US Army Corps
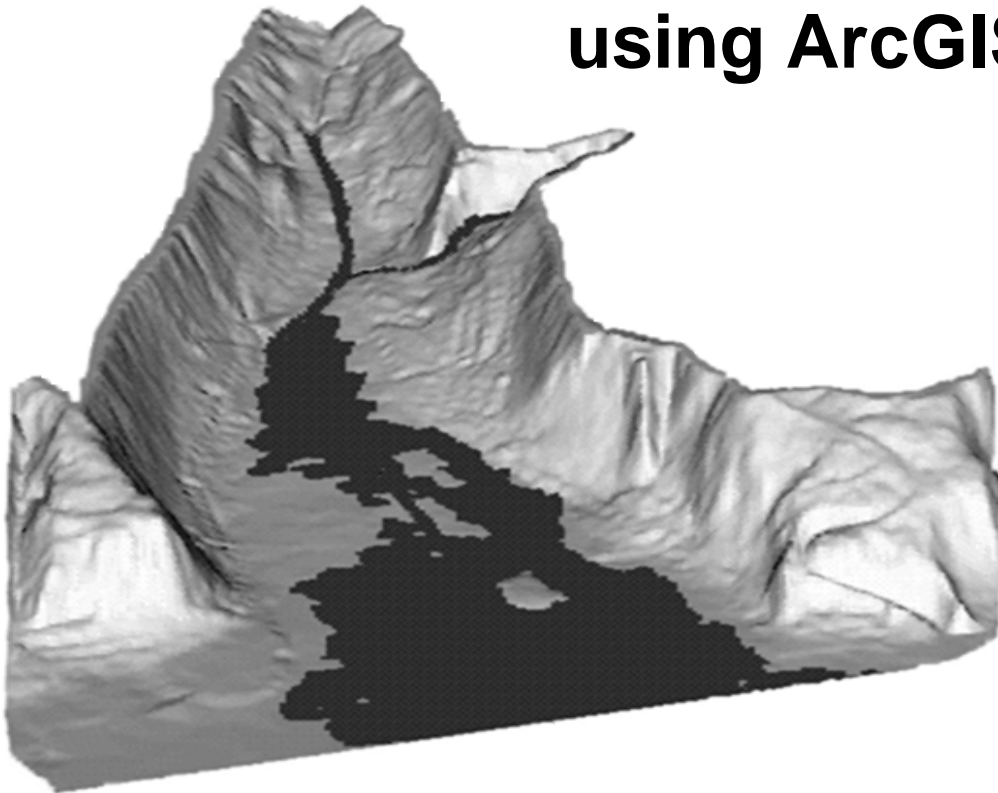**of Engineers**
Hydrologic Engineering Center

HEC-GeoRAS
GIS Tools for Support of HEC-RAS using ArcGIS®

User's Manual

Version 4.3.93
February 2011

CPD-83

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HEC-GeoRAS 4.3.93 intended use with HEC-RAS Version 4.0 or later and ArcGIS 9.3.

14. ABSTRACT

HEC-GeoRAS is an ArcGIS® extension specifically designed to process geospatial data for use with the Hydrologic Engineering Center's River Analysis System (HEC-RAS). The tools allow users with limited GIS experience to create an HEC-RAS import file containing geometric attribute data from an existing digital terrain model (DTM) and complementary data sets. Water surface profile results may also be processed to visualize inundation depths and boundaries.

HEC-GeoRAS is an extension for ArcGIS® software. ArcGIS® with the 3D Analyst and Spatial Analyst extensions are required to use HEC-GeoRAS.

ArcGIS® is a general purpose geographic information system (GIS) software program developed and copyrighted by the Environmental Systems Research Institute, Inc., Redlands, CA.

15. SUBJECT TERMS
Hydraulic modeling, geographic information systems (GIS), digital terrain model (DTM), triangulated irregular network (TIN), GRID, HEC-RAS, ArcGIS

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GIS Tools for Support of HEC-RAS using ArcGIS®, HEC-GeoRAS User's Manual

Table of Contents

Foreword

HEC-GeoRAS is an extension for use with ArcGIS, a general purpose Geographic Information System software program developed and copyrighted by the Environmental Systems Research Institute, Inc., (ESRI) Redlands, California.

The HEC-GeoRAS extension was initially developed though a Cooperative Research and Development Agreement between the Hydrologic Engineering Center (HEC) and ESRI and continues to be developed using Research and Development funds. HEC-GeoRAS Version 4 is the result of continued development by HEC and ESRI to migrate the functionality of GeoRAS Version 3.1 (for ArcView 3.x) to the ArcGIS platform.

The current HEC-GeoRAS software is based on the previous work performed at HEC by Thomas A. Evans in developing ArcInfo scripts and Cameron T. Ackerman adapting a user interface and coding enhancements. Initial development of HEC-GeoRAS for ArcView 3.2 was programmed by Dean Djokic at ESRI in the Avenue scripting language. HEC-GeoRAS 4.3 design and interface development was performed by Cameron Ackerman while core routines were programmed by Dean Djokic and Amit Sinha, ESRI. The Elevation Update tool was jointly developed by HEC and David Ford Consulting Engineers, Inc. with ESRI.

Contributions from HEC staff including Gary W. Brunner, Mark R. Jensen, and comments from the field continue to shape HEC-GeoRAS development. Christopher N. Dunn was Director during the release of HEC-GeoRAS 4.3.

This manual was written by Cameron T. Ackerman.

C H A P T E R   1

Introduction

HEC-GeoRAS is set of ArcGIS tools specifically designed to process geospatial data for use with the Hydrologic Engineering Center's River Analysis System (HEC-RAS). The extension allows users with limited GIS experience to create an HEC-RAS import file containing geometric data from an existing digital terrain model (DTM) and complementary data sets. Results exported from HEC-RAS may also be processed.

The current version of HEC-GeoRAS creates an import file, referred to herein as the *RAS GIS Import File*, containing river, reach and station identifiers; cross-sectional cut lines; cross-sectional surface lines; cross-sectional bank stations; downstream reach lengths for the left overbank, main channel, and right overbank; and cross-sectional roughness coefficients. Additional geometric data defining levee alignments, ineffective flow areas, blocked obstructions, and storage areas may be written to the RAS GIS Import File. GeoRAS Version 4, introduced capabilities for exporting hydraulic structure data for bridges, inline structures, and lateral structures. Water surface profile data exported from HEC-RAS may be processed into GIS data sets. GeoRAS version 4.2 introduced new capabilities for visualizing velocity results, shear stress results, stream power results and ice thickness data and tools for publishing results to the KMZ file format and animating floodplain results.

HEC-GeoRAS version 4.3 introduces new capabilities for extracting elevation data from multiple elevation data sources using the Elevation Update tool. GeoRAS 4.3 also has a more robust import and export routines that handle larger datasets.

This manual supports HEC-GeoRAS 4.3.93 for ArcGIS 9.3.

Chapter 1 discusses the intended use of HEC-GeoRAS and provides an overview of this manual.

Contents

- Intended Application of HEC-GeoRAS

- Overview of Requirements

- User's Manual Overview

Intended Application of HEC-GeoRAS

HEC-GeoRAS creates a file of geometric data for import into HEC-RAS and enables viewing of exported results from RAS. The import file is created from data extracted from data sets (ArcGIS Layers) and from a Digital Terrain Model (DTM). HEC-GeoRAS requires a DTM represented by a triangulated irregular network (TIN) or a GRID. The layers and the DTM are referred to collectively as the *RAS Layers.* Geometric data are developed based on the intersection of the RAS Layers.

Prior to performing hydraulic computations in HEC-RAS, the geometric data must be imported and completed and flow data must be entered. Once the hydraulic computations are performed, exported water surface and velocity results from HEC-RAS may be imported back to the GIS using HEC-GeoRAS for spatial analysis. GIS data is transferred between HEC-RAS and ArcGIS using a specifically formatted GIS data exchange file (*.sdf) as outlined in Appendix B.

Overview of Requirements

HEC-GeoRAS 4.3 is an extension for use with ArcGIS (Environmental Systems Research Institute, 2000) that provides the user with a set of procedures, tools, and utilities for the preparation of GIS data for import into RAS and generation of GIS data from RAS output. While the GeoRAS tools are designed for users with limited geographic information systems (GIS) experience, extensive knowledge of ArcGIS is advantageous. Users, however, must have experience modeling with HEC-RAS and have a thorough understanding of river hydraulics to properly create and interpret GIS data sets.

Software Requirements

HEC-GeoRAS 4.3.93 is for use with ArcGIS 9.3 Both the 3D Analyst extension and the Spatial Analyst extension are required. HEC-GeoRAS presently only runs on Microsoft Windows operating systems.

The full functionality of HEC-GeoRAS 4.3 requires HEC-RAS 4.0, or later, to import and export all of the GIS data options. Older versions of HEC-RAS may be used, however, with limitations on importing roughness coefficients, ineffective flow data, blocked obstructions, levee data, hydraulic structures, and storage area data. Further, data exported from older versions of HEC-RAS should be converted to the latest XML file structure using the SDF to XML conversion tools provided.

Data Requirements

HEC-GeoRAS requires a DTM in the form of a TIN or a GRID. The DTM must be a continuous surface that includes the bottom of the river channel and the floodplain to be modeled. Because all cross-sectional data will be extracted from the DTM, only high-resolution DTMs that accurately represent the ground surface should be considered for hydraulic modeling. Measurement units used are those relative to the DTM coordinate system.

User's Manual Overview

This manual provides detailed instruction for using HEC-GeoRAS to develop geometric data for import into HEC-RAS and view results from HEC-RAS simulations. The manual is organized as follows:

Chapter 1-2 provides an introduction to HEC-GeoRAS, as well as instructions for installing the extension and getting started.

Chapter 3 provides a detailed overview of HEC-GeoRAS.

Chapter 4 discusses in detail the tools, methods, and data requirements for developing geometric data for import into HEC-RAS.

Chapter 5 explains how to use GIS data with HEC-RAS and provides an overview for completing a hydraulic model.

Chapter 6 provides a detailed description of how to develop GIS data sets from HEC-RAS simulation results.

Chapter 7 is an example of how to import data into an HEC-GeoRAS geodatabase.

Chapter 8 is an example application of how to use HEC-GeoRAS and HEC-RAS to perform a river hydraulics study.

Chapter 9 provides an example of using multiple terrain models in HEC-GeoRAS.

Appendix A contains a list of references.

Appendix B provides the spatial data file format used by HEC-RAS for import and export with example data files.

Appendix C provides a discussion for interpolating HEC-RAS results using the stand-alone interpolator.

C H A P T E R   2

HEC-GeoRAS Installation

The installation procedure for the HEC-GeoRAS tools is discussed in this chapter.

Contents

- Software Requirements
- Installation
- Loading HEC-GeoRAS

Software Requirements

HEC-GeoRAS Version 4.3 requires ArcGIS 9.3 (ArcView license) for Windows. The 3D Analyst and Spatial Analyst extensions are also required. HEC-GeoRAS also requires that the Microsoft XML Parser 4.0 or later and .NET 2.0 Framework are installed.

Installation

The HEC-GeoRAS extension is installed using the HEC-GeoRAS installer and must be performed with Administrator priveledges. The installer will also install the Water Utilities Application Framework. If a previous version of the Water Utilities Application Framework (informally referred to as the ApFramework) is detected, you will be prompted that it must be unitnstalled. Removal of software previously installed may be performed through the Windows Control Panel using the Add/Remove Programs option.

The HEC-GeoRAS installer will follow the steps listed below and provide an installation wizard, shown in Figure 2-1.

1. Check that the Microsoft .NET Framework 2.0 is installed. This is required for the HEC-GeoRAS installer to run.

2. Check that ArcGIS 9.3 is installed.

3. Install the **MSXML Parser 4.0** (Microsoft XML Core Services), if required.

Check to see if the ApFramework is installed.
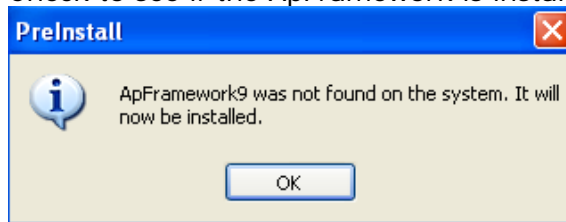
Install the **Water Utilities Application Framework**.

And then guide you through the installation using the installation wizard. The Water Utilities Application Framework will be installed to the "C:\Program Files\ESRI\WaterUtils\ApFramework" directory.

4. Install **HEC-GeoRAS**.
HEC-GeoRAS will be installed to the "C:\Program Files\HEC\HEC-GeoRAS" directory.
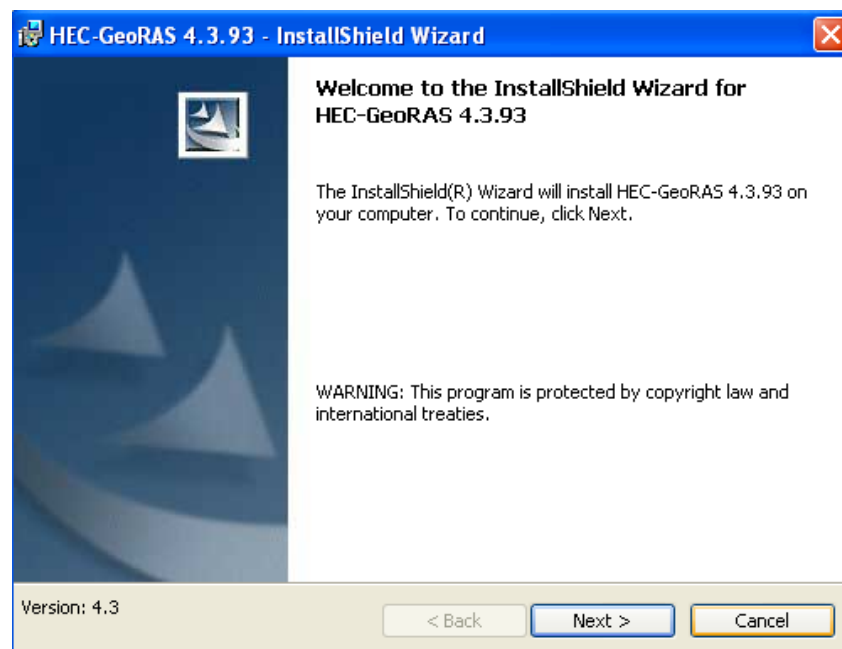
Figure 2-1. The HEC-GeoRAS installer dialog will provide installation updates.

Loading HEC-GeoRAS

The HEC-GeoRAS tools are loaded as a toolbar in ArcMap. To load the GeoRAS toolbar, select **Tools | Customize** from the main ArcMap interface (see Figure 2-2). Place a check in the checkbox

corresponding to **HEC-GeoRAS**. The HEC-GeoRAS toolbar will be added to the interface. Press the **Close** button when finished. You may dock the toolbar where desired.
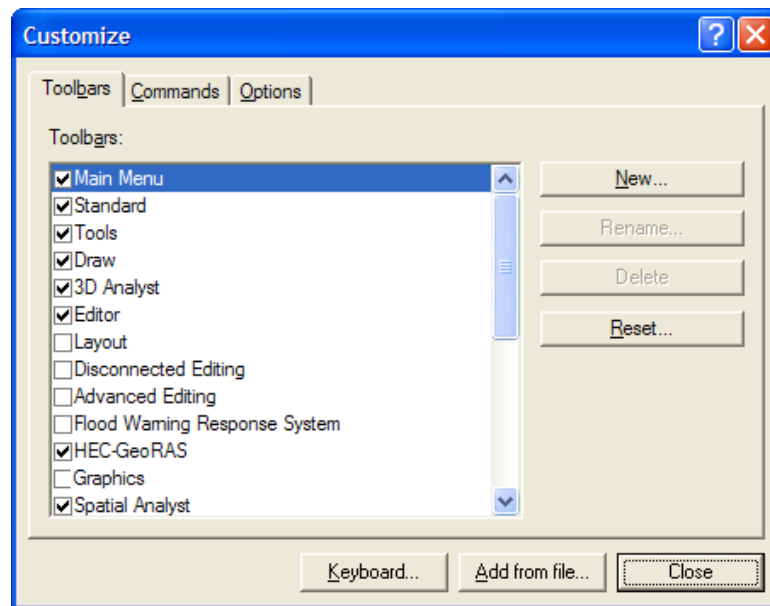
Figure 2-2. Loading the HEC-GeoRAS toolbar in ArcGIS.

C H A P T E R   3

Working with HEC-GeoRAS – An Overview

HEC-GeoRAS is a set of procedures, tools, and utilities for processing geospatial data in ArcGIS. The GeoRAS software assists in the preparation of geometric data for import into HEC-RAS and processing simulation results exported from HEC-RAS.

To create the import file, the user must have an existing digital terrain model (DTM) of the river system in a TIN or GRID format. The user creates a series of point, line, and polygon layers pertinent to developing geometric data for HEC-RAS. The line layers created are the Stream Centerline, Flow Path Centerlines (*optional*), Main Channel Banks (*optional*), and Cross Section Cut Lines referred to, herein, as the *RAS Layers*.

Additional RAS Layers may be created/used to extract additional geometric data for import in HEC-RAS. These layers include Land Use (for Manning's *n* values), Levee Alignments, Ineffective Flow Areas, Blocked Obstructions, Bridges/Culverts, Inline Structures, Lateral Structures, and Storage Areas.

Water surface profile data exported from HEC-RAS simulations may be processed by HEC-GeoRAS for GIS analysis.

An overview of the steps in developing the RAS GIS Import File (for importing geometric data into HEC-RAS) and processing the RAS GIS Export File (results exported from HEC-RAS) is provided to familiarize the user with the ArcGIS environment. An overview diagram of the HEC-GeoRAS process is shown in Figure 3-1.

Contents

- Getting Started
- Developing the RAS GIS Import File
- Running HEC-RAS
- Processing the RAS GIS Export File
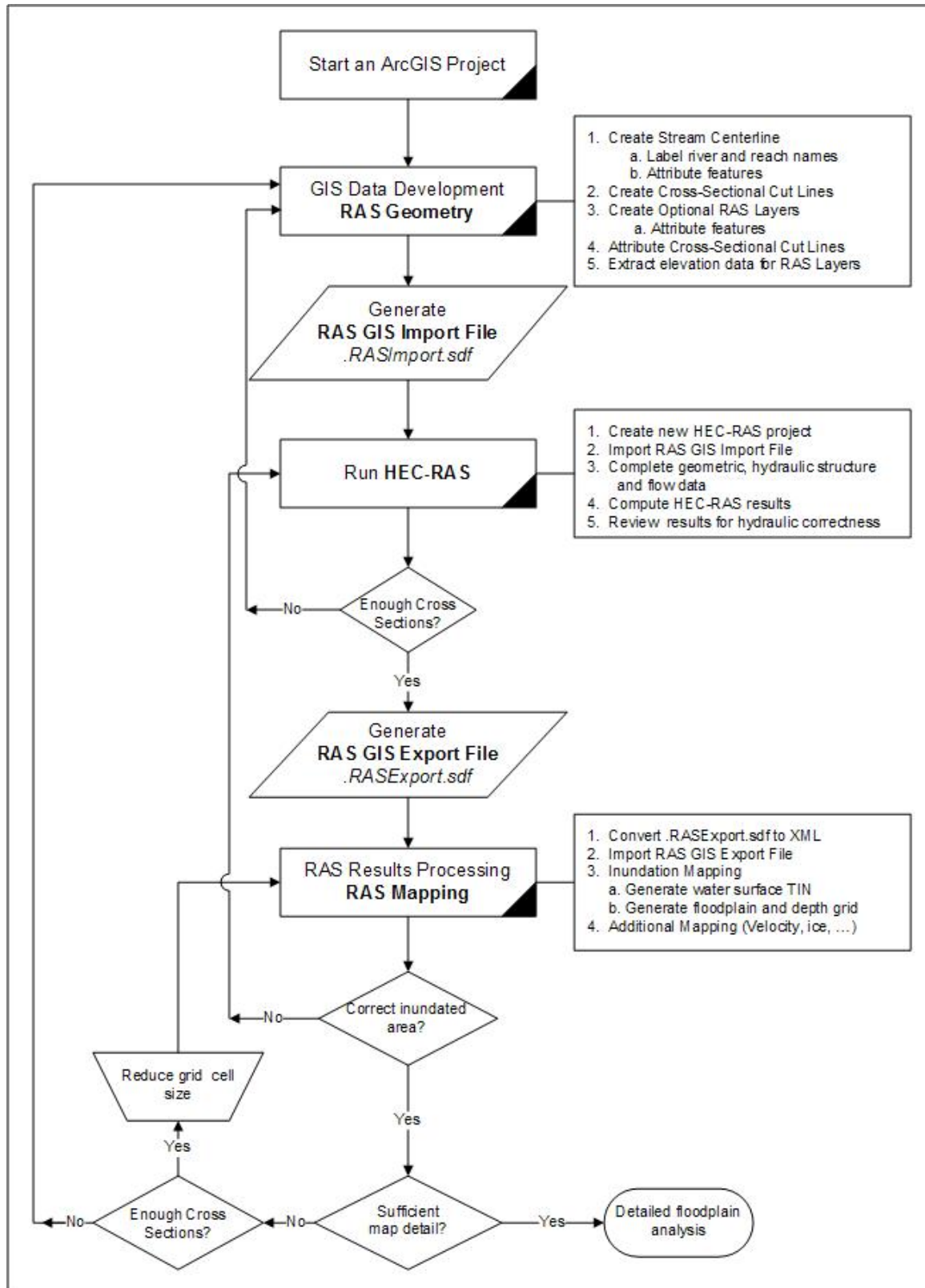
Figure 3-1. Process flow diagram for using HEC-GeoRAS.

Getting Started

Start ArcMap. Load the HEC-GeoRAS tools by selecting **Tools | Customize** from the main ArcMap interface and placing a checkbox next to **HEC-GeoRAS**. The Spatial Analyst and 3D Analyst extensions will automatically load whenever required by the tools.

When the HEC-GeoRAS extension loads, menus and tools are automatically added to the ArcMap interface. Menus are denoted by text and tools appear as buttons. These menus and tools are intended to aid the user in stepping through the geometric data development process and post-processing of exported HEC-RAS simulation results. The HEC-GeoRAS toolbar is shown in Figure 3-2.

Figure 3-2. The HEC-GeoRAS toolbar.

HEC-GeoRAS Menus

The HEC-GeoRAS menu options are RAS Geometry, RAS Mapping, ApUtilities, and Help. These menus are discussed below.

RAS Geometry

The RAS Geometry menu is for pre-processing geometric data for import into HEC-RAS. Items are listed in the RAS Geometry dropdown menu in the recommended (and sometimes required) order of completion. Items available from the RAS Geometry menu items are shown in Figure 3-3.

Figure 3-3. GeoRAS geometry processing menu items.

RAS Mapping

The RAS Mapping menu is for post-processing exported HEC-RAS results. Items available from the RAS Mapping dropdown menu are listed in the required order of completion. Items available from the RAS Mapping menu are shown in Figure 3-4.
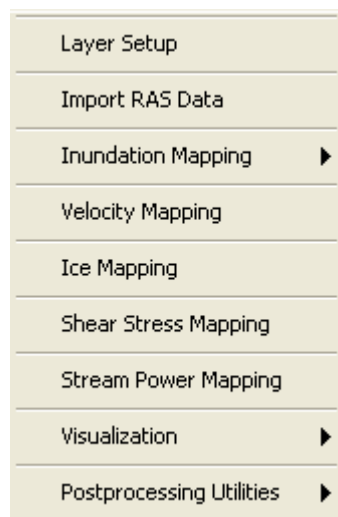
Figure 3-4. RAS Mapping menu items.

ApUtilites

Features available from the ApUtilities menu are used behind the scenes to manage the data layers created through GeoRAS. Also available from the ApUtilities menu is functionality to assign a unique HydroID to features. Only experienced users should use the items on the ApUtilites menu.

You MUST add new Data Frames (Maps) using the ApUtilites | Add New Map menu item. Otherwise GeoRAS will not find the proper data sets to work with!

Help

The Help menu will provide general online help information and will provide the version number. Use the "About HEC-GeoRAS" menu item to verify the version is consistent with the ArcGIS product it is being used with!

HEC-GeoRAS Tools

There are several tools provided in the toolbar. A tool waits for user action after being activated and will either invoke a dialog or change the mouse pointer, indicating the need for further action.

Table 3-1. Summary of HEC-GeoRAS tools.

Tool	Description
	Allows the user to assign *River* and *Reach* names to the stream network.
	Allows the user to assign station values to a stream endpoint.
	Assigns a *LineType* (Left, Channel, Right) value to the Flow Paths feature class.
	Generates cross-sectional cut lines perpendicular to a stream centerline at a specified interval.
	Interactively plots a selected cross section.
	Assigns elevation values to a levee alignment for interpolation.
	Converts HEC-RAS output in SDF format to XML file. Necessary prior to post-processing RAS results.

Developing the RAS GIS Import File

The main steps in developing the RAS GIS Import File are as follows:

- Start a New Project
- Create RAS Layers
- Generate the RAS GIS Import File

Start a New Project

Start a new project by opening a new ArcMap document. Next, load the DTM in TIN/GRID format. To load the Terrain DTM, press the (**Add Layer**) button on the ArcMap interface. This invokes a browser. Select the TIN/GRID dataset and press **OK**. The DTM is added to the current map. This will set the Coordinate System for the data frame will be the basis for your analysis.

You should then save the ArcMap project to an appropriate directory before creating any RAS Layers. (Save your ArcMap project to a directory that has no wild card characters in the pathname. Post-processing functions for the depth grids may not work if there are wild cards in the pathname to the grids. Further, the pathname must be less than 128 characters in length.) This may require using the file browser to create and name a new directory. The directory to which the ArcMap project is stored becomes the default location where the RAS geodatabase is created and the location where the RAS GIS Import File is written.

Create RAS Layers

The next step is to create the RAS Layers that will be used for geometric data development and extraction. The layers that need to be created are the Stream Centerline, Banks (*optional*), the Flow Path Centerlines (*optional*), and the Cross Section Cut Lines. Optional layers include: a polygon layer of land cover to estimate Manning's *n* values; a polyline layer of levee alignments; a polygon layer for representing ineffective flow areas; a polygon layer for representing blocked obstructions; a polyline layer of bridges/culverts; a polyline layer of inline structures; a polyline layer of lateral structures; and a polygon layer for floodplain storage areas.

Existing shapefiles or ArcInfo coverages may be used; however, they will need to contain the required database fields. If shapefiles or ArcInfo coverages are used, always convert/import them to a feature class, as discussed in Chapter 7. The existing layers must have a HydroID field populated for them to be useful. You can use the HydroID tool from the ApUtilities menu or the ArcHydro toolbar to add this field and populate HydroID values.

One simple way to ensure that that your data set has the required fields of the GeoRAS geodatabase design is to create an empty feature class using the **RAS Geometry | Create RAS Layers |** *Feature Class* (where *Feature Class* corresponds to a RAS Layer) menu items and copy and paste the features from your existing data set. This action however, will not populate the attributes. Importing existing data into an existing geodatabase will allow you to import attribute data. An example on importing data is provided in Chapter 7.

Feature layers are created using basic ArcGIS editing tools. The GeoRAS RAS Geometry menu directs the user through the data development procedure. The following section provides an overview for creating the RAS Layers.

Stream Centerline

The Stream Centerline layer should be created first. Select the **RAS Geometry | Create RAS Layers | Stream Centerline** menu item as shown in Figure 3-6.
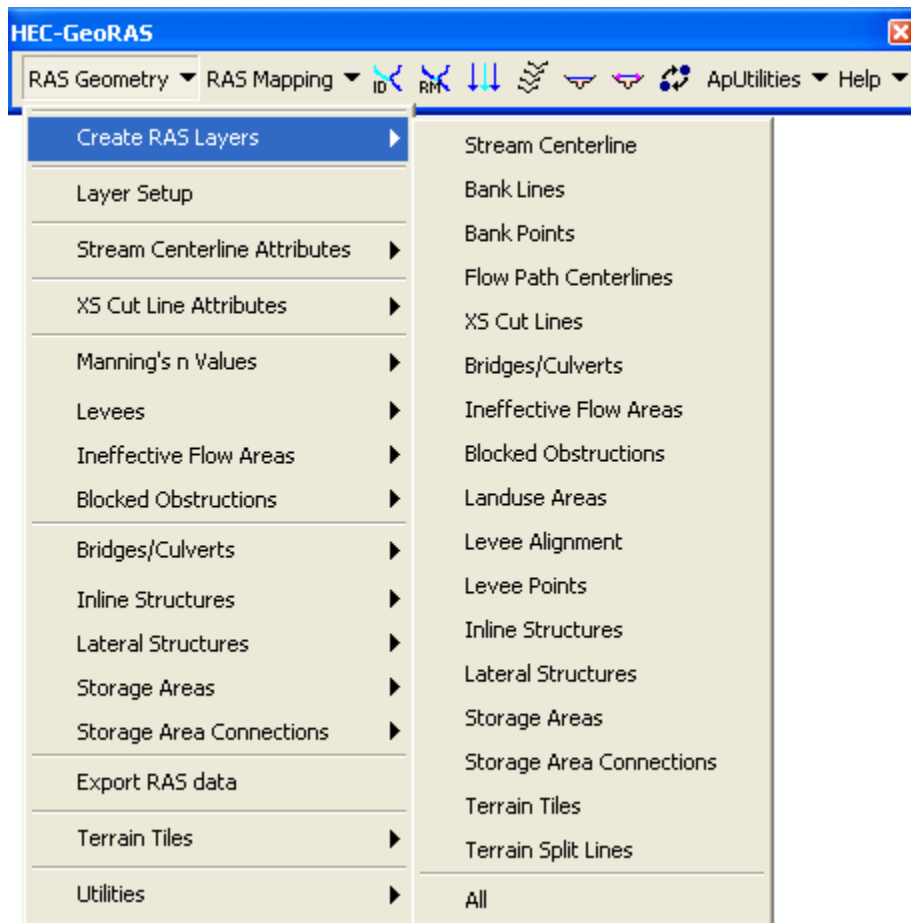
Figure 3-5. Create RAS Layers menu items.

The dialog shown in Figure 3-6 will appear. Enter the layer name (or accept the default name) and press **OK**.
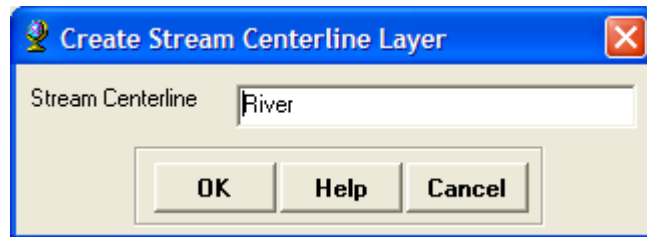
Figure 3-6. Create Stream Centerline layer dialog.

The Stream Centerline layer is added to the Map. To start adding features to the Stream Centerline layer you will need to start an edit session on the feature class.

Editing is done using the **Editor** toolbar. Ensure the editing toolbar is loaded by selecting the **Tools |Customize** menu item and placing a checkbox next to the Editor toolbar. The toolbar shown in Figure 3-7 will be added to the interface.

Figure 3-7. Editor toolbar in ArcGIS.

Select the **Editor | Start Editing** menu item. If you have layers loaded from more than one geodatabase (or shapefiles), a dialog will prompt you to choose the geodatabase you wish to edit. Once you have selected the geodatabase, you must select the **Target** feature class (layer) you wish to edit and select the **Task** (Create New Feature, Modify Feature, etc).

Lastly, select the **Sketch** tool and begin drawing the river reaches one by one on the map. River reaches must be drawn from upstream to downstream. Each river reach is represented by one line having a series of vertices. After creating the river network, save your edits (**Editor | Save Edits**) and stop editing (**Editor | Stop Editing**).

The Stream Centerline layer, however, is not complete until each River and Reach has been assigned a name. Select the (**Reach and River ID**) tool. Cross hairs will appear as the cursor is moved over the map display. Use the mouse to select a River Reach. The dialog shown in Figure 3-8 will be invoked allowing you to name the river and reach. Previously specified river names are available from a drop down list using the down arrow to the right of the river name field. Reach names for the same river must be unique.
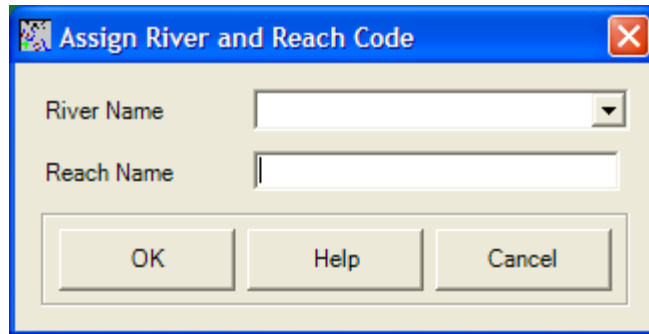
Figure 3-8. River and reach name assignment.

Main Channel Banks

Creating the Main Channel Banks layer is optional. If you do not create the banks layer, you will need to define the bank station locations in HEC-RAS.

Select the **RAS Geometry** | **Create RAS Layers | Bank Lines** menu item. Enter the layer name and press **OK**.

Start editing and draw the location of the channel banks. Separate lines should be used for the left and right bank of the river. Bank lines from tributary rivers may overlap the bank lines of the main stem. After defining each bank line, save edits.

Flow Path Centerlines

Creating the Flow Path Centerlines layer is optional. If omitted, distances between cross-sections will need to be added manually through the HEC-RAS interface.

Select the **RAS Geometry** | **Create RAS Layers | Flow Path Centerlines** menu item. Enter the layer name and press **OK**.

If the Stream Centerline layer exists, the stream centerline is copied as the flow path for the main channel. Each flow path must be labeled with an identifier of *Left*, *Channel*, *Right*, corresponding to the left overbank, main channel, or right overbank. One by one, use the (**Flowpath**) tool to label each flow path. After activating the Flowpath tool, select each flow path with the cross-hairs cursor. The dialog shown in Figure 3-9 will appear allowing the user to select the correct flow path label from a list.
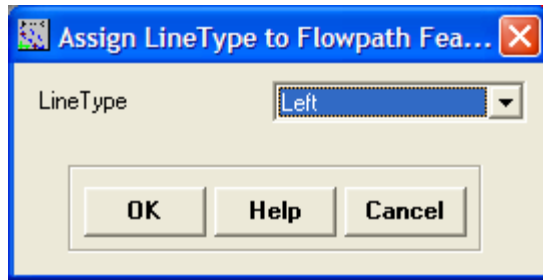
Figure 3-9. Label the Flow Path Lines with Left, Channel, or Right.

Cross-Sectional Cut Lines

Select the **RAS Geometry | Create RAS Layers | XS Cut Lines** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the **Sketch** tool to draw the locations where cross-sectional data should be extracted from the terrain model. Each cross-sectional cut line should be drawn from the left overbank to the right overbank, when facing downstream. Cross-sectional cut lines are multi-segment lines that should be drawn perpendicular to the flow path lines. Cut lines must cross the main channel only once and no two cross sections may intersect.

Cross sections can be generated automatically at a specified interval and width using the (**Construct XS Cut Lines**) tool. This is NOT the preferred method and should be used with caution because the lines are not generated following the guidelines necessary for modeling one-dimensional flow (i.e. cross sections could end up crossing each other and the main channel multiple times).

Bridges/Culverts

Creating the Bridge/Culvert feature class is optional.

Select the **RAS Geometry | Create RAS Layers | Bridges/Culverts** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the sketch tool to draw the locations where bridge deck data should be extracted from the terrain model. Each deck cut line should be drawn from the left overbank to the right overbank, when facing downstream.

You will also need to specify the top width and distance to the next upstream cross section in the Bridge/Culvert attribute table.

Ineffective Areas

Creating the Ineffective Areas feature class is optional.

Select the **RAS Geometry | Create RAS Layers | Ineffective Areas** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the sketch tool to draw polygons around areas that should be modeled as ineffective. Ineffective areas should be used near bridge abutments and other areas where flow is expected to stagnate.

Blocked Obstructions

Creating the Blocked Obstructions feature class is optional.

Select the **RAS Geometry | Create RAS Layers | Blocked Obstructuions** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the sketch tool to draw polygons around areas that should be modeled as blocked out from flow. Blocked obstructions should be used in areas where there has been floodplain encroachment.

Levee Alignments

Creating the Levee Alignments feature class is optional.

Select the **RAS Geometry | Create RAS Layers | Levee Alignment** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the sketch tool to draw the alignment of the levee. Elevation data may be provided along the levee using the Levee Tool or GeoRAS will use the elevation data from the DTM. Levees should be along high areas such as levees, roads, and ridges that prevent flow from flowing out into the floodplain.

Land Use

Creating the Land Use layer and estimating n values is optional.

If you choose to use this layer, you will need to create a data set that covers the entire extent of each cross section. Further, you may not use a polygon data set that is MULTIPART. Using the "clipping" feature of ArcMap is useful feature for creating polygons that share a common edge.

Land use data may be used to estimate Manning's *n* values for each cross section. Select the **RAS Geometry | Create RAS Layers | Land Use** menu item. Enter the layer name in the dialog that appears and press **OK** or load the land use layer from an existing data set.

Start editing and use the sketch tool to draw polygons around areas that you want to represent with a single roughness coefficient. If you have a field with the name "N_value", enter the corresponding roughness coefficients for each polygon.

If you have an existing data set that has a descriptive field you can link roughness values to, you will need to create a linked table using the **RAS Geometry | Manning's n Value | Create LU-Manning Table** menu item. Enter the roughness estimate in the "N_value" field based on the linked description.

Inline Structures

Creating the Inline Structures feature class is optional.

Select the **RAS Geometry | Create RAS Layers | Inline Structures** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the sketch tool to draw the locations where inline structure data should be extracted from the terrain model. Each inline structure cut line should be drawn from the left overbank to the right overbank, when facing downstream.

You will also need to specify the top width and distance to the next upstream cross section in the Inline Structures attribute table.

Lateral Structures

Creating the Lateral Structures feature class is optional.

Select the **RAS Geometry | Create RAS Layers | Lateral Structures** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the sketch tool to draw the locations where lateral structure data should be extracted from the terrain model. Each lateral structure cut line should be drawn in the downstream direction.

You will also need to specify the top width and distance to the upstream cross section just upstream in the Inline Structures attribute table.

Storage Areas

Creating the Storage Areas feature class is optional.

Select the **RAS Geometry | Create RAS Layers | Storage Areas** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the sketch tool to draw polygons around areas that will act as floodplain storage.

Storage Area Connections

Creating the Storage Area Connections feature class is optional.

Select the **RAS Geometry | Create RAS Layers | Storage Area Connections** menu item. Enter the layer name in the dialog that appears and press **OK**.

Start editing and use the sketch tool to draw the locations where the storage area connection data (weir profile) should be extracted from the terrain model. Each storage area connection should be drawn from the left overbank to the right overbank, when facing downstream.

You also need to attribute the connections with the nearest storage areas and weir's top width.

Importing RAS Layers

The other option to creating a layer is to import an existing layer, and assign a HydroID value to each feature. The HydroID field is required for the GeoRAS tools to work. This is particularly useful for users who already have layers containing all the required fields in the specified format, though it is probably better to import the basic RAS Layers, assign attributes, and then create the associated 3D layers using the GeoRAS tools. If these layers are created in GeoRAS, the HydroID fields are automatically populated.

The HydroID field could be created and values assigned through the HydroID tool in the **ApUtilites** menu shown in Figure 3-10. The menu item will invoke a dialog that allows the user to specify a feature class (RAS Layer) and assign unique HydroIDs. If the HydroID field does not exist, the field will be created. **Note that HydroID values must be assigned prior to attributing any of the feature classes. The HydoID provides the link from each feature to an attribute in an associated table.**
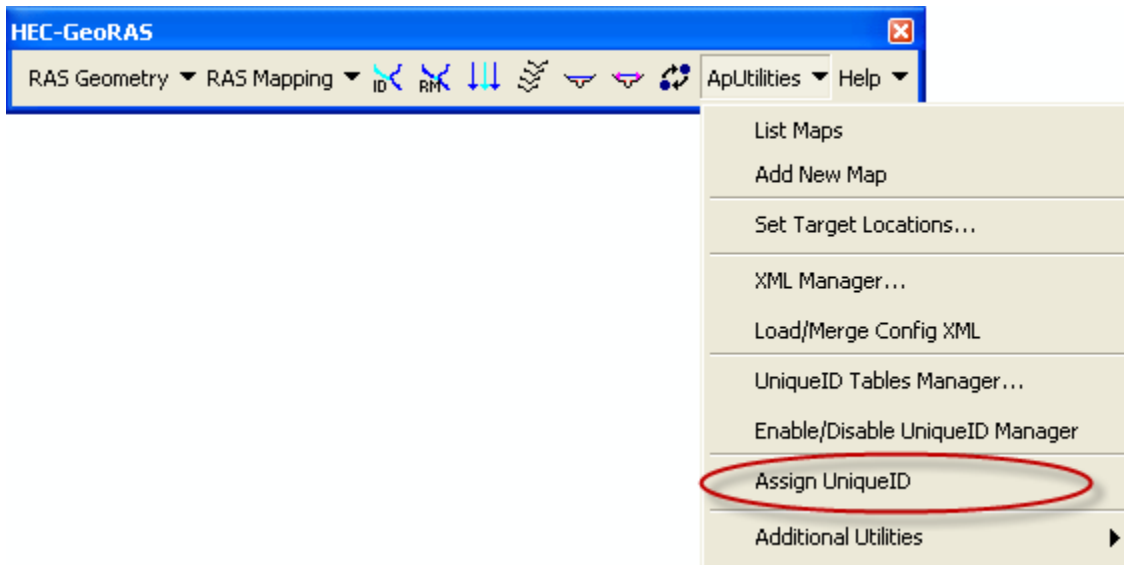
Figure 3-10. Assign Unique HydroIDs menu item is on the ApUtilites menu.

Importing Shapefiles to a Geodatabase

To migrate a shapefile to a geodatabase, perform the following steps (for a more detailed example refer to the data import example in Chapter 7):

1. Start ArcCatalog.

2. Navigate to the dataset in the personal geodatabase where you want to import the shapefile.

3. Right click on the dataset, click on **Import | Shapefile** to Geodatabase Wizard tool. Select the shapefile. Click on Next.

4. Enter the desired **feature class name**. Click on **Next** button.

5. Instead of using defaults, elect to **specify the remaining parameters**. Keep clicking on **Next** buttons. You will be offered to change the Spatial Index Grid, Item to Field Mapping, and Current Spatial Reference. On the **Item to Field Mapping** page, change the names of field to the names desired**.**

6. Click on **Finish** to complete data migration from shapefile to geodatabase.

An alternative (simple) route is to perform the following:

1. Start ArcMap.

2. Create the feature class of interest using the GeoRAS **RAS Geometry | Create RAS Layers |** *Feature Class.* *This creates all the require fields.*

3. Add the shapefile.

4. Select all the features in the shapefile.

5. Copy the features to the clipboard (Edit | Copy).

6. Start Editing the new feature class.

7. Paste the features into the feature class (Edit | Paste).

8. Stop Editing.

9. Attribute the feature class using the GeoRAS tools provided or enter the data by hand. (You may need to repeat Steps 3-7 for multiple feature classes.)

Generating the RAS GIS Import File

After creating/editing each RAS Layer, select the **RAS Geometry | Layer Setup** menu item. The pre-processing layer setup dialog shown in Figure 3-11 allows you to select the RAS Layers used for data development and extraction. There are several tabs with dropdown lists. Click through each tab and select the corresponding data.
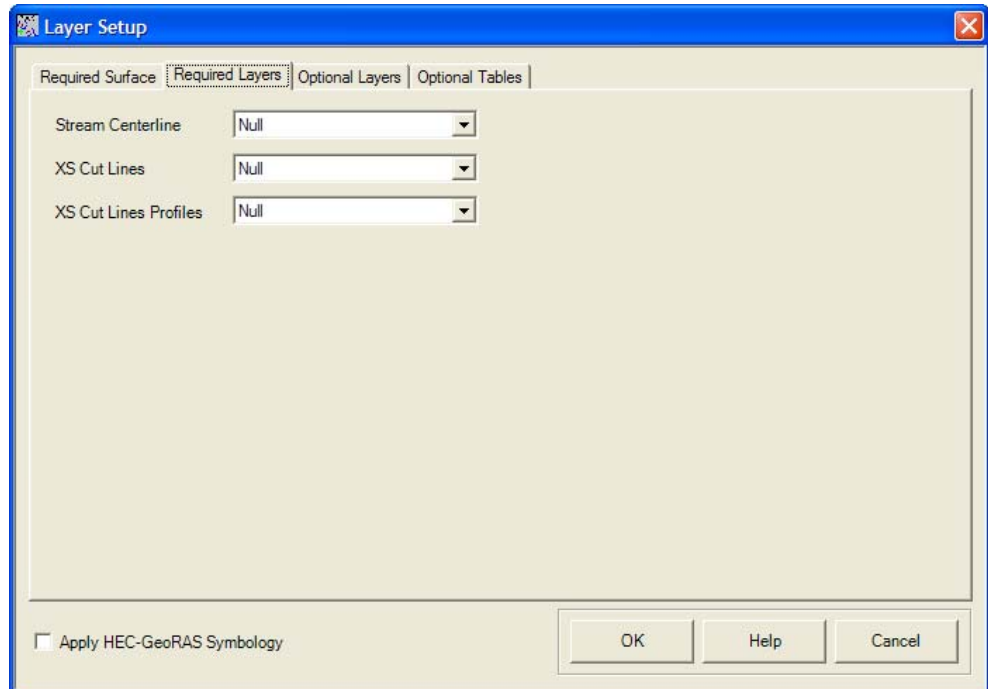
Figure 3-11. Layer Setup dialog for pre-processing RAS Layers.

From the **Required Surface** tab, select the terrain data type: TIN or GRID. Use the drop down lists to select the Terrain TIN/GRID.

From the **Required Data** tab, verify that the Stream Centerline layer and XS Cut Lines layer are selected. The XS Cut Line Profiles will be created by GeoRAS in a later step.

From the **Optional Layers** tab, verify/select the layers you have created. Press the **OK** button when finished.

Next, select the **RAS Geometry | Stream Centerline Attribute | Topology** menu item. This process completes the centerline topology by populating the *FromNode* and *ToNode* fields. In addition, a table is also created to store nodes x, y, and z coordinates. These are used later to create the GIS import file. Select **RAS Geometry | Stream Centerline Attribute | Length/Stations** to assign length and station values to river features.

Optionally, select **RAS Geometry | Stream Centerline Attribute | Elevations** to create 3D stream centerline layer from the 2D layer using elevations from the DTM. *This step is not required – HEC-RAS does not use the elevation data extracted along the stream centerline!*

The next step is to add geometric attributes to the Cross Section Cut Line layer. Select the items under the **RAS Geometry | XS Cut Line Attributes** menu one-by-one verifying the data that is appended to the XS Cut Line attribute table after each step. If an error message is invoked, fix your data set, and repeat the menu item. River and reach names, river station, bank station (optional), and downstream reach length (optional) information will be appended to each cross section cut line.

To complete the cross-sectional data, station-elevation data needs to be extracted from the DTM. Select the **RAS Geometry | XS Cut Line Attributes | Elevations** menu item. This will create a 3D cross-sectional surface line layer from the cross-sectional cut lines.

If you have a Land Use layer with estimated roughness coefficients, select the **RAS Geometry | Manning's n Values | n Values Extract** to determine the horizontal variation in Manning's *n* values along each cross section. An option to either use a summary Manning table or directly use an *N_Value* field from a Land Use layer is available. Thus, if the Land Use layer already has the Manning field populated, you can directly use the Land Use layer as the source of Manning's *n* values to create a table listing cross-section segments and its manning value.

If the **Manning n Values | Create LU-Manning table** tool is used, an option to choose the field to cross-reference for Manning's *n* values from the Land Use layer is added. A summary Manning table is created with empty Manning's *n* values and you will have to manually enter them.

If you have the Levee layer, select **RAS Geometry | Levee | Profile Completion** to create 3D Levee features from the 2D features using the DTM as source of elevation. This tool will optionally apply the user-defined elevations from the LeveePoints feature class to interpolate the Levee elevations. Select **RAS Geometry | Levee | Positions** to calculate the intersection of the levees at the cross sections.

If you have ineffective flow data, select the **RAS Geometry | Ineffective Flow Areas | Positions** to calculate the location of ineffective flow areas at the cross sections.

If you have a Bridges/Culverts layer, select the **RAS Geometry | Bridges/Culverts | River/Reach Names** to assign the River and Reach Names to the feature from the Stream Centerline layer. Select the **RAS Geometry | Bridges/Culverts | Stationing** to assign river station values to the Bridge/Culvert features. Select the **RAS Geometry | Bridges/Culverts | Elevations** to create a 3D layer by extracting elevations from the DTM.

If you have an Inline Structures layer, select the **RAS Geometry | Inline Structures | River/Reach Names** to assign the River and Reach Names that the Inline Structures intersects. Select the **RAS Geometry | Inline Structures | Stationing** to assign station values to the Bridge/Culvert features. Select the **RAS Geometry | Inline Structures | Elevations** to create a 3D layer by extracting elevations from the DTM.

If you have a Lateral Structures layer, select the **RAS Geometry | Lateral Structures | River/Reach Names** to assign the River and Reach Names that the Lateral Structure lies along. Select the **RAS Geometry | Lateral Structures | Stationing** to assign station values to the Bridge/Culvert features. Select the **RAS Geometry | Lateral Structures | Elevations** to create a 3D layer by extracting elevations from the DTM.

If you have storage areas, select the **RAS Geometry | Storage Areas | Elevation Range** to calculate the minimum and maximum elevation. Select the **RAS Geometry | Storage Areas | Elevation-Volume Data** to calculate elevation-volume relationship for each storage area of interest. Optionally. Select the RAS Geometry | Storage Areas | TIN Point Extraction to extract all TIN points that fall within the storage area. *(HEC-RAS does not currently use the points extracted within the Storage Area, therefore, skipping this step is recommended.)*

Lastly, select the **RAS Geometry | Extract GIS Data** menu item. This step writes the header information, river and reach information contained in the *Stream Centerline* layer, and cross-sectional information contained in the *XS Cut Line Profiles* layer to the RAS GIS Import File in the HEC-RAS spatial data format. Manning's *n* values, levee alignment data, ineffective flow data, blocked obstruction data, bridge/culvert data, inline structure data, lateral structure data, and storage data will be written, if available. This tool generates the RAS

GIS import file in two formats: one in the SDF format and the other in the XML format. The XML format is designed for future use. Note that this tool uses predefined XML and XSL files located under the "bin" folder in the HEC-GeoRAS install folder. These files are automatically installed, and must not be moved by the user. The tool expects to find these files at this location.

Running HEC-RAS

Create and save a new HEC-RAS project. From the Geometric Schematic choose the **File | Import Geometry Data | GIS Data** menu option. Select the *.RASImport.sdf* file to import. The Import Option dialog will appear as shown in Figure 3-12, though the dialog will be set to the Intro tab. Select the unit system to import the data into. Next, select the stream centerline by River and Reach name to import. Then select the cross sections to import by placing a check in the corresponding box. Select the properties to import for each cross section. When finished identifying the data for import press the **Finished – Import Data** button.
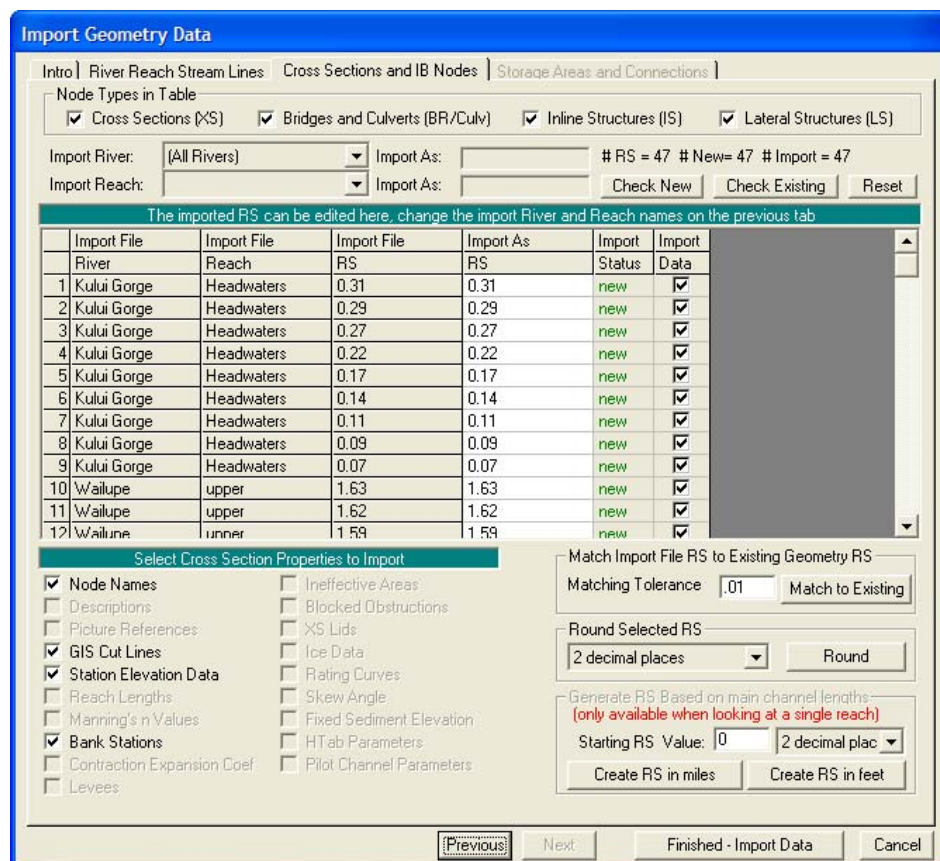
Figure 3-12. HEC-RAS geometric data import options dialog.

After importing the geometric data extracted from the GIS, completion of the hydraulic data will be necessary. Hydraulic data that may not

be imported includes hydraulic structure data, ineffective flow areas, levees locations, blocked obstructions and storage areas. Flow data and the associated boundary conditions need to be supplied, as well. For a more complete discussion on importing geometric data, refer to the section devoted to using HEC-RAS or the HEC-RAS User's Manual, Chapter 13 (Hydrologic Engineering Center, 2009).

