)** values *"10"* and *"12"* for **Study** and **Supply**, respectively.

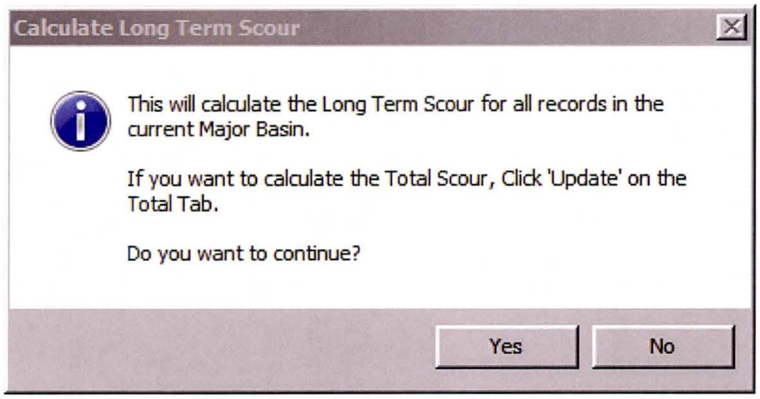
(f) Enter the **D16 (mm)** values *"0.5"* and *"1.0"* for **Study** and **Supply**, respectively.

(g) Enter *"800"* into **Length to Pivot Pt (ft).**

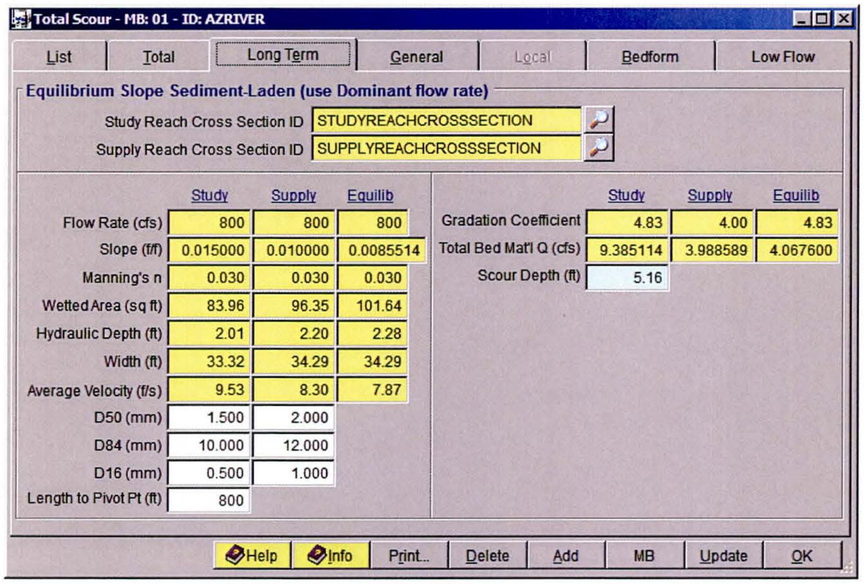
(h) Click the **Save** button to save the entered data. (The window will look like what is shown in the following figure).



(i) Click the **Update** button to start the computation; select *"This Major Basin"* from the **SELECTION OPTION** window, and click **Yes** to continue.



After the update, the final result of the long term scour calculation is shown in the following figure.



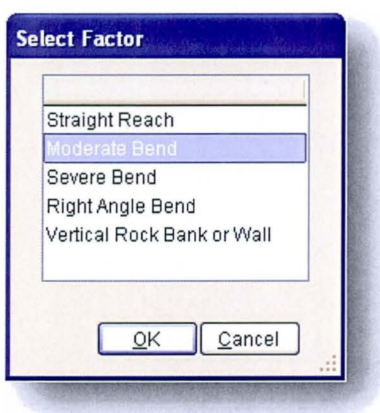
(C.3) Calculate the General Scour

(a) Click to open the **General** tab.

(b) Click browse button beside the **Cross Section ID** to select the cross section ID *"STUDYREACHCROSSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** window.

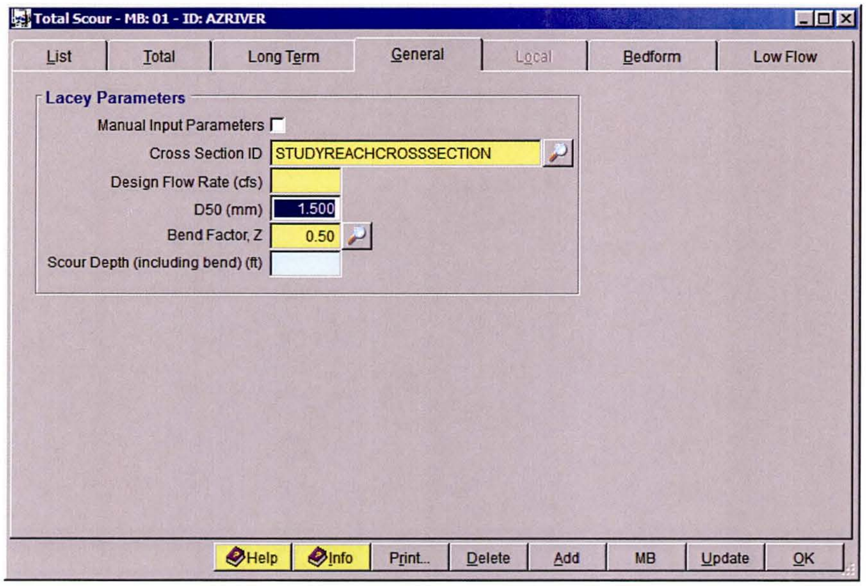
(c) Enter *"1.5"* into the **D50 (mm)** textbox.

(d) Click the browse button beside the **Bend Factor, Z** textbox to open the **SELECT FACTOR** window and select the *"Moderate Bend"* bend factor.

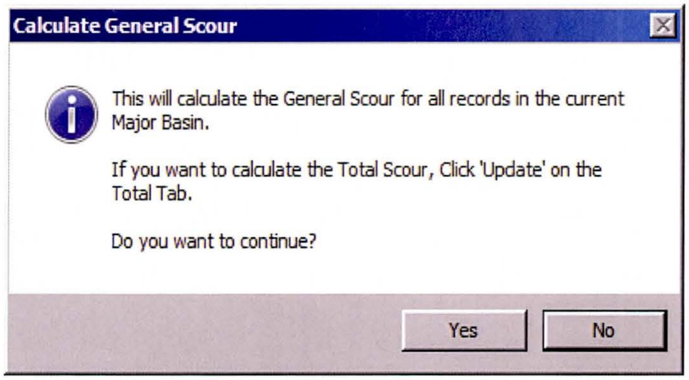


(e) Click the **Save** button to save the entered data.

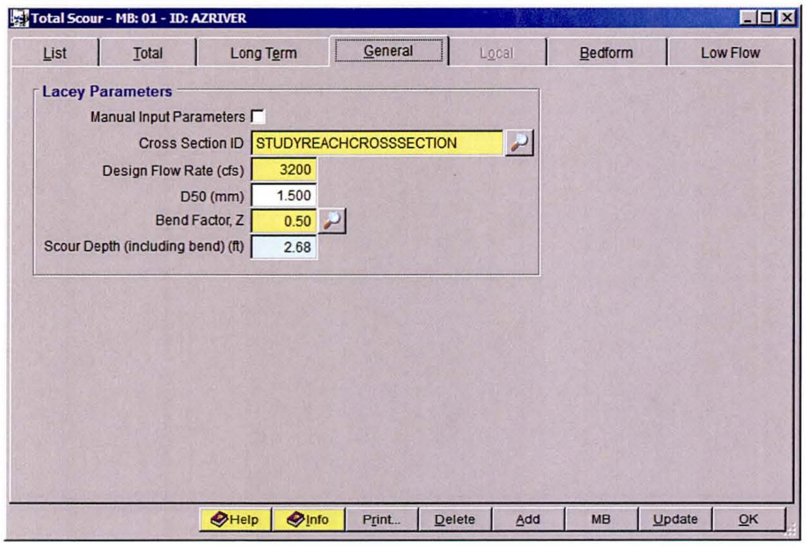
The following figure shows what the window looks like after the data entry.



(f) Click the **Update** button and select *"This Major Basin"* from the **SELECTION OPTION** window. Click **Yes** from the confirmation message to proceed.



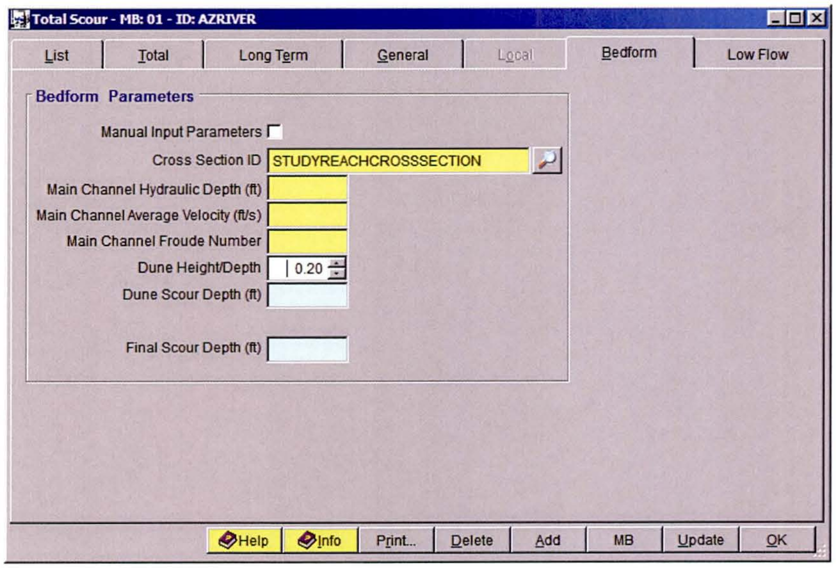
After the update, the final result of the general term scour calculation is shown in the following figure.



(C.4) Calculate the Bedform Scour

In this section, a procedure on how to calculate the bedform scour will be provided.

On the **TOTAL SCOUR** form, select the **Bedform** tab. The following figure shows what the window looks like before data entry.

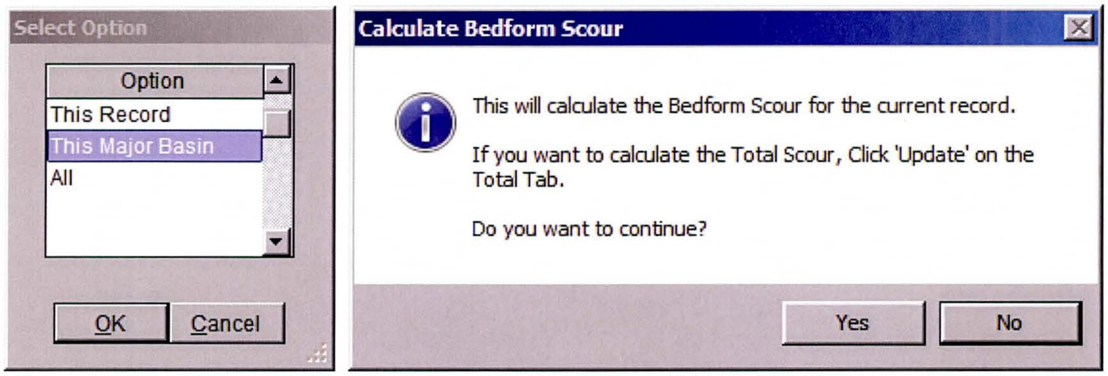


(a) Click browse button beside the **Cross Section ID** to select the cross section **ID** *"STUDYREACHCROSSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** window.

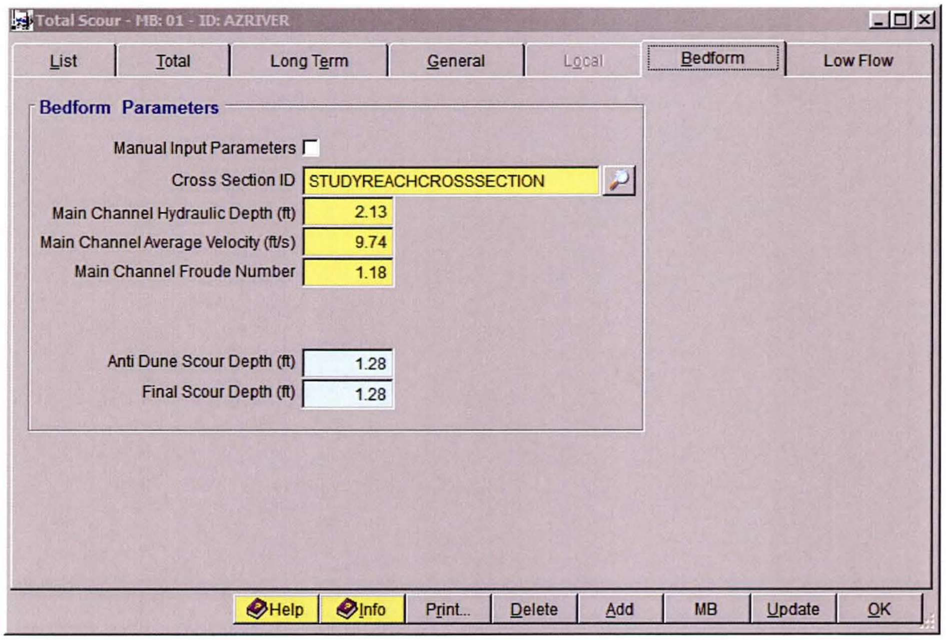
(b) Set the **Dune Height/Depth** value to *"0.20"*.

(c) Click the **Save** button to save the data just entered.

(d) Click the **Update** button and select *"This Major Basin"* from the **SELECTION OPTION** window. Click **Yes** to continue.



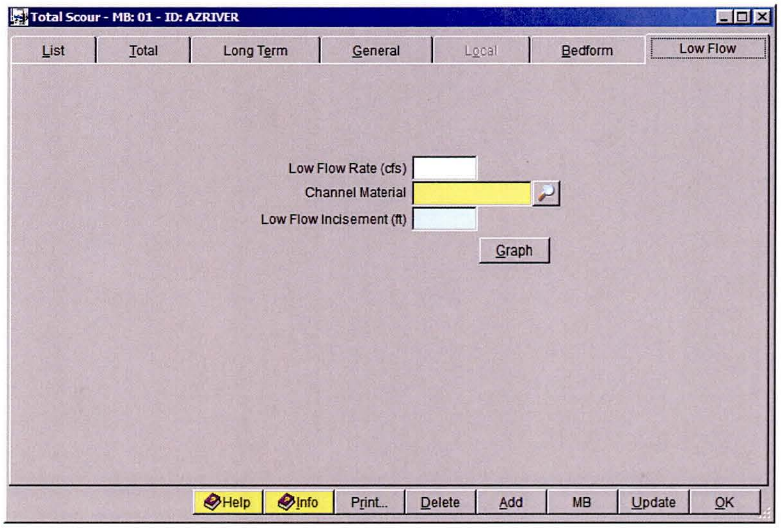
After the update the final result of the bedform scour calculation result shows in the following figure.



(C.5) Calculate the Low Flow Scour

In this section, a procedure on how to calculate the low-flow scour will be provided.

On the **TOTAL SCOUR** form, select the **Low Flow** tab. The following figure shows what the window looks like before data entry.

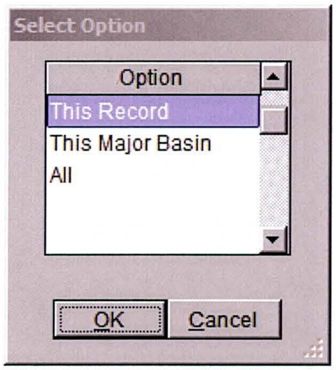


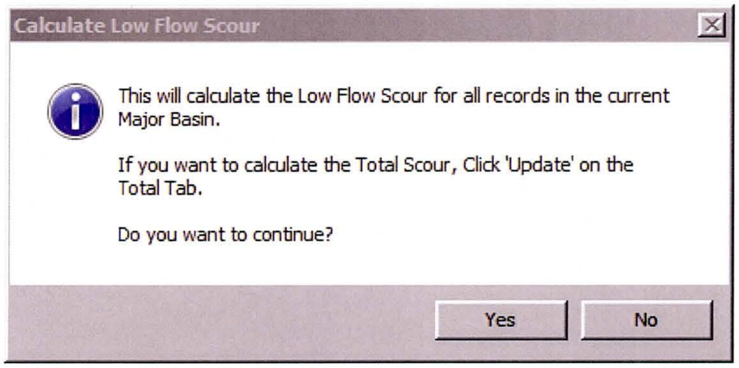
(a) Enter *"100"* into the **Low Flow Rate (cfs)** textbox.

(b) Click browse button beside the **Channel Material** to select the channel material data. Choose *"Medium Sand"* and click **OK** to exit the **SELECT CHANNEL MATERIAL** window.

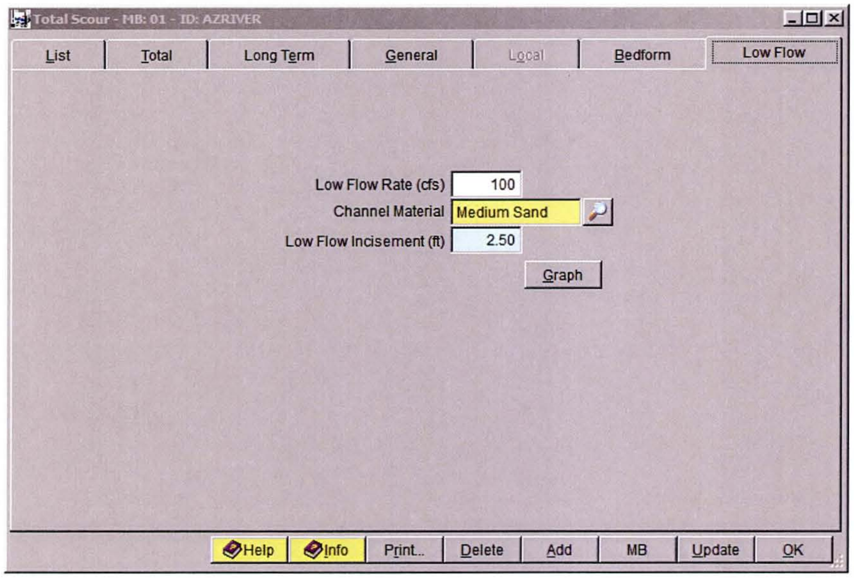
(c) Click the **Save** button to save the data just entered.

(d) Click the **Update** button and select *"This Major Basin"* from the **SELECTION OPTION** window. Click **Yes** to continue.



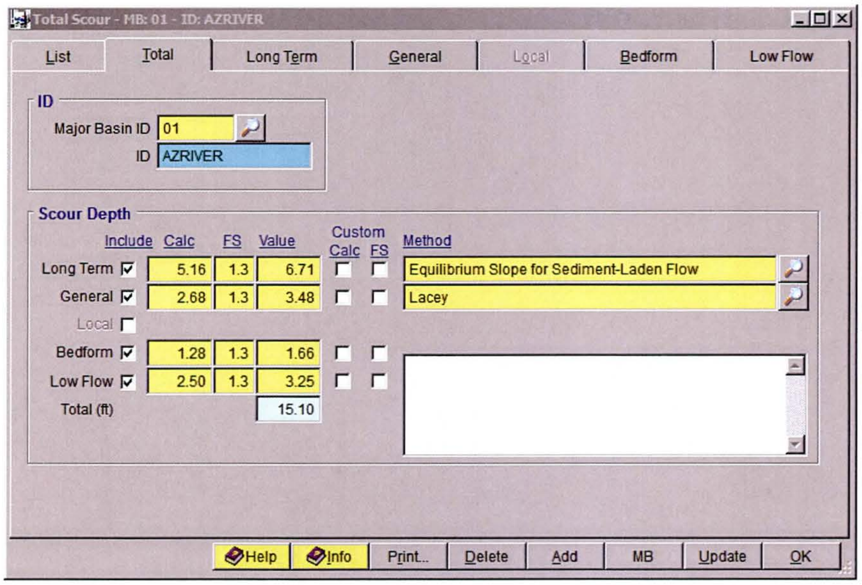


After the update, the final result of the low flow scour calculation is shown in the following figure



(C.6) Calculate the Total Scour

On the **TOTAL SCOUR** form, select the **Total** tab. The following figure shows what the window looks like.



As shown, the analysis results for the total scour which is the combination of the individual scour components previously analyzed are displayed.

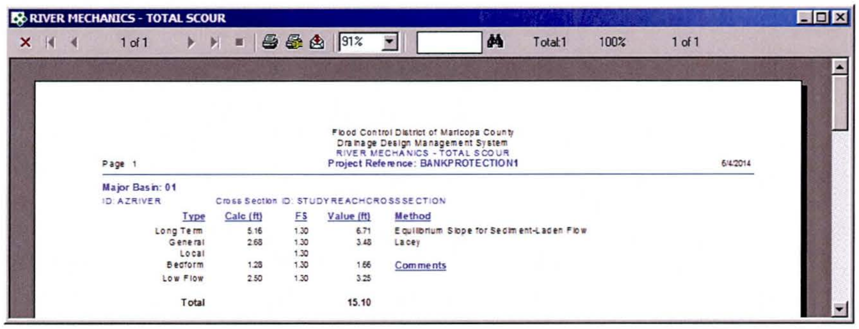
(D) Step 4 - Report the Results

In this section, procedures will be given on how to view, print, and export the calculation results for the total scour analysis.

The total scour is the sum of the long term scour, general scour, local scour, bedform scour and low flow scour. In this tutorial, only the following four scours are covered, that is, the long term scour, general scour, bedform scour and low flow scour.

Make sure all the four scours listed above are checked in the "Total" scour tab and all the listed scours are updated.

(a) To view the results on the screen, click the **Print ...** button on the **TOTAL SCOUR – MB: 01 – ID: AZRIVER** window, a report will be generated as is shown in the following figure.



(b) To print out the results on a printer, click the printer symbol ( ).

(c) To export the results in PDF format or other formats, click the export symbol ( )

(d) The individual scour components results and cross section hydraulics results can also be viewed, printed, and exported by clicking the **Print...** button under individual component scour menus and **Cross Section Hydraulics** menu.

2.2 Calculate Total Scour for Bridge Pier

2.2.1 Problem Statement

To estimate the total scour depth for a bridge pier (use sediment-laden equilibrium slope method for long-term scour, use Neil's method for general scour including a moderate bend, and use the local scour at the piers) with the following given conditions:

❖ The Cross Section *"BRIDGECROSSSECTION"*

➢ Parameters for Hydraulics and Geometry:

- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rates (cfs):** *800*
- **Channel Slope** for **Design Flow (ft/ft):** *0.015*
- **Channel Slope** for **Dominant Flow (ft/ft):** *0.015*
- **Manning's n** for **Design Flow:** *0.035*
- **Manning's n** for **Dominant Flow:** *0.030*
- The geometry (station and elevation) of this:

Station (X)	Elevation (Y)
100	*100*
106	*98*
131	*98*
141	*95*
166	*95*
176	*98*
201	*98*
207	*100*

❖ The Cross Section *"STUDYREACHCROSSSECTION"*

➢ Parameters for Hydraulics and Geometry:

- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rates (cfs):** *800*
- **Channel Slope** for **Design Flow (ft/ft):** *0.015*
- **Channel Slope** for **Dominant Flow (ft/ft):** *0.015*
- **Manning's n** for **Design Flow:** *0.035*
- **Manning's n** for **Dominant Flow:** *0.030*

- **Length to Pivot Point (ft):** *800*
- The geometry (station and elevation) of this cross section:

Station (X)	Elevation (Y)
100	*100*
106	*98*
156	*98*
166	*95*
191	*95*
201	*98*
251	*98*
257	*100*

❖ The Cross Section *"SUPPLYREACHCROSSSECTION"*

➢ Parameters for Hydraulics and Geometry:

- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rates (cfs):** *800*
- **Channel Slope** for **Design Flow (ft/ft):** *0.010*
- **Channel Slope** for **Dominant Flow (ft/ft):** *0.010*
- **Manning's n** for **Design Flow**: *0.035*
- **Manning's n** for **Dominant Flow:** *0.030*
- The geometry (station and elevation) of this cross section:

Station (X)	Elevation (Y)
100	*100*
106	*98*
181	*98*
191	*95*
216	*95*
226	*98*
301	*98*
307	*100*

❖ Parameters for the *"Long Term Scour"*:

- **D50 (mm)** for Study Reach: *1.50*
- **D84 (mm)** for Study Reach: *10.00*
- **D16 (mm)** for Study Reach: *0.50*

- **D50 (mm)** for Supply Reach: *1.50*
- **D84 (mm)** for Supply Reach: *12.00*
- **D16 (mm)** for Supply Reach: *1.00*

❖ Parameters for the **General Scour**:

- **Exponent m:** *Coarse Gravel (0.85)*
- **Bend Factor, z:** *Moderate Bend (0.60)*
- **D50 (mm):** *1.50*
- **Bend Angle (Degrees):** *45.00*

❖ Parameters for the **Low Flow Scour**:

- **Low Flow Rate (cfs):** *100.00*
- **Channel Material** *Medium Sand*

❖ Parameters for the **Local Scour**:

- **Pier With, a (ft):** *2.50*
- **Pier Length, L (ft):** *60.00*
- **Angle of Attack (Degrees):** *30.00*
- **D50 (mm):** *1.50*
- **D95 (mm):** *20.00*
- **Nose Shape Factor, K1:** *1.0 (Round Nose)*
- **Bed Condition Factor, K3:** *1.2 (Medium Dune)*

2.2.2 Step-by-Step Procedures

Step 1: Establish a New Project and Defaults Set-up

Step 2: Prepare the Cross Section Geometry

Step 3: Calculate Total Scour at Bridge Piers at Bend

Step 3.1: Set up Total Scour Basic Data

Step 3.2: Calculate the Long Term Scour

Step 3.3: Calculate the General Scour

Step 3.4: Calculate the Local Scour

Step 3.5: Calculate the Low Flow Scour

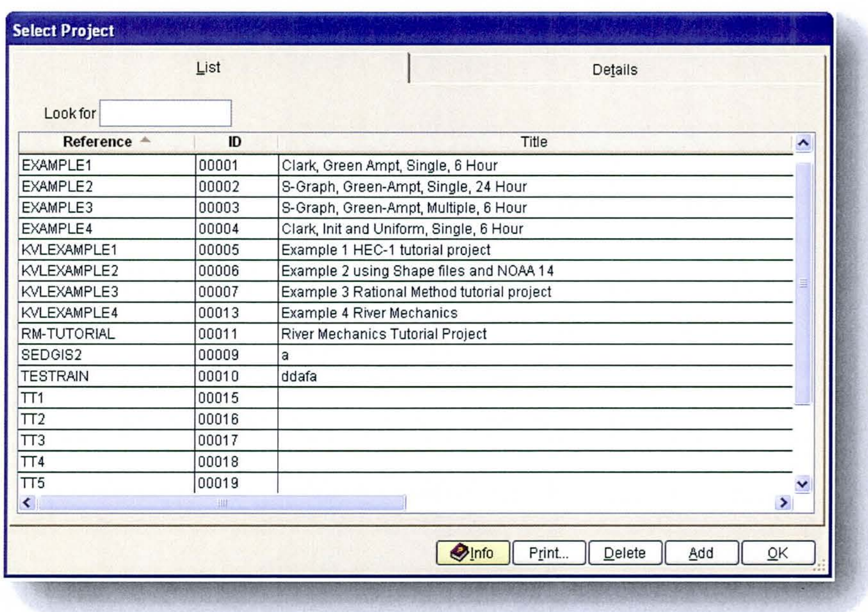
Step 3.6: Calculate the Total Scour

Step 4: Report the Results

(A) Step 1 - Establish a New Project and Defaults Set-up

(a) Click the **DDMSW** icon on the Desktop or Program menu to launch the **DDMSW.** Click the **OK** button to accept the software disclaimer as shown in the following figure.

After the **DDMSW** is launched, the **SELECT PROJECT** window is automatically opened as shown in the following figure.



(b) Click the **Add** button on the **SELECT PROJECT** window to start a new project (Or **File → New Project → Add**).

(c) Type *"BRIDGEPIER1"* into the **Reference** textbox. This is the name of this newly created project. Users can choose any name for the Reference textbox as long as it does not exist in the current **DDMSW** project database.

(d) Type into the **Title** textbox a brief descriptive title for this project. ***(Optional)***

(e) Type into the **Location** textbox the location of this project. ***(Optional)***

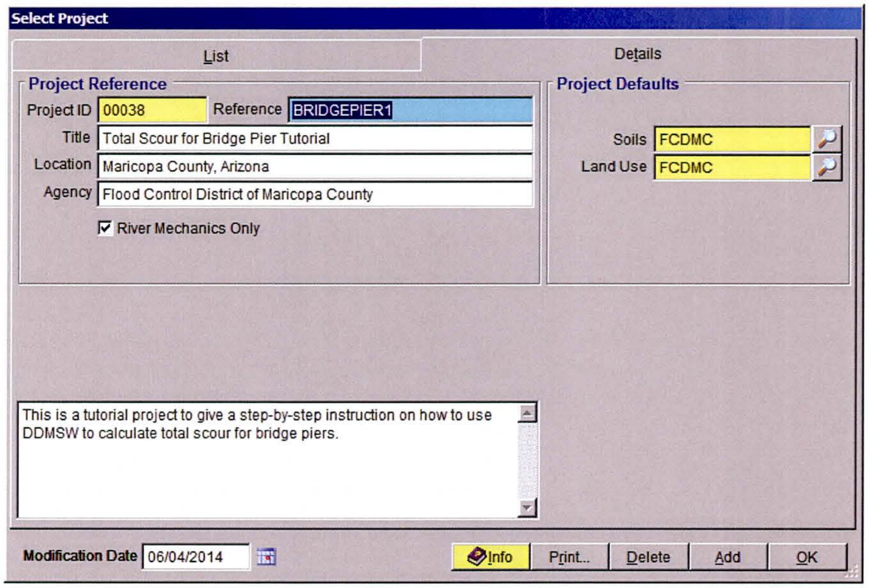
(f) Type into the **Agency** textbox the agency or company name**.** ***(Optional)***

(g) Check **River Mechanics Only** checkbox for this project.

(h) Type a detailed description of this project into the comment area under the **Project Reference** frame. ***(Optional)***

(i) Click the **Save** button to save the entered data.

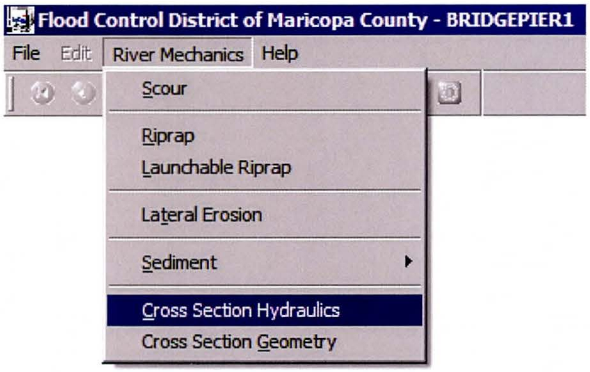
(j) Click the **OK** button on the **SELECT PROJECT** window, and click the **OK** button on the pop-up message box. The following figure shows what the window looks like.



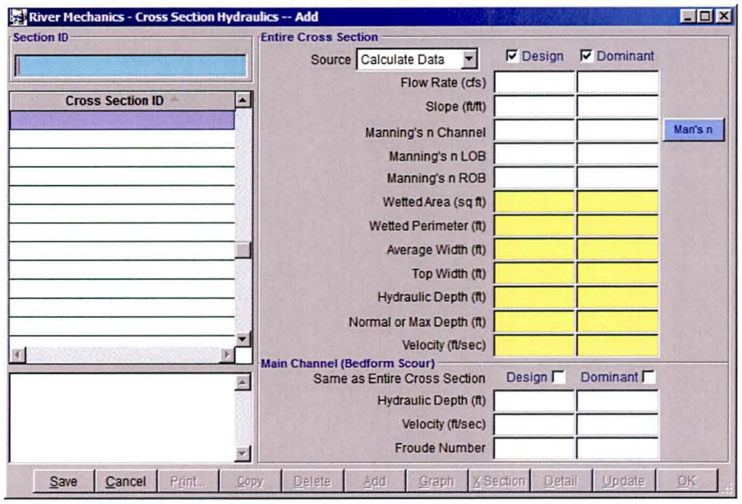
Note: the **Project ID** *"00038"* in the above figure is the unique database record identifier for the project, which is automatically generated by the program when a new project is created. When users create a new project, the **Project ID** of the new project will not be the same as the **Project ID** shown in the above figure.

(B) Step 2 - Prepare the Cross Section Hydraulics

(a) From the menu bar of the main application window, click **River Mechanics ➔ Cross Section Hydraulics** as shown in the following figure.



(b) Click the **Add** button on the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window to activate all the necessary data entry fields.



(c) Select the *"Calculate Data"* for the **Source** in the **Entire Cross Section** frame (*"Enter Data"* can also be selected for the **Source** if the hydraulic results for a cross-section are available.)

(d) Type *"BRIDGECROSSSECTION"* into the **Section ID** frame.

(e) By default, checkboxes for both the **Design** and **Dominant** flow events in the **Entire Cross Section** frame are checked. If not, please check these two checkboxes.

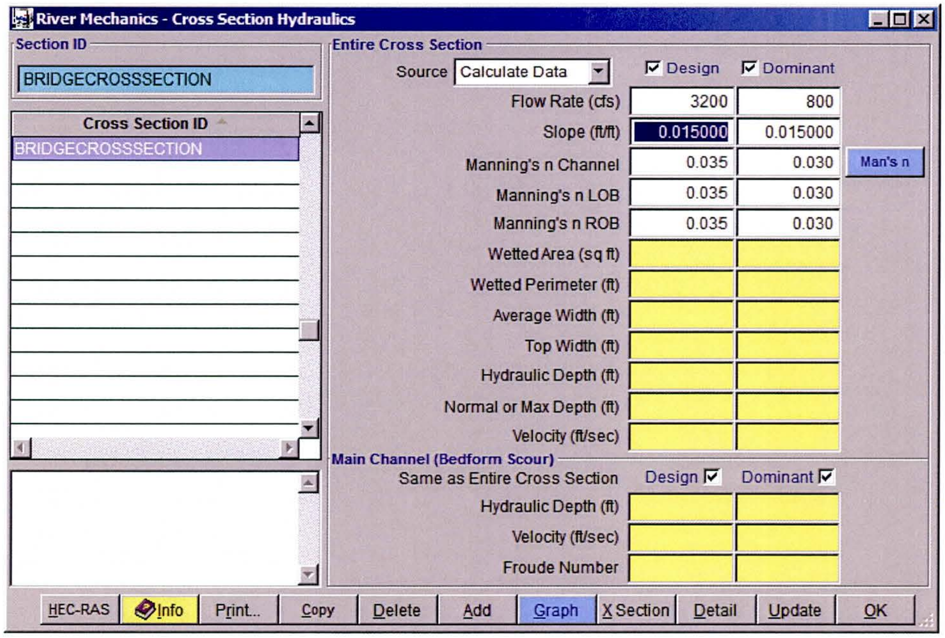
(f) Type in *"3200"* and *"800"* into the **Flow Rate (cfs)** textboxes under the **Design** and **Dominant** checkboxes, respectively.

(g) Type in *"0.015"* and *"0.015"* into the **Slope (ft/ft)** textboxes under the **Design** and **Dominant** checkboxes, respectively.

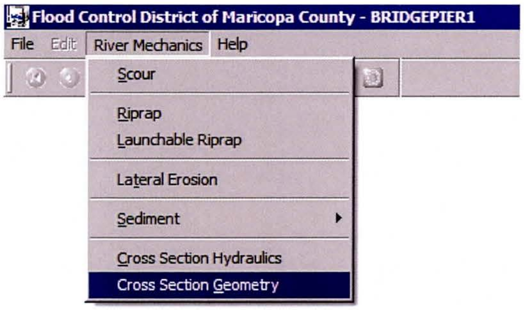
(h) Type in *"0.035"* and *"0.030"* into the **Manning's n** textboxes (values are the same for **Channel**, **LOB**, and **ROB**) for **Design** and **Dominant**, respectively.

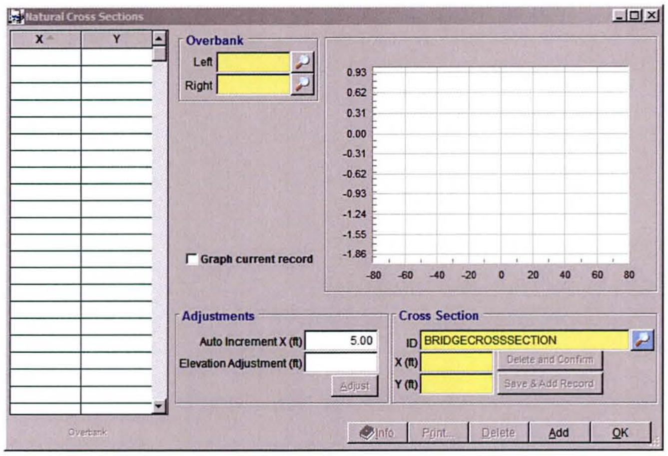
(i) Check both the **Design** and **Dominant** checkboxes in the **Main Channel (Bedform Scour)** frame (Note: These boxes are checked if the bedform scour computation is based on the entire cross-section hydraulics).

(j) After the data entry, click the **Save** button. The window looks like what is shown in the figure below. Click the **OK** button to close the window.

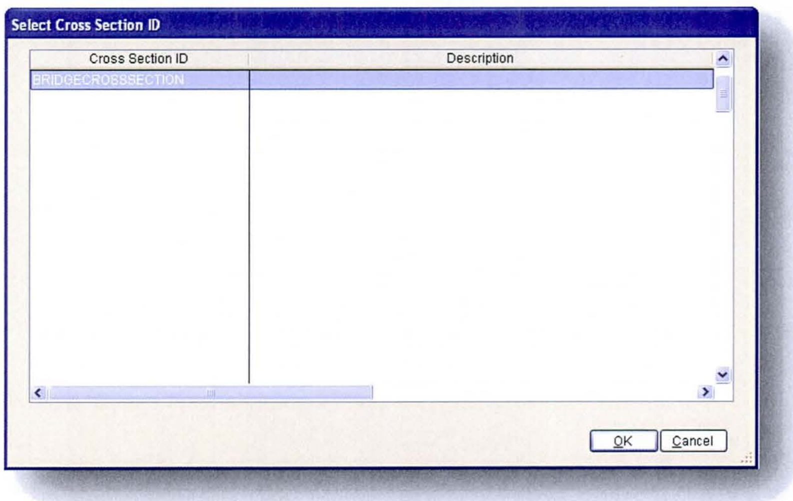


(k) From the menu bar of the main application window, click **River Mechanics ➔ Cross Section Geometry** as shown in the figure below. (Note: The **NATURAL CROSS SECTIONS** window opens).





