1D River Modeling

The purpose of this training module is to teach users how to use XP's tools to simulate the storage and transport or routing of water through a 1 Dimensional (1D) river system. Users will learn how to build the nodes and links in a river modeling collection network. XP tools will be used to extract data from GIS files as well as to create a digital terrain map (DTM). Other tools in XP will be shown to help users understand and model 1D river modeling.

Objectives

A river model network can be developed in the graphical interface using a variety of methods. In this example, users will learn how to utilize tools to build on the model started in Workshop Example 2 using various tools to add data to the model. You will learn how to:

1. Build a river model from HEC-RAS data import
2. Create a digital terrain model (DTM) from a .ASC grid file
3. Enter the basic configurations settings for solving in Hydraulics mode (HDR)
4. Obtain results from the output file and the Review Results tool
5. Generate Cross-Sections from DTM and add a lateral
6. Prepare 1D Flood maps and animate water levels

Data files to be used are:

1D River Starter.xp including: Image1.jpg and Image1.jpw, Image2.jpg and Image2.jpw, Image3.jpg and Image3.jpw
E116-05-00.g01
whiteoak1.xptin
HECRAS Flows.xls

Building a xpswmm/xpstorm model using HEC-RAS and a DTM

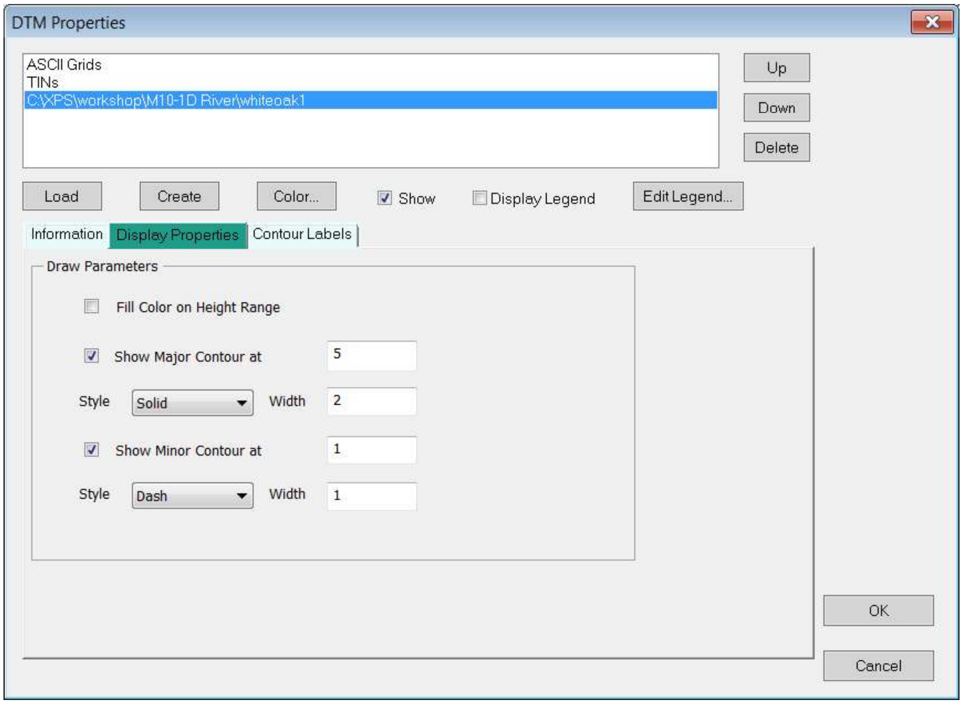
This example will show users how to convert an existing HEC-RAS model to an XPSWMM/XPSTORM model.

Importing HEC-RAS Data

1. Open xpswmm/xpstorm. At the opening dialog, select **Browse**.

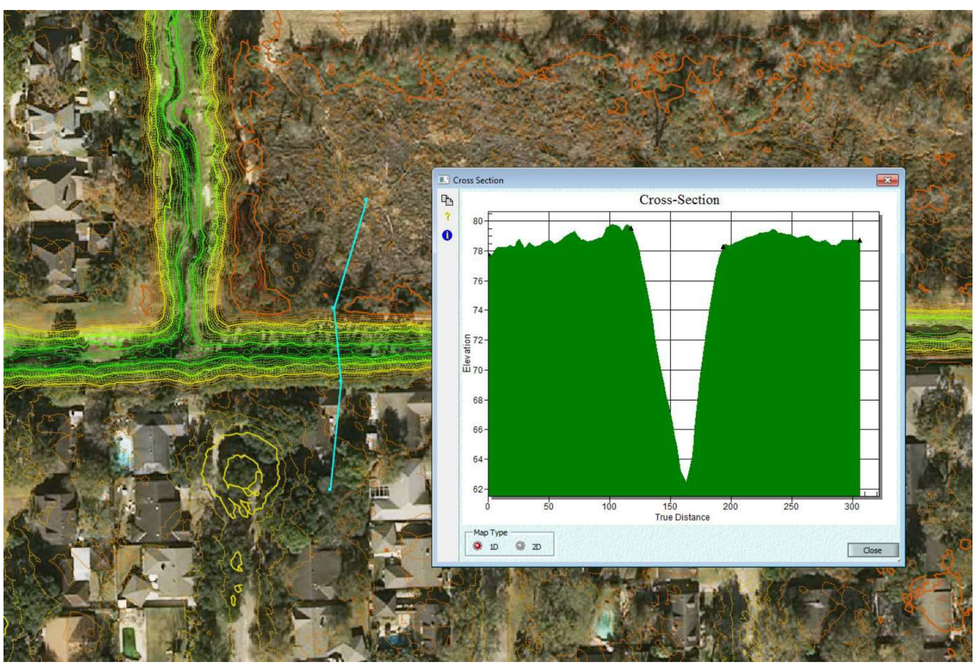
2. In the Windows Explorer, navigate to **XPS\Workshop\M10-1D River** folder and select the file **1D River Starter.xp**. Click on **Open**.

3. **Right-click** on the **DTM** layer, select **Properties**. Choose the **Display Properties** tab and turn off the Fill Color on Height Range and then set the **Major Contour** interval to **5ft** and **Minor Contour** intervals to **1ft**, as shown below.



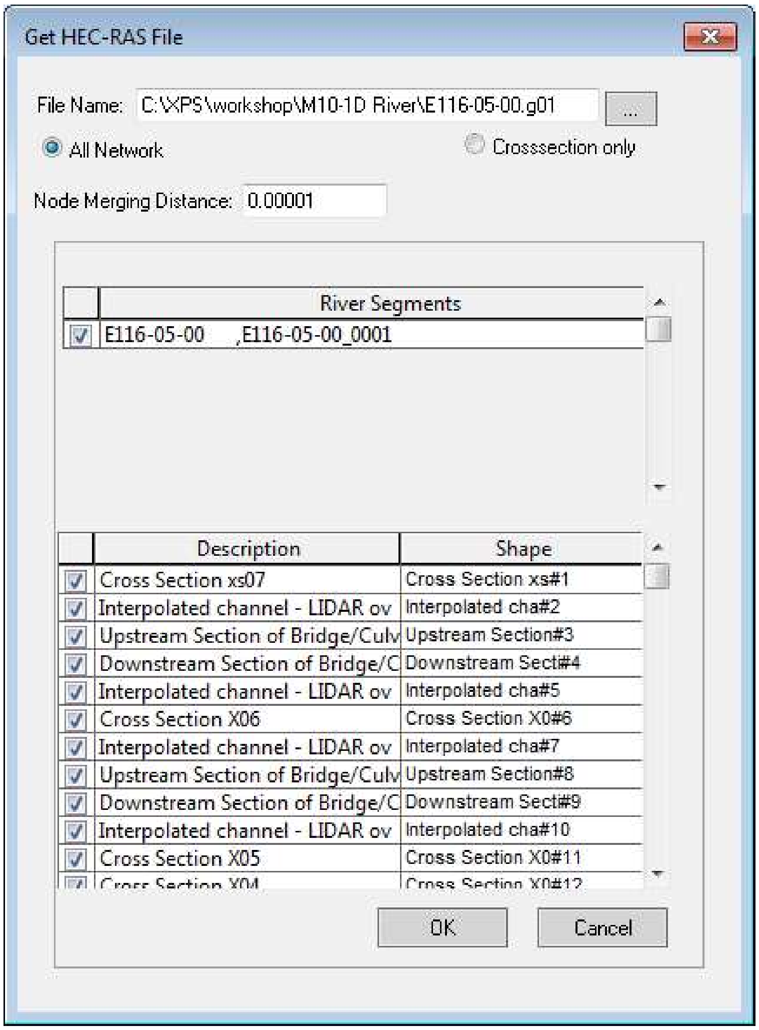
4. From the **File** menu choose **Save As… 1D River.xp**

5. Zoom to a location to clearly see the river and contours. Using the **Section Profile** Tool compare how well the xptin surface and the aerial photos align at the river reach.



6. Browse to **File**->**Import/Export Data->Import Hec-Ras Data...**

7. The HEC–RAS file geometry file which we will be importing is located in the workshop folder and is named **E116–05–00.G01**. Using the ellipsis button  browse to this file in the Module-10 directory and select **Open**.

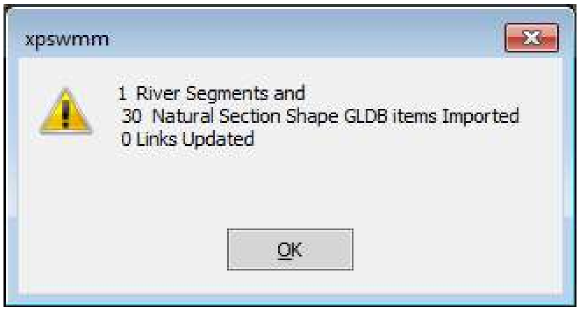


8. After selecting the HEC-RAS geometry file ensure that **All Network** is **selected.** This will import not only the HEC-RAS cross section data but also the reach centerline and apply the cross sections to the appropriate corresponding reach links. By default the **Node Merging Distance** is left at a **default** of **0.00001**.