After running various simulations in HEC-RAS, export the results using the **File | Export GIS Data** dialog on the main HEC-RAS window (see Figure 3-13). For a more complete discussion on exporting GIS data, refer to the HEC-RAS User's Manual, Chapter 13 (Hydrologic Engineering Center, 2009).
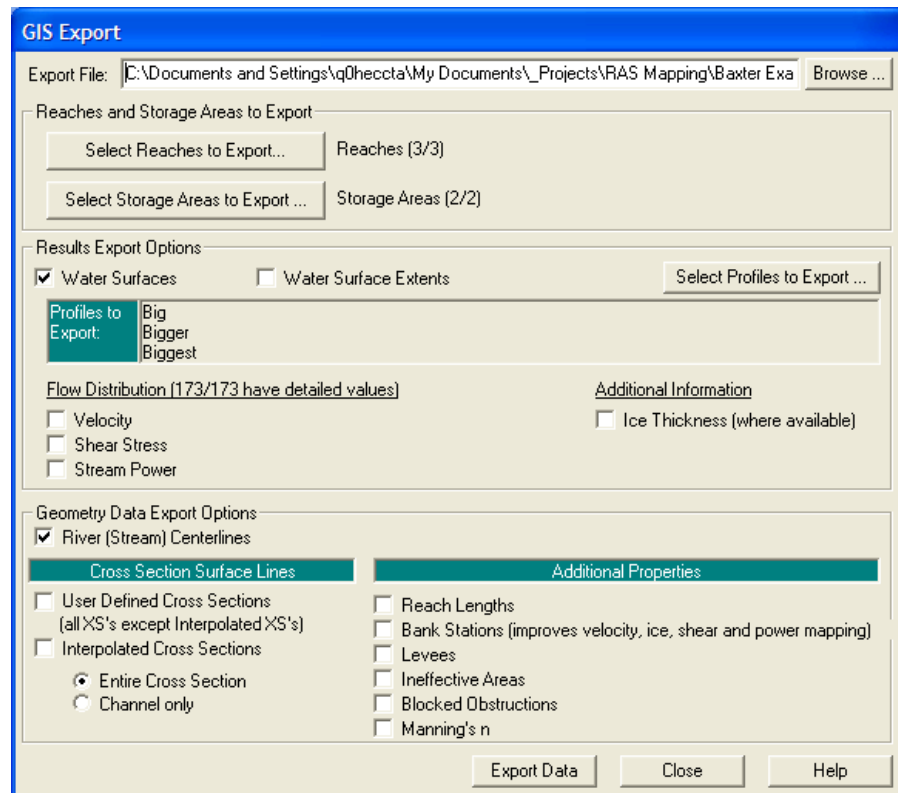
Figure 3-13. HEC-RAS dialog for exporting water surface profile result to the GIS.

Processing the RAS GIS Export File

The main steps in processing HEC-RAS results are as follows:

- Reading the RAS GIS Export File
- Processing RAS Results Data

Reading the RAS GIS Export File

The first step to importing HEC-RAS results into the GIS is to convert the SDF output data into an XML file, because the GeoRAS only use this format. Click the 🔁 (Convert RAS SDF to XML) button to execute this task. This tool initiates an external executable program, named SDF2XML.exe located under the "bin" folder, and dialog shown in Figure 3-14 will appear. Select the RAS GIS Export File *(.RASExport.sdf)* in the. Click on the OK button convert this file to XML format.
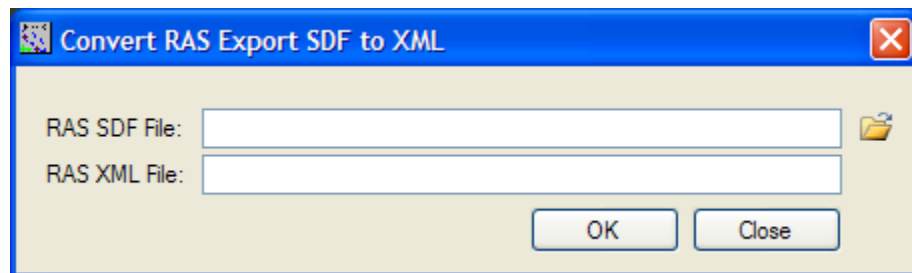
Figure 3-14. Convert HEC-RAS output file (.sdf) to XML file dialog.*

The next step to importing HEC-RAS results into the GIS is to setup the necessary variables for post RAS analysis. Select the **RAS Mapping | Layer Setup** menu item. The dialog shown in Figure 3-15 will appear to allow you to either start a new analysis or re-run an existing analysis. When you re-run an existing analysis, the variables input in the layer setup cannot be changed. For a new analysis, you need to specify a name for the analysis, RAS GIS Export File, terrain TIN/GRID, output directory, output geodatabase, dataset name, and a rasterization cell size.

Note that the output directory path and name may not have wild card characters. The pathname must also be less than 128 characters when using TIN models (this includes the TIN name and subsequent file names used to create the TIN).

The names of water surface TINs and floodplain GRIDs are hardwired in GeoRAS, and it is recommend that these names not be changed. The name of the feature class on disk is specified in the layers data source property. Each new analysis requires a new directory.

The RAS GIS Export File is the XML export file generated in the previous step. Some post-processing results such as water surface tin and flood delineation grid will be saved into the output directory. Vector data generated in post-processing will be saved into the dataset within the specified geodatabase. The rasterization cell size will be used in grid calculations.
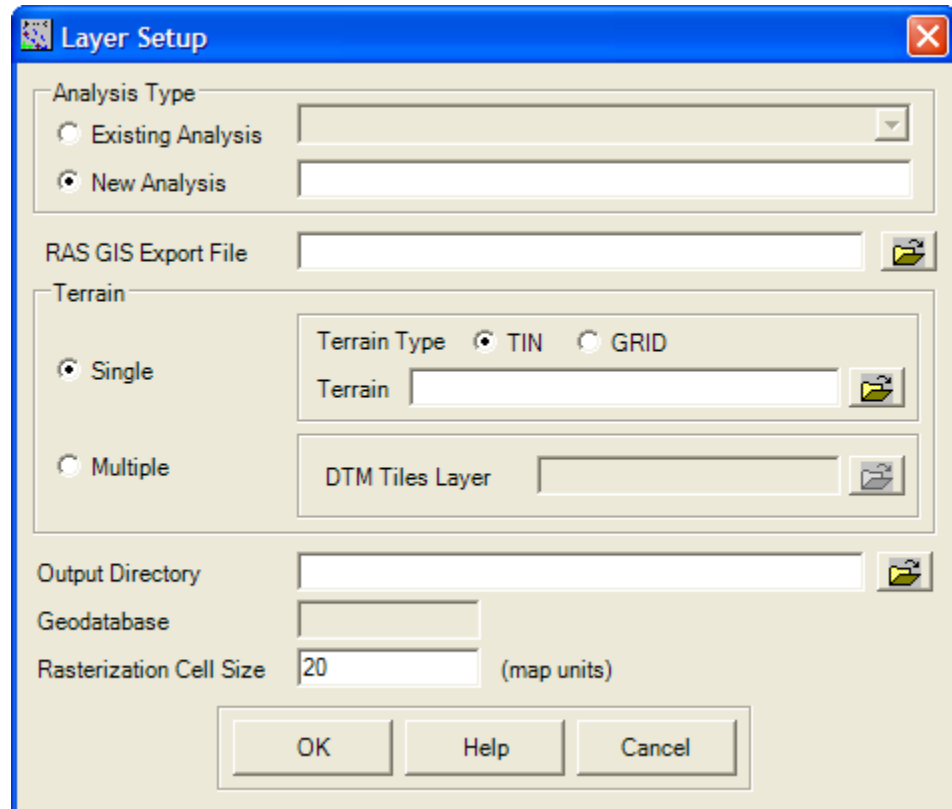
Figure 3-15. Layer setup dialog for post-processing HEC-RAS results.

To create preliminary data sets that are essential to post processing, select the **RAS Mapping | Read RAS GIS Export File** menu item.

HEC-GeoRAS will read the export file and begin creating preliminary data sets. Preliminary feature classes created include the following:

- Cross section cut lines – "XS Cut Lines" layer

- Bounding polygon for each water surface profile – "Bounding Polygons" layer

These two data sets are created without user input and will be used later for building floodplain data sets. For each new analysis, a new data frame is created that is named after the Analysis. A separate directory is required as specified in the Layer Setup. A new personal geodatabase is created under this directory and it shares the same name as the Analysis and data frame (map).

The name of the dataset in the geodatabase by default is "RASResults". This is hardwired in GeoRAS. The "RASResults" dataset contains the cross section cut lines and bounding polygon layers that will be used in further analysis. After the "RASResults" data set is successfully created, a new map (data frame) with the name of the Analysis is created. Both cross-sectional cut line and bounding polygon layers are added to the map as feature layers (see Figure 3-16).
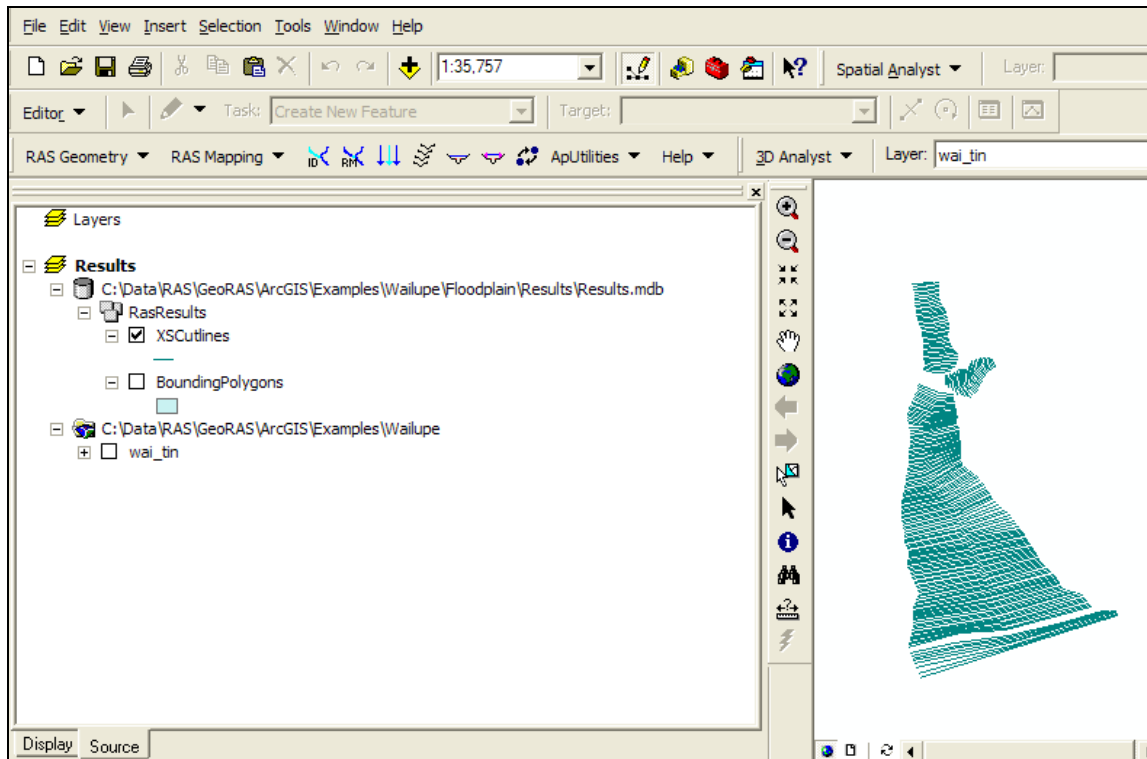
Figure 3-16. Base data read in and processed from the RAS GIS Import File.

Additional data for the bank stations, water surface extents, velocities, and ice thickness will be read in and feature classes created, if the data exists in the RAS Export file.

Processing RAS Results Data

Post-processing of RAS results creates GIS Layers for inundation and velocity analysis. All GIS Layers developed during RAS post-processing are based on the content of the RAS GIS Export File and the Terrain TIN/GRID. For data consistency, the same Terrain TIN/GRID used for generation of the RAS GIS Import File should be used for post-processing.

Inundation Results

Once the RAS GIS Export File has been read, the user can begin creating inundation data sets. The first step is to create water surface

TINs for each water surface profile. Select the **RAS Mapping | Inundation Mapping | Water Surface Generation** menu item. This will invoke a dialog shown in Figure 3-17 with a pick list of water surface profile names. Multiple water surface profiles may be selected by holding the SHIFT key down during selection. Press **OK** to build the water surface TINs.
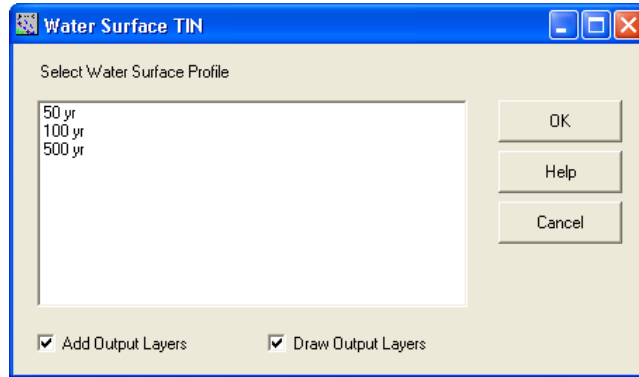
Figure 3-17. Water surface profile TIN selection dialog.

One water surface TIN will be created for each selected water surface profile. The TIN is created based on the water surface elevation at each cross section and the bounding polygon data specified in the RAS GIS Export File. The water surface TIN is generated without considering the terrain surface. The water surface TINs created will be named as a concatenation of "t" and the water surface profile name (e.g., "t 100yr"); and they will be saved into the output directory specified in the Layer Setup.

After a water surface TIN has been created, it is added to the map. An example is provided in Figure 3-18.
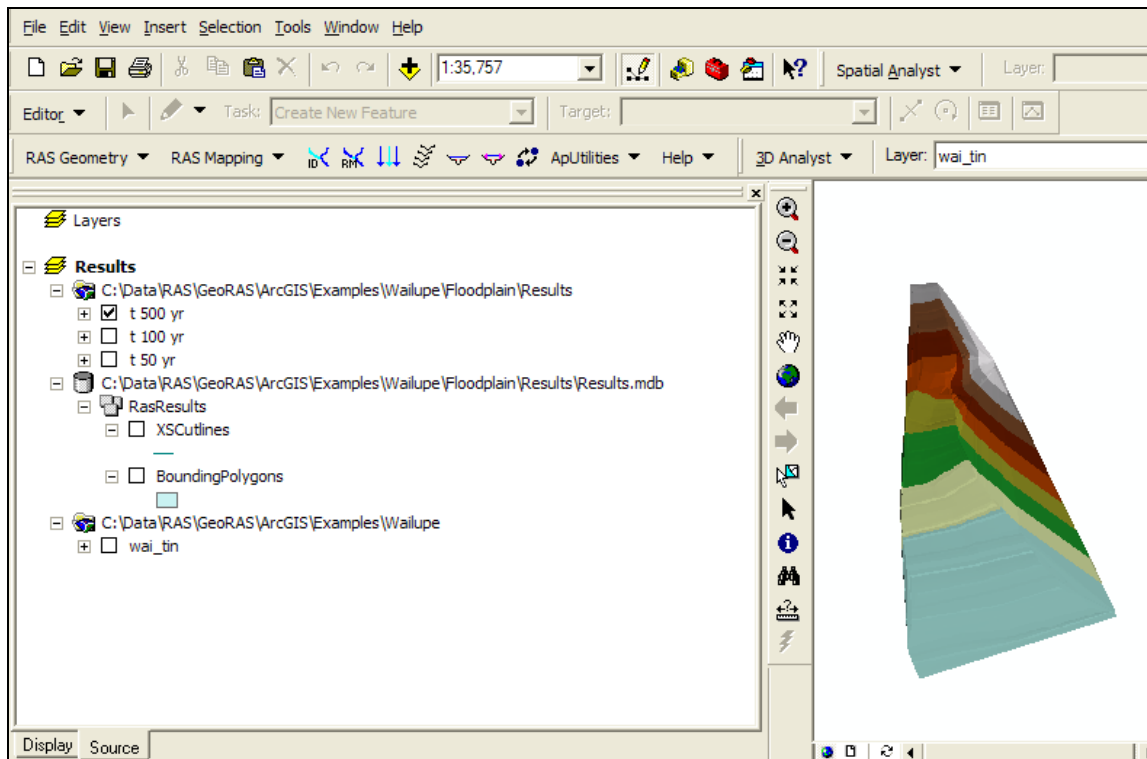
Figure 3-18. Water surface TINs are generated for each water surface profile and added to the map. Water surface profile names are prefixed with a "t".

The floodplain may then be delineated for each water surface profile for which a water surface TIN exists. Select the **RAS Mapping | Inundation Mapping | Floodplain Delineation** menu item. This will invoke a selection dialog to pick from the water surface profile names. Multiple water surface profiles may be selected by holding the SHIFT key down during selection. By default, the option to perform a "Smooth Floodplain Delineation" will be selected. Press **OK** to build floodplain polygon feature classes.
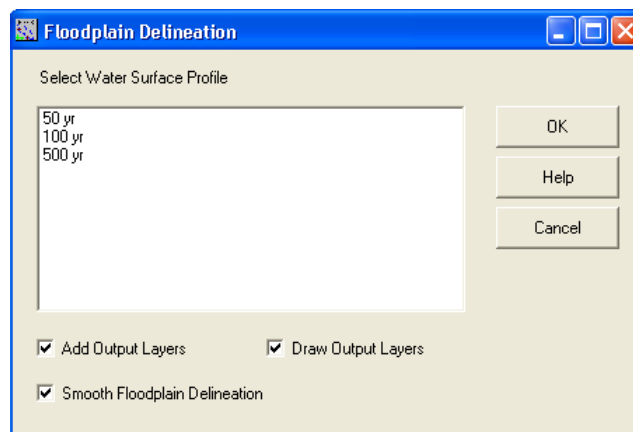
Figure 3-19. Selection dialog for performing floodplain delineation provides an option for a "Smooth Floodplain Delineation".

A floodplain polygon will be created based on the water surface profile TIN that was created previously. Each floodplain polygon results from intersecting the water surface and terrain surface. The water surface TIN and Terrain TIN are converted to grids with the same cell size and origin. A depth grid is then created with values where the water surface grid is higher than the terrain grid. The depth grid is then clipped with the bounding polygon to remove area not included in the river hydraulics model. Each depth grid is named as a concatenation of "d" and the water surface profile name (e.g., "d 100yr"); and it is saved into the output directory specified in the Layer Setup. The depth grid is then converted into a floodplain polygon feature class that is also saved in the specified dataset of the personal geodatabase. The floodplain boundary polygons are named as a concatenation of "b" and the water surface profile name (e.g., "b 100yr").

After the floodplain delineation, the depth grid and floodplain boundary feature class are added to the map having the same name of dataset specified in the Layer Setup. Figure 3-20 presents an example of the floodplain boundary feature class.
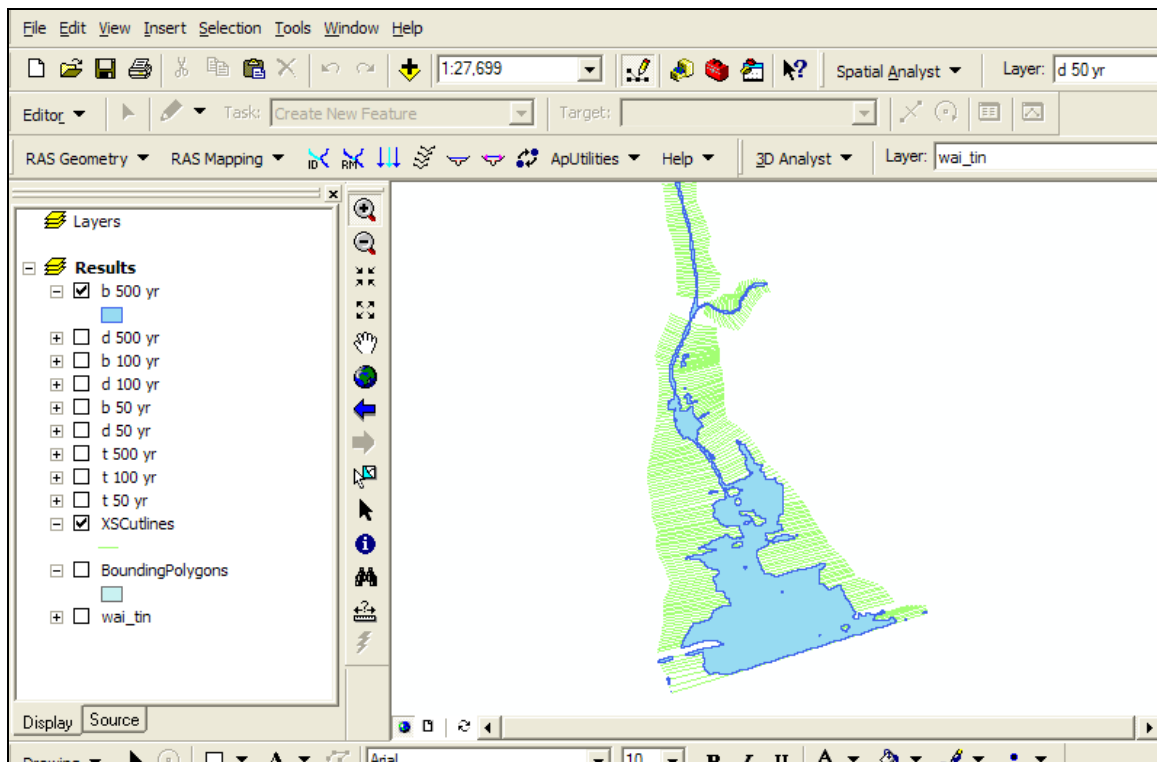
Figure 3-20. Floodplain delineation creates depth grids prefixed by "d" and floodplain boundary feature class prefix with a "b".

Velocity Results

Velocity results exported from HEC-RAS may be visualized using HEC-GeoRAS. Select the **RAS Mapping | Velocity Mapping** menu item. This will invoke a selection dialog to pick from the water surface profile

names. Multiple water surface profiles may be selected by holding the SHIFT key down during selection. Press **OK** to create the individual velocity grids for each profile.

A velocity grid for each profile is created based on the floodplain point velocities and the previously computed floodplain boundary. The raster dataset is added to the map. Each depth grid is named as a concatenation of "v" and the water surface profile name (e.g., "v 100yr"); and it is saved into the output directory specified in the Layer Setup.

Ice Thickness Results

Ice thickness results exported from HEC-RAS may be visualized using HEC-GeoRAS. Select the **RAS Mapping | Ice Mapping** menu item. This will invoke a selection dialog to pick from the water surface profile names. Multiple water surface profiles may be selected by holding the SHIFT key down during selection. Press **OK** to create the individual ice grids for each profile.

Shear Stress Results

Shear stress results exported from HEC-RAS may be visualized using HEC-GeoRAS. Select the **RAS Mapping | Shear Stress Mapping** menu item. This will invoke a selection dialog to pick from the water surface profile names. Multiple water surface profiles may be selected by holding the SHIFT key down during selection. Press **OK** to create the individual shear stress grids for each profile.

Stream Power Results

Stream power results exported from HEC-RAS may be visualized using HEC-GeoRAS. Select the **RAS Mapping | Stream Power Mapping** menu item. This will invoke a selection dialog to pick from the water surface profile names. Multiple water surface profiles may be selected by holding the SHIFT key down during selection. Press **OK** to create the individual shear stress grids for each profile.

C H A P T E R   4

Developing Geometric Data

The RAS GIS Import File consists of geometric data necessary to perform hydraulic computations in HEC-RAS. Cross-sectional elevation data are derived from an existing Digital Terrain Model (DTM) of the channel and surrounding land surface, while cross-sectional properties are defined from points of intersection between RAS Layers. The DTM may be in the form of a TIN or GRID.

Required RAS Layers created include the Stream Centerline and XS Cut Lines. Optional RAS Layers include the Main Channel Banks, Flow Path Centerlines, Land Use, Levee Alignment, Ineffective Areas, Blocked Obstructions and Storage Areas.   Hydraulic structure layers may also be created for Bridges/Culverts, Inline Structures and Lateral Structures. Geometric data and cross-sectional attributes are extracted to generate a data file that contains:

- River, reach, station identifiers;

- Cross-sectional cut lines and surface lines;

- Main channel bank station locations;

- Reach lengths for the left overbank, main channel and right overbank;

- Roughness coefficients;

- Levee positions and elevations;

- Ineffective flow areas and obstructions to flow;

- Bridge/culvert cut line locations and elevation profiles;

- Inline and lateral structure locations and elevation profiles;

- Storage area locations and elevation-volume relationships; and

- Storage area connection locations and elevation profiles.

Expansion/contraction coefficients are not written to the RAS GIS Import File.

Chapter 4 discusses the data layers and steps required to develop the RAS GIS Import File.

Contents

- Adding a Map

- Digital Terrain Model

- Background Data

- Stream Centerline Layer

- XS Cut Lines Layer

- Bank Lines Layer

- Flow Paths Centerline Layer

- Land Use Layer

- Levee Alignment Layer

- Bridges/Culverts Layer

- Ineffective Flow Areas Layer

- Blocked Obstructions Layer

- Inline Structures Layer

- Lateral Structures Layer

- Storage Areas Layer

- Storage Area Connections Layer

- Layer Setup

- Generating the RAS GIS Import File

Adding a Map

Prior to using GeoRAS, you need to save the ArcMap document (*.mxd*). Data you create will be based on the name of the map document and will be stored in the same location as the *.mxd* file. Select the **ApUtilities | Add Map** menu item to add a new map. Enter a map name and press **OK**. The ApUtilities will register the map with the behind-the-scenes data management system.

Once the Map has been added to the ArcMap document, set the coordinate system for analysis. Access the coordinate system through the map **Properties** and the **Coordinate System** tab. The coordinate system of the map will be used to define the coordinate system for each RAS Layer you create. If you do not set the coordinate system it will be set when you load the terrain model (provided it has projection information). The terrain model will be used to determine the spatial extent for the each RAS Layer. **NOTE: all RAS Layers and terrain model must be in the same coordinate system!**

Digital Terrain Model

HEC-GeoRAS requires an existing DTM that represents the channel bottom and the adjacent floodplain areas. The DTM may be in the form of a triangulated irregular network (TIN) or a GRID. A TIN is the preferred method for surface modeling for river hydraulics because it is well suited to represent linear features, such as channel banks, roads, and levees. The terrain model should be constructed to completely depict the floodplain of interest from elevation point data and breaklines identifying linear features of the landscape. Elevation data will be extracted from the DTM for each cross section. The DTM will also be used for floodplain mapping – to determine floodplain boundaries and to calculate inundation depths.

Developing a good hydraulic model begins with an accurate geometric description of the surrounding land surface, especially the channel geometry. Channel geometry typically dictates flow in river systems; therefore, only highly accurate DTMs describing the channel geometry should be considered for the basis of performing hydraulic analysis. Further, RAS Layers should be created with thoughtful evaluation of the river hydraulics as governed by the terrain.

Terrain Tiles Layer

GeoRAS offers the capability to use a single DTM of the study area or multiple DTMs. Predominantly, this documentation assumes that you are using a single DTM; however multiple DTMs may be required if the size of the study area results in a very large terrain model. Note that even when using multiple DTMs, there are file size limitations that will be evident during floodplain mapping and may require the delineation to occur over several separate reaches. An example for use of multiple DTMs is provided in Chapter 9.

Rules!

- Multiple DTMs exist for the study area.

- DTMs should overlap to properly represent the terrain surface at the edge of each terrain model (necessary for TIN models).

- DTMs should break at straight river reaches, if possible, and not at confluences.

- A polygon feature class must exist containing a record for each terrain tile that represents the bounds of the terrain model.

- Each RAS Layer feature (cross section cut line, lateral structure, storage area, etc.) must be contained within one bounding polygon feature so that elevation data may be extracted from a single DTM.

Creating the Terrain Tiles Layer

The polygon feature class is created by GeoRAS using the **RAS Geometry | Create RAS Layers | Terrain Tiles**. The definitions of fields for the polygon feature class that will need to be completed are provided in Table 4-1.

Table 4-1. Polygon feature attributes.

Field	Description
HydroID	Long Integer – A unique feature identifier.
TileName	String – Name of the TIN or GRID.
TileDirectory	String – Directory where the terrain model is located.
TerrainType	Short Integer – Indicates whether the terrain model is a TIN or GRID (0=GRID, 1=TIN).

Creating Terrain Tiles from a Single DTM

Large terrain models are not handled very efficiently by ArcGIS. There is a limit on the number of points that can be used in an ESRI TIN and the ESRI Grid format doesn't efficiently compress "NoData" cells. This results in large datasets that cannot be processed by GeoRAS and/or large data files. Difficulties with large datasets become especially evident during the floodplain delineation process.

One method of handling large datasets is to "tile" the terrain model. Tiling a dataset results in breaking the large dataset up into several smaller (more manageable) datasets. HEC-GeoRAS provides a method for tiling either TINs or Grids by creating grids based on the extents of features within the Terrain Tiles Layer.

To create terrain tiles from a single terrain dataset, create the Terrain Tiles Layer and digitize the extents of what will be the new smaller terrain datasets. Select the **RAS Geometry | Terrain Tiles | Extract TIN/GRID** menu option. In the dialog provided (shown in Figure 4-1), select the input and output parameters. Note that the user is provided the option to output TIN or Grid datasets (if a TIN is the Terrain source).   It is suggested that the output datasets should be in the Grid format for floodplain mapping, as it will preempt the conversion step during the RAS Mapping process.

The terrain tiles will be created in the specified output directory and the Terrain Tiles Layer attributes will automatically be populated with the "TerrainType", "TileName", and "TileDirectory". If the output datasets are of the gridded format, the tiles will be registered such that the grid cells from overlapping tiles are aligned.
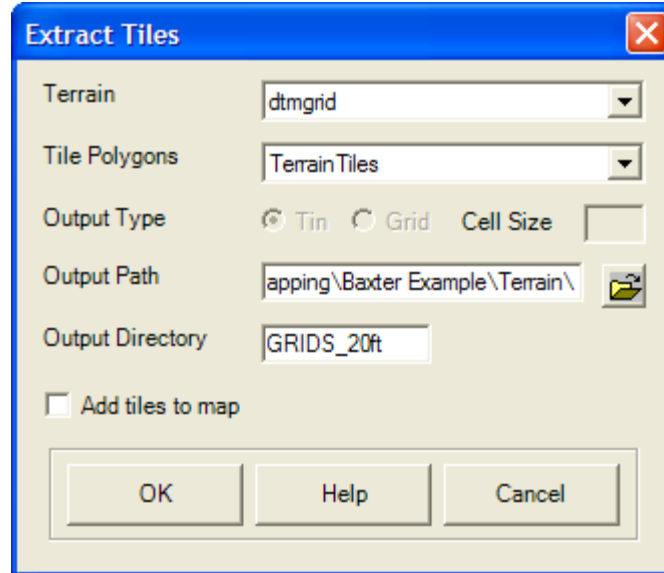
Figure 4-1. Converting a very large terrain dataset to tiled datasets.

Figure 4-2. The Terrain Tiles Layer attributes are automatically populated during the tiling process.

Background Data

Displaying the Terrain TIN (or GRID) provides detailed information on the river network and floodplain, but the display may prove agonizingly slow to refresh during digitizing, panning, or zooming. Creating background data such as contours or grid from the DTM will help you identify the study area and will redraw quickly to provide a good visualization for delineating the river network and locating cross sections.

To create a grid from a TIN model, select the **3D Analyst | Convert | TIN to Raster** menu item. The dialog shown in Figure 4-3 allows you to select the *Input TIN* and other parameters. Typically, the default cell size will provide a good balance between accuracy and file size

when viewing the terrain model at a small scale (zoomed out). Press the **OK** button after providing a filename and location.

Processing time will be dependent on the TIN and cell size. A grid will be created by sampling the TIN based on the grid-cell size and added to the Map. You can then set the *Scale Range* properties for both the TIN and GRID, such that the TIN is displayed when zoomed in on the river channel and the GRID is display when zoomed out.

Figure 4-3. TIN to GRID conversion dialog.
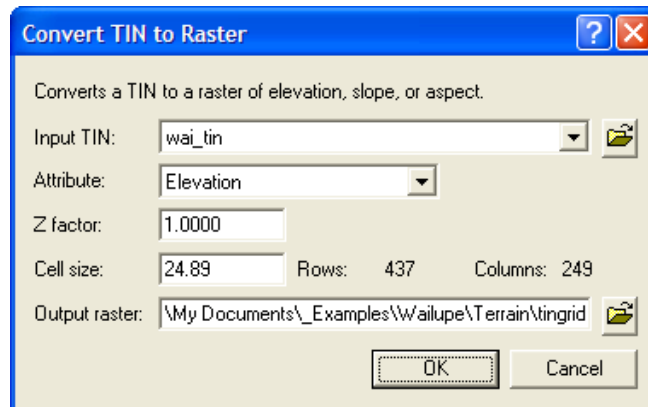
To create contours from a DTM, select the **Surface Analysis | Contour** menu item from the 3D Analyst or Spatial Analyst toolbar. The dialog shown in Figure 4-4 allows you to select the *Input Surface*, *Contour Interval*, *Output* feature data set, and other parameters.
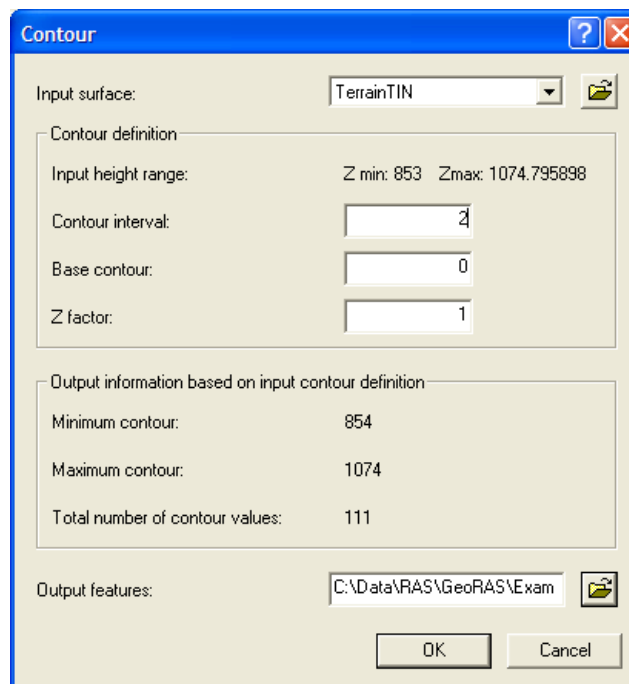

Figure 4-4. Contour setup dialog.

The contour interval selected should be based on the resolution of the terrain model. After setting the parameters, press the **OK** button.

The status bar at the bottom of the ArcMap interface will provide information on the status of the contouring process. When completed, you will be asked if you wish to add the features to the current Map. Note: the contour layer is used for visualization only and is not used during the data extraction process.

Stream Centerline Layer

The river and reach network is represented by the Stream Centerline layer. The network is created on a reach by reach basis, starting from the upstream end and working downstream following the channel thalweg. Each reach is comprised of a River Name and a Reach Name.

The Stream Centerline Layer is used for assigning river stations to cross sections and to display as a schematic in the HEC-RAS Geometric editor. It may also be used to define the main channel flow path.

Rules!

* The Stream Centerline must be created in the downstream direction – each river reach line must start at the upstream end (the *FromNode*) and finish at the downstream end (the *ToNode*).

* Each river reach must have a unique combination of its River Name (*River*) and Reach Name (*Reach*).

* All river reaches must be connected at junctions. Junctions are formed when the downstream endpoint (*ToNode*) of a reach coincides with the upstream endpoint (*FromNode*) of the next reach downstream.

* Junctions are formed from the intersection of two (or more) rivers, each having a different River Name (*River*). A River name represents one continuous flow path. For instance, the Mississippi River has many reaches but is one river. Tributaries that enter the Mississippi River, such as the Ohio River, have a new River name.

* Stream Centerlines should not intersect, except at confluences (junctions) where endpoints are coincident.

Creating the River Network

Select the **RAS Geometry | Create RAS Layer | Stream Centerline** menu item. The dialog shown in Figure 4-5 will allow you to enter a name for the new feature class – "River" is the default.
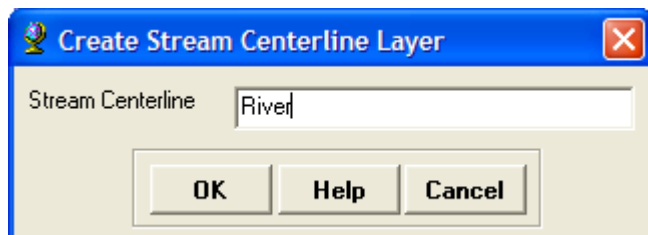
Figure 4-5. Supply a name when creating a new feature class.

Press **OK** and a new feature class with several empty fields in the attribute table (as summarized in Table 4-2) will be created. The empty feature class will be added to the active Map.

Table 4-2. Summary of Stream Centerline fields.

Field	Description
HydroID	Long Integer – unique feature identifier.
River	String – River Name specified by user.
Reach	String – Reach Name specified by user.
FromNode	Short Integer – Identifies starting/upstream endpoint of reach.
ToNode	Short Integer – Identifies ending/downstream endpoint of reach.
ArcLength	Float – Length of reach.
FromSta	Float – Measurement at *ToNode* (normally 0.0).
ToSta	Float – Measurement length to *FromNode*.

You must be in Edit mode to create a river reach. To begin editing, select **Start Editing** from the Editor toolbar. After selecting the geodatabase to edit, select the ✏ (**Sketch**) tool. Use the mouse to digitize the stream centerline. Use the left mouse button to create the first point and continue creating the centerline in the downstream direction, using the left mouse click to add vertices. Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the stream centerline features, save edits and stop editing the layer.

The pan and zoom tools are available from the Tools toolbar while editing. Simply choose a tool, use it and then reactivate the sketch tool to continue digitizing.

After completing the river network, you must populate the *River* and *Reach* fields with river reach names using the ⎇ (**River ID**) tool. After activating the River ID tool, select a reach with the mouse

pointer. Enter the River Name and Reach Name in the dialog provided (shown in Figure 4-6).

Figure 4-6. Dialog for River Name and Reach Name assignment.

Junctions

Junctions are formed at the confluence of three or more reaches. In HEC-RAS, you may only have a new reach (and a junction) at a flow change location. In order for a junction to be formed, reach endpoints must be coincident. One method to ensure that junctions are formed at endpoints is to use the snapping method described below.

1. **Start Editing** the Stream Centerline feature class using **Modify Feature** as the Task.

2. Select the **Editor | Snapping** menu item and select the Stream Centerline feature class to have snapping at the endpoint.
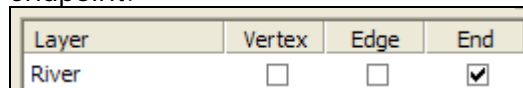
3. Select the **Editor | Options** menu item and set the **Snapping Tolerance** on the General tab.
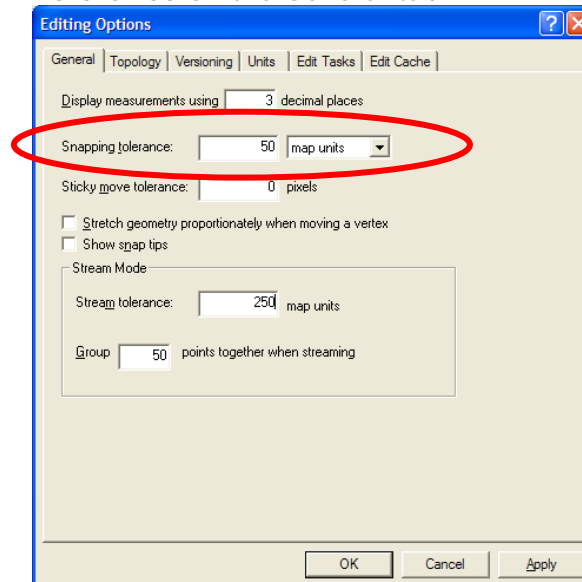
4. Activate the ▶ (**Edit**) tool.

5. Select an endpoint at the junction location.

6. Move the endpoints from the other reaches toward the junction location one at a time allowing the snapping and tolerance to snap the endpoints together.

Uniqueness

The river network must have unique reach names for each river. A river name is used for one river – one, connected flow line. Verify that each river and each river reach is unique by opening the Stream Centerline attribute table.

Directionality

The Stream Centerline must be created in the downstream direction. To verify the orientation of the stream network, change the line symbol to a line symbol with arrows.

If the line was created in the wrong direction, you can flip the line to point downstream. While in edit mode, right-click on the feature and select **Flip** from the context sensitive menu.

Attributing the Stream Centerline Layer

You must specify the River and Reach names for the Stream Centerline layer. The HydroID data will be completed by the ApFramework. The remaining attributes are completed by running GeoRAS menu items for the Stream Centerline as summarized in Table 4-3. ***The Elevations menu item is OPTIONAL – the data is not used in HEC-RAS – and typically should NOT be run.***

Table 4-3. Stream Centerline completion menu items.

Menu Item	Description
Topology	Populates the *FromNode* and *ToNode* fields.
Lengths/Stations	Calculates the length for each river reach. Populates the *FromSta* and *ToSta* fields.
Elevations	Extracts elevation data from the DTM and creates a 3D feature class. (*Optional*)
All	Performs all tasks listed above in order.

Topology

The Topology menu item is used to verify that the Stream Centerline created a river network. Each reach endpoint (*FromNode* and *ToNode*) is given an integer ID. Reach endpoints at a junction should each have the same integer ID. If endpoints are not coincident between two river reaches, the river stationing will not be consistently applied to cross sections. **You must check the values assigned to the FromNode and ToNode fields to verify the connectivity of the river network – that junctions are formed by coincident reach endpoints!**

Lengths/Stations

The Lengths/Stations menu item calculates the length of each river reach and determines the flow direction. This will be used to compute the river station for each cross section. Lengths and values for the *FromSta* and *ToSta* will be computed based on the units for the coordinate system (feet or meters).

FromSta and *ToSta* data may be overwritten. This may be done using the ![RM] (**River Mile**) tool or by computing a new value in the attribute table. Adjust the river stationing if you would like your study reach to start at a specific river station other than "0.0".

Elevations

The Elevations menu item will convert the Stream Centerline 2D layer to a 3D layer. *Elevation data for the stream centerline is not used in HEC-RAS, so this is an unnecessary step.*

All

This menu option will run the Topology, Lengths/Stations, and Elevations menu items in sequence.

Cross-Sectional Cut Lines Layer

The location, position, and extent of cross sections are represented by the Cross-Sectional Cut Line layer. Cut lines should be perpendicular to the direction of flow; therefore, it may be necessary to "dog-leg" the cut lines to conform to this one-dimensional flow requirement.

While the cut lines represent the planar location of the cross sections, the station-elevation data are extracted along the cut line from the DTM.

Rules!

- Cross-sectional cut lines must be oriented from the left overbank to the right overbank, when looking downstream.

- Cut lines should be perpendicular to the direction of flow (considering the entire range of flow events).

- Cut lines should not intersect.

- Cut lines must cross the Stream Centerline exactly once.

- Cut lines may not extend beyond the extents of the DTM.

Creating Cross-Sectional Cut Lines

Select the **RAS Geometry | Create RAS Layer | XS Cut Lines** menu item. A dialog will allow you to enter a name for the new feature class – "XSCutlines" is the default.

A new feature class with several empty fields in the attribute table (as summarized in Table 4-4) will be created. The empty feature class will be added to the active Map.

Table 4-4. Summary of the XS Cut Lines fields.

Field	Description
HydroID	Long Integer – unique feature identifier.
River	String – Populated from the Stream Centerline layer.
Reach	String – Populated from the Stream Centerline layer.
Station	Float – River station assigned from Stream Centerline layer.
LLength	Float – Downstream reach length for the left overbank calculated from Flow Path Centerlines layer.
ChLength	Float – Downstream reach length for the main channel calculated from Flow Path Centerlines layer.
RLength	Float – Downstream reach length for the right overbank calculated from Flow Path Centerlines layer.
LeftBank	Float – Percent along the cut line to left bank calculated from Bank Lines layer.
RightBank	Float – Percent along the cut line to right bank calculated from Bank Lines layer.
NodeName	String – Cut line description specified by user.

You must be in edit mode to create a cross-sectional cut line. Select the ✏ (**Sketch**) tool and use the mouse to digitize a cut line. Use the left mouse button to create the first point and continue creating the cut line from the left overbank to the right overbank, using the left mouse click to add vertices. Cut lines should be created perpendicular to the direction of flow, intersect the stream centerline only once, and should not cross any other cut lines. Each cut line should cover the entire extent of the floodplain and not extend beyond the extent of the terrain model.

Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the cut line features, stop editing the feature class. Verify that the cut lines were constructed from the left to right bank by adding an arrow symbol. The direction of the cut line may be flipped (while in edit mode) by right-clicking on the feature and selecting Flip from the context sensitive menu.

Previewing Cross Sections

Cross sections can be previewed using the ▽ (**XS Plot**) tool. To preview a cross section, activate the **XS Plot** tool and then use the mouse pointer to select the cut line of interest. GeoRAS will extract elevation information from the terrain model and display it in a graphics window.

If the *River*, *Reach*, and *Station* data have been attributed to the feature it will be added to the title of the cross section plot, as shown in Figure 4-7. The x-axis will be labeled "Station" and corresponds to the distance from the left end of the cut line, while the y-axis will be labeled with "Elevation". All units will be based on the units of the terrain model.
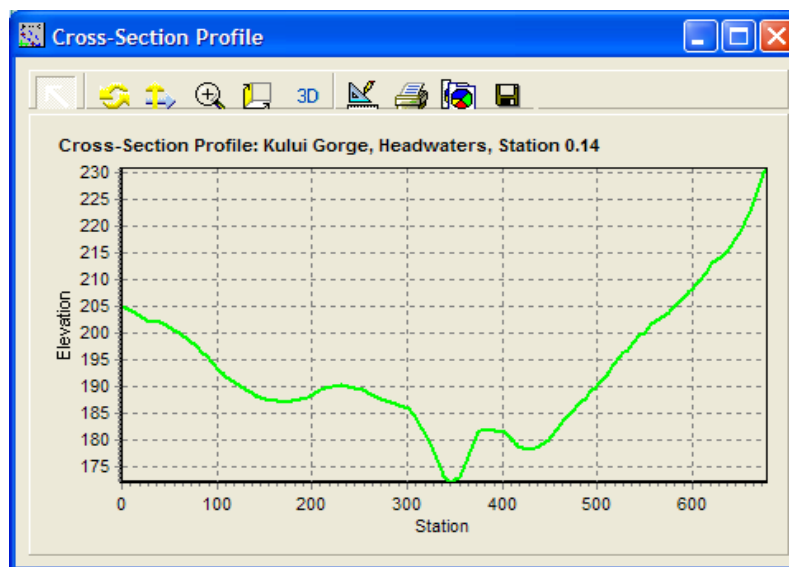

Figure 4-7. Sample cross section plot.

Attributing the Cross-Sectional Cut Lines Layer

HydroID data will be completed by the HydroID Manager. The remaining attributes are completed by running GeoRAS menu items for the XS Cut Lines as summarized in Table 4-5.

Table 4-5. XS Cut Line completion menu items.

Menu Item	Description
River/Reach Names	Populates the *River* and *Reach* fields based on the Stream Centerline layer.
Stationing	Calculates the river station for each cut line based on the intersection with the Stream Centerline Layer. Populates the *Station* field.
Bank Stations	Calculates the Left and Right bank positions as a percentage along the cut line using the Bank Lines layer. Populates the *LeftBank* and *RightBank* fields.
Downstream Reach Lengths	Calculates the Left, Channel, and Right reach lengths based on the Flow Path Centerlines layer. Populates *LLength*, *ChLength*, and *RLength* fields.
Elevations	Extracts elevation data from the DTM and creates a 3D feature class. The default name is "XSCutLines3D".
All	Performs all tasks listed above in order.
Update Elevations	Extracts additional elevation data from an point elevation dataset.

River/Reach Names

Each cut line is attributed with a *River* and *Reach* name based on the names in the Stream Centerline layer. Cut lines must intersect the Stream Centerline layer exactly once.

Stationing

A river *Station* is calculated for each cut line based on the distance from the most downstream point on the *River*. Calculations are based on the *FromSta* and *ToSta* values in the Stream Centerline layer. The calculated station is used to order cross sections when computing water surface profiles in HEC-RAS.

Bank Stations

The main channel banks of each cut line will be computed if the Bank Lines layer is provided. The *LeftBank* and *RightBank* fields are

populated with the percent distance along the cut line to the bank position based on the intersection of the cut line and bank line. This computation is optional. The method for computing bank station positions is illustrated in Figure 4-8.
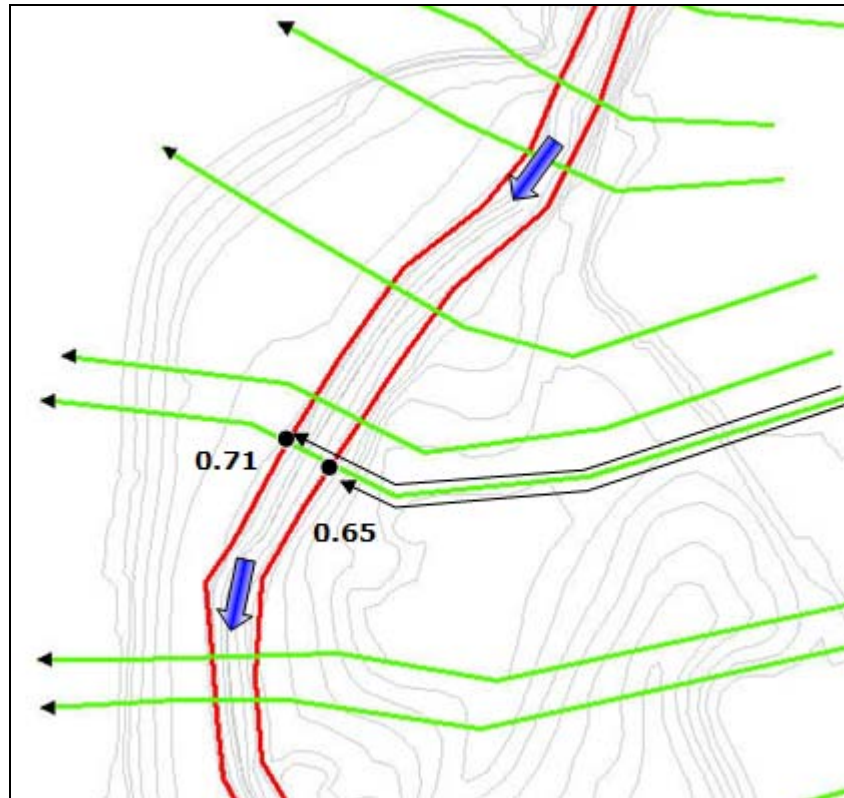
Figure 4-8. Calculation of bank station locations from bank lines and cut lines.

Downstream Reach Lengths

Downstream reach lengths will be computed for the Left overbank, main Channel, and Right overbank based on the length of the flow path lines in the Flow Path Centerlines layer. The distances are recorded in the *LLength*, *ChLength*, and *RLength* fields. If only the main Channel flow path exists, only the *ChLength* distance will be computed. This computation is optional. The method for computing downstream distances is illustrated in Figure 4-9.
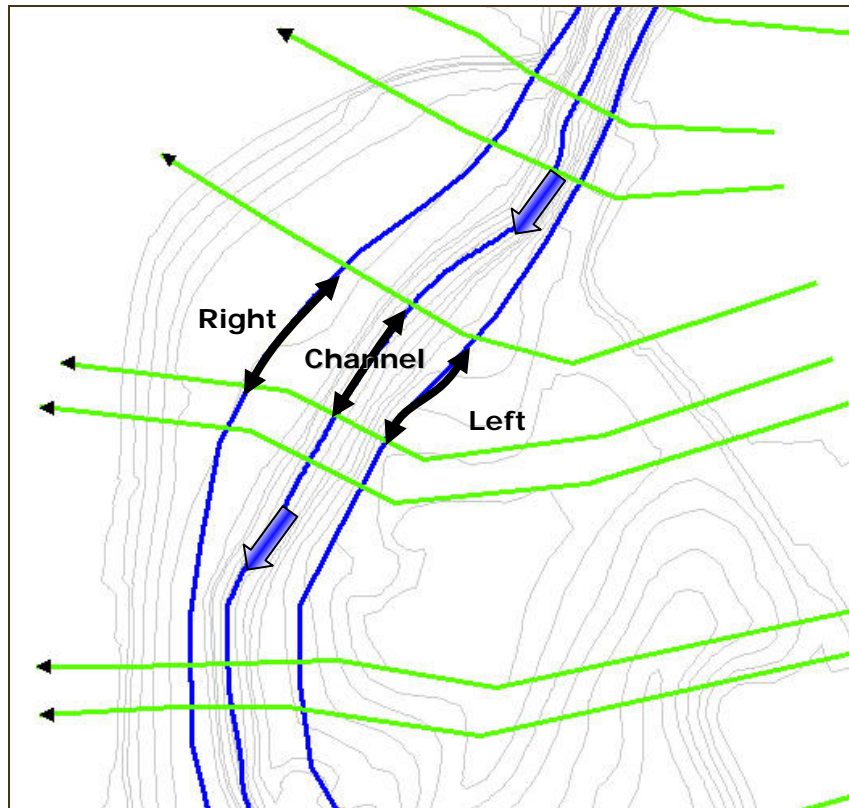
Figure 4-9. Calculation of downstream reach lengths from flow paths and cut lines.

Elevations

Elevations are extracted from the DTM for each cross section. The elevations are stored by converting the 2D cut line feature class to a 3D feature class (default name "XSCutLines3D"). If the DTM is a GRID, elevations are extracted at an interval defined by the grid-cell size. If the DTM is a TIN, elevations are extracted at the edge of each facet (triangle).

All

This menu option will run the River/Reach Names, Stationing, Bank Stations, Downstream Reach Lengths, and Elevations menu items in sequence.

Update Elevations

Elevations on the 3D feature class are replaced, using a point elevation feature class, based on the parameters specified. The Update Elevation option is intended to incorporate bathymetric information into a cross section that has been previously extracted from the land surface.

The Update Elevations method uses a bounding features layer, a point feature class with elevation values, and the XSCutlines3D feature class. The elevation values within the bounding features are removed and replaced with the point data elevations by snapping the point to the closest point on the cross section. The default method is to use the Bank Stations as the bounding features layers, thereby replacing elevation data into the main channel. An example of bathymetric data, bank lines and cross section is shown in Figure 4-10.
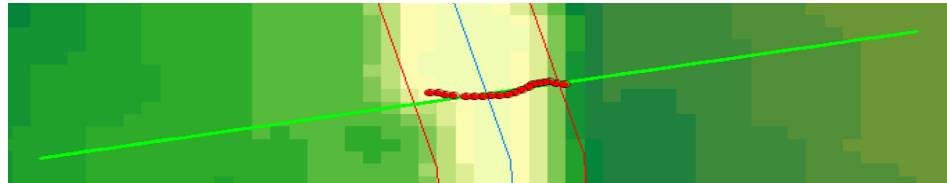
Figure 4-10. Bank lines define the limit of elevation replacement by point data on a cross section.