(l) Click the "Magnifying Glass" on the right side of the **Cross Section ID** textbox, and highlight **Cross Section ID** *"BRIDGECROSSSECTION"* in the **SELECT CROSS SECTIONS** window. Click **OK** to close the window.



(m) Click the **Add** button on the **NATURAL CROSS SECTIONS** window, then type *"100"* and *"100"* into the **X** and **Y** textboxes respectively. Click the **Save & Add Records** button.

(n) Repeat the above step for the rest of pairs of **X** and **Y** values shown below. After the entry of the last XY data pair, click the **Save** button instead of the **Save & Add Record** button.

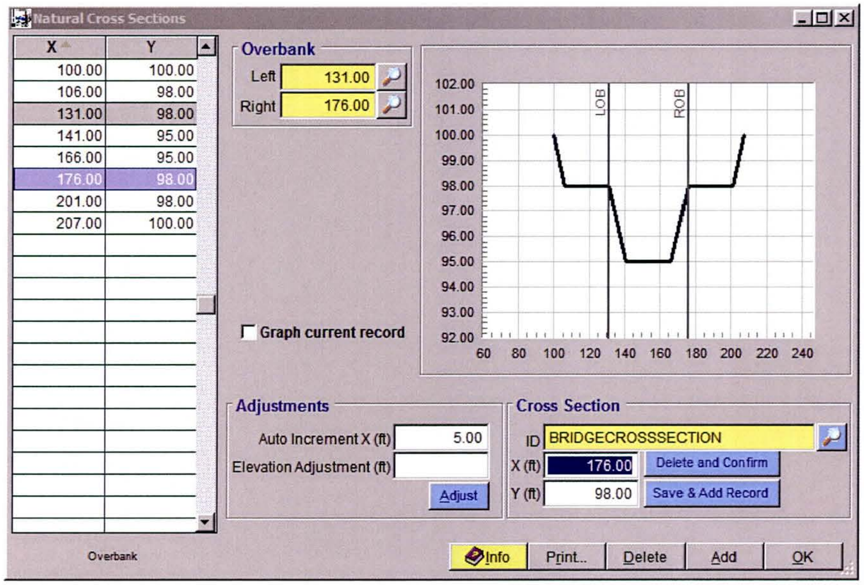
X	Y
106	*98*
131	*98*
141	*95*
166	*95*

X	Y
176	*98*
201	*98*
207	*100*

(o) To enter the **Left Bank Station**, highlight/select **Station (X)** *"131.00"* on the XY table grid, and click the magnifying glass on the right of the **Left Overbank** textbox. The textbox shows a value of *"131.00."*

(p) To enter the **Right Bank Station**, highlight/select the **Station (X)** *"176.00"* on the XY table grid, and click the magnifying glass on the right of the **Right Overbank** textbox. The textbox shows a value of *"176.00."*

After the XY values were all entered and after the **Left** and **Right Bank Stations** were defined, the **NATURAL CROSS SECTIONS** window will look like the following figure.

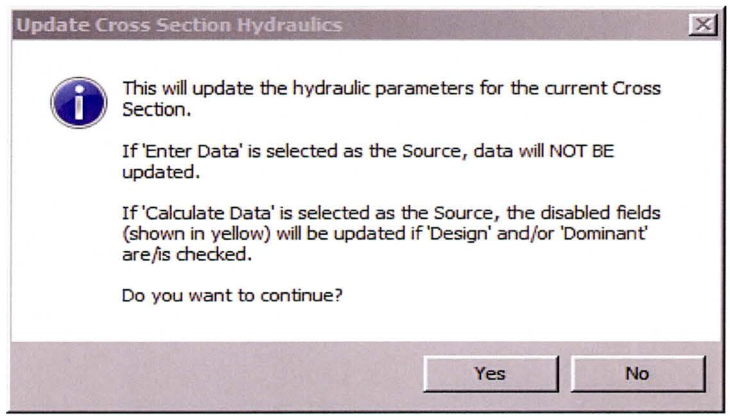


The cross-section data can be imported into **DDMSW** from text or table file. However, the XY data must be prepared based on **DDMSW** XY data format. To know the **DDMSW** XY data format, export the data for an existing cross-section (***File*** **➔** ***Export Data*** **➔** ***Section*** *(from the* **Section** *frame)* **➔** ***Hydraulics*** *(highlight "Hydraulics" from the* **SELECT SECTION** *window)* **➔** ***OK*** **➔** ***XLS*** *(select* **XLS** *radio button in the* **File Type** *frame)* **➔** ***Crosssections (****highlight Crosssections under* **Table Name** field***)*** **➔** ***Export*** **➔** ***Tempcrossections*** *(use the default file name or define a file name to use)***➔** ***Save*** **➔** ***Yes*** **➔** ***Yes*** **➔** ***OK***)

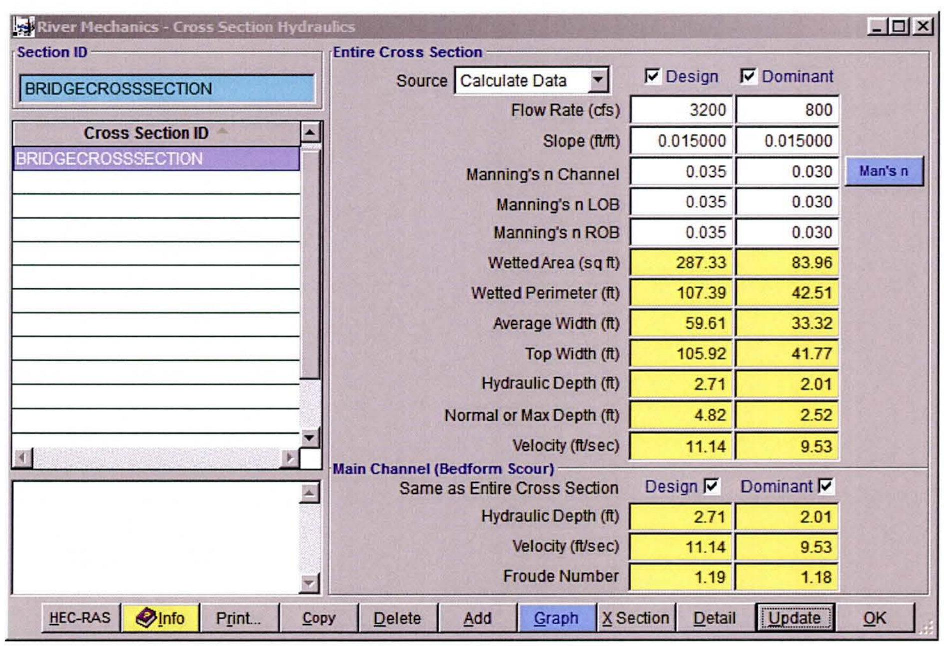
(p) Click **OK** to close the **NATURAL CROSS SECTIONS** window.

(q) Go back to the main application window, click **River Mechanics → Cross Section Hydraulics** from the menu bar to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window. Click the **Update** button to compute all the hydraulics parameters listed on the form.

(r) Highlight *"This Record"* and click the **OK** button to close the **SELECT OPTION** window. When the **UPDATE CROSS SECTION HYDRAULICS** window opens, click the **Yes** button to continue.



After the update, the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window looks like what is shown in the following figure.



All the above steps are the complete process of how to manually create hydraulics and geometric data sets. Please repeat the above steps to create another two cross section datasets, namely, *"STUDYREACHCROSSSECTION"* and *"SUPPLYREACHCROSSSECTION",* to be used for the scour analysis.

❖ **Study Reach Cross Section Data**

- **Section ID**: *"STUDYREACHCROSSSECTION"*
- **Data Source:** "Calculate Data"

Parameters	Design	Dominant
Flow Rate (cfs):	*3200*	*800*
Slope (ft/ft):	*0.015*	*0.015*
Manning's n Channel	*0.035*	*0.030*
Manning's n LOB	*0.035*	*0.030*
Manning's n ROB	*0.035*	*0.030*

Station (X)	**Elevation (Y)**
100	*100*
106	*98*
156	*98*
166	*95*
191	*95*
201	*98*
251	*98*
257	*100*

❖ **Supply Reach Cross Section Data**

- **Data Source:** *Calculate Data*
- **Section ID:** *SUPPLYREACHCROSSSECTION*

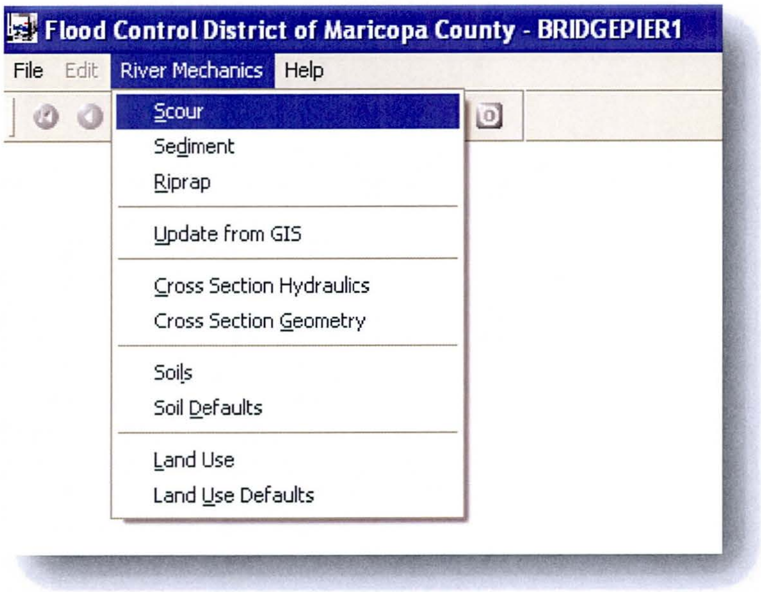
Parameters	**Design**	**Dominant**
Flow Rate (cfs):	*3200*	*800*
Slope (ft/ft):	*0.010*	*0.010*
Manning's n Channel	*0.035*	*0.030*
Manning's n LOB	*0.035*	*0.030*
Manning's n ROB	*0.035*	*0.030*

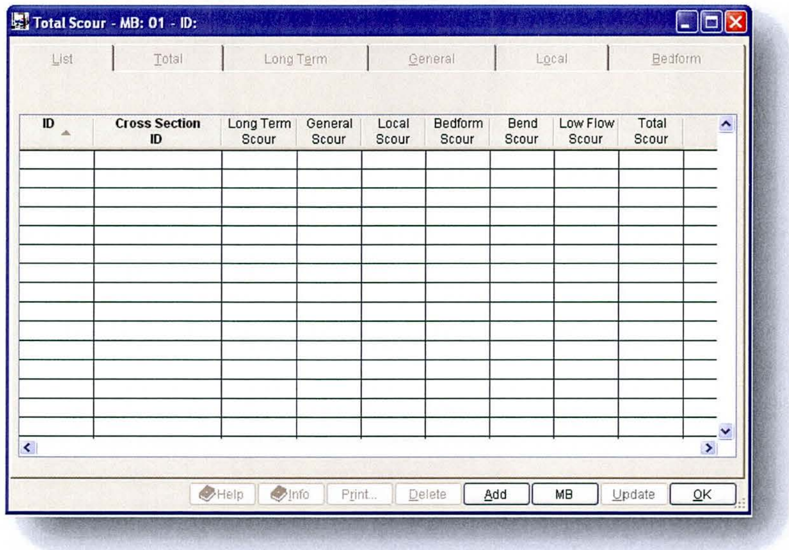
Station (X)	Elevation (Y)
100	*100*
106	*98*
181	*98*
191	*95*
216	*95*
226	*98*
301	*98*
307	*100*

(C) Step 3 - Calculate Total Scour at Bridge Piers at Bend

(C.1) Set up Total Scour Basic Data

(a) From the menu bar of main application window, click **River Mechanics ➔ Scour**, to open the **TOTAL SCOUR – MB: 01** window.



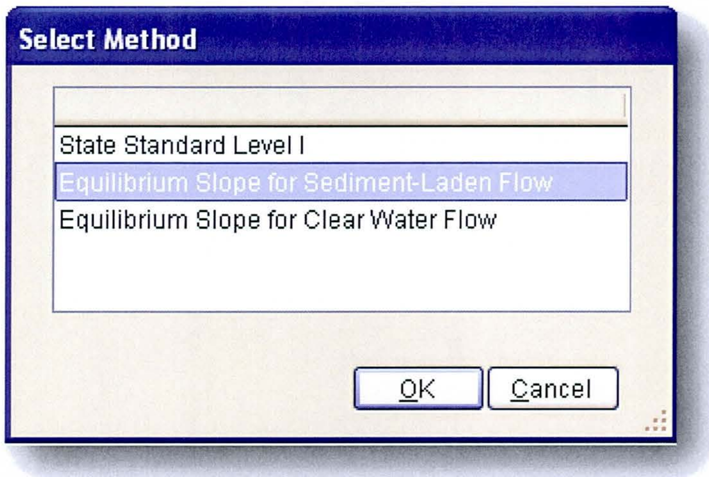


(b) Click the **Add** button to activate the necessary data entry fields.

(c) Type *"PIERNO1"* into the **ID** textbox (this **ID** indicates that it is for Pier No.1).

(d) Check the checkboxes **Long Term**, **General**, **Local**, and **Low Flow** (**Bed Form** is not computed because it will be part of pier local scour computation where the K3 factor, the *Bed Condition Factor*, will be used).

(e) Click the browse button in the **Method** column across **Long Term** check box to launch long term scour method select menu.

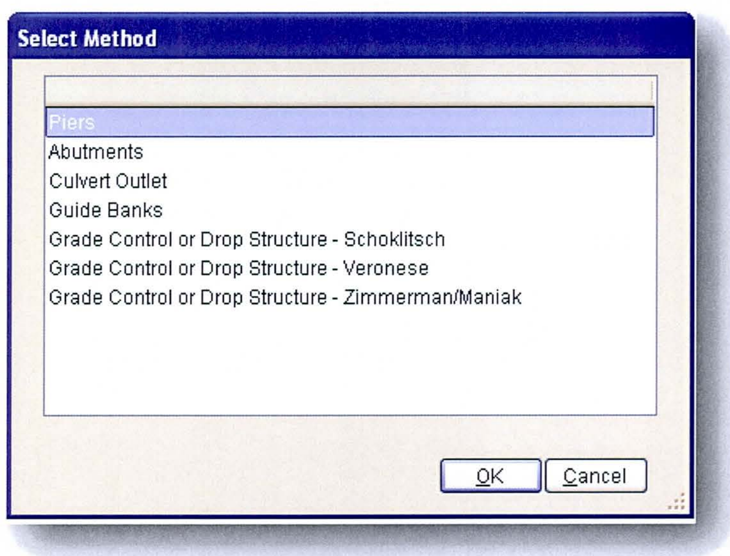


Select the *"Equilibrium Slope for Sediment-Laden Flow"* from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window.

(f) Click the browse button in the **Method** column across **General** check box to launch general scour method select menu.

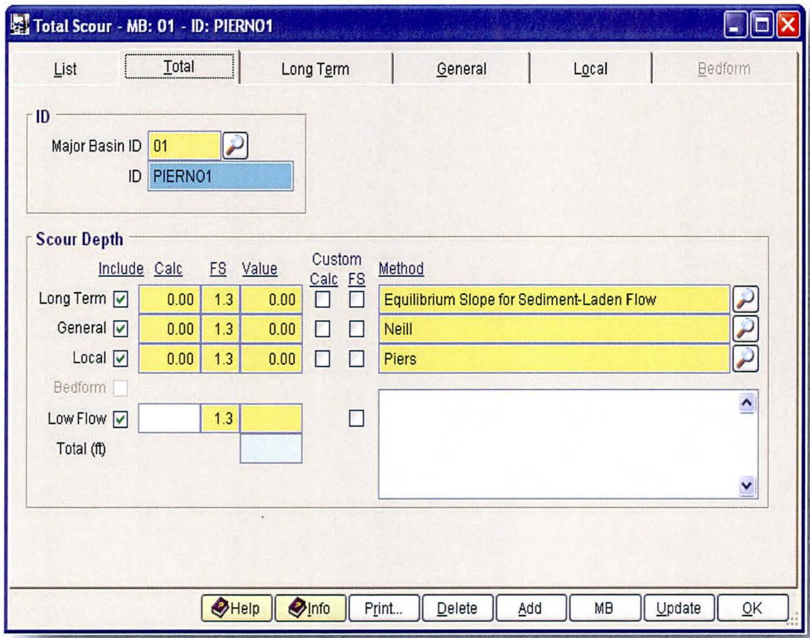
(g) Select the *"Neil"* from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window.

(h) Click the browse button in the **Method** column across **Local** check box to launch local scour method select menu.



(i) Select the *"Piers"* from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window.

(j) Click the **Save** button to save the entered data. The **TOTAL SCOUR – MB: 01 – ID: PIERNO1** window shows up like following figure.



(C.2) Calculate the Long Term Scour

(a) Click the **Long Term** tab.

(b) Click browse button beside the **Study Reach Cross Section ID** to select the cross section **ID** *"STUDYREACHCROSSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** window.

(c) Click browse button beside the **Supply Reach Cross Section ID** to select the cross section **ID** *"SUPPLYREACHCROSSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** window.

(d) Enter the **D50 (mm)** values *"1.5"* and *"1.5"* for **Study** and **Supply**, respectively.

(e) Enter the **D84 (mm)** values *"10"* and *"12"* for **Study** and **Supply**, respectively.

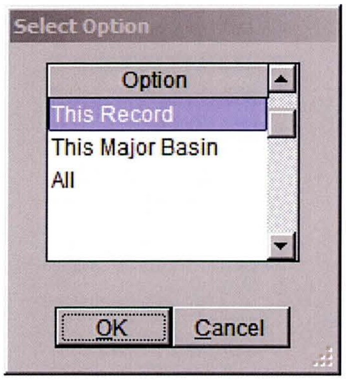
(f) Enter the **D16 (mm)** values *"0.5"* and *"1.0"* for **Study** and **Supply**, respectively.

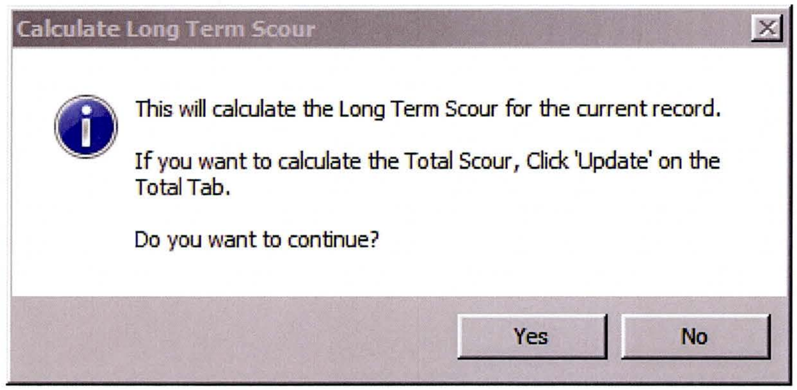
(g) Enter *"800"* into **Length to Pivot Pt (ft)**.

(h) Click the **Save** button to save the entered data.

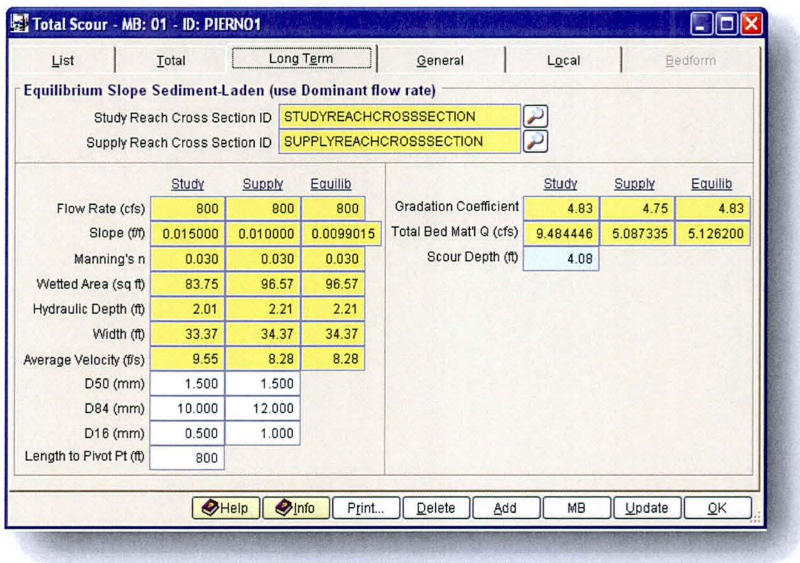
(i) Click the **Update** button to update the data.

(j) Select *"This Record"* from the **SELECTION OPTION** window, and click the **Yes** button on the **CALCULATE LONG TERM SCOUR** dialog box to proceed.





After the update, the result of the long term scour calculation shows in the following figure.



(C.3) Calculate the General Scour

(a) Click the **General** tab.

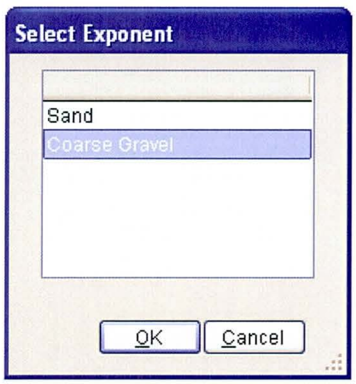
(b) Click the browse button beside the **Bridge Section ID** textbox to open the **Select Cross Section ID** window. Select the *"BRIDGECROSSSECTION"* and click **OK** to close the window.

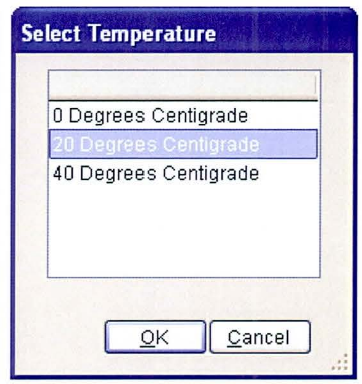
(c) Click the browse button beside the **Upstream Section ID** textbox to open the **Select Cross Section ID** window. Select the *"STUDYREACHCROSSSECTION"* and click **OK** to close the window (Note: Upstream section is for the area upstream of the bridge contraction. It can be generally represented by the study reach cross-section. The supply reach cross-section is not used as the upstream section because it is upstream of the study reach and is generally far away upstream from the bridge).

(d) Click the browse button beside the **Exponent m** textbox to open the **SELECT EXPONENT** window. Select the *"Coarse Gravel"*, and click **OK** to close the window.

(e) Click the browse button beside the **Bend Factor, Z** textbox to open the **SELECT FACTOR** window. Select the *"Moderate Bend"* bend factor and click **OK** to close the window.

(f) Click the browse button beside the **Water Temp (C)** textbox to open the **SELECT TEMPERATURE** window. Select the *"20 Degrees Centigrade"* and click **OK** to close the window.





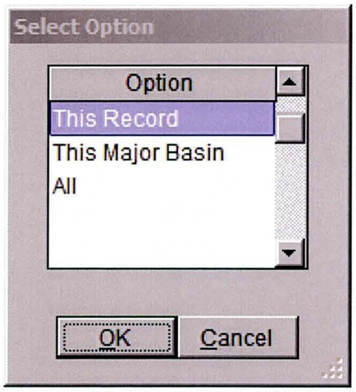
(g) **D50 (mm)**: Use the default value of *"1.5"* in the textbox (the default value is from the D50 value entered in study reach under Long Term scour menu for **Supply**). Or enter a value directly in this box. (Note: if a different value is entered here, the D50 value in Long Term for **Supply** will be changed).

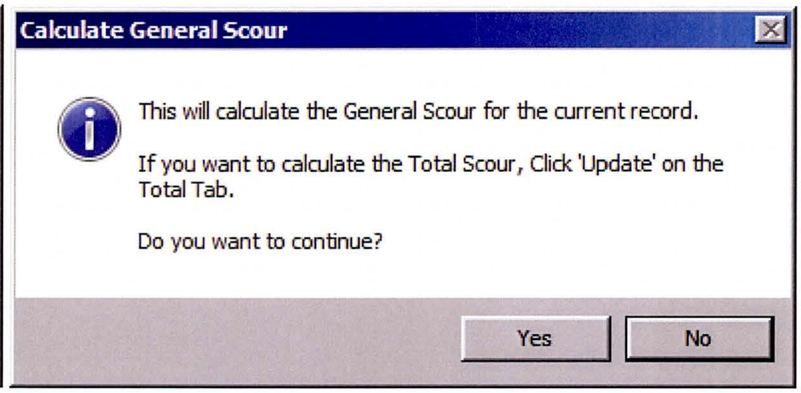
(h) Enter *"45"* into the **Bend Angle (Degrees)** textbox

(i) Click the **Save** button to save the entered data.

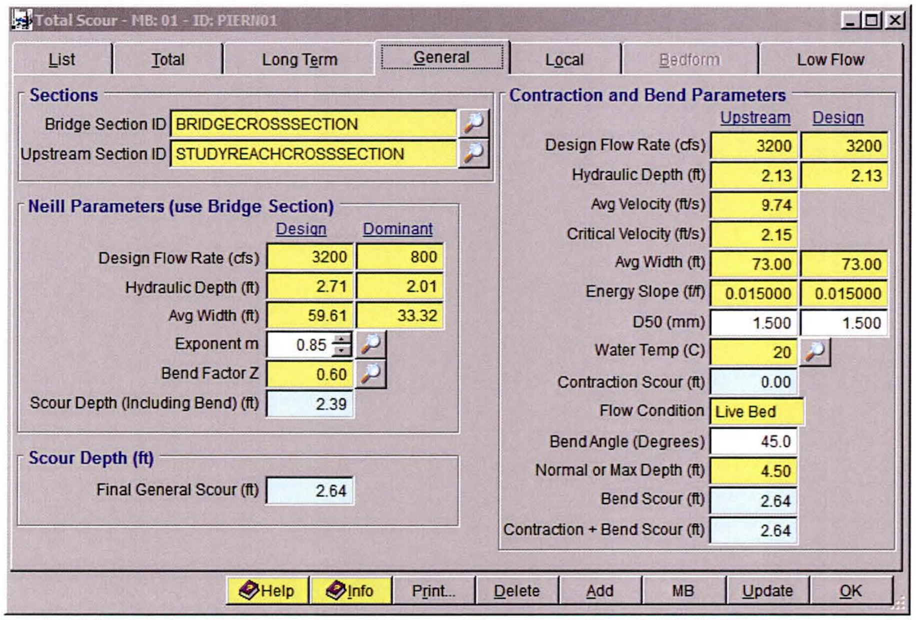
(j) Click the **Update** button on the **General** tab to update the data.

(k) Select *"This Record"* from the **SELECTION OPTION** window, and click the **Yes** button on the **CALCULATE GENERAL SCOUR** dialog box to proceed.





The following figure shows what the window looks like after the data entry.



(C.4) Calculate the Local Scour

(a) Click the **Local** tab.

(b) Click the browse button beside the **Bridge Section ID** textbox to open the **SELECT CROSS SECTION ID** widow. Select the *"BRIDGECROSSSECTION"* and click the **OK** button to close the window.

(c) Enter *"2.5"* into the **Pier Width, (ft)** textbox.

(d) Enter *"60"* into the **Pier Length, L (ft)** textbox.

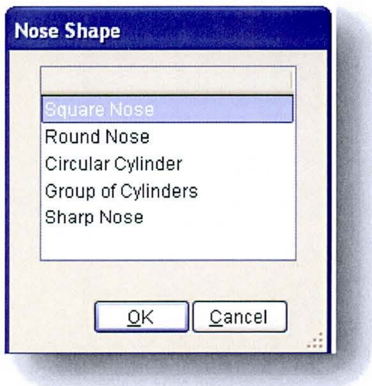
(e) Enter *"30"* into the **Angle of Attack (Degree)** textbox.

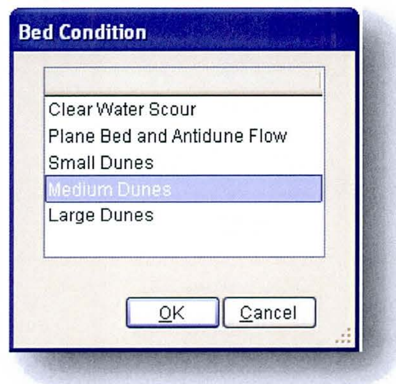
(f) Enter *"1.5"* into the **D50 (mm)** textbox.

(g) Enter *"20.0"* into the **D95 (mm)** textbox.

(h) Click the browse button beside the **Nose Shape Factor, K1** textbox to open the **NOSE SHAPE** window. Select *"Round Nose"* item, and click **OK** button to close it.

(i) Click the browse button beside the **Bed Condition Factor, K3** textbox to open the **BED CONDITION** window. Select *"Medium Dunes"* item and click **OK** button to close the window.



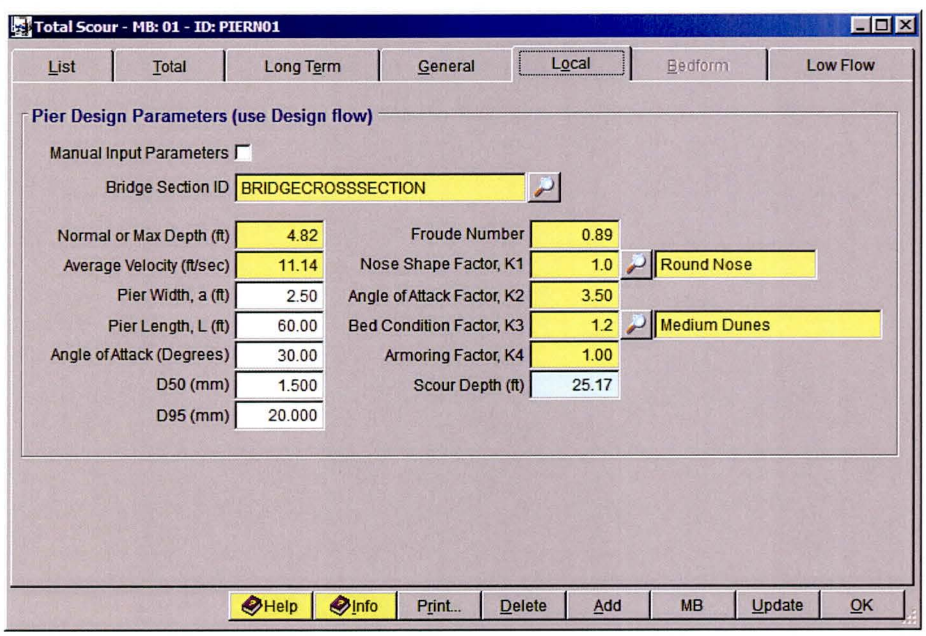


(j) Click the **Save** button to save the entered data.

(k) Click the **Update** button to update the data.

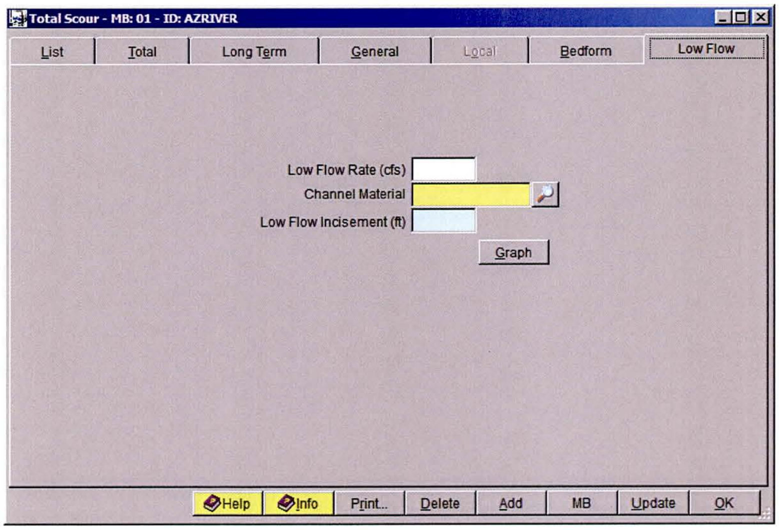
(l) Select *"This Record"* from the **SELECTION OPTION** window, and click **Yes** from the confirmation message to proceed.

After the update the window looks like what is shown in the following figure.



(C.5) Calculate the Low Flow Scour

On the **TOTAL SCOUR** form, select the **Low Flow** tab. The following figure shows what the window looks like before data entry.

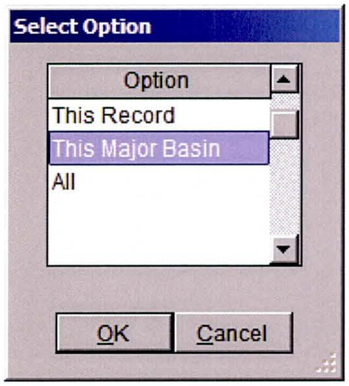


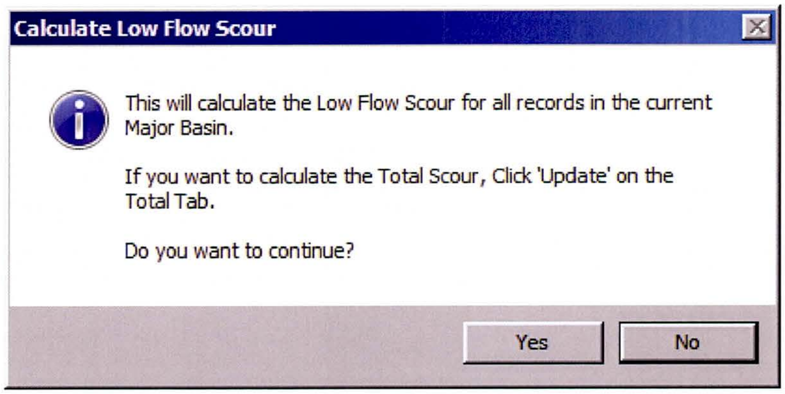
(a) Enter *"100"* into the **Low Flow Rate (cfs)** textbox.

(b) Click browse button beside the **Channel Material** to select the channel material data. Choose *"Medium Sand"* and click **OK** to exit the **SELECT CHANNEL MATERIAL** window.

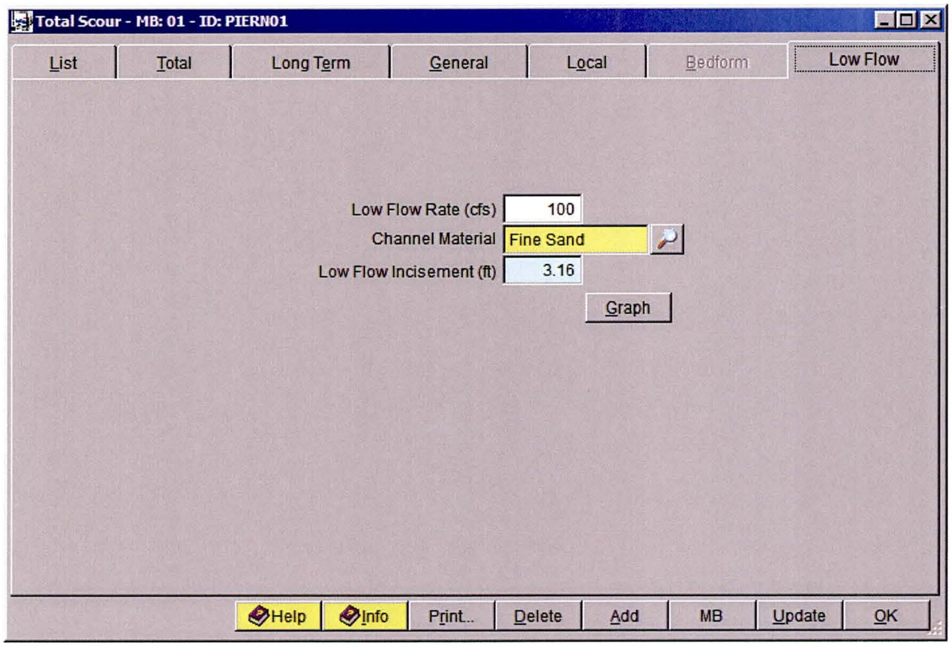
(c) Click the **Save** button to save the data just entered.

(d) Click the **Update** button and select *"This Major Basin"* from the **SELECTION OPTION** window. Click **Yes** to continue.





After the update the final result of the low flow scour calculation result shows in the following figure

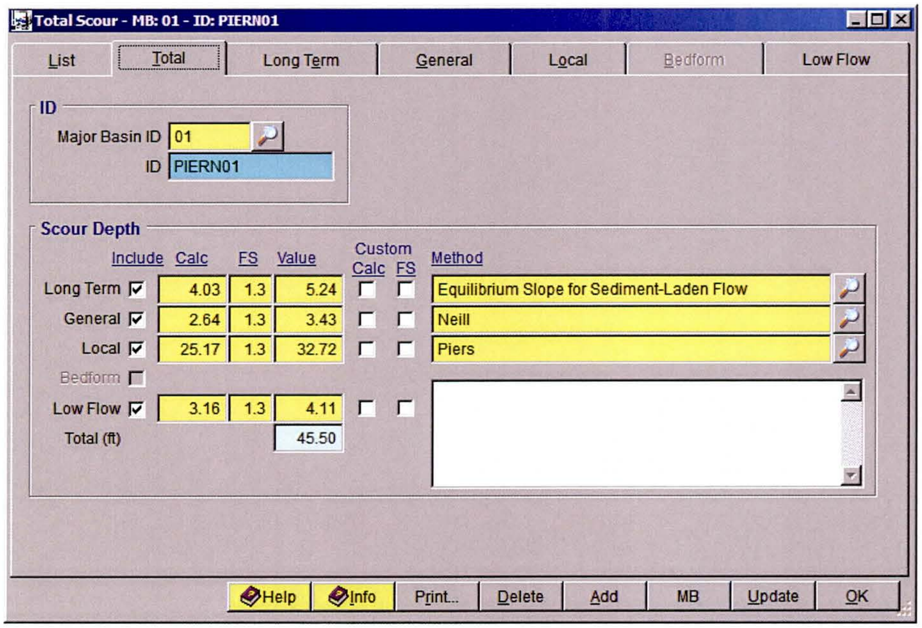


(C.6) Calculate the Total Scour

(a) Click the **Update** button to compute the total scour and individual scour components.