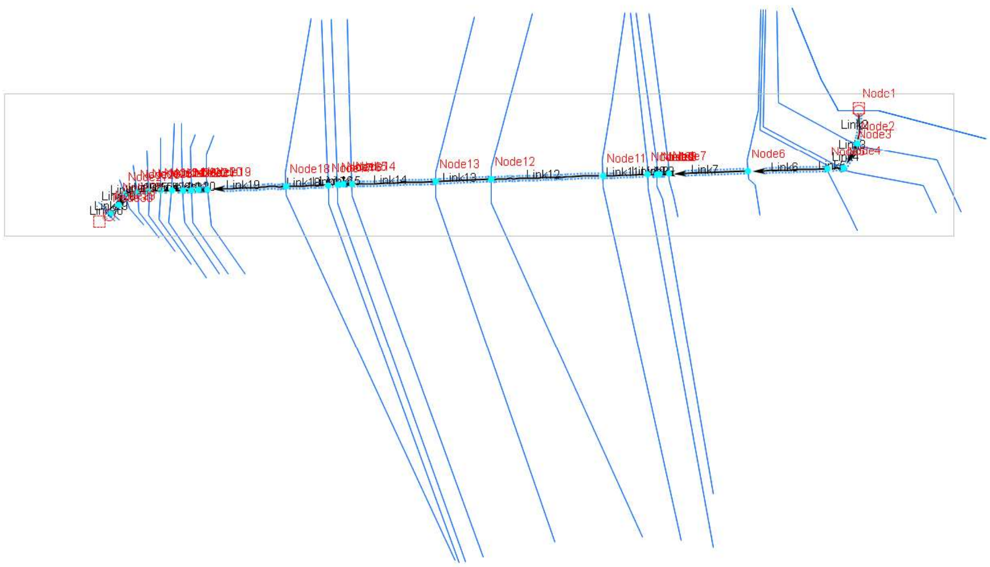
   If only select HEC-RAS cross section and reach data is desired to be imported, the check box for the shapes shown could be unchecked, leaving only the items desired to be imported checked.

   Note that the Natural Channel shape names within xp are limited to 20 characters, HEC-RAS shape names longer than 20 characters will be abbreviated when imported.

9. Select **OK**, the import log message will appear showing what objects are updated. Select **OK** at this dialog.

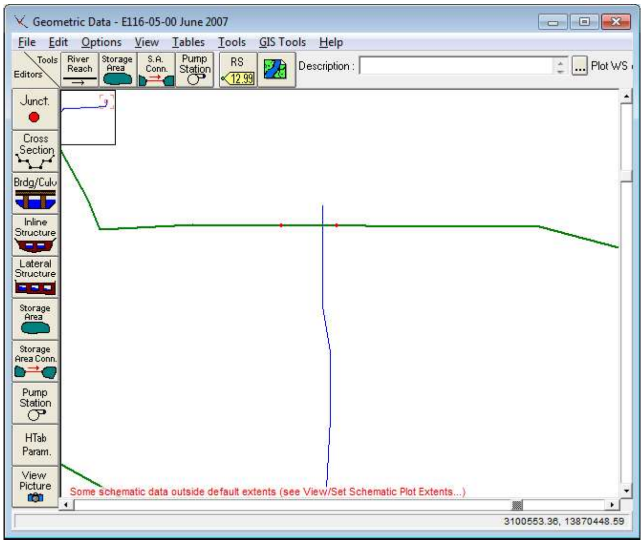


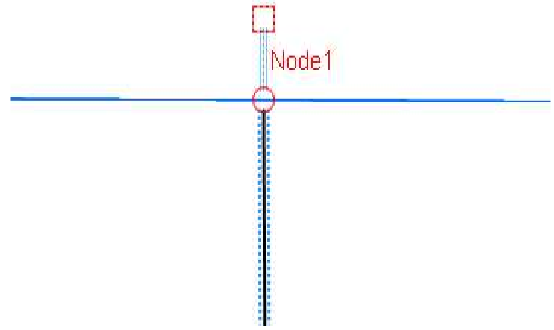
10. The xp model objects are now imported and the error.log file will be generated, listing any warnings or errors encountered during the import. Most of these will be regarding processing of bridge data due to the difference in model setup for bridges.



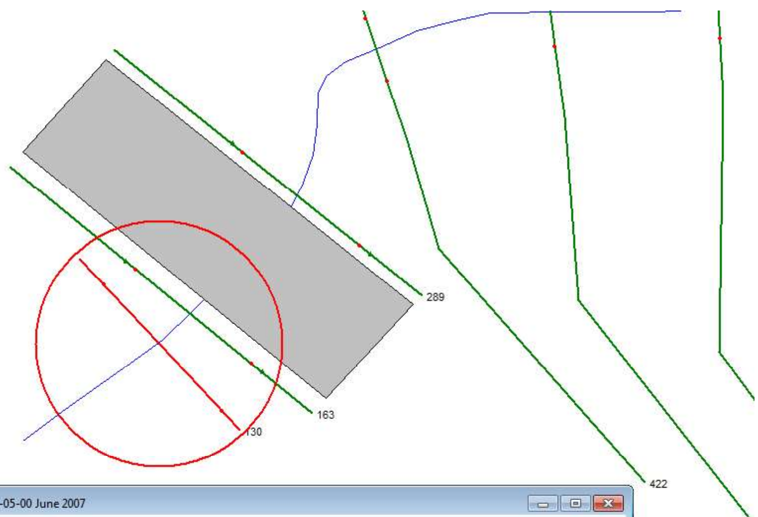
11. Check the imported model - review the most u/s and d/s nodes and links. The u/s most node and link are 'extra' objects which are brought into the model based on the segment of HEC-RAS river reach centerline which extends beyond the top most cross section.

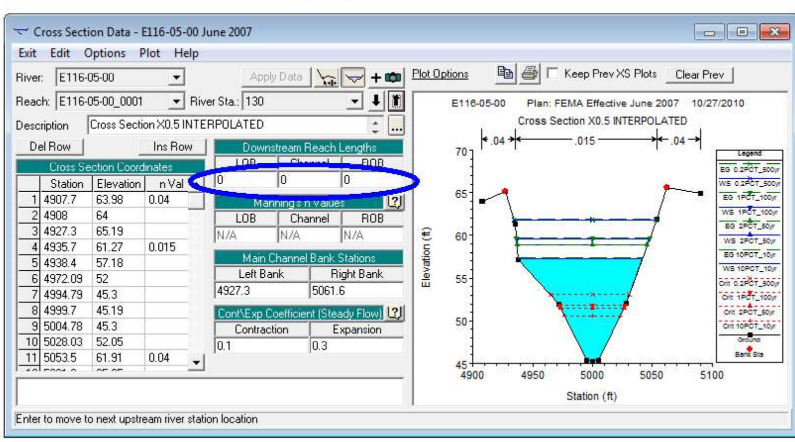
    Since this u/s node and link are not hydraulically significant and have missing data, Node0 and Link1, have been automatically made inactive.



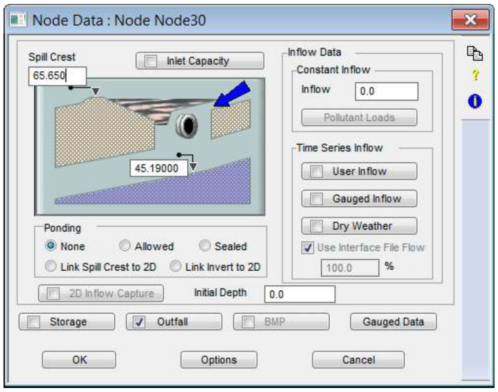


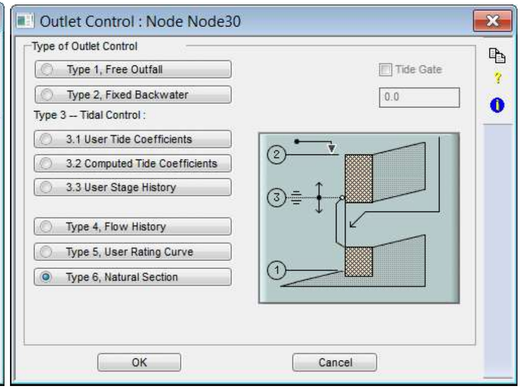
Likewise, the d/s most node and link are created from the HEC-RAS reach geometry though are not used in the hydraulic simulation. As shown below, the final cross section within the HEC-RAS model has a zero length and is only used as a boundary condition. Hence **Node31** and **Link31** have also been made **Inactive**.

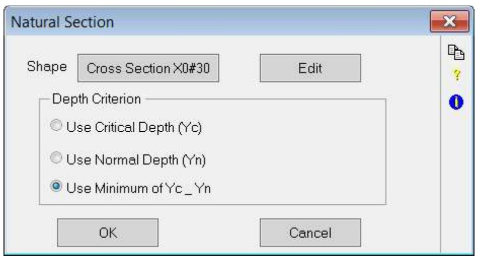




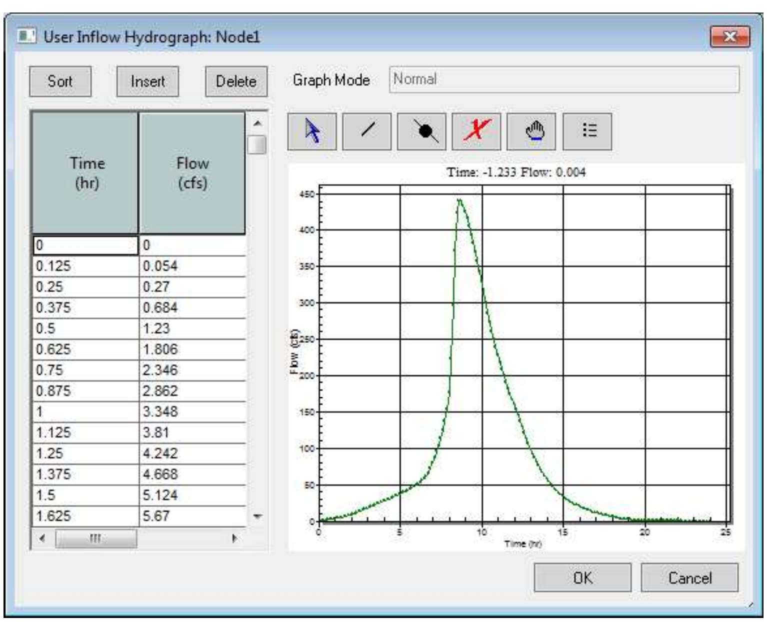
12. **Double-click** the new d/s most node, **Node30**, select **Outfall** and then **Type 6, Natural Section**.







13. HEC-RAS flow hydrographs can be added to the xp model by viewing the chosen dss hydrograph in HEC-RAS and copying the data to an excel spreadsheet. The date/time typically need to be adjusted to decimal hours. This has been done already and is in the file called **HECRAS flow.xls**. **Double-click** on **Node1** and click on **User Inflow** under Time Series Inflow. Insert one row and copy the time and flow hydrograph data from the Upstream tab into the dialog. Click **OK** twice to return to the project window.