The Elevation Update tool requires a point feature class with a field of elevation values. If the Bank Extents option is selected, you must also specify a maximum distance tolerance between an elevation point and a cross section; if the point is not within the XS Tolerance, it will not be used. If the Bathymetry Extents option is selected, you must specify the extents to use the bathymetry using a polygon feature class and the limiting extents of the cross section to be analyzed. The Update Elevations dialog is shown in Figure 4-11.
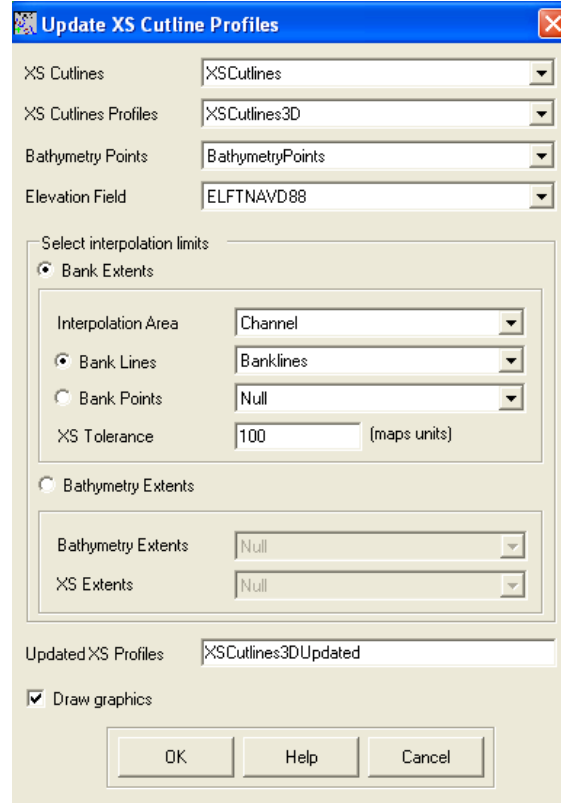
Figure 4-11. Update Elevations dialog.

When the updated XS profiles feature class is created ("Updated" is appended to the XSCutlines3D feature class name), the elevation points layer will have a new field (ElevUpdate) added with a "1" indicating if the point was used. If the "Draw Graphics" option is turned on the elevation points used will be highlighted along with the extents of analysis, as shown in Figure 4-12.
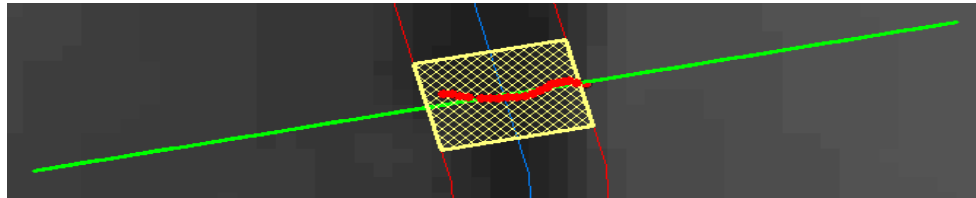
Figure 4-12. Elevation points used in the update process are highlighted along with the extents used for point inclusion.

The updated cross section profile feature class may then treated as any XSCutlines3D feature class. It may be exported for import to RAS or used again in the Update Elevations process. An example illustrating the incorporation of bathymetry data is shown in Figure 4-13.
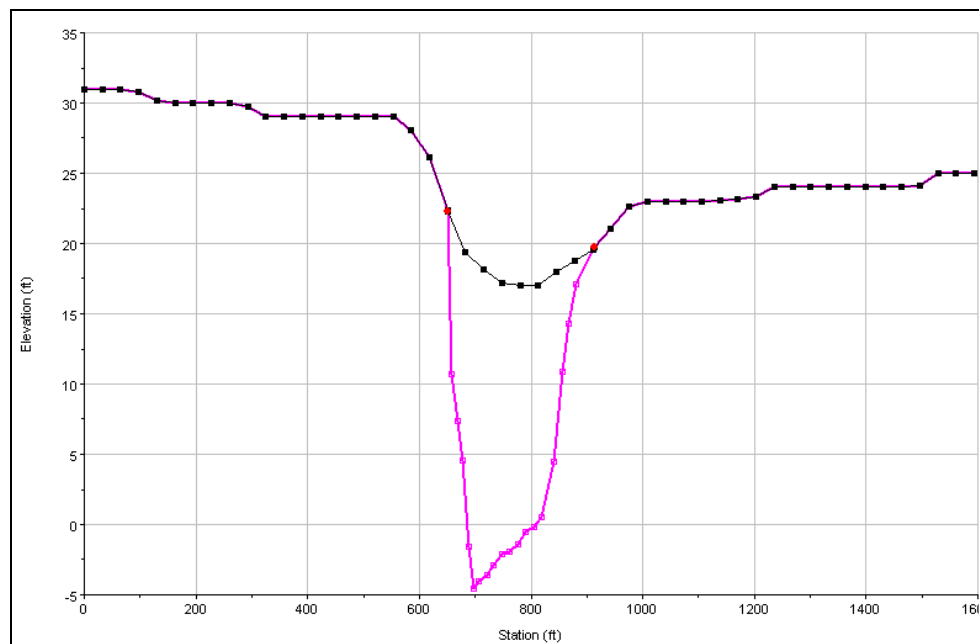
Figure 4-13. Comparison of original cross section with updated profile with channel data.

Bank Lines Layer

The Bank Lines layer defines the main channel flow from flow in the overbanks. Bank stations will be assigned to each cross section based on the intersection of the bank lines with the cut lines. It is often more efficient to skip this layer and complete the data in HEC-RAS using the Graphical Cross Section Editor tools.

Rules!

- Exactly two bank lines may intersect each cut line.

- Bank lines may be broken (discontinuous).

- Orientation of the bank lines is not important (you may create the lines from upstream to downstream or downstream to upstream).

- Optional – creating this layer is not required.

Creating the Bank Lines Layer

Select the **RAS Geometry | Create RAS Layer | Bank Lines** menu item. A dialog will allow you to enter a name for the new feature class – "Banks" is the default.

A new feature class will be created and added to the active Map. The only field of interest added to the feature class is the HydroID field which will be populated by the HydroID Manager as each feature is created. Bank lines should be created on either side of the channel to differentiate the main conveyance channel from the overbank areas.

You must be in edit mode to create the banks lines. Select the ![sketch icon] (**Sketch**) tool and use the mouse to digitize a bank line. Use the left mouse button to create the first point and continue creating the line, using the left mouse click to add vertices. Each bank line should only intersect a cross-sectional cut line once.

Double-click the mouse button to finish drawing the line. When you have completed digitizing the cut line features, stop editing the feature class.

Flow Path Centerlines Layer

The Flow Path Centerlines layer is used to identify the hydraulic flow path in the left overbank, main channel, and right overbank by identifying the center-of-mass of flow in each region. Further, creating the flow path centerline layer will assist you in properly laying out the cross-sectional cut lines. If the Stream Centerline layer already exists you have the option to copy the stream centerline for the flow path in the main channel. Flow paths are created in the direction of flow (upstream to downstream).

Downstream reach lengths are calculated for each cut line based on the distance between cut lines along the flow path centerlines for the left overbank, main channel, and right overbank.

Rules!

- Flow path lines must point downstream (in the direction of flow).
- Each flow path line must be continuous for each River.
- Each flow path line must intersect a cut line exactly once.
- Flow path lines should not intersect.
- Optional – creating this layer is not required.

Creating the Flow Path Centerlines Layer

Select the **RAS Geometry | Create RAS Layer | Flow Path Centerlines** menu item. A dialog will allow you to enter a name for the new feature class – "Flowpaths" is the default. If the Stream Centerline layer already exists, you will be asked if you would like to use the stream centerline for the main channel flow path (see Figure 4-14). Choose "Yes" to copy the stream centerline.
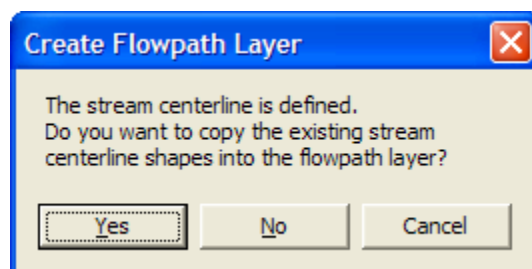

Figure 4-14. Copy stream centerline to flow path centerline.

A new feature class will be created and added to the active Map. The feature class will have the *HydroID* field and a *LineType* field. The

LineType field will designate whether the flow path line is for the main "Channel", "Left" overbank, or "Right" overbank.

Table 4-6. Summary of Flow Path Centerlines fields.

Field	Description
HydroID	Long Integer – unique feature identifier.
LineType	String – Populated using the Assign LineType tool – "Left", "Channel", "Right" values designate the flow path.

You must be in edit mode to create the flow path lines. Select the 🖉 (**Sketch**) tool and use the mouse to digitize a flow path line. Use the left mouse button to create the first point and continue creating the line, using the left mouse click to add vertices. The flow path line must be created in the downstream direction and intersect a cut line exactly once.

Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the cut line features, stop editing the feature class.

Attributing the Flow Path Centerlines Layer

Each flow path line must be identified as being in the "Left" overbank, main "Channel", or "Right" overbank. You can assign the *LineType* using the ⇊ (**Assign LineType**) tool. Activate the **LineType** tool and use the mouse pointer to select a flow path. In the dialog that appears (see Figure 4-15), select the corresponding type of flow path. You must click on each flow path individually.
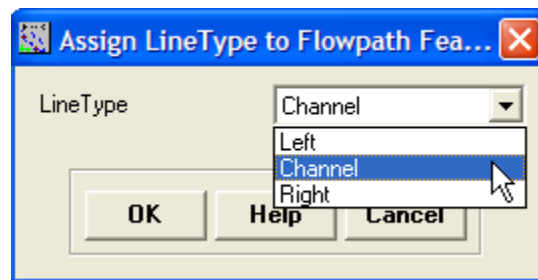
Figure 4-15. Assign a line type to each flow path centerline.

Bridges/Culverts Layer

The locations of river crossings are represented by the Bridge/Culvert layer. Cut lines for bridges and culverts are treated much the same as

for cross sections. Cut lines will be used to identify the correct river station for the bridge or culvert and will extract station-elevation data for the top-of-road for the bridge deck from the DTM.

Rules!

- Cut lines must be oriented from the left overbank to the right overbank, when looking downstream.

- Cut lines must cross the Stream Centerline exactly once.

- A cut line may not extend beyond the extents of the DTM.

- Optional – creating this layer is not required.

Creating the Bridges/Culverts Layer

Select the **RAS Geometry | Create RAS Layer | Bridges/Culverts** menu item. A dialog will allow you to enter a name for the new feature class – "Bridges" is the default.

A new feature class with several empty fields in the attribute table (as summarized in Table 4-7) will be created. The empty feature class will be added to the active Map.

Table 4-7. Summary of Bridge/Culvert fields.

Field	Description
HydroID	Long Integer – unique feature identifier.
River	String – Populated from the Stream Centerline layer.
Reach	String – Populated from the Stream Centerline layer.
Station	Float – River station assigned from Stream Centerline layer.
USDistance	Float – User specified distance from upstream face of bridge to next cross section upstream.
TopWidth	Float – User specified width (in direction of flow) of the bridge deck.
NodeName	String – Description of bridge specified by user.

You must be in edit mode to create a bridge/culvert cut line. Select the ✎ (**Sketch**) tool and use the mouse to digitize a cut line. Use the left mouse button to create the first point and continue creating the cut line from the left overbank to the right overbank, using the left mouse click to add vertices.

Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the cut line features, stop editing the feature class. Enter the Top Width of the bridge deck and Distance to the next cross section upstream. You need not complete this data in the GIS, but HEC-RAS will require this information to perform a simulation.

Attributing the Bridges/Culverts Layer

HydroID data will be completed by the ApFramework. The remaining attributes are completed by running GeoRAS menu items for the Bridge/Culvert as summarized in Table 4-8.

Table 4-8. Bridge/Culvert completion menu items.

Menu Item	Description
River/Reach Names	Populates the *River* and *Reach* fields based on the Stream Centerline layer.
Stationing	Calculates the river station for each cut line based on the intersection with the Stream Centerline Layer. Populates the *Station* field.
Elevations	Extracts elevation data from the DTM and creates a 3D feature class. The default name is "Bridges3D".
All	Performs all tasks listed above in order.

River/Reach Names

Each bridge is attributed with a *River* and *Reach* name based on the names in the Stream Centerline layer. Cut lines must intersect the Stream Centerline layer exactly once.

Stationing

A river station is calculated for each cut line based on the distance from the most downstream point on the *River*. Calculations are based on the *FromSta* and *ToSta* values in the Stream Centerline layer. The calculated *Station* is used to order cross section nodes when computing water surface profiles in HEC-RAS.

Elevations

Elevations are extracted from the DTM for each bridge. The elevations are stored by converting the 2D bridge/culvert feature class to a 3D feature class (default name "Bridges3D").

All

This menu option will run the River/Reach Names, Stationing, and Elevations menu items in sequence.

Ineffective Flow Areas Layer

The Ineffective Flow Areas layer identifies portions of the floodplain that do not actively convey flow. This layer is created in areas of zero velocity such as the dead-water zones upstream and downstream of bridges and culverts. The position of ineffective areas will be extracted based on the intersection of the Ineffective Flow Areas layer and the Cross-Sectional Cut Lines layer.

Rules!

- Ineffective polygons should be constructed to form "blocks".

- Consult the HEC-RAS Hydraulic Reference Manual and RD-42 (HEC, 1995) for guidance on flow transitions at bridges.

- Optional – creating this layer is not required.

Creating the Ineffective Flow Areas Layer

Select the **RAS Geometry | Create RAS Layer | Ineffective Flow Areas** menu item. A dialog will allow you to enter a name for the new feature class – "IneffectiveAreas" is the default.

A new feature class will be created and added to the active Map. The only field of interest added to the feature class is the HydroID field which will be populated by the ApFramework when each feature is created.

You must be in edit mode to create a ineffective area. Select the (**Sketch**) tool and use the mouse to digitize each area. Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the polygon features, stop editing the feature class.

Ineffective Flow Area Attributes

Ineffective flow area positions and elevations are extracted by selecting the **RAS Geometry | Ineffective Flow Areas | Positions** menu item. The dialog shown in Figure 4-16 will allow you to choose the Ineffective Flow Areas layer, Cross-Sectional Cut Lines layer, DTM, and provide a name for the table that will hold the ineffective positions

("IneffectivePostions" is default). You can also specify to "keep current user elevations" to prevent overwriting previously stored data.
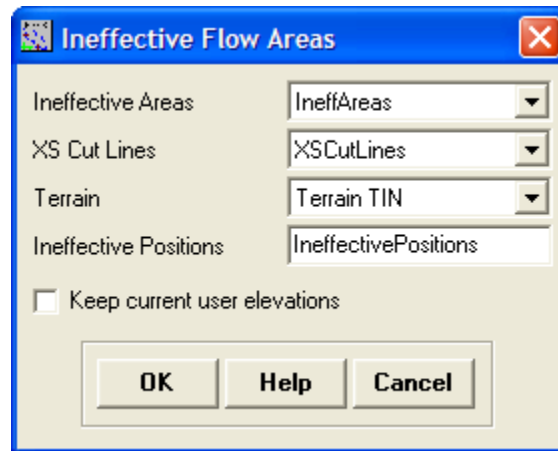
Figure 4-16. Ineffective flow areas data extraction dialog.

Ineffective flow area data are extracted based on the intersection of the cut lines and ineffective area and is written to the *IneffectivePositions* table. The beginning and ending position of intersection between the ineffective flow area and the cut line is calculated as well as the corresponding elevation from the DTM. The elevation extracted from the DTM will be used as a "trigger" elevation in HEC-RAS for turning off the ineffective areas. If the user specifies a *UserElev* it will be used, otherwise the larger of the two elevations computed for the beginning and ending position will be used. The *IneffectivePosition* table fields are summarized in Table 4-9.

Table 4-9. Summary of IneffectivePositions table fields.

Field	Description
XS2DID	Long – Integer corresponding to the cross-sectional cut line's HydroID.
IA2DID	Long – Integer corresponding to the ineffective flow areas HydroID.
BegFrac	Float – Fraction of the distance along the cut line to the beginning of the ineffective area.
EndFrac	Float – Fraction of the distance along the cut line to the beginning of the ineffective area.
BegElev	Float – Elevation at the *BegFrac*.
EndElev	Float – Elevation at the *EndFrac*.
UserElev	Float – User specified Elevation

Blocked Obstructions Layer

The Blocked Obstructions layer identifies portions of the floodplain that permanently remove flow area from the cross section. This layer is created in areas of floodplain encroachment. The position of blocked obstructions will be extracted based on the intersection of the Blocked Obstructions layer and the Cross-Sectional Cut Lines layer.

Rules!

• Blocked obstruction polygons should be constructed to form "blocks".

• Optional – creating this layer is not required.

Creating the Blocked Obstructions Layer

Select the **RAS Geometry | Create RAS Layer | Blocked Obstructions** menu item. A dialog will allow you to enter a name for the new feature class – "BlockedObs" is the default.

A new feature class will be created and added to the active Map. The only field of interest added to the feature class is the HydroID field which will be populated by the ApFramework when each feature is created.

You must be in edit mode to create a blocked obstruction area. Select the ✏️ (**Sketch**) tool and use the mouse to digitize each area. Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the polygon features, stop editing the feature class.

Blocked Obstruction Attributes

Blocked obstruction extents and elevations are extracted by selecting the **RAS Geometry | Blocked Obstructions | Positions** menu item. The dialog shown in Figure 4-17 will allow you to choose the Blocked Obstructions layer, Cross-Sectional Cut Lines layer, DTM, and provide a name for the table that will hold the blocked positions ("BlockedPositions" is default). You can also specify to "keep current user elevations" to prevent overwriting previously stored data.
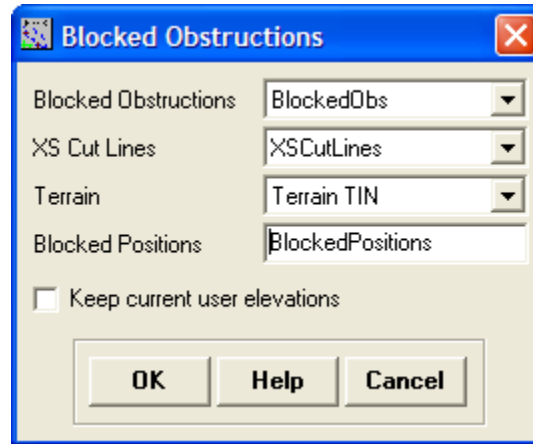
Figure 4-17. Blocked obstruction data extraction dialog.

Blocked obstruction data are extracted based on the intersection of the cut lines and blocked area polygons and is written to the *BlockedPositions* table. The beginning and ending position of the intersection between the blocked area and the cut line is calculated as well as the corresponding elevation from the DTM. The elevation extracted from the DTM will be used as the top-of-obstruction elevation in HEC-RAS. If the user specifies a *UserElev* it will be used, otherwise the larger of the two elevations computed for the beginning and ending position will be used. The *BlockedPosition* table fields are summarized in Table 4-10.

Table 4-10. Summary of fields in the BlockedPositions table.

Field	Description
XS2DID	Long – Integer corresponding to the cross-sectional cut line's HydroID.
BO2DID	Long – Integer corresponding to the blocked obstruction HydroID.
BegFrac	Float – Fraction of the distance along the cut line to the beginning of the blocked obstruction.
EndFrac	Float – Fraction of the distance along the cut line to the beginning of the blocked obstruction.
BegElev	Float – Elevation at the *BegFrac*.
EndElev	Float – Elevation at the *EndFrac*.
UserElev	Float – User specified Elevation.

Land Use Layer

A Land Use layer may be used to estimate Manning's *n* values along each cut line. The land use data set must be a polygon layer and have a field to reference for *n* values (*N_Value* for instance). If an *N_Value* field does not exist, GeoRAS provides tools for creating a summary table of *n* values based on a land use field. Alternatively, you may add the *N_Value* field to an existing polygon feature class using standard ArcGIS functionality for GeoRAS to use.

Rules!

- The land use data set must be a 2D polygon data set that encompasses the entire set of cut lines.

- Multipart polygons are not supported.

- The land use layer must have (or reference) an *N_Value* field.

- Polygons must share an edge.

- Optional – creating this layer is not required.

Creating the Land Use Layer

Select the **RAS Geometry | Create RAS Layer | Landuse Areas** menu item. A dialog will allow you to enter a name for the new feature class – "LandUse" is the default.

A new feature class with empty fields in the attribute table (as summarized in Table 4-11) will be created. The empty feature class will be added to the active Map.

Table 4-11. Summary of Land Use fields.

Field	Description
LUCode	String – Short description of land use type.
N_Value	Float – Manning's *n* value.

You must be in edit mode to create a land use area. Select the (**Sketch**) tool and use the mouse to digitize each area. One method is to begin by digitizing a bounding area around the project area. This ensures that each cross section is contained by a viable polygon.

Continue by digitizing polygons around specific land use classes. Left-click to add a vertex point, double-click to end a sketch. After each polygon is digitized, select **Clip** from the **Editor** toolbar. In the Clip properties dialog (shown in Figure 4-18), choose a *Buffer Distance* of

"0.0" and to Discard the intersecting area. This will create a unique, non-overlapping polygon.
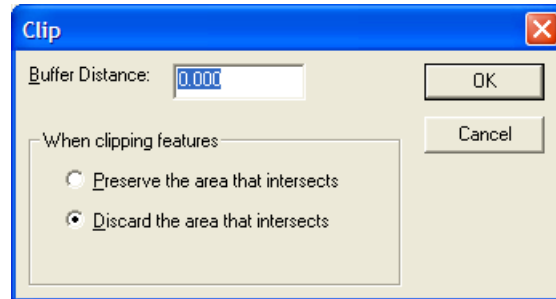

Figure 4-18. Clip land use polygons to create unique, non-overlapping features.

After completing the polygon, enter a description in the **LUCode** field. The description should be standardized – you will use it again for a similar land use area. You may also enter the *n* value in the *N_Value* field. If you enter the *N_Value* data, the *LUCode* data is not required.

When you have completed digitizing the stream centerline features, stop editing the layer.

Creating the Land Use Layer Table

If the *N_Value* data is not present in the Land Use layer, you can use GeoRAS to create a summary table to which you can add *n* values. Select the **RAS Geometery | Manning's n Values | Create LU-Manning Table**. This will invoke the dialog shown in Figure 4-19 which allows you to specify the Land Use layer, the Land Use description field, and the name of the *Summary Manning Table* to create.
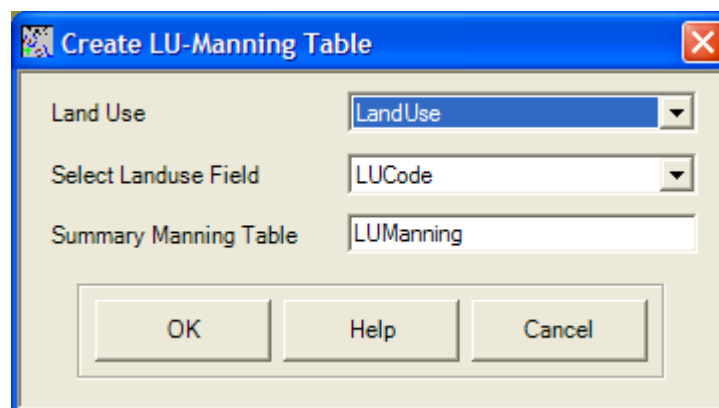

Figure 4-19. Specify the Land Use classification field to summarize n value data.

A new table will be created that summarizes the types of land use specified in the *LUCode* field and is added to the ArcMap document. Change the ArcMap Table Of Contents tab to the **Source Tab**. Right-click on the *LUManning* table to access the table. The table will have

a summary of the land use descriptions and have an empty *N_Value* data field. Enter *n* value data into the table that corresponds to the land use description.

Manning's *n* Value Attributes

After completing the *n* value data entry in the Land Use layer or the *LUManning* table, you can attribute each cut line with the Manning's *n* value information. Select the **RAS Geometery | Manning's n Values | Extract N Values** menu item. The dialog shown in Figure 4-20 is invoked and allows you to specify the input/output data. You have the choice of using the Manning's *n* value field (*N_Value*) from the Land Use layer by choosing the "Manning Values in Land use Layer" option or the values in the *LUManning* table by choosing the "Table of Manning Values" option.
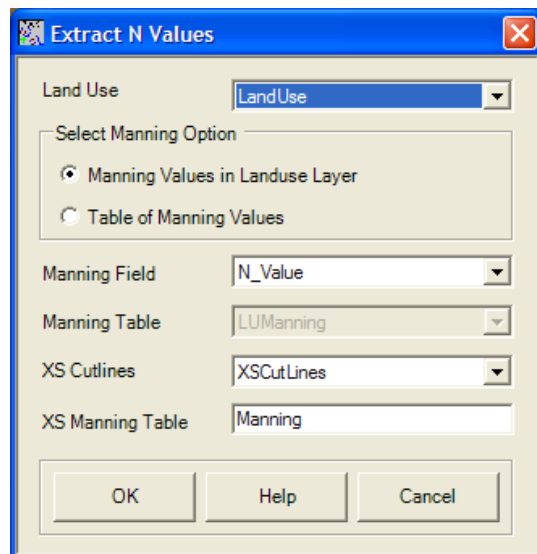
Figure 4-20. Manning's n value extraction dialog.

Specify the name of the output table ("Manning" is default) and press **OK**. Manning's *n* values will be extracted for each cross-sectional cut line, as shown in Figure 4-21, and reported to the *Manning* output table. The output table will be populated with the HydroId for the cut line and the Manning's *n* value with the corresponding location on the cut line. The location of the beginning of each land use area polygon is reported as a fraction along the cut line. A summary of the fields in the *Manning* table is provided in Table 4-12.
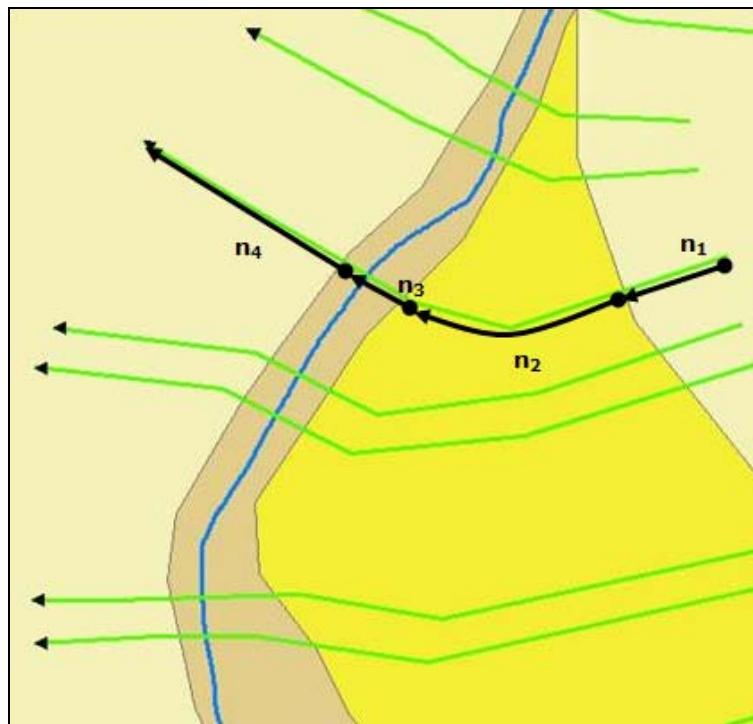
Figure 4-21. Calculation of Manning's n value positions.

Table 4-12. Summary of Manning table fields for extraction of n value data.

Field	Description
XS2DID	Long – Integer corresponding to the cross-sectional cut line's HydroID
Fraction	Float – Fraction of the distance along the cut line to the beginning of the land use type
N_Value	Float – Manning's *n* value

Levee Alignment Layer

The Levee Alignment layer is used to define a linear feature that contains the lateral flow of water in the floodplain. The levee layer is intended to be used to represent leveed systems, but should also be used to indicate high ground that contains water such as roads or ridges that connect multiple cross sections.

Note that at Version 4.0, HEC-RAS only supports one levee per bank per cross section – one levee in the left overbank, one in the right overbank.

The levee alignment tools are intended to work with both existing and proposed levee features. Existing levee features are those that have

been incorporated in the terrain model, while proposed features are those that do not have profile information in the terrain model.

Rules!

- A single levee line may intersect a cross section exactly once.

- One levee per bank (HEC-RAS limitation).

- Optional – creating this layer is not required.

Creating the Levee Alignment Layer

Select the **RAS Geometry | Create RAS Layer | Levee Alignment** menu item. A dialog will allow you to enter a name for the new feature class – "Levees" is the default.

A new feature class will be created and added to the active Map. The only field of interest added to the feature class is the HydroID field which will populated by the ApFramework when each feature is created.

You must be in edit mode to create the levee lines. Select the (**Sketch**) tool and use the mouse to digitize a levee line. Use the left mouse button to create the first point and continue creating the line, using the left mouse click to add vertices. Each levee line should only intersect a cross-sectional cut line once.

Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the cut line features, stop editing the feature class.

Entering Levee Elevation Data

If the levee profile information has not been incorporated in the DTM, you can enter profile data using the (**Levee Elevation**) tool. When the Levee Elevation tool is activated, the dialog shown in Figure 4-22 will be invoked allowing you to choose the Levee Alignment layer, the DTM layer, and the name of a table to add station-elevation points ("LeveePoints" is default).
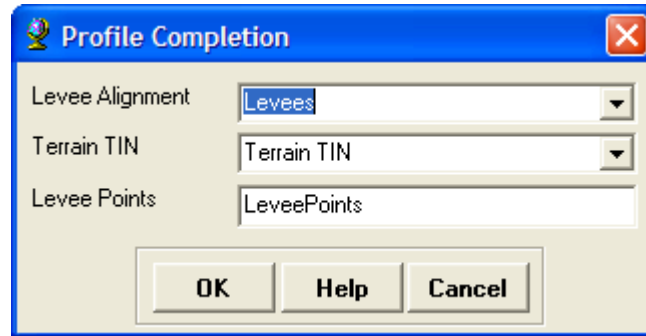
Figure 4-22. LeveePoints table input dialog.

The *LeveePoints* table will be created and added to ArcMap. Data will be atttributed to the fields shown in Table 4-13 as you enter data using the Levee Elevation tool.

Table 4-13. Summary of LeveePoints table fields.

Field	Description
LeveeID	Long – Integer corresponding to the levee line's HydroID in the Levee Alignment layer.
Station	Float – Distance along the levee line to Elevation.
Elevation	Float – User defined elevation at the corresponding Station.

Using the mouse pointer, click on a levee line. The pointer will be snapped to the levee line and graphic will be drawn to the screen. A dialog (shown in Figure 4-23) will then report to you the elevation of the DTM at that point and await entry for the new elevation. The specified location, elevation, and levee ID will be entered into the *LeveePoints* table.

Figure 4-23. Levee elevations data entry dialog.

Completing the Levee Alignment Layer

Prior to assigning the levee position and elevation attributes to the Cross-Sectional Cut Line layer, the Levee Alignment layer must be converted to a 3D feature class. This is performed by selecting the

RAS Geometry | Levees | Profile Completion menu item. The dialog shown in Figure 4-24 will allow you to choose the Levee Alignmen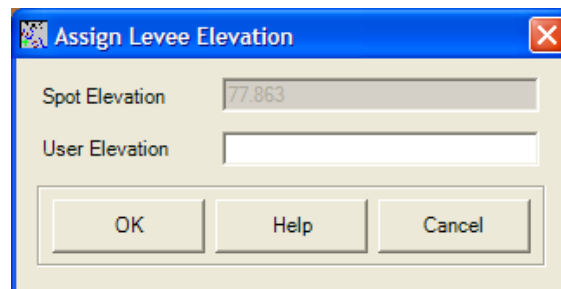t layer and name of the Levee Profiles (3D) layer. You are also provided the option to use the *LeveePoints* table or to use the terrain model for the elevations along the levee line.
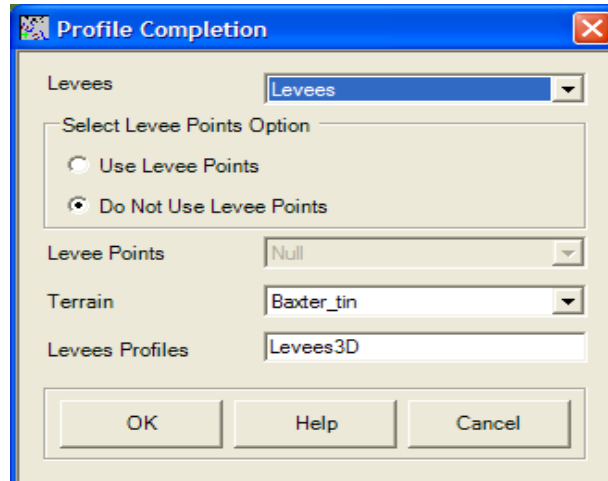
Figure 4-24. The Levee Alignment is converted to a 3D feature class prior to attributing the cut lines.

Levee Attributes

The intersection of the Levee Profiles layer and Cross-Sectional Cut Lines layer will extract the levee position and elevation at each cut line. Levee positions are extracted by selecting the **RAS Geometry | Levees | Positions** menu item. The dialog shown in Figure 4-25 will allow you to select the Levee Profiles layer, XS Cut Lines layer, DTM, and enter the name for the levee position/elevation data ("LeveePositions" is default). The LeveePositions table will be created with several fields (summarize in Table 4-14) and data will be populated based on the intersection of each levee line and each cut line.

Figure 4-25. Levee position/elevation data extraction dialog.

Table 4-14. Summary of LeveePositions table fields.

Field	Description
Lev2DID	Long – Integer corresponding to the levee line's HydroID in the Levee Alignment layer.
XS2DID	Long – Integer corresponding to the cut line's HydroID in the Cross-Sectional Cut Line layer.
Fraction	Float – Position along the cut line as a fraction of the total cut line length.
GrndElev	Float – Elevation of the DTM at the levee position.
Elevation	Float – Top-of levee Elevation at the levee position.

Inline Structures Layer

The locations of inline weirs (and dams) are represented by the Inline Structures layer. Cut lines for inline structures are treated similar to bridges/culverts. Cut lines will be used to identify the river station for the inline structure and will extract station-elevation data for the top-of-weir profile from the DTM.

Rules!

- Cut lines must be pointed from the left overbank to the right overbank, when looking downstream.

- Cut lines must cross the Stream Centerline exactly once.

- Cut lines may not extend beyond the extents of the DTM.

- Optional – creating this layer is not required.

Creating the Inline Structures Layer

Select the **RAS Geometry | Create RAS Layer | Inline Structures** menu item. A dialog will allow you to enter a name for the new feature class – "InlineStructures" is the default.

A new feature class with several empty fields in the attribute table (as summarized in Table 4-15) will be created. The empty feature class will be added to the active Map.

Table 4-15. Summary of Inline Structure fields.

Field	Description
HydroID	Long Integer – unique feature identifier.
River	String – Populated from the Stream Centerline layer.
Reach	String – Populated from the Stream Centerline layer.
Station	Float – River station assigned from Stream Centerline layer.
USDistance	Float – User specified distance from upstream face of weir to next cross section upstream.
TopWidth	Float – User specified width (in direction of flow) of the weir.
NodeName	String – Description of structure specified by user.

You must be in edit mode to create an inline structure cut line. Select the 🖉 (**Sketch**) tool and use the mouse to digitize a cut line. Use the left mouse button to create the first point and continue creating the cut line from the left overbank to the right overbank, using the left mouse click to add vertices.

Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the inline structure features, stop editing the feature class. Enter the top width of the weir and distance to the next cross section upstream. You need not complete this data in the GIS, but HEC-RAS will require this information to perform a simulation.

Attributing the Inline Structures Layer

HydroID data will be completed by the ApFramework. The remaining attributes are completed by running the GeoRAS menu items for the Inline Structures as summarized in Table 4-16.

Table 4-16. Inline Structure completion menu items.

Menu Item	Description
River/Reach Names	Populates the *River* and *Reach* fields based on the Stream Centerline layer.
Stationing	Calculates the river station for each cut line based on the intersection with the Stream Centerline Layer. Populates the *Station* field.
Elevations	Extracts elevation data from the DTM and creates a 3D feature class. The default name is "InlineStructures3D".
All	Performs all tasks listed above in order.

River/Reach Names

Each structure is attributed with a *River* and *Reach* name based on the names in the Stream Centerline layer. Cut lines must intersect the Stream Centerline layer exactly once.

Stationing

A river station is calculated for each cut line based on the distance from the most downstream point on the *River*. Calculations are based on the *FromSta* and *ToSta* values in the Stream Centerline layer. The calculated *Station* is used to order computation nodes when computing water surface profiles in HEC-RAS.

Elevations

Elevations are extracted from the DTM for each weir. The elevations are stored by converting the 2D inline structure feature class to a 3D feature class (default name "InlineStructures3D").

All

This menu option will run the River/Reach Names, Stationing, and Elevations menu items in sequence.

Lateral Structures Layer

The locations of lateral structures to represent weirs and gated structures are represented by the Lateral Structures layer. Cut lines for lateral structures are treated similar to inline structures. Cut lines will be used to identify the correct river station for the lateral structure and will extract station-elevation data for the weir profile from the DTM.

Lateral structures should be constructed parallel to the main river and located at the end of cross-sectional cut lines. Lateral structures are used in areas where flow is expected to leave the main river and spill over a weir into another river or storage area.

Rules!

- Cut lines must be pointed in the downstream direction.
- Cut lines may not extend beyond the extents of the DTM.
- Optional – creating this layer is not required.

Creating the Lateral Structures Layer

Select the **RAS Geometry | Create RAS Layer | Lateral Structures** menu item. A dialog will allow you to enter a name for the new feature class – "LasteralStructures" is the default.

A new feature class with several empty fields in the attribute table (as summarized in Table 4-17) will be created. The empty feature class will be added to the active Map.

Table 4-17. Summary of Lateral Structure fields.

Field	Description
HydroID	Long Integer – unique feature identifier.
River	String – Populated from the Stream Centerline layer.
Reach	String – Populated from the Stream Centerline layer.
Station	Float – River station assigned from Stream Centerline layer.
USDistance	Float – User specified distance from upstream end of weir to next cross section upstream.
TopWidth	Float – User specified width of the weir deck.
NodeName	String – Description of weir specified by user.

You must be in edit mode to create a lateral structure cut line. Select the ✏ (**Sketch**) tool and use the mouse to digitize a cut line. Use the left mouse button to create the first point and continue creating the cut line in the downstream direction, using the left mouse click to add vertices.

Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the lateral structure features, stop editing the feature class. Enter the Top Width of the weir and Distance to the next cross section upstream. You need not complete this data in the GIS, but HEC-RAS will require this information to perform a simulation.

Attributing the Lateral Structures Layer

HydroID data will be completed by the ApFramework. The remaining attributes are completed by running GeoRAS menu items for the Lateral Structures as summarized in Table 4-18.

Table 4-18. Lateral Structure completion menu items.

Menu Item	Description
River/Reach Names	Populates the *River* and *Reach* fields from the closest Stream Centerline feature.
Stationing	Calculates the river station for each lateral structure based on the upstream end of the weir and the closest Stream Centerline feature. Populates the *Station* field.
Elevations	Extracts elevation data from the DTM and creates a 3D feature class. The default name is "LateralStructures3D".
All	Performs all tasks listed above in order.

River/Reach Names

Each structure is attributed with a *River* and *Reach* name based on the names in the Stream Centerline layer. The lateral structure looks for the nearest river reach.

Stationing

A river station is calculated for each lateral structure based on the distance from the most downstream point on the *River*. Calculations are based on the *FromSta* and *ToSta* values in the Stream Centerline layer. The calculated *Station* is based on the shortest distance to the most upstream end of the lateral structure feature that is orthogonal to the stream centerline, as shown in Figure 4-26. Verify the computed river station! The station will be used to determine bounding cross section nodes when computing water surface profiles in HEC-RAS.
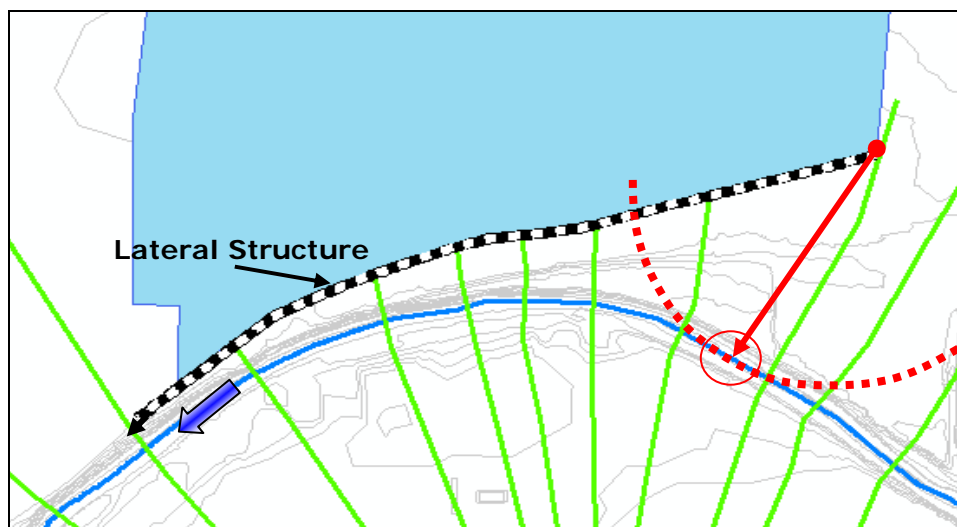

Figure 4-26. Calculation of river station for a lateral structure

Elevations

Elevations are extracted from the DTM for each weir. The elevations are stored by converting the 2D lateral structure feature class to a 3D feature class (default name "LateralStructures3D").

All

This menu option will run the River/Reach Names, Stationing, and Elevations menu items in sequence.

Storage Areas Layer

Storage areas are used to model floodplain detention storage where the simulated water surface will be horizontal. Storage areas are not reflected in the cross-sectional geometry.   Typically, a storage area is connected to a series of cross sections using a lateral structure.

Rules!

- Storage areas must be contained within the bounds of the DTM.

- Storage areas should not overlap one another or cross sections.

Creating the Storage Areas Layer

Select the **RAS Geometry | Create RAS Layer | Storage Areas** menu item. A dialog will allow you to enter a name for the new feature class – "StorageAreas" is the default.

A new feature class with empty fields in the attribute table (as summarized in Table 4-19) will be created. The empty feature class will be added to the active Map.

Table 4-19. Summary of Storage Area fields.

Field	Description
HydroID	Long Integer – unique feature identifier.
MaxElev	Float – Maximum elevation found from the DTM within the storage area boundary.
MinElev	Float – Minimum elevation found from the DTM within the storage area boundary.
UserElev	Float – User specified maximum elevation for computing elevation-volume relationship.

You must be in edit mode to create a storage area. Select the ✏️ (**Sketch**) tool and use the mouse to digitize each area. Digitize polygons around specific areas that will store flood waters. Left-click to add a vertex point, double-click to end a sketch.

Storage areas should be created at the ends of cross-sectional cut lines. This is important for proper floodplain mapping as the area with the storage area will be given one, continuous water surface elevation. Storage areas that will be connected by a storage area connection in HEC-RAS should share a common edge.

Attributing the Storage Areas Layer

HydroID data will be completed by the ApFramework. The remaining attributes are completed by running GeoRAS menu items for the Storage Areas as summarized in Table 4-20.

Table 4-20. Storage Area completion menu items.

Menu Item	Description
Elevation Range	Populates the *MaxElev* and *MinElev* from the DTM.
Elevation – Volume Data	Calculates elevation-volume curve for the storage area from the minimum elevation to the maximum elevation. If the *UserElev* is specified, it is used as the maximum elevation.
Terrain Point Extraction	Extracts point data from the DTM. This data is not used in HEC-RAS and is not required.
All	Performs all tasks listed above in order.

Elevation Range

The Elevation Range menu item will search the terrain model for the lowest and highest elevation within the storage area. The *MinElev* and *MaxElev* fields will be populated with this data. The range of elevations will be used as the bounds for computing the elevation-volume relationship for the storage area. While GeoRAS supports both GRID and TIN format terrain models, **the algorithm used for TINs is extremely fast** compared to that used for gridded data!

Elevation-Volume Data

Elevation-volume data will be extracted over the range of elevations. The elevation specified in the *UserElev* field will be used to override the maximum elevation computed by GeoRAS if the "Apply User Elevation" option on the elevation-volume extraction dialog, shown in Figure 4-27, is checked. While GeoRAS supports both GRID and TIN

format terrain models, **the algorithm used for TINs is extremely fast** compared to that used for gridded data!

The elevation-volume data is computed from the DTM and stored in a table specified by the user ("ElevVol" is default) (see Figure 4-27).
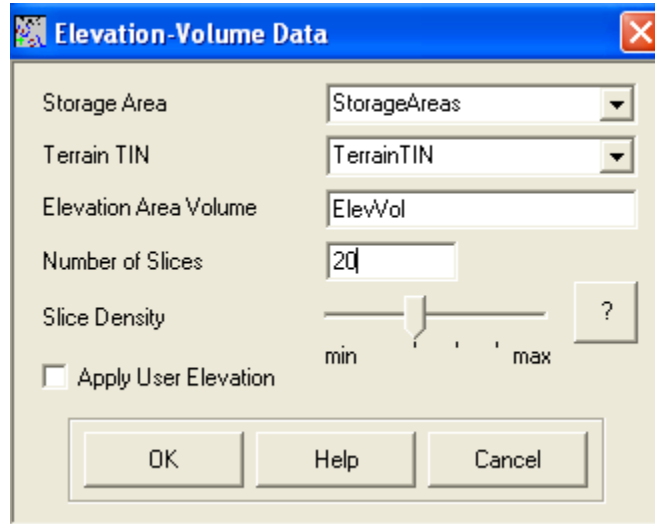

Figure 4-27. Specify the data input layers and output table for elevation-volume calculations.

Volume calculations are performed based on incremental elevations (20 slice increments are used by default) starting at the minimum elevation and going up to the maximum elevation. The "Slice Density" option allows you to choose the incrementing method. Choosing the minimum slice density extracts volume information on an even interval starting at the *MinElev* and going up to the *MaxElev*. The maximum slice density will extract more volume information at elevations near the *MinElev* (with 80% of the volume information extracted within the first 50% of the elevation range). Figure 4-28 illustrates the impact of the slice density on data extraction.
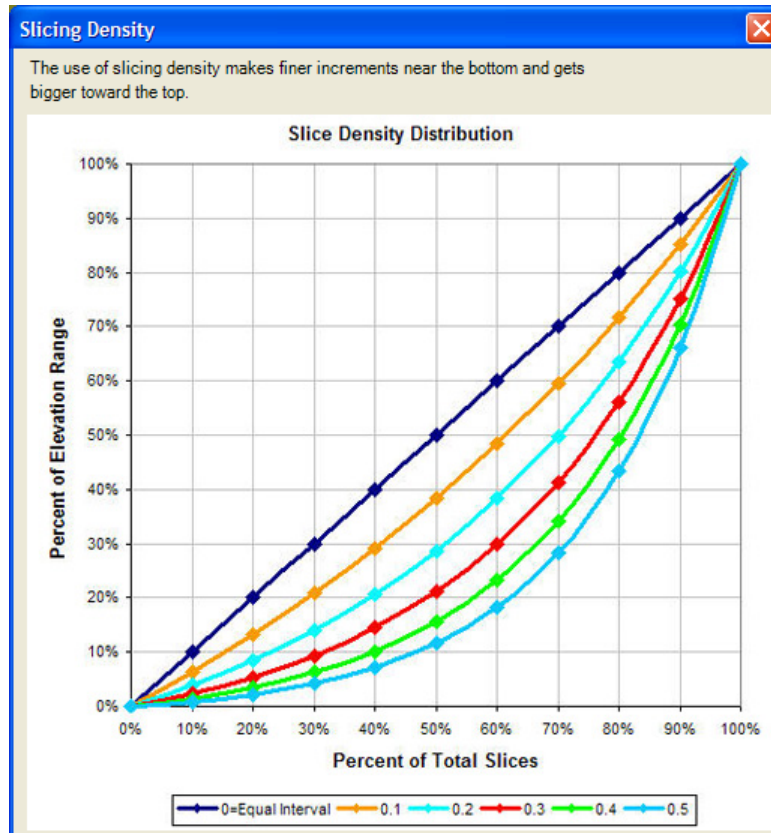
Figure 4-28. The Slice Density option for Storage Areas allows for more detailed volume information to be extracted near the minimum elevation.

The *ElevVol* table will be created to store the elevation-volume relationship for each storage area. The fields populated by the data calculations are summarized in Table 4-21.

Table 4-21. Summary of Storage Area fields.

Field	Description
SAID	Long – Integer corresponding to the storage area's HydroID in the Storage Area layer.
Elevation	Float – Elevation of a horizontal surface within the storage area.
Volume	Float – Volume between the elevation and the DTM (cubic units).
Area	Float – Area of horizontal surface at the elevation.

Terrain Point Extraction

The terrain points within the storage area will be extracted and saved to a point feature class. The dialog shown in Figure 4-29 allows you to

specify the Storage Area layer, DTM, and point feature class to be created. ***HEC-RAS does not currently utilize the point data; therefore, this step is not necessary – do not use it.***
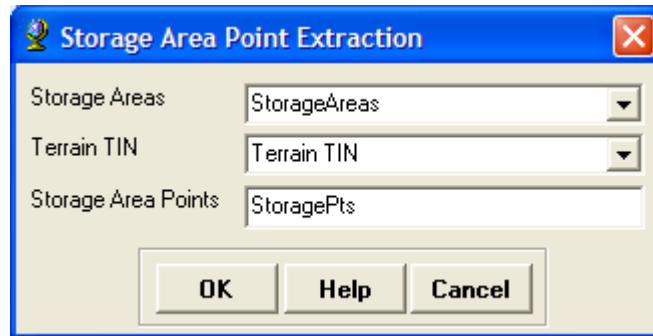

Figure 4-29. Specify an output feature class prior to extracting terrain point data.

All

This menu option will run the Elevation Range, Elevation-Volume Data, and Terrain Point Extraction menu items in sequence.

Storage Area Connections Layer

Storage area connections are used to pass flow between storage areas. The storage area connection may be modeled as a weir with hydraulic structures in HEC-RAS.

Rules!

- Storage area connections should be oriented from left to right when looking in the downstream direction.

- For each connection, there is exactly one upstream storage area and one downstream storage area.

Creating the Storage Area Connections Layer

Select the **RAS Geometry | Create RAS Layer | SA Connections** menu item. A dialog will allow you to enter a name for the new feature class – "SAConnections" is the default.

A new feature class with empty fields in the attribute table (as summarized in Table 4-22) will be created. The empty feature class will be added to the active Map.

Table 4-22. Summary of Storage Area Connections fields.

Field	Description
HydroID	Long Integer – unique feature identifier.
USSA	Integer – corresponds to SAID (Storage Area ID) of upstream storage area.
DSSA	Integer – corresponds to SAID (Storage Area ID) of downstream storage area.
TopWidth	Float – User specified width of the weir.
NodeName	String – Description of connection specified by user.

You must be in edit mode to create a storage area connection. Select the ✐ (**Sketch**) tool and use the mouse to digitize each area. Digitize the location of the high ground separating two storage areas. Use the left mouse button to create the first point and continue creating the cut line from the left to the right, using the left mouse click to add vertices.

Double-click the mouse button to finish drawing the sketch. When you have completed digitizing the connections, stop editing the feature class. Enter the top width of the weir.

Attributing the Storage Area Connections Layer

HydroID data will be completed automatically. The remaining attributes are completed by running GeoRAS menu items for the Storage Areas as summarized in Table 4-23.

Table 4-23. Storage Area completion menu items.

Menu Item	Description
Assign Nearest SA	Calculates the nearest two storage areas. Populates the *USSA* and *DSSA* fields.
Elevations	Extracts elevation data from the DTM and creates a 3D feature class. The default name is "SAConnections3D".
All	Performs all tasks listed above in order.

Assign Nearest SA

Identifies the nearest two storage areas to the connection and populates the *USSA* and *DSSA* fields with the SAID from the storage areas. You must verify the computed storage areas are correct!

Elevations

Elevations are extracted from the DTM for each connection. The elevations are stored by converting the 2D storage area connections feature class to a 3D feature class (default name "SAConnections3D").

All

This menu option will run the Assign Nearest SA and Elevations menu items in sequence.

Layer Setup

HEC-GeoRAS will keep track of the feature classes generated, data layers used for extracting attribute information, and the tables that hold extracted data. However, the Layer Setup will allow you to specify data you wish to write to the RAS GIS Import File by choosing which RAS Layers to use.

Select the **RAS Geometry | Layer Setup** menu item to access the Layer Setup window. Note that there are four tabs for specifying data: Required Surface, Required Layers, Optional Layers, and Optional Tables.

Required Terrain Surface

The Required Surface tab shown in Figure 4-30 allows you to specify which terrain model you wish to use for extracting elevation data. When you convert the Cross-Sectional Cut Lines (2D) feature class to a 3D feature class you will be provided a dialog to choose the terrain model. If you want to specify a different terrain model you can through the Layer Setup.
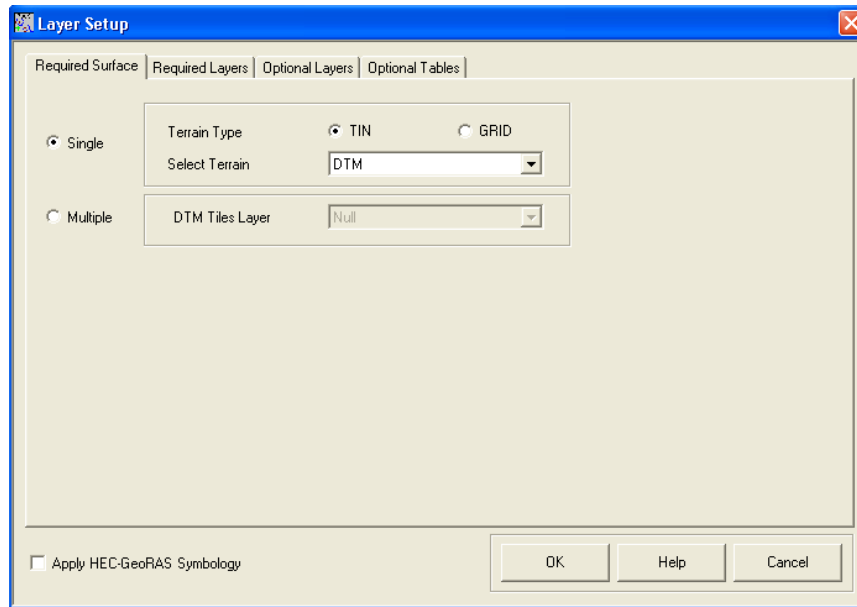
Figure 4-30. A terrain model is required for use with GeoRAS.