(b) Select *"This Record"* from the **SELECTION OPTION** window to proceed.

After the update the window, the total scour results and individual scour components are displayed as shown in the following figure.

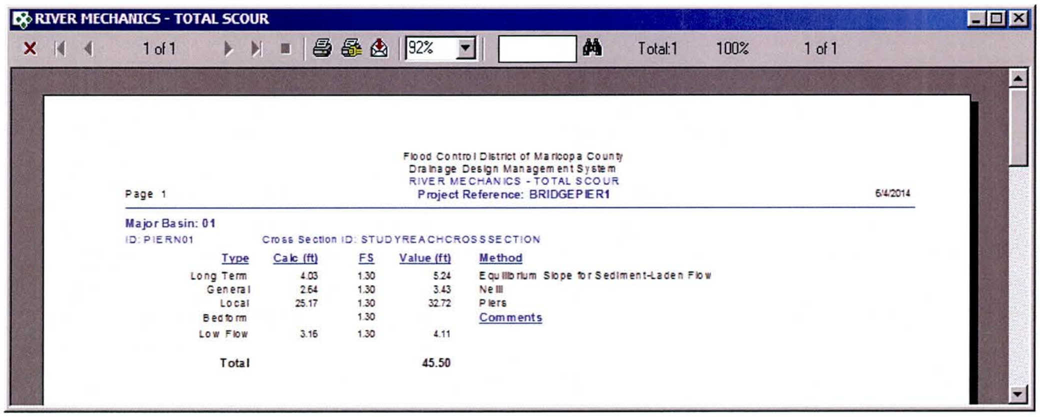


(D) Step 4 - Report the Results

In this section, the instruction will be given on how to view, print, and export the calculation results of the total scour.

The total scour is the sum of the long term scour, general scour, local scour, bedform scour and low flow scour. In this tutorial, these scour components are covered.

(a) To view the results on the screen, click the **Print ...** button on the **TOTAL SCOUR – MB: 01 – ID: PIERNO1** window, a report will be generated as is shown in the following figure.



(b) To print out the results on a printer, click the printer symbol ().

(c) To export the results in PDF format or other formats, click the export symbol ()

(d) The individual scour components results and cross section hydraulics results can also be viewed, printed, and exported by clicking the **Print...** button under individual component scour menus and **Cross Section Hydraulics** menu.

2.3 Calculate Sediment Yield for a Watershed

2.3.1 Problem Statement

To estimate the sediment yield for a watershed, including wash load and bed load, with the following given design parameters:

- The Cross Section *"STUDYLOCATIONCROSSSECTION"*
  - Parameters for Hydraulics and Geometry:
    - **Design Flow Rate (cfs):** *3200*
    - **Dominant Flow Rates (cfs):** *800*
    - **Channel Slope** for **Design Flow (ft/ft):** *0.015*
    - **Channel Slope** for **Dominant Flow (ft/ft):** *0.015*
    - **Manning's n** for **Design Flow:** *0.035*
    - **Manning's n** for **Dominant Flow:** *0.030*
    - The geometry (station and elevation) of this cross section:

Station (X)	Elevation (Y)
100	*100*
106	*98*
156	*98*
166	*95*
191	*95*
201	*98*
251	*98*
257	*100*

  - Parameters for **Sediment Yield**:

Return period	Q (cfs)	Volume (ac-ft)
2 year	*277*	*12.00*
5 year	*486*	*18.00*
10 year	*645*	*23.00*
25 year	*869*	*30.00*
50 year	*1046*	*36.00*
100 year	*1231*	*42.00*
Design	*1231*	*42.00*

- Parameters for **Wash Load**:

• **Sediment Area (sq mi):**	*0.3508*
• **D10 (mm)** for channel bed material soil sample:	*0.500*
• **Slope Length (ft):**	*400*
• **Slope (%):**	*2.50*

- Parameters for **Bed Load**:

• **D16 (mm)**:	*0.800*
• **D50 (mm)**:	*1.500*
• **D84 (mm)**:	*10.00*

- Parameters for **Soils**:

Sediment Area ID	Soil ID	Area
• *SED1*	*6453*	*0.0508*
• *SED1*	*64590*	*0.0447*
• *SED1*	*64591*	*0.2548*
• *SED1*	*64598*	*0.0004*

- Parameters for **Land Uses**:

Sediment Area ID	Land Use Code	Area
• *SED1*	*120*	*0.0022*
• *SED1*	*150*	*0.1647*
• *SED1*	*160*	*0.0620*
• *SED1*	*180*	*0.0296*
• *SED1*	*230*	*0.0314*
• *SED1*	*410*	*0.0609*

2.3.2 Step-by-Step Procedures:

Step 1: Establish a New Project and Default Set-up

Step 2: Prepare the Cross Section Geometry

Step 3: Compute Sediment Yield

Step 3.1: Set up Sediment Yield Basic Data.

Step 3.2: Prepare Sediment Area Land Use and Soil Data

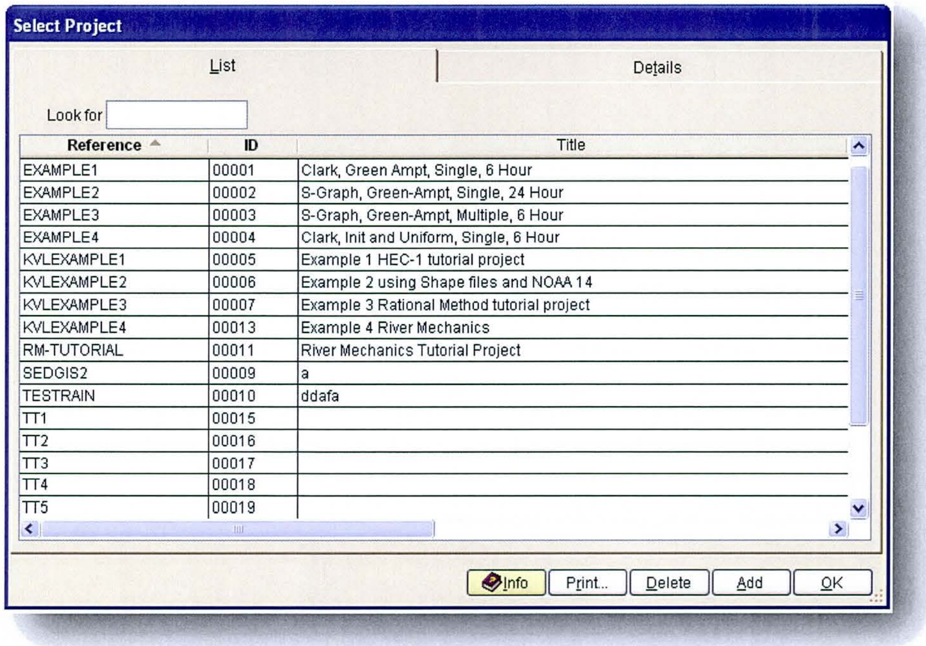
Step 4: Calculate the Sediment Yield

Step 5: Report the Results

(A) Step 1 - Establish a New Project and Defaults Set-up

(a) Click the **DDMSW** icon on the Desktop or Program menu to launch the **DDMSW**. Click **OK** to accept the software disclaimer as is shown in the following figure.

After the **DDMSW** is launched, the **SELECT PROJECT** window is automatically opened as is shown in the following figure.



(b) Click the **Add** button on the **SELECT PROJECT** window to start a new project (A new project can also be started by clicking **File ➔ New Project** under the menu bar).

(c) Type *"SEDIMENTYIELD1"* into the **Reference** textbox. This is the name of this newly created project. The users can choose the name as long as it does not exist in the **DDMSW** database.

(d) Type into the **Title** textbox a brief descriptive title of this project. ***(Optional)***

(e) Type into the **Location** textbox the location of this project. ***(Optional)***

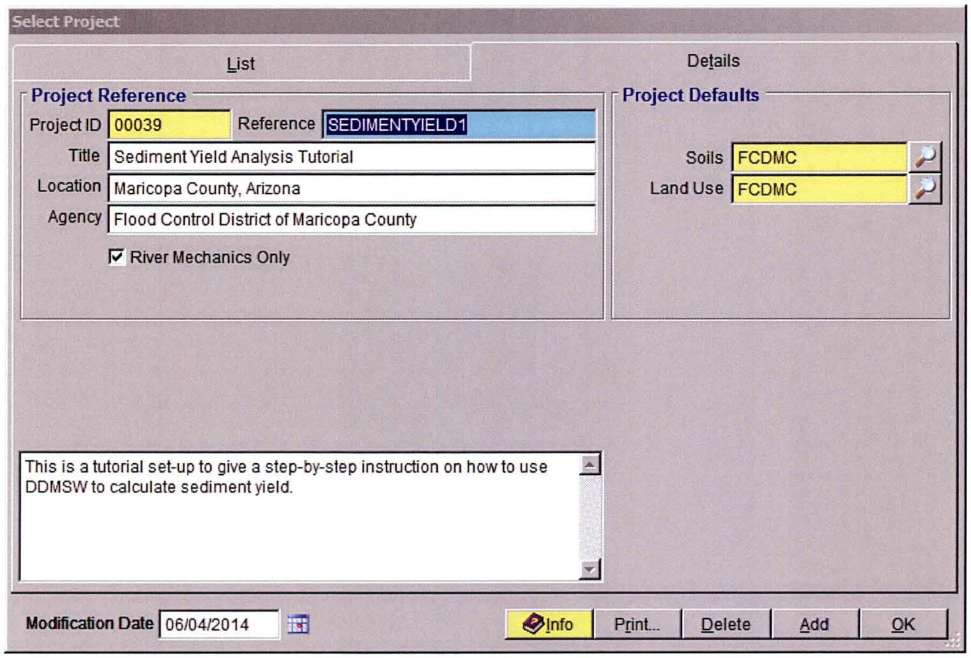
(f) Type into the **Agency** textbox the agency or company name. ***(Optional)***

(g) Check **River Mechanics Only** checkbox for this project.

(h) Type a detailed description of this project into the comment area under the **Project Reference** frame. ***(Optional)***

(i) Click **Save** button to save the entered data.

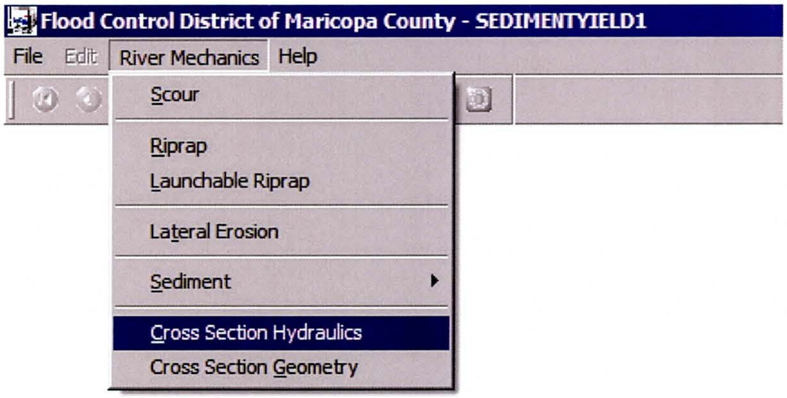
(j) Click **OK** button on the **SELECT PROJECT** window, and click **OK** button on the pop-up message box for landuse, soils data, etc. The following figure shows what the window looks like.

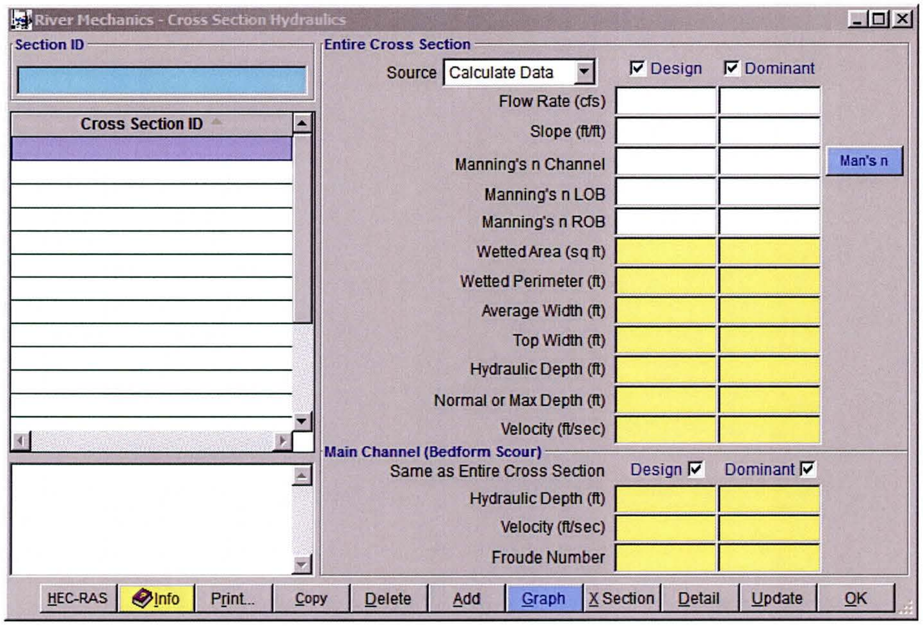


Note: the **Project ID** *00039* in the above figure is the database records unique read-only identifier of the project, which is automatically generated by the program when a new project is created. When the users create a new project, the **Project ID** of this new project will not be the same as the **Project ID** shown in the above figure.

(B) Step 2 - Prepare the Cross Section Hydraulics

(a) From the menu bar of the main application window, click **River Mechanics ➔ Cross Section Hydraulics** to open **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window.





(b) On the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window, select the "*Calculate Data*" for the **Source** in the **Entire Cross Section** frame ("*Enter Data*" can also be selected for the **Source** if the hydraulic results for a cross-section are available.)

(c) Type "*STUDYLOCATIONCROSSSECTION*" into the **Cross Section ID**

(d) By default, both the **Design** and **Dominant** checkboxes are already checked in the **Entire Cross Section** frame. If they are not checked, please check these two checkboxes.

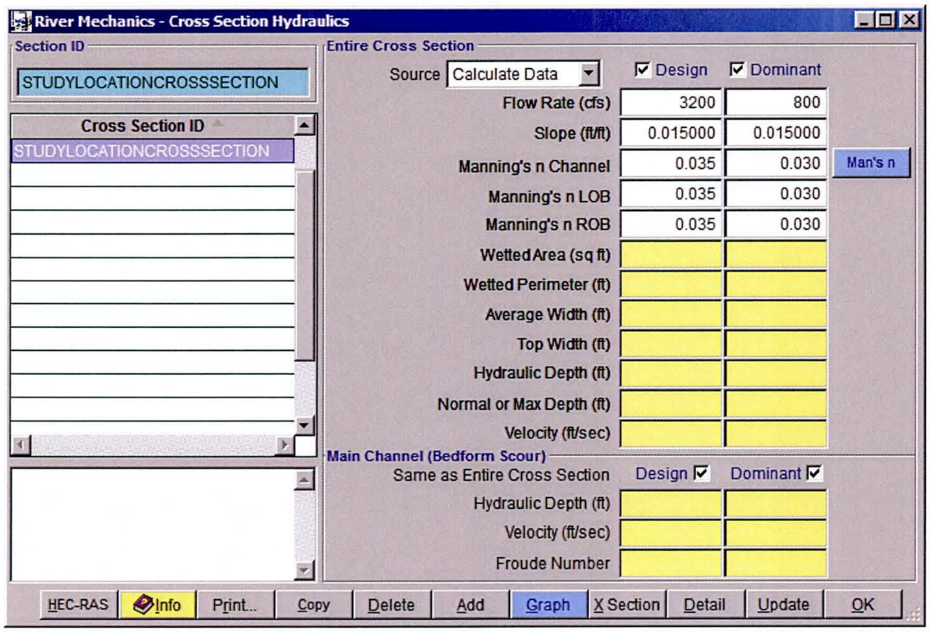
(e) Type in "*3200*" and "*800*" into the **Flow Rate (cfs)** textboxes for **Design** and **Dominant**, respectively.

(f) Type in "*0.015*" and "*0.015*" into the **Slope (ft/ft)** textboxes for **Design** and **Dominant**, respectively.

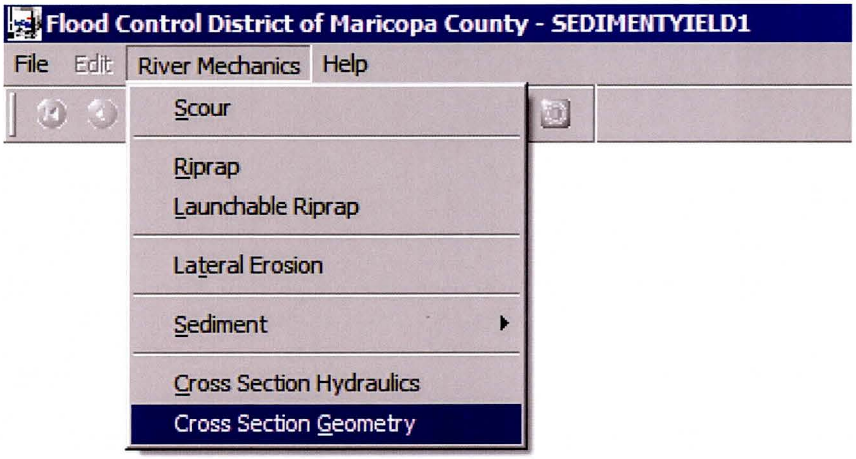
(g) Type in "*0.035*" and "*0.030*" into the **Manning's n** textboxes (the same values for **Channel**, **LOB**, and **ROB** for **Design** and **Dominant**, respectively.

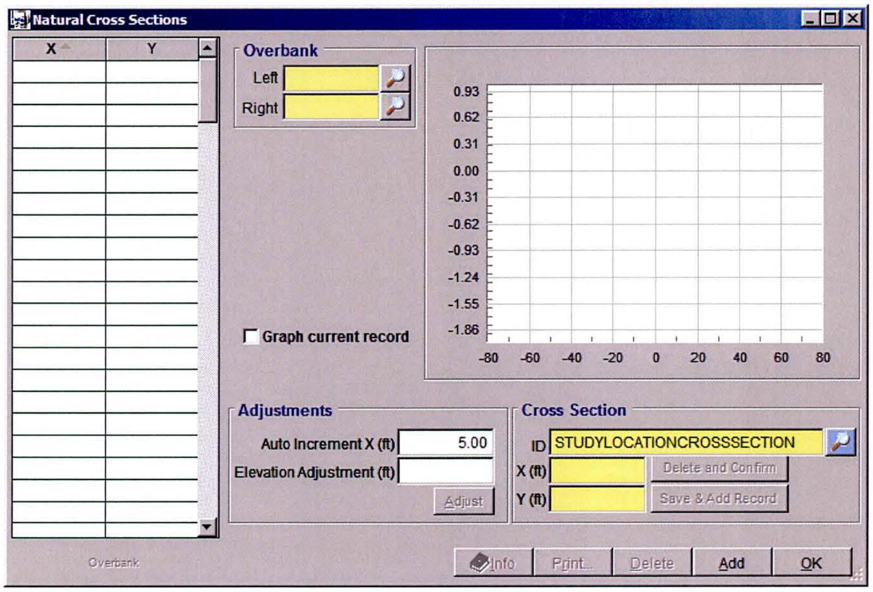
(h) Check **Same as Entire Cross Section** checkboxes for both the **Design** and **Dominant** in the **Main Channel (Bedform Scour)** frame (Note: These checkboxes are checked if the bedform scour computation is based on the entire cross-section hydraulics).

(i) After the data entry, click the **Save** button to save the entered data. The window looks like the figure shown below. Click the **OK** button to close the window.

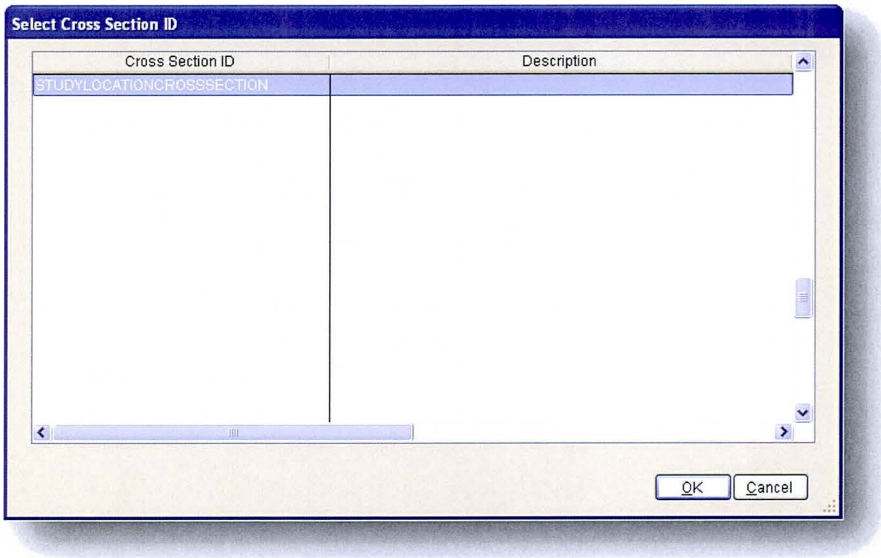


(j) From the menu bar of the main application window, click **River Mechanics ➔ Cross Section Geometry** to open the **NATURAL CROSS SECTIONS** window.





(k) On the **NATURAL CROSS SECTIONS** window, click the magnifying glass across the **ID** textbox in the **Cross Section** frame to open the **SELECT CROSS SECTION ID** window. Highlight **Cross Section ID** "*STUDYLOCATIONCROSSSECTION*" and click **OK** to close the window.



(l) Click the **Add** button on the **NATURAL CROSS SECTIONS** window and type "*100*" and "*100*" into the **X** and **Y** textboxes. Click the **Save & Add Record** button.

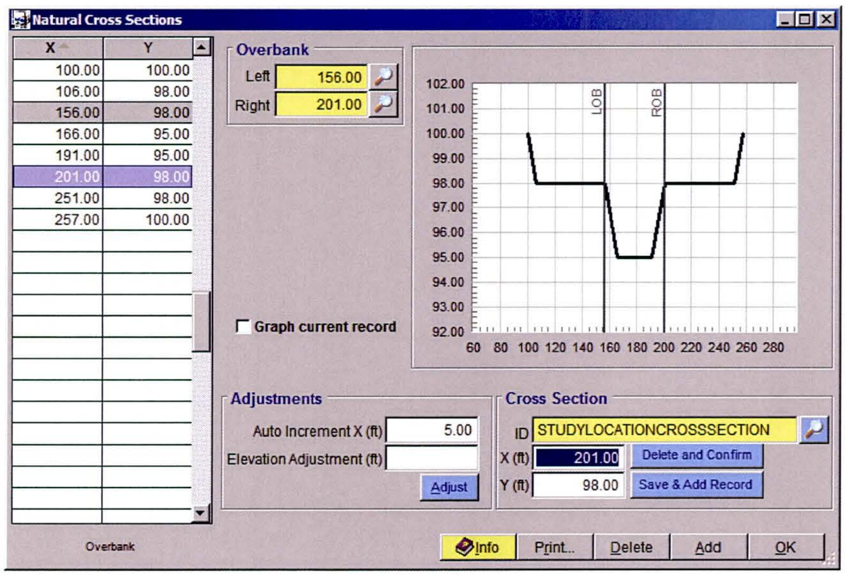
(m) Repeat the above step for the rest of pairs of **X** and **Y** values.

Station (X)	Elevation (Y)
106	*98*
156	*98*
166	*95*
191	*95*
201	*98*
251	*98*
257	*100*

(n) To enter the **Left Bank Station**, highlight/select **Station (X)** *"156.00"* on the XY table grid, and click the magnifying glass on the right of the **Left Overbank** textbox. The textbox shows a value of "156.00."

(o) To enter the **Right Bank Station**, highlight/select the **Station (X)** *"201.00"* on the XY table grid, and click the magnifying glass on the right of the **Right Overbank** textbox. The textbox shows a value of *"201.00."*

After all the XY values are entered and after the **Left** and **Right Bank Stations** are defined, the **NATURAL CROSS SECTIONS** window should look like the following figure.

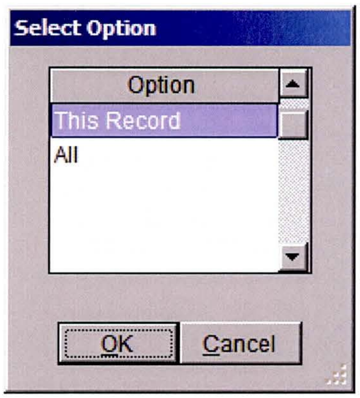


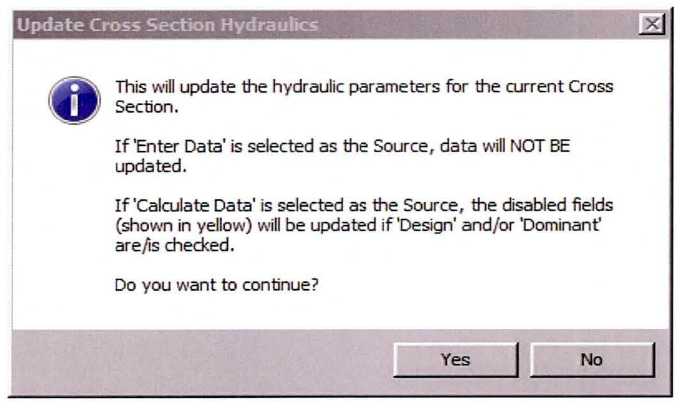
The cross-section data can be imported into **DDMSW**. However, the XY data must be prepared based on **DDMSW** XY data format before the cross-section is imported. To know the DDMSW XY data format, export the data for an existing cross-section (**File ➔ Export Data ➔** Section ➔ **Hydraulics ➔***select "Crosssections" under* **Table Name** column ➔ *check a radio button for format* *such as* **XLS** *for* **Excel ➔ Export ➔** *use default file name or define a file name* **➔ Save ➔ Yes➔ OK**).

(p) Click **OK** to close the **NATURAL CROSS SECTIONS** window.

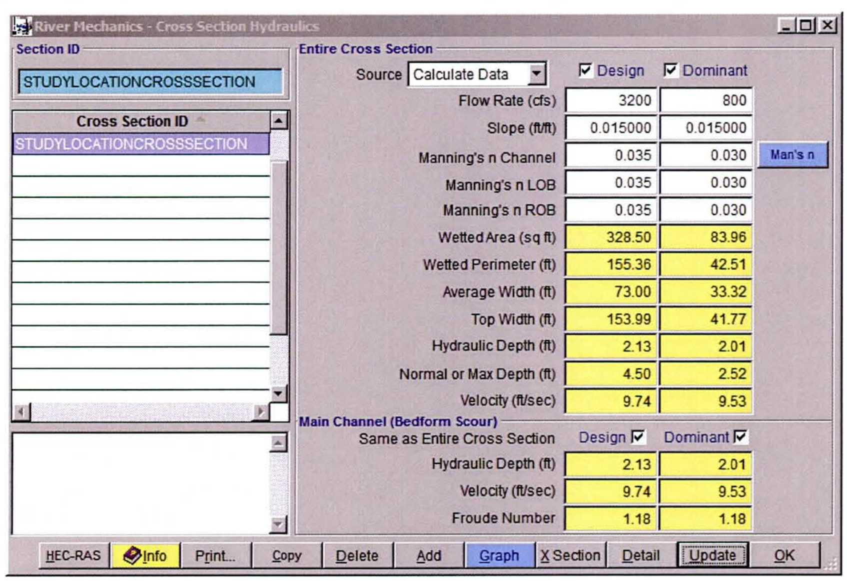
(q) Go back to the main application window and click **River Mechanics ➔ Cross Section Hydraulics** from the menu bar to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window. Click the **Update** button to evaluate the hydraulics.

(r) Highlight *"This Record"*, click **OK** button to close the **SELECT OPTION** window. The update process starts.





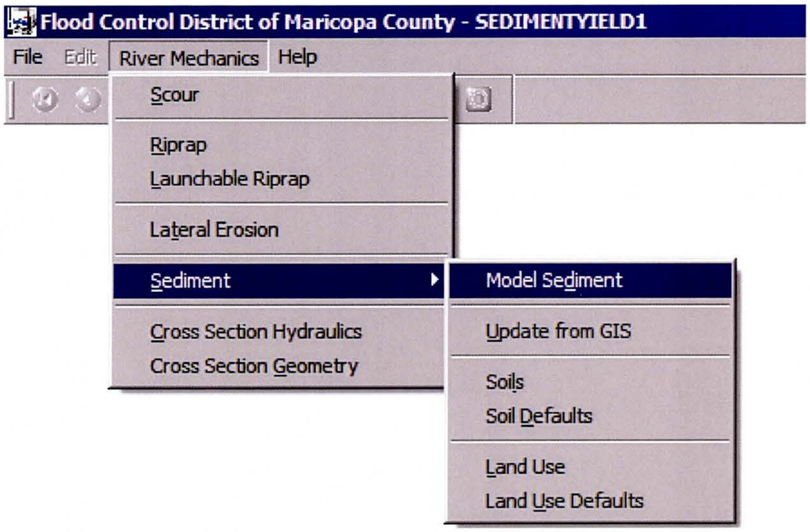
After the update, the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window should look like the following figure. Click **OK** to close the window.



(C) Step 3 - Compute Sediment Yield

(C.1) Set up Sediment Yield Basic Data

(a) From the menu bar of main application window, click **River Mechanics ➔ Sediment ➔ Model Sediment** to open the **RIVER MECHANICS – SEDIMENT - MB: 01** window.



(b) Click **Add** button to activate the necessary data entry fields.

(c) Type *"DAM1"* into the **ID** textbox, a unique **ID** for the location on the water course.

(d) Check the **Wash Load** and **Bed Load** checkboxes in the **Calculate** frame.

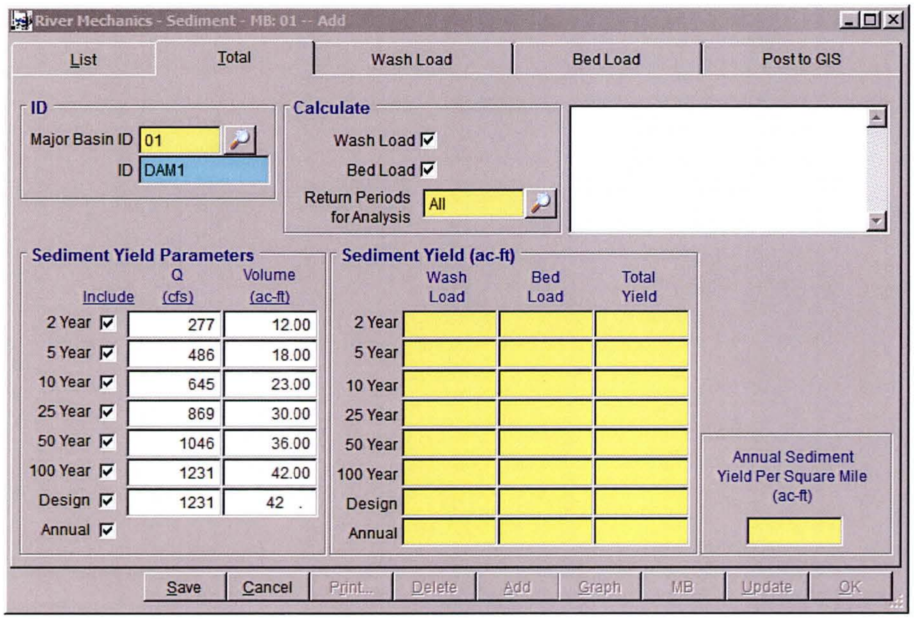
(e) Click the browse button beside the **Return Periods for Analysis** textbox in the **Calculate** frame to select *"All"* for the return periods.

(f) Check all the checkboxes in the **Sediment Yield Parameters** frame to activate all the discharges and volumes textboxes. Enter the following discharge and volume values for the sediment yield parameters

Return Period	Q (cfs)	Volume (ac-ft)
2 year	*277*	*12.00*
5 year	*486*	*18.00*
10 year	*645*	*23.00*
25 year	*869*	*30.00*
50 year	*1046*	*36.00*

100 year	*1231*	*42.00*
Design	*1231*	*42.00*

(g) Click the **Save** button to save the entered data. After the data entry, the window should look like the following figure.



(h) Click the **Wash Load** tab.

(i) Enter *"SED1"* into the **Sediment Area ID** textbox (**Sediment Area ID** is the unique ID for the drainage area that contributes sediment to the study location. This ID is used when land use and soil data are used to compute the wash load).

(j) Enter *"0.3508"* in the **Area (sq mi)** textbox.

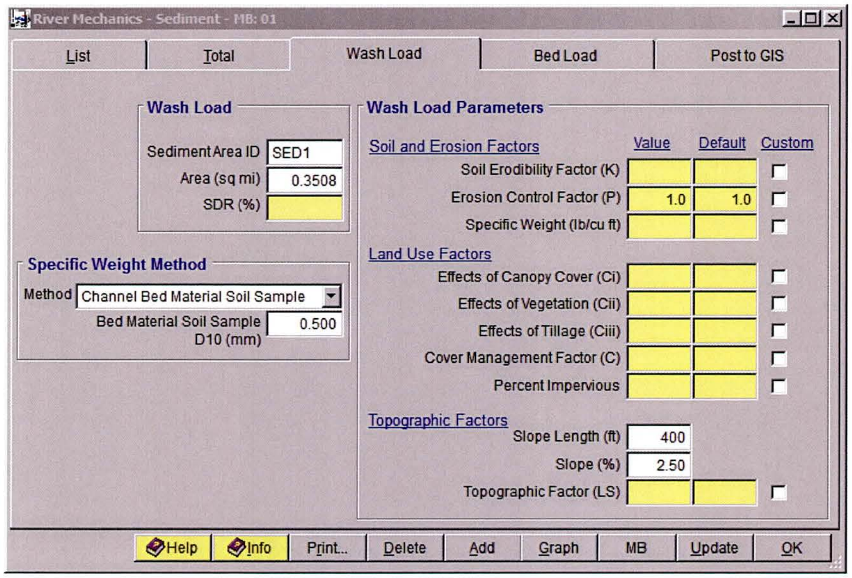
(k) Select *"Channel Bed Material Soil Sample"* as the **Specific Weight Method**.

(l) Enter *"0.50"* into the **Bed Material Soil Sample D10 (mm)** textbox.

(m) Enter *"400"* into the **Slope Length (ft)** textbox in the **Wash Load Parameters** frame.

(n) Enter *"2.50"* into the **Slope (%)** textbox in the **Wash Load Parameters** frame.

(o) Click the **Save** button to save data entry. The **RIVER MECHANICS – SEDIMENT – MB: 01** window should look like the following figure.



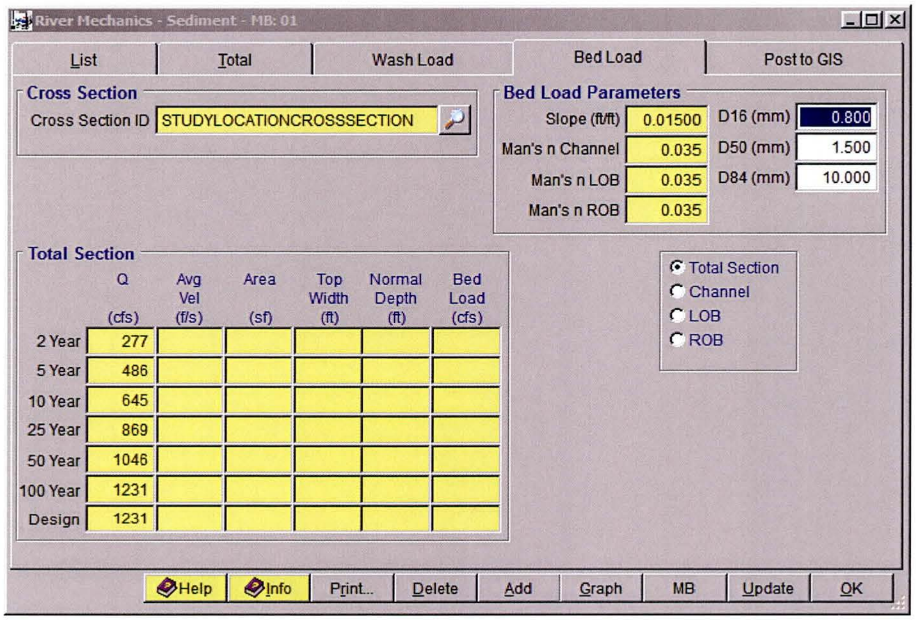
(p) Click the **Bed Load** tab and click browse button  beside the **Cross Section ID** textbox in the **Cross Section** frame to select *"STUDYLOCATIONCROSSSECTION"* as the cross section **ID**. Click **OK** to exit the window.

(q) Enter **D16 (mm) =** *0.80*

(r) Enter **D50 (mm) =** *1.50*

(s) Enter **D84 (mm) =** *10.00*

(t) Click the **Save** button to save the data entry. The **River Mechanics – Sediment – MB: 01** window should look like the following figure. Click **OK** to close the window.