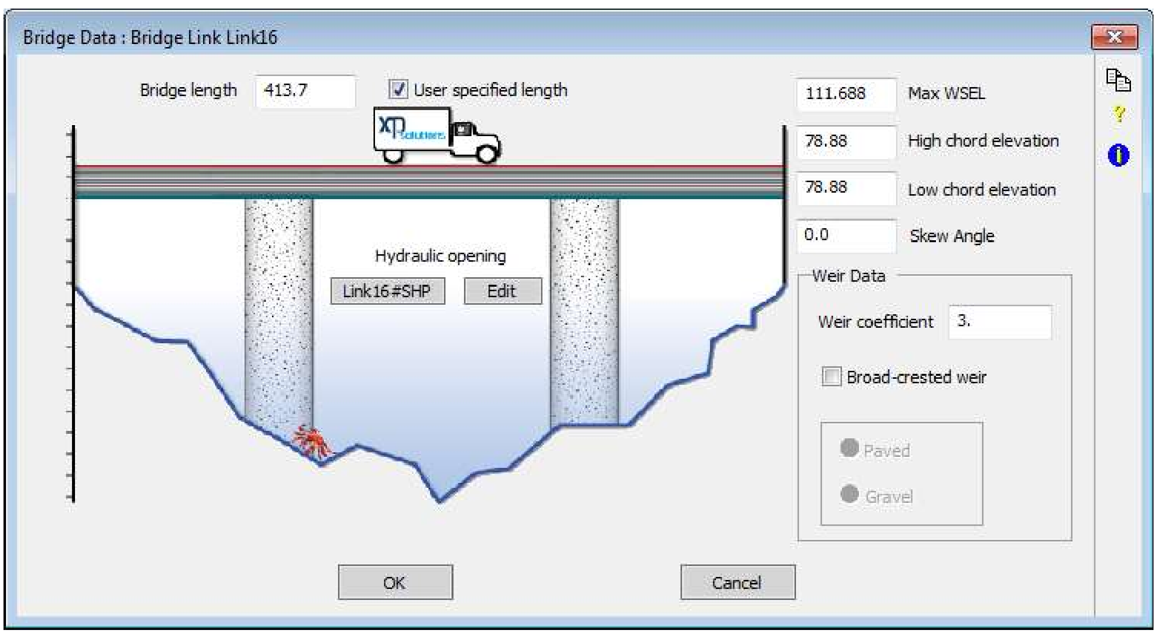
Repeat this process and copy flow from the **IN-LINE** tab to **User Inflow** at **Node12**.

14. Browse to the **Hydraulic Job Control**, update the **Time Control** if not already a **24 hour** simulation duration. Set the **Save Results Every** interval to be **5** minutes.

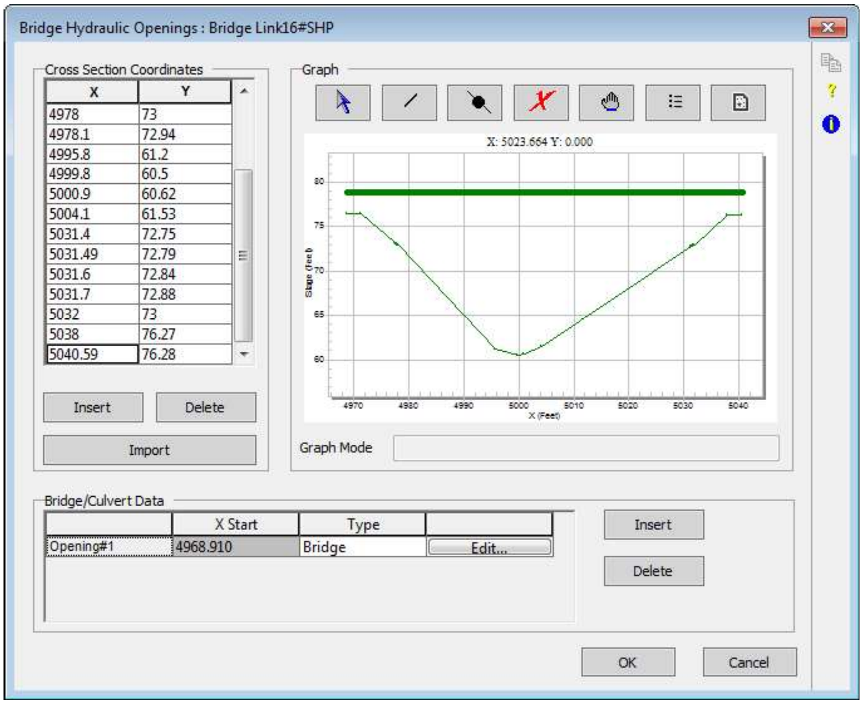
15. **Save** your model as **1D River2.xp**.

16. Most bridge data is imported from HECRAS models, however we will manually update some bridge crossings to ensure completeness.

17. Use **CRTL-F** to find **Link 16. Double-click** Link 16 to get the bridge dialog.



18. Select **Edit** for the Hydraulic Opening. In that dialog from the bottom and the top delete the rows representing the left and right overbanks to trim the section to just the part under the bridge deck. This would leave data from only stations 4968.91 and 5040.59 as shown below. Press OK twice to return to the plan view. **Save** the model.



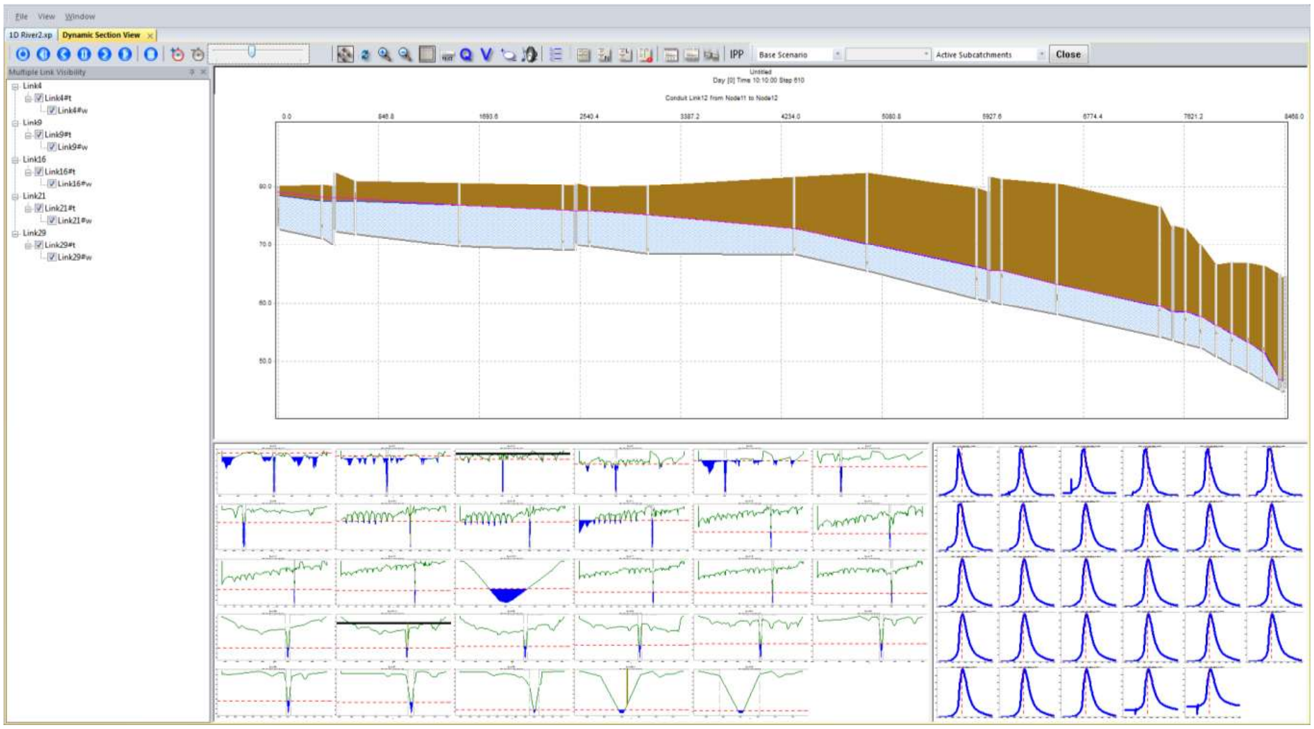
Model results

1. **Solve the model** by browsing to Analyze->Solve, by selecting the toolbar icon or by pressing F5.

2. A list of model errors and/or warnings will be shown in the Error.log file. Note that there are no errors in the model, so we can proceed with the simulation by pressing **Yes**, on the warning message check dialog if enabled. The warnings listed in the error file are due to the roughness values adopted from the HEC-RAS model being outside the typical range of open channel roughness values.

```
Data Generation Diagnostics

WARNING: HDR: Links 'Link2': The mannings roughness, 0.99, for the left overbank, is out of reasonable range.
WARNING: HDR: Links 'Link2': The mannings roughness, 0.99, for the right overbank, is out of reasonable range.
WARNING: HDR: Links 'Link7': The mannings roughness, 0.99, for the left overbank, is out of reasonable range.
WARNING: HDR: Links 'Link7': The mannings roughness, 0.655, for the right overbank, is out of reasonable range.
WARNING: HDR: Links 'Link12': The mannings roughness, 0.903, for the left overbank, is out of reasonable range.
WARNING: HDR: Links 'Link13': The mannings roughness, 0.68, for the left overbank, is out of reasonable range.
WARNING: HDR: Links 'Link14': The mannings roughness, 0.933, for the left overbank, is out of reasonable range.

0 Error(s) and 7 Warning(s) were encountered
Data Export Completed Successfully
```

3. After solving, hold **Shift** while clicking the **Select All node** and **Link** keys , to select only the active network objects, then select **Dynamic Section Views**



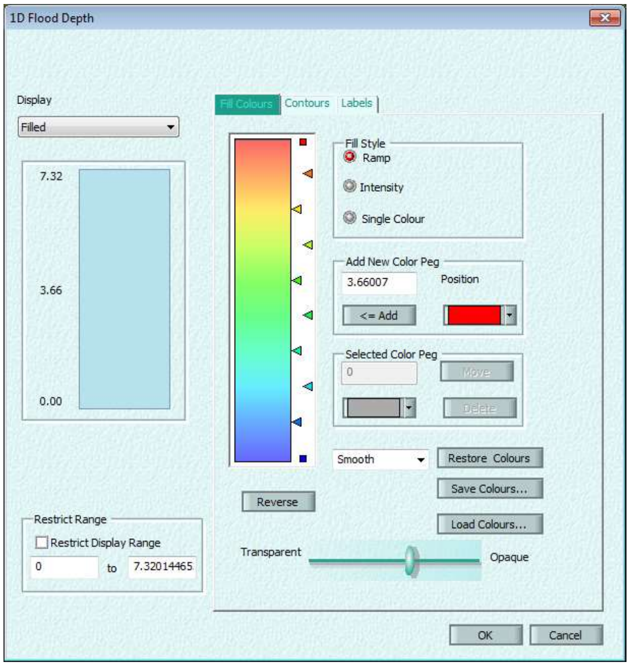
4. Animate the HGL or slide the time control midway to see the water fill the channel cross sections and profile.

5. Save the model using **Save As… 1D River3.xp**

1D Flood Maps

1. The upstream most cross section is fully inundated outside the channel banks. We can use the 1D Flood Maps tool in order to create a flood map of the simulation based on the 1D channel WSL results and the xptin surface.

   In the Layer Control Panel turn on the **1D Flood Maps**. The 1D hydraulic results will be interpolated against the xptin surface at each time step – providing not only a maximum extents but a simulation animation of the results. This process may take several seconds to complete.