Required Layers

GeoRAS requires the Stream Centerline (2D) layer, the Cross-Sectional Cut Lines (2D) layer, and the Cross Sections (3D) layer. You can specify which layers will be used to generate the RAS GIS Import File in the Layer Setup window on the Required Layer tab shown in Figure 4-31.
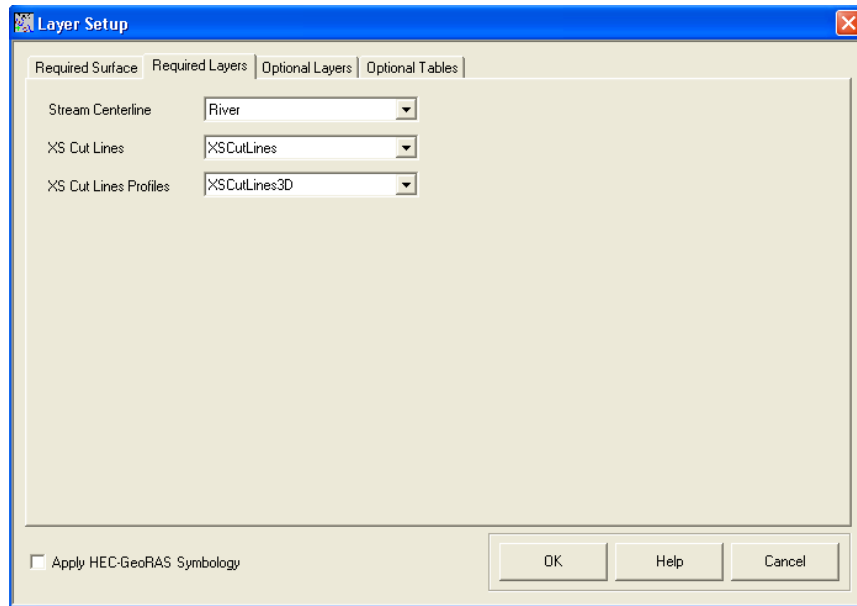

Figure 4-31. Required layers for creating the RAS GIS Import File.

Optional Layers

Optional Layers are used in GeoRAS to extract additional information. They are not required. Geospatial information and elevation data from selected 3D feature classes will be written to the RAS GIS Export File. Optional data layers are shown in Figure 4-32.
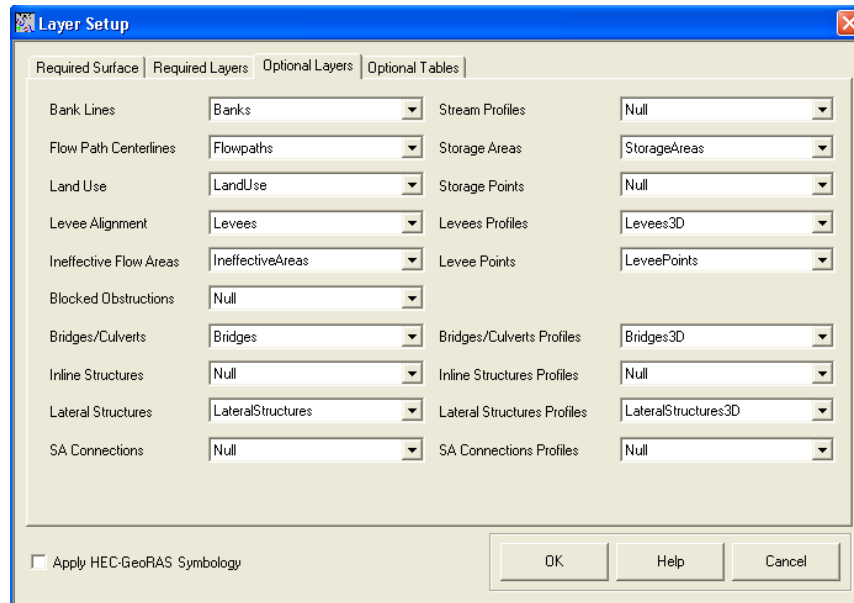

Figure 4-32. Optional data layers supported by GeoRAS.

Optional Tables

Data tables selected on the Optional Tables tab, shown in Figure 4-33, will be written to the RAS GIS Import File. Most data tables are linked to an associated 2D feature class which holds the geospatial shape information.
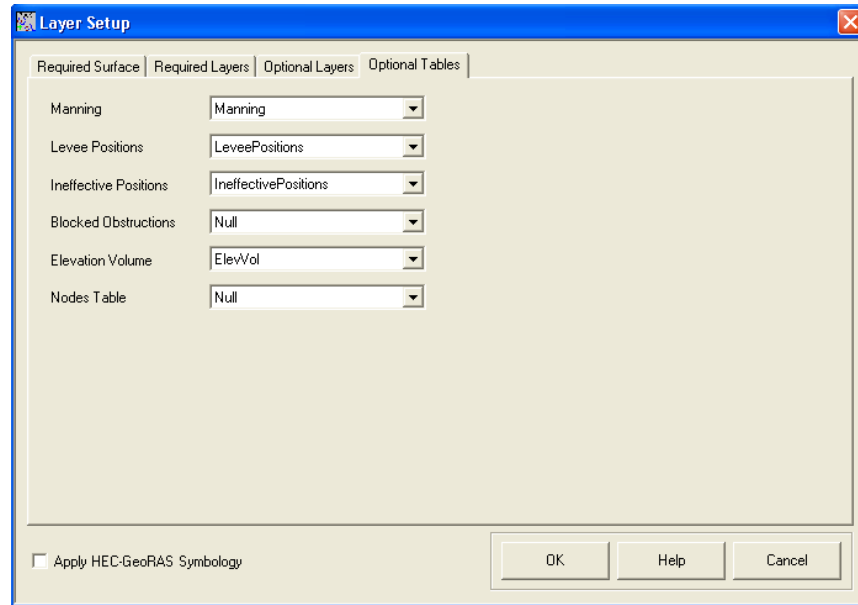
Figure 4-33. Optional data tables used in GeoRAS.

Generating the RAS GIS Import File

To generate the RAS GIS Import File, select the **RAS Geometry | Export GIS Data** menu item. The dialog shown in Figure 4-34 will be displayed and allow you to pick a file location and file name.
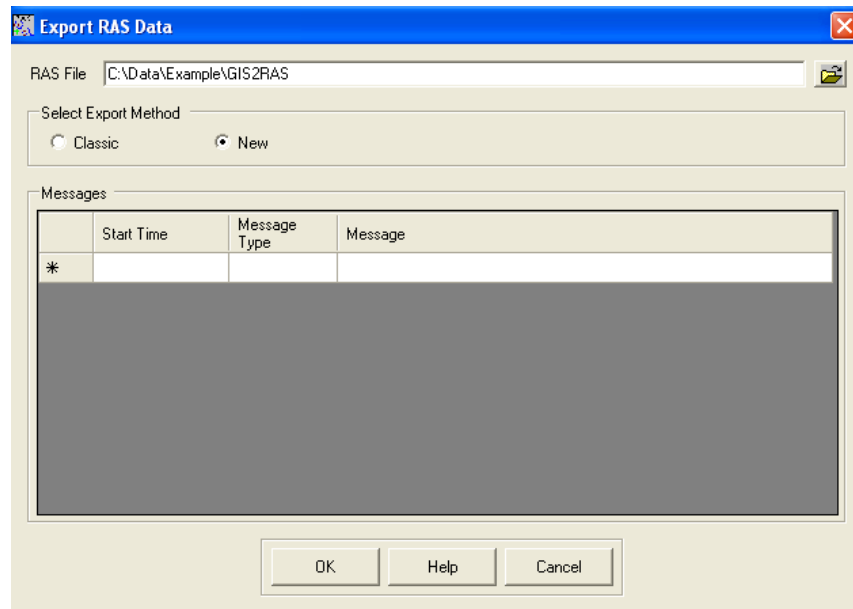

Figure 4-34. Export GIS data dialog.

Additionally, there are export options: "Classic" and "New". The "Classic" option is the same option that has been available in previous

versions of HEC-GeoRAS. The "New" option is more efficient at handling large geodatabases and provides feedback to the user during export. Once export is complete, the "Cancel" button with change to a "Close" button.

An ASCII file with the *RASExport.sdf* file extension will be created in the designated location. An intermediate XML file will also be extracted. At this time, HEC-RAS will only import the SDF file. Both the SDF and XML formats are fluid and may change as new features are added to the GeoRAS software.

The RAS GIS Import File has multiple sections. The first section is the *Header* section. HEC-RAS only uses the "UNITS" parameter of the header when importing data, to assist you in conversions when importing the data. The *Stream Network* section of the import file will define the river network by River and Reach name and the geospatial portion (x, y points) will be used to create the river schematic. The other required section in the import file is the *Cross Sections* section. The cross-sectional data is exported based on the Cross-Sectional Profiles (3D) feature class. River and reach names, river station, cut line information, and station-elevation data will be specified. Other properties such as main channel bank stations, downstream reach lengths, ineffective flow areas, blocked obstructions, Manning's n values, levee positions and elevations may also be written to the import file.

Other structure data may be written out for Bridges/Culverts, Inline Structures, Lateral Structures, Storage Areas, and Storage Area Connections.

For a more detailed discussion of the spatial data format for GIS data exchange with HEC-RAS, please refer to Appendix B.

C H A P T E R   5

GIS Data Exchange with HEC-RAS

HEC-RAS has the capability to import geospatial data that follows the spatial data format discussed in Appendix B. Importing data generated from GIS layers, however, will not create a complete river hydraulics model. After completing the river hydraulics model, HEC-RAS results can be exported for processing by GeoRAS.

This chapter will discuss the methods available for importing GIS data, how to complete the hydraulic model for simulation, and export results to the GIS for inundation mapping.

Contents

- Importing GIS Data to HEC-RAS
- Completing the Geometric Data
- Completing the Flow Data and Boundary Conditions
- Exporting HEC-RAS Results

Importing GIS Data to HEC-RAS

To import GIS data, select the **File | Import Geometry Data | GIS Format** menu item from the Geometric Data editor in HEC-RAS, as shown in Figure 5-1.
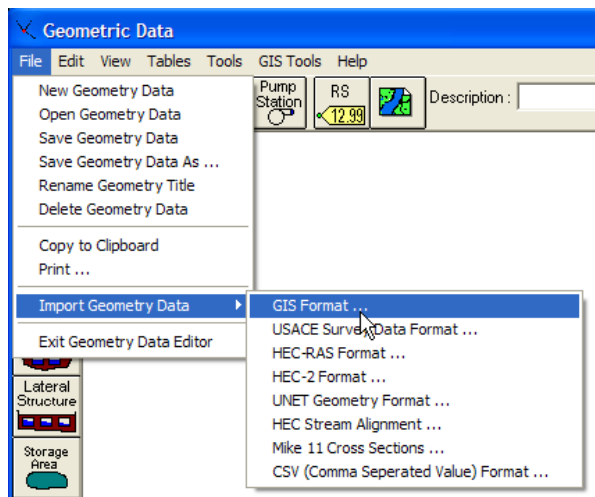
Figure 5-1. The GIS data import option on the HEC-RAS Geometric Data editor.

Intro

The Import Options window will guide you through the process of importing all or part of the GIS import file. The initial tab of the Import Options dialog is the Intro tab, shown in Figure 5-2. HEC-RAS will read the import file and look for a "UNITS" tag. Based on the value associated with the tag, you will be offered the option to import the data in the current unit system or to convert the data from one unit system to another. If no unit system is found in the GIS file the import dialog will default to your current RAS project units.
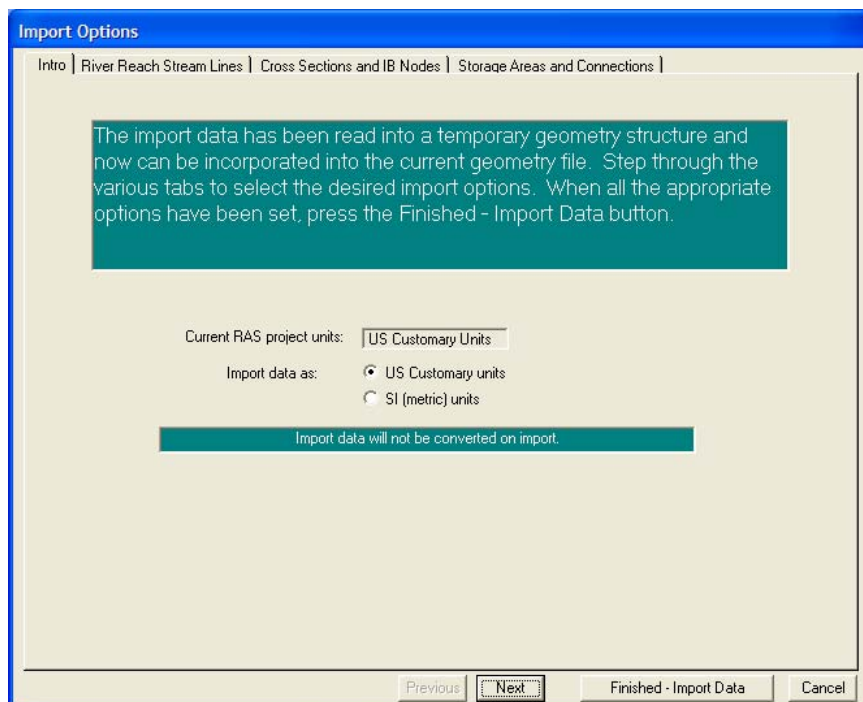

Figure 5-2. Unit system conversion is an import option in HEC-RAS.

River Reach Stream Lines

The next tab on the import options is the River Reach Stream Lines
(see Figure 5-3). This set of options allows you to specify which river
reaches to import, how to import the data, and what to name the river
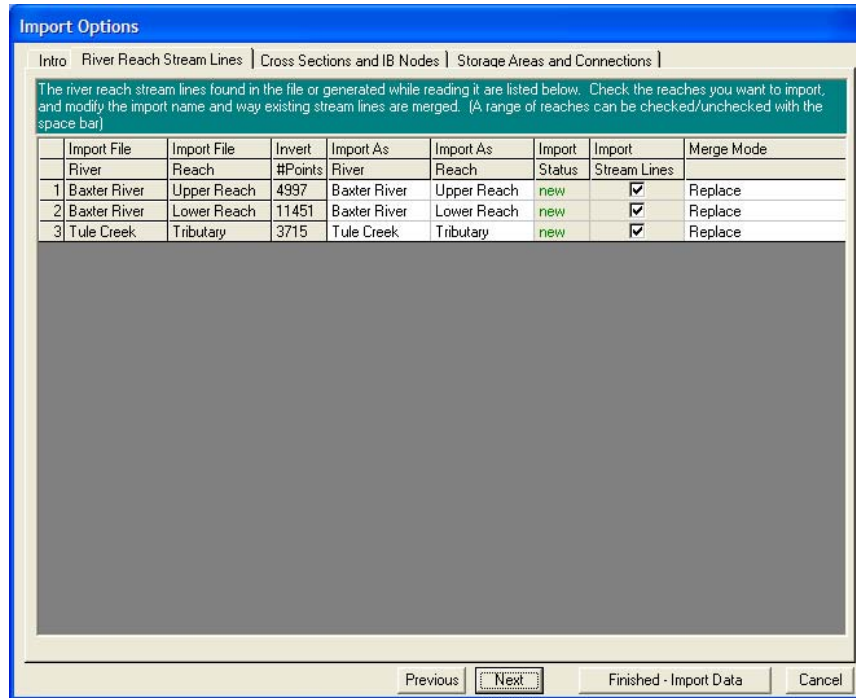and reach. Import options for the river and reaches are summarized
in Table 5-1.

Figure 5-3. River and reach import options.

Table 5-1. Summary of River Reach Import option fields.

Column	Description
Import As River	The name of the River once it is imported to HEC-RAS.
Import As Reach	The name of the Reach once it is imported to HEC-RAS.
Import Status	Identifies whether the river reach exists in the HEC-RAS geometry file or is new.
Import Stream Lines	Checkbox to choose what river reaches to import. Use the spacebar to toggle the checkbox. All rows can be selected by clicking on the column header.
Merge Mode	The river reach can replace existing data, append upstream, or append downstream.

Cross Section and IB Nodes

The next tab on the Import Options window allows you to import cross sections and internal boundaries (bridges/culverts, lateral structures, and inline structures). The Cross Sections and IB Nodes screen options are shown in Figure 5-4.

Figure 5-4. Cross section and internal boundary import options.

There are several options for importing cross-sectional data. You must first specify the "Import River" and "Import Reach" upon which the cross sections reside. The import dialog will inform you what river and reach name the data will import to (Import As) in the HEC-RAS geometry. (The Import As information was specified on the River Reach Stream Lines tab). You can filter the data based on the node type (cross section, bridge/culvert, inline structure, lateral structure). You then specify the cross sections to import and the specific property to import.

Only those cross-sectional properties available in the import file will be marked as available for import. Properties selected will be imported for each cross section specified during the import process. The properties import option will allow you to update individual pieces of data (such as bank station data) without modifying the other data already specified in HEC-RAS.

The cross sections that will be imported and how they will be imported are specified in the import table. Import table options are summarized in Table 5-2.

Table 5-2. Summary of Cross Section and IB Nodes Import option fields.

Column	Description
Import File River	The name of the River in the import file. Refer to the associated *Import As* field to see the name of the river that the cross section will be imported into.
Import File Reach	The name of the Reach in the import File. Refer to the associated *Import As* field to see the name of the reach that the cross section will be imported into.
Import File RS	The name of the River Station in the import file.
Import As RS	The name of the River Station the cross section will be imported into. This data may be user-specified and changed using the provided tools. The "Reset" button will replace the river station data with the data in the import file.
Import Status	The Import Status will be "New" or "Exists". New will add the cross section to the data. Exists will update (replace) the existing data with the properties specified.
Import Data	Checkbox to choose what river stations to import. Use the spacebar to toggle the checkbox. All rows can be selected by clicking on the column header. You can also use the buttons provided to select all of the New cross sections (Check New) or those that Exist (Check Existing).

There are also several tools provided to change the river station name. River station identifiers are the link between the GeoRAS generated data and the HEC-RAS data. Cross-sectional river stations must be numbers in HEC-RAS. HEC-RAS will use the river stations (along with River names) for determining the order of cross sections for performing water surface profile calculations. River station numbers must increase in the upstream direction. Import options for river stations allow you to match river stations to the existing geometry, round the river station value for import, and create river stationing.

Match River Stations to Existing Geometry

The *Match Import File RS to Existing Geometry RS* option allows you to specify a numeric tolerance to search for duplicate cross sections in existing geometry files. This tool is useful when you are re-importing cross section data where you may have modified the stream centerline or cross section layout. The newly computed river stations may differ from the original stationing due to small spatial changes made in the

GIS. This tool is also convenient if you are updating cross sections that have river stations that were rounded during the initial import of the data.

Round River Stations

GeoRAS may export the river stationing to more decimal places than are necessary. You can round the river stations to the precision appropriate for your study.

Create River Stations

By default, GeoRAS will compute river stations in the unit system of the digital terrain model and will use a zero station at the most downstream end of each river reach. If you wish to change the river stationing you can do so in the GIS, or you can do so during the import process. It is recommended that you document the method used if you change the river stations. Documenting the method used to compute new river stations will be important if you need to re-import cross-sectional data – the river station identifier is the link between the GeoRAS generated data and the HEC-RAS data.

Storage Areas and Connections

The Storage Areas and Connections tab, shown in Figure 5-5, allows you to specify storage areas and storage area connections to import and what name to import them with. You can choose to import the storage area outline and/or the elevation-volume relationship.
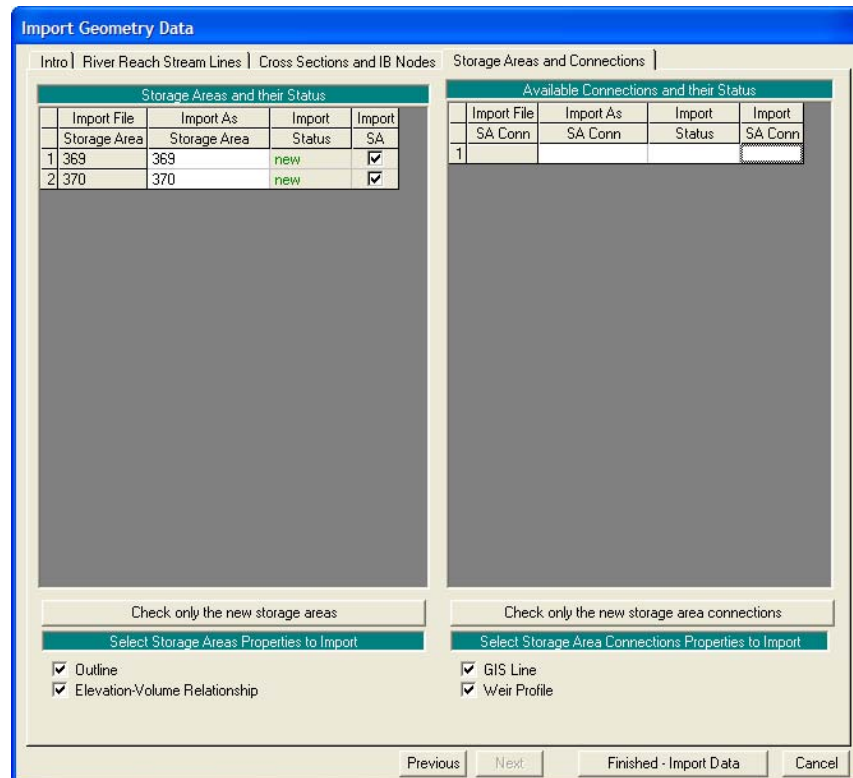
Figure 5-5. Storage Areas and Connections import options.

Completing the Geometric Data

After importing any data into HEC-RAS, you must always verify that the data imported is representative of the data you intended to import. Next, you must verify that that the data does not have any significant errors or gaps. Data that is incomplete must be corrected to properly represent the physical system.

The cross section plots, tables, and tools in HEC-RAS will assist you in scrutinizing, entering, and modifying data. The Cross Section Plot and Graphical Cross Section Editor are two good ways to visualize the imported cross section data.

Graphical Cross Section Editor

The Graphical Cross Sectional Editor is advantageous because not only can you visualize the cross section, you can add, delete, and modify cross section properties. The editoris accessed from the HEC-RAS Geometric Data editor by selecting the **Tools | Graphical Cross Sectional Edit** menu, as shown in Figure 5-6.
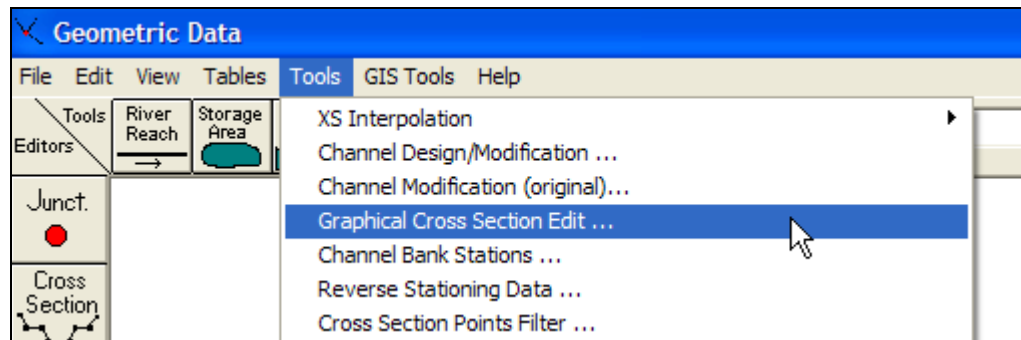
Figure 5-6. Accessing the Graphical Cross Section Editor.

The Graphical Cross Section Editor, shown in Figure 5-7, allows you to visualize the shape of the cross section and all of the properties on the cross section. You can also move, add, or delete objects in the cross section from the editor. To change modes, right click in the editor and select from the context menu the mode you wish to work in. The Move Object mode is the default when entering the editor.

There are also tools for moving bank stations and Manning *n* values in the editor.
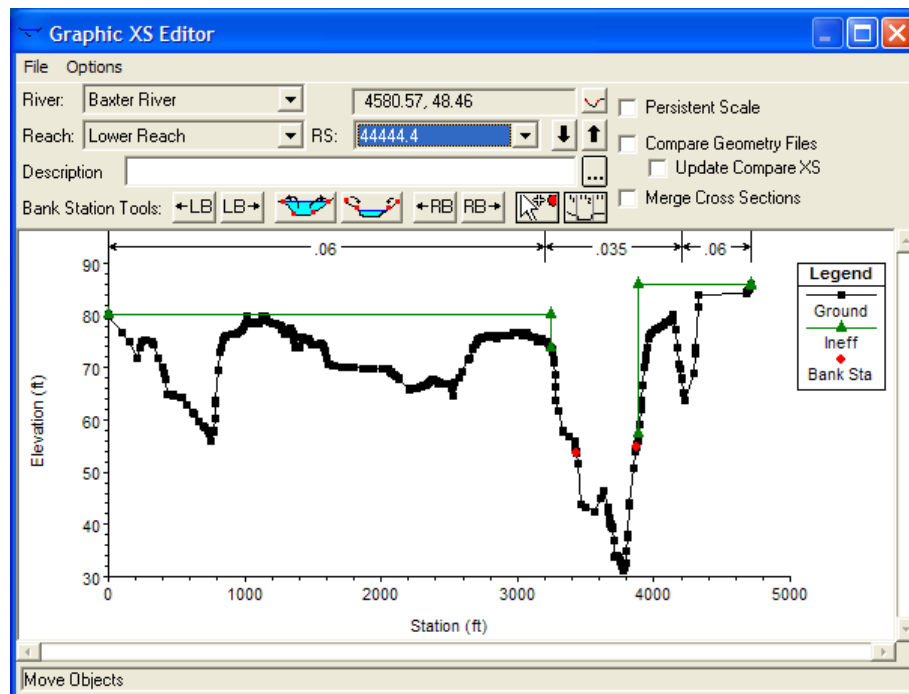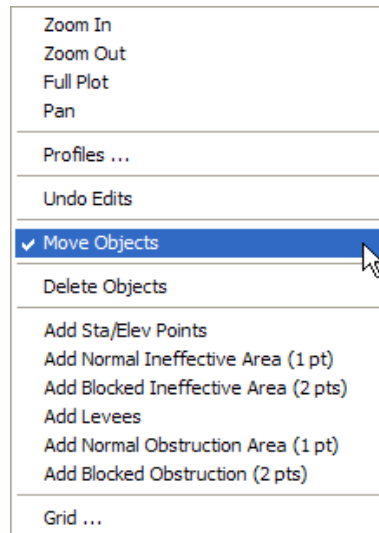
Figure 5-7. HEC-RAS Graphical Cross Section Editor.

Manning's n Values

Several tables are also convenient for verifying and entering data. Manning's *n* value data may be entered using the **Tables | Manning n or k values** menu item.
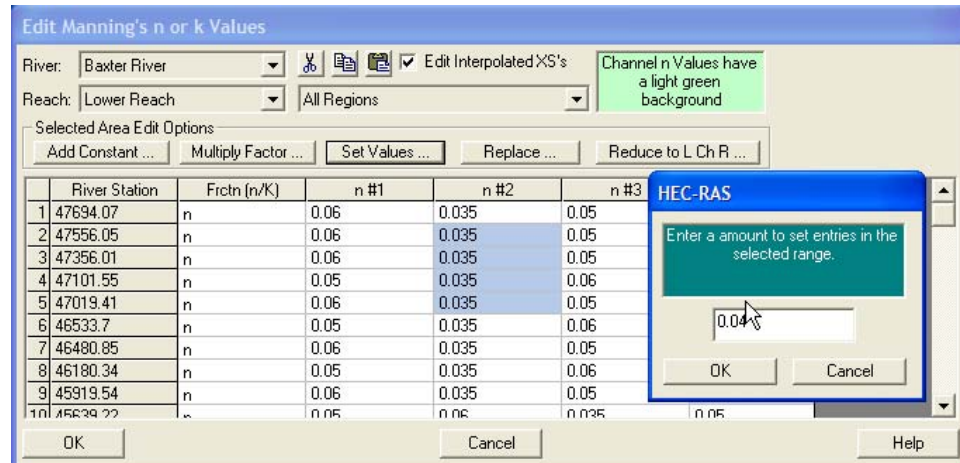
Figure 5-8. Entry of Manning's n values through tables in HEC-RAS.

Bridges and Hydraulic Structures

Hydraulic structure data may be imported from the GIS. Bridge data will be the most incomplete. Likely the bridge deck top-of-road information will have been imported, but the bridge opening information, piers, and modeling approach information will need to be completed. As illustrated in Figure 5-9, often, only the bridge abutment information is included in the digital terrain model and must be completed. Bridge data is completed in the Bridge and Culvert Data editor accessed from the Geometric Schematic.
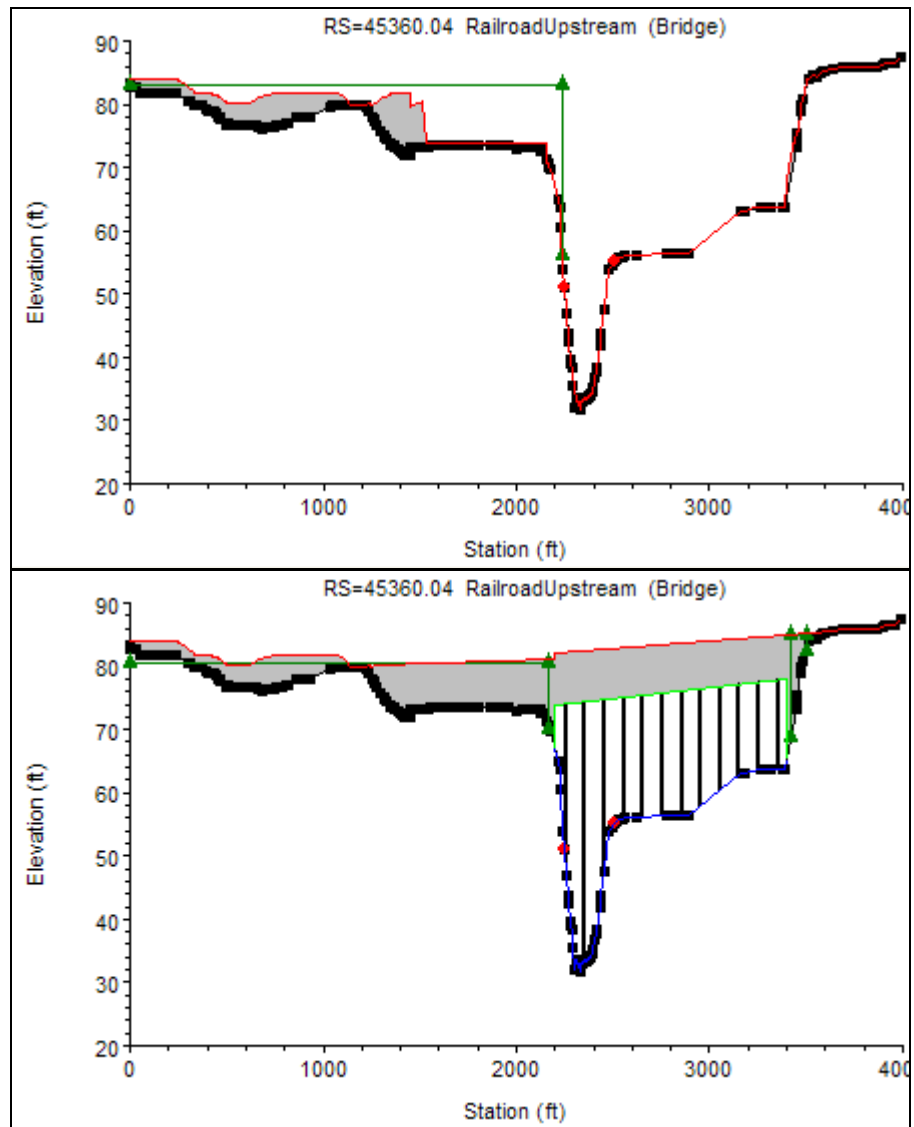
Figure 5-9. Completion of bridge data imported from GeoRAS.

Lateral structures should be examined to verify that the structure begins and ends in the correct location in the HEC-RAS model. If the river station for the lateral structure was not verified prior to GeoRAS export, it must be verified in HEC-RAS. Inline structure and lateral structure data will need to be completed, much like the bridge data. Top–of-weir profile data, gate geometry and settings, and computation methods will need to be modified and entered.

Cross Section Points Filter

Cross sections in HEC-RAS can only have 500 station-elevation points. If you try to run the simulation with more than 500 points the HEC-RAS interface will stop and inform you of the cross sections that have too many points.

To filter cross section points, select the **Tools | Cross Section Points Filter** menu item from the Geometric Data Editor. You can filter cross sections at a single cross section or at multiple locations. You also have the choice of filtering based on the slope between each point or based on minimizing the change in area in the cross section.
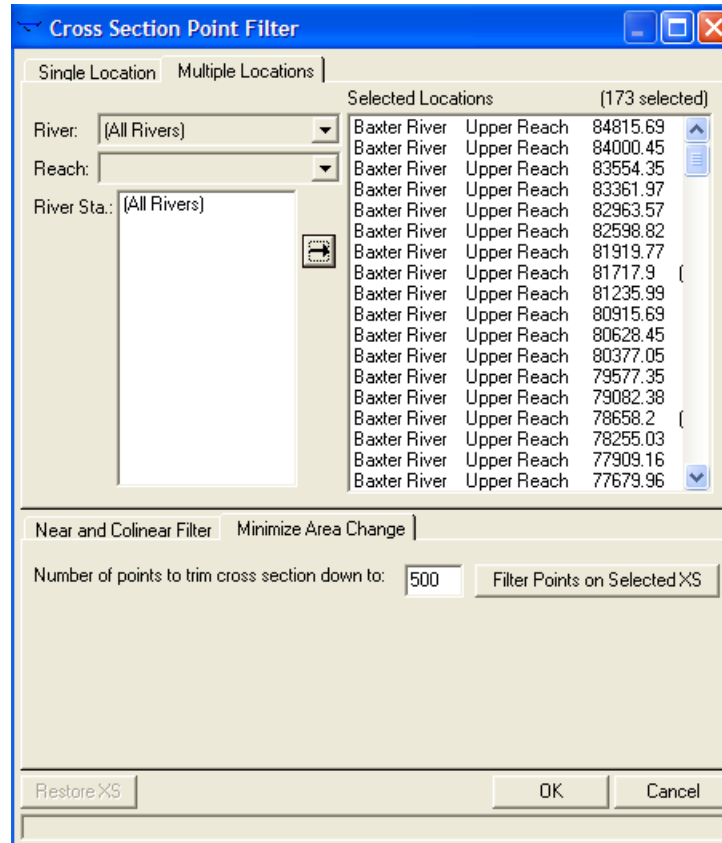
Figure 5-10. Cross section points filter dialog.

Completing the Flow Data and Boundary Conditions

Flow data will not be imported from the RAS GIS Import File. You will have to create a Steady Flow or Unsteady Flow file and enter flow change locations and boundary condition data. It is also important in steady-flow simulations to label the flow profiles with a meaningful name.

Examining Results

After performing a steady or unsteady flow simulation, you must verify the hydraulic results using the standard plots and tables available in

HEC-RAS. You must also verify that the computed water surface profile(s) will result in an appropriate floodplain. For instance, cross sections should be closely spaced together around bends in the river and extend across the entire floodplain. Cross sections should also be wide enough to allow for nonlinear floodplain delineation between cross section.

Prior to exporting the water surface profile results, you should also verify the bounding polygon. The bounding polygon (discussed in detail in Chapter 6) limits the area that will be used for floodplain delineation. This is especially important when the river system has levees that may be overtopped by one of the water surface profiles. If a levee upstream is overtopped, you will need to verify that the levees downstream are turned off, as well.

Bounding polygon information for each profile can be verified in the Geometric Data editor. Select the **GIS Tools | Plot GIS Reach Profile Bounds** menu item. You must then select the Profile and River Reach for which to plot data.
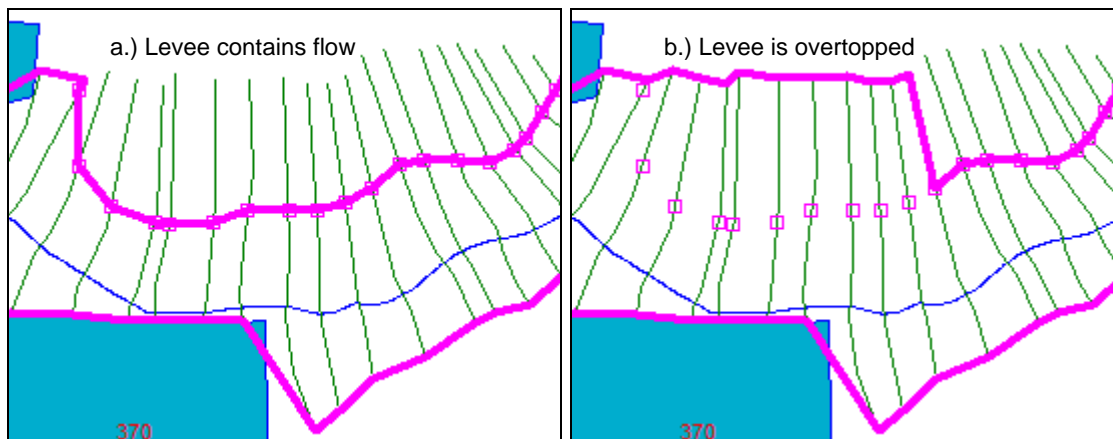
Figure 5-11. GIS bounding polygon information (thick line) for a leveed system (a) contains flow and (b) is overtopped.

Exporting the HEC-RAS Results

After steady or unsteady flow simulation, HEC-RAS results can be exported for processing in the GIS by GeoRAS. Select the **File | Export GIS Data** menu option from the main HEC-RAS interface as shown in Figure 5-12.
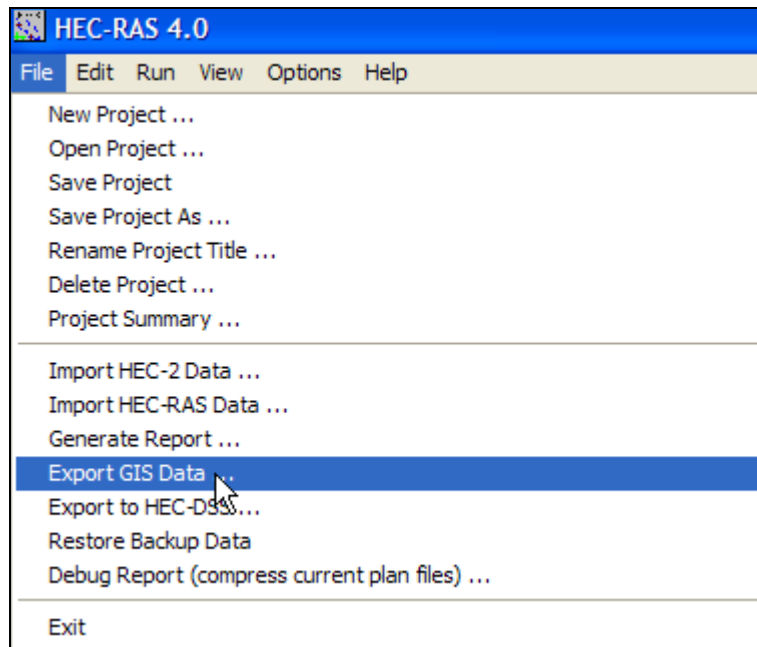
Figure 5-12. Access the GIS export options from the main HEC-RAS interface.

The dialog shown in Figure 5-13 will allow you to choose the file location to write the GIS information to and select the output options. Be sure to select the water surface profiles of interest. The GIS data will be written to the RAS GIS Export file (*.RASExport.sdf*).
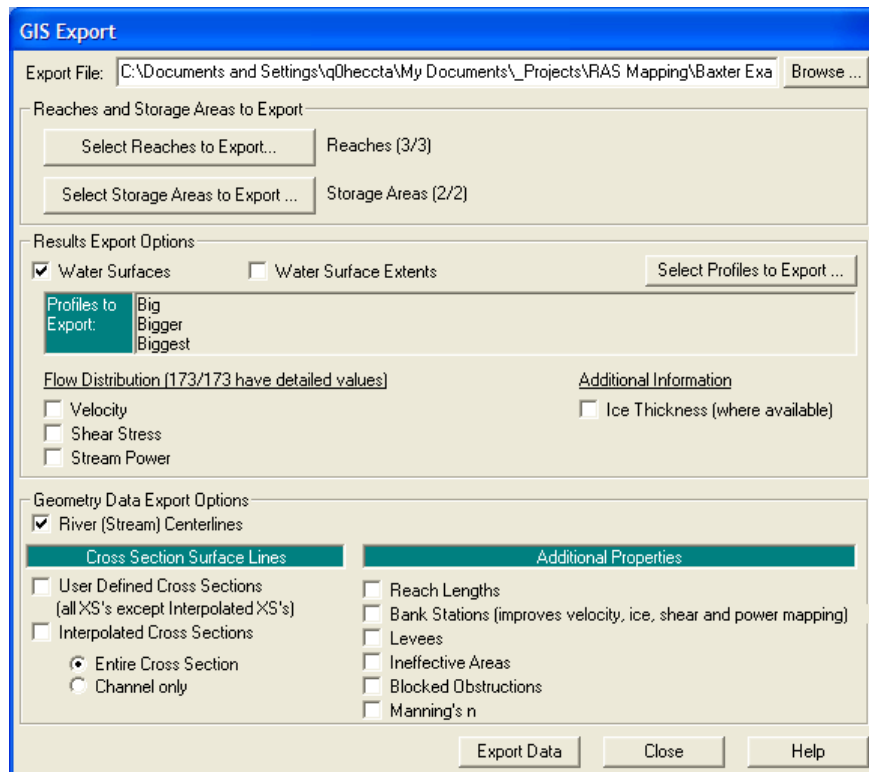
Figure 5-13. GIS export options in HEC-RAS.

There are many GIS Export options available from HEC-RAS. With HEC-RAS 4.0 or later, the option to select the River Reach of interest and/or Storage Areas is provided. The user may also choose to export the velocity, shear stress, stream power, or ice data for interpolation and mapping using HEC-GeoRAS.

If you choose to export velocity, shear stress, or stream power data, the Bank Stations will also be export along with the Active Water Surface Extents. This is necessary for improved interpolation.

You should take care to only export the water surface profiles and parameters of interest. The export file can grow very rapidly and importing to the GIS can become burdened with excessive data.

Geometric data options are also available for export. The user may select to export the "Cross Section Surface Line" for the entire cross section or the channel only. Upon import into GeoRAS, a 3D feature class of the cross sections will be created. This is helpful for doing surface analysis. Additional properties may be export for visualization in a GIS; however, HEC-GeoRAS will import only the bank stations property.

C H A P T E R   6

RAS Mapping

HEC-GeoRAS facilitates the generation of floodplain maps from exported HEC-RAS simulation results. Floodplain boundary and inundation depth data sets may be created from exported cross-sectional water surface elevations. Mapping of the water surface extents as point locations, velocities, and ice information are also available.

Chapter 6 discusses processing exported HEC-RAS results using HEC-GeoRAS.

Contents

- Importing the RAS GIS Export File
- Inundation Mapping
- Velocity Mapping
- Ice Mapping
- Data Storage

Importing the RAS GIS Export File

HEC-GeoRAS does not read the *.RASExport.sdf* file directly. It must first be converted to XML format. After converting the data from the SDF to XML format the data is read into the GIS and HEC-RAS results are processed.

SDF Conversion to XML

The spatial data format (SDF) file written by HEC-RAS is not read directly into HEC-GeoRAS. To convert an SDF file to the XML format, select the [icon] (**Convert RAS SDF to XML File**) button on the GeoRAS interface. This will invoke the dialog, shown in Figure 6-1, allowing you to choose the RAS Output File and will automatically create a default XML File name in the same directory (.xml file extension). The file will be created when you press **OK**.
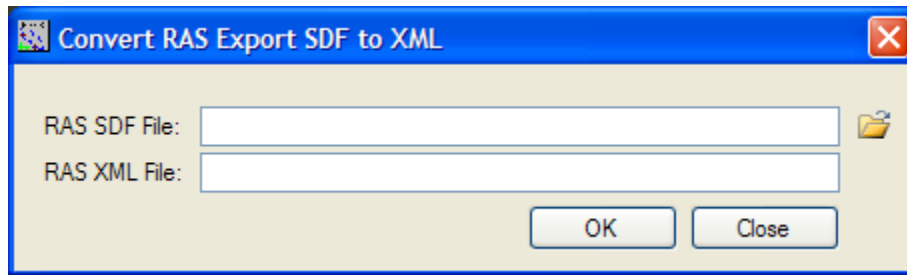
Figure 6-1. Dialog for converting RAS SDF file to XML file format.

Layer Setup

In order to process HEC-RAS results, you must first identify the analysis you are going to perform – a new analysis or continuing working with an existing analysis. This is performed through the Layer Setup dialog.

Select the **RAS Mapping | Layer Setup** menu item from the HEC-GeoRAS toolbar. The dialog shown in Figure 6-2 will allow you to specify the output data and parameters. A summary of data inputs is provided in Table 6-1.
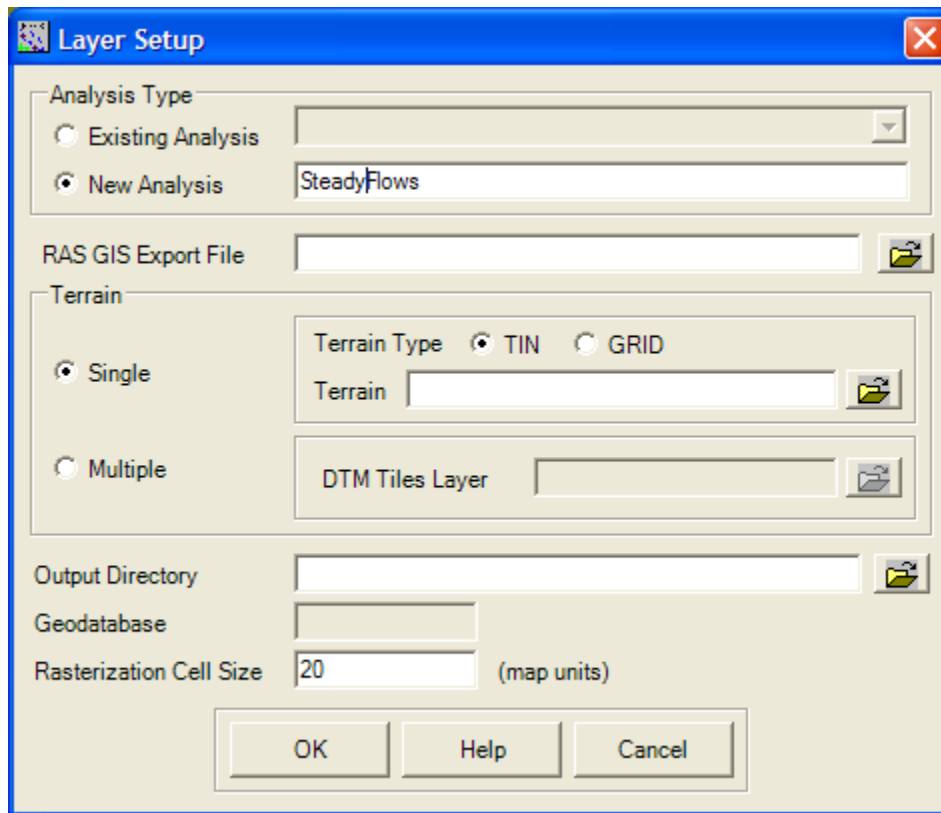
Figure 6-2. Floodplain mapping layer setup dialog.

Table 6-1. Floodplain mapping layer setup input options.

Data Input	Description
Analysis Type	*Existing Analysis* – changes the active Map to the analysis selected.
	New Analysis – creates a new Map and directory with the name entered.
RAS GIS Export File	Specify the XML file containing HEC-RAS results.
Terrain	*Single* – Select the TIN or GRID for floodplain analysis.
	Multiple - Select the polygon feature class representing the terrain tiles for floodplain analysis.
Output Directory	Specify the directory location. A new directory with the *Analysis* name will be created in the Output Directory for all results.
Output GeoDatabase	A geodatabase will be automatically created with the name of the *Analysis*.
Rasterization Cell Size	Specify the grid-cell size for inundation depth grids.

Analysis Type

The Analysis Type allows you to choose to work on an *Existing Analysis* or start a *New Analysis.* The Analysis Type allows you flexibility in performing the floodplain analysis and modifying results. If you choose Existing, the Map (data frame) of the same name will be activated. You can then continue processing results from previous GeoRAS analysis or reporcess portions from an analysis (such as floodplain delineation). A *New Analysis* will be chosen each time a new set of HEC-RAS results are brought read into the GIS.

Pressing the **OK** button from the Layer Setup dialog will activate the existing map or create a new map and new analysis directory based on the Analysis Type selected.

RAS GIS Export File

The RAS GIS Export File must be in the XML format. It is converted from the SDF file using the Import RAS SDF File button.

Terrain

You must specify the terrain model to be used for performing the floodplain delineation. GeoRAS allows for a DTM in the format of a TIN or a GRID. Further, the terrain data may be one single data set or multiple terrain tiles. Using multiple terrain tiles to represent very large data sets is discussed in Chapter 9.

Output Directory

The Output Directory specifies the parent directory where you will store the post-processing results. Another directory will be created within the output directory having the name entered for the *New Analysis.* Water surface TINs and depths grids will be stored in the directory having the analysis name.

Output GeoDatabase

The Output GeoDatabase is created in the directory having the analysis name. All feature classes created during post-processing will be stored in the geodatabase.

Rasterization Cell Size

The Rasterization Cell Size will determine the grid-cell size for the inundation depth grids. If the input DTM is of type GRID, the cell size of the GRID will be used. A smaller grid-cell size will result in longer processing time for floodplain delineation. The Rasterization Cell Size should be based on the resolution of the DTM. As a practical consideration, start with a larger cell size and evaluate the resulting floodplain delineation and processing time. Refine the cell size during future floodplain delineations to improve the resulting floodplain boundary.

Import RAS Data

After establishing the post-processing data input options, RAS results are read into the GIS for processing. Select the **RAS Mapping | Import RAS Data** menu option from the GeoRAS toolbar. The DTM selected will be brought into the Map and data will be read from the specified XML file. If the RAS GIS Export File is large (having numerous cross sections with velocity or other parameter data) it may take several minutes to read in the XML file.

The DTM will be loaded to the Map and a copy will be rasterized based on the *Rasterization Cell Size* and stored in the output directory for later use. The raster version of the DTM will be named "DTMGRID". Base feature classes will be created for the cross-sectional cut line and

bounding polygons. These feature classes will be used for post-processing.

Stream Centerline

A stream centerline feature class will be created in the Output GeoDatabase based on the centerline location in HEC-RAS. *River* and *Reach* attribute information will be added. This data set is not used in post-processing by GeoRAS.

Cross-Sectional Cut Lines

A cross-sectional cut lines feature class will be created in the Output GeoDatabase. The cut lines will represent the location of the cross sections in HEC-RAS and attribute the cross sections with water surface elevations for each profile. The feature class will have the name "XS Cut Lines" and will be added to the analysis Map.

An additional field with the name "P00n" is added to the cross-sectional cut line feature class for each water surface profile, where "00n" represents the profile number. The alias for the field name will have the profile name exported from HEC-RAS.

Additional fields will be added to the cut line feature class such as the *River*, *Reach*, and river *Station* information. A field will also be added indicating whether the cross section was interpolated.

Storage Areas

If Storage Areas are in the RAS Export file, a "Storage Area" feature class of polygon outlines will be created. A field for each water surface profile will be added with a corresponding water surface elevation.

Bounding Polygons

A bounding polygon feature class will be created containing a polygon feature for each water surface profile. The field *ProfileID* will hold a "P00n" value corresponding to the water surface profile in the cut lines feature class. A *ProfileName* field will also be added and will hold the profile name exported from HEC-RAS. The feature class will have the name "Bounding Polygon" and be added to the analysis Map.

Profile Definition Table

A table called "ProfileDefinition" will be created and will summarize the profile names exported from HEC-RAS and the profile field names in the Cross-Sectional Cut Line feature class.

Water Surface Extents

A "Water Surface Extents" feature class will be created. These features will identify the edge of the water surface as computed in HEC-RAS (not the GIS) for each water surface profile. To visualize the water surface extents for any one profile, a "Definition Query" for a specific water surface profile will be required.

Bank Stations

If bank station data are available in the RAS Export file, a feature class called "BankPoints" will be created. This data is important if you intend on performing velocity mapping.

Velocity Point Data

The "Velocities" point feature class will be created from velocity data in the RAS Export file. The velocities are exported based on the Velocity Distribution computed in HEC-RAS, with one point at the centroid of a flow distribution location.

Ice Thickness Data

Ice thickness data for the Left overbank, Channel, and right overbank will be imported, if available, to the "Ice Thickness" feature class. Ice thickness data is considered constant in the left overbank, channel, and right overbank.

Shear Stress Point Data

A shear stress point feature class will be created from velocity data in the RAS Export file. The shear stress data are exported based on the Velocity Distribution computed in HEC-RAS, with one point at the centroid of a flow distribution location.

Stream Power Point Data

A stream power feature class will be created from velocity data in the RAS Export file. The stream power data are exported based on the Velocity Distribution computed in HEC-RAS, with one point at the centroid of a flow distribution location.

Inundation Mapping

Inundation mapping is performed using the water surface elevations on the Cross-Sectional Cut Lines feature class and is limited to Bounding Polygon features. These two feature classes must be created prior to performing the inundation mapping. Floodplain delineation also requires the digital terrain model. When using the GRID Intersection method for floodplain delineation, the "DTMGRID" data source must be present in the analysis output directory.