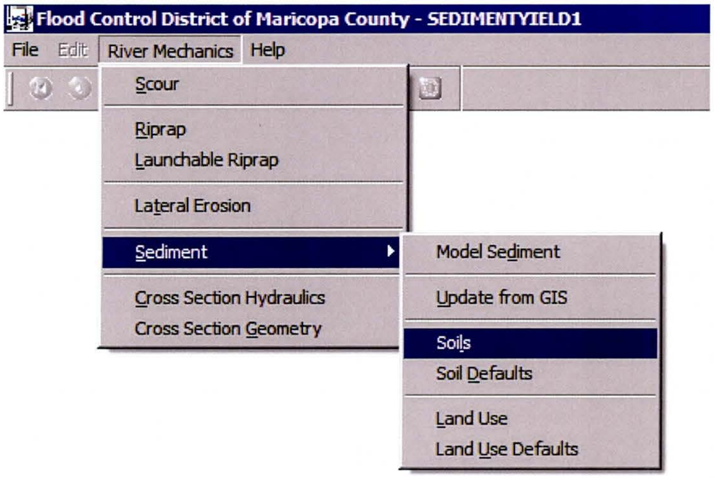


(C.2) Prepare Sediment Area Land Use and Soil Data

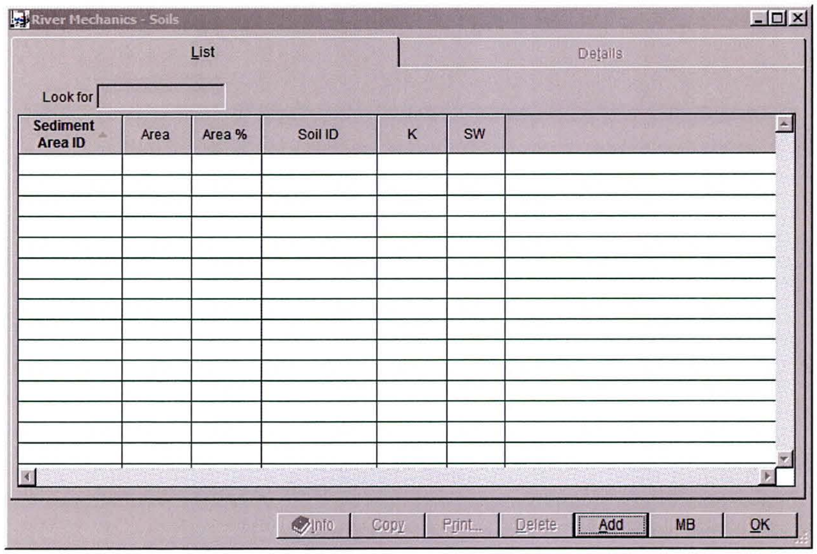
In this section the instruction will be given on how to prepare the landuse and soil data for the sediment area defined in the previous step.

(C.2.1) How to Prepare Soil Data

(a) Click **River Mechanics ➔ Sediment ➔ Soils** from the menu bar on the main application window as is shown in the following figure and a blank **RIVER MECHANICS – SOILS** window opens.



(b) Click the **Add** button on the **RIVER MECHANICS – SOILS** window to activate the data entry.

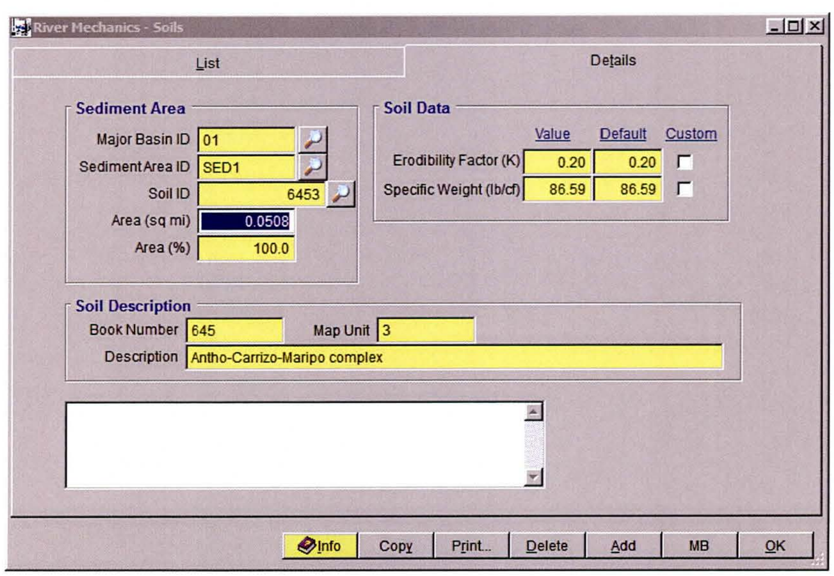


(c) On the **RIVER MECHANICS – SOILS** window, click the browse button beside the **Sediment Area ID** textbox in the **Sediment Area** frame. On the **SELECT ID** window, highlight *"SED1"* and click **OK** to close the window.

(d) Click the browse button beside the **Soil ID** textbox in the **Sediment Area** frame. On the **SELECT ID** window, highlight **Soil ID** *"6453"* and click **OK** to select and close the window.

(e) Enter *"0.0508"* into the **Area (sq mi)** textbox in the **Sediment Area** frame.

(f) Click the **Save** button to save the data just entered. The window should look like the following figure.



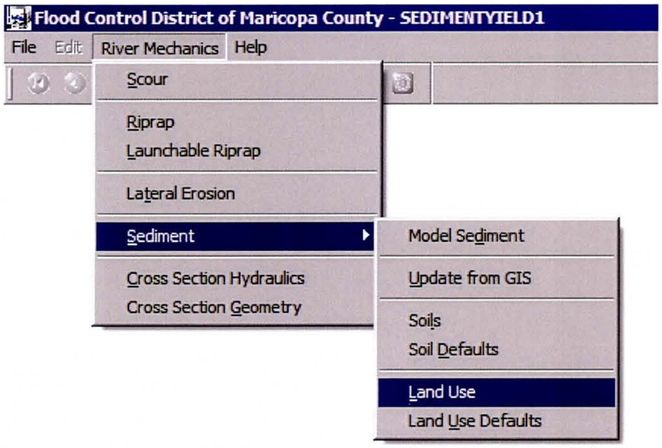
Repeat the above five steps to enter the rest of the soils data for this sediment area.

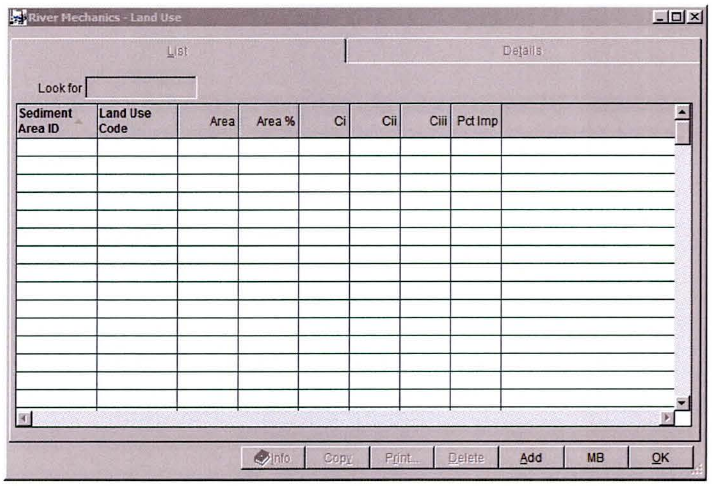
Sediment Area ID	Soil ID	Area (sq mi)
• *SED1*	*64590*	*0.0447*
• *SED1*	*64591*	*0.2548*
• *SED1*	*64598*	*0.0004*

(g) After the data entry, click **OK** to close the window.

(C.2.2) How to Prepare Land Use Data

(a) Click **River Mechanics ➔ Sediment ➔ Land Use** from the menu bar on the main application window as is shown in the following figure and the blank **RIVER MECHANICS – LAND USE** window opens.





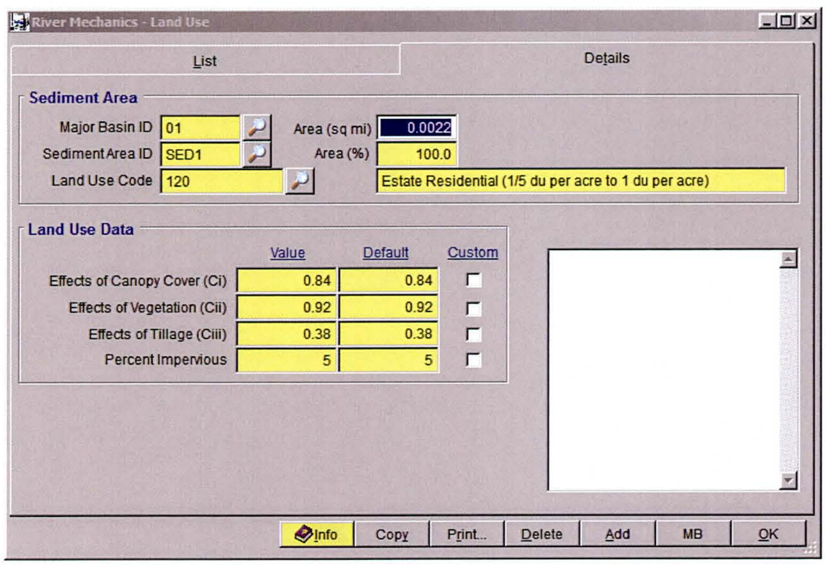
(b) Click the **Add** button to activate the data entry.

(c) Click the browse button beside the **Sediment Area ID** textbox in the **Sediment Area** frame to open the **SELECT ID** window. Highlight *"SED1"* and click **OK** to select and close the window.

(d) Click the browse button beside the **Land Use Code** textbox in the **Sediment Area** frame to open the **SELECT ID** window. Highlight code *"120"* and click **OK** to select and close the window.

(e) Enter *"0.0022"* into the **Area (sq mi)** textbox in the **Sediment Area** frame of the **RIVER MECHANICS – LAND USE** window.

(f) Click the **Save** button. The window should look like the following figure.



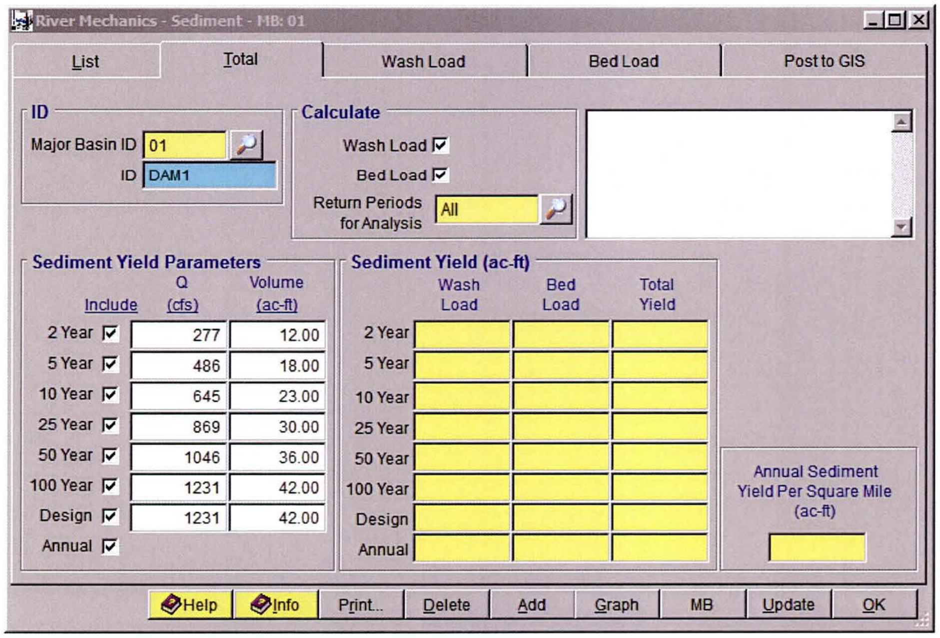
Repeat the above five steps to enter the rest of the land use data for this sediment area.

Sediment Area ID	Land Use Code	Area (sq mi)
• *SED1*	*150*	*0.1647*
• *SED1*	*160*	*0.0620*
• *SED1*	*180*	*0.0296*
• *SED1*	*230*	*0.0314*
• *SED1*	*410*	*0.0609*

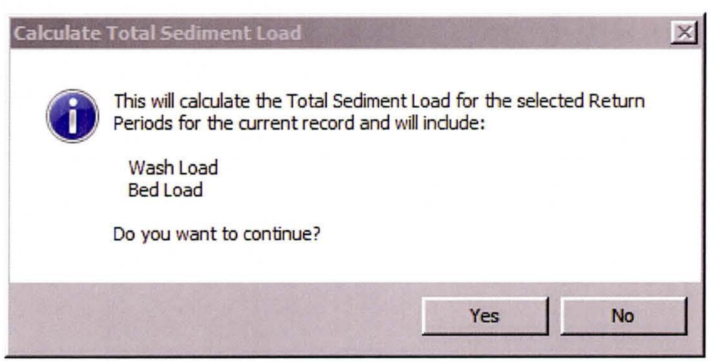
(g) After the data entry, click **OK** to close the window.

(D) Step 4 - Calculate the Sediment Yield

In this section, a step-by-step instruction will be provided how to calculate the sediment yield. Open the sediment yield window from the menu bar (**River Mechanics ➔ Sediment ➔ Model Sediment**) and on the **RIVER MECHANICS – SEDIMENT** window, click the **Total** tab.



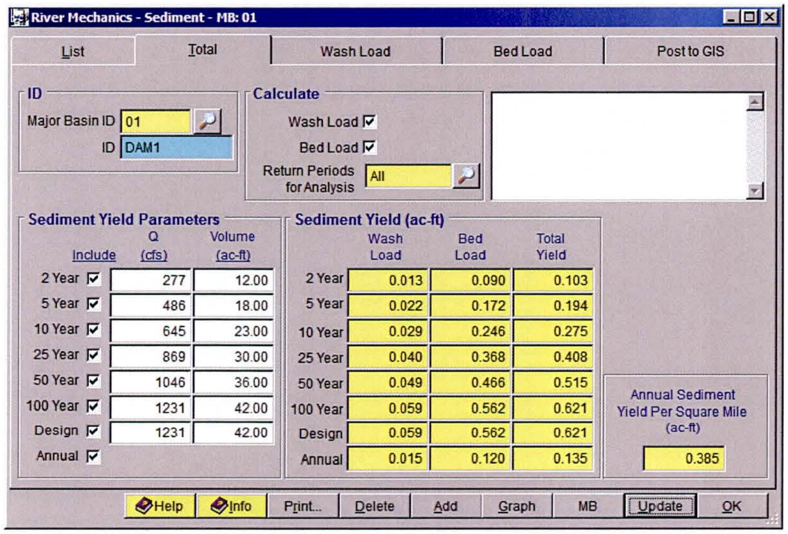
(a) Click the **Update** button on the **RIVER MECHANICS – SEDIMENT – MB: 01** window to compute the sediment yield. A new window **SELECT OPTION** opens, select *"This Major Basin"*, and click **OK** to close it.

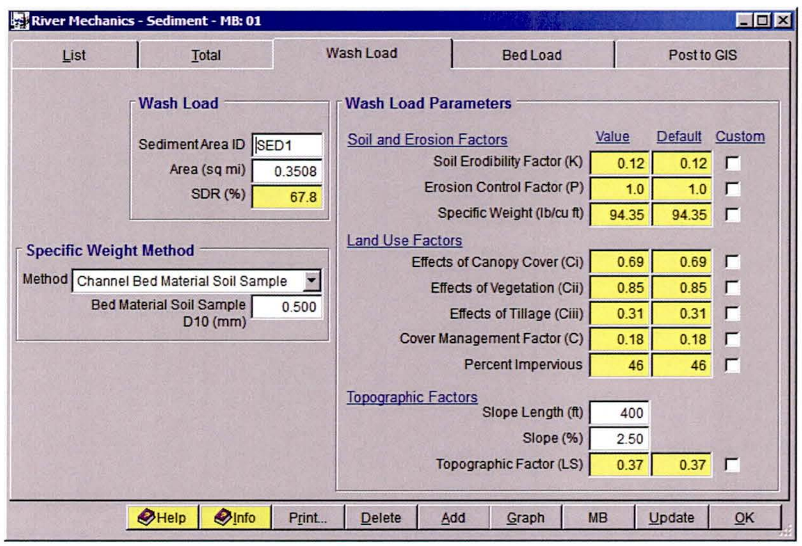


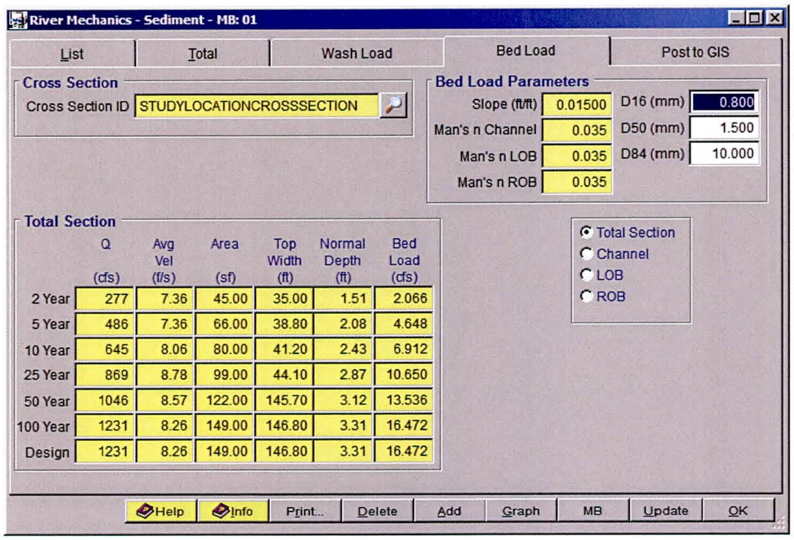
(b) On the **CALCULATE TOTAL SEDIMENT LOAD** dialog box, click **Yes** to continue.

The following three figures show the results in the **Total**, **Wash Load** and **Bed**

Load tabs when the *"Channel bed Material Soil Sample"* method is used in **Wash Load**.



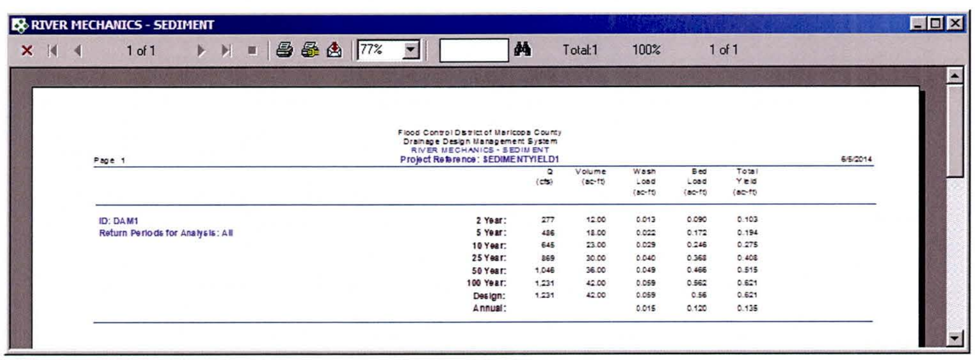




(E) Step 5 - Report the Results

In this section, the instruction will be given on how to view, print, and export the calculation results of the sediment yield.

(a) Report the results for Total Sediment Yield: Click the **Print ...** button on the **Total** tab of the **RIVER MECHANICS – SEDIMENT – MB: 01** window to generate a report like the following figure.



(b) To print the results, click the printer symbol ( ).

(c) To export the results in PDF format or other formats, click the export symbol ( )

(d) More detailed information for wash load, bed load, and **Cross Section Hydraulics** can also be viewed, printed, and exported by clicking the **Print...** button under **Wash Load, Bed Load** and **Cross Section Hydraulics** menu.

2.4 Calculate Riprap Size for Bank Protection at a Bend

2.4.1 Problem Statement

To estimate the riprap sizing for bank protection using "*Channel Banks on Straight Reach*" type with the following given design parameters:

- The Cross Section "*STUDYLOCATIONCROSSSECTION*"
  - Parameters for Hydraulics and Geometry:
    - **Design Flow Rate (cfs):** *3200*
    - **Channel Slope (ft/ft):** *0.015*
    - **Design Manning's n:** *0.035*
  - The geometry (station and elevation) of this cross section:

Station (X)	Elevation (Y)
100	*100*
106	*98*
156	*98*
166	*95*
191	*95*
201	*98*
251	*98*
257	*100*

  - Parameters for Channel Banks:
    - **Bank Slope Angle (Degrees):** *45.00*
    - **Specific Weight for Stone (lb/cu ft):** *150.00*
    - **Specific Weight for Water (lb/cu ft):** *62.40*

2.4.2 Step-by-Step Procedures

Step 1: Establish a New Project and Default Set-up

Step 2: Prepare the Cross Section Geometry

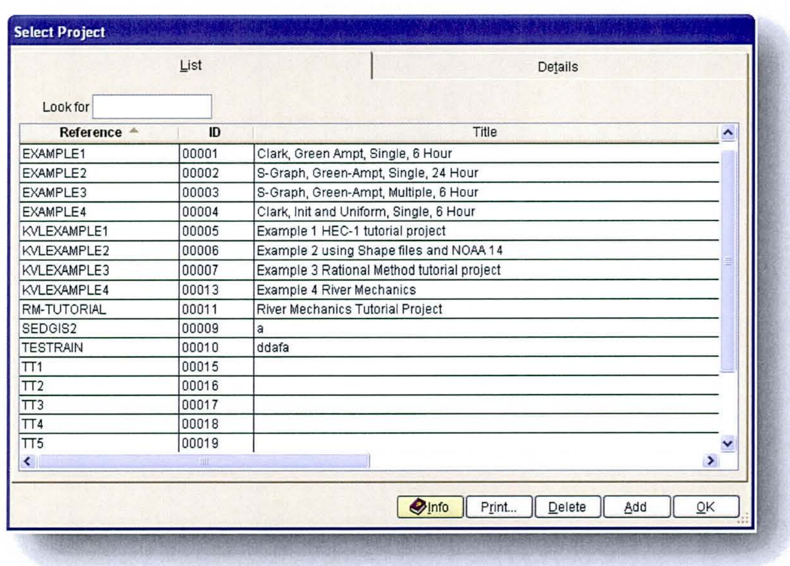
Step 3: Calculate Riprap Sizing

Step 4: Report the Results

(A) Step 1 - Establish a New Project and Defaults Set-up

(a) Click the **DDMSW** icon on the Desktop or Program menu to launch the **DDMSW**. Click **OK** to accept the software disclaimer as is shown in the following figure.

After the **DDMSW** is launched, the **Select Project** window is automatically opened as is shown in the following figure.



(b) Click the **Add** button on the **SELECT PROJECT** window to start a new project (or you can start a new project by **File → New Project**).

(c) Type *"RIPRAPSIZING1"* into the **Reference** textbox. This is the name of this newly created project. The users can choose the name as long as it does not exist in the **DDMSW** database.

(d) Type into the **Title** textbox a brief descriptive title of this project. ***(Optional)***

(e) Type into the **Location** textbox the location of this project. ***(Optional)***

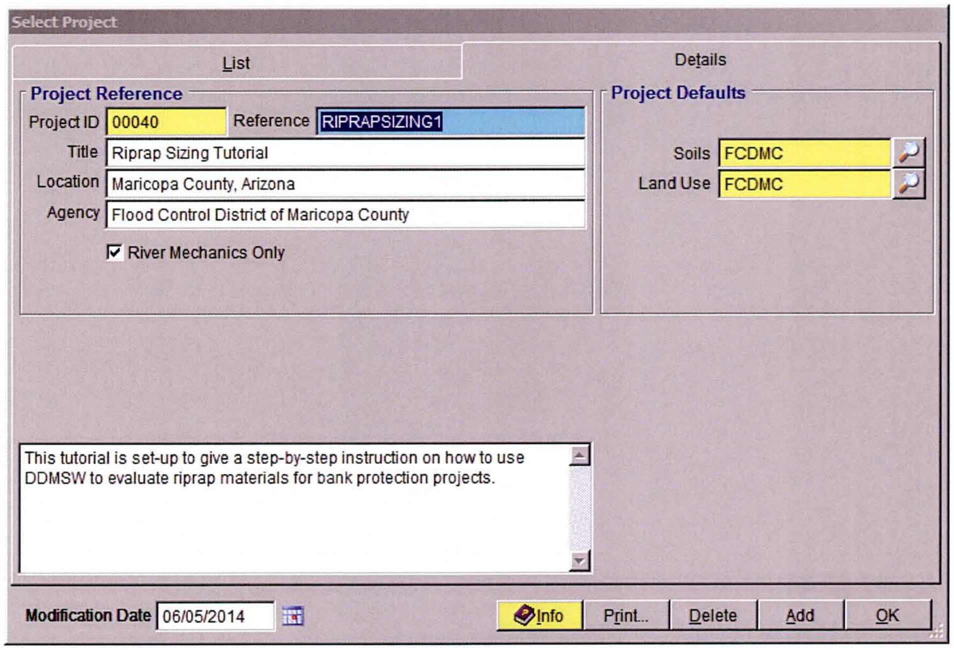
(f) Type into the **Agency** textbox the agency or company name. ***(Optional)***

(g) Check **River Mechanics Only** checkbox for this project.

(h) Type a detailed description of this project into the comment area under the **Project Reference** frame. ***(Optional)***

(i) Click **Save** button to save the entered data.

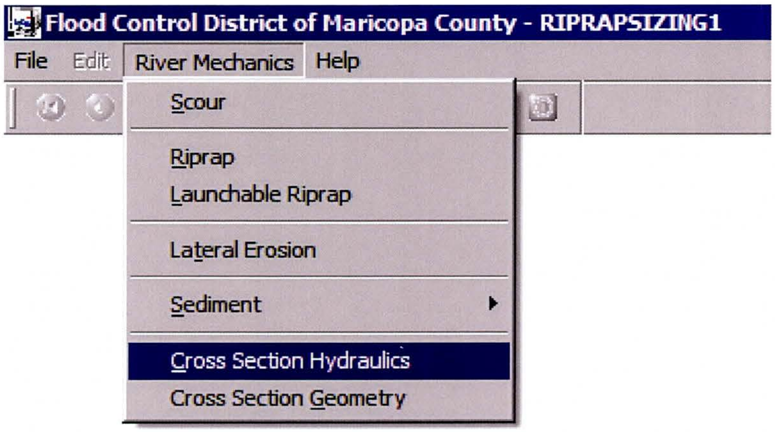
(j) Click **OK** button on the **SELECT PROJECT** window, and click **OK** button on the pop-up message box. The following figure shows what the window looks like.



Note: the **Project ID** *00040* in the above figure is the database records unique read-only identifier of the project, which is automatically generated by the program when a new project is created. When the users create a new project, the **Project ID** of this new project will not be the same as the **Project ID** shown in the above figure.

(B) Step 2 - Prepare the Cross Section Hydraulics

(a) From the menu bar of the main application window, click **River Mechanics ➔ Cross Section Hydraulics** to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window.



(b) Click **Add** button on the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window to activate all the necessary data entry fields.

(c) Select the "*Calculate Data*" for the **Source** ("*Enter Data*" can also be selected for the **Source** if the hydraulic results for a cross-section are available.)

(d) Type "*STUDYLOCATIONCROSSSECTION*" into the **Cross Section ID** textbox.

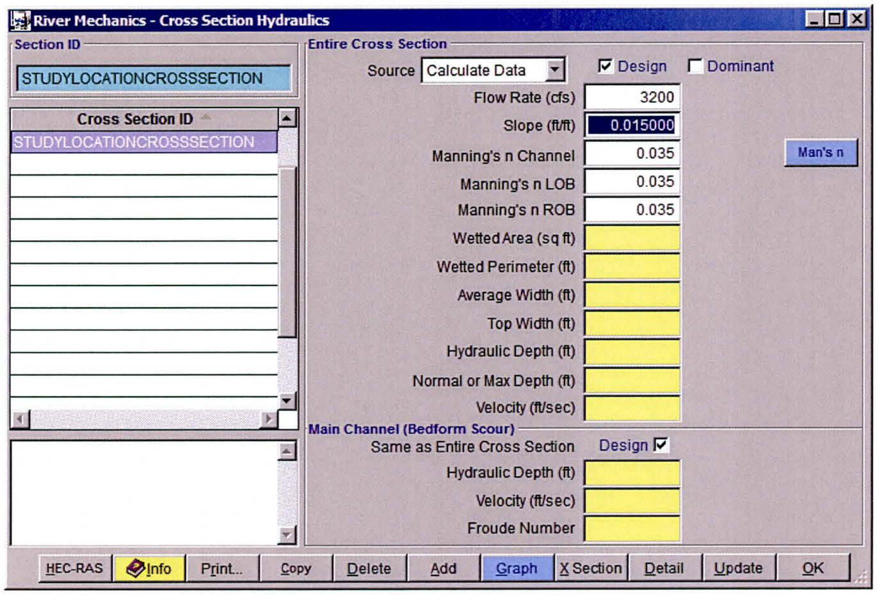
(e) Uncheck the checkbox for **Dominant** in the **Entire Cross Section** frame since dominant discharge will not be used for riprap sizing. By default, both the **Design** and **Dominant** checkboxes are checked in the **Entire Cross Section** frame.

(f) Type in "*3200*" into the **Flow Rate (cfs)** textbox for **Design**.

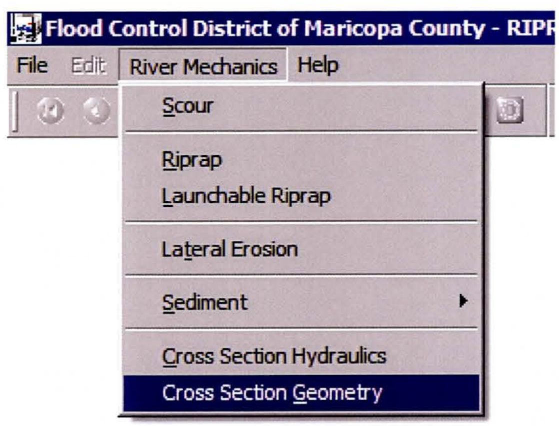
(g) Type in "*0.015*" into the **Slope (ft/ft)** textbox for **Design**.

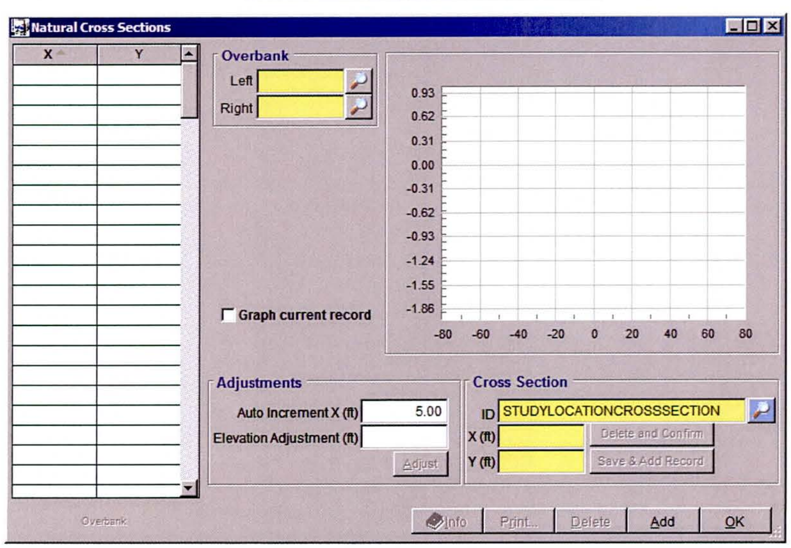
(h) Type in "0.035" into the **Manning's n Channel** textbox for **Design**. Use the same values for **Manning's n LOB** and **Manning's n ROB** textboxes.

(i) After the data entry, click the **Save** button. The window should look like the figure below. Click the **OK** button to close the window.

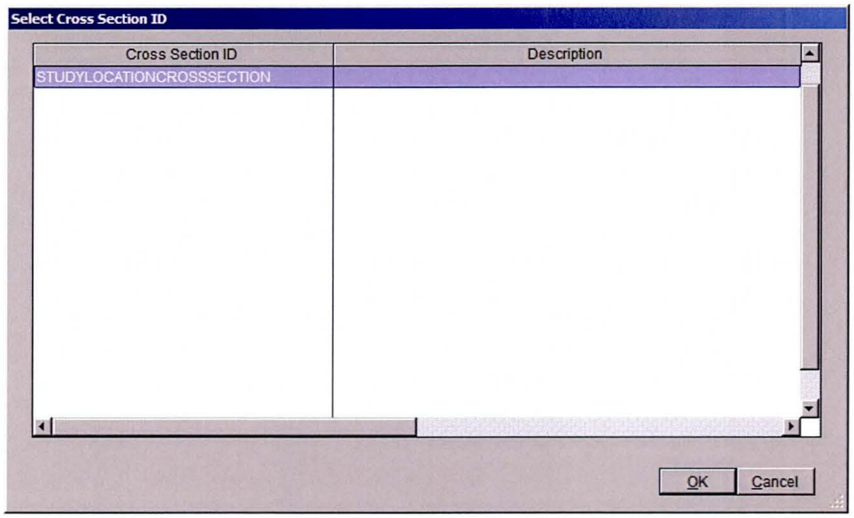


(j) From the menu bar of the main application window, click **River Mechanics → Cross Section Geometry** to open the **Natural Cross Sections** window opens.





(k) Click the browse button ("Magnifying Glass") on the right side of the **Cross Section ID** textbox to open the **SELECT CROSS SECTION ID** window. On the **SELECT CROSS SECTION ID** window, highlight **Cross Section ID** *"STUDYLOCATIONCROSSSECTION"* and click **OK** to close the window.



(l) Click the **Add** button on the **NATURAL CROSS SECTIONS** window and enter *"100"* and *"100"* into the **X** and **Y** textboxes respectively. Click the **Save & Add Record** button to save the data.

(m) Repeat the above step for the rest of pairs of **X** and **Y** values.

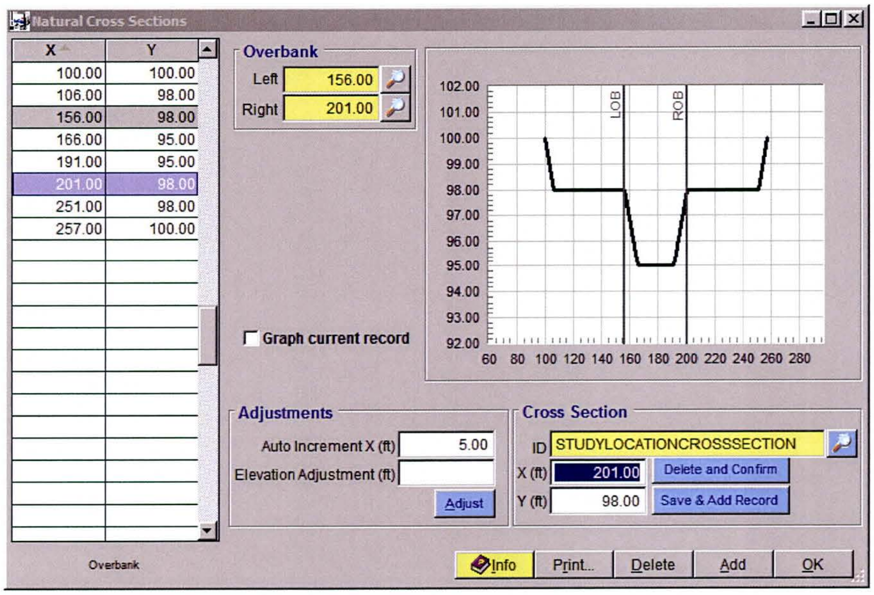
Station (X)	Elevation (Y)
106	*98*
156	*98*
166	*95*
191	*95*
201	*98*
251	*98*
257	*100*

(n) To enter the **Left Bank Station**, highlight/select **Station (X)** *"156.00"* on the XY table grid, and click the magnifying glass on the right of the **Left Overbank** textbox. The textbox shows a value of "156.00."

(o) To enter the **Right Bank Station**, highlight/select the **Station (X)** *"201.00"* on the XY table grid, and click the magnifying glass on the right of the **Right Overbank** textbox. The textbox shows a value of *"201.00."*

After all the XY values are entered and after the **Left** and **Right Bank Stations** are defined, the **NATURAL CROSS SECTIONS** window looks like the following figure.

(p) Click **OK** to close the window.

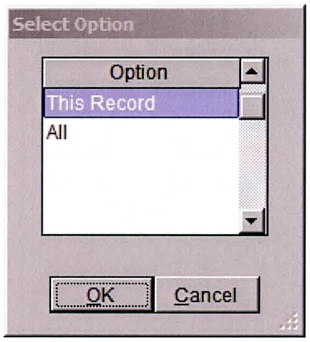


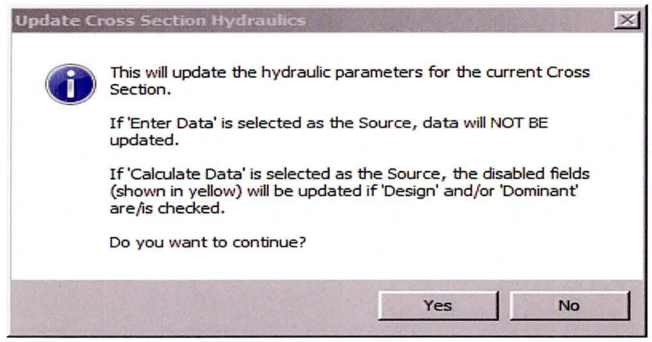
The cross-section data can be imported into **DDMSW**. However, the XY data must be prepared based on **DDMSW** XY data format before the cross-section is imported. To know the **DDMSW** XY data format, export the data for an existing cross-section (**File** ➔ **Export Data** ➔ **Section** ➔ **Hydraulics** ➔ **OK** ➔ *select "Crosssections" under* **Table Name** field name ➔ *check* **XLS** *radio button in the* **File Type** *frame for* **Excel** ➔ **Export** ➔ *use default file name or define a file name* ➔ **Save** ➔ **Yes** ➔ **OK**)

(q) Click **OK** to close the **NATURAL CROSS SECTIONS** window.

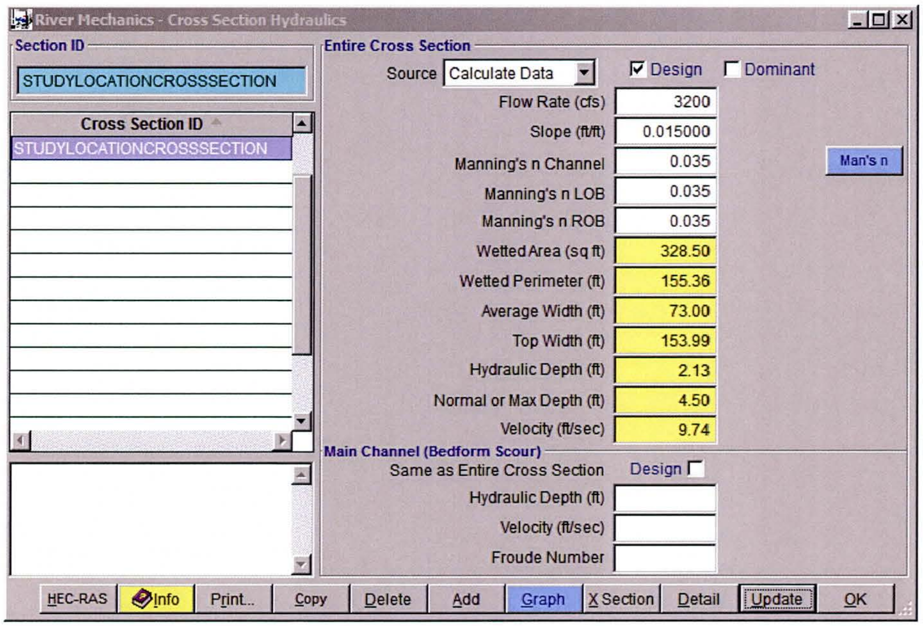
(r) Go back to the main application window, click **River Mechanics** ➔ **Cross Section Hydraulics** from the menu bar to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window. Click the **Update** button to evaluate the hydraulics.