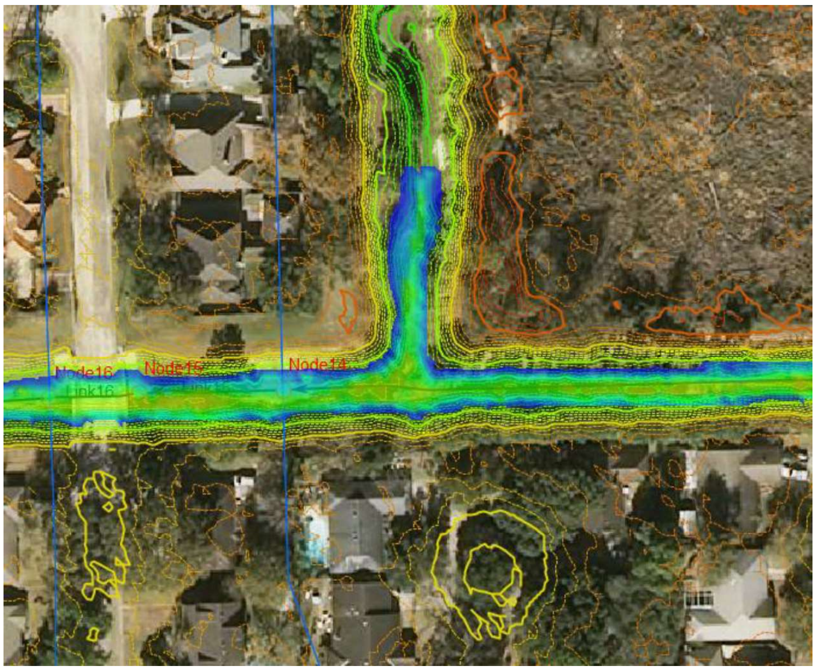
2. Right-click on the **1D Flood Maps** and choose **Properties**. **Reverse** the color gradient and move the **Transparency** slider to about 50%. Click **OK**.

3. Use the **Green Arrow** (Maximum) from the Animation Controls in the Status Bar to show the maximum flooded extent.

Adding in Lateral Catchment

1. Use **Save As…** using the name **1D River4.xp**.

2. Using the 1D Flood Maps tool we can see that immediately u/s of Node14 there is a lateral drainage area which is not being represented in the original HEC-RAS model. In our model we can see the 1D Flood Map back filling a lateral channel which should be incorporated into our study area.



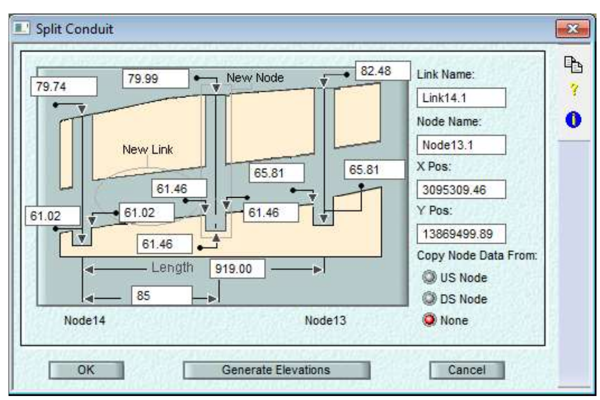
We will add the Lateral Channel segments, including the bridge crossing, into the model as well as model the inflow into this reach by defining the hydrologic catchment in the Runoff mode.

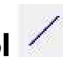
3. Turn off **1D Flood Maps**.

4. The Confluence of the lateral and the main reach is **85 ft** upstream of **Node 14**. We need to Add in a node at this point to create the junction. First step is to **right-click** on **Link14** and select **Non-river Link** since a River Link cannot be split.

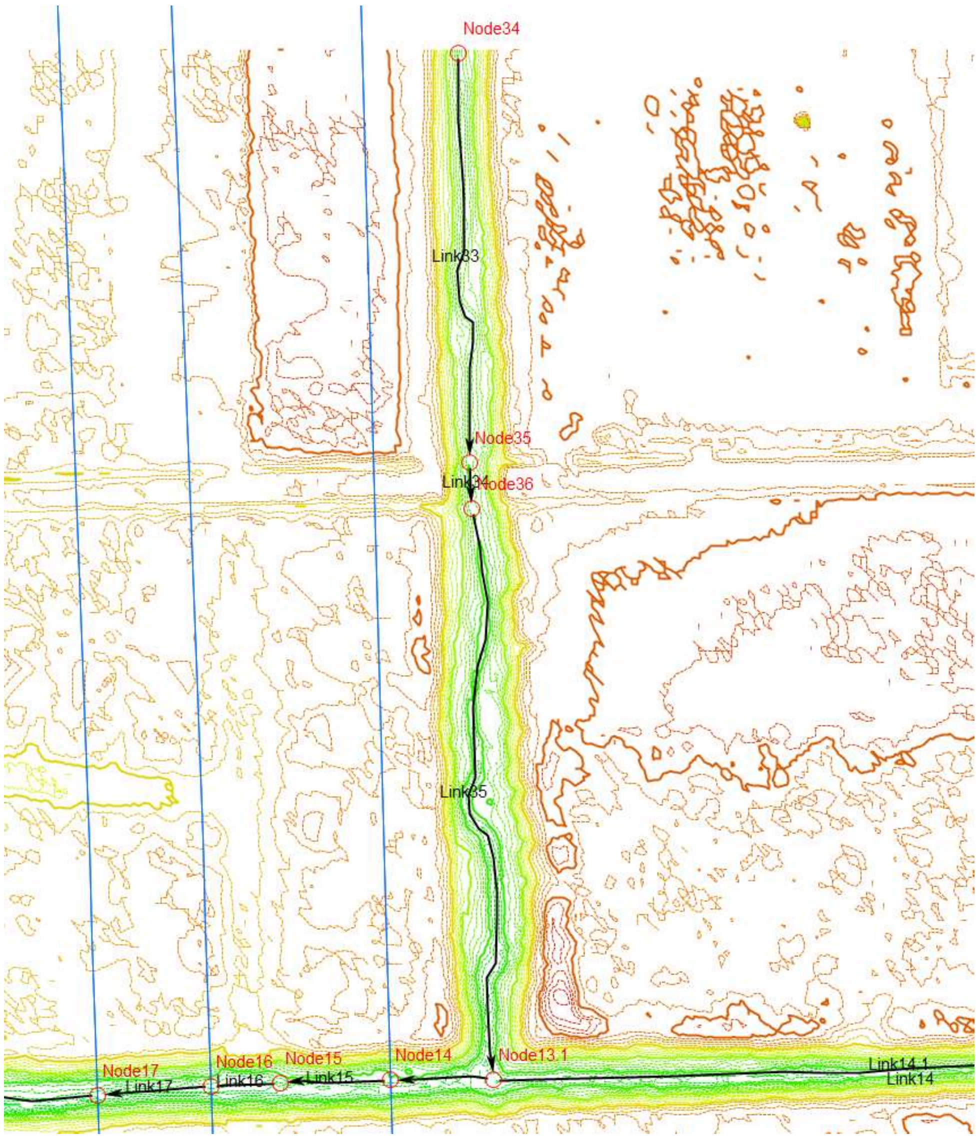
5. Next **right-click** on **Link14** and select **Split Conduit**.

6. By default, the conduit will be split in half, update the d/s split length to **85 ft** and select **Generate Elevations**. Click **OK**. This will create a new node at the desired location and duplicate the link geometry upstream and downstream of the new node.



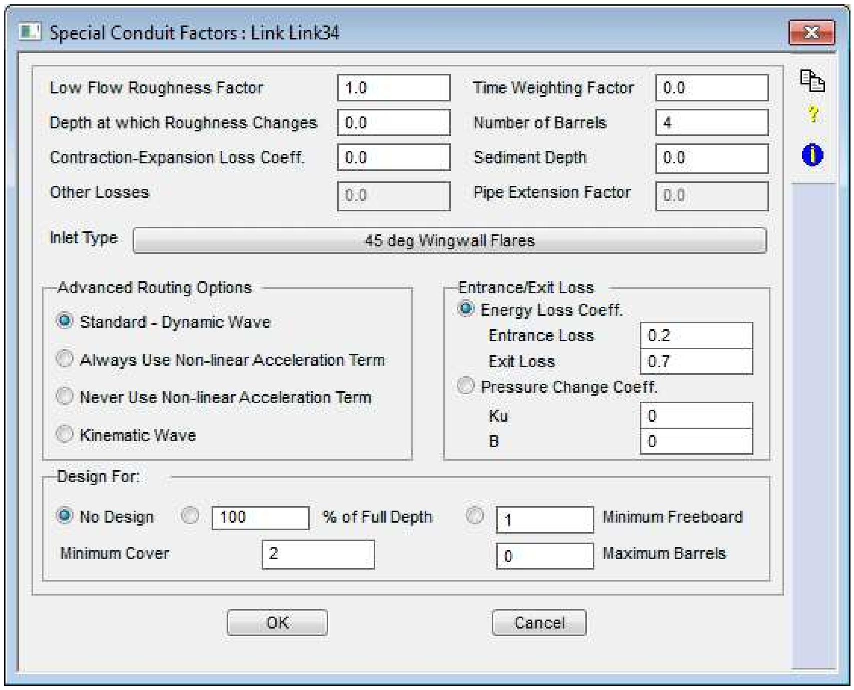
7. Begin drawing the lateral reach at the u/s end. **Select** the **Link drawing tool**  and **click once** at the edge of the xptin surface to draw the first node. While **holding CTRL** click along the centerline of the lateral reach until you reach the bridge. **Release CTRL**, click once on each side of the bridge to draw the bridge objects, then hold CTRL and click along the lower lateral reach length centerline until Node13.1, then double-click on Node13.1 to finish.

   Note: To save time simply import the Lateral.XPX file which will create the 3 nodes and 3 links.

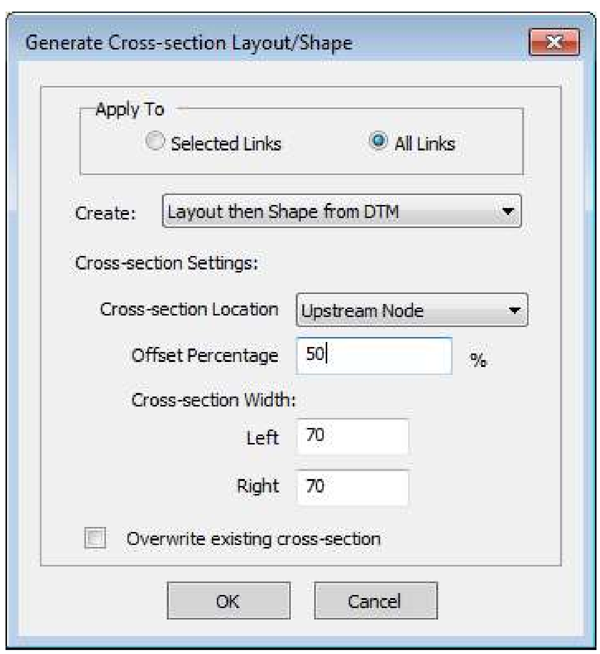


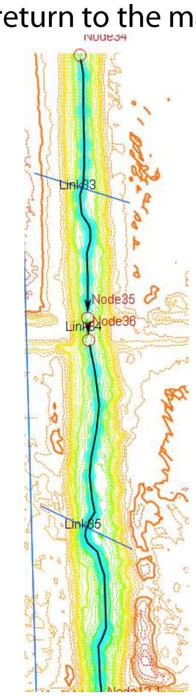
8. Edit **Link33** and **Link 35** and select **Natural** as the link type. Now, the link types are Natural for the reach segments u/s and d/s of the bridge. Double-click and open **Link34** and change the conduit type to **Rectangular**. Note that this link represents the 4 Box Culverts under the bridge span. Enter the height and width as **5 ft**.