Water Surface TIN Generation

The first step in the floodplain delineation process is to create a water surface TIN from the water surface elevations attached to each cross section. Select the **RAS Mapping | Inundation Mapping | Water Surface Generation** menu item to build the water surface TINs. The dialog shown in Figure 6-3 will allow you to choose the water surface profile(s) of interest. You can select multiple profiles using the Ctrl and Shift keys in combination with the left mouse click. You also have the option to add ("Add Output Layers") the TIN surface to the current map and to display ("Draw Output Layers") the added layer.

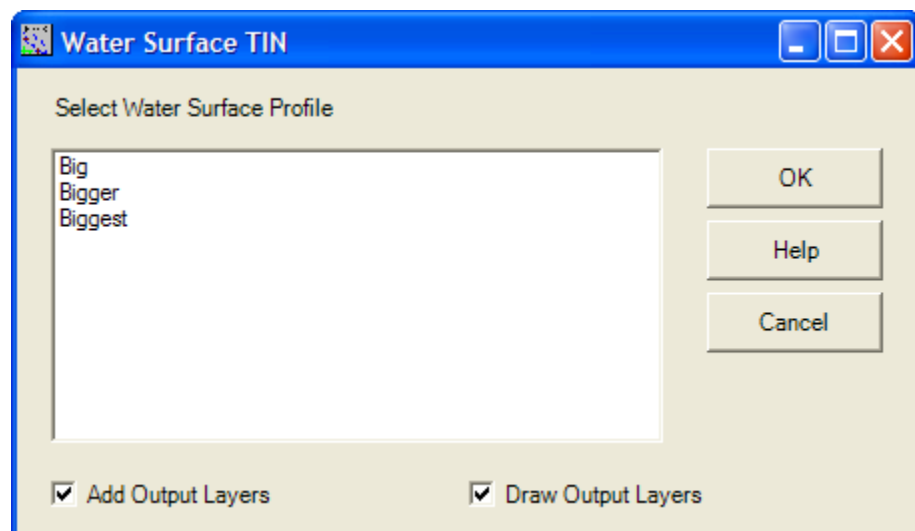*Figure 6-3. Select the water surface profiles to process.*

A water surface TIN for each profile will be created irrespective of the terrain model. The ArcGIS triangulation method will create the surface using cross sectional cut lines as hard breaklines with constant elevation.

Water surface TINs are stored in the analysis directory (corresponding to the Map name) using the assigned profile name "P00n" prefixed

with a "t". The TIN is then added to the analysis map using the profile name exported from HEC-RAS prefixed with a "t" ("t" is for TIN).

Floodplain Delineation

Floodplain delineation is performed using the **RAS Mapping | Inundation Mapping | Floodplain Delineation Using Rasters** menu item. Floodplain delineation will use the water surface TIN and terrain model to calculate the floodplain boundary and inundation depths.

Floodplain delineation results should be carefully examined. Spurious inundated areas may be present and should be deleted in the GIS or prevented from occurring by using levees in HEC-RAS. Inappropriately placed cross sections may result in the bounding polygon data incorrectly limiting the floodplain boundary. The floodplain delineation process using GeoRAS is an iterative process that should be used to refine the hydraulic model in HEC-RAS.

The floodplain delineation method rasterizes the water surface TIN using the *Rasterization Cell Size* and compares it to the "DTMGRID". (The raster version of the water surface TIN is stored in the analysis directory as "wsgridP00n".) The floodplain is calculated where the water surface grid is higher than the terrain grid. The Bounding Polygon is used to limit the floodplain only to the area modeled in HEC-RAS.

The inundation depth grid results from the water surface and terrain grid comparison. The depth grid is stored to the analysis directory having the name using the water surface profile name "P00n" and prefixed with a "d". The depth grid is added to the analysis map using the profile name exported from HEC-RAS prefixed with a "d" ("d" is for depth).

The floodplain boundary feature class is created based on the depth grid. The floodplain boundary is the exact outline of the depth grid. If the "Smooth Floodplain Delineation" option is selected, the resultant floodplain boundary will be a generalized polygon boundary of the depth grid. The floodplain boundary feature is stored in the output geodatabase in the *RASResults* dataset as "b" and the profile name "P00n". The floodplain boundary is then added to the analysis map using the HEC-RAS profile name prefixed with a "b" ("b" is for boundary).

Velocity Mapping

Velocity mapping is performed by interpolating the detailed velocity data be exported from HEC-RAS at each cross section using the Flow Distribution simulation option. In order to compute the velocity

distribution surface, a floodplain boundary layer must already exist for the corresponding profile. The interpolated velocity data is computed using the **RAS Mapping | Velocity Mapping** menu item. The dialog shown in Figure 6-4 will allow you to choose from the water surface profiles that have floodplain boundary maps and velocity information.
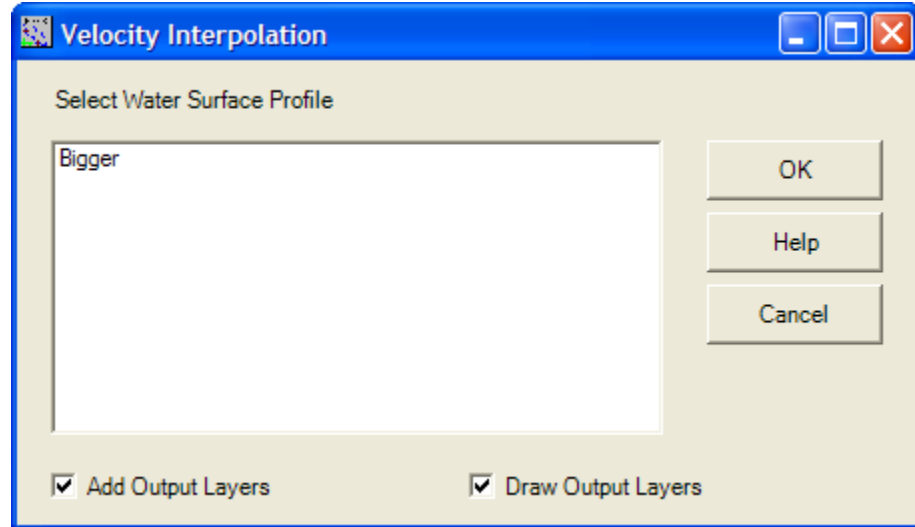

Figure 6-4. Selection dialog for performing velocity mapping.

The velocity interpolator does not use the "Velocities" point file that is loaded to the GIS, this is for visualization only. Instead, the data stored in the *RASExport.xml* file is used. For each profile selected, GeoRAS exports the floodplain boundary to a "Floodplains.xml" file which used to limit the interpolation and creates a "Parameters.xml" file to establish the input and output parameters for running the interpolation program. An example of the *Parameters* file is shown in Figure 6-5.

Figure 6-5. Example parameters file for running the interpolation program with HEC-GeoRAS.

Interpolation of the velocity data is done on a cross section by cross section basis. The first step in the interpolation process is to compute transition lines between cross sections in the main channel and overbanks. A transition line is computed for each point velocity on a cross section and transitions to the next cross section using the shape

of the stream centerline. An example of the transition lines are shown in Figure 6-6.
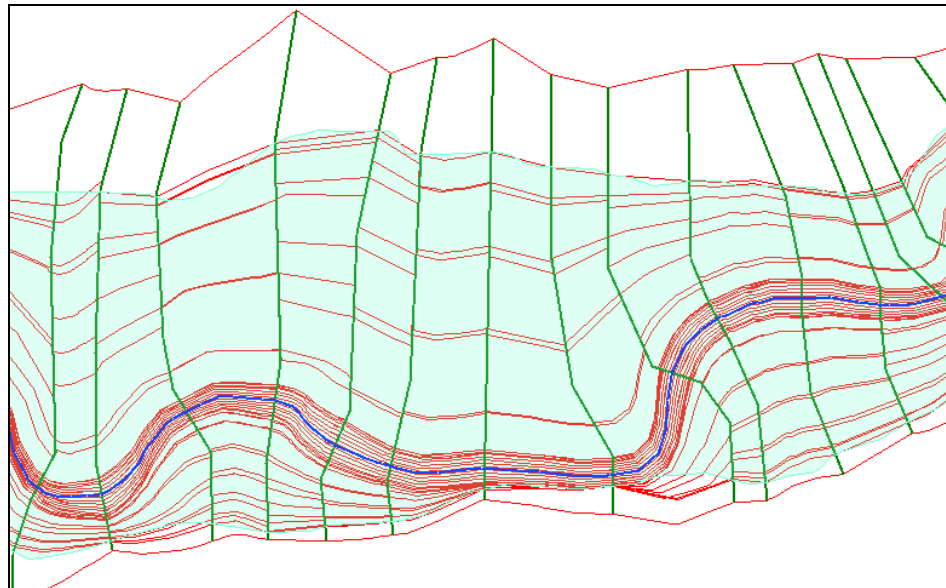
Figure 6-6. Transition lines computed for velocity interpolation is done from cross section to cross section.

Velocity data are then interpolated along the transition lines to create known values for input into a gridded matrix solver. The main channel (as defined by the main channel bank stations) is solved separately from the overbanks. The floodplain boundary uses a zero-velocity boundary for the solution space. The dialog shown in Figure 6-7 is shown during the interpolation to provide status updates.
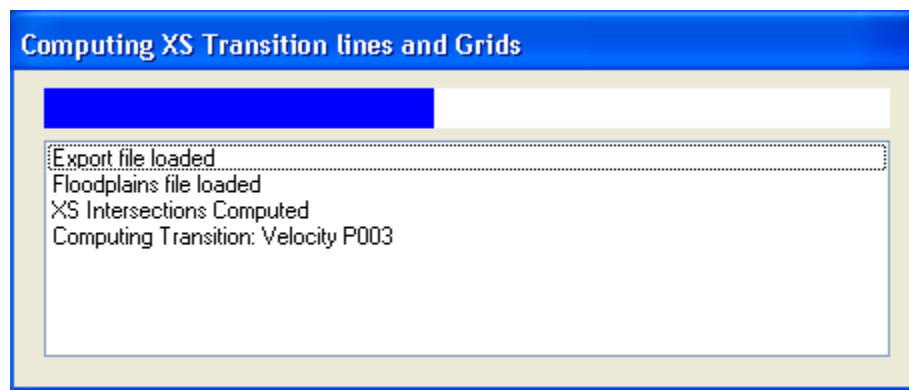
Figure 6-7. Interpolation status dialog keeps you updated on the progress.

Once the interpolation is complete, a velocity surface is created in the ESRI binary floating point format (.flt). The filename will be the profile name prefixed with the abbreviation "vel" ("velP001.flt", for instance). A second file with the ".hdr" file extension is created which specifies the parameters for the grid. The binary raster is then converted to the ESRI grid format and stored in the output directory with a "v" and the profile name "P00n". The velocity grid is then added to the analysis

Map using the HEC-RAS profile name prefixed with a "v" ("v" is for velocity).

Note: the velocity interpolation method is an attempt to allow for visualization of the distribution of the 1-dimensionally computed velocities between cross sections. The interpolation algorithm uses limited data to determine the transition of flow from one cross section to the next and cannot predict the 2-dimensional nature of flow around objects. Care should be taken when interpreting the interpolated velocity results and formulating hydraulic conclusions.

Interpolation of velocity data may also be performed outside of HEC-GeoRAS. This is useful if you have already performed the floodplain delineation (using a previous version of GeoRAS) and now want to visualize velocity data. Detailed instructions are provided in Appendix C on how to use the interpolation software in a stand alone mode.

Ice Thickness Mapping

Ice thickness mapping is performed in much the same way as the velocity mapping; however, ice thickness data values are constant in the left overbank, main channel, and right overbank. Further, the floodplain boundary is used only to limit the extents of the ice and not as a zero-value boundary as done for the velocity interpolation.

After interpolation, an ESRI binary raster is created using the "ice" prefix and assigned a profile name (iceP00n.flt). The binary raster is then converted to the ESRI grid format and stored in the output directory with an "i" and the assigned profile name "P00n". The ice thickness grid is then added to the analysis Map using the HEC-RAS profile name prefixed with an "i" ("i" is for ice thickness).

More details on interpolation can be found in Appendix C, which provides a full description of parameters and keywords for ice thickness data.

Shear Stress Mapping

Shear stress mapping is performed in much the same way as the velocity mapping. After interpolation, an ESRI binary raster is created using the "shear" prefix and assign profile name (shearP00n.flt). The binary raster is then converted to the ESRI grid format and stored in the output directory with an "s" and the assigned profile name "P00n". The velocity grid is then added to the analysis Map using the HEC-RAS profile name prefixed with an "s" ("s" is for shear).

More details on interpolation can be found in Appendix C, which provides a full description of parameters and keywords for shear stress data.

Stream Power Mapping

Stream power mapping is performed in much the same way as the velocity mapping. After interpolation, an ESRI binary raster is created using the "power" prefix and assign profile name (powerP00n.flt). The binary raster is then converted to the ESRI grid format and stored in the output directory with a "p" and the assigned profile name "P00n". The stream power grid is then added to the analysis Map using the HEC-RAS profile name prefixed with a "p" ("p" is for power).

More details on interpolation can be found in Appendix C, which provides a full description of parameters and keywords for stream power data.

Data Storage

HEC-GeoRAS will create numerous data sets during post-processing. The Layer Setup dialog will show you where all the data will be stored during processing. Familiarity with the data storage will assist you in properly managing data during the iterative process of floodplain delineation.

GeoRAS is set up so that all of the analysis results for a particular HEC-RAS simulation (or plan name) are stored in a single directory. This allows you to quickly manage an entire analysis. You may wish to delete an entire set of post-processed data after you find a mistake in the HEC-RAS model, for example, during the iterative floodplain delineation process. A sample data file structure is illustrated in Figure 6-8.

Output Directory ("Floodplains")

Analysis Directory ("Steady Flows")
GeoDatabase ("Steady Flows")

"RASResults" Dataset:
  - Bounding Polygons
  - Floodplain Boundaries ("bP00n")
  - XSCutlines

Depth Grids ("dP00n")

Raster of terrain model ("DTMGRID")

Water surface TINs ("tP00n")

Raster of water surface TINs
("wsgridP00n")

GeoRAS project (.mxd)
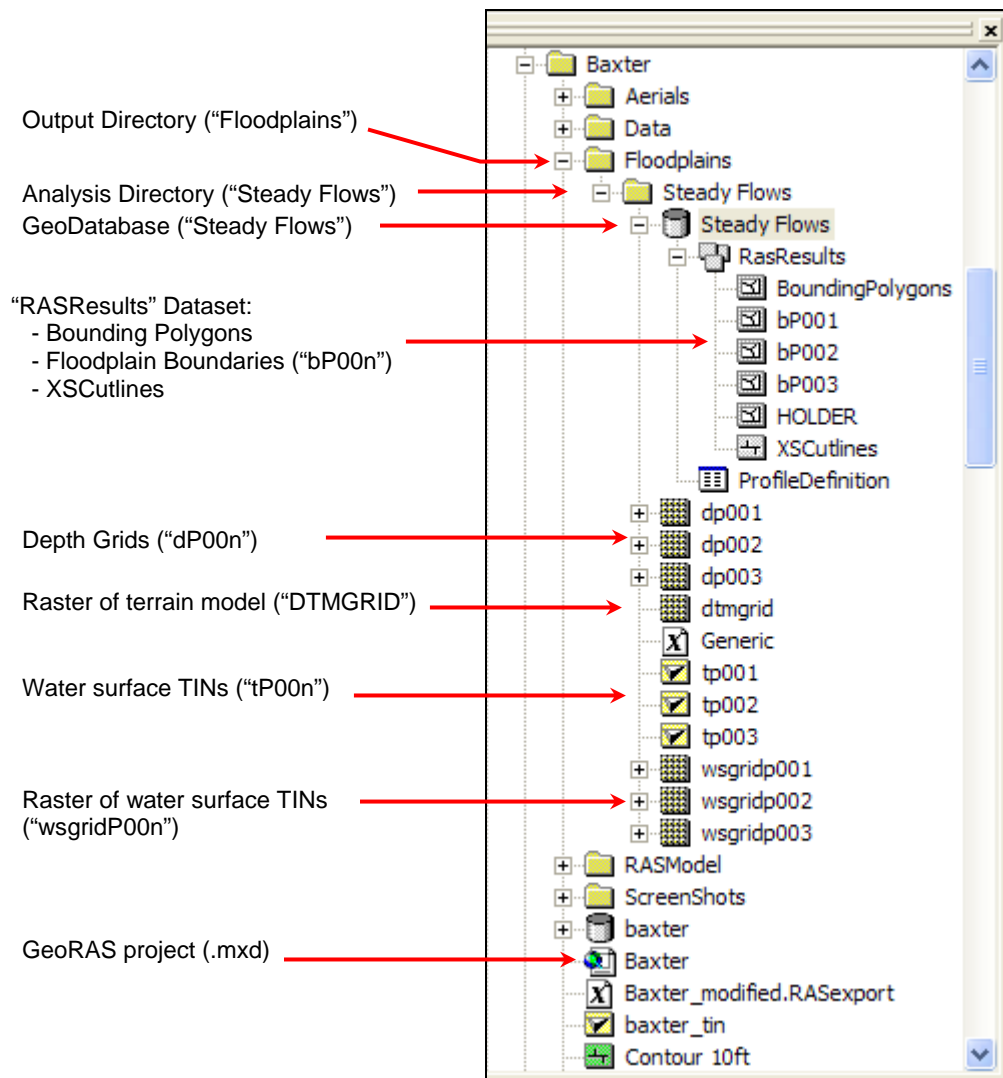
Figure 6-8. HEC-GeoRAS sample data structure for post-processed data.

Visualization

Visualization tools are provided in HEC-GeoRAS to assist you
understand and interpret the results of your mapping effort using
readily available base mapping data. The tools provided will assist you
in creating a animation of inundation mapping and publishing your
data to a KML client (such as Google Earth, Microsoft Virtual Earth, or
ESRI ArcGIS Explorer).

2D Animation

The floodplain animation control, shown in Figure 6-9, available through the **RAS Mapping | Visualization | 2D Animation** menu allows you to create a movie file having the .avi file extension. The animation control provides you with a list of all layers in the Map (Map Layers), "Animation Layers", and "Base Layers.
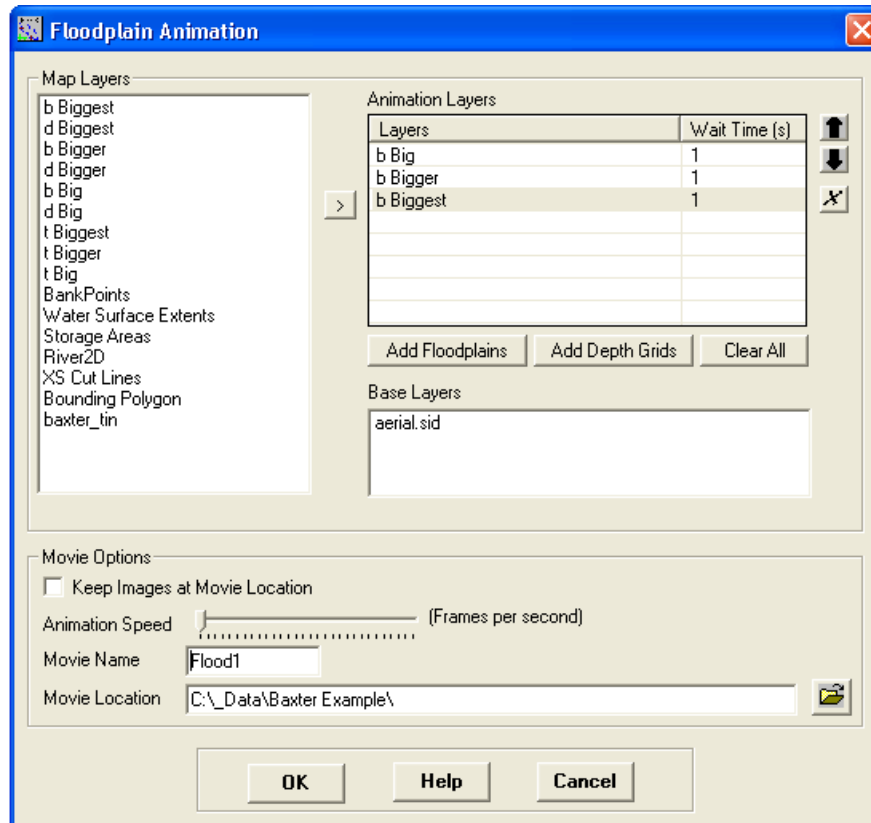

Figure 6-9. HEC-GeoRAS animation control allows you to create a movie file (.avi).

Base Layers are static layers that will be visible for the entire animation and must be displayed prior to accessing the animation control. After adding the layers to be animated to the "Animation Layers" list they can be ordered and removed using available tools. Buttons are also provided to add the floodplain boundaries and depth grids. The **Add Floodplains** button will add all layers preceded by a "b", while the **Add Depth Grid** button adds all layers preceded by a "d". The animation list also allows you to set the relative "Wait Time" (in seconds) for each layer.

The animation file will be created based on the "Movie Options" specified. This is accomplished by creating bitmaps of the display with the layers displayed in the order of the "Animation Layers" list. The bitmaps are then combined to create an animation file (.avi). If you wish to keep the bitmaps on disk, select the "Keep Images at Movie Location" option. You should enter a movie file name and output location for the output files.

Publish Layers to KML Client

Layers created in GeoRAS can be published to the KML format using the **RAS Mapping | Visualization | Publish Layers to KML Client** menu item. The KML publishing control, shown in Figure 6-10, lists the layers available in the current map. To create a KML file, select (highlight) the layer of interest, specify the output directory location, and press the **Create KML Files** button. The KMZ file that is created is a compressed KML file.
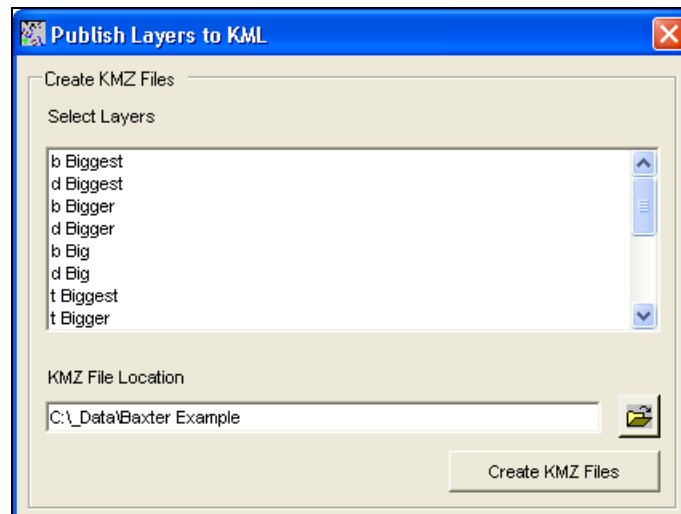

Figure 6-10. Layers created in HEC-GeoRAS can be exported to the KML format for display in KML viewers.

[It is a known issue that Google Earth has a limitation as to the size/number of points that can be displayed using a KML file. Therefore, it is recommended that floodplain boundary layers are generalized prior to exporting to KML.]

About KML

KML is the Keyhole Markup Language made popular by its use in Google Earth. It is a standard that has been adopted by the Open GIS Consortium (OGC). Data are stored in latitude and longitude as in the World Geodetic System of 1984 (WGS84) coordinate system.

Post-Processing Utilities

Post-processing utilities are available to assist you in performing mapping and visualization results. The options available from the **RAS Mapping | Postprocessing Utilities** are: **Copy Analysis**, **Delete Analysis**, **Clip GRID**, and **Symbolize Rasters**.

Copy Analysis

Copy Analysis allows you to copy the underlying geodatabase from an existing analysis so that you don't have to re-read the data into the GIS from the RAS GIS Export file. The **Copy Analysis** menu item invokes the Layer Setup dialog, as shown in Figure 6-11. You may select from any of the "Existing Analysis" that have been performed and must enter the name for the "New Analysis". Optionally, you can specify a new "Rasterization Cell Size" to identify the impacts of refining the grid-cell size for delineation. If you change the cell size the terrain model will be re-sampled otherwise the terrain model will be copied, as well.
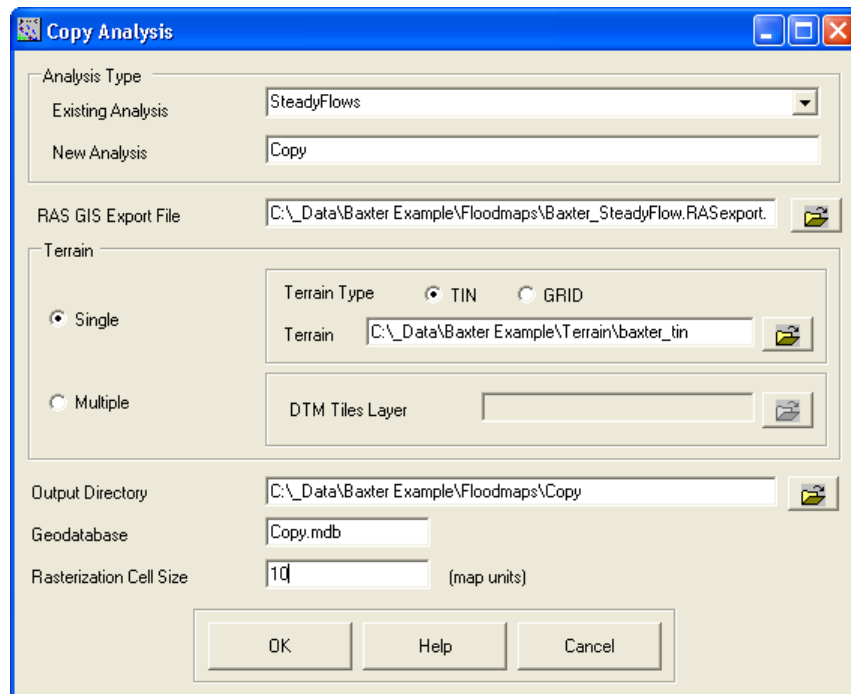
Figure 6-11. The Copy Analysis option will create a copy of an existing analysis but allow the user to modify the analysis parameters.

Delete Analysis

The **Delete Analysis** menu item allows you to delete an existing analysis from the HEC-GeoRAS configuration file and removes the corresponding Map. The data, however, must be deleted from disk manually, if desired.

Clip GRID

The **Clip GRID** option is provided to assist you in synchronizing the inundation boundary polygon with the depth grid. This tool, shown in Figure 6-12, is useful for clipping the depth grid to match the

boundary of a floodplain that has been manually edited to reduce the floodplain extents.
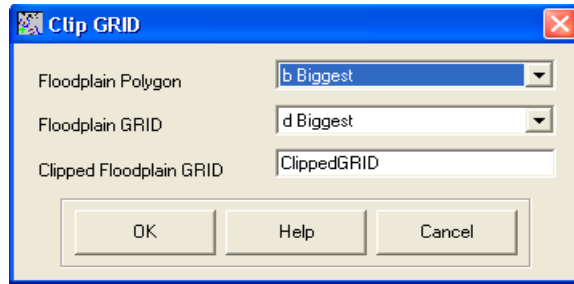

Figure 6-12. Depth grids can be clipped to extents of a floodplain boundary polygon.

Symbolize Rasters

The Symbolize Rasters option is used to assign an identical symbology to each depth grid created by GeoRAS. This is useful if you have many flood depth grids representing the rise and fall of a flood hydrograph and you want to use a consistent symbology to visualize the depth range for each depth grid.

In order to use the Symbolize Rasters tool, shown in Figure 6-13, you must set up the symbology for one raster that will act as the template. Typically, this will be set to display a color for the minimum flood depth and maximum flood depth for all grids. The raster template is selected as the "Source Raster" which is then applied to the list of selected rasters.
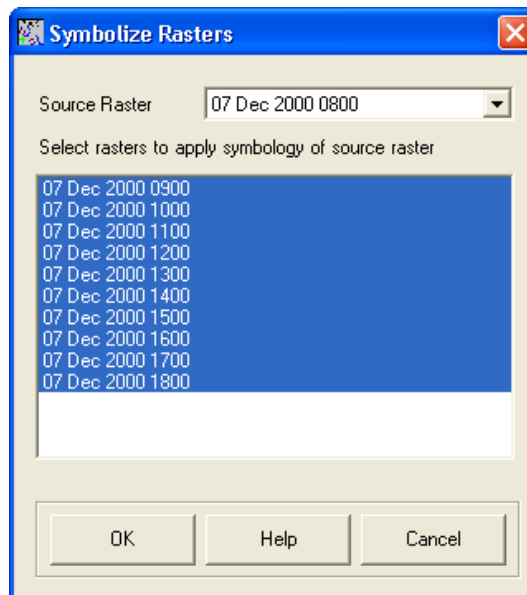

Figure 6-13. The Symbolize Rasters tool allows you to assign the same symbology to multiple raster datasets.

C H A P T E R   7

Example – Data Import

This chapter provides an example for importing data generated outside of HEC-GeoRAS for ArcGIS and importing it into a GeoRAS geodatabase. This is important for users that have created data sets using other tools, specifically HEC-GeoRAS for ArcView 3.2 or in incompatible versions of the geodatabase (like ArcGIS 8.x), and want to modify and re-extract data using GeoRAS in ArcGIS.

The data set used for this example is the Wailupe River data set that is referenced in previous HEC-GeoRAS user's documentation.

Main Tasks

- Start a New ArcMap project
- Generate the GeoRAS Feature Classes
- Import Data to Feature Classes
- Assign HydroIDs to Features
- Attribute Feature Classes

Start a New ArcMap project

The first step is to use GeoRAS to generate a geodatabase to import existing data into. This is done in ArcMap. **Start ArcMap** and load the HEC-GeoRAS extension. Save the ArcMap project ("Import.mxd") in a directory of your choosing.

Next, create a Map (data frame) for the geometric data. Maps are added through the **ApUtilities | Add Map** menu item. It is important to add maps using the ApUtilities so that GeoRAS "knows" which maps hold data. For this example, the map's name is "Geometry Import".

Assign a coordinate system to the map. You can do this through the map properties or you can load a data set that has the proper coordinate system. Add the terrain TIN ("wai_tin") and let ArcMap do the work for you! Verify that the coordinate system is correct by **right-clicking** on the **Geometry Import** map and selecting the **Properties** menu option. Select the Coordinate System tab as shown in Figure 7-1, and verify the coordinate system is correct.
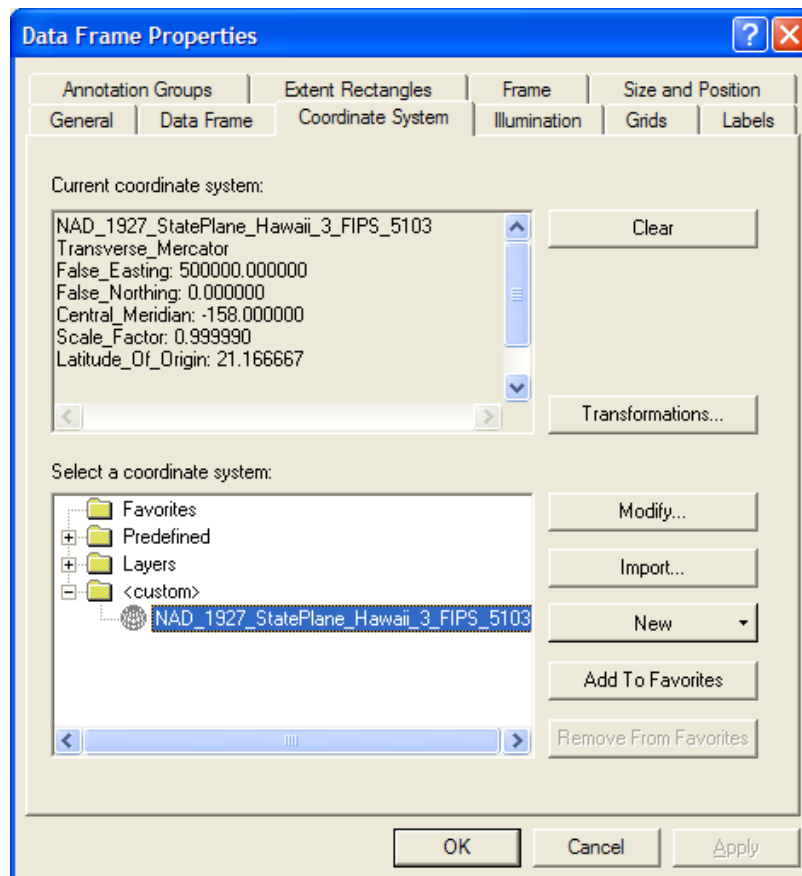
Figure 7-1. Map Properties dialog with the Coordinate System tab shown.

Generate the GeoRAS Feature Classes

Once the project is saved and the coordinate system is set, you are ready to create the GeoRAS feature classes. Select the **RAS Geometry | Create RAS Layers | All** menu item. (You could do each feature class one at a time.) The dialog shown in Figure 7-2 will be invoked to allow you to enter the names for each feature class. Pressing **OK** will build a geodatabase based on the name and location of the ArcMap project. In this case, a geodatabase called "Import" was created and is stored in the same directory as the "Import.mxd".
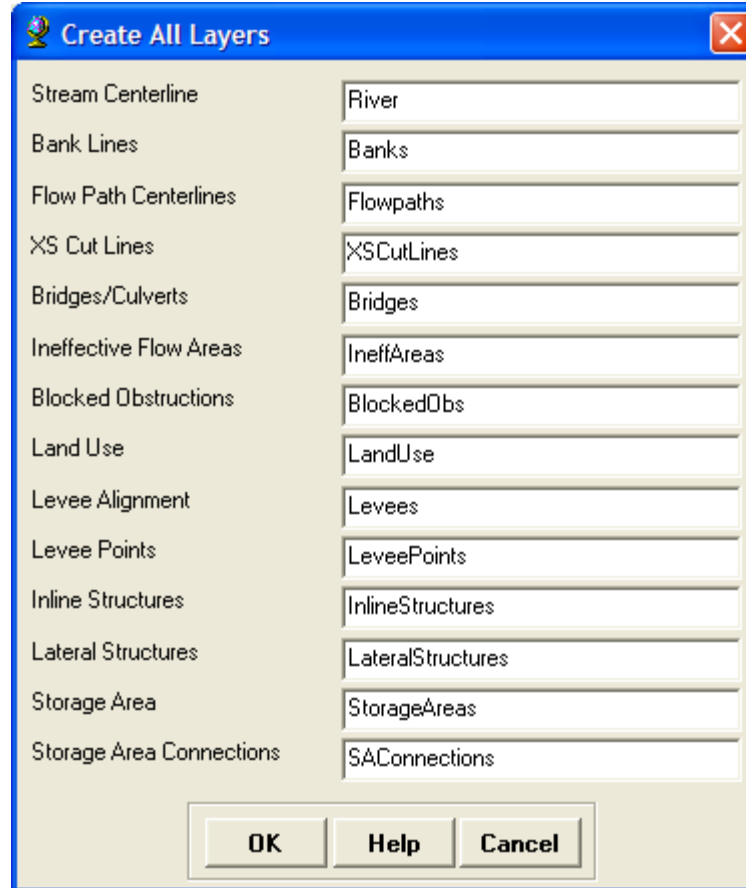
Figure 7-2. Dialog allowing user specified feature class names.

Once the feature classes have been generated, they will be added to the ArcMap table of contents. You may remove any data sets you don't plan on using from the Table of Contents. A blank feature class for the data set will remain in the geodatabase. For this example, you will next import existing data into the blank feature classes. First, however, **save** your project and then **close ArcMap**.
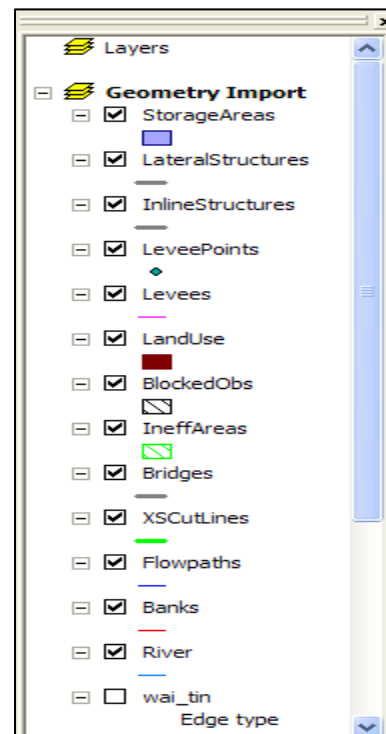
Import Data to Feature Classes

Data is imported into existing feature classes using ArcCatalog. Because ArcCatalog will be accessing data, you must make sure it is not being used in another ArcGIS session (such as ArcMap).

Start ArcCatalog and navigate to the geodatabase ("Import"), as shown in Figure 7-3. Note that the geodatabase and map document are stored in the same directory.
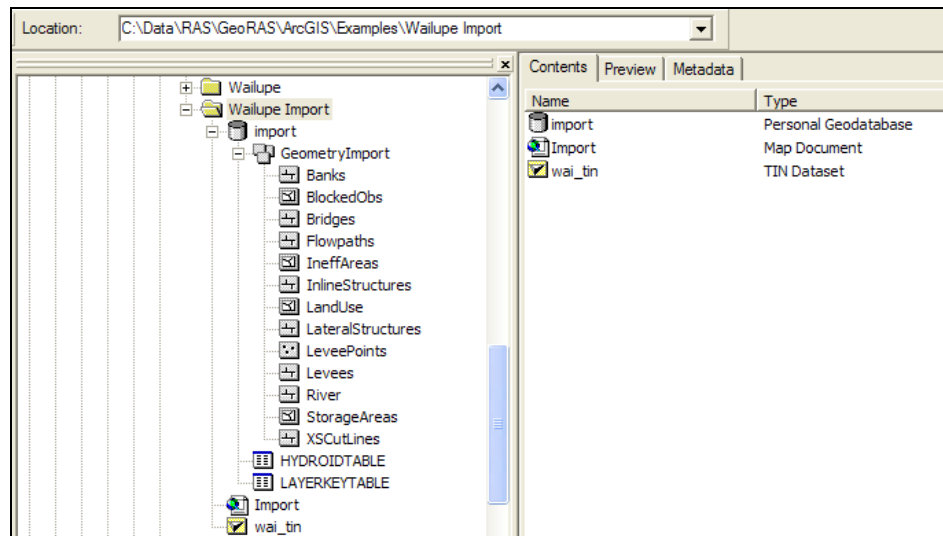
Figure 7-3. Browsing in ArcCatalog.

Double-click on the GeoDatabase and DataSet to access the feature classes. **Right-click** on a feature class (choose the **River** feature class) and select the **Load Data** menu item (see Figure 7-4).
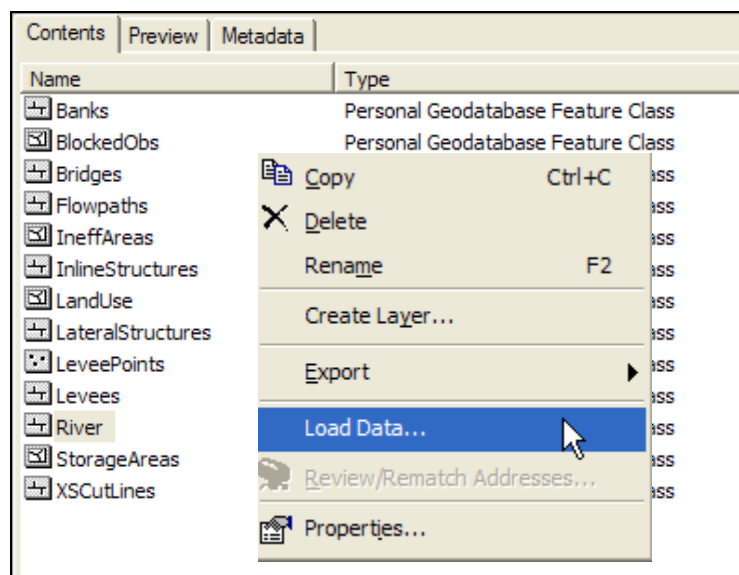
Figure 7-4. Right-click on a feature class to import data.

Load Data Process

The load data process is used to import features and assign attributes to fields. The process is enumerated in the following steps.

1. **Select** the data source to import by navigating to the associated shapefile (stream.shp is the "River" shapefile).
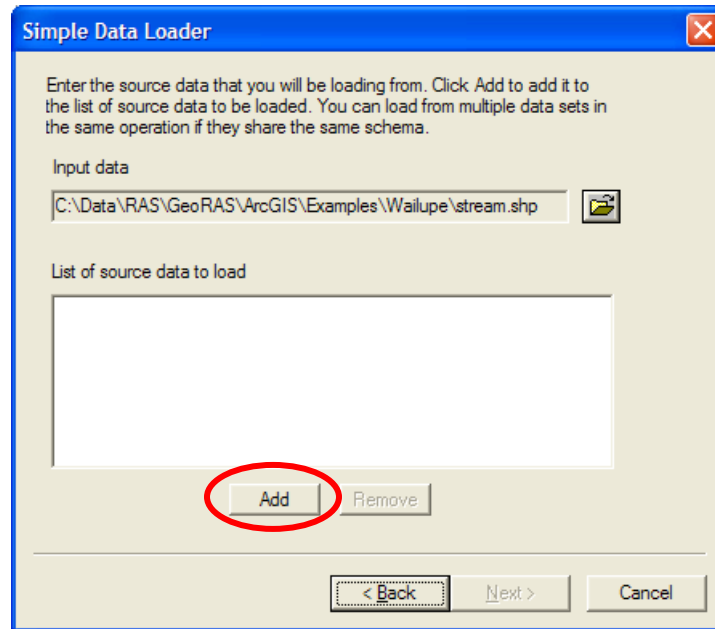
5. **Click** the **Add** button to choose the data set. **Click** the **Next** button to proceed.
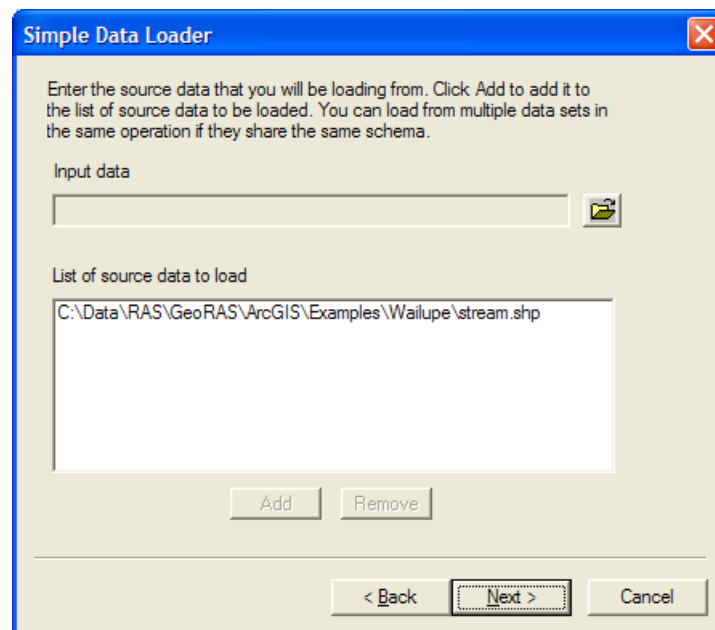
6. **Click Next** in the next dialog.
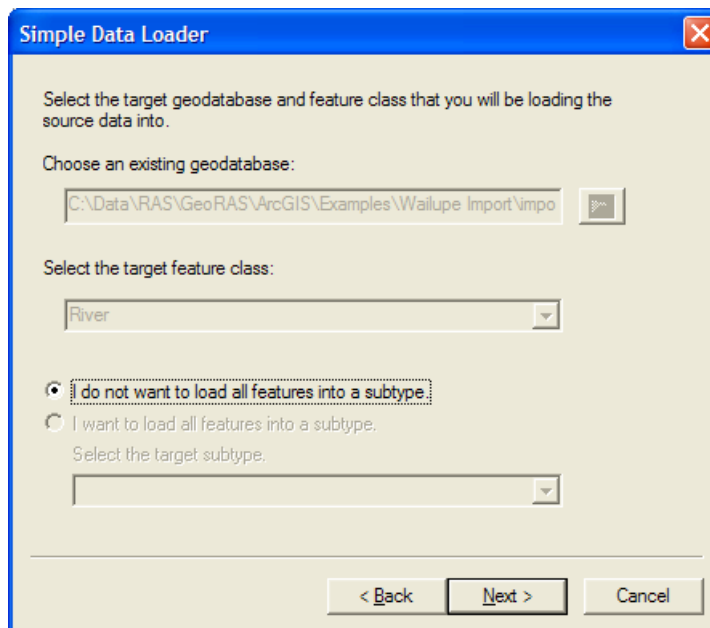
7. The dialog will allow you to match the source fields to the fields in the geodatabase. Field names will be similar, if not identical, in the geodatabase and shapefiles. Match the fields for the data you wish to import. Any attribute infomation not imported can be completed in ArcMap using GeoRAS. **Click Next** when the fields have been matched.
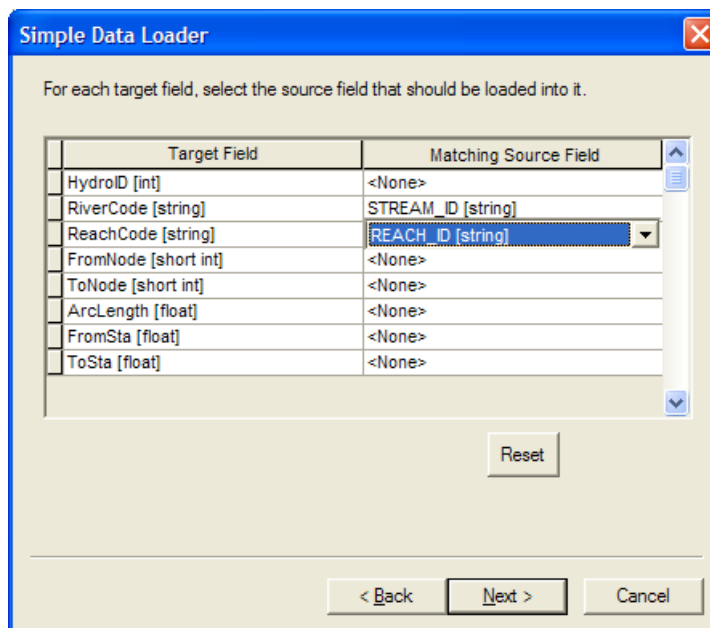
8. You can choose to import all features or load those that satisfy an attribute query. Select an option and **Click Next**.
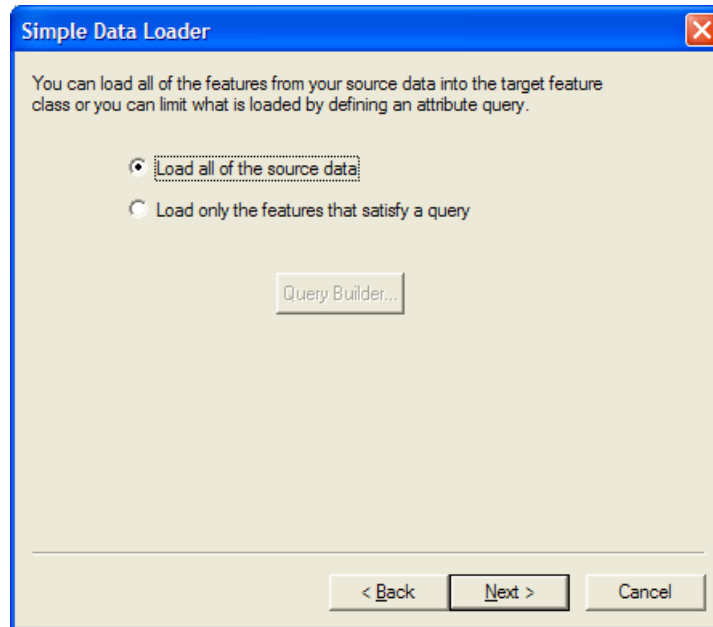
9. The data is imported and a summary dialog provides results.
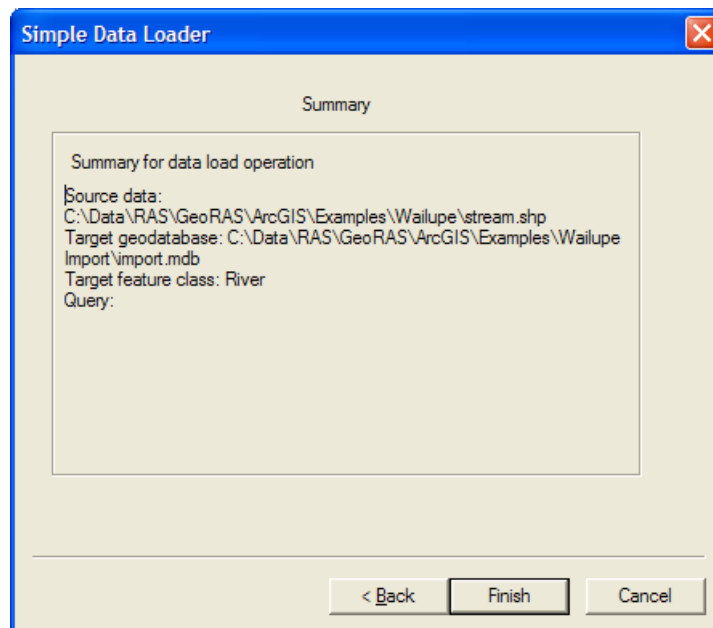
Repeat the data import process for **each feature class**.

Assign HydroIDs to Features

After importing data for each feature class, you will need to assign a HydroID to each feature. This is performed in ArcMap. **Start ArcMap** and open the "Import" project. For GeoRAS functions to work, each feature must have a unique HydroID.

Select the **ApUtilites | Assign UniqueID** menu item as shown in Figure 7-5.
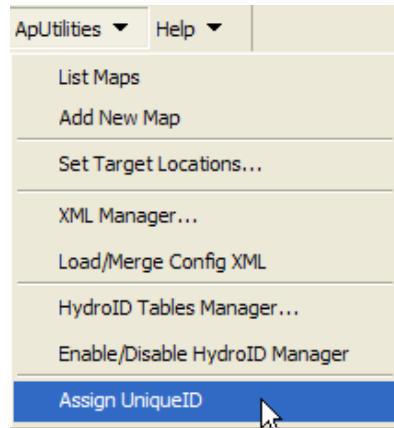
Figure 7-5. Assigning HydroIDs is performed through the ApUtilities menu.

The dialog shown in Figure 7-6 will be invoked allowing you to choose the feature classes (Layers) to which to assign HydroIDs. Press the **Select All** button.
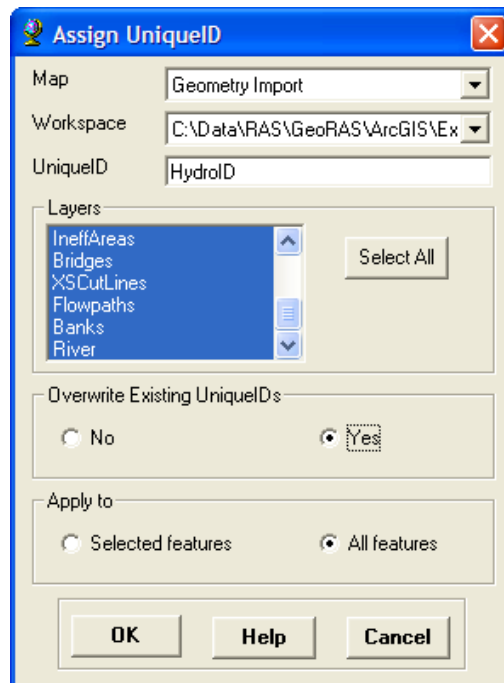
Figure 7-6. HydroID assignment options.

Also choose **YES** to overwrite existing IDs and choose **All Features**. Press **OK** and the HydroID field will be populated for each layer that has features. A status dialog (see Figure 7-7) will inform you of how many IDs were populated.
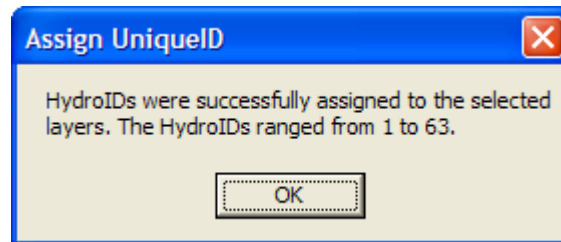
Figure 7-7. Successfull assignment of HydroIDs dialog.

Attribute Feature Classes

You must now verify that each feature was assigned a unique HydroID and that each feature has the appropriate attributes. Assuming that you imported all of the field data and the HydroID process was successful, you are done.

A good way to populate the attributes of the XS Cut Lines layer, however, is to run through the **RAS Geometry | XS Cut Line Attributes** menu items. In doing so, you can be sure that the features have been attributed based on the other feature classes. After populating attributes, open the attribute table for the feature class and verify that the data was appropriately populated.

C H A P T E R   8

Example Application

This chapter provides a detailed discussion of how to use the HEC-GeoRAS extension in ArcGIS for supporting hydraulic model development and analysis with HEC-RAS. This provides a step-by-step procedure for developing geometric data for import into HEC-RAS and how to develop GIS data sets from results exported from HEC-RAS.

This example is for the fictional Baxter River that majestically meanders through Tule Town, USA. We begin our example with a TIN of the river system that incorporates detailed terrain data for both the main channel and adjacent floodplain. The detailed terrain model will be the basis for this example.

The figures in this example are intended to demonstrate the GeoRAS process and underlying principles and may not be hydraulically accurate. For more discussion on the steps addressed in this example refer to Chapters 3-6.

Main Tasks

- Load HEC-GeoRAS
- Start a New Project
- Create Contours from a DTM
- Create RAS Layers
- Generate the RAS GIS Import File
- HEC-RAS Hydraulic Analysis
- Import the RAS GIS Export File
- Generate GIS Data from RAS Results

Load HEC-GeoRAS

Start the ArcMap program. Verify that the 3D Analyst and Spatial Analyst extensions are installed and loaded by selecting the **Tools | Extensions** menu item. Select the extensions as shown in Figure 8-1 – if they are not available, you will need to install them.
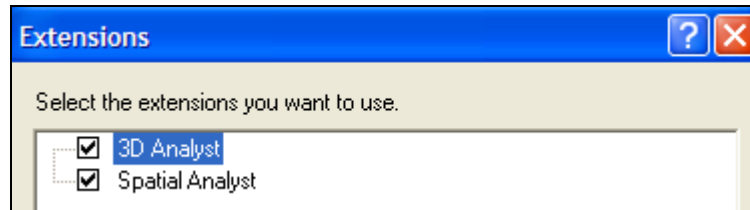
Figure 8-1. Load the ESRI extensions for use with GeoRAS.