(s) Highlight *"This Record"* and click **OK** button to close the **SELECT OPTION** window. When the **UPDATE CROSS SECTION HYDRAULICS** window opens, click **Yes** to continue.



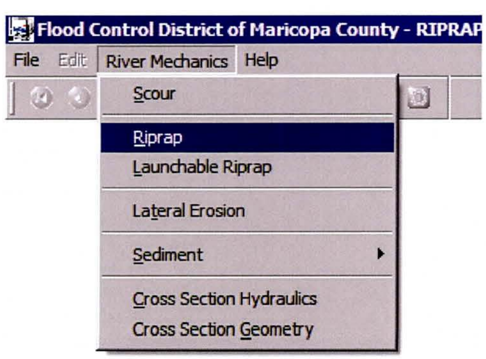


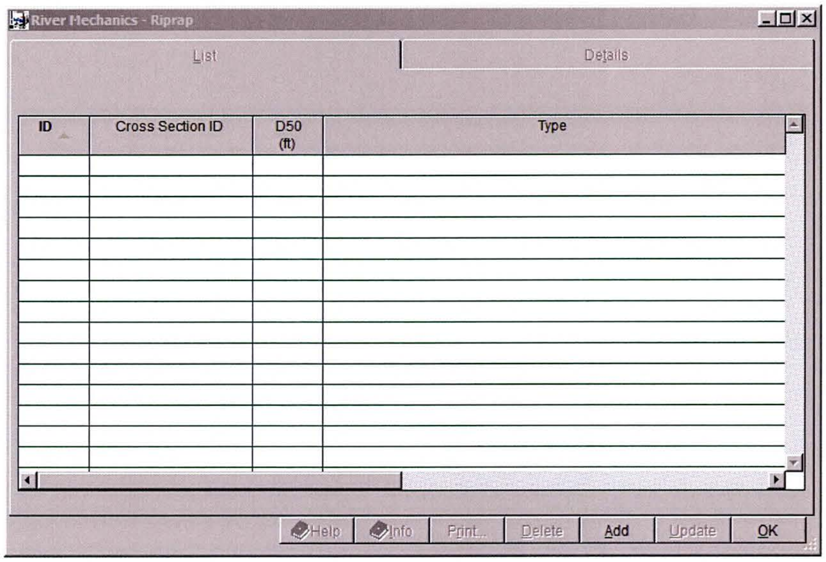
After the update, the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window looks like the following figure.



(C) Step 3 - Calculate Riprap Size

(a) From the menu bar of main application window, click **River Mechanics ➔Riprap** to open the **RIVER MECHANICS - RIPRAP** window.





(b) Click **Add** button on the **RIVER MECHANICS - RIPRAP** window.

(c) Enter *"CHNL1"* into the **Location ID** textbox

(d) Browse for *"Channel Banks on Curved Reach"* in the **Type** textbox

(e) Click **OK**

(f) Check **Use Cross Section ID** check box

(g) Browse for *"STUDYLOCATIONCROSSSECTION"* in the **Section ID** textbox.

(h) Click **OK**

(i) Enter *"45"* into the **Bank Angle (degrees)** textbox

(j) Enter *"150.00"* into the **Specific Weight Stone (lb/cu ft)** textbox

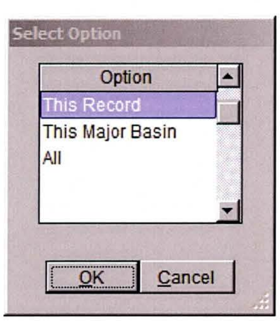
(k) Enter *"62.40"* into the **Specific Weight Water (lb/cu ft)** textbox

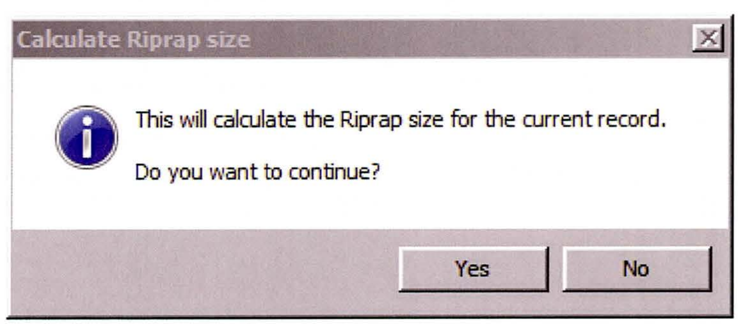
(l) Select *"Angular"* from the drop down for **Riprap Type** in the **Safety Factor** frame.

(m) Click the **Save** button.

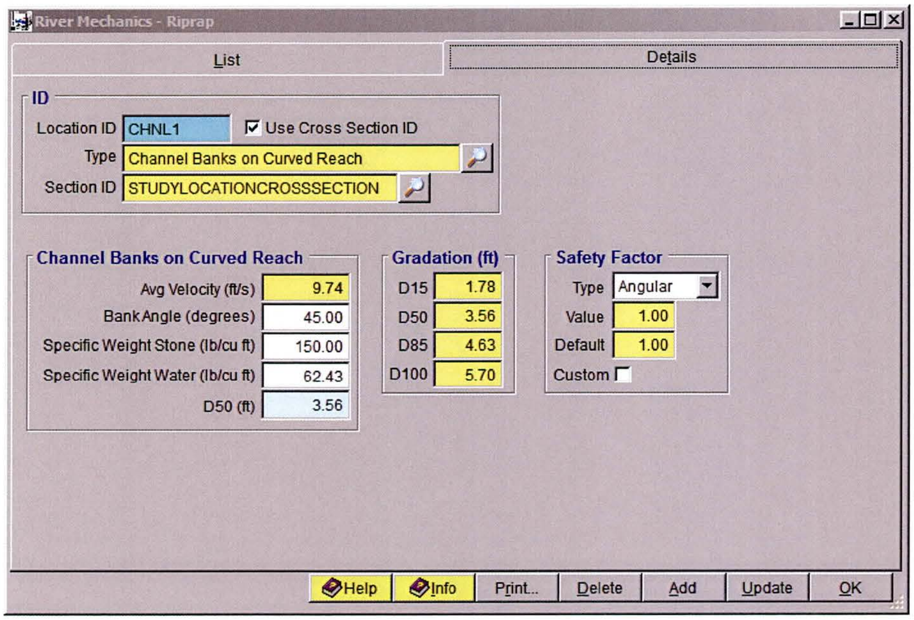
(n) Click **Update** button to compute riprap median size **D50** in feet.

(o) Highlight *"This Record"* in the **SELECTION OPTION** window and click **OK**. Click **Yes** when the **CALCULATE RIPRAP SIZE** dialog box opens.





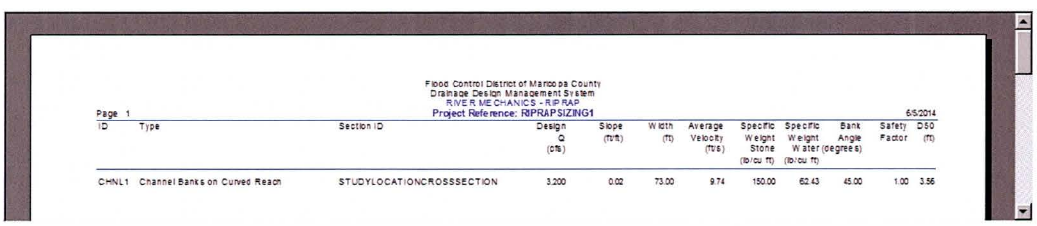
After the update process is finished, the window looks like what is shown in the following figure. Click **OK** to close the window.



(D) Step 4 - Report the Results

In this section, the instruction will be given on how to view, print, and export the calculation results of the riprap sizing.

(a) Click the **Print ...** button on the **RIVER MECHANICS – RIPRAP** window. A report will be generated as is shown in the following figure.



Flood Control District of Maricopa County
Drainage Design Management System
RIVER MECHANICS - RIPRAP
Project Reference: RIPRAPSIZING1

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ID	Type	Section ID	Design Q (cfs)	Slope (ft/ft)	Width (ft)	Average Velocity (ft/s)	Specific Weight Stone (lb/cu ft)	Specific Weight Water (lb/cu ft)	Bank Angle (degrees)	Safety Factor	D50 (ft)
CHNL1	Channel Banks on Curved Reach	STUDYLOCATIONCROSSSECTION	3.200	0.02	73.00	9.74	150.00	62.43	45.00	1.00	3.56

(b) To print the results , click the printer symbol ( ).

(c) To export the results in PDF format or other formats, click the export symbol ( )

(d) More detailed information for cross section hydraulics can also be viewed, printed, and exported by clicking the **Print...** button under **Cross Section Hydraulics** menu.

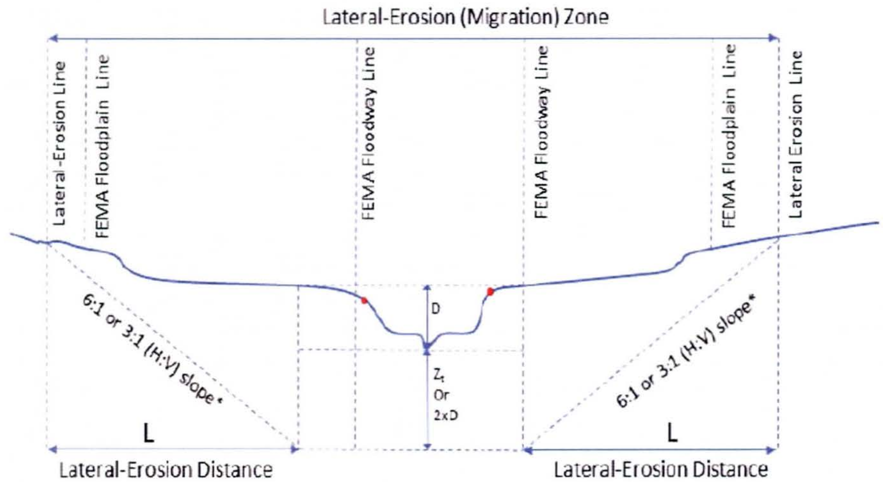
2.5 Lateral Erosion Analysis

This tutorial, for **Project Reference** *"LATEROSIONEXAMPLE"* provides a Lateral Erosion working example using **DDMSW**. If you do not see this project in **File ➔ Select Project**, then import it from the Backup directory (**File ➔ Project Management ➔ Import Project**).

The alternatives include selecting (or not selecting) the following available data:

1. Nothing Selected (No Data)
2. Scour
3. Historical Photo
4. Cross Section

All the alternative analyses reference the following figure:



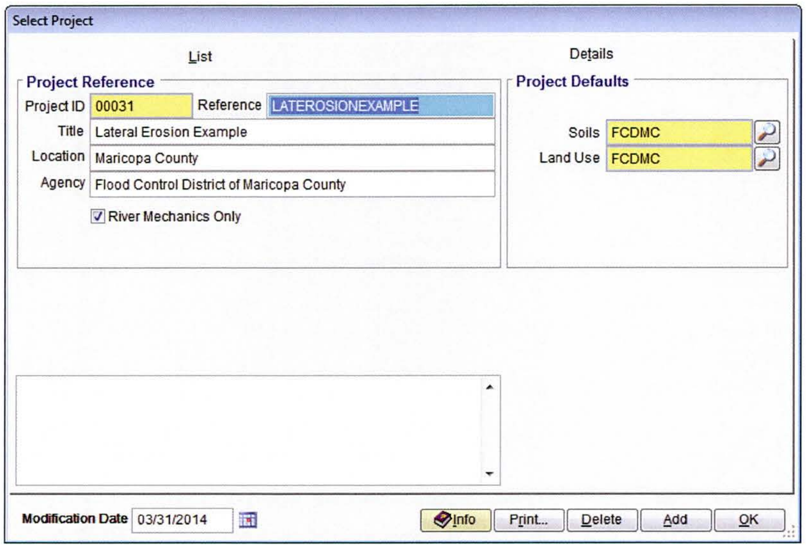
• Main-channel bank stations

*: 6:1 if no historical single-event lateral erosion distance is available from rectified aerial photos.
3:1 if the single-event lateral erosion distance is available from rectified aerial photos and is added to the computation of lateral erosion distance.

Z_t: scour depth

D: main channel depth measured from the intersection point between the highest FEMA floodway line and ground elevation. Use a higher FEMA floodway elevation on the banks to draw a horizontal line to intersect the ground elevation.

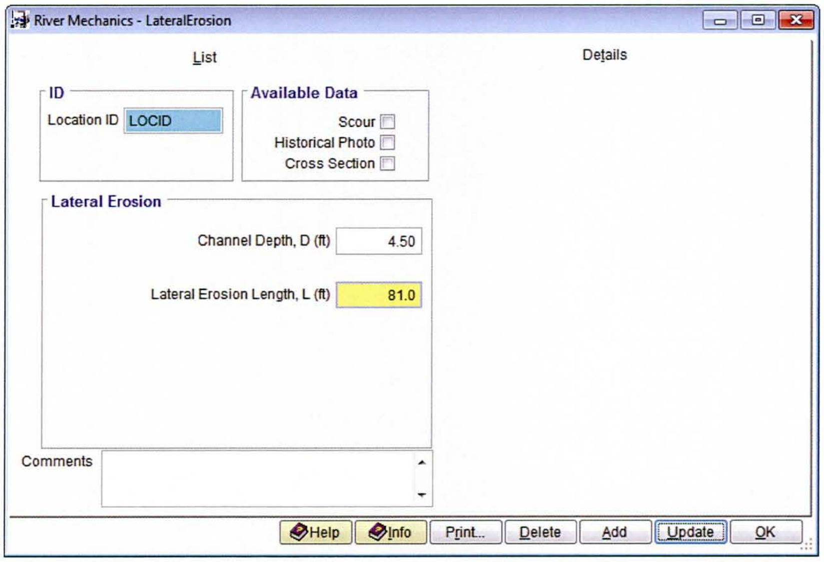
Project Defaults (**File ➔Select Project**). For this example select the data as shown on the following screen. Click **OK** to exit the **SELECT PROJECT** window.



Lateral Erosion (**River Mechanics ➔Lateral Erosion**). Add a new record and enter *"LOCID"* for the **Location ID**.

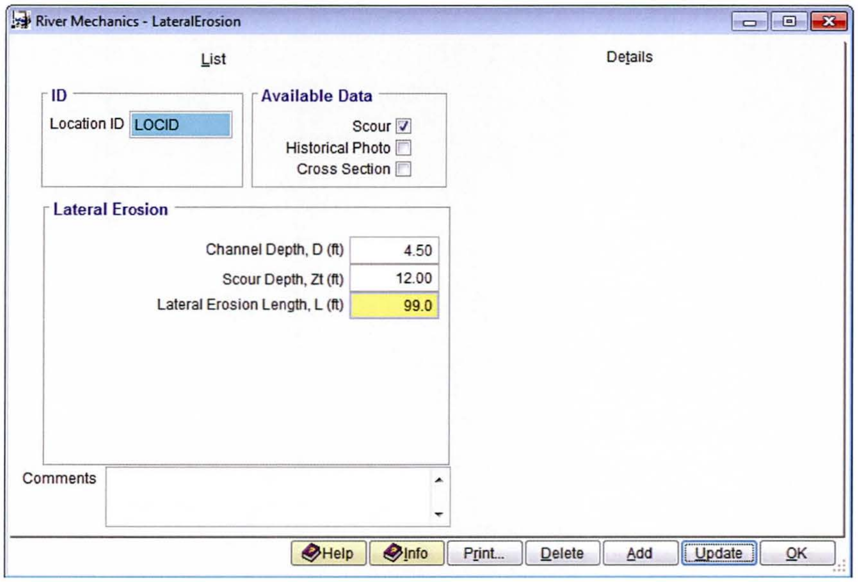
(A) Nothing Selected (No Data)

Enter *"4.5"* into the **Channel Depth, D (ft)** textbox and click **Save** to save the data entered. Click **Update,** then select *"This Record"* from the **SELECT OPTION** window and click **OK** to close the selection window. Click **Yes** to continue when the **CALCULATE LATERAL EROSION** window opens. The following figure shows the results.



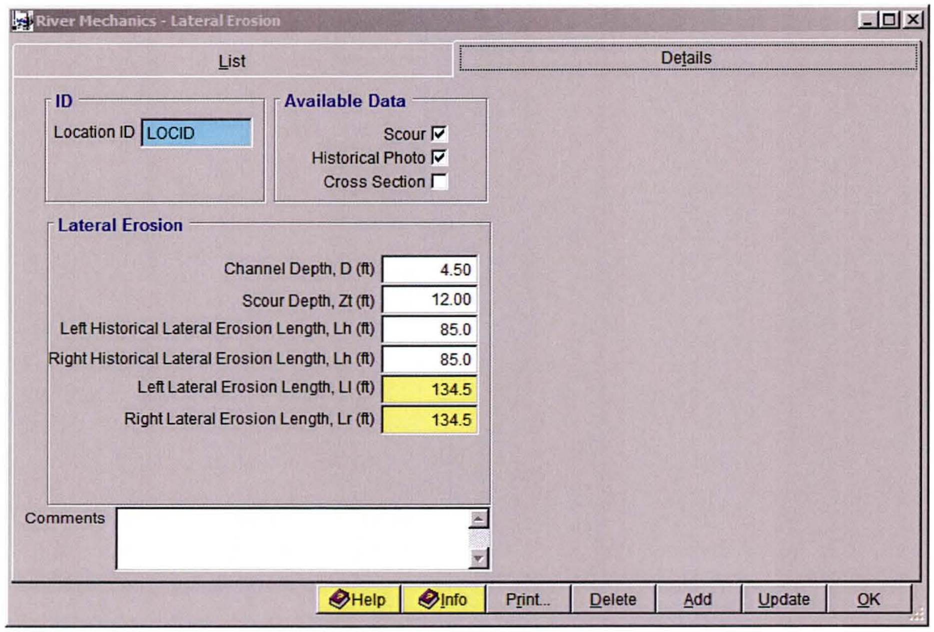
(B) Scour

Check Scour and enter *"12.00"* into the **Scour Depth, Zt (ft)** textbox. The scour depth would have been calculated using FCDMC methodologies or equivalent. Click **Update** and select *"This Record"* from the **SELECT OPTION** window. Click **OK** to close the selection window and click **Yes** to close the **CALCULATE LATERAL EROSION** window. The following shows the results.



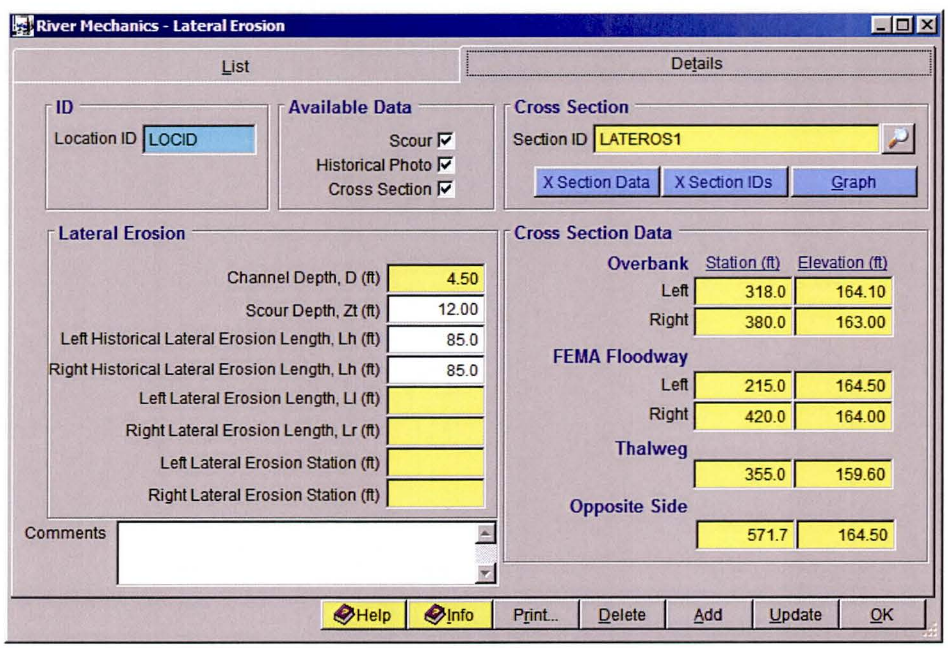
(C) Historical Photo

In addition to the above, check **Historical Photo** checkbox and enter "85.00" as the **Left** and **Right Historical Lateral Erosion Length, Lh (ft).** This data would probably have been measured from an historical rectified aerial photo. Click **Update**. Select *"This Record"* from the **SELECT OPTION** dialog box and click **OK**. The following shows the results.



(D) Cross Section

In addition to the above, check **Cross Section** and the following additional options are available.

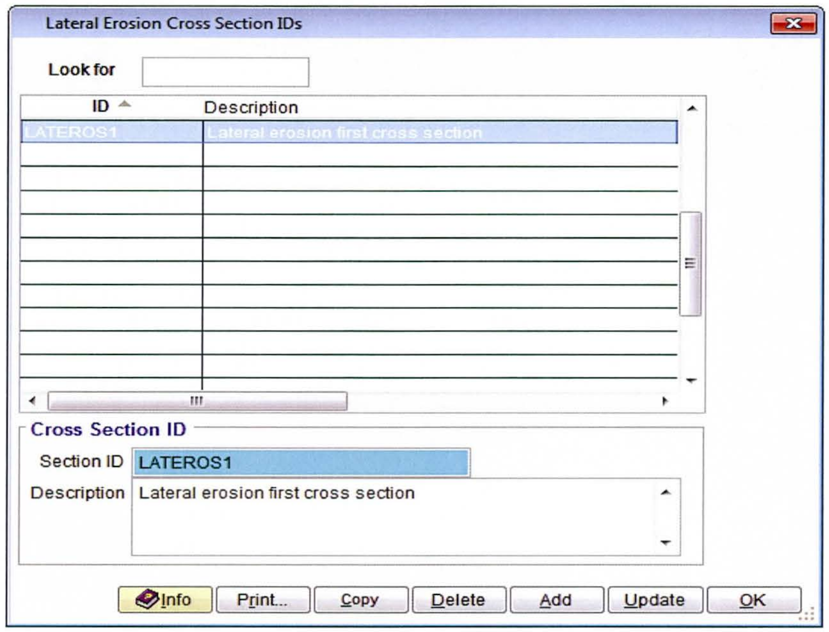


With this option, it is necessary to create the **Cross Section ID** and corresponding Cross Section data (**X Section Data**). Please note that

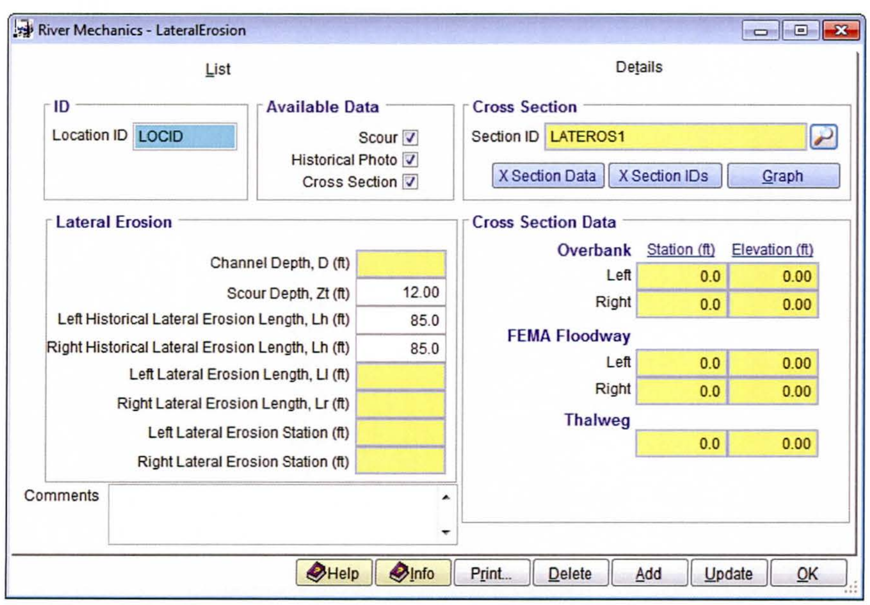
Channel Depth, D (ft) is now disabled as it will be selected / determined from the Cross Section data.

(D.1) Cross Section ID

Click **X Section IDs** button, to open the **LATERAL EROSION CROSS SECTION IDS** form and to add a record and enter the data shown below. After all data has been entered, click **OK** to close the form.

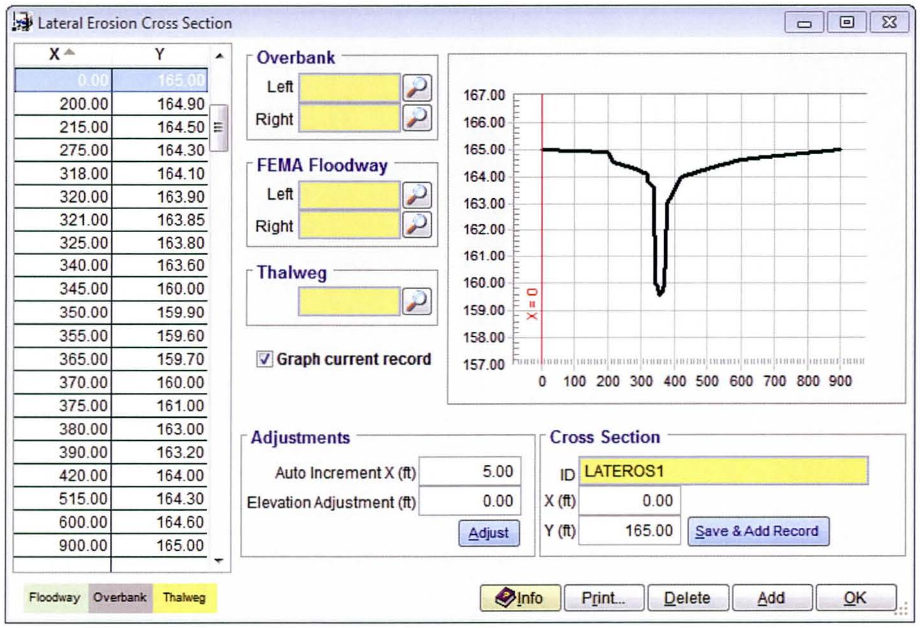


Now on the **LATERAL EROSION** form, select the **Section ID** as shown below.

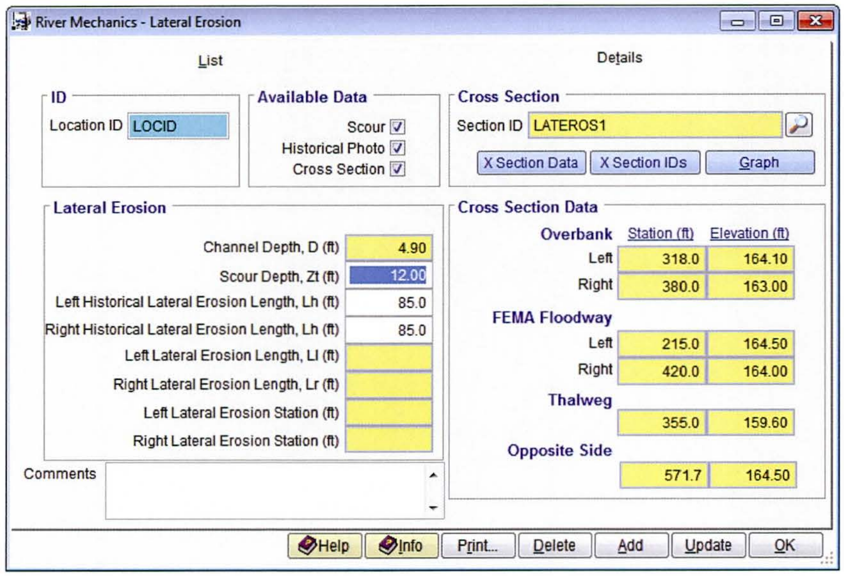


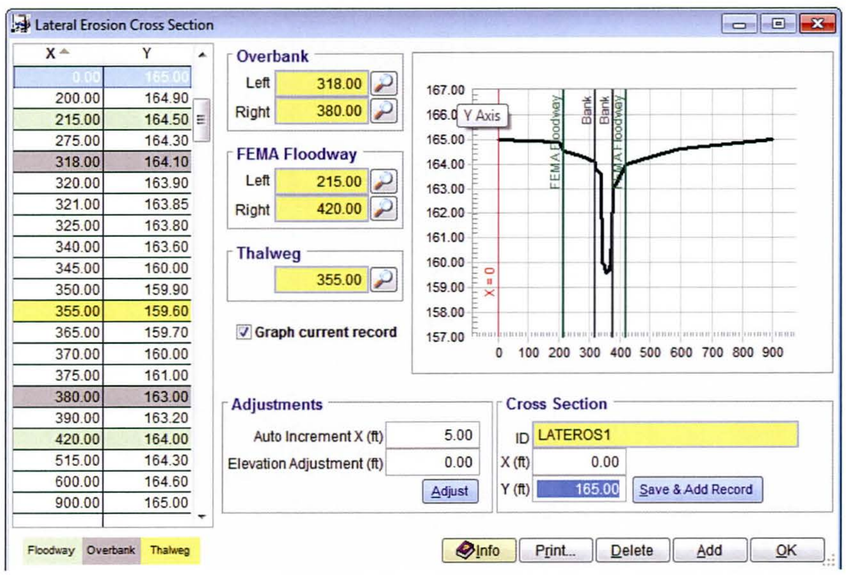
(D.2) Cross Section Data

Click the **X Section Data** button to open the **LATERAL EROSION CROSS SECTION** form and add **X, Y** data as shown below. Check **Graph current record** checkbox to graph the currently selected X value.

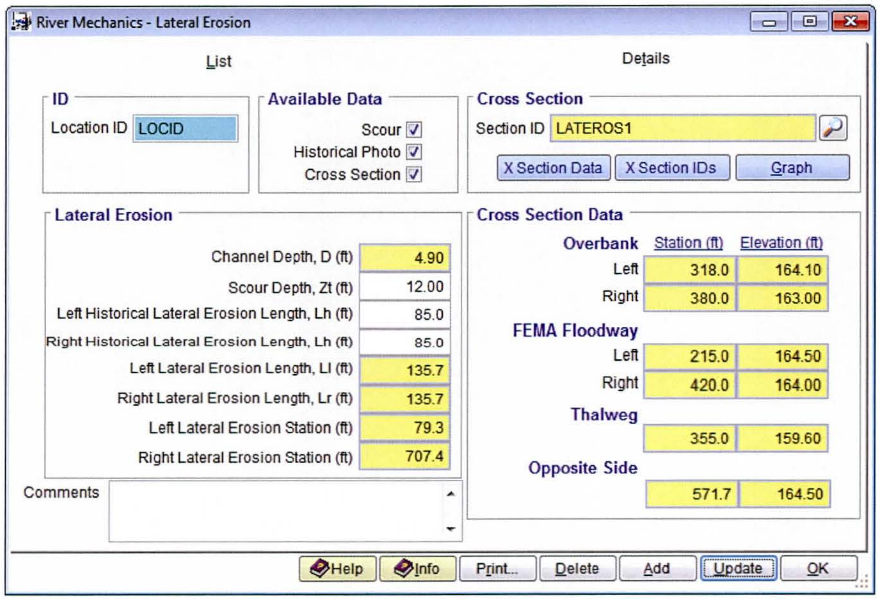


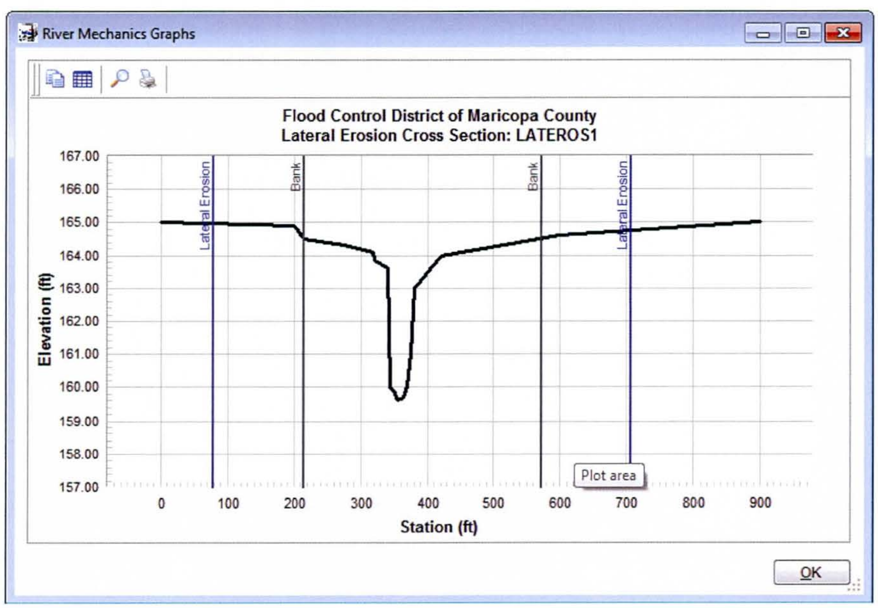
To graph the locations of the **Left** and **Right Overbank** stations, the **Left** and **Right FEMA Floodway** (if available) and the Thalweg, highlight the record on the grid and click the appropriate "Magnifying Glass" button. To blank any of these data, Right click on the appropriate "Magnifying Glass" button. The results are shown below. When the appropriate Overbank, FEMA Floodway and Thalweg stations are selected, the data is graphed and shown on the **LATERAL EROSION** form as shown below. Please note that when the left and right elevations are not the same, the **Opposite Side** station is calculated.


River Mechanics - Lateral Erosion
List
Details
ID
Location ID LOCID
Available Data
Scour
Historical Photo
Cross Section
Cross Section
Section ID LATEROS1
X Section Data
X Section IDs
Graph
Lateral Erosion
Channel Depth, D (ft) 4.90
Scour Depth, Zt (ft) 12.00
Left Historical Lateral Erosion Length, Lh (ft) 85.0
Right Historical Lateral Erosion Length, Lh (ft) 85.0
Left Lateral Erosion Length, Ll (ft)
Right Lateral Erosion Length, Lr (ft)
Left Lateral Erosion Station (ft)
Right Lateral Erosion Station (ft)
Cross Section Data
Overbank Station (ft) Elevation (ft)
Left 318.0 164.10
Right 380.0 163.00
FEMA Floodway
Left 215.0 164.50
Right 420.0 164.00
Thalweg
355.0 159.60
Opposite Side
571.7 164.50
Comments
Help
Info
Print...
Delete
Add
Update
OK


Lateral Erosion Cross Section
X Y
0.00 165.00
200.00 164.90
215.00 164.50
275.00 164.30
318.00 164.10
320.00 163.90
321.00 163.85
325.00 163.80
340.00 163.60
345.00 160.00
350.00 159.90
355.00 159.60
365.00 159.70
370.00 160.00
375.00 161.00
380.00 163.00
390.00 163.20
420.00 164.00
515.00 164.30
600.00 164.60
900.00 165.00
Floodway
Overbank
Thalweg
Overbank
Left 318.00
Right 380.00
FEMA Floodway
Left 215.00
Right 420.00
Thalweg
355.00
Graph current record
Y Axis
X = 0
FEMA Floodway
Bank
Bank
FEMA Floodway
167.00
165.00
164.00
163.00
162.00
161.00
160.00
159.00
158.00
157.00
0 100 200 300 400 500 600 700 800 900
Adjustments
Auto Increment X (ft) 5.00
Elevation Adjustment (ft) 0.00
Adjust
Cross Section
ID LATEROS1
X (ft) 0.00
Y (ft) 165.00
Save & Add Record
Info
Print...
Delete
Add
OK

Finally click **Update**. Select *"This Record"* from the **SELECT OPTION** dialog box and click **OK**. Then click **Graph** to graph/plot the results. The following shows the results.





DDMSW 4.8.0
Training Workshops
STORM DRAINAGE HYDRAULICS

Engineering Application Development and River Mechanics Branch
Engineering Division
Flood Control District of Maricopa County

June 12, 2014

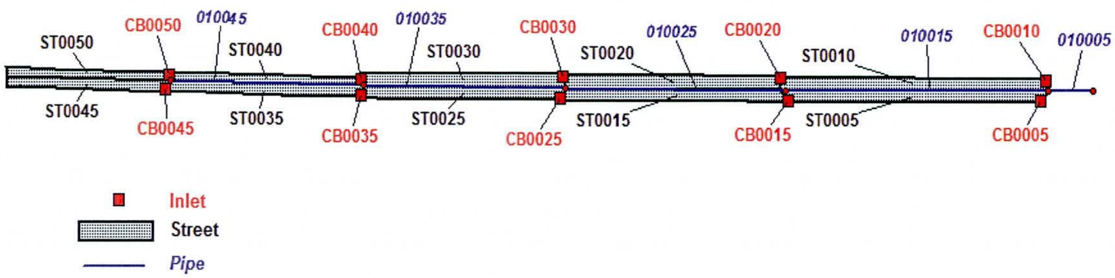
This document contains step-by-step tutorials for the Storm Drainage Hydraulics module of DDMSW. The two tutorials for the Storm Drainage Hydraulics cover the computations of street surface drainage and storm drainage system for hydraulic grade line analysis.