Tick on the **Conduit Factors** box and enter the **number of barrels** as **4**. There is also an inlet wall, from **Inlet Type** select **45 deg Wingwall Flares**. Add **0.2 Entrance** and **0.7 Exit** loss values. Click on **OK** twice and return to the network window.



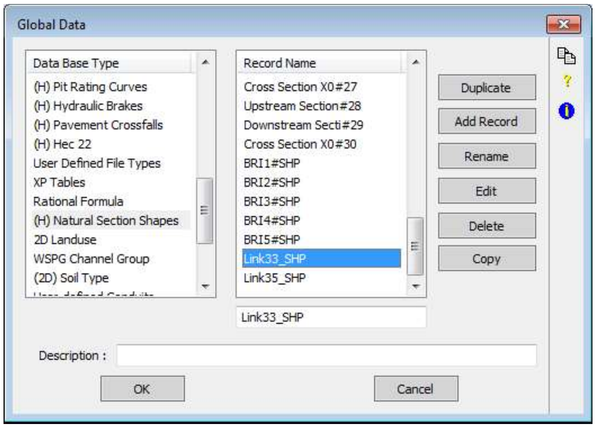
9. Get cross-sections for the links. Select **Link33** and **Link35** and go to the **Tools->Calculate Conduit/Cross-sections** menu. Complete the data entry as shown in the dialog. Click on **Yes** when prompted about overwriting any existing cross sections and you will be able to see the list of new cross-sections obtained. Click on **OK** and return to the main window.

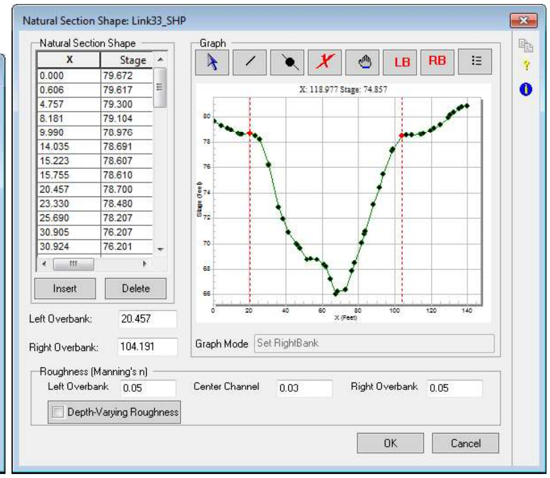




10. Select **Configuration->Global Data**. Select **Natural Section Shape** as the Database Type. Highlight and **Edit Link33_SHP**. Click on the **LB** button and click on the cross-section to add the left overbank station. Similary add right overbank also. Enter the **Mannings n** values for the overbanks as **0.05** and main channel as **0.03**.

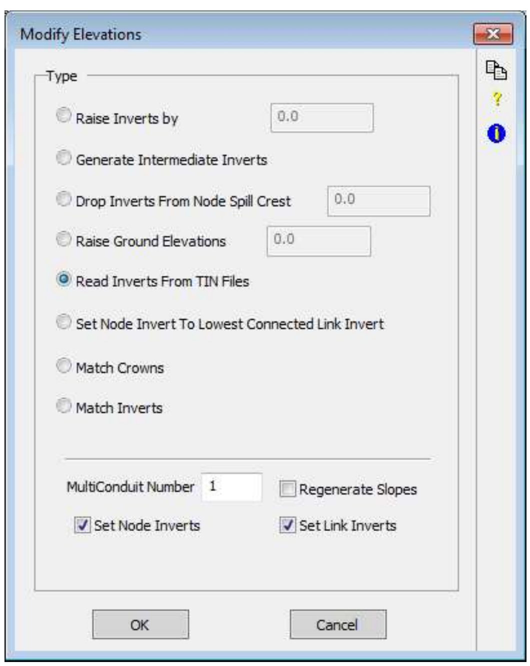
    Note: An XP-Table could be created for the Natural Channel cross sections in order to allow a fast copy and paste for all of the roughness values.

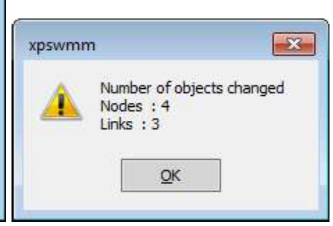




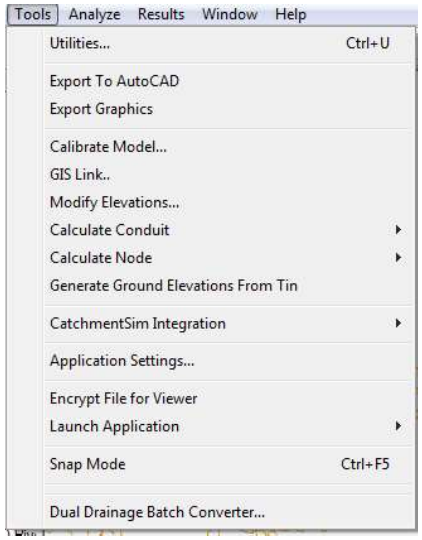
Repeat this procedure using the same roughness values for **Link35_SHP**.

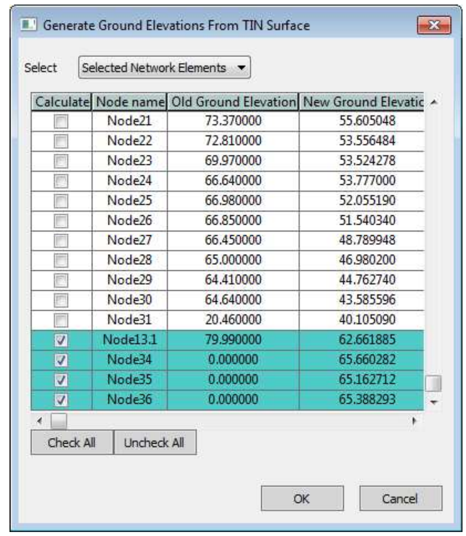
11. Select the lateral reach objects, from **Node34 to Node13.1**, go to the **Tools Menu** and access the **Modify Elevations** dialogue. Select the **Read Inverts from TIN Files** and switch on the **Set Node Inverts** and **Set Link Inverts** tick boxes. Click on **OK** and you will see the message 4 nodes and 3 links have been modified. Click on **OK**.



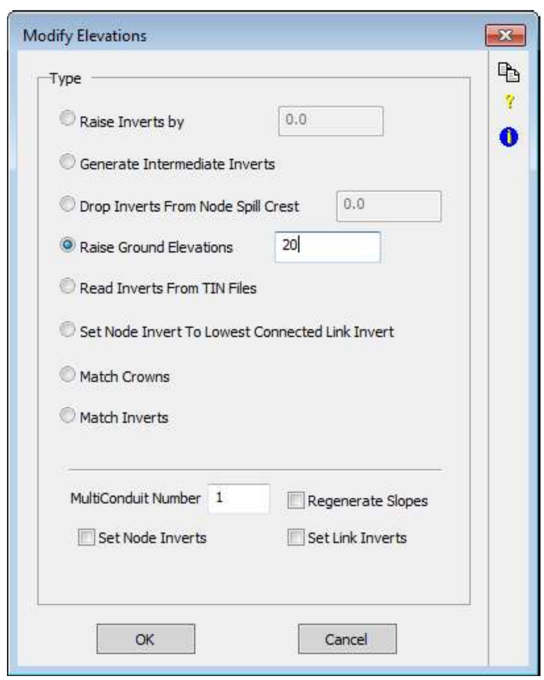


12. Now we will create the ground elevations for the nodes. With the same objects selected, from the **Tools Menu** select the option **Generate Ground Elevation from Tin.** Ensure that **Selected Network Elements** is chosen, scroll down to see the lateral reach 4 node objects. Click on **OK.**





Now, select **Node34**, **Node35** and **Node36,** from **Tools Menu/Modify Elevations**, **Raise Ground Elevations** by **20 ft**.



13. Select **Link33**, **Link34** and **Link35**, and go to the **Tools Menu/Calculate Conduit/Lengths**. Choose **Selected** and Calculate. Repeat the process for **Calculate Conduit/Slopes**.

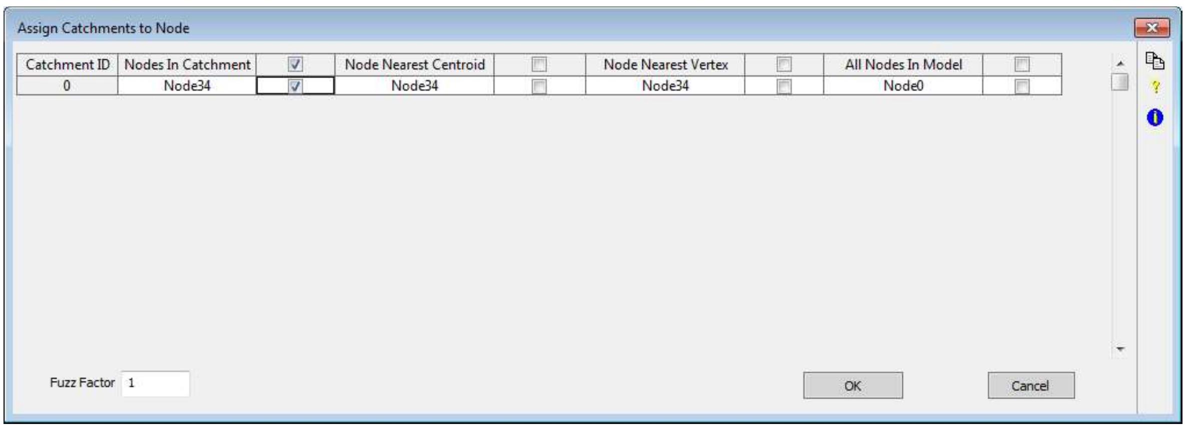
14. **Save** the model.