The HEC-GeoRAS tools are loaded as a toolbar in ArcMap. To load the GeoRAS toolbar, select **Tools | Customize** from the main ArcMap interface (see Figure 8-2). Place a check in the checkbox corresponding to **HEC-GeoRAS**. The GeoRAS toolbar will be added to the interface. Press the **Close** button when finished. You may dock the toolbar where desired.
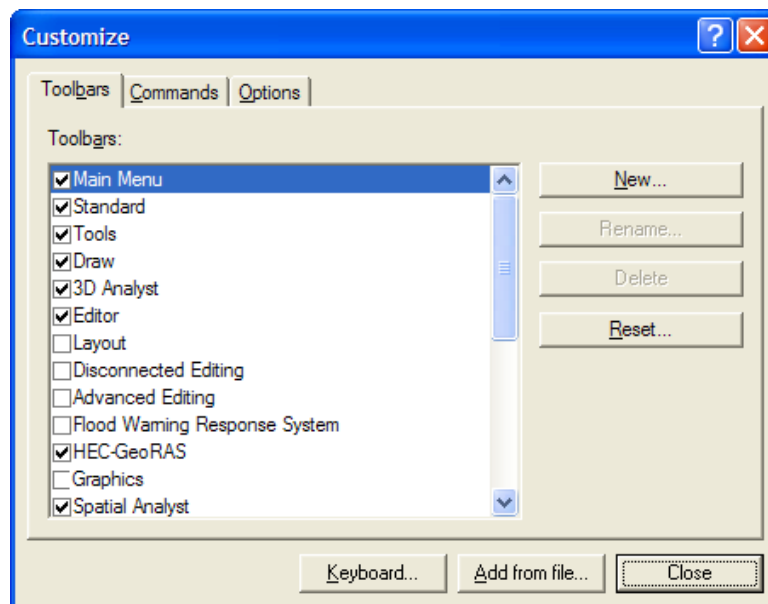
Figure 8-2. Add the HEC-GeoRAS toolbar to the map.

Start a New Project

Stop! You should save your project and save it often. Have you determined the directory structure for where you want to store the GeoRAS data layers? Decide on the location to store your GIS data. If the directory does not exist, create it using a file manager. Move/copy the terrain layer to an appropriate directory. For this example, the project directory has been named "Baxter Example".

Select the **File | Save** menu item to save the ArcMap document. Navigate to the project directory and enter the project name for the ArcMap document ("Baxter92" is used for this example).

Add a Map

Add a map to the ArcMap document by selecting the **ApUtilities |
Add New Map** menu item. Enter the name "**RAS Geometry**" for the
name and press **OK**.

Coordinate System

Set the coordinate system for analysis for the RAS Geometry map.
The coordinate system must match that of the terrain model! The
simple way to do this is by adding the DTM to the map. The projection
information for the map will be set based on the first data set loaded.

Add the "Baxter_tin" TIN to the map by pressing the **Add Data** button
and navigating to the location of the DTM. The TIN is added to the
map. Uncheck the box next to the DTM layers name to stop the
terrain from rendering.

Right-click on the map, select the **Properties** menu item. In the
Data Frame Properties dialog click on the **Coordinate System** tab and
verify the coordinate system as shown in Figure 8-3.
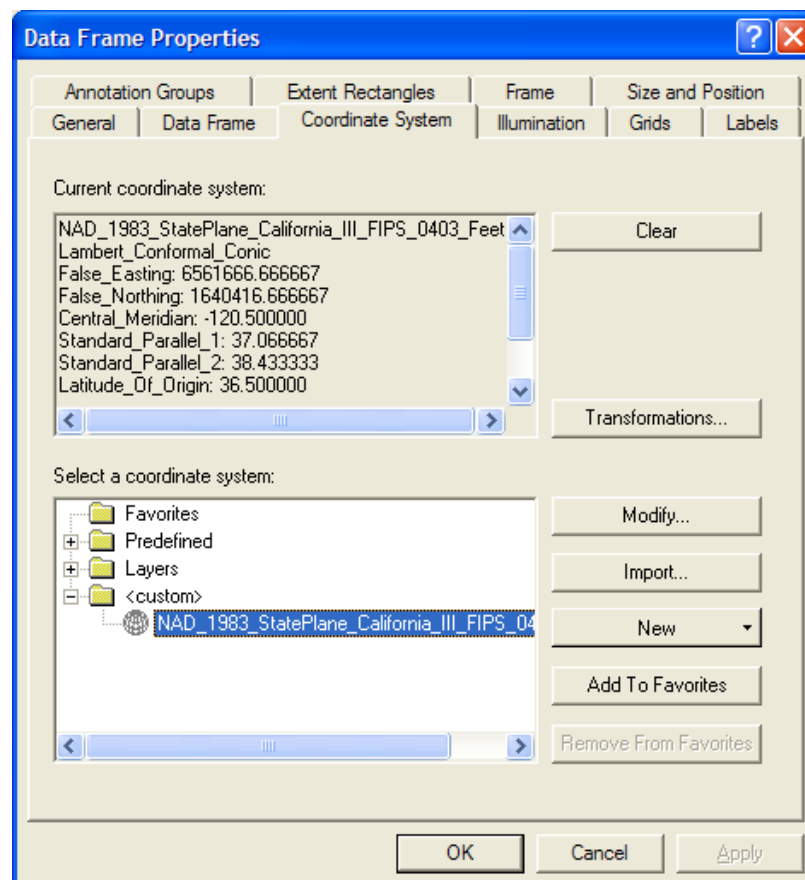
Figure 8-3. The coordinate system for the map must be set prior to using GeoRAS.

Create Contours from a DTM

You most likely have noticed that even small terrain models take quite some time to render. This delay during a screen refresh can be quite time consuming, while you are digitizing features or panning/zooming in the map. Contour lines are a good source of data for visualizing the terrain and will redraw more quickly.

Select the **3D Analyst | Surface Analysis | Contour** menu item. Enter a contour interval of 5 or 10 feet and an output location. Press **OK**. The data set will be created and added to the RAS Geometry map.

While you are zoomed out, the contours provide adequate information. But if you zoom in, you will likely want to see the channel defined by the DTM. To use the contours in harmony with the terrain model, set the *Scale Range* property of the "Baxter_tin" to only display features when zoomed in (not displayed when zoomed out beyond 1:8,000) as shown in Figure 8-4.
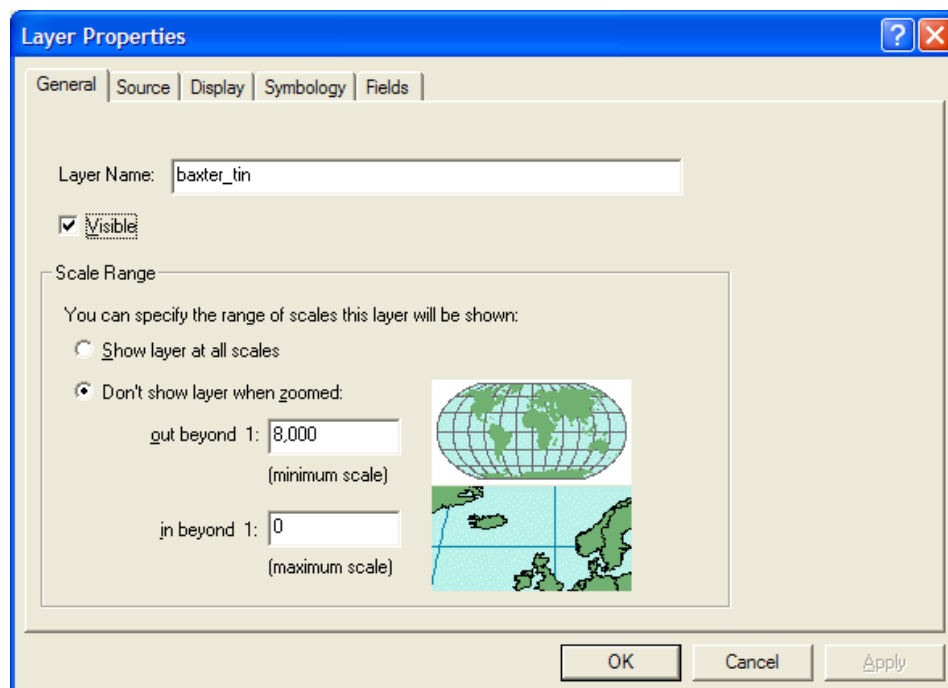
Figure 8-4. Use the Scale Range property of layers to display only when needed.

Next, decide how you want the contours to display. You can set the contours to be displayed until you zoom in and have them turn off when the TIN is rendered by setting the *Scale Range* property of the contours layer. The use of scale to render layers is demonstrated in Figure 8-5 through Figure 8-7.
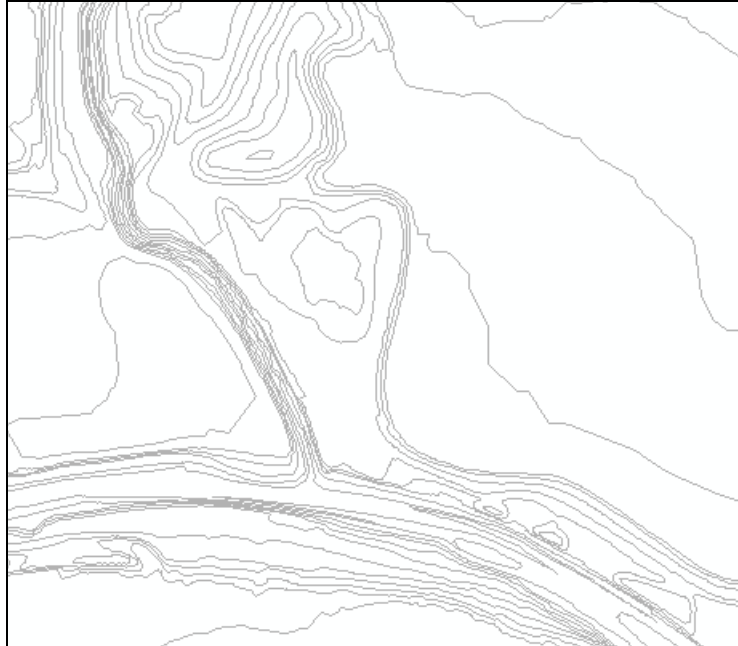
Figure 8-5. Contour lines near a junction, scale ~ 1:10,000.
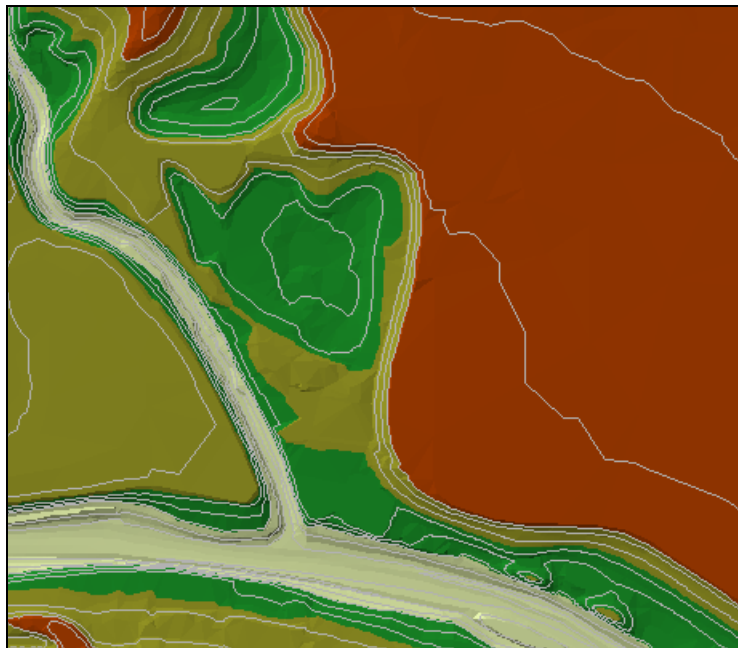
Figure 8-6. DTM rendered with contour lines at junction, scale just smaller than 1:6,000.

Figure 8-7. DTM rendered without contour lines, scale just greater than 1:6,000.

Create RAS Layers

In this section, you will create and edit a series of layers collectively referred to as the RAS Layers that are stored in a geodatabase. The RAS Layers are the basis for the geometric data extracted in the GIS for hydraulic analysis in HEC-RAS. The RAS Themes you will create include: Stream Centerline, Cross-Sectional Cut Lines, Bank Lines, Flow Path Lines, Bridges/Culverts, Ineffective Flow Areas, Blocked Obstructions, Land Use, Levee Alignments, Lateral Structures, and Storage Areas.

GeoDatabase

The RAS Layers are stored in a geodatabase. To create a new geodatabase with empty feature classes, select the **RAS Geometry | Create RAS Layers | All**.   This will create a geodatabase with the name "Baxter92.mdb" in the same location as the ArcMap document ("Baxter92.mxd"). Each feature class is added to the map with a unique line symbol style. You will now need to create features for each RAS Layer.

Stream Centerline

The Stream Centerline is used to establish the river reach network. The river network must be digitized in the direction of flow with reach end points coincident at junctions.
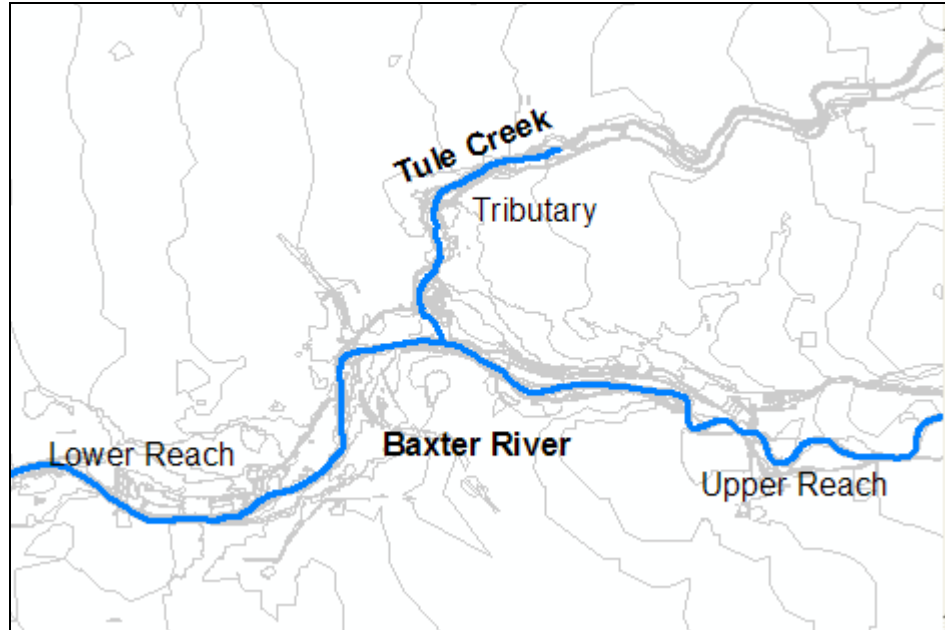
Figure 8-8. River network for the Baxter River.

Based on Figure 8-8 you have a general idea of what the river system looks like: the Baxter River flows East to West, from the Upper Reach to the Lower Reach, with the Tule Creek Tributary dividing the Baxter River into the two reaches. You will need to digitize the stream centerlines for the three river reaches shown.

Start editing the geodatabase by selecting the **Editor | Start Editing** menu item. Verify that you are selecting the "Baxter.gdb". The stream centerline must be created in the direction of flow, so start at the top end of the river and zoom in so that the channel is easily identified.

Select "***Create New Feature***" for the *Task* and "***River***" for the *Target* feature class. Select the **Sketch** tool and begin digitizing the line in the downstream direction. (Left-click drops a vertex.) Continue digitizing the line until you reach the junction. If you need to pan, simply select the **Pan** tool (or hold down the "C" key to interrupt the edit mode), pan through the map, and re-select the Sketch tool (or release the "C" key) to continue digitizing. To finish the reach line at the junction, double-click to drop the endpoint.

Digitize each river reach. There are three river reaches in total, with one junction at the confluence of Tule Creek. You will create the junction after creating all the reaches.

Creating a Junction

To create a junction, the endpoints of each reach must be coincident. While in Edit mode, select "*Modify Features*" for the *Task*. Next set the snapping tolerance, by selecting the **Editor | Options** menu item. On the **General** tab, set the *Snapping Tolerance* to "**10**" **map units**.

Next select the **Editor | Snapping** menu item. Click on snapping to the **End** points for the River layer, as shown in Figure 8-9.
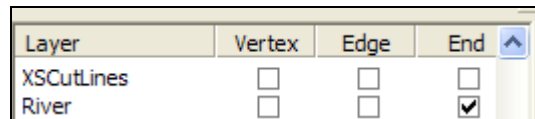
Figure 8-9. Turn on snapping properties for individual layers.

Next, select the **Edit** tool and grab the endpoint of a river reach line by pressing and holding the left mouse button. Move it towards another reach endpoint. When the point is within the snapping tolerance, a sketch of the endpoint will appear and snap to the endpoint. Release the mouse button and the endpoint will snap. The progression of steps to snap endpoints in illustrated in Figure 8-10.
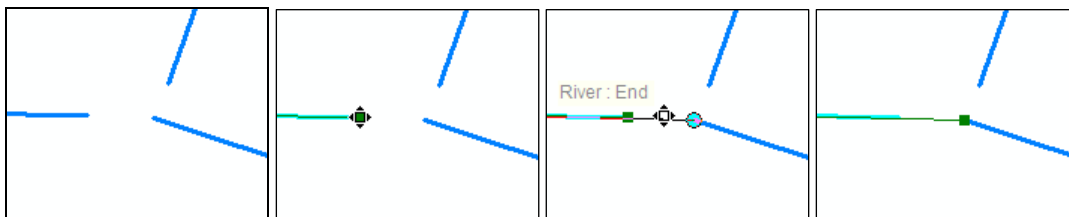
Figure 8-10. Progression for creating a junction using snapping.

Repeat the snapping process for the other reach. Verify that the reach network has been created in the downstream direction by changing the line symbol to include an arrow at the end of the line. In a later step, you will use the GeoRAS tools to double-check the connectivity.

River and Reach Names

Each river must have a unique river name, and each reach within a river must have a unique reach name. Use the ᴵᴰ (**River Reach ID**) tool to give each river reach a name.

Click on the **River Reach ID** tool to make it active. Use the cursor to select each river reach. The River and Reach Name dialog (shown in Figure 8-11) will appear allowing you to enter the river and reach name. For this example, the **Baxter River** has an **Upper Reach** and a **Lower Reach** and **Tule Creek** is a **Tributary**.

Figure 8-11. River Reach name assignment dialog.

After labeling each River reach, look at the attributes for the River layer. To open the attribure table, right-click on the River layer and select the **Open Attribute Table** menu item. Note the fields that are in the attribute table: *HydroID*, *River*, and *Reach*. The HydroID field data were automatically populated - you entered the data for the *River* and *Reach* fields. The *Shape* (link to the feature's shape), *OID* (unique object identifier for the feature), and *Shape_Length* (length of the line) fields will also be automatically populated as the data are created.

Shape*	OID*	Shape_Length	HydroID	River	Reach
Polyline	1	41221.342004	1	Baxter River	Upper Reach
Polyline	2	48157.068348	2	Baxter River	Lower Reach
Polyline	3	12551.496638	3	Tule Creek	Tributary

Figure 8-12. Stream Centerline attribute table.

Network Connectivity

To verify the river reach connectivity, select the **RAS Geometry | Stream Centerline Attributes | Topology** menu item. The fields *FromNode* and *ToNode* will be populated with integer data. Verify that the endpoints at the junction all share a common node number. The complete attribute table for the River layer is shown in Figure 8-13.

River	Reach	FromNode	ToNode	ArcLength	FromSta	ToSta
Baxter River	Upper Reach	1	2	41221.344	48157.0664	89378.4141
Baxter River	Lower Reach	2	3	48157.066	0	48157.0664
Tule Creek	Tributary	4	2	12551.497	0	12551.4971

Figure 8-13. Completed Stream Centerline attribute table.

Lastly, run the **RAS Geometry | Stream Centerline Attributes | Lengths/Stations** menu item. This computes the length of each reach for determining the cross-section river stationing. The *FromSta* and *ToSta* fields will be populated with the *FromSta* being the downstream endpoint of the reach. The *FromSta* and *ToSta* data are "backwards" from the *FromNode* and *ToNode* because the actual river stationing is calculated from downstream to upstream!

Bank Lines

The Bank Lines layer is used to identify the main channel conveyance area from that of the overbank floodplain areas. This layer is not required and there are good tools in HEC-RAS for assigning bank stations; however, the bank lines data may be required for post-processing of RAS results for velocity analysis and ice analysis. Identification of the main channel will also provide greater insight into the terrain, movement of water in the floodplain, and in identifying non-conveyance areas.

While in Edit mode, make sure the *Task* is "**Create New Feature**" and the *Target* is "**Banks**". Select the Sketch tool and digitize bank lines at the edge of the main channel. Accurate digitizing may require that the terrain model is displayed. Digitize a bank line for each bank of each river reach – bank lines may be continuous or broken for a river. An example of the bank lines near the confluence is shown in Figure 8-14.

Figure 8-14. DTM overlaid by the Bank Lines layer.

Flow Path Centerlines

The Flow Path Lines layer is used to determine the downstream reach lengths between cross section in the channel and overbank areas. A flow path line should be created in the center-of-mass of flow in the main channel, left overbank, and right overbank for the water surface profile of interest.

Select the **RAS Geometry | Create RAS Layers | Flow Path Centerlines** menu item. True, you already have generated this feature class, but GeoRAS will handle the data management. Allow

the default name of "Flowpaths" and press **OK**. A dialog will be invoked (see Figure 8-15) asking if you want to copy the stream centerline features to the flow path lines layer. By choosing "Yes", you won't have to re-digitize the main channel flow path. Choose **Yes**.
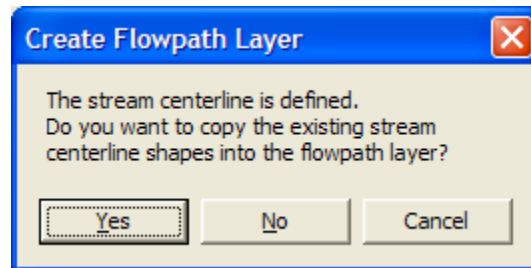
Figure 8-15. Stream centerline features will be copied to the flow path lines layer.

Make sure you are in Edit mode. Select "***Create New Feature***" for the *Task* and "***Flowpaths***" as the *Target*. Digitize the overbank flow path lines in the downstream direction, following the movement of water. An example of flow path lines on the Upper Reach of Baxter River is shown in Figure 8-16.

Figure 8-16. DTM overlaid by the Flow Path Lines layer.

Label Flow Path Lines

Label the flow path lines using the ↓↓↓ (**Flowpath**) tool. Use the cursor to select a flowpath. Upon selection, the dialog shown in Figure 8-17 will appear. Select the corresponding label from the dropdown list for the Left overbank, main Channel, or Right overbank.
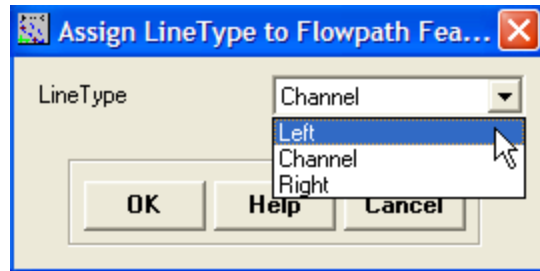
Figure 8-17. Each flow path must have an identifier of "Left", "Channel", or "Right".

Verify that the flow path type has been identified for each flow path by opening the flow path attribute table and verify that the *LineType* field has data for each feature.

Cross-Sectional Cut Lines

Cross-sectional Cut Lines are used to identify the locations where cross-sectional data are extracted from the DTM. The intersection of the cut lines with the other RAS Layers will determine bank station locations, downstream reach lengths, Manning's *n* values, ineffective areas, blocked obstructions, and levee positions. An example cross section layout is shown in Figure 8-18.
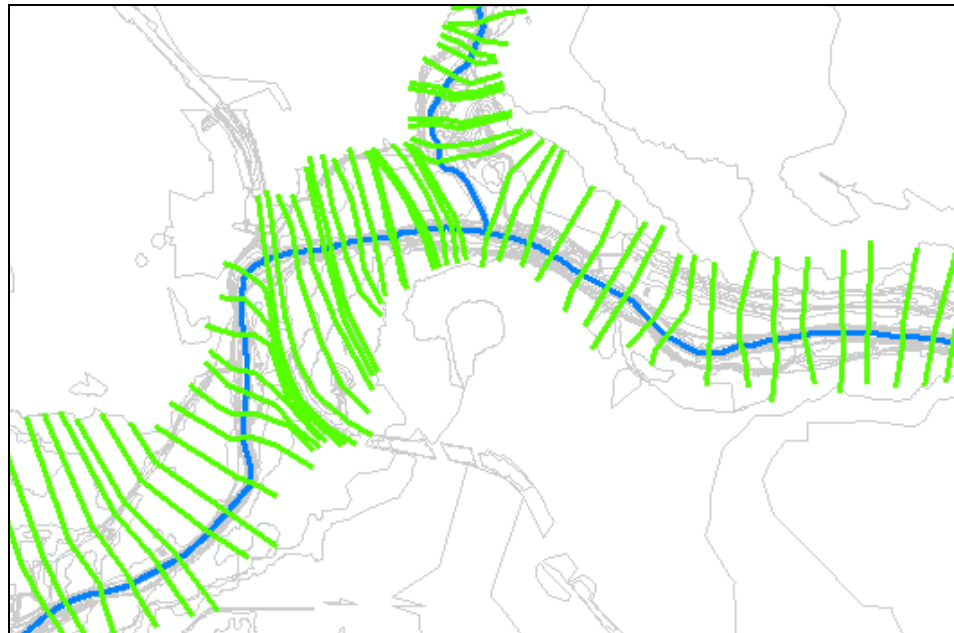
Figure 8-18. XS Cut Lines should span the entire floodplain.

Cut lines should always be located perpendicular to the direction of flow and oriented from the left to right bank. Cut lines must cover the entire extent of the floodplain to be modeled. Creating the Flow Path Centerlines layer prior to creating the cut lines will assist you in laying out the cut line perpendicular to flow.

Make sure you are in Editing mode. Select "***Create New Feature***" for the *Task* and "***XSCutLines***" as the *Target*. Digitize the cut lines from the left to right overbank as necessary to capture the floodplain geometry. Dog-leg the cut lines perpendicular to flow.

Previewing Cross Sections

The station-elevation data that will be extracted from the terrain model can be previewed using the **XS Plot** tool. This is useful to check that the cross section will span the entire floodplain to high ground and to identify the possible flow distribution in a cross section. To preview a cross section, follow the steps listed below.

1. Select the ▼ (**XS Plot**) tool.

2. Select the cross-sectional cut line of interest.

3. The cross section will be plotted in a new window, as illustrated in Figure 8-19.
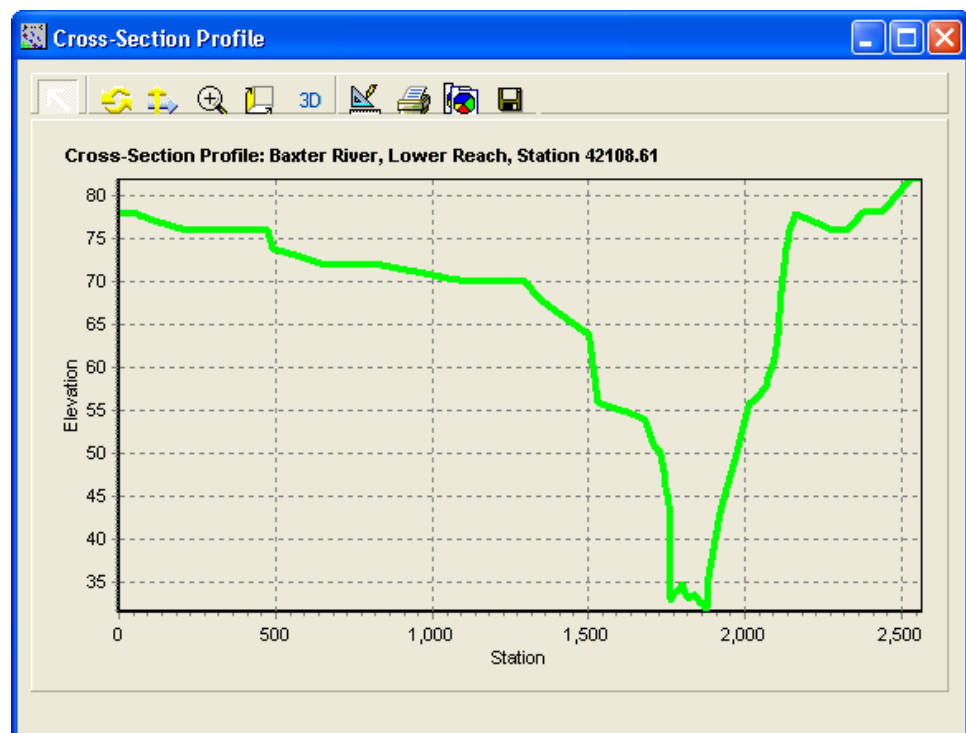
Figure 8-19. Example cross section plot.

The cross section plot title will contain the River, Reach, and Station information if the attributes have been computed for the cross section.

Attributes

Attributes are added to the Cross-Sectional Cut Lines layer from the **RAS Geometry | XS Cut Line Attributes** menu. Each attribute is computed based on the intersection of the cut lines with another layer.

Select the **River/Reach Names** menu item. This item will add river and reach names to each cut line based on the intersection with the stream centerline. If the process fails to run to completion, stop and fix your data prior to continuing.

Next, run the **Stationing** menu item. This will add a river station to each cross section based on the intersection with the stream centerline. Again, if the process fails to run to completion, stop and fix your data prior to continuing. However, this menu item will most likely work if the river reach names were successfully assigned.

Select the **Banks Stations** menu item to add the bank station locations to each cross section. Lastly, use the **Downstream Reach Lengths** menu item to assign reach lengths based on the flow path lines. You should verify that each cut line has been assigned a reach length.

If any operation fails to attribute you can find the problem cut line by opening the attribute table and looking at the associated field for the "first" record that has a zero value. This indicates the computation was not successful and no value could be assigned. Highlight the problem cut line and zoom to the selected feature in the map to identify (and fix) the origin of the issue.

Extract Elevations

Select the **RAS Geometry | XS Cut Line Attributes | Elevations** menu item to extract elevations from the terrain model. The elevation extraction process will convert the 2D features to 3D features. This will result in the generation of a new feature class. Elevations will be extracted at the edge of each triangle in a TIN or from the center of each GRID cell.

Bridges/Culverts

Bridges and culverts are treated much like cross sections. Make sure you are in Edit mode. Select "***Create New Feature***" for the *Task* and "***Bridges***" as the *Target*. Digitize the cut lines from the left to right overbank down the centerline of each bridge/culvert crossing.

Use background data, such as an aerial photo to locate bridge crossings. Final placement should be determined based on the terrain model so that the road centerline falls on the high ground of the approach. An example bridge location is shown in Figure 8-20. Note

how the high ground ends near the channel at the bridge opening. Bridge deck information will need to be completed in HEC-RAS.

Figure 8-20. Locate bridge cut lines at the road centerline to capture high ground.

Attributes

After digitizing each bridge location you will need to assign **River/Reach Names** and river **Stations** as done for the cross sections. These options are under the Bridge/Culverts menu item. Next, you will supply some bridge information in the attribute table. (You will need to be in Edit mode.) Enter the distance to the next cross section upstream in the *USDistance* field and the width of the bridge deck (in the direction of flow) in the *TopWidth* field. There is also a *NodeName* field provided for you to enter a short description of the bridge. Example attribute data for bridges is shown in Figure 8-21.

River	Reach	Station	USDistance	TopWidth	NodeName
Tule Creek	Tributary	4514.027832	100	96	Yosemite Street
Baxter River	Lower Reach	44367.347656	40	90	Highway
Baxter River	Lower Reach	45360.039063	40	20	Railroad

Figure 8-21. Example attribute data for bridges.

Extract Elevations

Select the **RAS Geometry | Bridges/Culverts | Elevations** menu item to extract elevations from the terrain model. The elevation

extraction process will convert the 2D features to 3D features. This will result in the generation of a new feature class.

Ineffective Flow Areas

Ineffective flow areas are used to identify non-conveyance portions of the floodplain. They are typically used around bridges to identify ineffective areas behind the bridge abutments through the contraction and expansion zones.

Make sure you are in Edit mode. Select "***Create New Feature***" for the *Task* and "***IneffectiveAreas***" as the *Target*. Digitize the polygons using the **Sketch** tool to represent the ineffective flow areas around the bridges you created earlier. One polygon should be used for each ineffective area. An example set of ineffective flow areas is shown in Figure 8-22. Note that although the contraction/expansion zones are non-linear the ineffective flow area data will only be extracted at the intersection with the cut lines.
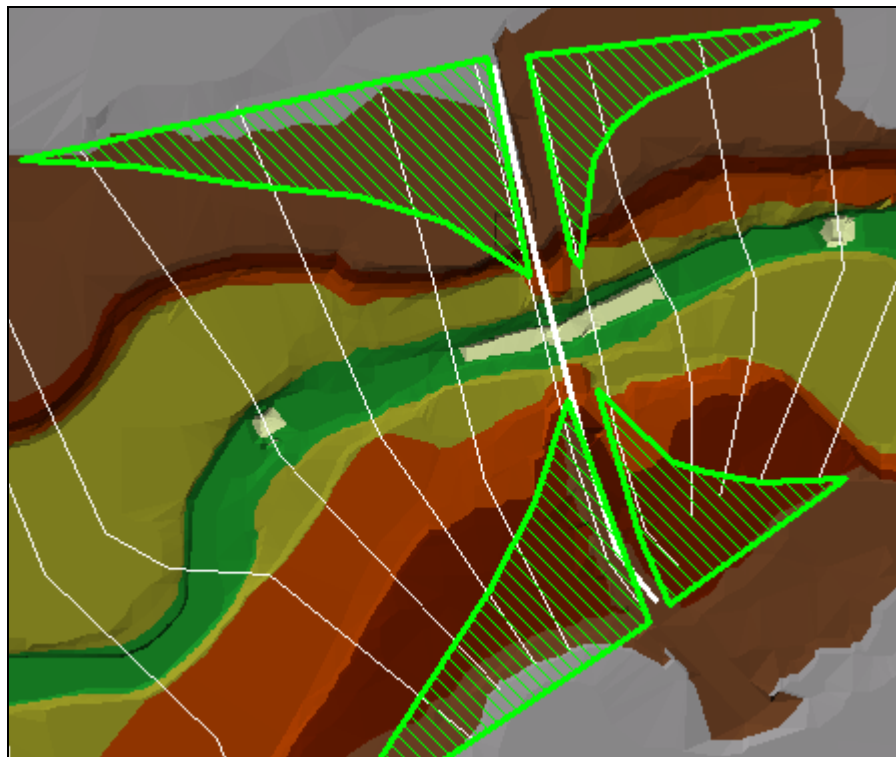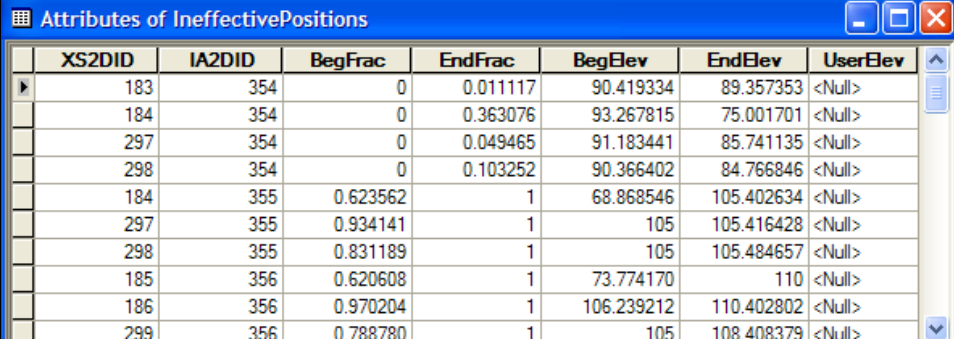
Figure 8-22. Example ineffective flow areas at a bridge.

After digitizing the ineffective areas, the positions and elevations at the cross sections are extracted. Select the **RAS Geometry | Ineffective Flow Areas | Positions** menu item. Data will be extracted for each ineffective area and saved to a table named "IneffectivePositions" (by default), as shown in Figure 8-23, which defines the beginning and end location of the ineffective area and the trigger elevation. You can override the default trigger elevation by

entering an elevation (like the top-of-road elevation) in the *UserElev* field. A dialog will also allow you to "keep current user elevations" if you had previously entered an elevation for a particular cross section.

	XS2DID	IA2DID	BegFrac	EndFrac	BegElev	EndElev	UserElev
▶	183	354	0	0.011117	90.419334	89.357353	<Null>
	184	354	0	0.363076	93.267815	75.001701	<Null>
	297	354	0	0.049465	91.183441	85.741135	<Null>
	298	354	0	0.103252	90.366402	84.766846	<Null>
	184	355	0.623562	1	68.868546	105.402634	<Null>
	297	355	0.934141	1	105	105.416428	<Null>
	298	355	0.831189	1	105	105.484657	<Null>
	185	356	0.620608	1	73.774170	110	<Null>
	186	356	0.970204	1	106.239212	110.402802	<Null>
	299	356	0.788780	1	105	108.408379	<Null>

Figure 8-23. Ineffective flow area data extracted at cross sections.

Blocked Obstructions

Blocked obstructions are used to remove flow area from cross sections and may be used to represent the impact of large buildings built in the floodplain – areas that are not represented in the DTM.

Make sure you are in Edit mode. Select "***Create New Feature***" for the *Task* and "***BlockedObs***" as the *Target*. Digitize the polygons using the **Sketch** tool to represent the area blocking out flow in the cross sections.

Figure 8-24. An obstruction (building) to flow in the floodplain is represented here using a blocked obstruction.

After digitizing the blocked obstructions, extract the positions at each cross section by selecting the **RAS Geometry | Blocked Obstructions | Positions** menu item. Data will be extracted for each obstruction and saved to a table named "BlockedPositions" (by default) as shown in Figure 8-25. You may enter an elevation for the top of each building in the *UserElev* field for each cross section.

XS2DID	BO2DID	BegFrac	EndFrac	BegElev	EndElev	UserElev
209	379	0.643788	1	74.596970	81.008850	<Null>
210	379	0.595829	1	74.856400	80.534325	<Null>
211	379	0.377860	0.954879	74.033295	79.191414	<Null>
212	379	0.747224	0.855509	75.370628	77.828659	<Null>
317	379	0.396623	0.903034	73.839996	78.352097	<Null>

Figure 8-25. Blocked obstruction positions table.

Land Use

The Land Use layer is a polygon data set used to establish roughness coefficients for each cut line. The Land Use layer must not be a "multi-part" data set for the GeoRAS methods to function (and there may be no gaps along a cross section). At a minimum, the land use data set must have a field that holds descriptive information about

each polygon. In this example, the field *LUCode* holds a description such as "Park".

You may digitize your own polygon data set or load the example data provided. Building a land use data set with numerous polygons is quite tedious. We will skip this and use the data set provided.

Remove the Land Use feature class built previously. Load the Land Use feature provided in the "Baxter.mdb" database. The land use data provided has numerous land use categories and even more polygons (as shown in Figure 8-26), so the first thing you need to do is assign an *n* value to each polygon.
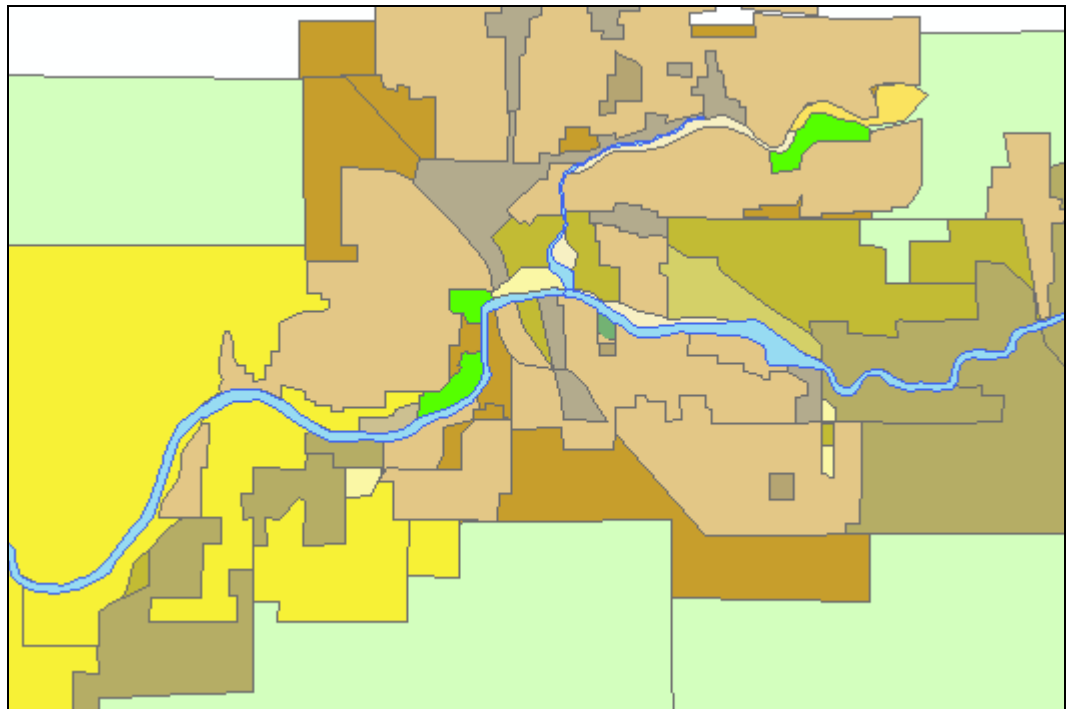

Figure 8-26. Land use data for the Baxter River area.

Use the **RAS Geometry | Manning's n Value | Create LU-Manning Table** menu item to create a summary table of land use data. In the dialog provided (see Figure 8-27), select the ***LUCode*** field for the *Landuse* field and press **OK**.
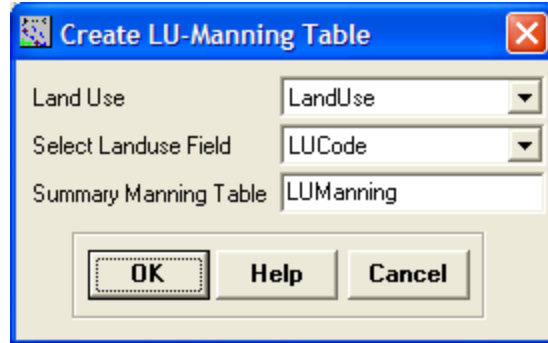
Figure 8-27. Create a summary table of land use types in which to enter n value data.

A table name "LUManning" will be created summarizing all of the land use types and allowing you to enter just one *n* value per land use. Make sure you are in Edit mode and open the "**LUManning**" table. Enter an *n* value for each land use type. An example of *n* values is provided in Figure 8-28.

Figure 8-28. Summary of land use type and associated n values.

Once the summary table is complete, you need to extract the *n* values along each cut line. Select the **RAS Geometry | Manning's n Value | Extract N Values** menu item. The dialog shown in Figure 8-29 will be invoked. You will need to select *LUManning* as the *Summary Manning Table*. Press **OK** to extract the data.
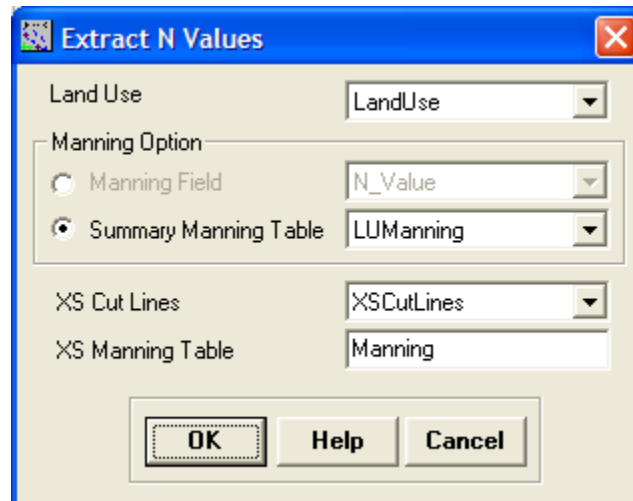
Figure 8-29. Extracting n values can be done from the Land Use layer or a summary n value table.

Manning's *n* value data are extracted for each cross section and reported to the "Manning" table. The position of the start of the *n* value as a fraction along the cut line and the value are reported to the table, as shown in Figure 8-30.

OBJECTID*	XS2DID	Fraction	N_Value
1777	202	0	0.060000
1778	202	0.275840	0.035000
1779	203	0	0.060000
1780	203	0.259681	0.035000
1781	204	0	0.060000
1782	204	0.236644	0.035000
1783	204	0.654236	0.050000
1784	205	0	0.060000
1785	205	0.179186	0.035000
1786	205	0.749720	0.060000
1787	206	0	0.060000
1788	206	0.238721	0.035000
1789	206	0.721169	0.050000
1790	207	0	0.060000

Figure 8-30. Example Manning's n value data extracted along cut lines.

Levee Alignments

The Levee Alignments layer is used to identify features that impede or direct the flow of water from moving out into the floodplain.

In our example, the members of the fictional Bushwood Country Club have elected to construct a levee to protect their beloved homes.

Although this levee is not in our DTM, we can incorporate the proposed elevation data into our GeoRAS model.

Make sure you are in Editing mode. Select "***Create New Feature***" for the *Task* and "**Levees**" as the *Target*. Digitize the levee line using the **Sketch** tool to represent the high ground. The levee alignment on the Baxter River (Lower Reach) protecting Bushwood Estates is shown in Figure 8-31.
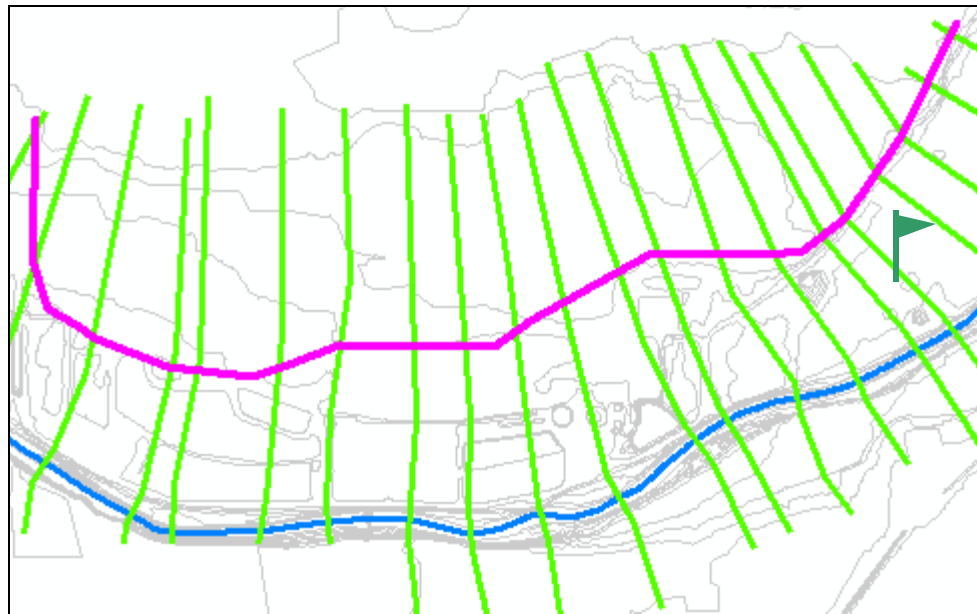
Figure 8-31. Levee alignment for Bushwood Estates.

Once the levee alignment is created, you need to assign elevations along the levee. A contractor has provided the top-of-levee information and we can easily enter it using the ⍟ (**Levee Elevations**) tool. Once the Levee Elevation tool is activated, click on the levee line. In the dialog that appears, the ground elevation will be reported. You can override the elevation by entering a specified elevation. A feature class named "LeveePoints" is created and the distance along the levee line and elevation are stored for each levee. The dialog for entering elevations and the levee point table is shown in Figure 8-32. Enter elevations along the entire levee alignment.
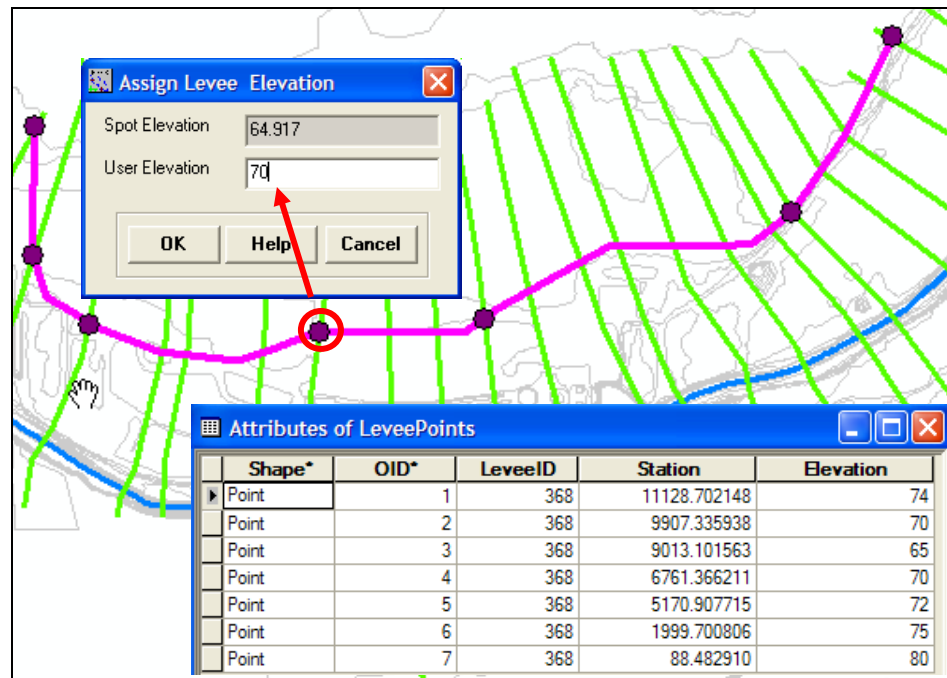
Figure 8-32. Levee elevation points are entered using the Levee Elevation tool.

After the levee elevation data are entered, you must convert the levee from a 2D feature to a 3D feature (this is also required if you get the elevation data from the DTM). Select the **RAS Geometry | Levees | Levee Completion** menu item. The elevation data entered in the "LeveePoints" feature class is interpolated (no extrapolation) along the levee line and the data is converted to a 3D feature.

Select the **Levees | Positions** menu item to extract the levee position and elevation at each cross-sectional cut line. A table named "LeveePositions" is created to store the data, as shown in Figure 8-33.

Figure 8-33. Levee position and elevation data extracted at cross sections.

Inline Structures

There are no inline structures in this example; however, they are treated similarly to the Bridge/Culvert feature class.

Lateral Structures

A lateral structure is used to represent a linear feature where flow will move laterally over a weir between reaches or between a river reach and storage area. A lateral structure is used to represent the top of a levee or high ground that may be overtopped. In our example, we will incorporate two storage areas on the Lower Reach of the Baxter River that will require a lateral structure.

Make sure you are in Editing mode. Select "***Create New Feature***" for the *Task* and "**Lateral Structures**" as the *Target*. Digitize the lateral structures in the **downstream direction**, using the **Sketch** tool, along the high ground. Cross-sectional cut lines should end at the lateral structures. Example lateral structures are shown in Figure 8-34.
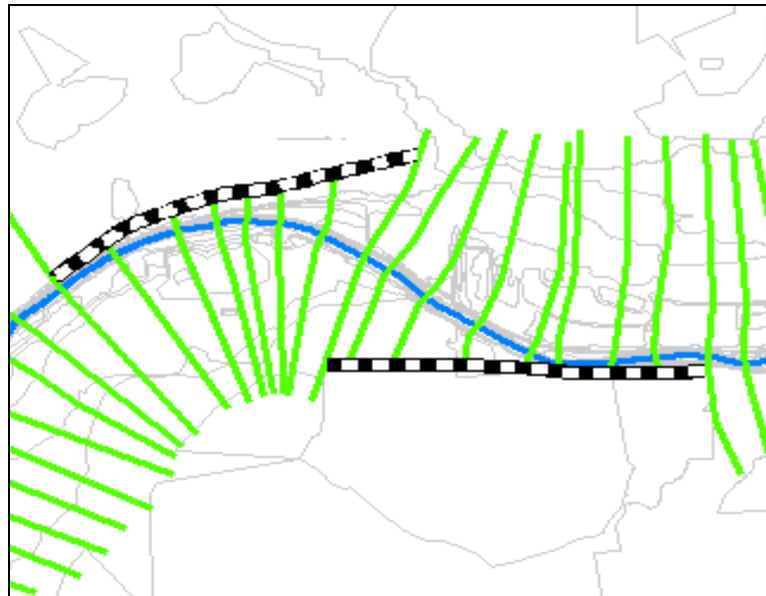
Figure 8-34. Example lateral structures at the end of cross sections.

Attributes

After creating the lateral structure locations, you must assign a river and reach name to the structure and identify the cross section to connect the structure. Select **the Lateral Structures | River/Reach Names** and the **Lateral Structures | Stationing** menu items. The assignment of the river station is computed based on the shortest distance from the upstream end of the structure to the nearest river reach. This process may not result in the desired river station – you may need to modify the river station!

Next (while in Edit mode) you need to specify a weir top width and distance to the upstream cross section. If you started the weir just downstream of a cross section the distance to the upstream cross

section could be entered as zero. Example data for the lateral weirs is shown in Figure 8-35.

	River	Reach	Station	USDistance	TopWidth	NodeName
▶	Baxter River	Lower Reach	27469.679688	0	20	North LS
	Baxter River	Lower Reach	33042.234375	0	20	South LS

Figure 8-35. Attribute information for lateral structures.

After the lateral structure information has been provided, you will need to convert the 2D feature class to a 3D feature class to extract the top-of-weir information. Select the **RAS Geometry | Lateral Structures | Elevations** menu item.

Storage Areas

Storage areas are used to model floodplain detention. A storage area is connected to a river reach by a lateral structure and to another storage area by a storage area connection. We have two storage areas in our example, one on the North side of the river and one on the South side of the river.