Table of Contents

STORM DRAINAGE HYDRAULICS

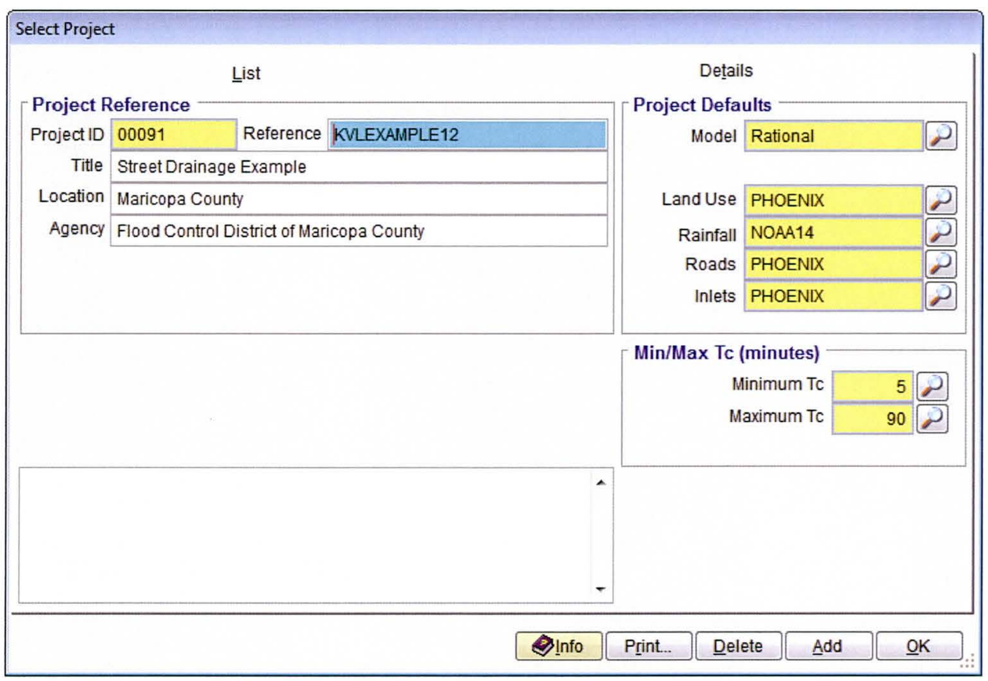
3.1 Street Drainage Example

This tutorial provides a Street Drainage working example using **DDMSW** (**KVLEXAMPLE12**). The layout of the system is shown below.



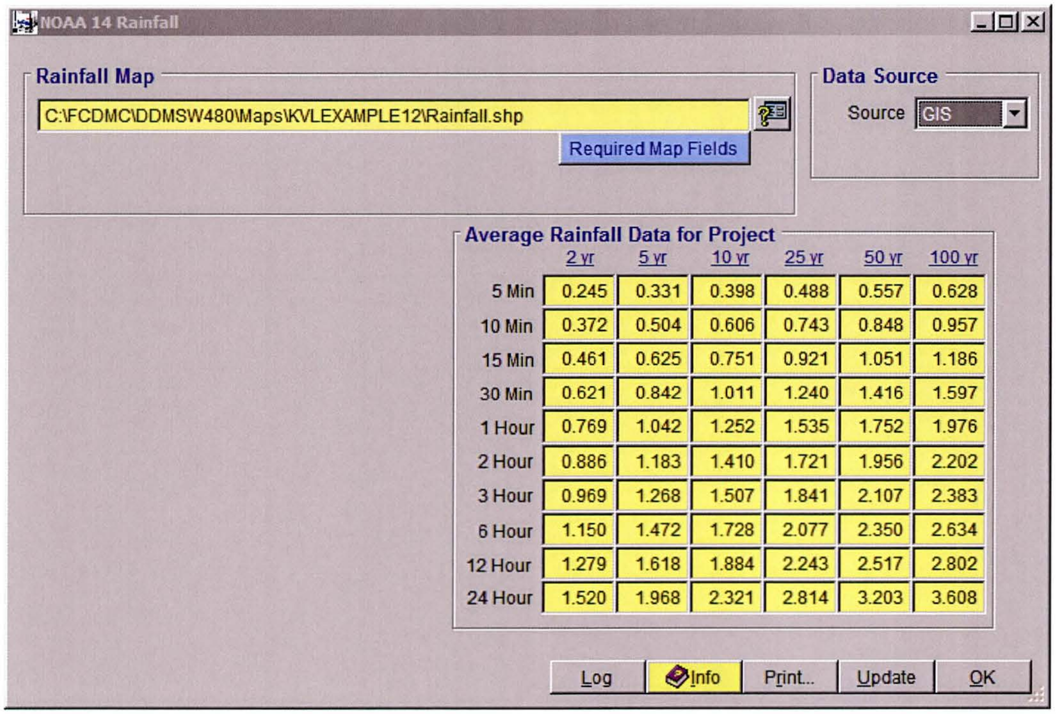
(A) Step 1 - Project Defaults (File ➔ Select Project)

For this example, select the data (**KVLEXAMPLE12**) as shown on the following screen.



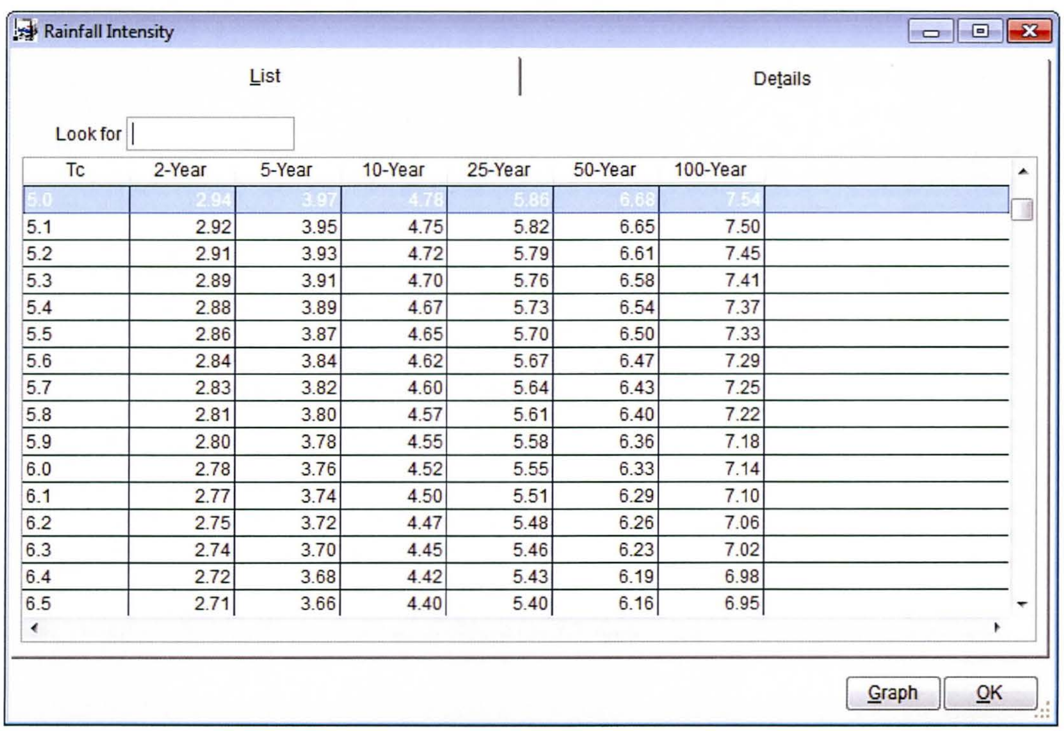
(B) Step 2 - Develop Rainfall (Hydrology ➔ Rainfall)

For this example, NOAA14 Rainfall shall be used and be developed using GIS. The GIS Shape file is included in the **KVLEXAMPLE12** subfolder in the **MAPS** folder (**C:\FCDMC\DDMSW480\Maps\KVLExample12**). Your path to this file may be different to that shown in this example. Enter the data as shown on the following screen and then click **Update** to develop the rainfall data. Click **Yes** to continue and to exit the **UPDATE NOAA14 RAINFALL USING GIS** window. Click **OK** to exit the **NOAA 14 RAINFALL** window.

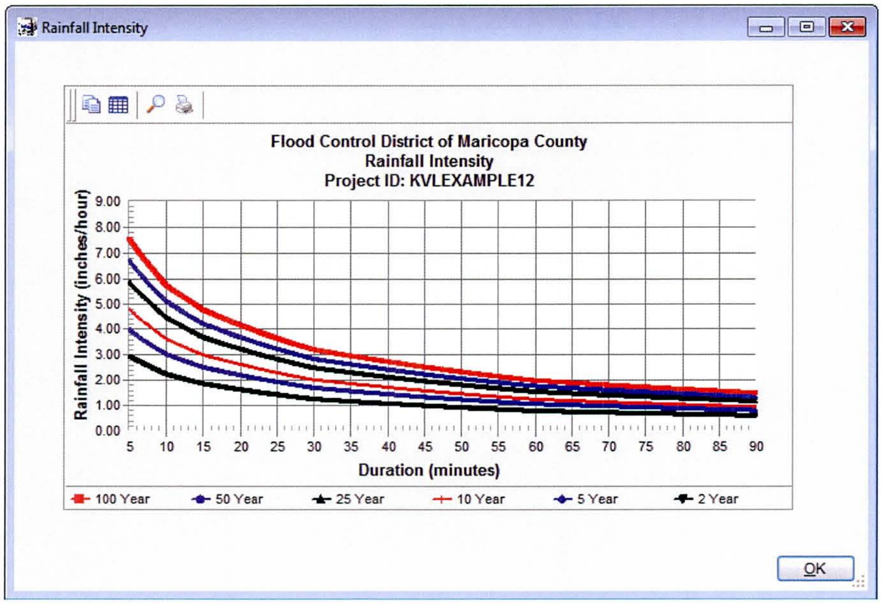


	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
5 Min	0.245	0.331	0.398	0.488	0.557	0.628
10 Min	0.372	0.504	0.606	0.743	0.848	0.957
15 Min	0.461	0.625	0.751	0.921	1.051	1.186
30 Min	0.621	0.842	1.011	1.240	1.416	1.597
1 Hour	0.769	1.042	1.252	1.535	1.752	1.976
2 Hour	0.886	1.183	1.410	1.721	1.956	2.202
3 Hour	0.969	1.268	1.507	1.841	2.107	2.383
6 Hour	1.150	1.472	1.728	2.077	2.350	2.634
12 Hour	1.279	1.618	1.884	2.243	2.517	2.802
24 Hour	1.520	1.968	2.321	2.814	3.203	3.608

To see a graph of the IDF curves, go to (**Hydrology →Rational Method →Rainfall Intensity**) and click **Graph.**

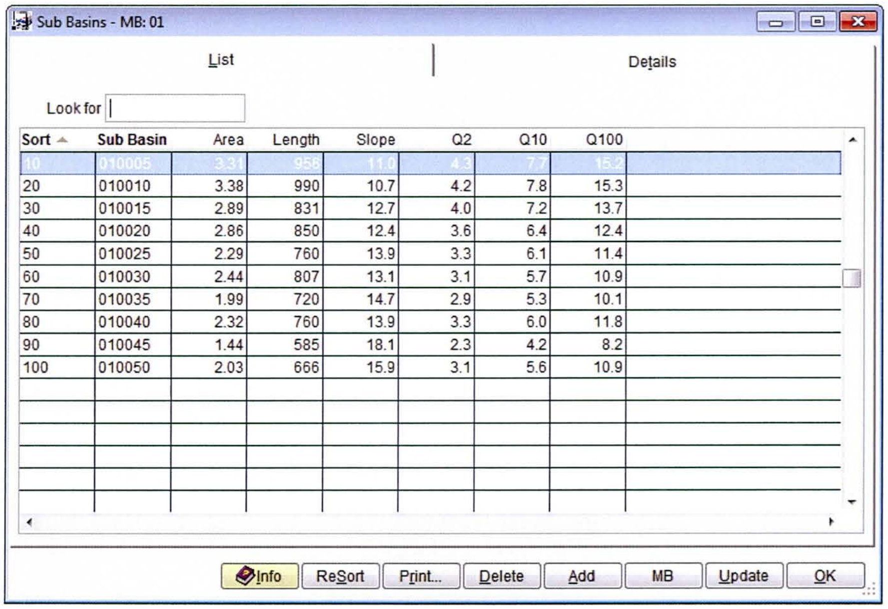


Tc	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5.0	2.94	3.97	4.78	5.86	6.68	7.54
5.1	2.92	3.95	4.75	5.82	6.65	7.50
5.2	2.91	3.93	4.72	5.79	6.61	7.45
5.3	2.89	3.91	4.70	5.76	6.58	7.41
5.4	2.88	3.89	4.67	5.73	6.54	7.37
5.5	2.86	3.87	4.65	5.70	6.50	7.33
5.6	2.84	3.84	4.62	5.67	6.47	7.29
5.7	2.83	3.82	4.60	5.64	6.43	7.25
5.8	2.81	3.80	4.57	5.61	6.40	7.22
5.9	2.80	3.78	4.55	5.58	6.36	7.18
6.0	2.78	3.76	4.52	5.55	6.33	7.14
6.1	2.77	3.74	4.50	5.51	6.29	7.10
6.2	2.75	3.72	4.47	5.48	6.26	7.06
6.3	2.74	3.70	4.45	5.46	6.23	7.02
6.4	2.72	3.68	4.42	5.43	6.19	6.98
6.5	2.71	3.66	4.40	5.40	6.16	6.95

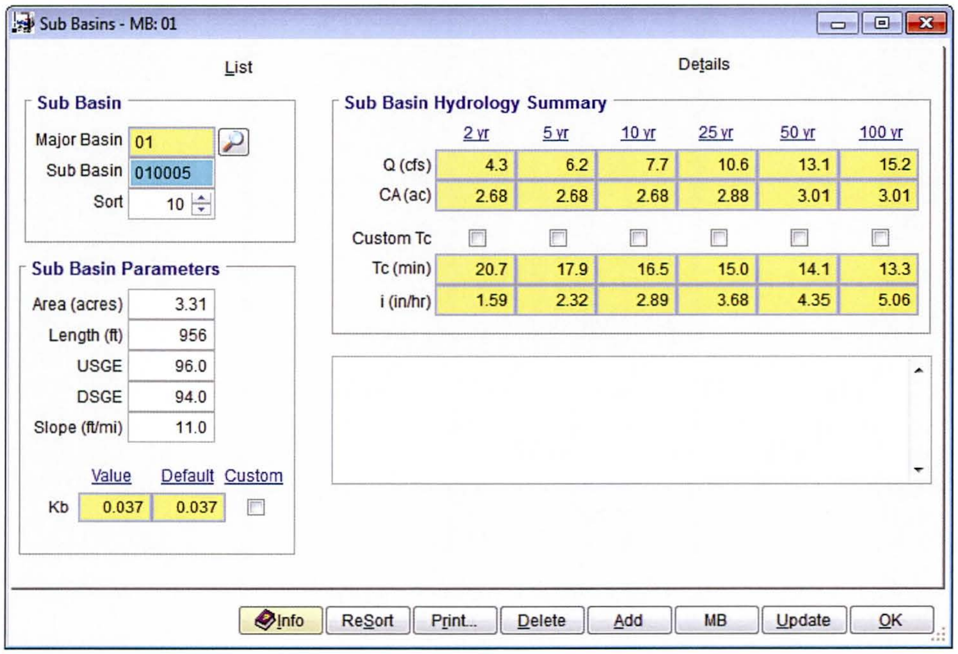


(C) Step 3 - Develop Sub Basin Data (Using GIS) (Maps ➔ Update Hydrology)

The Sub Basin and Land Use data will be developed using GIS. The shape files include SubBasin, Landuse and Tc which are all located in the **KVLExample12** folder (**C:\FCDMC\DDMSW480\Maps\KVLExample12**). Again, your path to these files may be different. Enter the data shown below and click **Update.** After the update is complete, you can check to see if all the Sub Basin parameters has been evaluated (**Hydrology ➔ Sub Basins**).

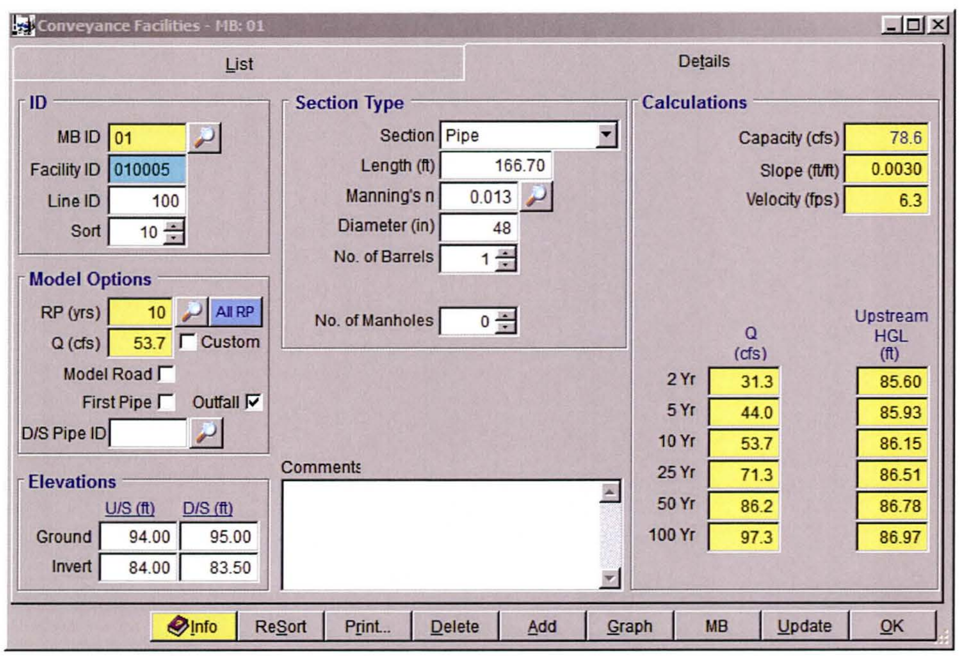


Sort	Sub Basin	Area	Length	Slope	Q2	Q10	Q100
10	010005	3.31	956	11.0	4.3	7.7	15.2
20	010010	3.38	990	10.7	4.2	7.8	15.3
30	010015	2.89	831	12.7	4.0	7.2	13.7
40	010020	2.86	850	12.4	3.6	6.4	12.4
50	010025	2.29	760	13.9	3.3	6.1	11.4
60	010030	2.44	807	13.1	3.1	5.7	10.9
70	010035	1.99	720	14.7	2.9	5.3	10.1
80	010040	2.32	760	13.9	3.3	6.0	11.8
90	010045	1.44	585	18.1	2.3	4.2	8.2
100	010050	2.03	666	15.9	3.1	5.6	10.9



(D) Step 4 - Update Conveyance Facilities Data (Hydraulics➔ Conveyance Facilities)

For this example, the **StormPro** backwater model will be used to develop the hydraulic grade line (HGL). Therefore it is necessary to Sort the Conveyance facilities in the correct order and establish the **Line ID** for each Conveyance Facility. With respect to the Figure (i.e., configuration of the drainage system) shown on the first page, all Conveyance Facilities will be **Line** *"100"*.

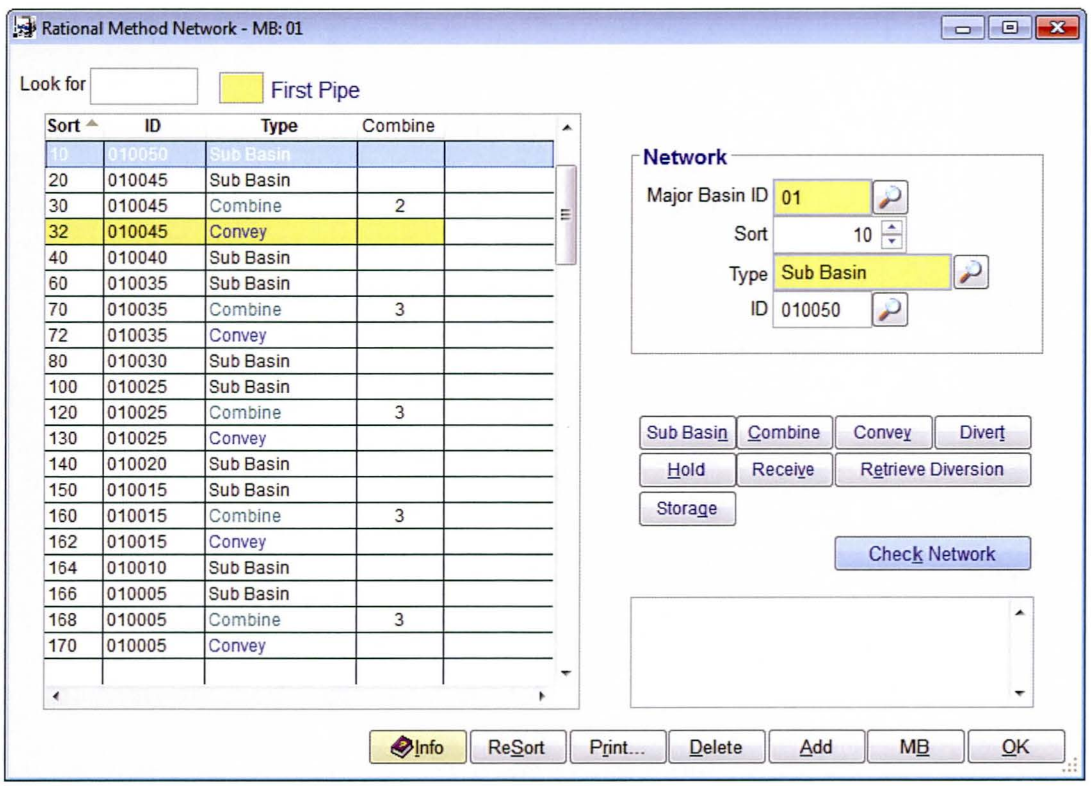


The following table presents the input data for all Conveyance Facilities. Common to all are the following: All *"Pipe"* **Section**; **Manning's n** is *"0.013"*; **No of Barrels** is *"1"*.

ID			Model Options					Elevations				Section		
Facility ID	Line ID	Sort	RP	Model Road	First Pipe	Outfall	DS Pipe ID	USGE	DSGE	USIE	DSIE	Length	Dia	Manholes
010005	100	10	10			X		94.00	95.00	84.00	83.50	166.70	48	
010015	100	20	10					95.00	94.00	85.00	84.00	100.00	48	1
010025	100	30	10					96.00	95.00	86.50	85.50	829.30	42	1
010035	100	40	10					97.00	96.00	88.00	87.00	761.10	36	1
010045	100	50	10		X			98.00	97.00	89.50	88.50	727.10	30	1

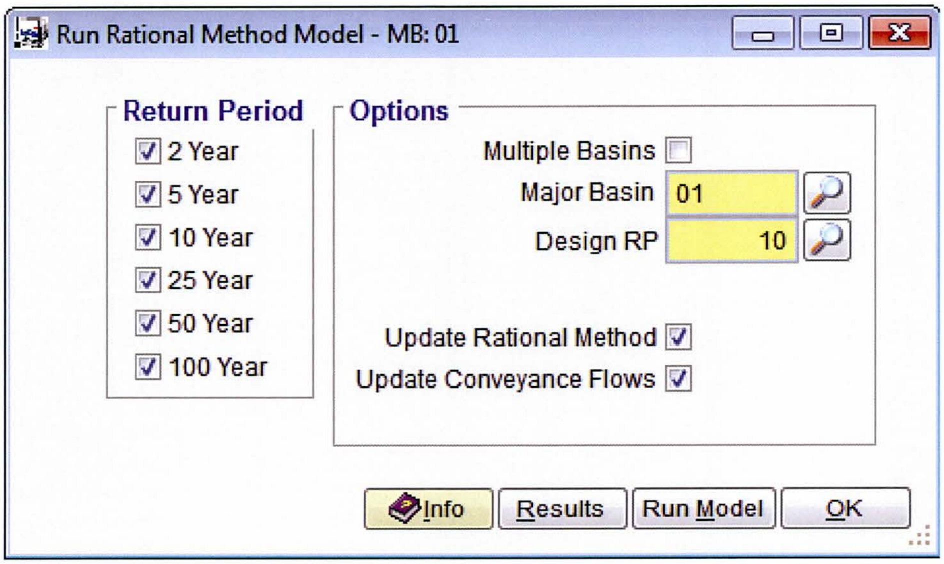
(E) Step 5 - Develop Rational Method Network (Hydrology➔Rational Method ➔Network)

Enter the data as shown below:



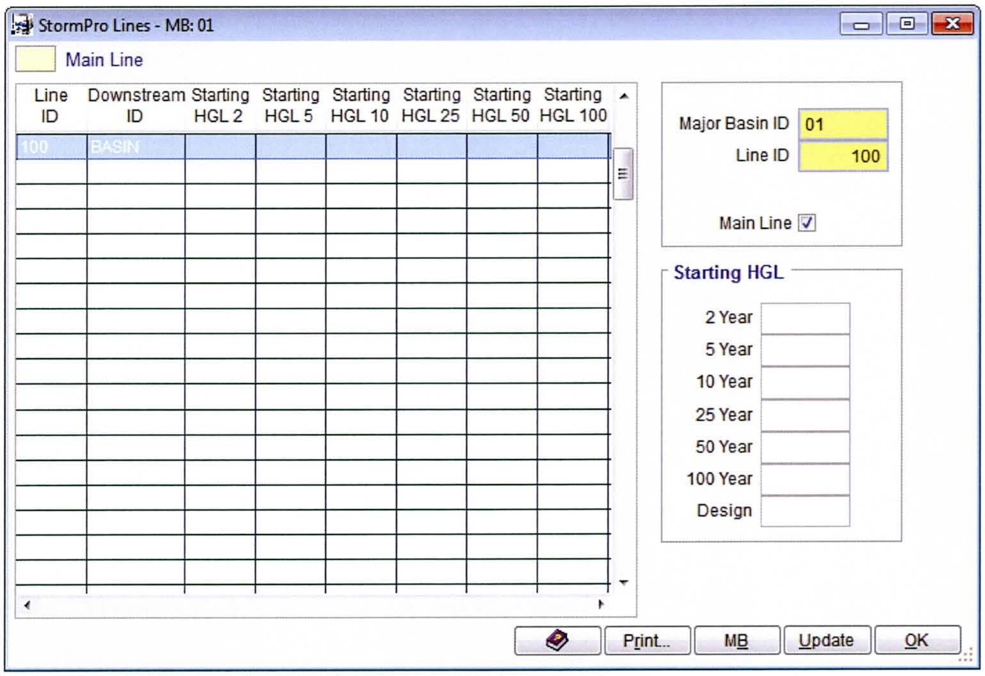
(F) Step 6 - Run Rational Method Model (Hydrology ➔ Rational Method ➔ Model)

Enter the data as shown below and then click **Run Model**.



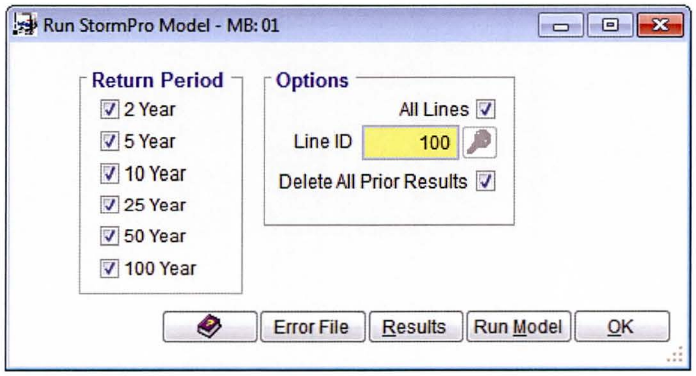
(G) Step 7 - Update StormPro Lines (Hydraulics ➔ StormPro Backwater ➔ Lines)

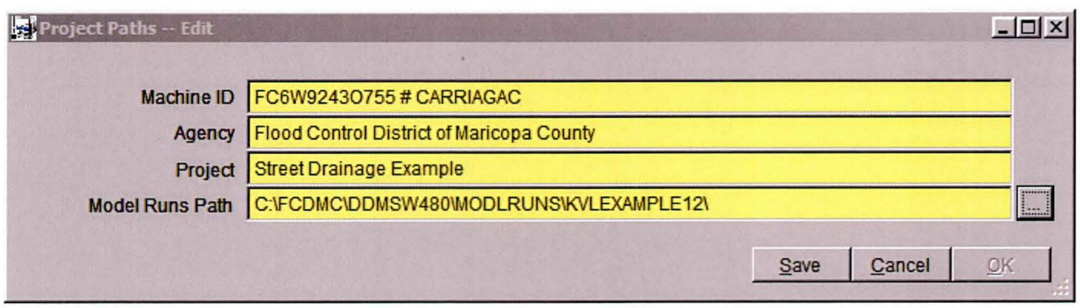
It is necessary to establish the starting water surface elevation for **Line ID** *100*. If left blank, the value will default to (D+Dc)/2, where D is the depth of the facility, and Dc is the critical flow depth. For **Line ID** *100*, check that it is a **Main Line**.

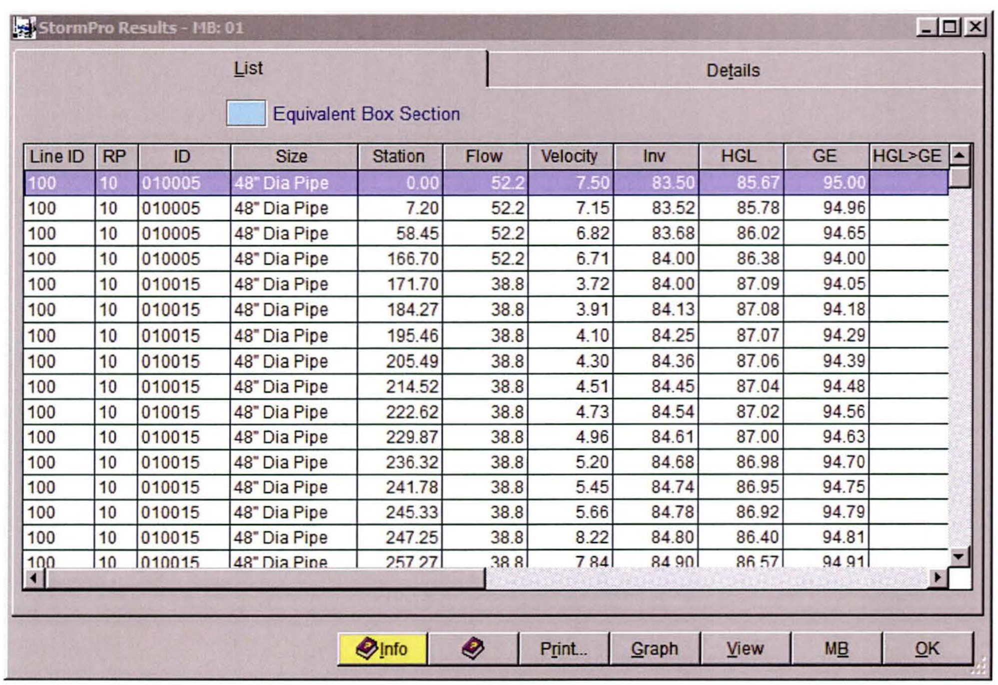


(H) Step 8 - Run StormPro Model (Hydraulics ➔ StormPro Backwater ➔ Model)

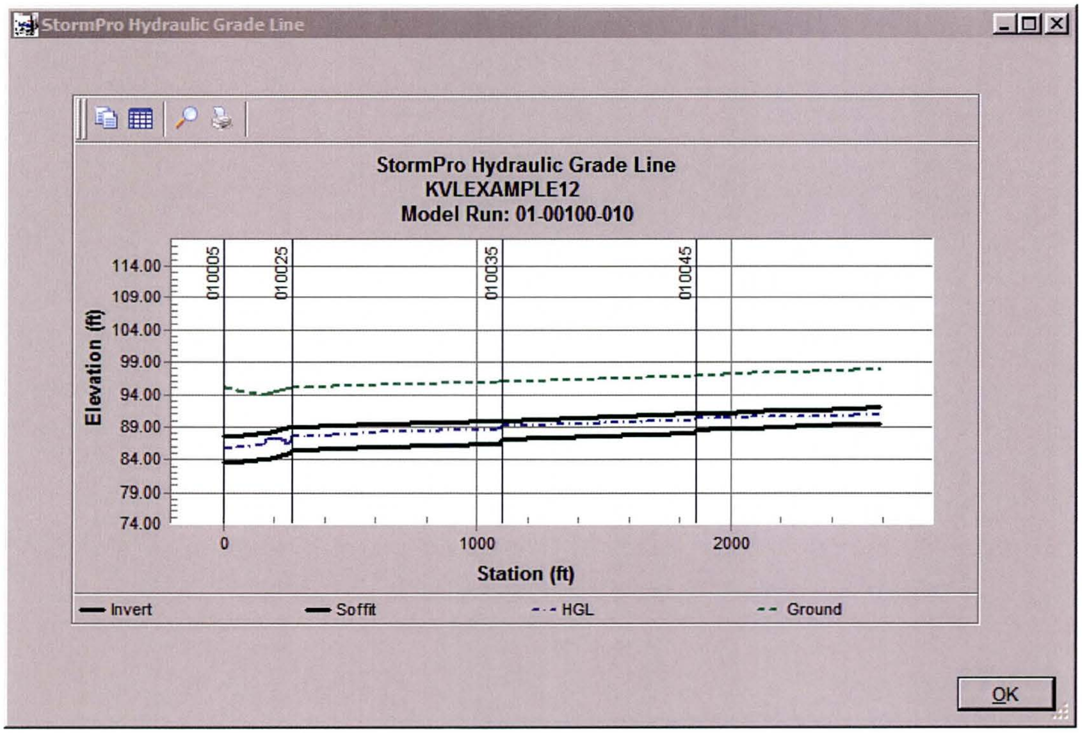
Select all **Return Periods**, check **All Lines** checkbox and check **Delete All Prior Results**. Please note that it is necessary to establish a folder for the model results. The results can be viewed by clicking **Results** and can be graphed by clicking **Graph** on the **StormPro Results** window.





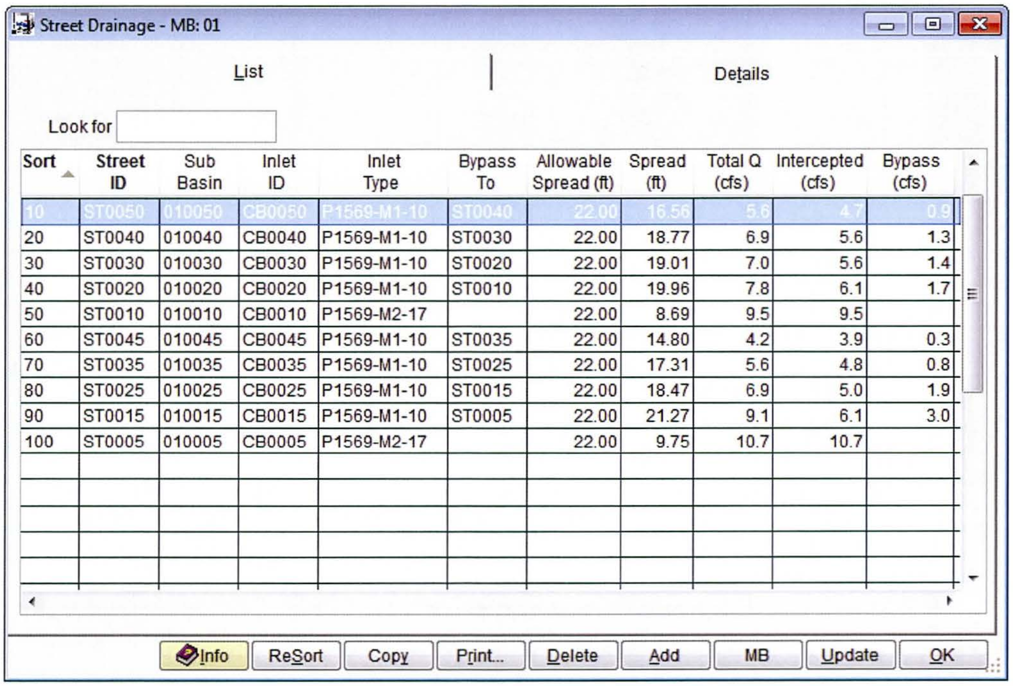


Line ID	RP	ID	Size	Station	Flow	Velocity	Inv	HGL	GE	HGL>GE
100	10	010005	48" Dia Pipe	0.00	52.2	7.50	83.50	85.67	95.00	
100	10	010005	48" Dia Pipe	7.20	52.2	7.15	83.52	85.78	94.96	
100	10	010005	48" Dia Pipe	58.45	52.2	6.82	83.68	86.02	94.65	
100	10	010005	48" Dia Pipe	166.70	52.2	6.71	84.00	86.38	94.00	
100	10	010015	48" Dia Pipe	171.70	38.8	3.72	84.00	87.09	94.05	
100	10	010015	48" Dia Pipe	184.27	38.8	3.91	84.13	87.08	94.18	
100	10	010015	48" Dia Pipe	195.46	38.8	4.10	84.25	87.07	94.29	
100	10	010015	48" Dia Pipe	205.49	38.8	4.30	84.36	87.06	94.39	
100	10	010015	48" Dia Pipe	214.52	38.8	4.51	84.45	87.04	94.48	
100	10	010015	48" Dia Pipe	222.62	38.8	4.73	84.54	87.02	94.56	
100	10	010015	48" Dia Pipe	229.87	38.8	4.96	84.61	87.00	94.63	
100	10	010015	48" Dia Pipe	236.32	38.8	5.20	84.68	86.98	94.70	
100	10	010015	48" Dia Pipe	241.78	38.8	5.45	84.74	86.95	94.75	
100	10	010015	48" Dia Pipe	245.33	38.8	5.66	84.78	86.92	94.79	
100	10	010015	48" Dia Pipe	247.25	38.8	8.22	84.80	86.40	94.81	
100	10	010015	48" Dia Pipe	257.27	38.8	7.84	84.90	86.57	94.91	



(l) Step 9 – Analyze Street Drainage Hydraulics (Hydraulics→Street Drainage→Network Model)

There are 10 street sections that need to be modeled as shown on the Figure in the first page of this tutorial. A summary of the data is shown below and details for each section are shown on the figures that follow. **It is important that the records are sorted in the order they need to be modeled.** After entering all the data, click **Update** to run the Model.