Add Lateral Catchment Inflow Hydrology

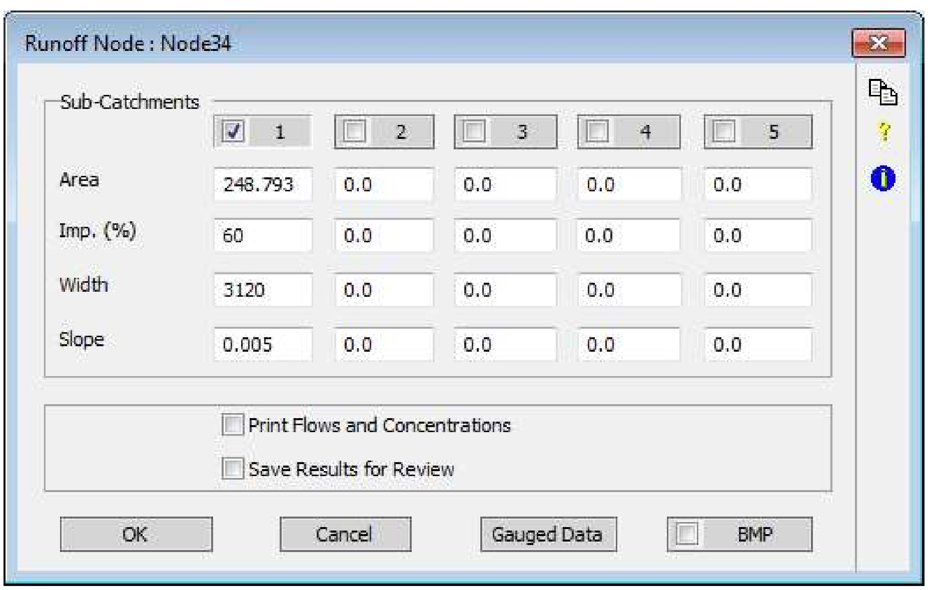
15. **Right click** on the **Catchments** layer and select **Import from GIS**. Browse to the M10 folder and select **Catchment.shp**. Uncheck the import attributes flag and click **OK**.

16. Switch to the **Runoff mode**, and make **Node34 Active**. Under **Tools->Calculate Node->Catchment Drainage**, click Nodes in Catchment to automatically link the polygon to Node34. Note that other options also would have connected to polygon to Node34.

    Alternatively, the catchment can be manually connected to the node by selecting the catchment centroid and dragging it to the node.

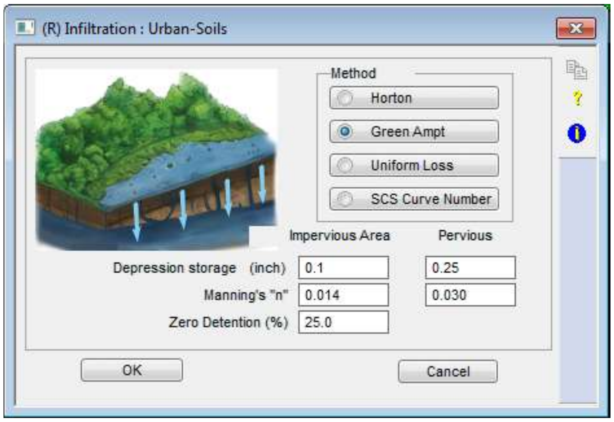


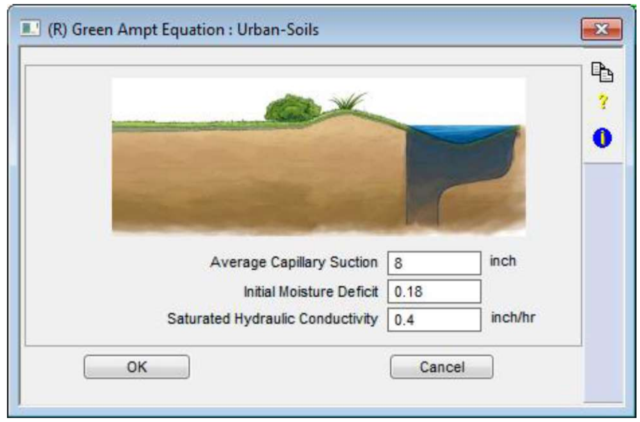
17. Edit **Node34** and enter the Sup-Catchment data as shown below:



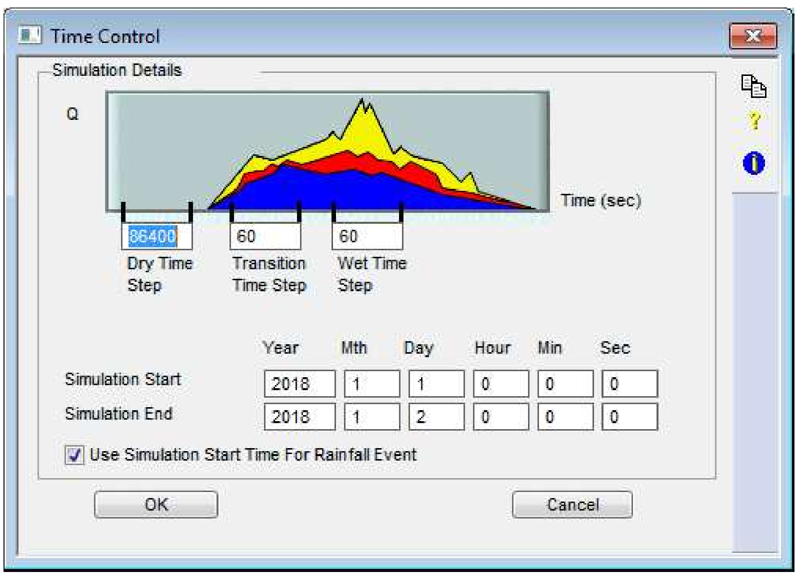
18. Click on Sub-Catchment 1 flag, as we are using the SWMM Runoff routing method the rainfall and infiltration must both be specified. Click the **Rainfall button**, highlight the **SCS Type II rainfall record** and select **Edit**. Under **Constant Time Interval**, update the **multiplier** to **6.1** inches – representing the total depth of the 100-year rainfall ARI event. Click **OK** twice and then **Select**.

19. Click on **Infiltration** and type in name **Urban-Soils**, then select **Add**, then **Edit**. Update the Infiltration record based on the images below. Select this record then click **OK** twice to accept the sub-catchment data.

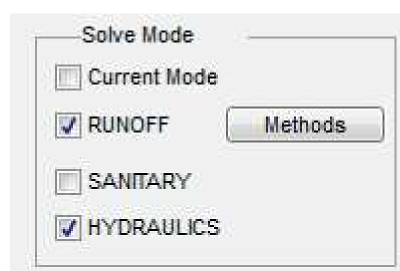




20. Edit the **Runoff Job Control->Time Control** to set a 24-hour simulation period and check the **Use Simulation Start Time For Rainfall Event** option, as shown below.



21. Browse to **Configuration->Mode Properties**, under **Solve Mode** uncheck **Current Mode** and select both **Runoff** and **Hydraulics** modes. Within the **Hydraulic Job** Control enable the **Run Hydrology/Hydraulics Simultaneously** option.



22. **Save** the model.

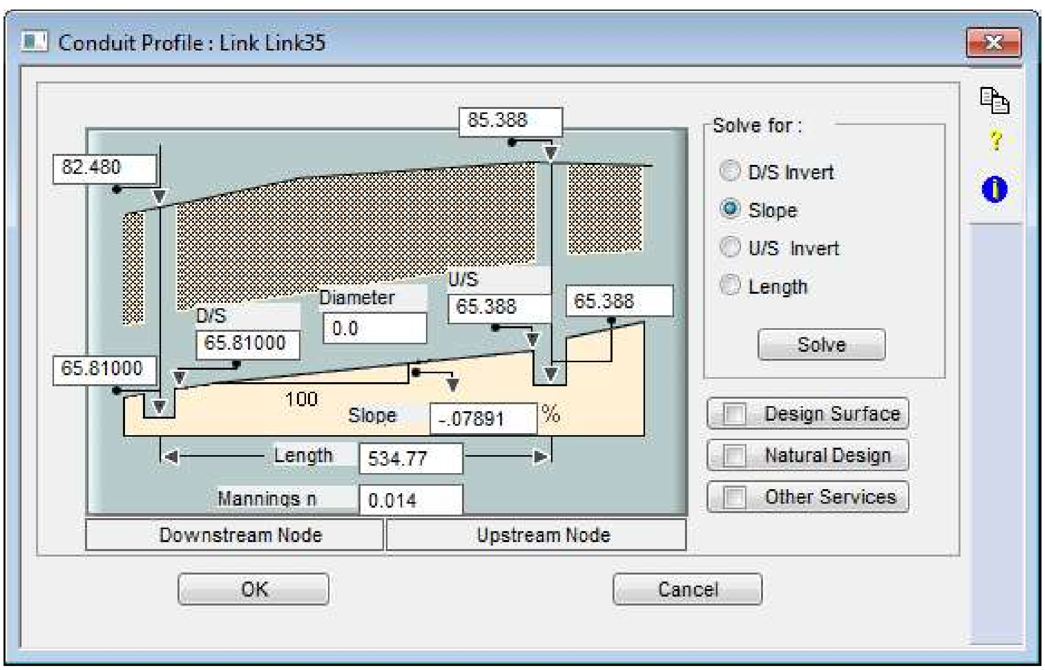
23. Now click on the **Solve** icon button to analyze the model. You may get a few error messages as shown:

```
Data Generation Diagnostics

ERROR: HDR: Links 'Link14': Downstream Conduit invert below Node invert
ERROR: HDR: Links 'Link14.1': Upstream Conduit invert below Node invert
WARNING: HDR: Links 'Link34': Conduit Length (30.75) less then minimum length for Analysis (32.81): Set Configuration Parameter MINLEN=
WARNING: HDR: Links 'Link2': The mannings roughness, 0.99, for the left overbank, is out of reasonable range.
WARNING: HDR: Links 'Link2': The mannings roughness, 0.99, for the right overbank, is out of reasonable range.
WARNING: HDR: Links 'Link7': The mannings roughness, 0.99, for the left overbank, is out of reasonable range.
WARNING: HDR: Links 'Link7': The mannings roughness, 0.655, for the right overbank, is out of reasonable range.
WARNING: HDR: Links 'Link12': The mannings roughness, 0.903, for the left overbank, is out of reasonable range.
WARNING: HDR: Links 'Link13': The mannings roughness, 0.68, for the left overbank, is out of reasonable range.
WARNING: HDR: Links 'Link14': The mannings roughness, 0.933, for the left overbank, is out of reasonable range.
ERROR: HDR: Links 'Link14': Upstream Crown or Top of Bank (82.48) above Node Ground Elevation (78.88)
WARNING: HDR: Links 'Link14.1': The mannings roughness, 0.933, for the left overbank, is out of reasonable range.

3 Error(s) and 9 Warning(s) were encountered
Data Export Was NOT Completed Successfully
```

These error messages refer to Node13.1 in the Hydraulic mode which was adjusted vertically when the lateral reach was configured. Select **Node13.1** and browse to **Tools->Modify Elevations**, and select **Set Node Invert to Lowest Connected Link Invert**.