Make sure you are in Editing mode. Select "*Create New Feature*" for the *Task* and "**StorageAreas**" as the *Target*. Digitize polygons representing the storage areas using the **Sketch** tool. The storage areas used for this example are shown in Figure 8-36.
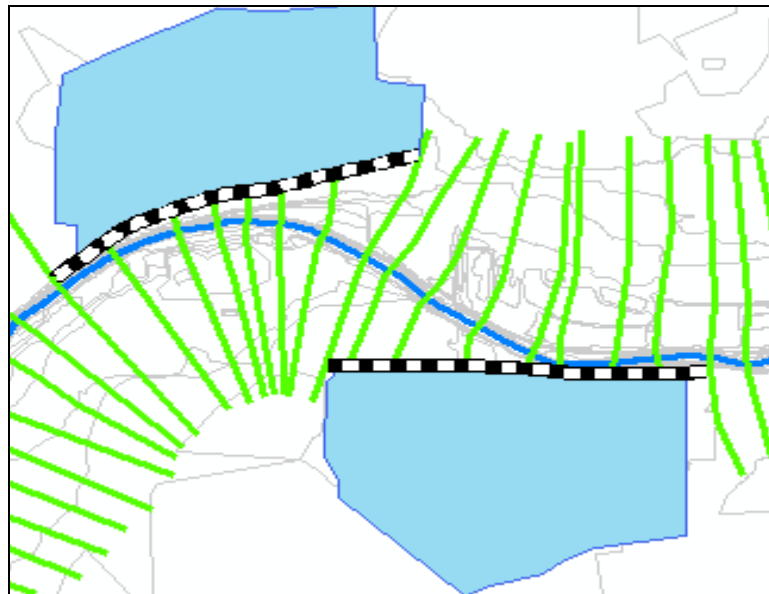

Figure 8-36. Storage areas connect to the river reach by lateral structures.

After digitizing the storage areas, extract the elevation-volume data. Select the **RAS Geometry | Storage Areas | Elevation Range**

menu item. This will identify the lowest and highest point within the storage areas and assign those attributes to the storage areas table under the names of *MinElev* and *MaxElev*. You can override the maximum elevation by entering an elevation in the *UserElev* field.

Next, extract the elevation-volume relationship by selecting the **RAS Geometry | Storage Areas | Elevation-Volume Data** menu item. Elevation-volume data will be written to a table named "ElevVol" for each storage area from the minimum to maximum elevation. The elevation interval is based on the elevation range divided by the "SliceCount" property (default is 10). Resultant elevation-volume data for the example storage areas is shown in Figure 8-37.

OBJECTID*	SAID	Elevation	Volume	Area
1	369	63.340000	0	0
2	369	64.589996	272682.78125	532602.75
3	369	65.839996	2102153.25	6547175.5
4	369	67.089996	11305359	8041993
5	369	68.339996	22415348	9809258
6	369	69.589996	35058528	10318466
7	369	70.839996	49214080	12055797
8	369	72.089996	64778916	12845528
9	369	73.339996	80952256	13013651
10	369	74.589996	97345688	13240751
11	369	75.839996	114224928	13613173
12	370	68.085831	0	0
13	370	69.214676	293325.96875	777340.9375

Figure 8-37. Elevation-volume data for storage areas.

Storage Area Connections

There are no storage area connections in this example. Storage area connections would be created much like a lateral structure, though it would connect a storage area with another storage area rather than storage area to a river cross section.

Generating the RAS GIS Import File

Prior to writing the results to the RAS GIS Import File, you should verify that GeoRAS is aware of which data sets you want to export. Select the **RAS Geometry | Layer Setup** menu item. Click through the tabs and verify that the dropdown list for each Layer contains the name of the correct data set. Screen shots for the Layer Setup for this example are shown in Figure 8-38 through Figure 8-41.
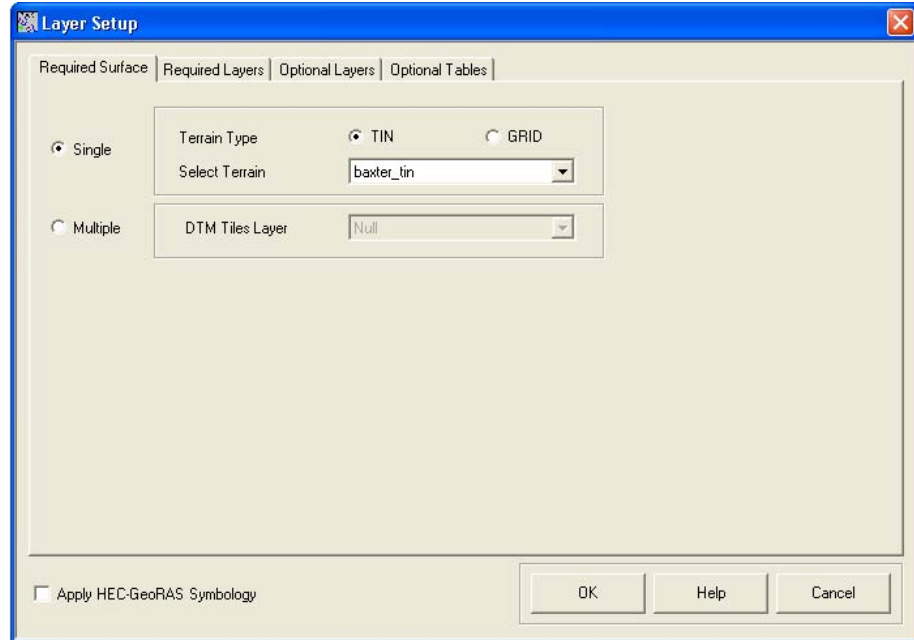
Figure 8-38. Layer Setup for geometric data extraction: Required Surface tab.

Figure 8-39. Layer Setup for geometric data extraction: Required Layers tab.

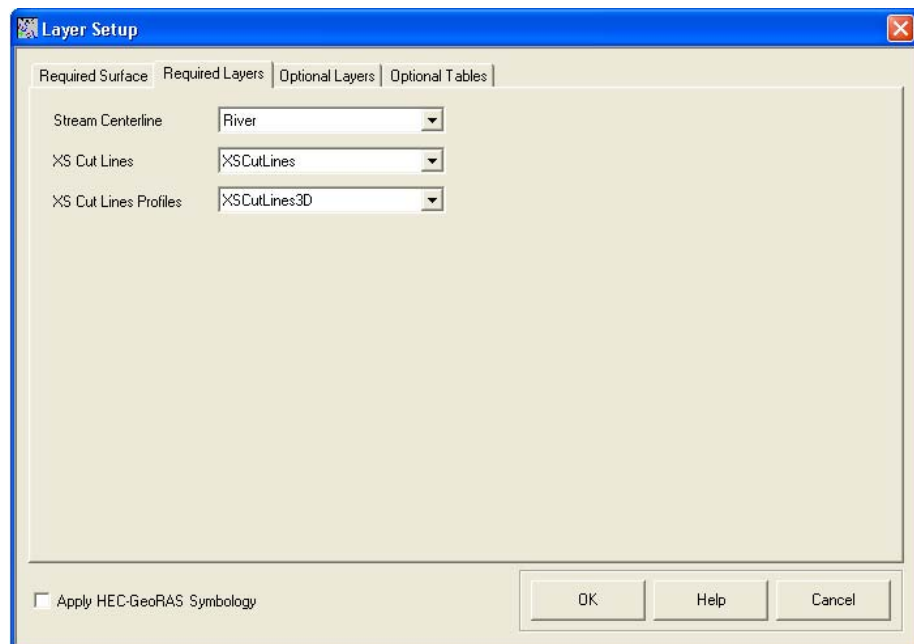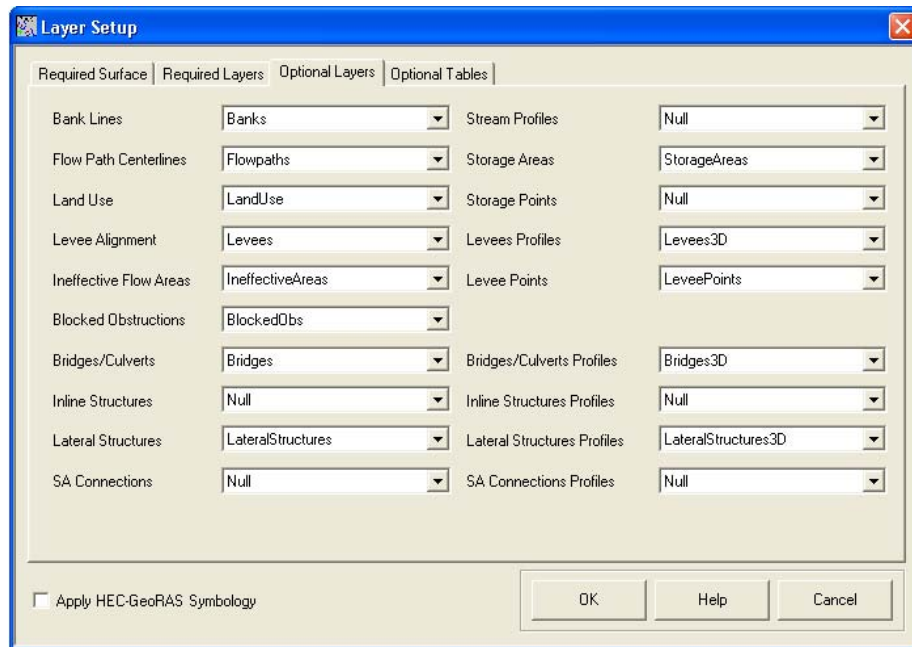*Figure 8-40. Layer Setup for geometric data extraction: Optional Layers tab.*
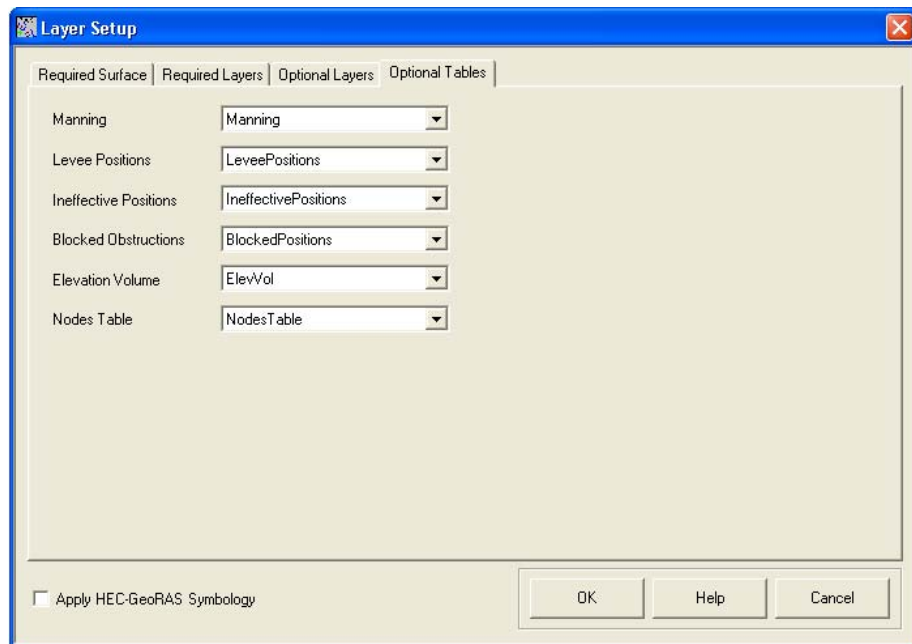
Figure 8-41. Layer Setup for geometric data extraction: Optional Tables tab.

After verifying the data that will be exported, select the **RAS Geometry | Export RAS Data** menu item. The dialog shown in Figure 8-42 will be invoked allowing you to choose the destination directory and filename.
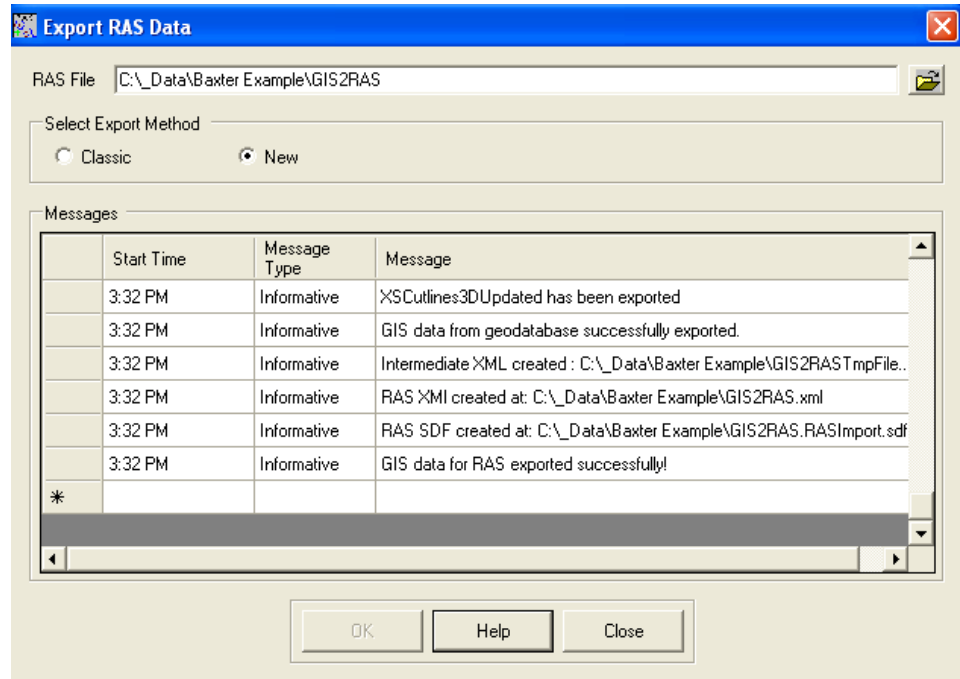
Figure 8-42. Filename and location for GIS export.

After pressing **OK**, GeoRAS will export the GIS data to an XML file and then convert the XML file to the SDF format. Two files will be created: "GIS2RAS.xml" and "GIS2RAS.RASImport.sdf". This process will take several seconds. Successful completion will result in the "GIS data for RAS exported successfully!" message and access to the **Close** button.

HEC-RAS Hydraulic Analysis

HEC-RAS allows you to perform one-dimensional steady-flow and unsteady-flow analysis of river systems. The general steps in using HEC-RAS in concert with GeoRAS are discussed in this section. A complete discussion on using HEC-RAS software, modeling guidelines, and technical information can be found in the HEC-RAS User's Manual, Applications Manual, and Hydraulic Technical Reference Manual.

Start a New Project in HEC-RAS

Open HEC-RAS and save the project to the directory to which you want the HEC-RAS data files to be saved.

Import the RAS GIS Import File

Open the Geometric Data Editor and select **File | Import Geometry | GIS Format**. Navigate to the RAS GIS Import File

"**BaxterRiver.RASImport.sdf**" and select it. The data will be read into the data importer. Several tabs will provide you with import options.

The data set is in US Customary units so click on the **Next** button on the *Intro* tab (see Figure 8-43).
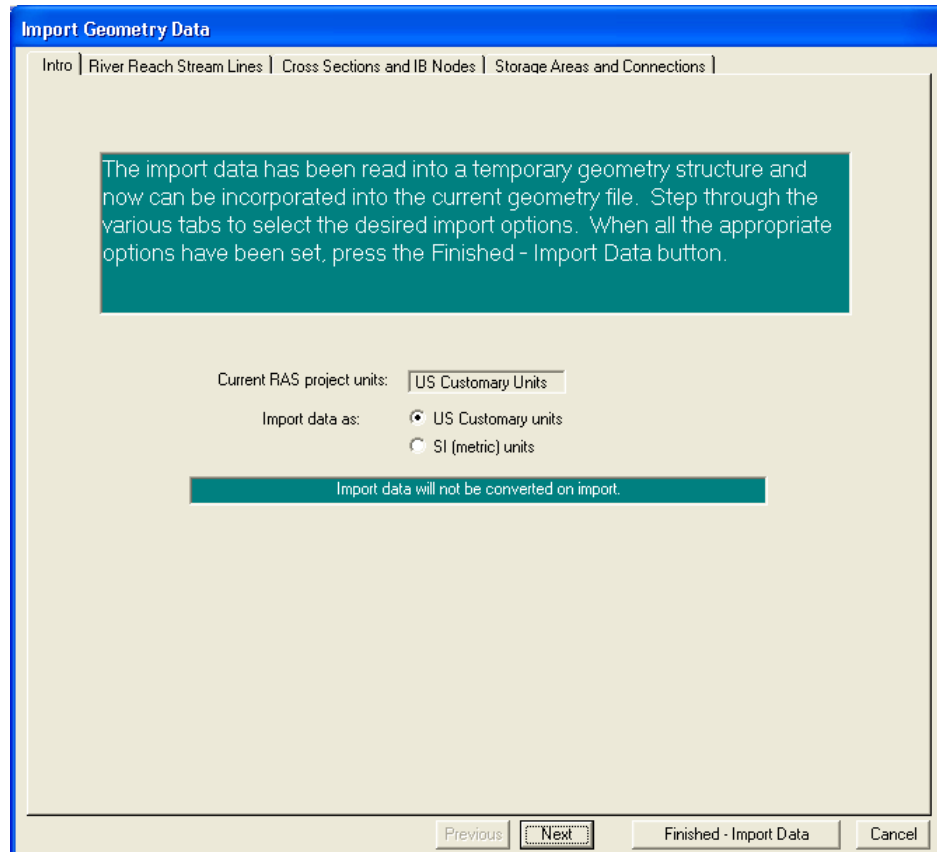
Figure 8-43. The first import option allows you to convert units.

The *River Reach Stream Lines* tab, shown in Figure 8-44, allows you to choose which stream centerlines to import. Make sure that all stream lines are check and press the **Next** button.
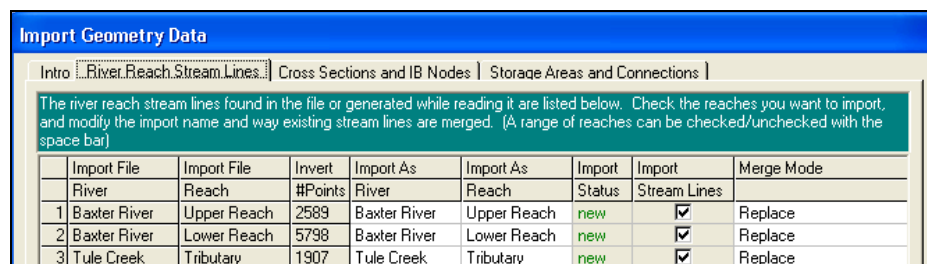
Figure 8-44. Import options for river and reaches.

The *Cross Sections and IB Nodes* tab, shown in Figure 8-45, has the most options available. This is the window that will allow you to import various cross sections and their properties.

Figure 8-45. Cross section and internal boundaries import options.

Go through each node and **Turn Off** the data import for all bridges (BR nodes). To do this select on the Bridge and Culvert node type, then uncheck the Import Data option, as shown in Figure 8-46. You are going to import them later.

Figure 8-46. You can access different node types, such as bridges, through the data importer.

Next, as shown in Figure 8-47, select the entire **Import AS RS** column by clicking in the header. Select the number of decimal places to be "**0**" and press the **Round** button. This will change the river stations to show the river stationing to the nearest foot. Press the **Next** button to continue.
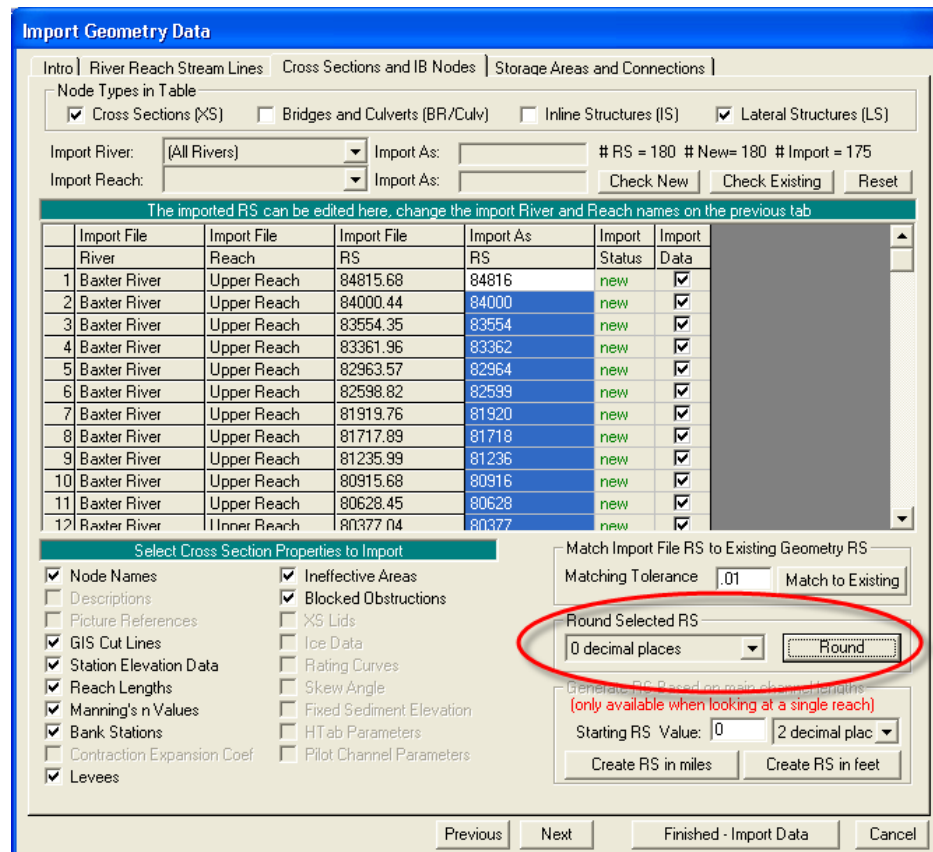
Figure 8-47. Import options allow you to change the cross section river stations.

The next tab brings you to the *Storage Areas and Connections* options, shown in Figure 8-48. The two storage areas are checked. Press the **Finished –Import Data** button to import the data.
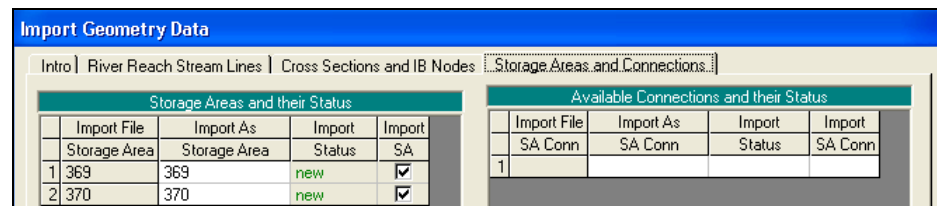
Figure 8-48. Storage areas import options.

Once the data is imported, the Geometric Data editor schematic will show a georeferenced schematic of the river system, as illustrated in Figure 8-49. You will see the river network, cross sections, storage areas, and feature labels. Other display options are available from the **View** menu. **Save** the geometry.
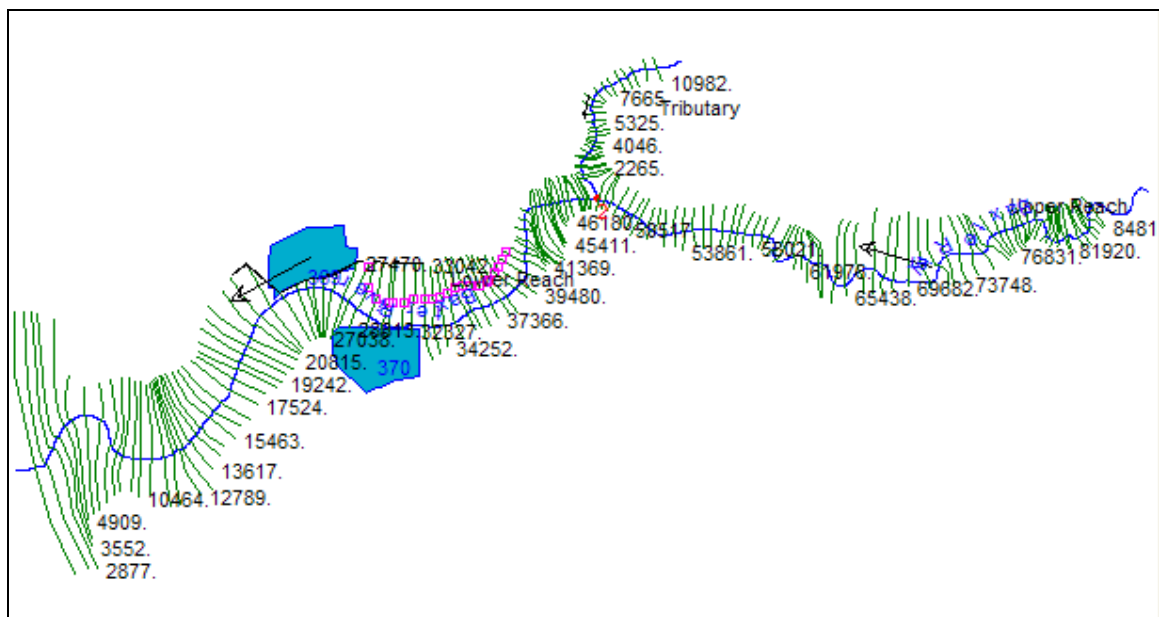
Figure 8-49. Georeferenced HEC-RAS schematic generated from imported GIS data.

After importing the geometric data, the first thing you need to do is perform a quality check on the data. Make sure there are no obviously erroneous or missing data. Next, look at your data more closely by going though the plot of each cross section. Check that the Manning's *n* value data are reasonable, bank stations are placed correctly, levees, ineffective areas, and blocked obstructions are placed correctly spatially and have the correct vertical component.

One of the best tools for visualizing and editing data is the Graphical Cross Section Editor. Select the **Tools | Graphical Cross Section Edit** menu item on the Geometric Data editor. The Graphical Cross Section Editor, shown in Figure 8-50, allows you to perform numerous editing tasks.

- Move the expanse of Manning's *n* values.

- Move the location of bank station data.

- Add/move/delete ground points.

- Add/move/delete levees, ineffective areas, and blocked obstructions.

- Compare and merge cross section elevation data.
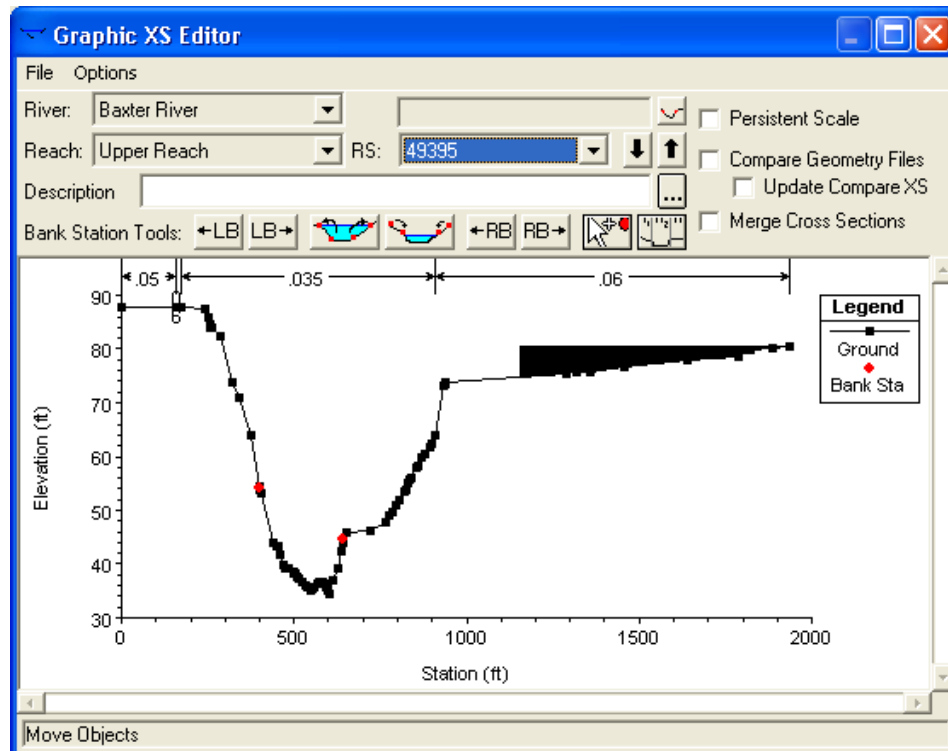
Figure 8-50. Graphical cross section editor in HEC-RAS.

Cross Section Points Filter

Cross sections can have a maximum of 500 elevation points in HEC-RAS. This number is typically <u>far more</u> than you need to adequately describe the cross section, given the accuracy of the underlying terrain model. HEC-RAS has a cross section point filter that you can use to remove excess/duplicate points. Select the **Tools | Cross Section Points Filter** menu item.

In the points filter, select the **Multiple Locations** tab and **Minimize Area Change** tab, as shown in Figure 8-51. Next select **All Rivers** for the River option and press the **arrow** button. This will select all cross sections to filter. Enter **100** for the number of points to filter down to. In this example, note that most of the data has about 100 points, but some have almost 500. Press the **Filter Points on Selected XS** button.
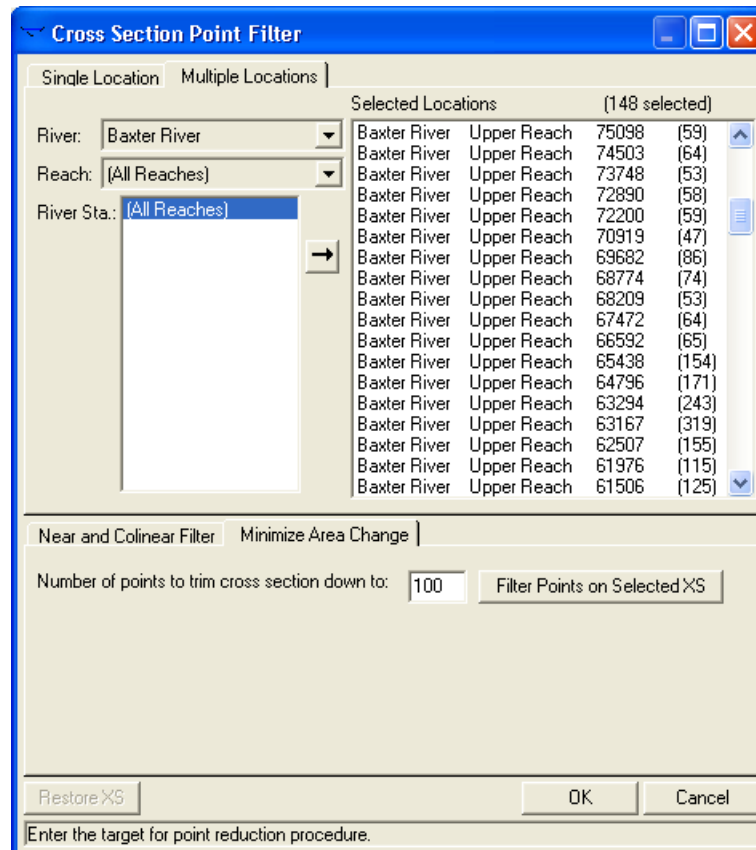
Figure 8-51. Use the cross section points filter to remove redundant points.

Points will be filtered to reduce (minimize) the impact to the overall area of the cross section. The dialog shown in Figure 8-52 will report the results of the filtering when finished. Note that only a few sections had significant point removal. You can click back on the *Single Location* tab to see the impact filtering had on any given cross section.

Figure 8-52. Results of the filtering process.

Hydraulic Structure Data

Prior to looking at the lateral structures, modify the names of the storage areas. On the Geometric Schematic, select the **Edit | Change Name** menu item. Click on the storage area and enter "Northside" and "Southside" for the respective storage areas, as shown in Figure 8-53. After renaming the storage areas, uncheck the Change Name menu item.
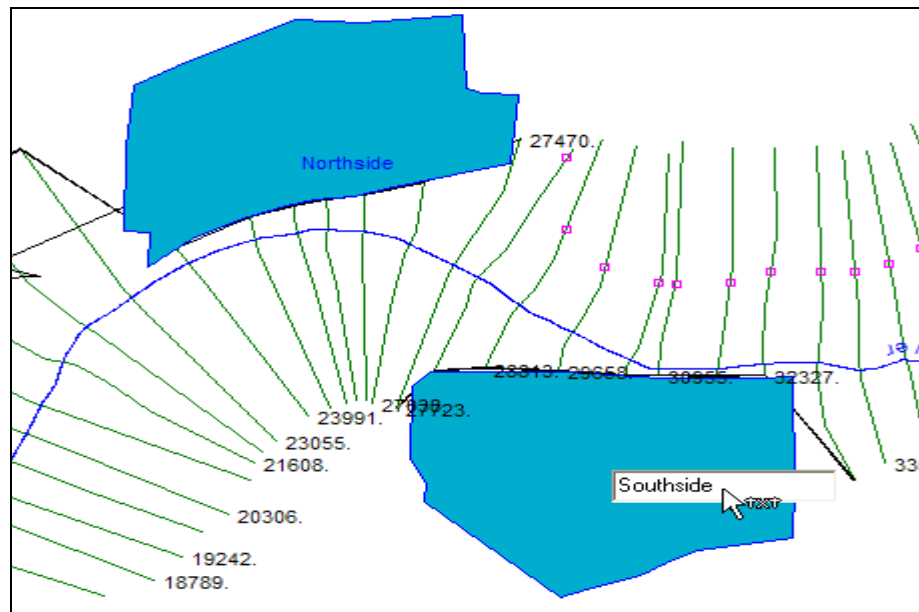
Figure 8-53. Rename the storage areas with meaningful names.

At this point, the only hydraulic structures that have been imported are the lateral structures. You will need to complete the data for the lateral structures. Access the Lateral Structures editor shown in Figure 8-54. Select the Baxter River Lower Reach and make sure that the "North LS" is on the "**Right Overbank**" and the "South LS" is on the "**Left Overbank**".

You will also need to connect the structures to the respective storage areas. Connect the lateral structure to a storage area by choosing the **Set SA** button in the *Tailwater Connection* frame. We will not be changing any of the other structure properties. After setting both storage areas, apply the data changes and save the geometry file.
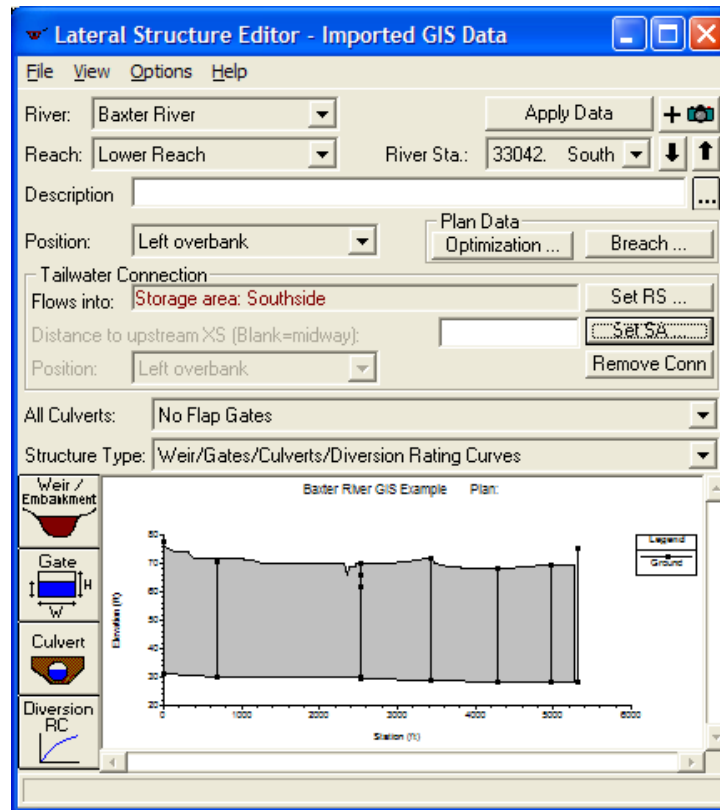
Figure 8-54. Lateral structures editor in HEC-RAS.

Now import a bridge and go through the typical steps for completing bridge data. Select the **File | Save As** menu item on the Geometric Data editor. Save the RAS geometry to a new name (like "GIS Import + Bridge"). Next, select the **File | Import Geometry | GIS Format**. Navigate to the RAS GIS Import File "***BaxterRiver.RASImport.sdf***" and select it. The data will be read into the data importer. This time you are ONLY importing 1 bridge!

On the *River Reach Stream Lines* tab unselect all of the river reaches, as shown in Figure 8-55, by clicking in the **Import Stream Lines** header and toggling the checkboxes off with the spacebar.

Figure 8-55. Do not re-import the reach lines.

On the *Cross Sections and IB Nodes* tab make sure the *Import River* is set to **All Rivers** and uncheck the **Import Data** option for all river stations. Using the *Round Selected RS option*, round the river stations

to "**0 decimal places**" for **All Rivers**. Then check only the *Bridges and Culverts* node type. Next, place a check next to the bridge located on the Baxter River Lower Reach at river station **45360**, as shown in Figure 8-56. Make sure this is the only river station checked for import.
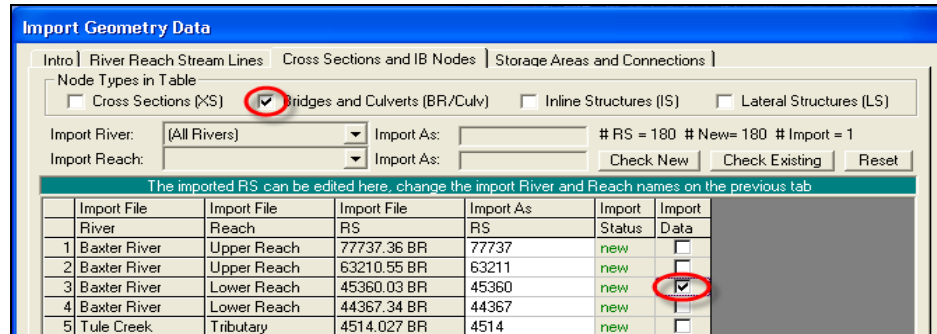
Figure 8-56. Import a single bridge using the GIS data importer.

On the *Storage Areas and Connections* tab, make sure no storage areas are checked for import. Press the **Finished — Import Data** button when ready. The single bridge will be imported into the HEC-RAS geometry. Save your geometry.

Access the Bridge/Culvert editor and select the "Railroad" bridge just imported. As shown in Figure 8-57, the bridge deck information is not complete. This is because the bridge deck data was not in the terrain model. You can see the approximate elevation of the bridge deck on the left bank and the elevation it should tie into on the right bank.
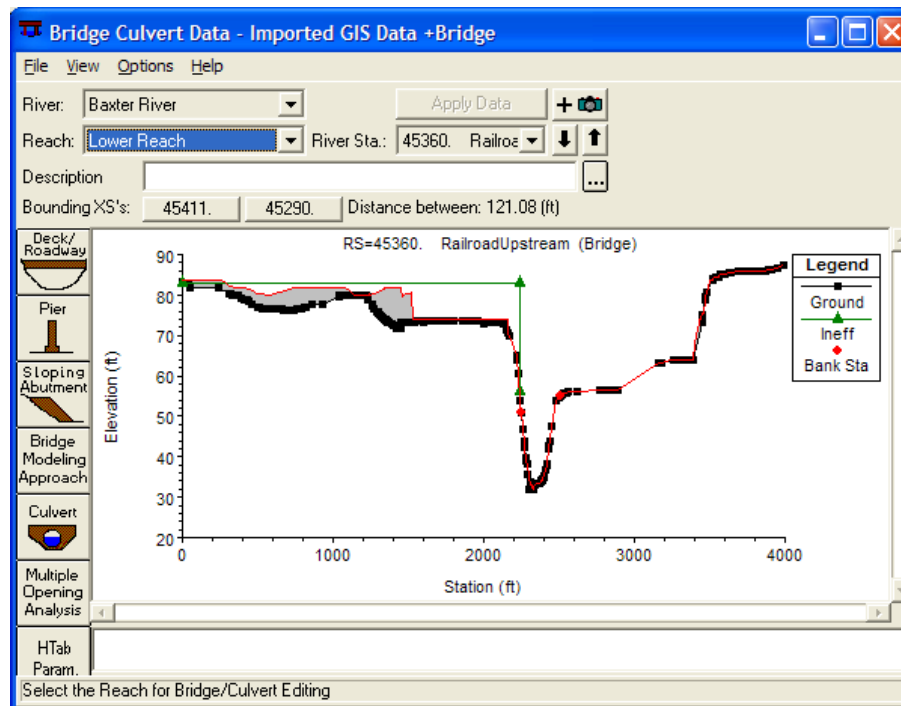
Figure 8-57. Bridge deck information imported from GIS data will not be complete.

We will approximate the bridge as having an opening 1200 feet wide with bridge deck elevation of 83 feet and 5 feet deep. There are 12 piers, 10 feet wide, spaced at 100 foot intervals. Use the deck/roadway editor and the Bridge Design editor to enter the bridge information shown in Figure 8-58. You will also need to modify the ineffective areas on the cross sections bounding the bridge. The final bridge is shown in Figure 8-59.
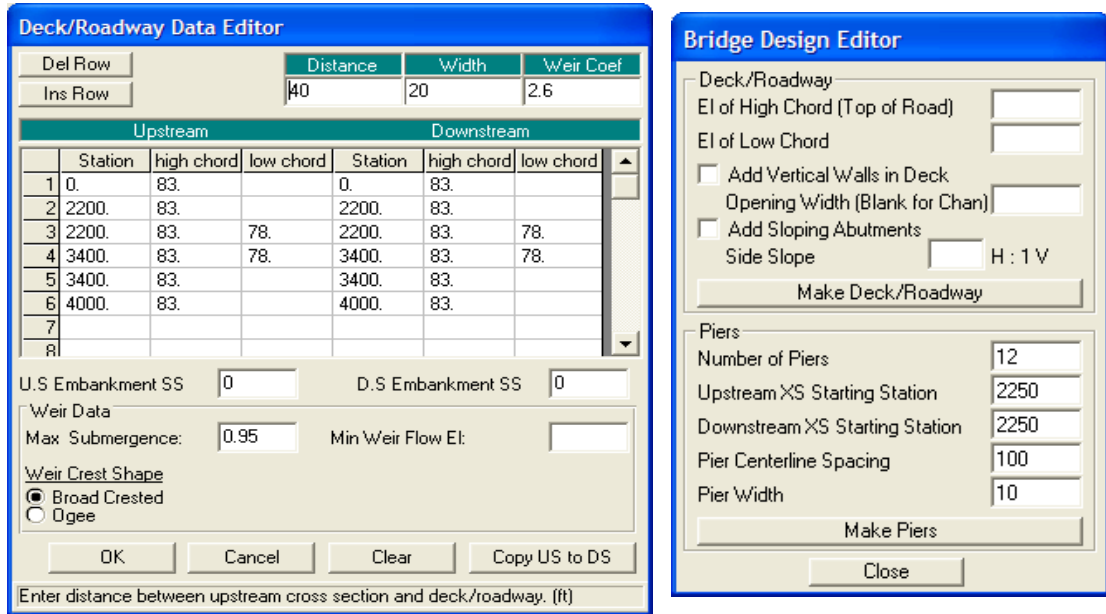
Figure 8-58. Bridge deck and pier information.
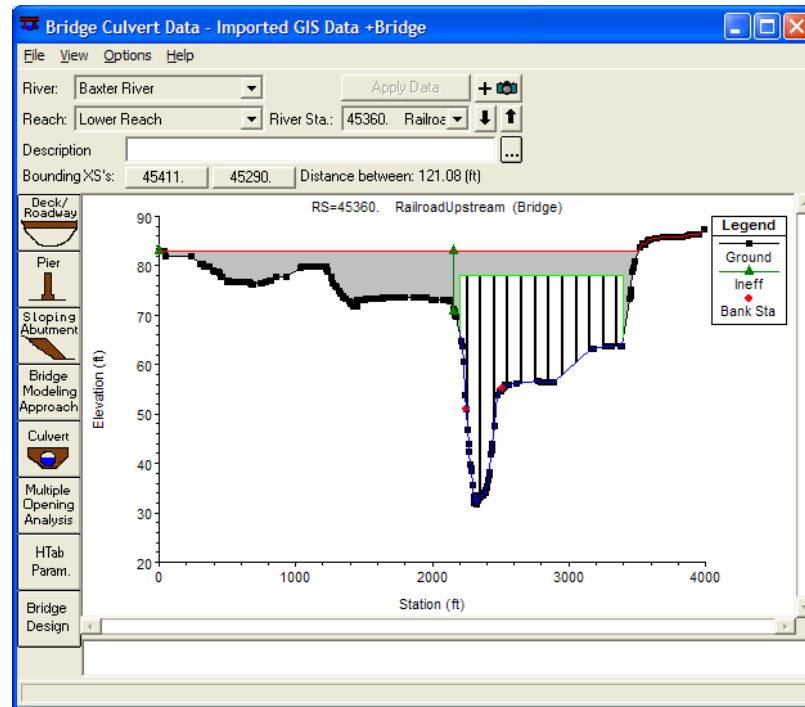
Figure 8-59. Completed bridge information.

You may continue by importing additional bridges and completing the data. You will also need to set the *Bridge Modeling Approach* for each bridge and adjust other parameters.

After the bridge data has been entered, revisit the ineffective flow area data and adjust the spatial location and elevations around bridges. You will also need to go through each blocked obstruction and raise the elevation to the height of the building it is representing.

Flow Data and Boundary Conditions

For this example, we are going to put together an unsteady-flow model. When developing an unsteady-flow model, however, you should always put together a steady-flow model to evaluate the river system under a range of flows.

Steady Flow

Enter multiple profiles to cover the range of flows the unsteady-flow model will experience. In this example, enter **3** steady flow profiles (though typically you would enter many profiles to cover the range of flows), as shown in Figure 8-60. Enter a descriptive name for each profile by selecting the **Options | Edit Profile Names** menu item. You will also need to set the downstream boundary condition (use Normal Depth Slope = **0.001**) using the **Reach Boundary Conditions** button. Set the initial storage area elevations to the minimum elevation of each storage area by selecting the **Options | Set Storage Area Elevations** menu item.
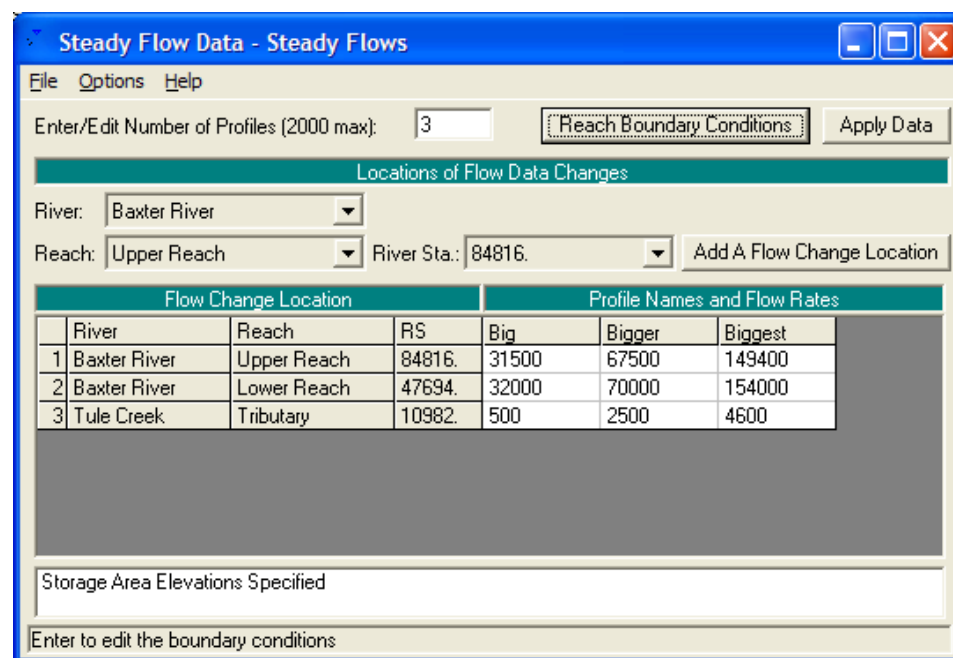
Figure 8-60. Steady flow and boundary conditions data editor.

Access the **Steady Flow Analysis** window and press the **Compute** button to calculate water surface profiles for the three flows. HEC-RAS will perform checks on your data. If you did not enter all the required data for performing a steady-flow run, HEC-RAS will not compute and will give you an error message to fix your data.

After successful simulation, you should go through the RAS output and verify the results. The Profile Plot and Cross Section Plots are very effective tools for identifying problem areas. Most likely, you will need to adjust ineffective areas around bridges so that the conveyance upstream and downstream of the bridge becomes effective at the same time.

The last item to verify is the bounding polygon information, using the **GIS Tools | Plot GIS Profile Reach Bounds** tool. You want to make sure that the HEC-RAS results will produce an appropriate floodplain in the GIS. For this example, we have a levee on the North side of the Lower Reach. If the levee is overtopped, you expect the bounding polygon to go to the edge of the cross section – and you would want all of the levees in the surrounding area to be overtopped together. If it is not overtopped, you expect the bounding polygon to follow the edge of the levee as is illustrated in Figure 8-61.
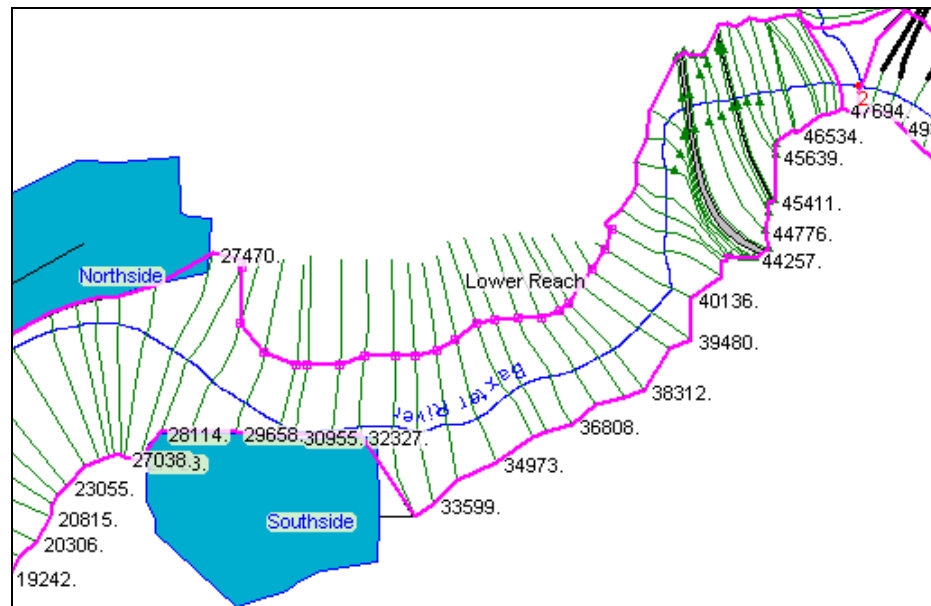
Figure 8-61. Examine the bounding polygon for each water surface profile.

After verifying the RAS results, you would export the water surface profile results to the GIS and perform floodplain delineation with GeoRAS. You would then examine the floodplain boundary and identify how you could improve the river hydraulics model. The floodplain mapping step is discussed later in this section.

Unsteady Flow

Unsteady-flow modeling is more complicated than steady-flow modeling. You should always put together a steady-flow analysis to iron out issues with your model prior to modeling in unsteady flow.

For unsteady-flow modeling, you will need to examine the hydraulic properties tables for each cross section and each bridge. You want to avoid having abrupt changes in hydraulic properties and you want the properties to cover the entire range of expected flows. HEC-RAS will come up with default parameters for building hydraulic property tables for cross sections, but for bridges (at a minimum) you will need to specify a maximum head water elevation. The hydraulic table properties are accessed from the Cross Section editor and Bridge editor from the **HTab** button.

You will need to enter hydrographs, boundary conditions and initial conditions through the Unsteady Flow editor, shown in Figure 8-62. For this example, use an inflow hydrograph for the Baxter River that has a baseflow of about 2,000 cfs and peak of about 150,000 cfs (see Figure 8-63). The inflow hydrograph for Tule Creek has a baseflow of about 2,000 cfs and peak of about 10,000 cfs.
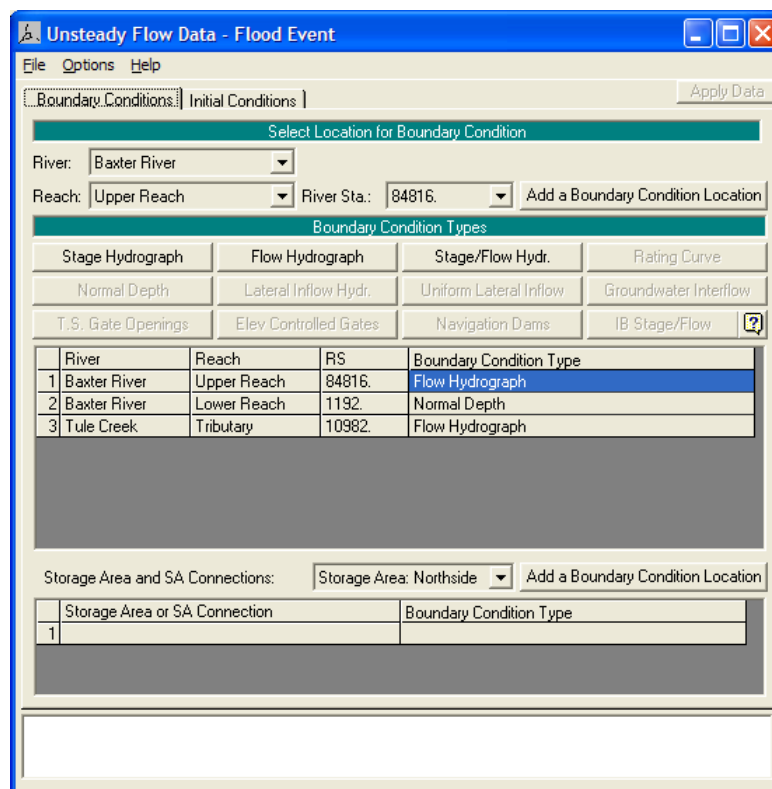
Figure 8-62. Unsteady Flow data editor in HEC-RAS.