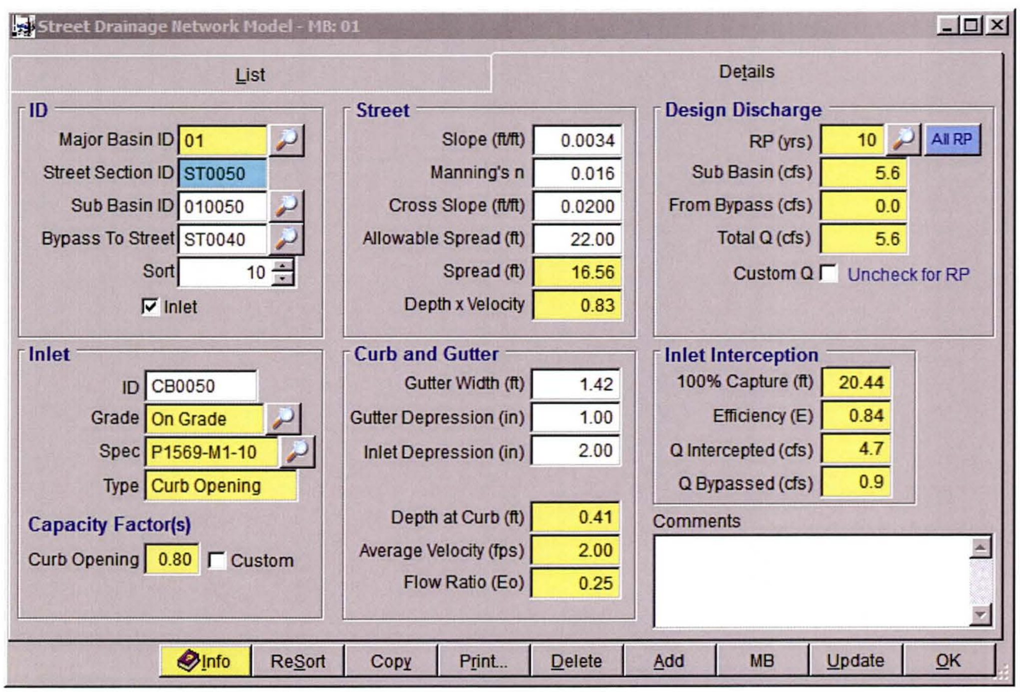
Street Drainage - MB: 01

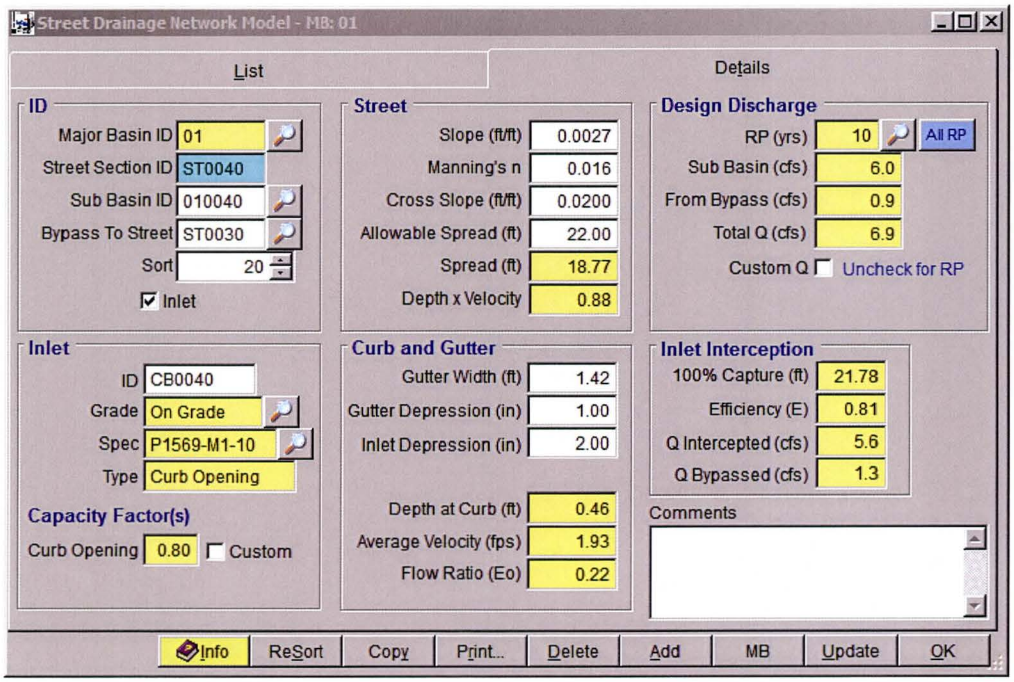
List | Details

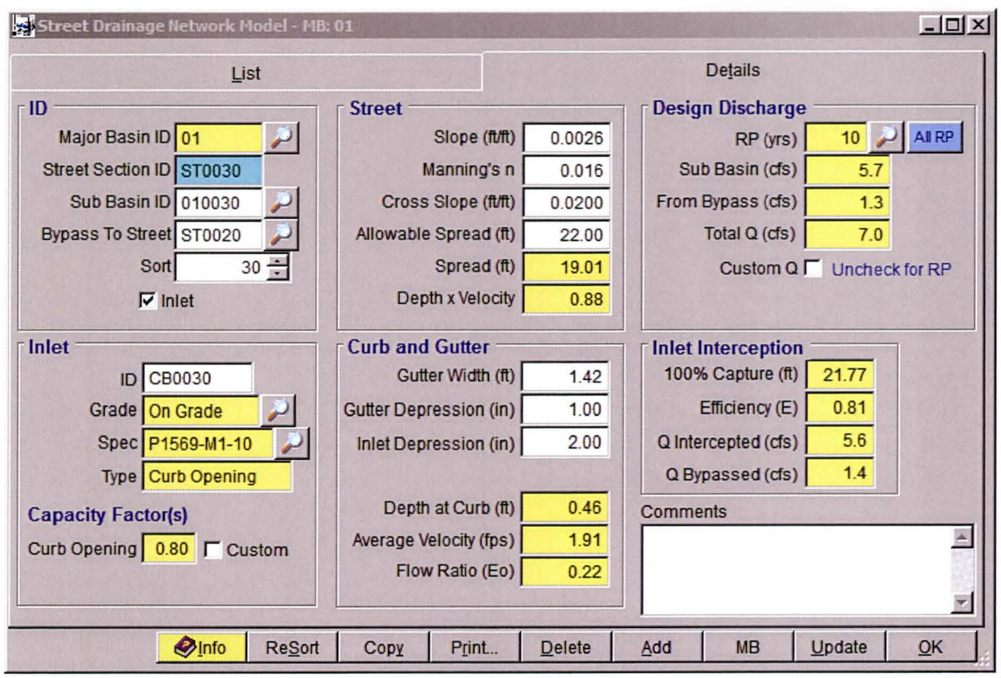
Look for

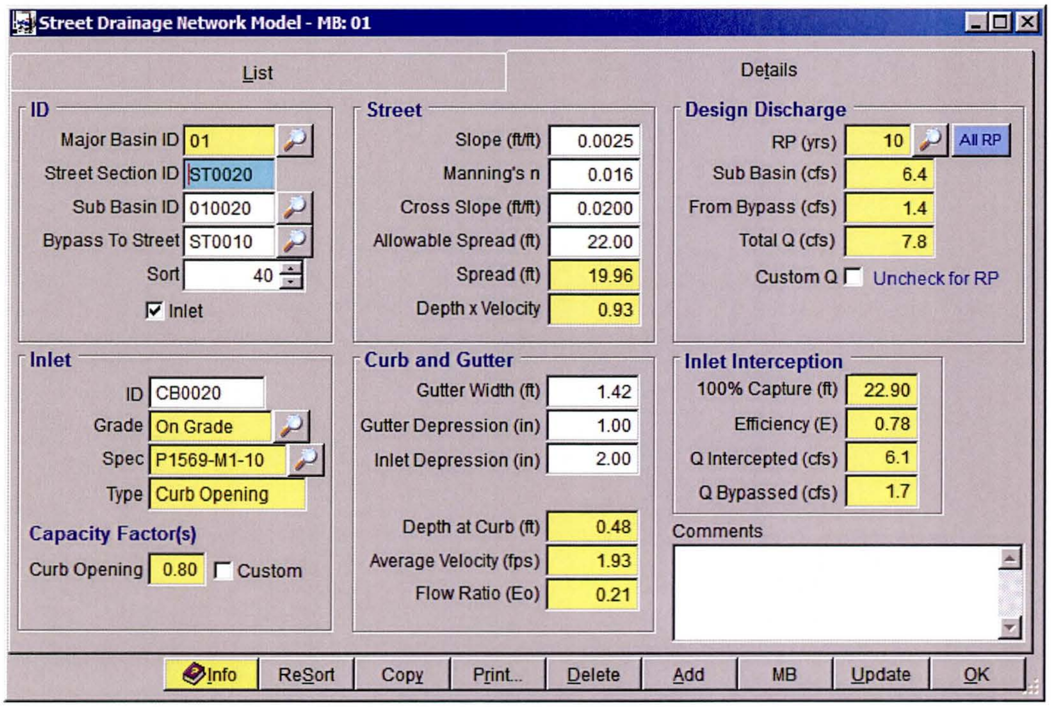
Sort	Street ID	Sub Basin	Inlet ID	Inlet Type	Bypass To	Allowable Spread (ft)	Spread (ft)	Total Q (cfs)	Intercepted (cfs)	Bypass (cfs)
10	ST0050	010050	CB0050	P1569-M1-10	ST0040	22.00	16.56	5.6	4.7	0.9
20	ST0040	010040	CB0040	P1569-M1-10	ST0030	22.00	18.77	6.9	5.6	1.3
30	ST0030	010030	CB0030	P1569-M1-10	ST0020	22.00	19.01	7.0	5.6	1.4
40	ST0020	010020	CB0020	P1569-M1-10	ST0010	22.00	19.96	7.8	6.1	1.7
50	ST0010	010010	CB0010	P1569-M2-17		22.00	8.69	9.5	9.5	
60	ST0045	010045	CB0045	P1569-M1-10	ST0035	22.00	14.80	4.2	3.9	0.3
70	ST0035	010035	CB0035	P1569-M1-10	ST0025	22.00	17.31	5.6	4.8	0.8
80	ST0025	010025	CB0025	P1569-M1-10	ST0015	22.00	18.47	6.9	5.0	1.9
90	ST0015	010015	CB0015	P1569-M1-10	ST0005	22.00	21.27	9.1	6.1	3.0
100	ST0005	010005	CB0005	P1569-M2-17		22.00	9.75	10.7	10.7	

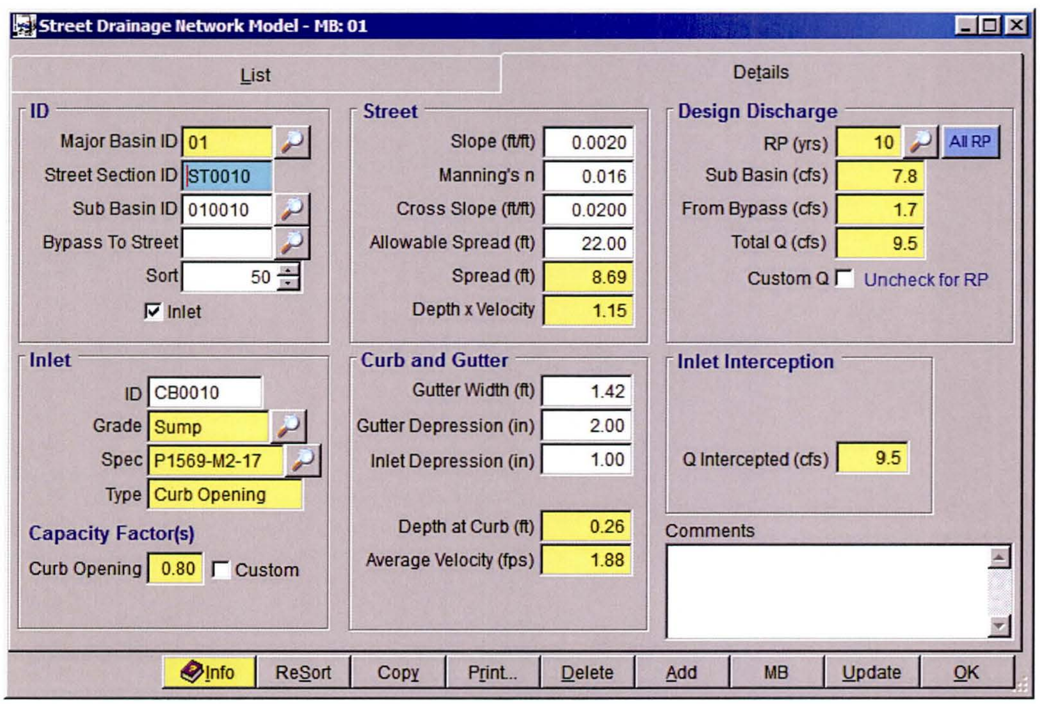
Info | ReSort | Copy | Print... | Delete | Add | MB | Update | OK

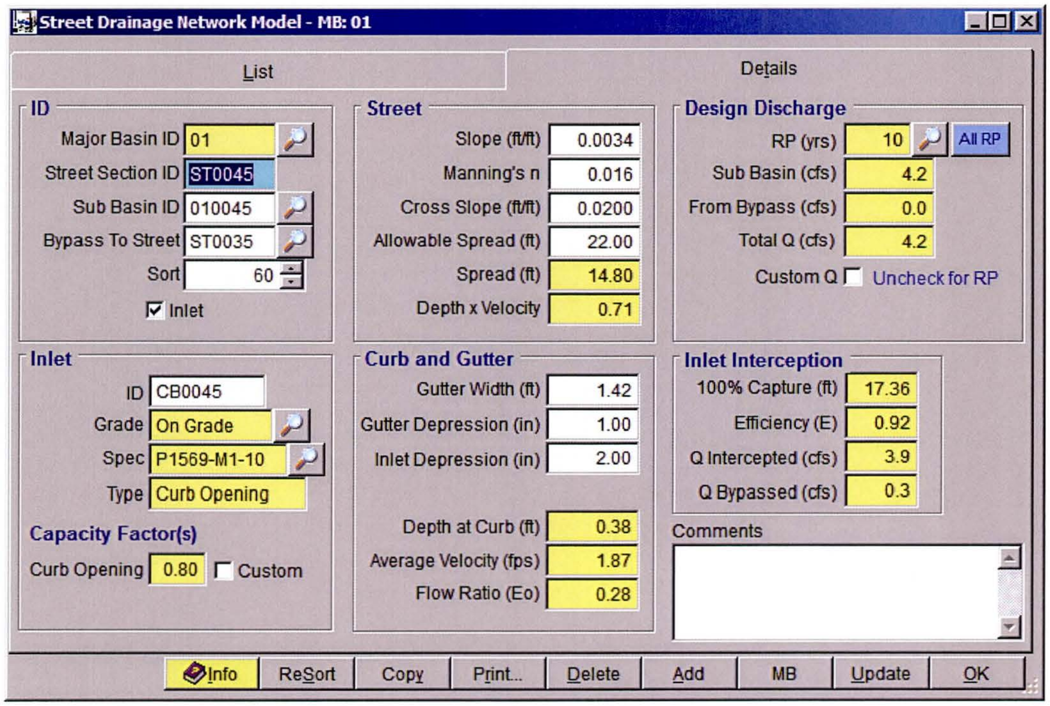


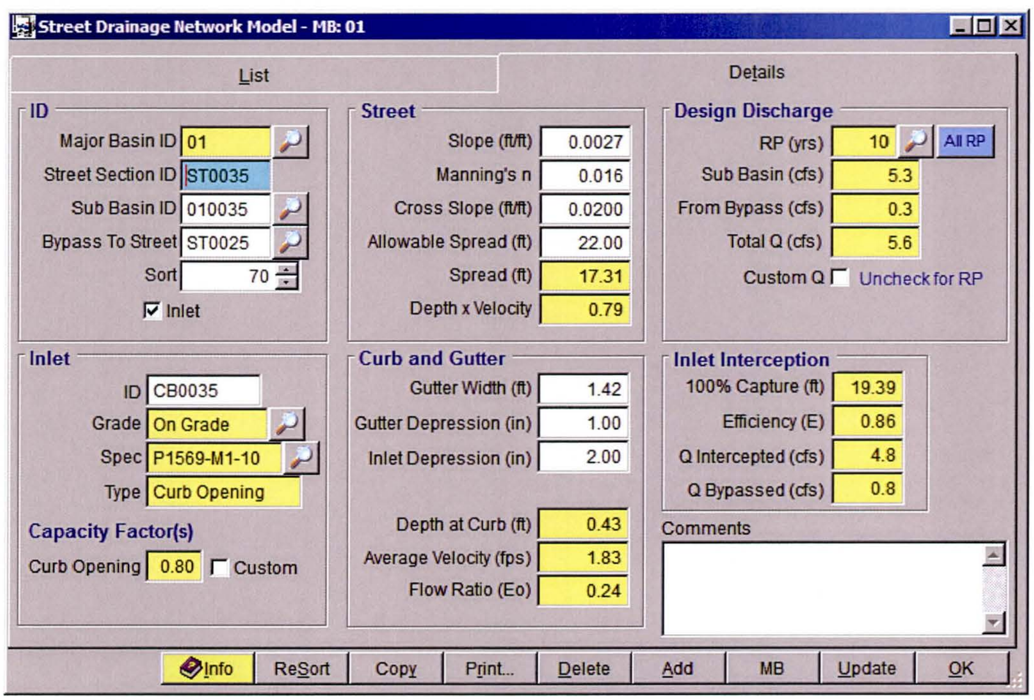

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0040
Sub Basin ID 010040
Bypass To Street ST0030
Sort 20
Inlet
Street
Slope (ft/ft) 0.0027
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 18.77
Depth x Velocity 0.88
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 6.0
From Bypass (cfs) 0.9
Total Q (cfs) 6.9
Custom Q
Uncheck for RP
Inlet
ID CB0040
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.46
Average Velocity (fps) 1.93
Flow Ratio (Eo) 0.22
Inlet Interception
100% Capture (ft) 21.78
Efficiency (E) 0.81
Q Intercepted (cfs) 5.6
Q Bypassed (cfs) 1.3
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

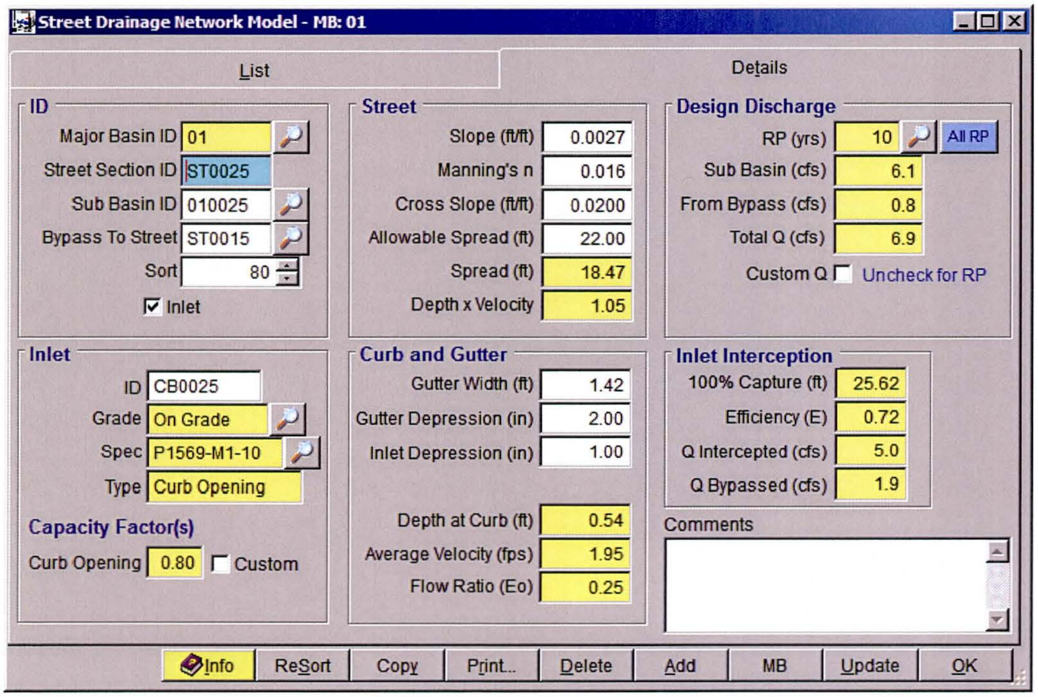

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0030
Sub Basin ID 010030
Bypass To Street ST0020
Sort 30
Inlet
Street
Slope (ft/ft) 0.0026
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 19.01
Depth x Velocity 0.88
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 5.7
From Bypass (cfs) 1.3
Total Q (cfs) 7.0
Custom Q
Uncheck for RP
Inlet
ID CB0030
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.46
Average Velocity (fps) 1.91
Flow Ratio (Eo) 0.22
Inlet Interception
100% Capture (ft) 21.77
Efficiency (E) 0.81
Q Intercepted (cfs) 5.6
Q Bypassed (cfs) 1.4
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK


Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0020
Sub Basin ID 010020
Bypass To Street ST0010
Sort 40
Inlet
Street
Slope (ft/ft) 0.0025
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 19.96
Depth x Velocity 0.93
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 6.4
From Bypass (cfs) 1.4
Total Q (cfs) 7.8
Custom Q
Uncheck for RP
Inlet
ID CB0020
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.48
Average Velocity (fps) 1.93
Flow Ratio (Eo) 0.21
Inlet Interception
100% Capture (ft) 22.90
Efficiency (E) 0.78
Q Intercepted (cfs) 6.1
Q Bypassed (cfs) 1.7
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

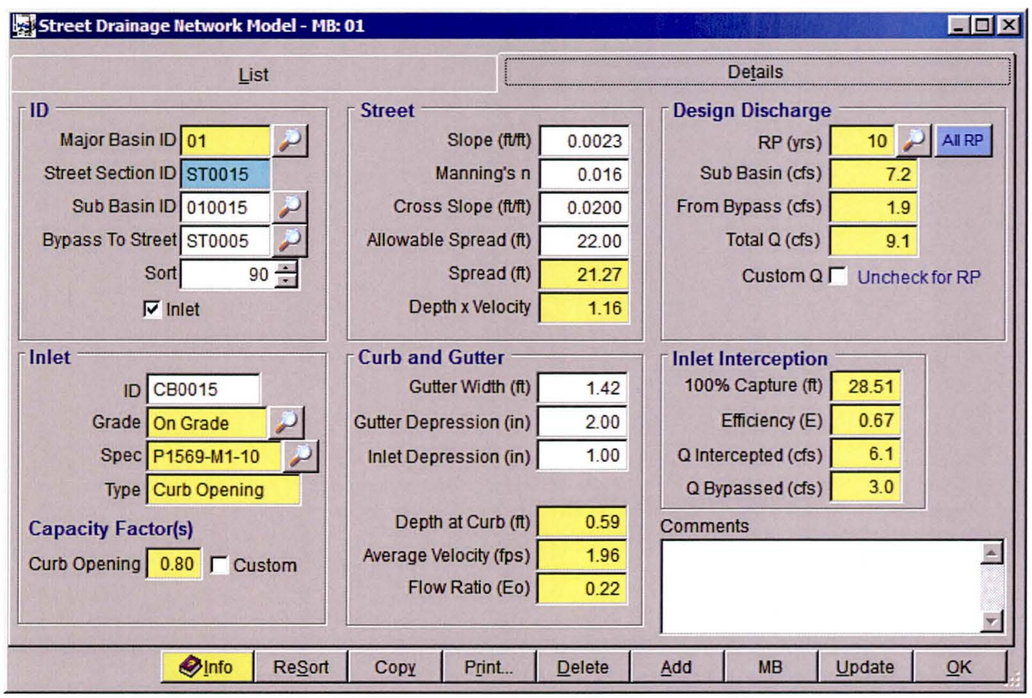

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0010
Sub Basin ID 010010
Bypass To Street
Sort 50
Inlet
Street
Slope (ft/ft) 0.0020
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 8.69
Depth x Velocity 1.15
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 7.8
From Bypass (cfs) 1.7
Total Q (cfs) 9.5
Custom Q
Uncheck for RP
Inlet
ID CB0010
Grade Sump
Spec P1569-M2-17
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 2.00
Inlet Depression (in) 1.00
Depth at Curb (ft) 0.26
Average Velocity (fps) 1.88
Inlet Interception
Q Intercepted (cfs) 9.5
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK


Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0045
Sub Basin ID 010045
Bypass To Street ST0035
Sort 60
Inlet
Street
Slope (ft/ft) 0.0034
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 14.80
Depth x Velocity 0.71
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 4.2
From Bypass (cfs) 0.0
Total Q (cfs) 4.2
Custom Q
Uncheck for RP
Inlet
ID CB0045
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.38
Average Velocity (fps) 1.87
Flow Ratio (Eo) 0.28
Inlet Interception
100% Capture (ft) 17.36
Efficiency (E) 0.92
Q Intercepted (cfs) 3.9
Q Bypassed (cfs) 0.3
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

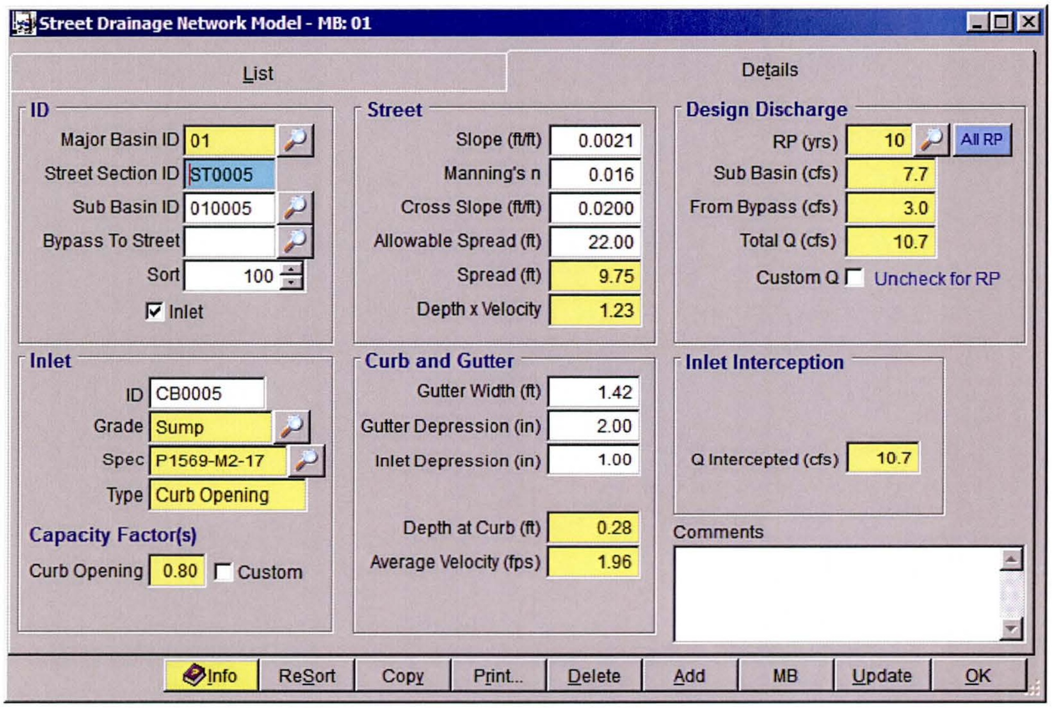

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0035
Sub Basin ID 010035
Bypass To Street ST0025
Sort 70
Inlet
Street
Slope (ft/ft) 0.0027
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 17.31
Depth x Velocity 0.79
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 5.3
From Bypass (cfs) 0.3
Total Q (cfs) 5.6
Custom Q
Uncheck for RP
Inlet
ID CB0035
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.43
Average Velocity (fps) 1.83
Flow Ratio (Eo) 0.24
Inlet Interception
100% Capture (ft) 19.39
Efficiency (E) 0.86
Q Intercepted (cfs) 4.8
Q Bypassed (cfs) 0.8
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK



Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0025
Sub Basin ID 010025
Bypass To Street ST0015
Sort 80
Inlet
Street
Slope (ft/ft) 0.0027
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 18.47
Depth x Velocity 1.05
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 6.1
From Bypass (cfs) 0.8
Total Q (cfs) 6.9
Custom Q
Uncheck for RP
Inlet
ID CB0025
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 2.00
Inlet Depression (in) 1.00
Depth at Curb (ft) 0.54
Average Velocity (fps) 1.95
Flow Ratio (Eo) 0.25
Inlet Interception
100% Capture (ft) 25.62
Efficiency (E) 0.72
Q Intercepted (cfs) 5.0
Q Bypassed (cfs) 1.9
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK



Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0015
Sub Basin ID 010015
Bypass To Street ST0005
Sort 90
Inlet
Street
Slope (ft/ft) 0.0023
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 21.27
Depth x Velocity 1.16
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 7.2
From Bypass (cfs) 1.9
Total Q (cfs) 9.1
Custom Q
Uncheck for RP
Inlet
ID CB0015
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 2.00
Inlet Depression (in) 1.00
Depth at Curb (ft) 0.59
Average Velocity (fps) 1.96
Flow Ratio (Eo) 0.22
Inlet Interception
100% Capture (ft) 28.51
Efficiency (E) 0.67
Q Intercepted (cfs) 6.1
Q Bypassed (cfs) 3.0
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

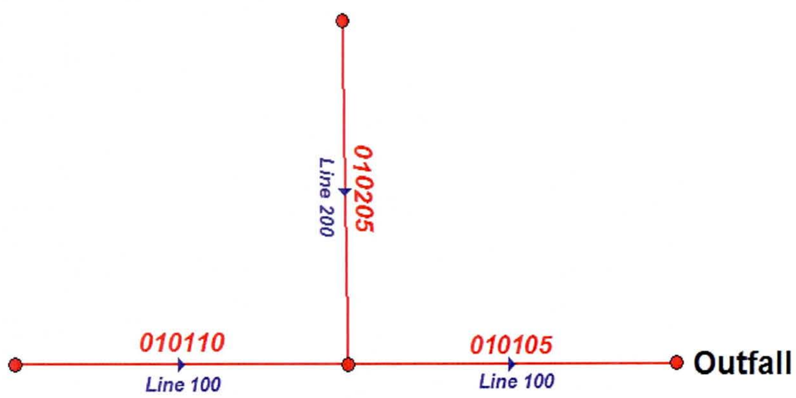

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID
01
Street Section ID
ST0005
Sub Basin ID
010005
Bypass To Street
Sort
100
Inlet
Street
Slope (ft/ft)
0.0021
Manning's n
0.016
Cross Slope (ft/ft)
0.0200
Allowable Spread (ft)
22.00
Spread (ft)
9.75
Depth x Velocity
1.23
Design Discharge
RP (yrs)
10
All RP
Sub Basin (cfs)
7.7
From Bypass (cfs)
3.0
Total Q (cfs)
10.7
Custom Q
Uncheck for RP
Inlet
ID
CB0005
Grade
Sump
Spec
P1569-M2-17
Type
Curb Opening
Capacity Factor(s)
Curb Opening
0.80
Custom
Curb and Gutter
Gutter Width (ft)
1.42
Gutter Depression (in)
2.00
Inlet Depression (in)
1.00
Depth at Curb (ft)
0.28
Average Velocity (fps)
1.96
Inlet Interception
Q Intercepted (cfs)
10.7
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

3.2 StormPro Backwater Model Tutorial

This tutorial provides a working example for the use of the **StormPro** Backwater Model. For this example, **KVLExample7** will be used. Before developing the backwater model, it is necessary to develop the hydrology using the Rational Method and enter the data for all conveyance facilities. The detailed procedure for the Rational Method and Conveyance Facilities for this tutorial is provided in **Tutorials for DDMSW Hydrology Modeling – Tutorial 3 Rational Method Modeling.** This tutorial starts after the **Rational Method Modeling Tutorial** has been completed.

The specific requirements for running **StormPro** using the pipe network shown below include:

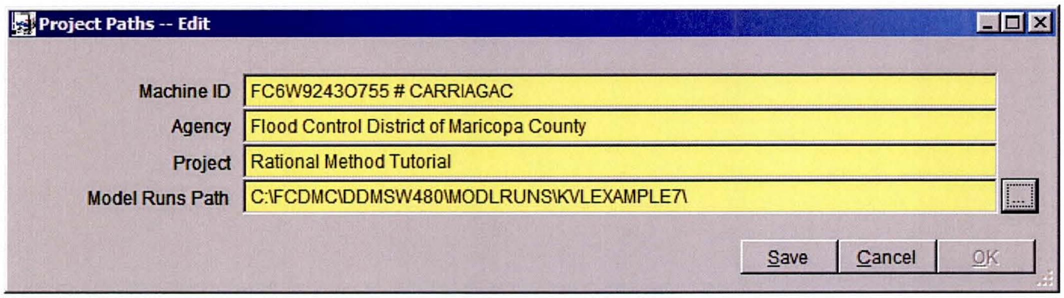
1. Establishing a folder for the model runs
2. Modifying the Conveyance Facilities
3. Establish the details for the Line IDs
4. Run Model



KvlExample7 Pipe Network

(A) Step 1 - Create a Folder for Model Runs (File → Project Paths)

For this example, a new folder (**C:\FCDMC\DDMSW480\Modlruns\kvlExample7**) was created.



(B) Step 2 - Modify Conveyance Facilities (Hydraulics ➔ Conveyance Facilities)

In addition to the data previously entered (in the **RATIONAL METHOD MODELING TUTORIAL**) for the Conveyance Facilities, the following data needs to be entered:

Line ID: STORMPRO models each line separately starting with the lowest **Line ID.** It is important to enter the **Line ID**'s in the order that the model should run. This is to establish the starting water surface elevation for Lines entering another Line. In the above network, all conveyance facilities in the **Main Line** (that goes to an Outfall) are labeled **Line ID** *100*. The upstream Line in this example is labeled **Line ID** *200*.

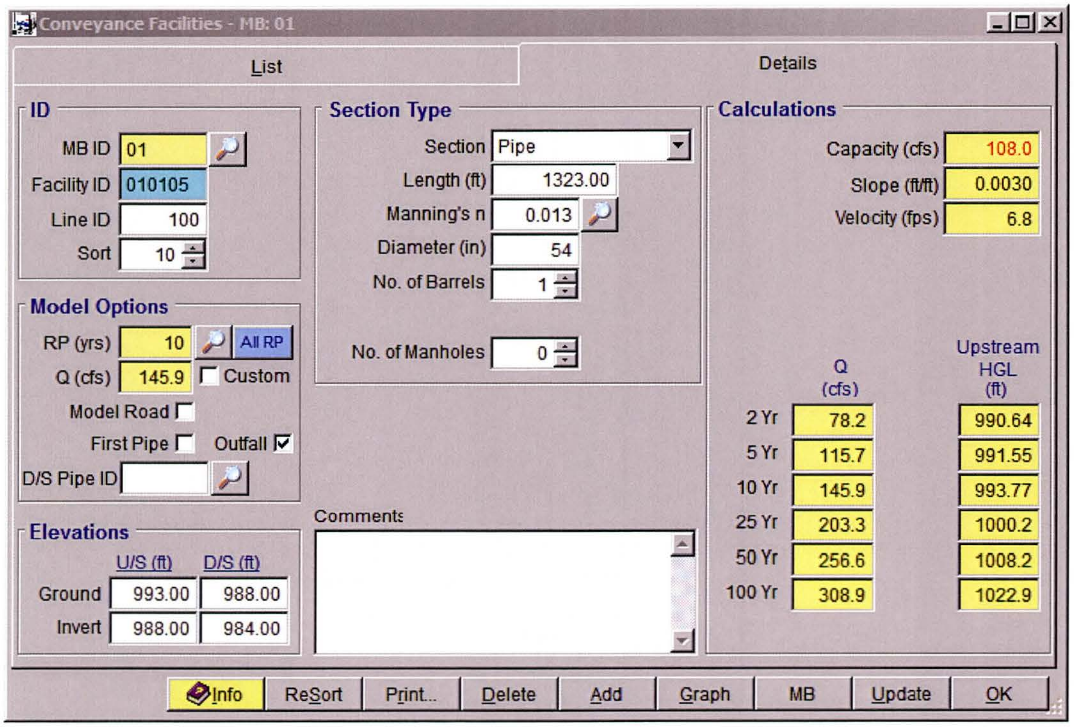
Sort: For **STORMPRO** to run correctly, the **Facility ID**'s must be sorted in the order from Downstream to Upstream. Use the **Sort** field to force the correct order. **This is critical.**

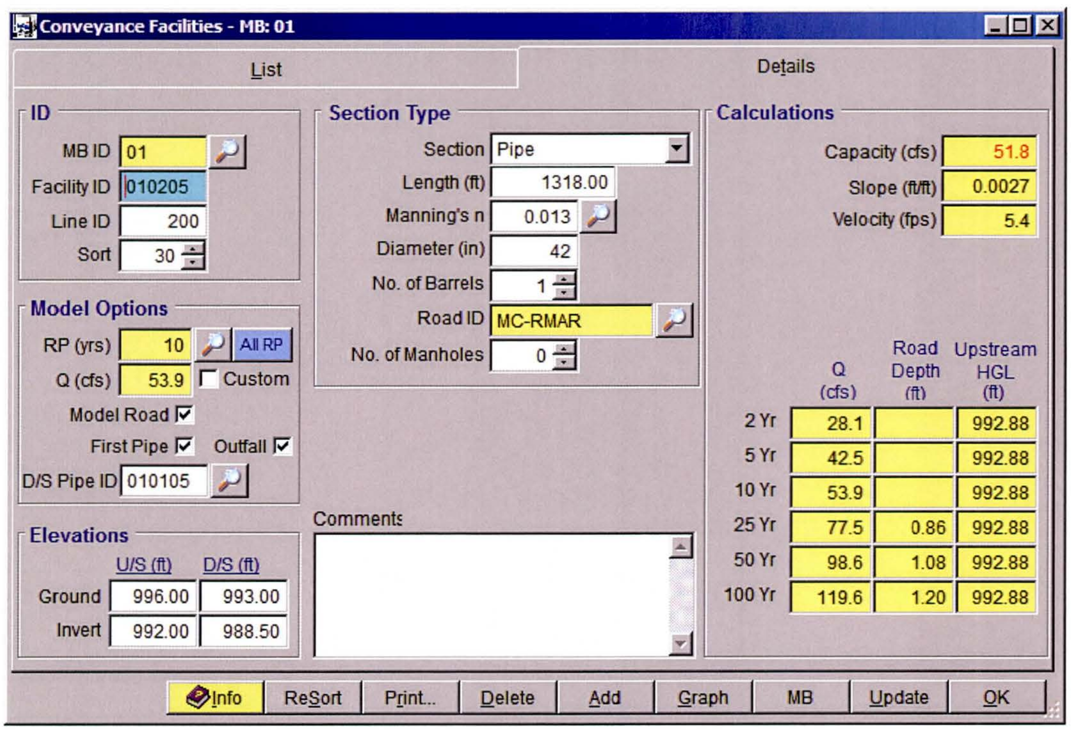
Outfall: If a **Facility ID** is an Outfall, then check the **Outfall** checkbox. In this case, there are two outfalls. They are **Facility IDs** *010105* and *010205* for **Line IDs** *100* and *200* respectively.