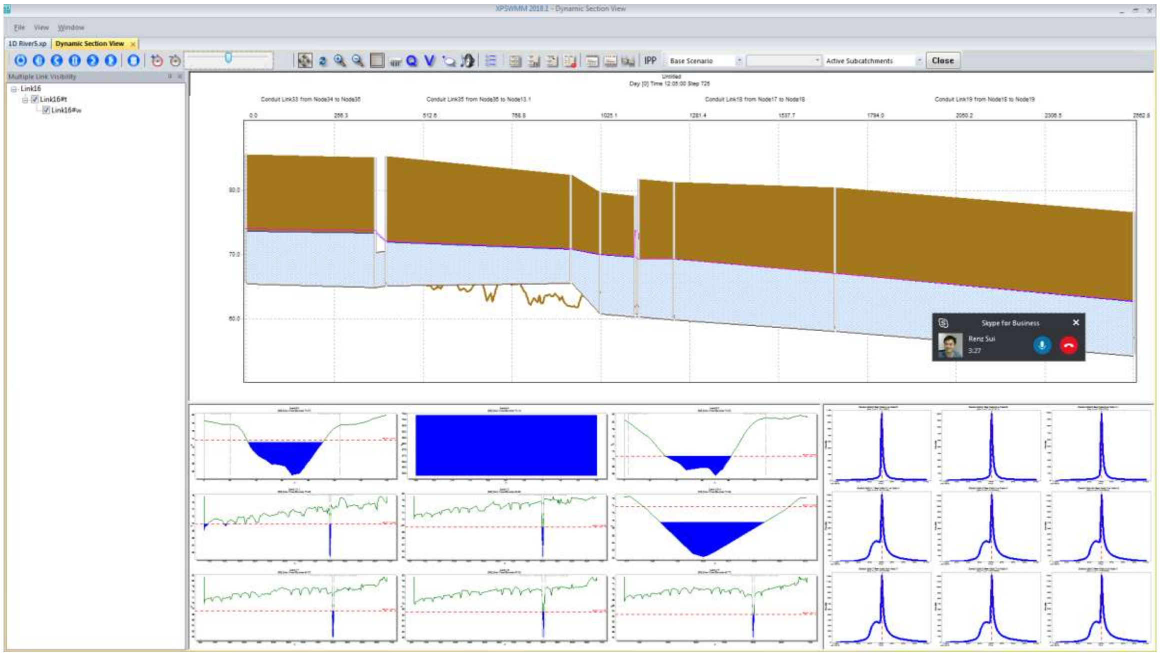
To fix the error related to Link14 **right-click** on the **Link14** and **Link14.1** and choose **River Link**. Edit the **Node13** and increase the **Ground Elevation** to **82.48**.

Then to complete the edits to resolve the errors select **Link35** then **F3** to get the conduit profile. Make the downstream invert match the node invert and resolve for the slope.

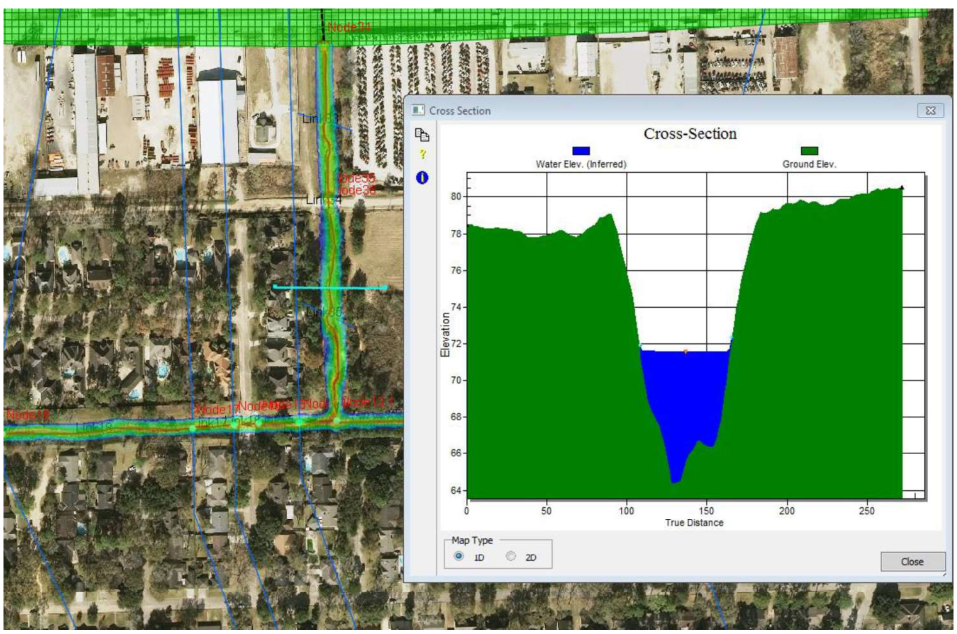


24. **Save** the model and then **Solve**. Select **Yes** to proceed with the simulation despite any remaining roughness value warnings.

25. Select from the top of the lateral reach to the end of the network, **Node34 to Node19**, and review the **Dynamic Section Views** for this reach segment.



26. As before, **select** the **1D Flood Maps** layer and allow the 1D hydraulic results to be triangulated into simulation extents maps for the current model configuration.



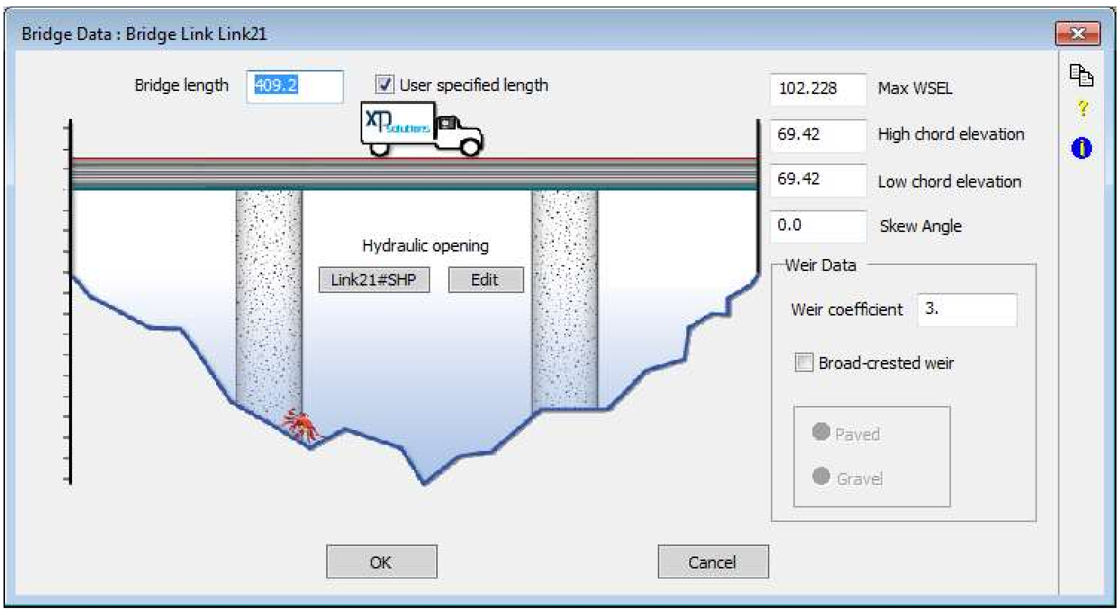
27. **Save As…** and use the name **my1D River6.xp.**

Modeling bridges

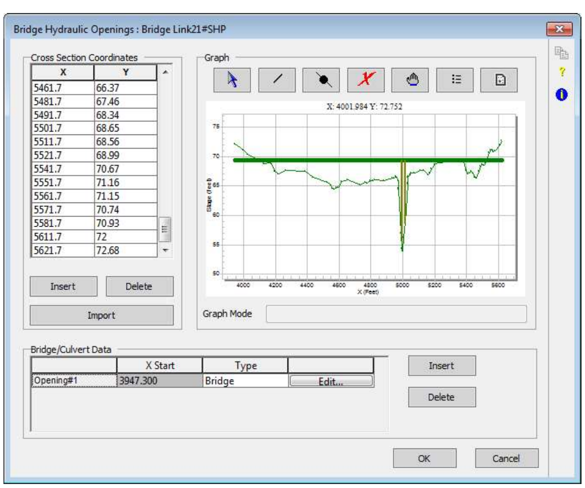
1. Open **1D River6.xp** if not directly continuing from the previous section.

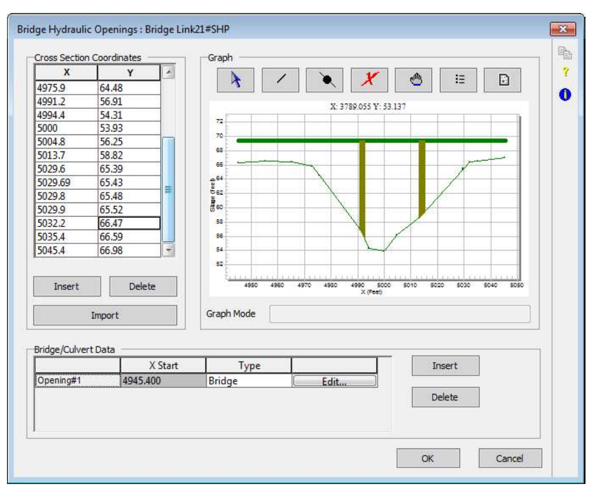
2. There is another bridge crossings, at **Link21** which we can inspect and improve by clipping the Hydraulic Opening. **Right-click** on **Link21**, then **Edit Data**.

3. **Bridge Link Data** …dialog shows the **Max WSEL**, **High/Low Chord** and **Weir Data** as shown below – note the bridge deck overtopping occurs at the High Chord Elevation and the Max WSEL is the level at which the bridge deck overflow would become pressurized. In our case this was set arbitrarily high at import.

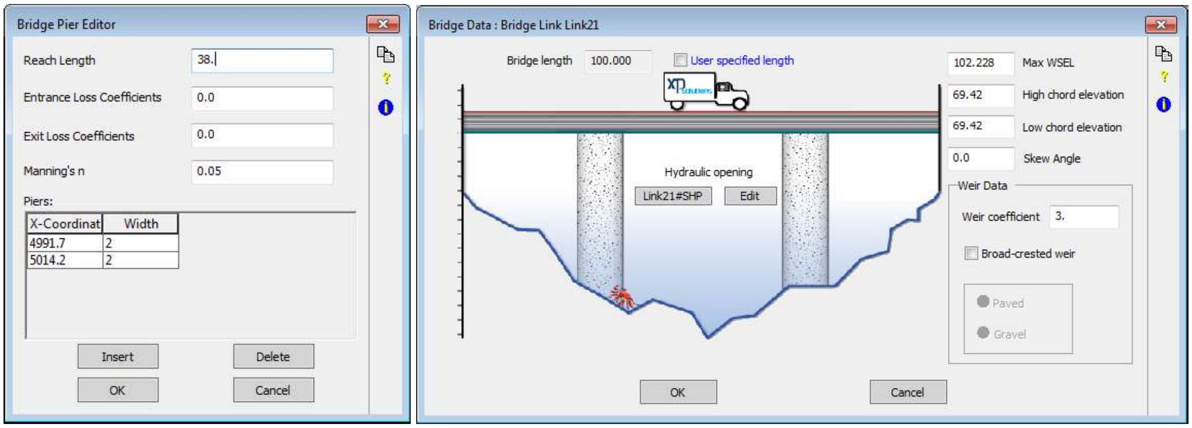


4. **Edit** the **Hydraulic Opening**. Notice the default Hydraulic Opening uses the entire cross section imported from HEC-RAS. This should be trimmed down to represent only the bridge opening. **Delete** the **cross section points** in the X,Y table so that the table range is from **X=4945.4** to **X=5045.4**.