D/S Pipe ID: If a **Facility ID** enters a downstream Line, then enter the **D/S Pipe ID.** In the case of **Facility ID** *010205* for **Line ID** *200*, enter **Pipe ID** *010105* (of **Line ID** *100*) as the **D/S Pipe ID**.

Manholes: Enter the number of manholes in each **Facility ID**.

Screen Captures for **Facility ID** *010105* and *010205* are shown below.



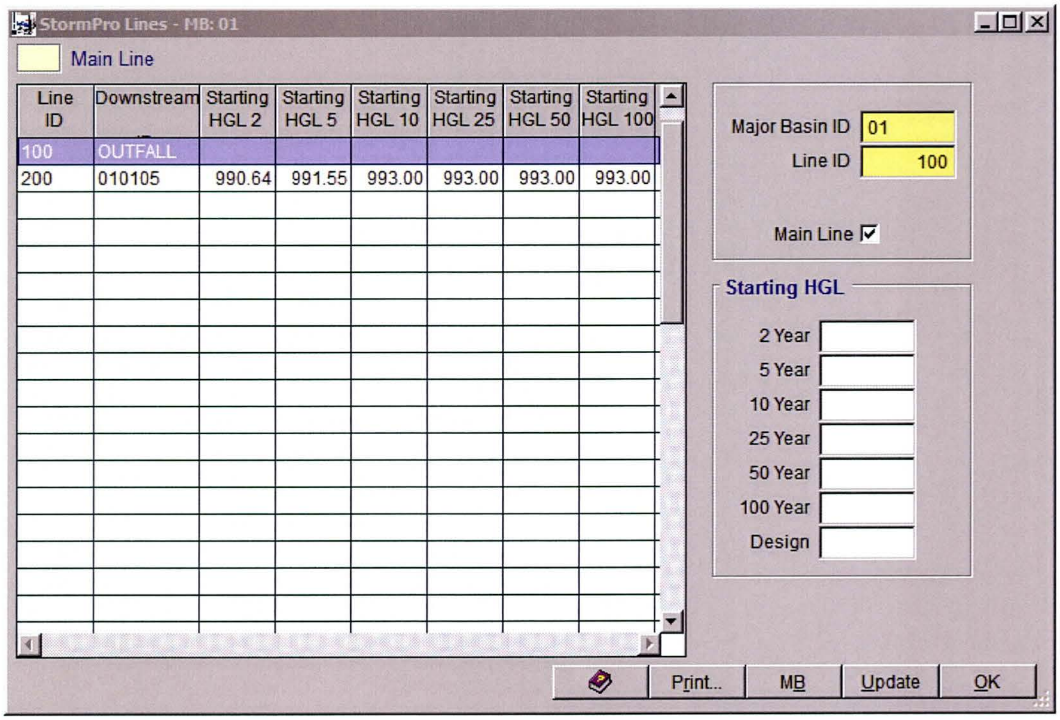


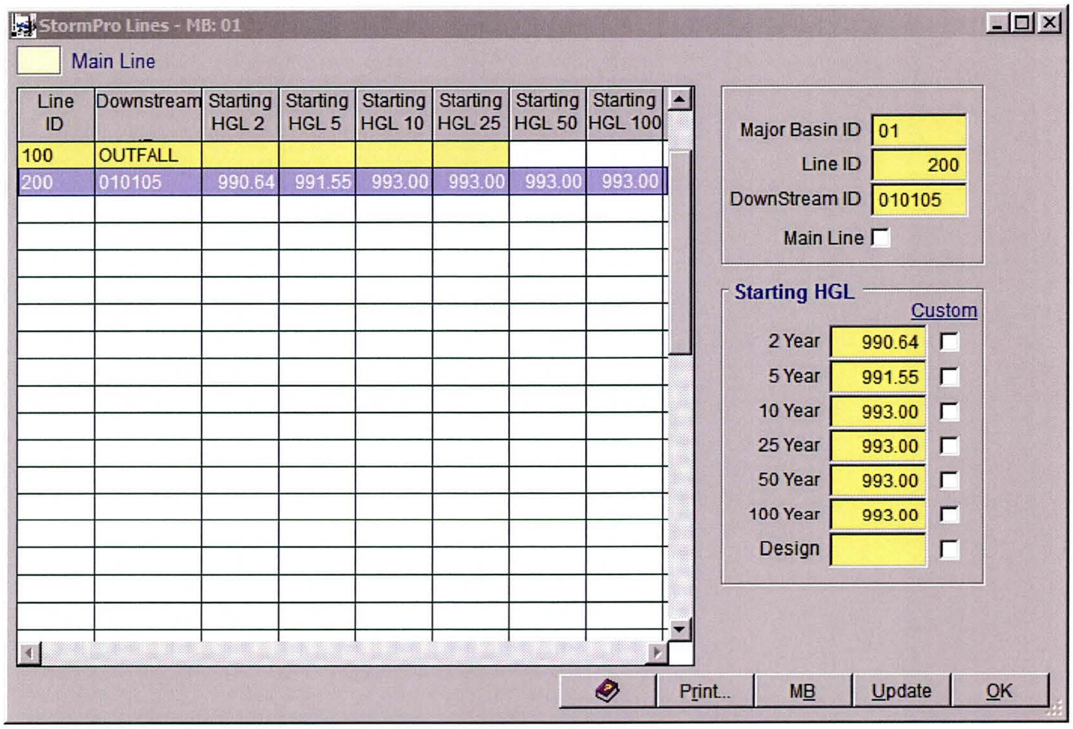
(C) Step 3 - Establish Line IDs (Hydraulics → STORMPRO Backwater → Lines)

When first going into this form, there will be no data and there will not be an **Add** button. The data for the Lines is established when clicking the **Update** button. In this case a warning will be given that there is no **Downstream ID** for **Line ID** *100* (because it is an **Outfall**). For this **Line ID** *100*, check **Main Line**. It is important to note that if the Conveyance Facilities are modified, then the **STORMPRO** Lines should be updated before running a **STORMPRO** Model.

For a **Main Line**, the Starting Hydraulic Grade Line for each return period can be entered. If left blank, the model uses the formula (Dc+D)/2, where Dc is the critical depth and D is the height of the **Facility ID**.

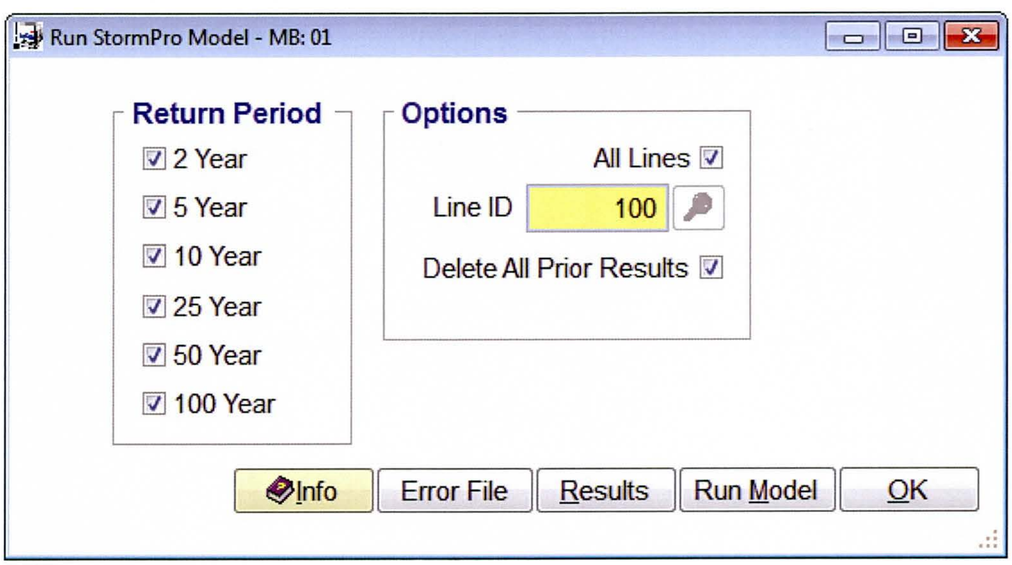
For Lines that are not a Main Line, a Starting Hydraulic Grade Line can be entered by checking the appropriate **Custom** for each return period. If left blank, the model establishes the value from the modeled Line that this Line enters.





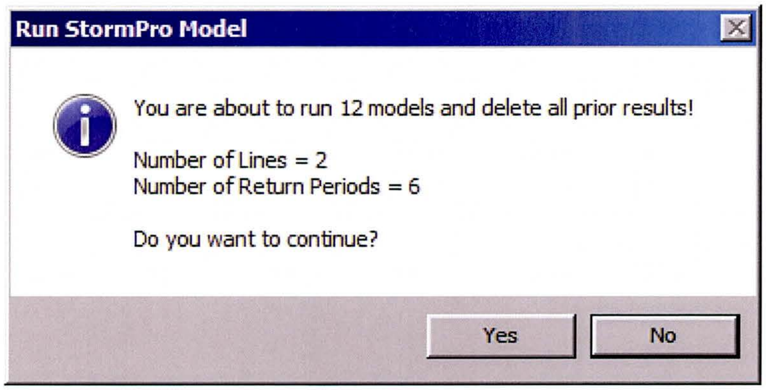
This is a view after the model has been run (**Starting HGL** is automatically loaded from results).

(D) Step 4 - Run Model (Hydraulics ➔ STORMPRO Backwater ➔ Model)

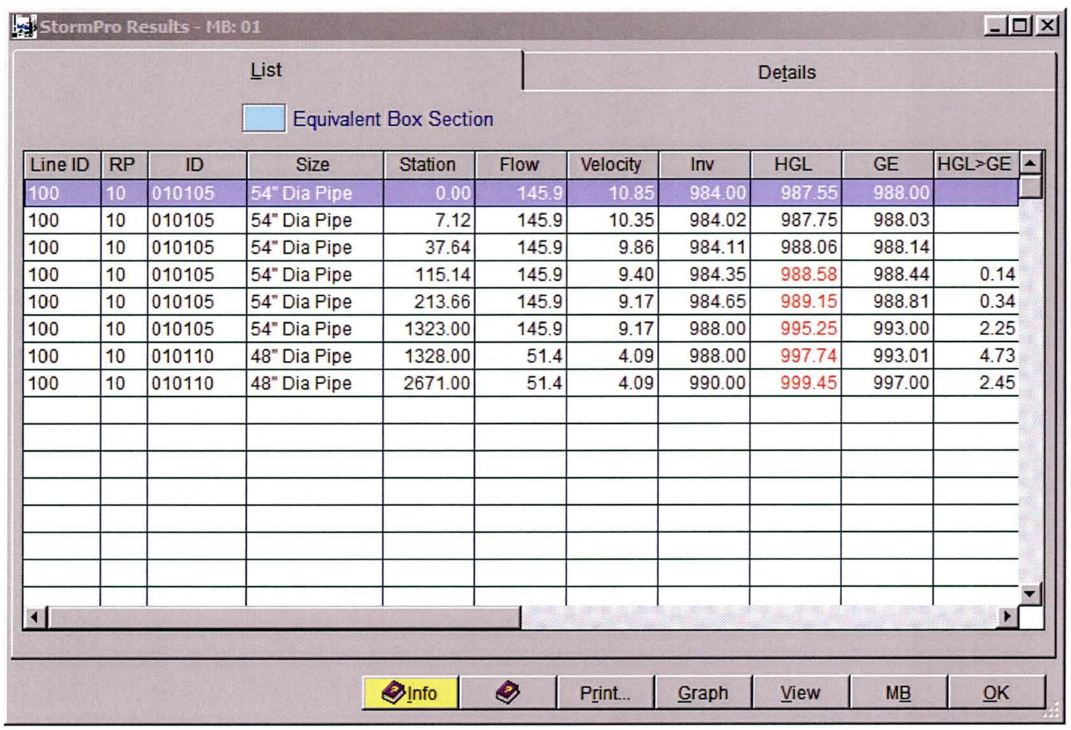


Options when running a **STORMPRO** Model include **Return Period**, **Line ID** and Delete Prior Results. If **All Lines** is checked, then **STORMPRO** will model all the selected return periods for **Line** *100* then model all the selected return periods for **Line** *200* (in that order).

Click **Run Model** to run the model. Click **Ye**s to continue.

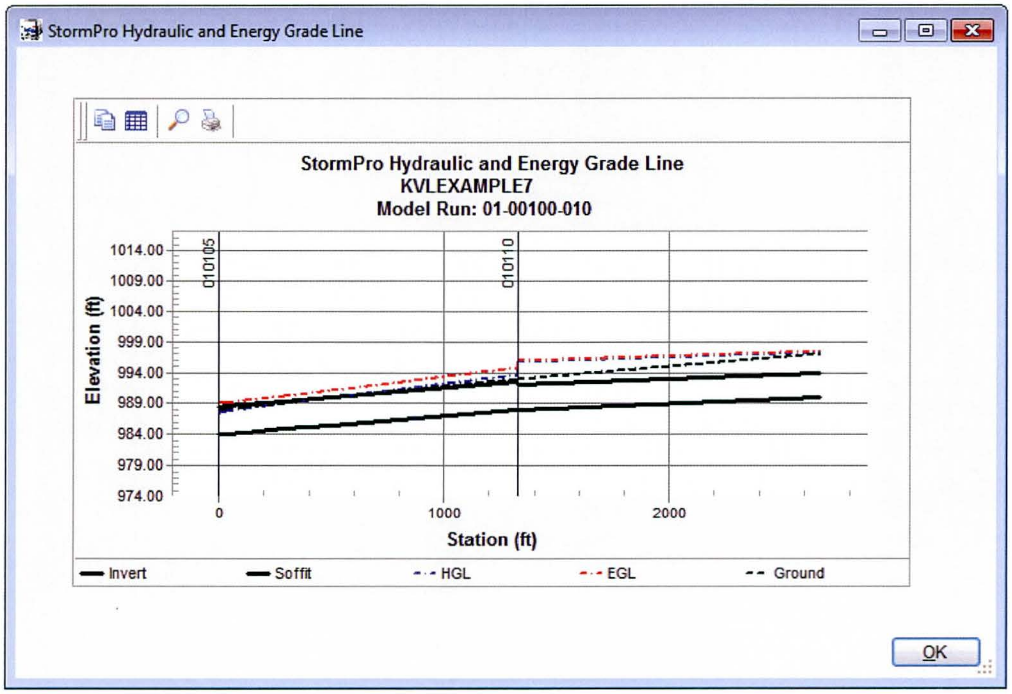


Click **Results** to view the model results.

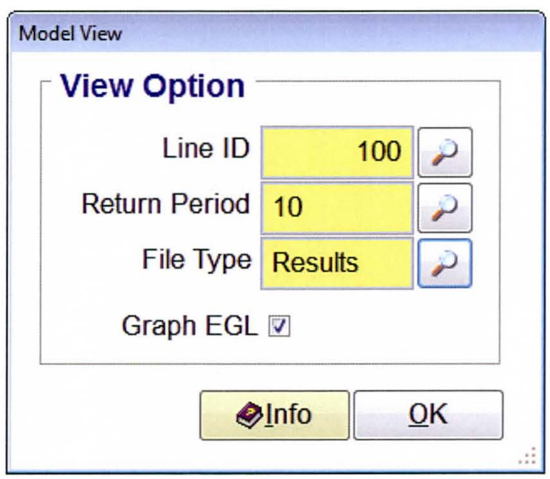


Line ID	RP	ID	Size	Station	Flow	Velocity	Inv	HGL	GE	HGL>GE
100	10	010105	54" Dia Pipe	0.00	145.9	10.85	984.00	987.55	988.00	
100	10	010105	54" Dia Pipe	7.12	145.9	10.35	984.02	987.75	988.03	
100	10	010105	54" Dia Pipe	37.64	145.9	9.86	984.11	988.06	988.14	
100	10	010105	54" Dia Pipe	115.14	145.9	9.40	984.35	988.58	988.44	0.14
100	10	010105	54" Dia Pipe	213.66	145.9	9.17	984.65	989.15	988.81	0.34
100	10	010105	54" Dia Pipe	1323.00	145.9	9.17	988.00	995.25	993.00	2.25
100	10	010110	48" Dia Pipe	1328.00	51.4	4.09	988.00	997.74	993.01	4.73
100	10	010110	48" Dia Pipe	2671.00	51.4	4.09	990.00	999.45	997.00	2.45

Click **Graph** to view the graph of the model results.



To view another line and/or return period, click the **View** button.



Options include selecting the **Line ID**, **Return Period**, **File Type** and an option to graph the Energy Grade Line (**Graph EGL**). When selecting a **File Type** the following options are available:

Results will select the data from the **STORMPRO RESULTS** filtered for the selected **Line ID** and **Return Period**.

HGL>GE will select the data from the **StormPro Results** filtered for the selected **Line ID**, **Return Period** and sections where the hydraulic grade line is above the ground elevation.

Input, Output and *Warning* will open the model Input, Output and Warning files, respectively (See below for examples of the Input File, Output File, and Warning File).

INPUT FILE:

```
JD
T1          Flood Control District of Maricopa County
T2          File: 01-00100-010.SPI
T3          Major Basin: 01 - Line ID: 100 - RP: 10
SO     0.00 984.00  2
R   1323.00 988.00  2      .013                                      0   0.000
JX  1328.00 988.00  1  1   .000    94.5         988.00        90.0
R   2671.00 990.00  1      .013                                      0   0.000
SH  2671.00 990.00  1                             0.00
CD   1  4            4.00
CD   2  4            4.50

Q            51.4
```

OUTPUT FILE:

```
                              Flood Control District of Maricopa County
                              File: 01-00100-010.SPI
                              Major Basin: 01 - Line ID: 100 - RP: 10
I STATION   INVERT   DEPTH      W.S.        Q     VEL     VEL   ENERGY  SUPER CRITICAL            HGT/  BASE/   ZL  NO  AVBPR
             ELEV   OF FLOW     ELEV                      HEAD  GRD.EL. ELEV   DEPTH              DIA   ID NO.      PIER
I L/ELEM    SO                                           SF AVE   HF                  NORM DEPTH                ZR
*******************************************************************************************************************************
I    0.00  984.00     3.55    987.55    145.9   10.85    1.83   989.38   0.00    3.55             4.50   0.00  0.00   0   0.00
I    7.12  0.00302                                    0.00566     0.04                 4.50                     0.00
I    7.12  984.02     3.73    987.75    145.9   10.35    1.66   989.42   0.00    3.55             4.50   0.00  0.00   0   0.00
I   30.52  0.00302                                    0.00518     0.16                 4.50                     0.00
I   37.64  984.11     3.95    988.06    145.9    9.86    1.51   989.57   0.00    3.55             4.50   0.00  0.00   0   0.00
I   77.50  0.00302                                    0.00486     0.38                 4.50                     0.00
I  115.14  984.35     4.23    988.58    145.9    9.40    1.37   989.95   0.00    3.55             4.50   0.00  0.00   0   0.00
I   98.52  0.00302                                    0.00510     0.50                 4.50                     0.00
I  213.66  984.65     4.50    989.15    145.9    9.17    1.31   990.45   0.00    3.55             4.50   0.00  0.00   0   0.00
I 1109.34  0.00302                                    0.00547     6.07                 4.50                     0.00
I 1323.00  988.00     7.25    995.25    145.9    9.17    1.31   996.56   0.00    3.55             4.50   0.00  0.00   0   0.00
IJUNCT STR 0.00000                                    0.00393     0.02                                          0.00
I 1328.00  988.00     9.74    997.74     51.4    4.09    0.26   998.00   0.00    2.15             4.00   0.00  0.00   0   0.00
I 1343.00  0.00149                                    0.00128     1.72                 3.04                     0.00
I 2671.00  990.00     9.45    999.45     51.4    4.09    0.26   999.71   0.00    2.15             4.00   0.00  0.00   0   0.00
```

WARNING FILE

```
T1          Flood Control District of Maricopa County
T2          File: 01-00100-010.SPI
T3          Major Basin: 01 - Line ID: 100 - RP: 10
SO      0.00 984.00  2
R    1323.00 988.00  2      .013                                            0    0.000
JX   1328.00 988.00  1  1   .000    94.5        988.00        90.0
R    2671.00 990.00  1      .013                                            0    0.000
SH   2671.00 990.00  1                            0.00
                                                          SP
                                WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                     PAGE    1
 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR    INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH               DROP

 CD      1    4                       4.00
 CD      2    4                       4.50
EADING LINE NO 1 IS -
                                Flood Control District of Maricopa County
EADING LINE NO 2 IS -
                                File: 01-00100-010.SPI
EADING LINE NO 3 IS -
                                Major Basin: 01 - Line ID: 100 - RP: 10
ELEMENT NO    1 IS A SYSTEM OUTLET       *       *    *
                    U/S DATA   STATION    INVERT  SECT                                  W S ELEV
                                 0.00  984.00    2                                        0.00
ELEMENT NO    2 IS A REACH               *       *    *
                    U/S DATA   STATION    INVERT  SECT            N                                     RADIUS  ANGLE  ANG_PT  MAN_H  IMINORL  CMINORL
                              1323.00  988.00    2            0.013                                     0.00   0.00   0.00     0       0      0.000
ELEMENT NO    3 IS A JUNCTION            *       *    *    *            *            *      *
                    U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2   N      Q3       Q4   INVERT-3 INVERT-4  PHI 3   PHI 4
                              1328.00  988.00    1     1     0  0.014    94.5      0.0  988.00     0.00  90.00   0.00
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
ELEMENT NO    4 IS A REACH               *       *    *
                    U/S DATA   STATION    INVERT  SECT            N                                     RADIUS  ANGLE  ANG_PT  MAN_H  IMINORL  CMINORL
                              2671.00  990.00    1            0.013                                     0.00   0.00   0.00     0       0      0.000
ELEMENT NO    5 IS A SYSTEM HEADWORKS             *                   *
                    U/S DATA   STATION    INVERT  SECT                                  W S ELEV
                              2671.00  990.00    1                                        0.00
```

APPENDIX A

DDMSW USER'S MANUAL

Drainage Design Management System for Windows

User's Manual

K · V · L

KVL Consultants, Inc.

K · V · L

KVL Consultants, Inc.

Table of Contents

Introduction

System Overview

The Drainage Design Management System for Windows (DDMSW) has been written to facilitate data management and computational procedures required for drainage analysis. This manual serves as a guide in the use of the program and is intended to be used in conjunction with the Agency's Drainage Design Manuals.

The program is written in Microsoft Visual FoxPro and generally includes modules for File, Edit, Hydrology, Hydraulics, Tools, Admin, Agency and Help. Agency is only available with a password.

DDMSW is a relational database that can manage multiple projects from one single location. The System is a multi-tasking window based application that enables the user to open several 'windows' simultaneously. New features include pull-down menus, user-friendly screens which the user can arrange on the desktop, and windows editing tools to facilitate data entry. DDMSW utilizes a relational database that includes tables for data entry and editing. Each table appears as a separate '.DBF' file on disk. The tables are related to each other based on the key field 'ProjectID' which is established when starting a new project. Model runs are automated from a menu and the data for running the models is extracted from the various tables in the database.

- ## Basic Database Terminology

The application stores data (values) in a relational Database. This data is organized into *tables, fields*, and *records* to make it more meaningful. For example, 01 by itself is meaningless. However, in a table called 'Basins', in a field called 'BasinId', in a record corresponding to 'EXAMPLE1', we now understand that 01 is a major basin in project EXAMPLE1.

A table is a grouping of data. The data is dynamic because it can be modified, deleted, added to and used in other relations. The following is an example of a table:

Table: Basins

ProjectID	BasinID	Description	Sort
00002	01	Major Basin 01	10
00002	02	Major Basin 02	20

A table is composed of one or more fields. In the example, the fields are ProjectID, BasinID, Description, and Sort. Fields are similar to columns in a spreadsheet. All fields in a table have the same format (e.g. text of maximum 70 characters, numeric 12 places with 2 decimals) and they share the same characteristics.

A table also consists of one or more records. Records are similar to rows in a spreadsheet. In the example, "00002, 01, Major Basin 01, 10' compose one record in the table 'Basins'. The example shows a total of two records and four fields.

In DDMSW, the database is composed of tables that organize and store information. A common field in each table, ProjectID, ties all the table data together for each individual project.

Program Installation

• DDMSW

The software used in DDMSW requires:

DDMSW	Compiled application
Acrobat Reader	PDF file reader

All required software for DDMSW (including models and other external programs) is included except Acrobat Reader, which can be downloaded from the Web.

Generally, the software comes as a self-extracting executable file. The setup files should be extracted to a temp directory. Then by running Setup.exe, the program can be installed. As it is installing, follow the instructions on the screen.

The user can choose the program's location, but assuming C:\DDMSW\ST\ the following directory structure will be created:

C:\DDMSW\ST	Program files
C:\DDMSW\ST\Backup	Directory for archiving data
C:\DDMSW\ST\Data	Data Files
C:\DDMSW\ST\Help	Help files
C:\DDMSW\ST\Maps	Example map files
C:\DDMSW\ST\Models	Model programs
C:\DDMSW\ST\ModlRuns	Directory for example model runs
C:\DDMSW \ST\Reports	Reports
C:\DDMSW\ST\Temp	Directory for temp files

The procedure will notify the user when the installation is complete.

• Adobe Acrobat Reader

Adobe Acrobat Reader is required to print the user manual and view other files. If Adobe Acrobat Reader is not currently installed on your computer, then it will be necessary to install the program. The latest version can be downloaded from Adobe's website at www.Adobe.Com. Follow their instructions to download and install 'Acrobat Reader'.

Starting the Software

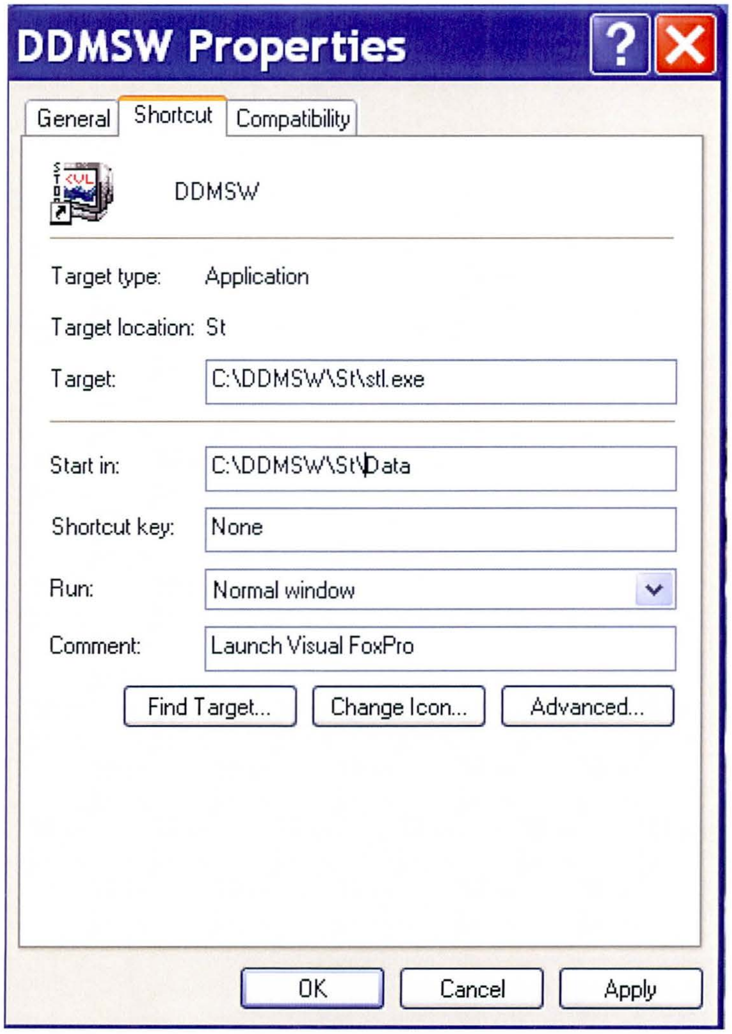
DDMSW is started by running 'STL.EXE'. The program can be accessed from the Windows Startup menu or other selected folder or by double-clicking on the icon.

The Startup directory should be 'C:\DDMSW\ST\Data' or wherever the data files are located.

When the software is first installed, it is necessary to access:

1. 'File/Select Project to establish project defaults.
2. 'File/Project Paths to establish project paths.
3. 'Tools/Options' to establish system settings and paths.

The following is a sample of the desktop icon to run the application and the properties of the program. These may vary depending on the installation directory selected.



NOTE

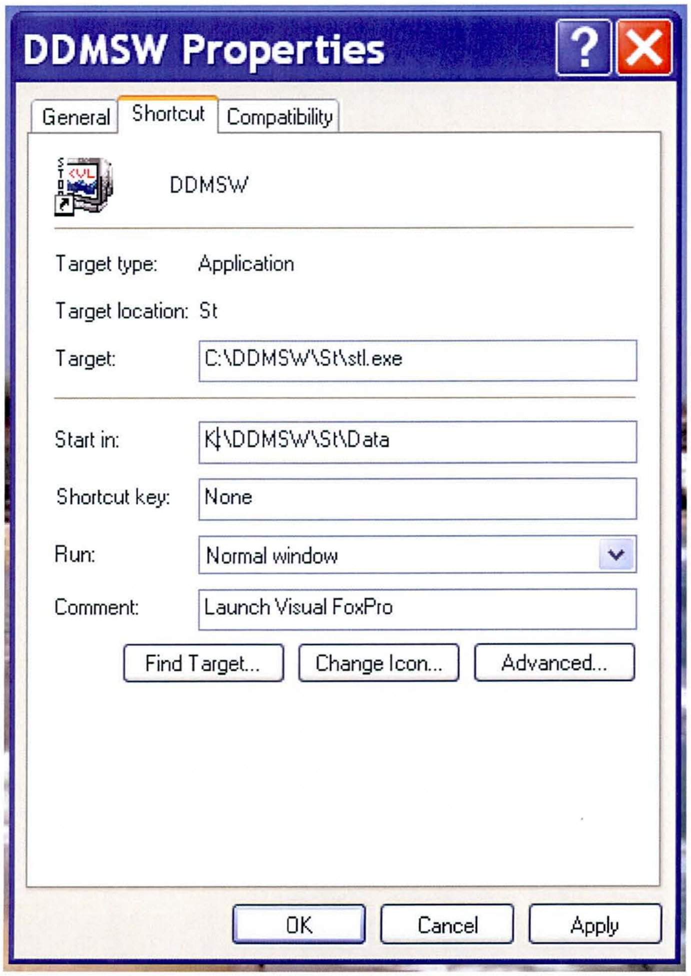
If the startup icon is lost from the system and needs to be reconstructed do the following:

1. Create a shortcut on the desktop for the file STL.EXE (located in the ST directory)
2. Right click on the icon and open properties.
3. Change the "Start in" to the data directory (ST\Data)

Network Installation

For Users wishing to manage their projects on a network, the following procedure should be followed:

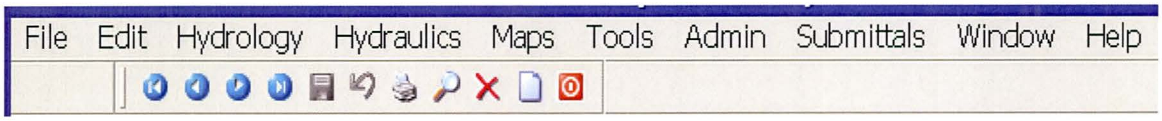
1. Install the application on all computers that will be running the application.
2. Install the application on the network drive (Shown as K: on the figure below).Right click on the icon used to start the software and select properties.
3. Modify the Start in property to point to the "Data" subdirectory on the Network Drive. For example, assume that the network installation for DDMSW is located at "K:\DDMSW\ST" where "K" is a mapped directory to the local network, and then modify the "Start in:" field of the DDMSW properties to "K:\DDMSW\ST\Data".



When software patches become available, it is ONLY NECESSARY TO UPDATE THE NETWORK INSTALLATION. When individual users access the network data, a check of the Network's application version, reports, models and help files is carried out and any necessary updates to the local machine are carried out automatically.

General Features

Main Menu



The Main Menu is the center of the application. This is the screen that is displayed when the user starts the application. It is also the screen the user is always returned to after closing a submenu or screen.

Specific actions can be accessed through the pull-down menus shown on the Main Menu bar. This manual will explain the functions available on each menu and will describe the individual elements shown on data entry screens. Depending on the type of application installed, some of these menu options may not be available.

Standard Buttons

There is a toolbar of standard buttons, which is identical on each data entry screen. The buttons become available/unavailable depending on the current action.

 Goes to the first record in the table.

 Moves to the previous record.

 Moves to the next record.

 Goes to the last record in the table.

 Save the changes to the current record.

 Undoes the last command or action.

 Prints a report of the current table to the screen.

 Searches for the first record based on the typed selection criterion.

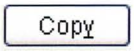
 Deletes the current record. Use this with caution! Deleted records cannot be retrieved.

 Use this to add a new record. When this button is clicked, a blank record appears for the user to enter values. Select *Save* to keep the data, or *Cancel* to discard the addition.

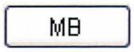
 Closes the current screen and returns the user to the Main Menu or previous screen. Pressing [Esc] will also close the screen and return the user to the previous screen. However, changes to the current record may not take effect.

Common Buttons

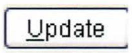
The following buttons appear on several forms and basically perform the same function:



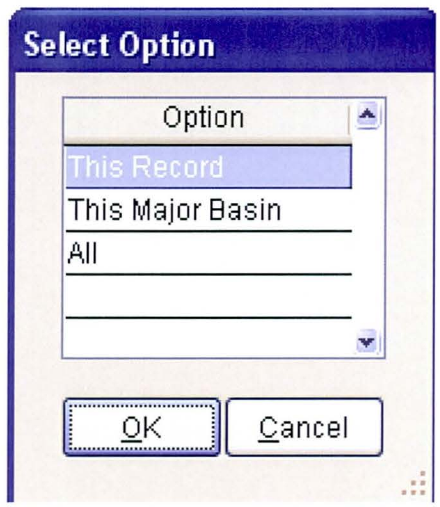
Copies the existing record to a new record so that only changes need to be edited.

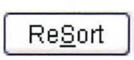


Shows a screen of all available major basins in the current project. Data on open forms will be filtered to the selected major basin.



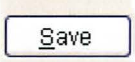
There are two types of update:
On a default form, it updates default data from agency data. Check the options to be updated. On a non-default form, it updates the data by performing calculations. The user selects the This Record, This Major Basin or All for the entire project to be updated.



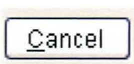


This renumbers the current 'sort' data in tens.

Prints the corresponding report for this data.



Saves the record with the current edits. This is only visible in "Edit" mode.



Discards all current edits. This is only visible in "Edit" mode.

Shows instructions for the currently opened form.

Data Screens

Screens display multiple records on a grid and details of the current record. Only data for the current record can be edited. Use the vertical scroll bar to move through records on the grid and highlight a record to edit.

The user can move and resize screens according to preference. Changes made to window position are retained in the application.

Detailed information is available on the Info Button on each form.

Edit Menu

The Edit menu is available to the user during data entry or editing. The menu comprises the following functions. Some or all may be available depending on the action currently being executed.

Undo	Undoes the last command or action.
Redo	Repeats the last command or action.
Cut	Removes the selection and places it onto the Clipboard.
Copy	Copies the selection onto the Clipboard.
Paste	Pastes the contents of the Clipboard.
Clear	Removes the selection and does not place it onto the Clipboard.
Select All	Selects all text or items in the current window.
Find	Not available
Replace	Not available

Window

This menu item is available when a screen is opened.

Arrange All	Arranges the open screens tiled on the desktop.
Cascade	Arranges the open screens in a cascading from left to right on the desktop.
Close All	Closes all open screens.

Lists all open screens with a checkmark next to the current one.

Printing

Select the report to be printed, and choose the output location (Screen or Printer), and click Print... .

FCDMC
Drainage Design Management System
SOILS
Project Reference: EXAMPLE1

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Area ID	Soil ID	Area (sq mi)	Area (%)	XKSAT	Rock Percent (%)	Effective Rock (%)
1A	64512	1.720	25.70	0.01	-	100
	64519	0.450	6.70	0.19	-	100
	64512	0.270	4.00	0.01	-	100
	64572	0.890	13.30	0.09	30.00	100
	64522	0.670	10.00	0.04	-	100
	64577	0.220	3.30	0.05	-	100
	64522	1.120	16.80	0.04	-	100
	64524	1.340	20.10	0.02	-	100
1B	64512	1.380	24.20	0.01	-	100
	64519	1.230	21.50	0.19	-	100

Keep in mind that when a report outputs to the screen, the user is able to select to print or export it by using the Reports toolbar at the top of the report. By clicking , the user can choose to print all or selected pages of the report. Click the Export Icon to select a format and destination for the export file. This enables the user to exchange project data with other applications. Always close the current report view when you are finished, otherwise the report generator will remain open.

Graphs Toolbar

When graphs are opened the following tools are commonly available on the graph screen:

Copies the graph to the clipboard as a bitmap, metafile, text or OLE object.

Data Editor. This displays the data values at the bottom of the screen. These values can be edited, and the graph dynamically reflects these changes.

	1	2	3	4	5	6	7	8
— 1	510	1510	1585	1596	1600	1612	1662	2262
	99.70	94.10	93.60	92.20	92.20	93.60	94.90	99.70

Zoom tool. Click this icon and draw an area of the graph to be magnified.

Prints the graph.

Please note that the data for the graphs has been rounded to facilitate the graphing function. Therefore the data is not as precise as the data in the application.

Reindex Data

! Caution: Reindexing and packing tables take a few minutes to complete. Interrupting the process once it has begun will result in data corruption.

This function can only be used when there are no other users accessing the application. The option is used for two purposes. In the event of a corrupt index, the administrator needs to reindex tables and rebuild the table indexes.

The option also packs all tables in the database. When a record is deleted, it is not physically erased from disk until the database is packed. Packing permanently removes deleted records and restores disk space occupied by those deleted records. The database should be packed occasionally to restore disk space.

Agency Password

Access to the Agency menu is restricted. Enter the password to access the Agency menu.

Change Agency Password

This is only visible if an appropriate Agency password has been entered. This enables the user to change the password. A window appears confirming the new password. If this is correct, click *OK* to confirm the change.