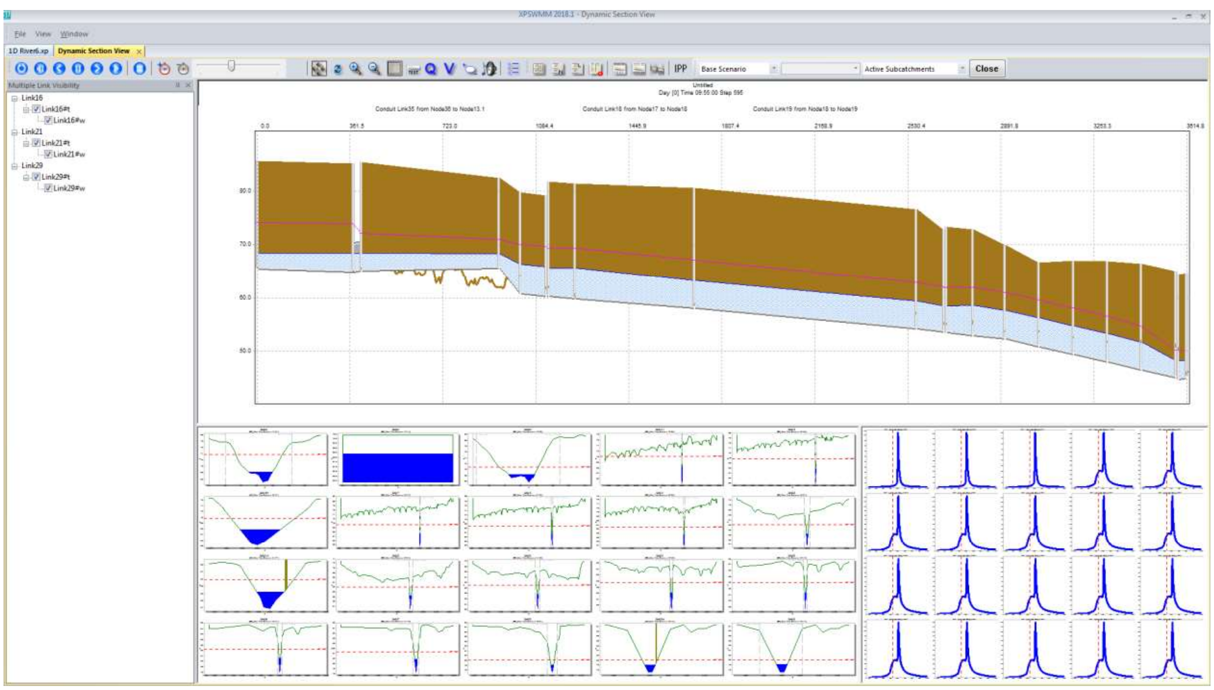




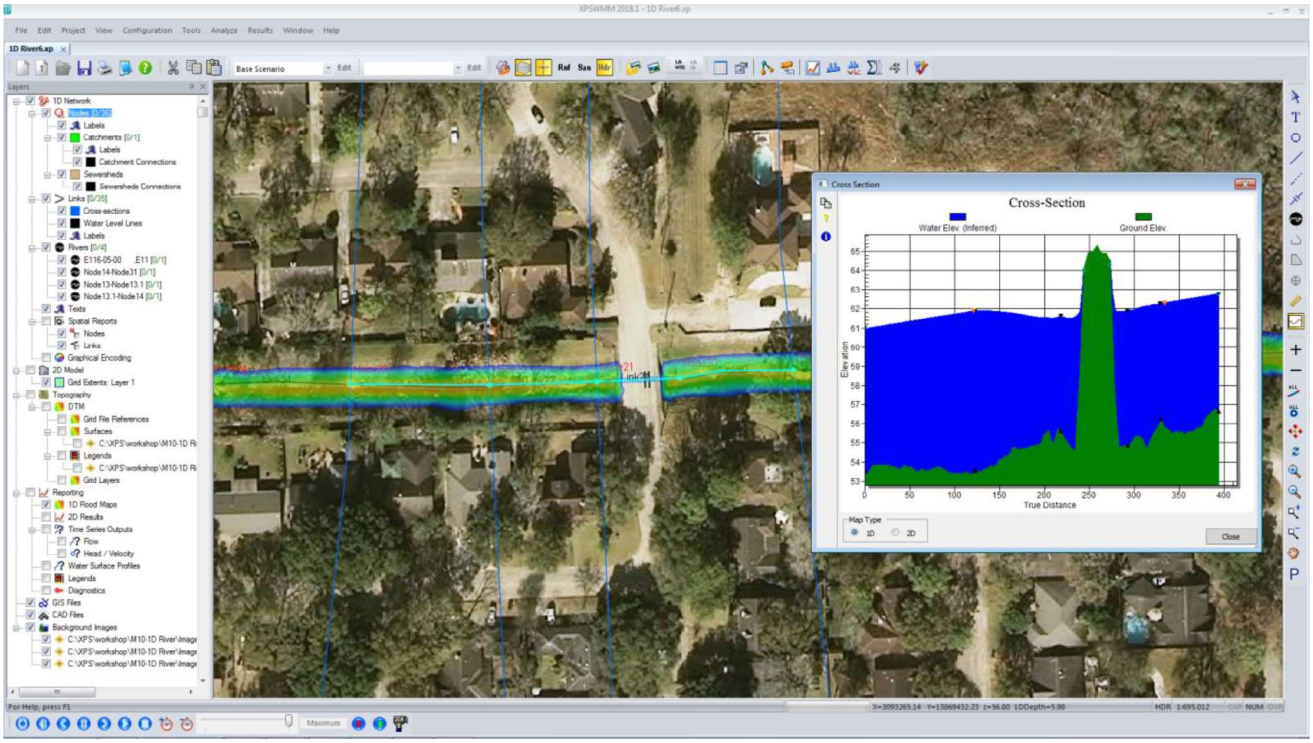
5. **Edit** the **Bridge/Culvert Data**, view the **reach length**, **loss** and **roughness** values as shown below imported from the HECRAS model. We also see and could edit piers in this dialog. Click **OK** two times. Uncheck **User Specified Length**. Note that the new length of bridge is 100 ft.



6. **Save** the model, then select **Solve**. After the model solves select from **Node34 to Node30** and select **Dynamic Section Views**.



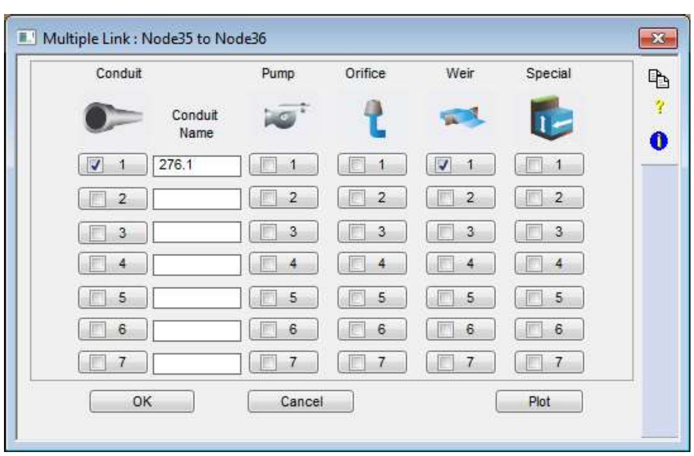
7. **Check** the **1D Flood Maps** layer and allow the map generator to interpolate the 1D results from the xptin surface. Create a Section Profile Line from a few links upstream to downstream through the bridge.



Lateral Reach Crossing – Bridge Deck

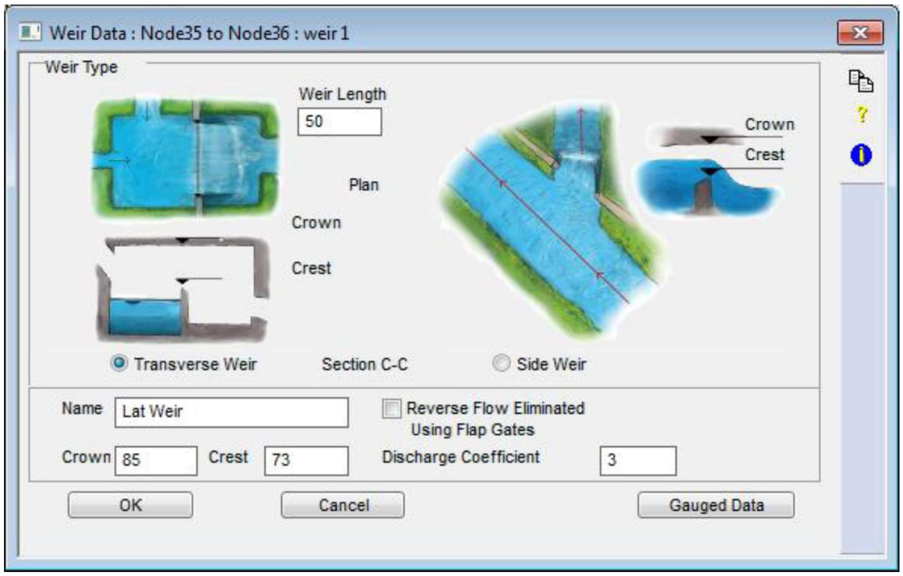
1. Within the Lateral Reach, the bridge crossing is currently only represented as 4 box culverts, with the flow over the roadway deck ignored. This may be artificially raising the Lateral Reach WSL and should be corrected so large flows can be accommodated that would overtop.

2. **Right-click** on **Link34** and select **Multilink**, then a **Weir** check box.



3. **Name** the Weir **Latweir**, input **50 ft** for the **Weir Length** of the **Transverse Weir** and **3** for the **Discharge Coefficient**.

4. **Set Weir Crest** level to **73.0** and the **Crown** to **85**. This will represent the flow over the top of the bridge deck (at elevation 73.0) and the Crown is set arbitrarily high at 85 as flow over the roadway deck will never become surcharged.



5. Click **OK** twice and **Save** the model. After **Solving** the model review the Lateral Reach crossing at **Link34** using **Review Results**, use the diversion icon  to assess the overtopping flow through the weir.