Initial conditions were set for the Baxter River and Tule Creek as shown in Figure 8-64. Note that you must set an initial stage for the

storage areas. The initial elevations for the storage areas were set to make them "dry" at the start of the simulation.
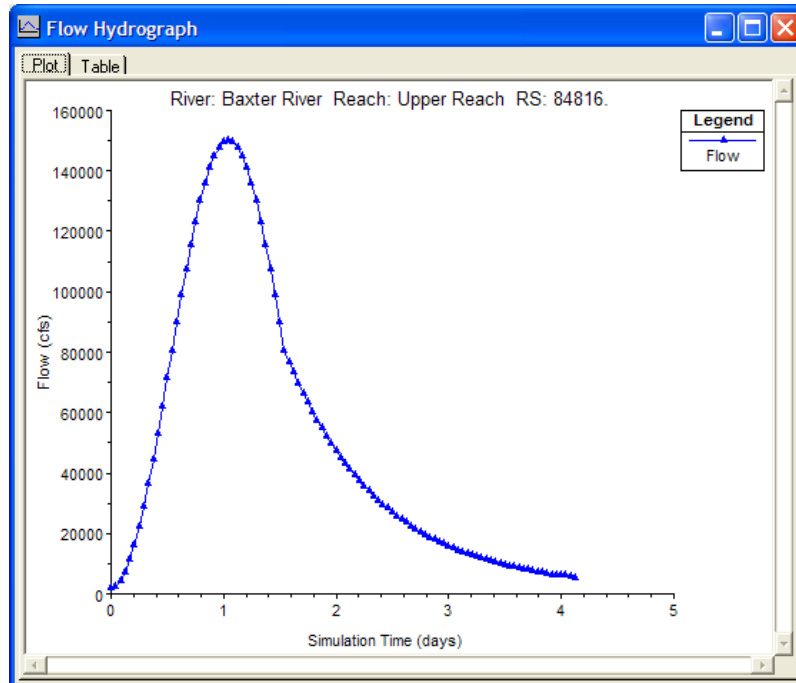
Figure 8-63. Example inflow hydrograph for the Baxter River.
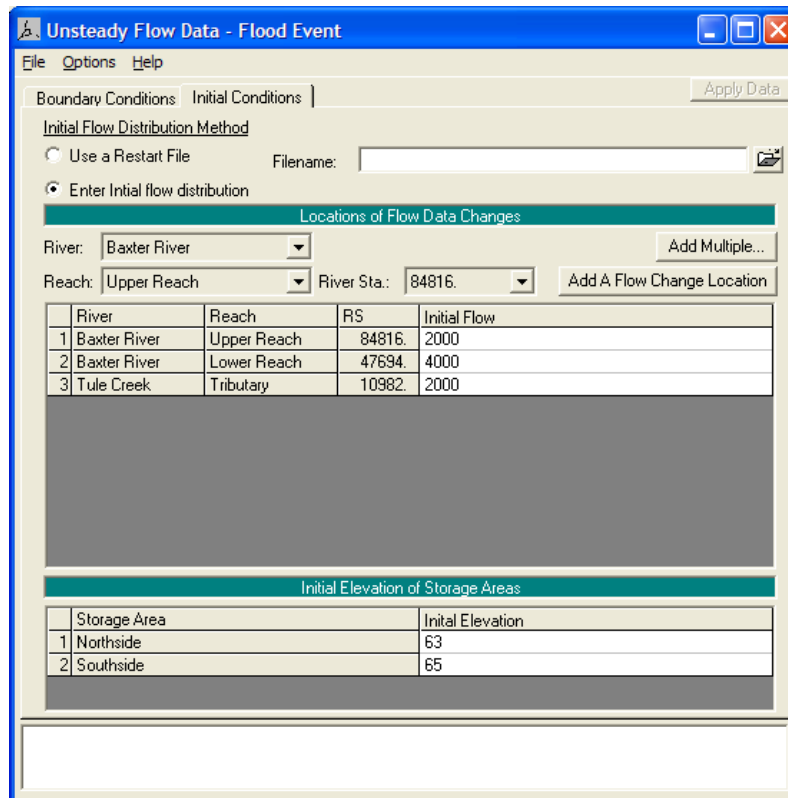
Figure 8-64. Unsteady flow boundary conditions.

Once the geometry and flow data has been entered (checked and refined) you are ready to simulate. Open the Unsteady Flow Analysis window and create a new plan. to compute detailed velocities, select the **Options | Flow Distribution** Locations menu item. In the dialog that appears, select the Global Subsections for the left overbank, main channel, and right overbank, as shown in Figure 8-65.
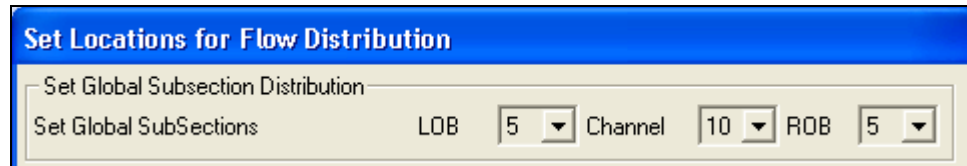
Figure 8-65. Detailed velocity output easily selected for all cross sections using the Global Subsections option.

Next, check on the three programs to run: **Geometry Preprocessor**, **Unsteady Flow Simulation** and **Post Processor**. Establish a *Simulation Time Window* and select the *Computation Settings*. You will need to select an appropriate *Computation Interval* based on cross section shape, spacing, and hydrograph characteristics. This example is not very sensitive to the time step selected – here we have selected a 10-minute time step. Your Unsteady Flow Analysis window should look similar to that shown in Figure 8-66. Press the **Compute** button to perform the unsteady flow simulation.
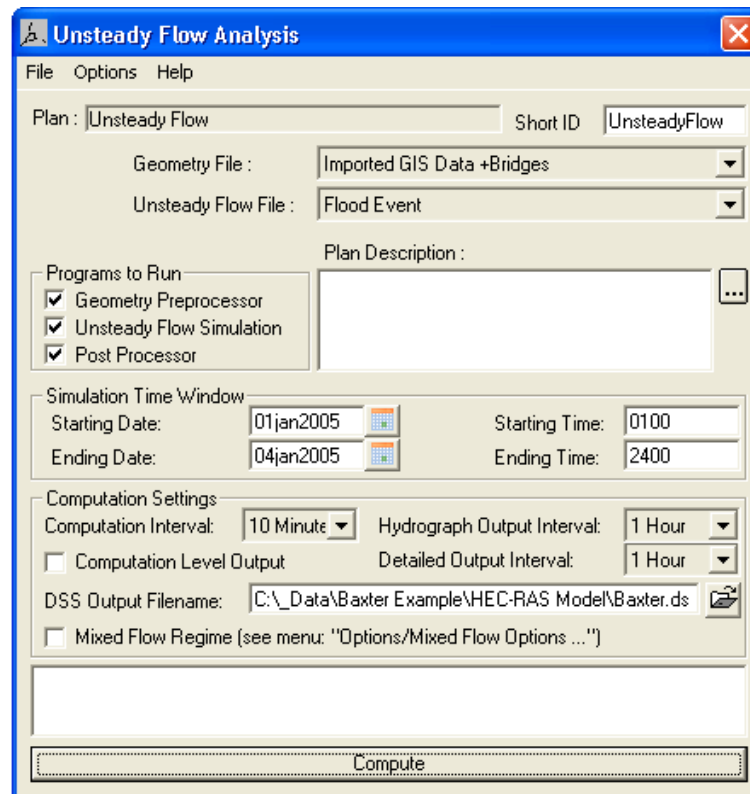
Figure 8-66. Unsteady Flow Analysis window for HEC-RAS.

Assuming the program successfully runs to completion, you will need to review the detailed model output and assess how you can improve your model. Model refinement may require getting more data from the GIS or adjusting model parameters. You may need to modify the initial conditions, computation interval, or program tolerances to create a stable RAS model.

After reviewing all the data, simulate again. Review model results, refine the model, and simulate. Once you are satisfied with the hydraulic model, export the results to the GIS for inundation mapping.

Export the HEC-RAS Results

Open the "Steady Flow" HEC-RAS plan. Select the **File | Export GIS Data** menu item from the main HEC-RAS window. The dialog shown in Figure 8-67 will be invoked allowing you to select the profiles of interest to export. For steady flow, you will have three profiles to choose from, while for unsteady flow you would have many profile choices.

Enter the filename and directory to store the RAS GIS Export File (*RASExport.sdf*). It will default to the directory where your project is stored. Press the **Select Profiles to Export** button and select all of the profiles. Also, turn on the **Velocity Distribution** export option.

Press the **Export Data** button to generate the export file.
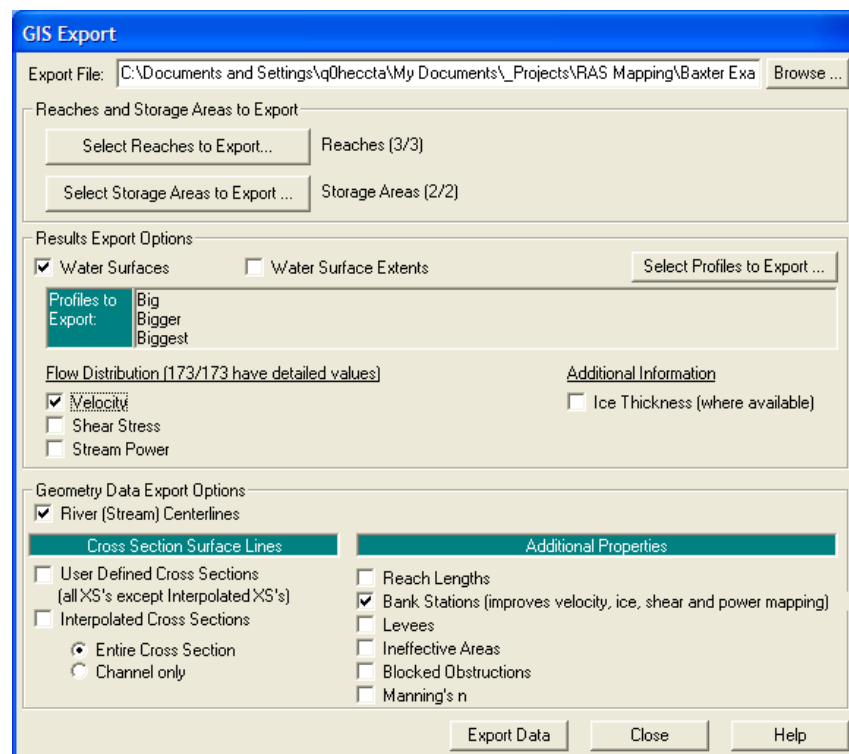
Figure 8-67. HEC-RAS GIS Export dialog.

RAS Mapping

The mapping of HEC-RAS results occurs with two basic tasks: (1) import the HEC-RAS results to the GIS as feature classes and (2) perform the mapping analysis.

Import the RAS GIS Export File

You must convert the SDF file exported from RAS to an XML format that GeoRAS can read. Press the ⚡ (**Convert SDF to XML**) button on the GeoRAS toolbar. The dialog shown in Figure 8-68 will allow you to select the RAS GIS Export File (SDF) and will convert it to an XML file. The same filename and directory are used to store the new file.
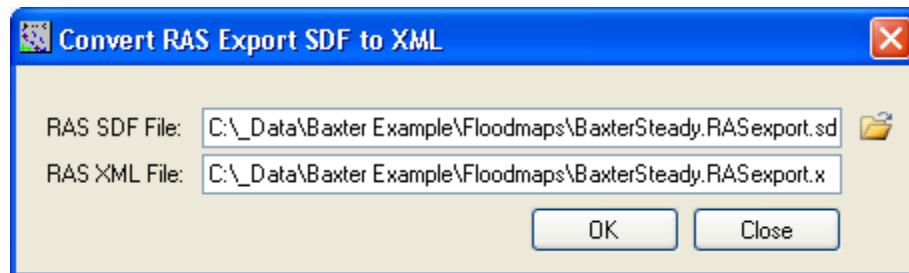
Figure 8-68. RAS SDF conversion to XML dialog.

Next, select the **RAS Mapping | Layer Setup** menu item to access the Layer Setup dialog, shown in Figure 8-69.
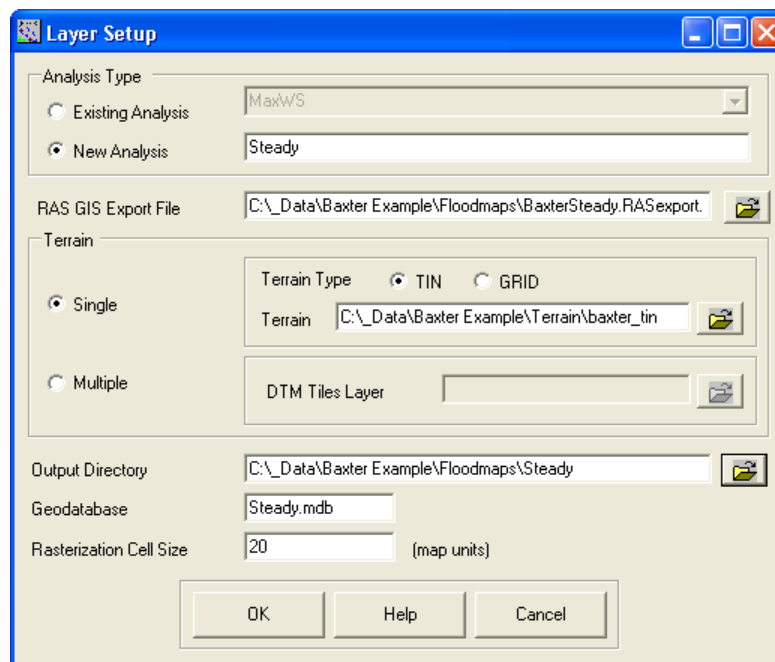
Figure 8-69. Layer Setup dialog for processing HEC-RAS results in GeoRAS.

Enter a *New Analysis* name "***Steady***" and select the ***RASExport.xml*** file to read. Verify the *Terrain* model and select the directory to store results. The name of the Analysis will be appended to the directory you choose. Enter a *Rasterization Cell Size* (here we've used 20) for the resultant inundation depth grid (you may need to refine the grid-cell size to improve the floodplain delineation). Press **OK** to dismiss the layer setup. A new map called "Steady" will be created and the terrain model will be loaded.

Select the **RAS Mapping | Import RAS Data** menu item. This process will take a few minutes as the HEC-RAS results are imported into feature classes and the terrain TIN is converted to a GRID. There will be a feature class created for cut lines, bounding polygon information, and storage areas. The cut line feature class ("XS Cut Lines") will hold the cross section locations attributed with a water surface elevation for each cross section for each profile. The bounding polygon layer ("Bounding Polygon") will have a bounding polygon feature for each water surface profile. Point feature classes will be created for the velocities ("Velocities") and bank point locations ("BankPoints"). The storage area layer ("Storage Areas") will have a feature for each storage area and be attributed with a water surface elevation for each profile.

After the import of the data is complete, examine the bounding polygon for the "Biggest" event (or P003 as it appears in the attribute table) that was imported to the GIS. This polygon will limit the extents of the inundation mapping. Is the bounding polygon consistent with the RAS model and will it allow the appropriate floodplain delineation? One specific place to check is at the levee. As illustrated in Figure 8-70, the bounding polygon follows the levee until it is overtopped. Downstream of the overtopped levee the bounding polygon is out at the edge of the cross sections. This is consistent with the RAS model, but will significant backwater result behind the levee? In this case, no, there is high ground upstream of the overtopped area.
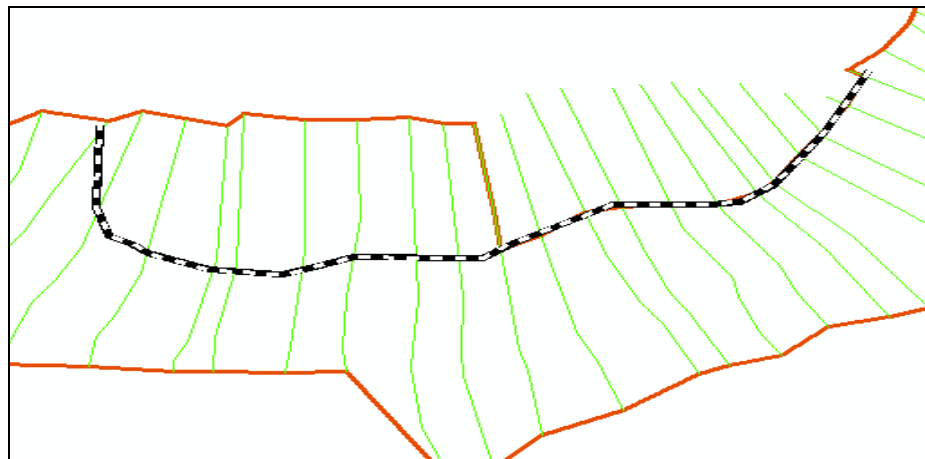
Figure 8-70. Examine the bounding polygon for consistency prior to floodplain delineation.

After the feature classes are created and added to the map, the DTM will also be converted to a raster data set. The grid-cell size will be determined by the *Rasterization Cell Size* entered during the layer setup process. The raster copy of the terrain model will be named "DTMGRID" and stored in the *Analysis* directory.

Inundation Mapping

Inundation mapping is performed in two basic steps. First a water surface TIN is constructed from the cross sections and water surface elevations. In the next step, the water surface TIN is compared with the DTM.

Water Surface TIN

Select the **RAS Mapping | Inundation Mapping | Water Surface Generation** menu item. The dialog shown in Figure 8-71 will allow you to pick the water surface profile to process. For this example, choose the "**Biggest**" profile and press **OK**.
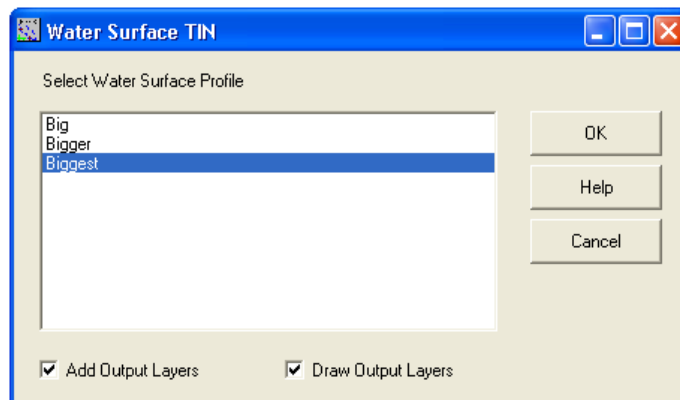
Figure 8-71. Water surface profile selection dialog for building water surface TINs.

The water surface TIN will be created and added to the analysis map with the name "t Biggest". The TIN will be saved to disk in the Analysis directory as "tP003". The water surface TIN will include a surface outside the area of interest. This non-modeled area will be removed during the delineation process with the bounding polygon.

Floodplain Delineation

Select the **RAS Mapping | Inundation Mapping | Floodplain Delineation Using Rasters** menu item. The dialog shown in Figure 8-72 will allow you to pick the water surface profile to process. By default, the "Smooth Floodplain Delineation" option is selected – if you want the floodplain boundary to precisely follow the depth grid, uncheck the smoothing option. Choose the "**Biggest**" profile and press

OK. Watch the *Status Bar* (at the bottom of the ArcMap window) for status messages and completion percentage.
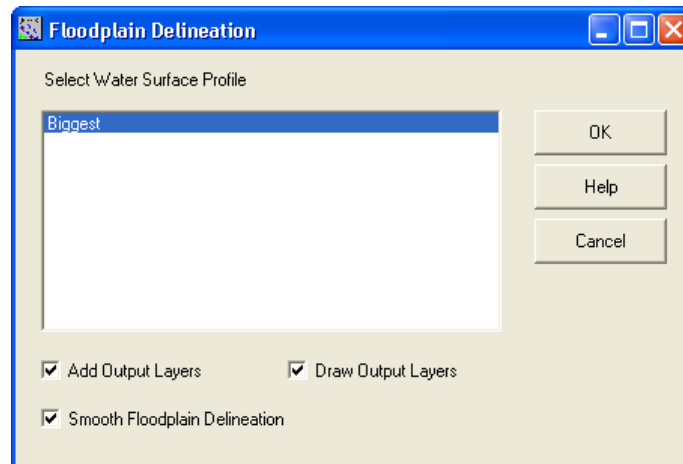
Figure 8-72. Water surface profile selection dialog for performing floodplain delineation.

The water surface TIN will be converted to a GRID based on the Rasterization Cell Size. It is then compared with the raster DTM to compute the elevation difference within the bounding polygon. Water surface elevations greater than the terrain elevation are included in the inundation depth grid. The Storage Areas layer will also be converted to a GRID and flood depths will be added to the depth grid. The inundation depth grid is then converted to a vector data set defining the floodplain boundary. When the delineation is complete, new layers will be added to the map and a dialog will be invoked updating you that the "Floodplain mapping completed successfully!"

The inundation depth grid will be added to the analysis map with the name "d Biggest" and the floodplain boundary will be added with the name "b Biggest". The depth grid is stored on disk as "dP003" in the Analysis directory while the floodplain boundary is stored in the output geodatabase as "bP003".

The resulting floodplain delineation for the "Biggest" profile (for a portion of the model) is shown in Figure 8-73. The first thing you should verify is that the extent of the cross sections are wide enough to allow for floodplain delineation. This is especially important at the outside portion of bends in the river.
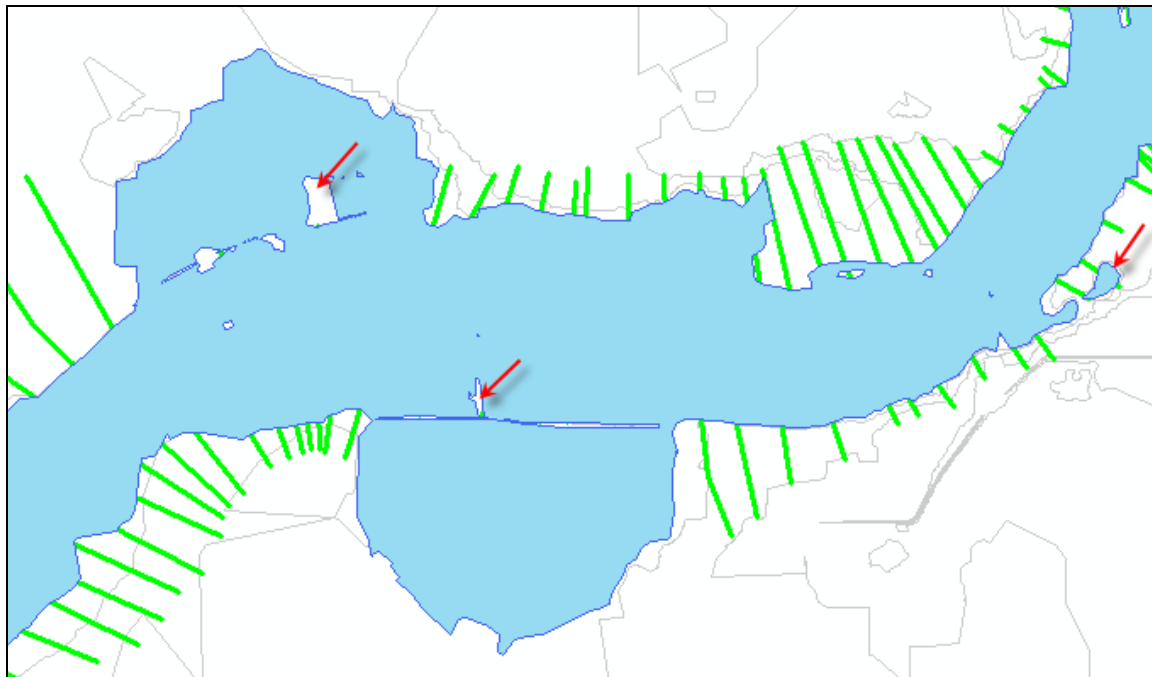
Figure 8-73. Initial floodplain delineation overlaying contours and cut lines.

Note that the floodplain delineation resulted in some interesting features identified by the arrows in Figure 8-73. One prominent feature is the disconnected water body on the south-east side of the river. We must consider whether this is appropriate and makes hydraulic sense.

It can be determined whether the disconnected "pond" should be included in the delineation by looking a the cross section plot in HEC-RAS (you can use the GIS to identify the river station). A quick look at the cross section plot indicates that the area should not be wet. You should go back to the RAS model and add a levee to the high ground to keep water from flowing out into the left bank (or edit the floodplain polygon manually).   The cross section without the levee is shown in Figure 8-74. In addition, the levee option should be used on the next cross section downstream.

The other areas to look at are the a few areas of dry land (islands) near the storage area locations. Cursory review of the dry land indicates that it is indeed high ground.
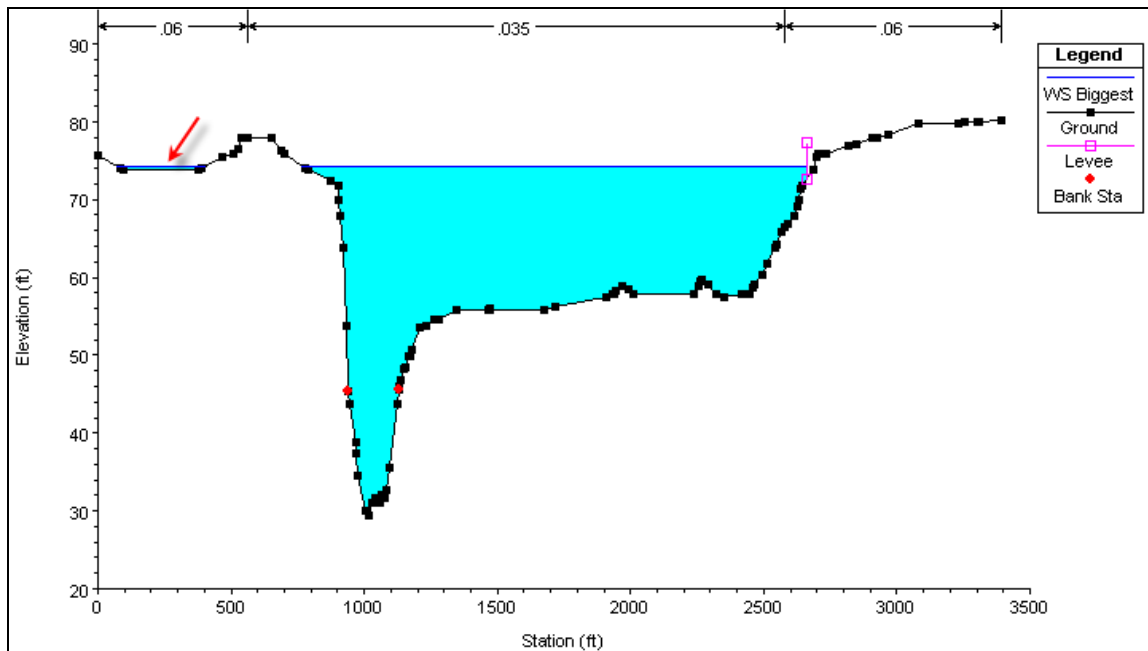
Figure 8-74. HEC-RAS cross section shows flooding in the left overbank that should be limited using the levee option.

Another set of areas to consider are the slender regions at the end of the cross sections where storage areas are used. These areas are not inundated because the cross sections and the storage areas did not properly overlap and a gap was left between the features. The area adjacent to a storage area may not be wet because it could be a high linear feature like a road or levee and water is passed to the storage area through a culvert or gate – so the high ground would not be inundated. In this example, however, the high ground separating the cross sections and the storage area should be inundated. You should fix this issue by editing the Storage Areas in HEC-RAS (Edit | Move Object menu item) so that future delineations are correct. The next floodplain delineation iteration is shown in Figure 8-75. It is important to note that edits made within the HEC-RAS model have longevity and will propagate through to future floodplain delineations, whereas edits made within the GIS are more singular events.
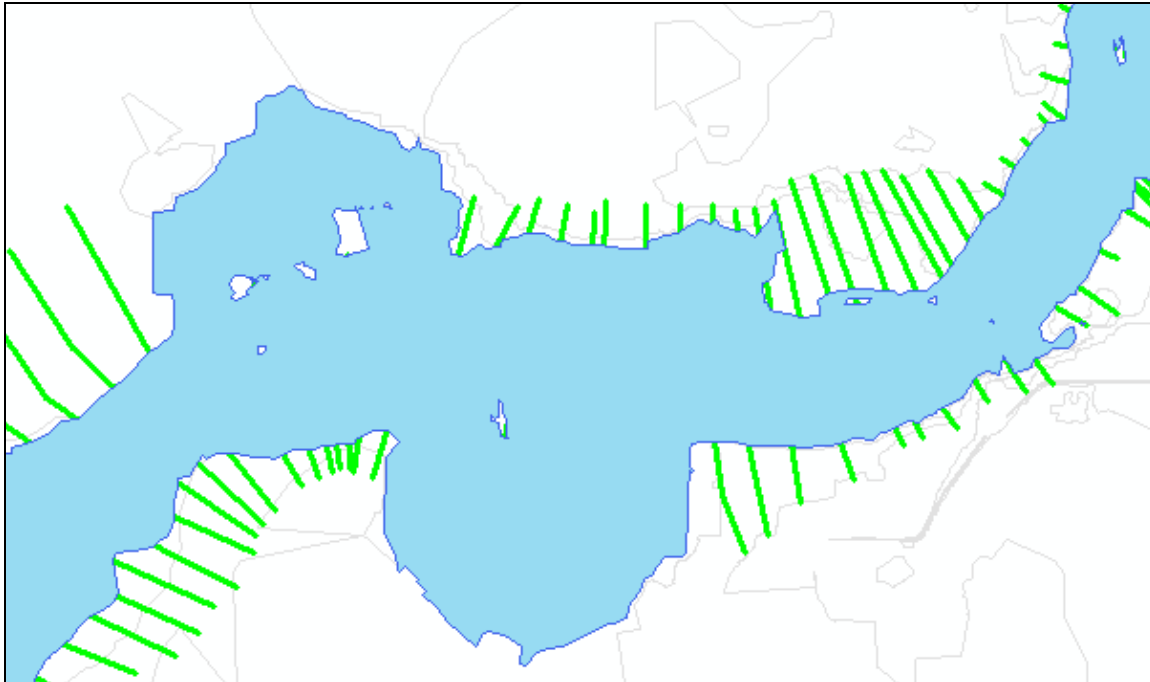
Figure 8-75. Final floodplain delineation overlaying contours and cutlines.

There are still several areas we would want to investigate for the correctness in the floodplain delineation. There are still several small islands in the floodplain and disconnected ponds of water. Further, it appears that the bounding polygon has removed part of the floodplain on the north side of the river (behind the levee). Perhaps, if the levee was overtopped farther downstream, water would flow back up behind the levee. You would need to revisit the hydraulics model and identify how you should adjust your cross sections and options to best represent the flow situation.

You could continue the investigation by zooming into areas and comparing the floodplain with the terrain model to gain more insight into correcting the river hydraulics model. This is a looped process that requires several iterations between HEC-RAS and the GIS to arrive at results that are hydraulically correct. We will neglect further model refinement in this example.

Next, use the depth grid to evaluate the floodplain. Using the depth grid with a color gradient will quickly allow you to identify areas flooded to greater (or lesser) depth. The **Identify** tool can be used to find water depths at various locations, as shown in Figure 8-76. Further, you will want to zoom in along the edge of the floodplain and determine whether the grid-cell size used is small enough to accurately delineate the floodplain. The 20ft cell size used in this example may not be appropriate for other studies.
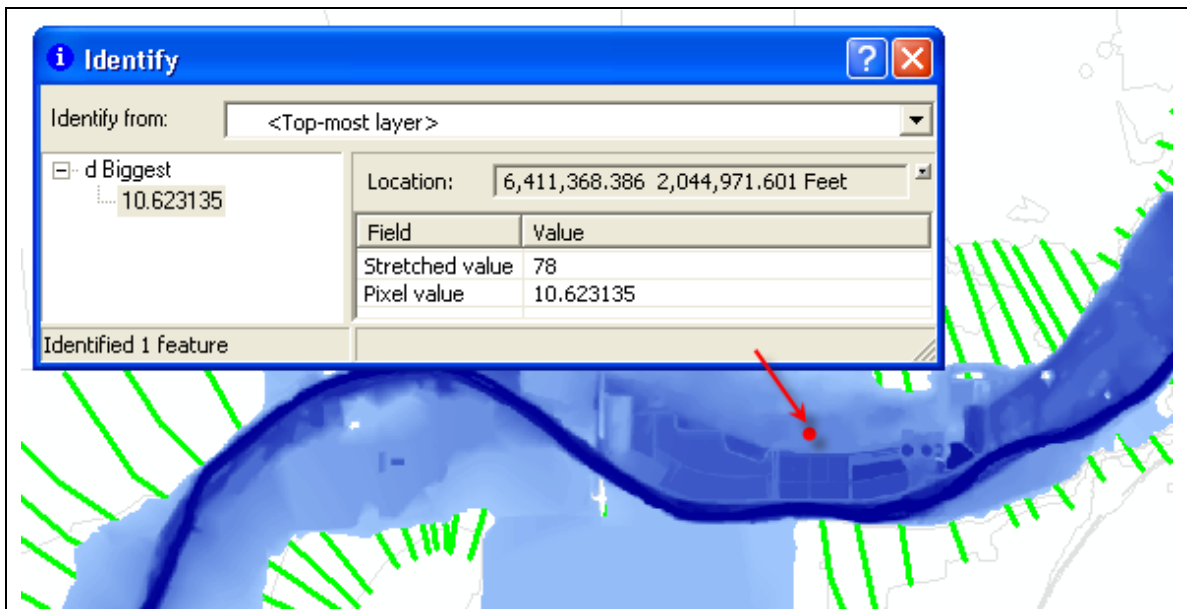
Figure 8-76. Inundation depths are easily identified in the GIS.

Velocity Mapping

Velocity mapping is completed by interpolating detailed velocity information between cross section. In order to perform the velocity mapping, the floodplain boundary for the profile of interest must exist.

Select the **RAS Mapping | Velocity Mapping** menu item and choose the profile of interest ("Biggest") for interpolation, as shown in Figure 8-77.
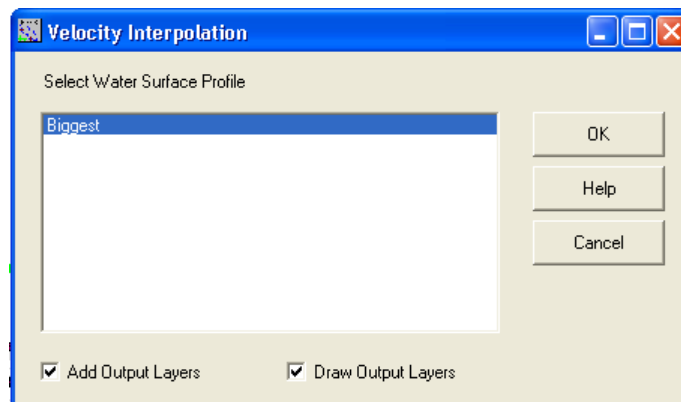
Figure 8-77. Select the profile of interest to perform velocity interpolation.

The floodplain boundary, velocities, and bank station data are used to interpolate velocities between cross sections. During interpolation, a dialog will provide status updates as to the progress, as shown in Figure 8-78.
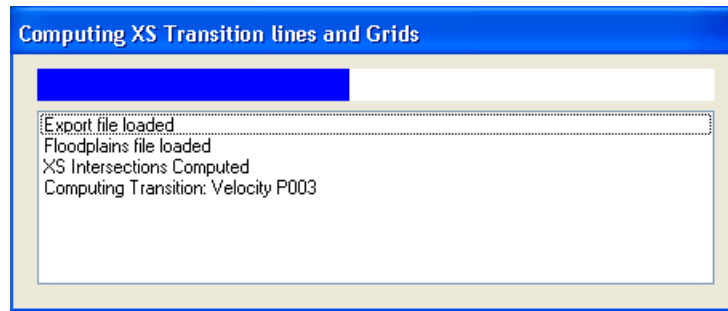
Figure 8-78. Interpolation status is updated during the computations.

After the interpolation is complete, the velocity grid is added to the Map. As shown in Figure 8-79, the velocities transition between the cross sections in the channel and floodplain, but the velocity is zero in the storage areas.
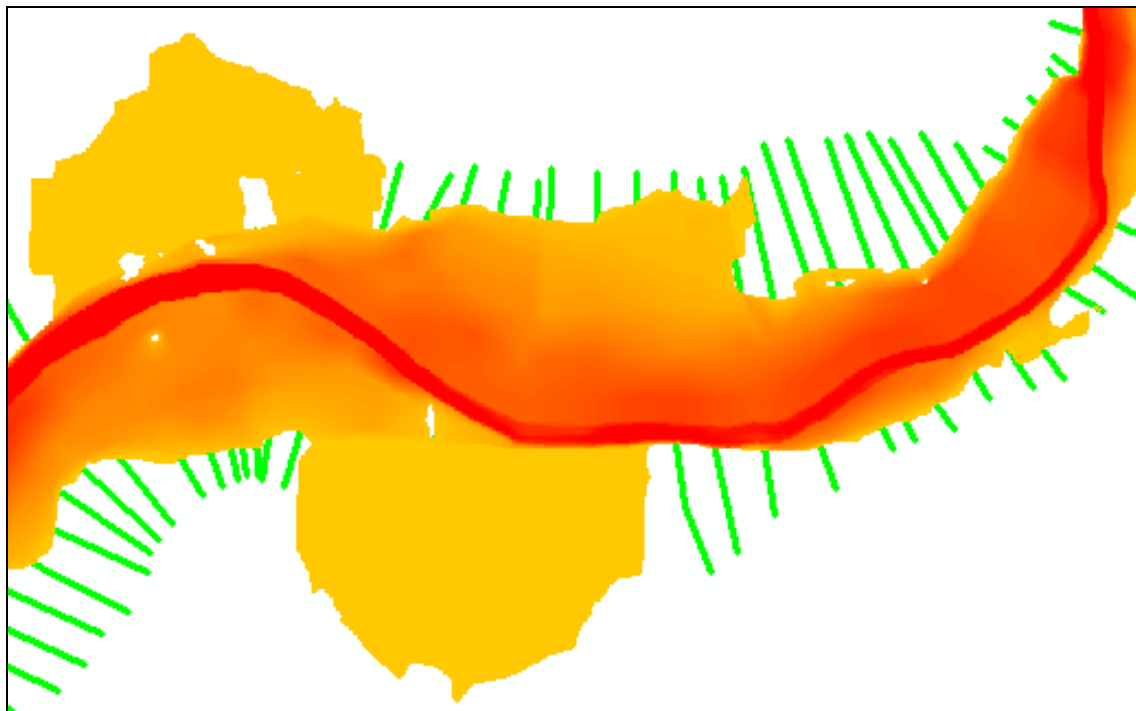
Figure 8-79. Interpolated velocities export from HEC-RAS.

Using the point velocity data on top of the interpolated surface can also be helpful in determining model deficiencies. In Figure 8-80, for instance it is clear that the spit of water on the north side of the river should be an area of zero velocity. The HEC-RAS model should be refined to reflect this using an ineffective flow area.
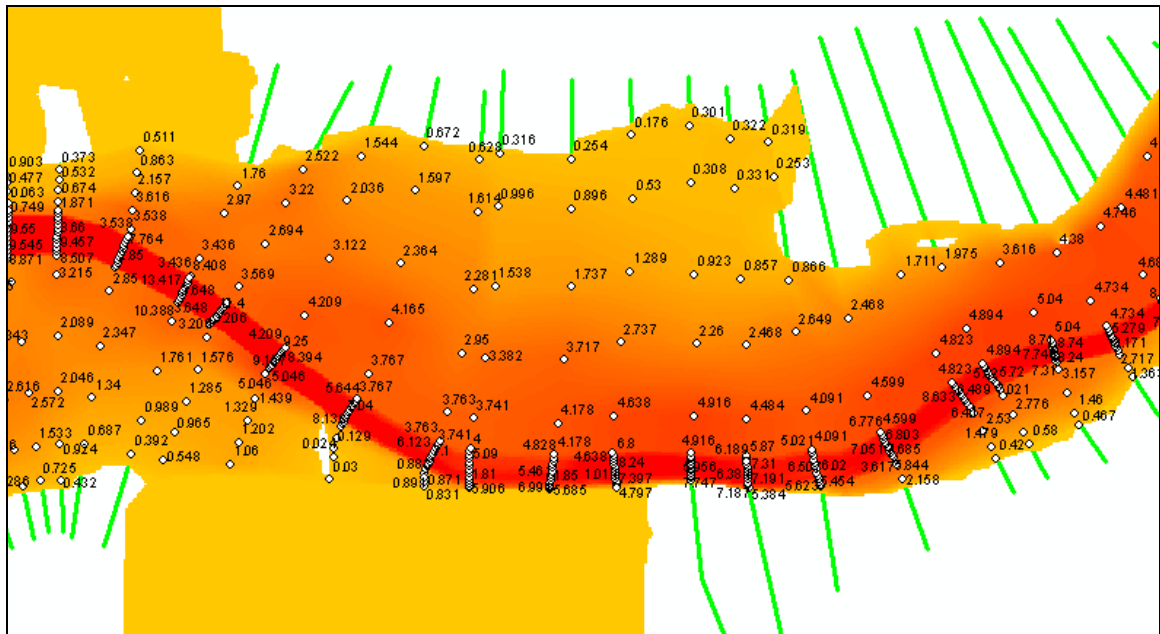
Figure 8-80. Interpolated velocity surface overlaid with point velocity data.

Shear Stress Mapping

Shear stress mapping is performed in the identical manner as velocity mapping, except you must select the "Shear Stress" output option when creating the RAS GIS Export File in RAS and selecting the **RAS Mapping | Shear Stress Mapping** menu item in HEC-GeoRAS.

Stream Power Mapping

Stream Power mapping is performed in the identical manner as velocity mapping, except you must select the "Shear Stress" output option when creating the RAS GIS Export File in RAS and selecting the **RAS Mapping | Stream Power Mapping** menu item in HEC-GeoRAS.

Ice Thickness Mapping

In order to perform the ice mapping portion of this example, you need to export the results for the "Ice Jam" plan in the HEC-RAS model, as shown in Figure 8-81. This fictitious model demonstrates the capability of RAS to calculate ice thickness in a cross section due to an ice jam at a bridge.
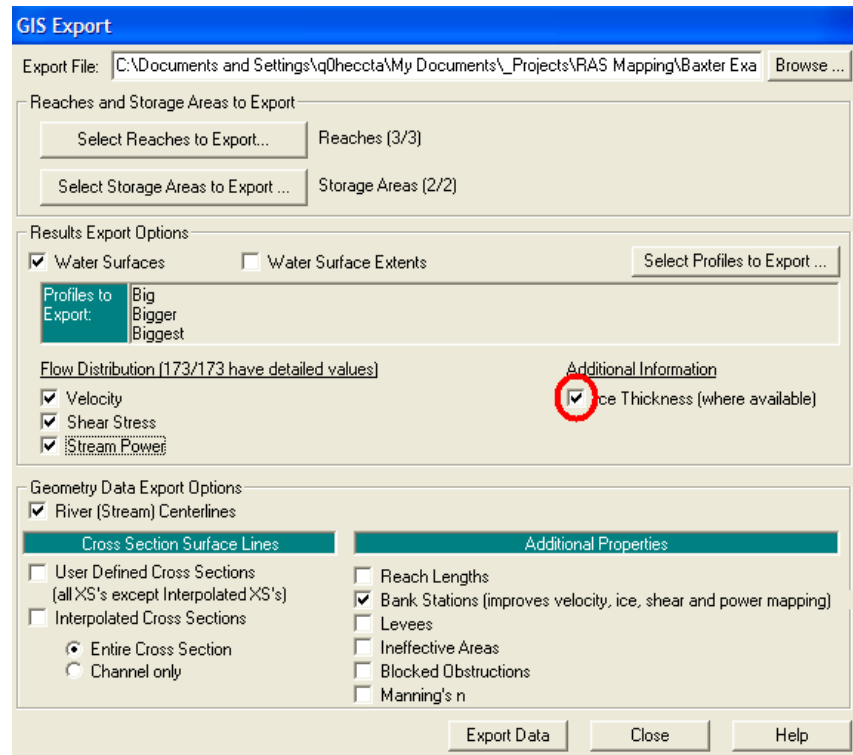
Figure 8-81. Export HEC-RAS results for ice thickness information.

Convert the *RASExport.sdf* file to XML, perform the RAS Mapping Layer Setup, and import the RAS results. Note that this time, a point feature class ("IceThickness") has been created with ice thickness information for some of the cross sections. As with the velocity analysis, perform the floodplain delineation for the available profile ("Biggest"). Once the floodplain has been delineated, you are ready to perform the ice mapping.

Select the **RAS Mapping | Ice Mapping** menu item. The standard profile selection dialog will allow you to pick the profile to perform the ice interpolation on, as shown in Figure 8-82.
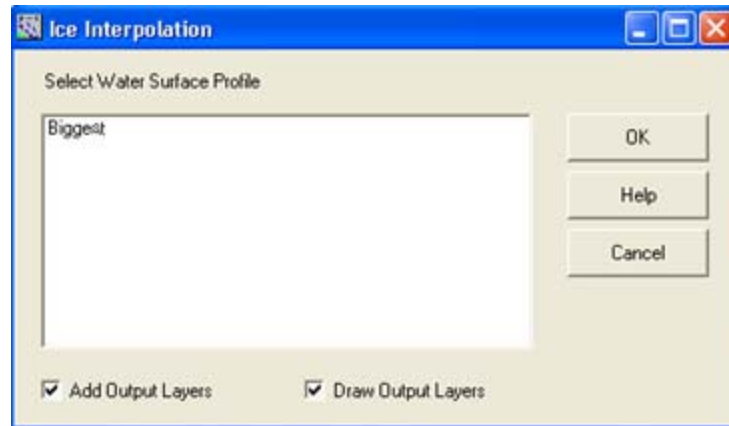
Figure 8-82. Water surface profile selection dialog for ice interpolation.

After selecting a profile and pressing the **OK** button, the interpolation status window will appear providing progress updates. After the interpolation is complete, the ice thickness grid is added to the map. Observe the distinct change in ice values at the bridge, as shown in Figure 8-83, indicative of an ice jam situation.
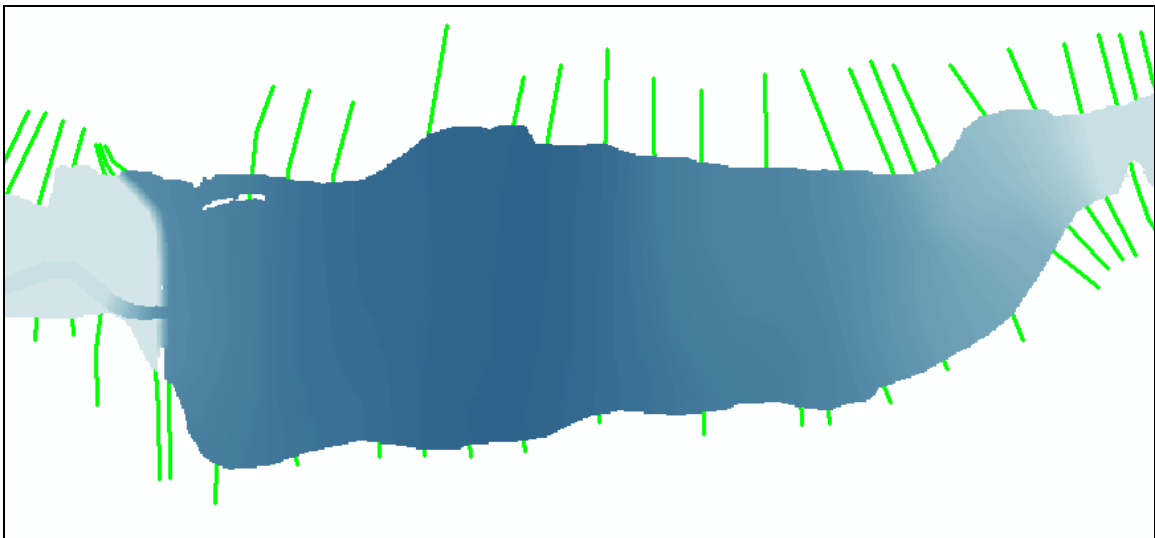
Figure 8-83. Display of interpolated ice thickness data at an ice jam

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C H A P T E R   9

Example – Multiple DTMs

Representing terrain with a triangulated irregular network (TIN) is an efficient method of modeling. Areas requiring little definition may be represented by a few data points while complex areas (such as the channel) can have an increased concentration of elevation data. You can represent a very large area using the TIN model representation by gathering and using a minimum of data points. A gridded representation of a similar terrain surface, however, may require many, many more data points resulting in a very large data set.

Very large terrain models may result in data sets that are unmanageable to work with in the ArcGIS environment. If this is the case, HEC-GeoRAS provides the functionality to use multiple terrain models rather than the single large model. This chapter will demonstrate the use of multiple terrain models using the Wailupe River and floodplain terrain model and data layers.

Tasks

- Start a GeoRAS project
- Create the Terrain Tiles Feature Class
- Extract Cross Sections
- Inundation Mapping

Start a GeoRAS project

To utilize multiple terrain models, you must already have either multiple terrain tiles or a single terrain model from which you want to create smaller models. The Wailupe River DTM has already been divided into three DTMs (using the process discussed in Chapter 4) and we will use them as the basis of the terrain. The other requirement is to have a polygon feature class that represents the bounds of each DTM to use for each cross section. The polygon feature class is the only thing that is differs from the single DTM processes discussed in this document.

Start by opening ArcMap and loading the 3D Analyst, Spatial Analyst and HEC-GeoRAS extensions. Save the project. Add a new map using the **ApUtilities | Add Map** menu item and name it "**Geometry**".

We will first load the terrain models. For this example, we have three TINs called "Upper", "Middle", and "Lower" representing the Wailupe River watershed. Load the terrain models and verify that they overlap each other.
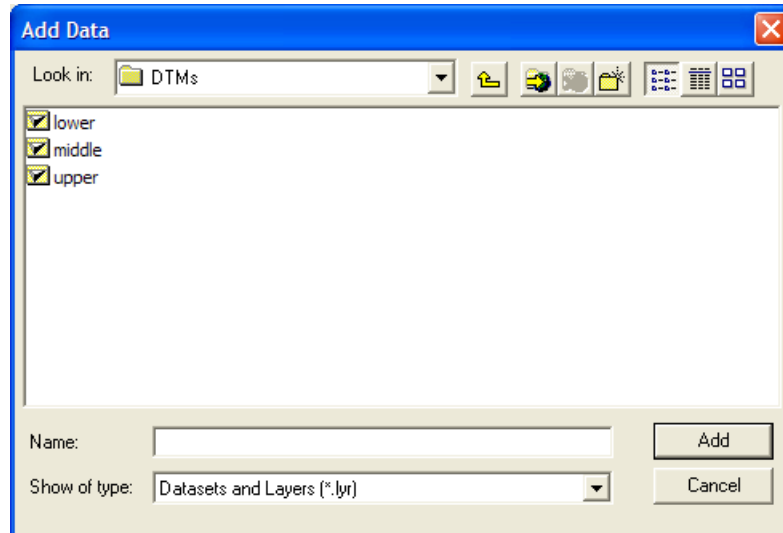
Making sure that the terrain models overlap is extremely important so that the triangulation in the transition zones from one TIN to the next is done correctly. GeoRAS doesn't actually require that the TINs are loaded, the polygon feature class will have pathnames directing GeoRAS to the location of the TINs.

Next, load the feature classes from the "TerrainTiles" geodatabase. The "River" and "XSCutLines" features are the only necessary feature classes because we completed the attribute data during the "Data Import" example, but if you plan on adjusting cut line locations you will want to add the bank lines and flow path lines.

Verify that each cut line lies completely within one of the three terrain models.

Create the Terrain Tiles Feature Class

You can create a polygon feature class for the Terrain Tiles layer directly in GeoRAS using the **RAS Geometry | Terrain Tiles** menu item. Provide a name for the feature class, as shown in Figure 9-1, and press **OK**.
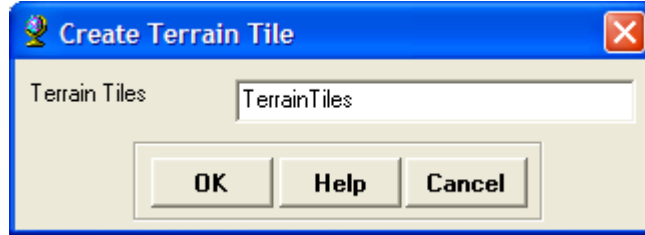
Figure 9-1. Creating a new feature class in GeoRAS.

Start editing the new "TerrainTiles" feature class and choose "**Create New Feature**" as the *Task* and "**TerrainTiles**" as the *Target*, as shown in Figure 9-2. Select the **Sketch** tool and draw the bounds of the "Upper" TIN.

Figure 9-2. Editor options when adding polygon features.

An example of the bounds for the "Upper" TIN is shown in Figure 9-3. Note that in creating the polygon, we are really just considering the bounds of the cross-sectional cut line. You want to make sure that each cut line is completely with the polygon and completely with the bounds of the terrain model that the polygon is representing!
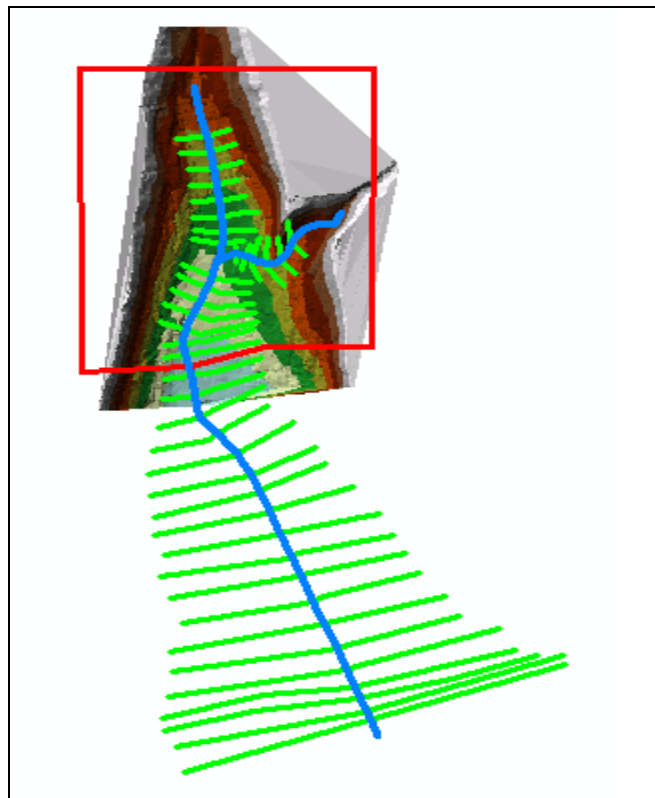
Figure 9-3. Polygon feature for the Upper TIN.

Next, enter attribute information for the polygon. The HydroID information will be automatically populated as you create each polygon feature by GeoRAS (which has the ApUtilities menu loaded). You will have to enter the name of the terrain model (*TileName*), the path to the location on disk (*TileDirectory*) and the type of terrain (*TerrainType: 1=TIN, 0=GRID*) in the attribute table, as shown in Figure 9-4.

Shape *	OB	Shape_Len	Shape_Are	HydroID	TerrainType	TileName	TileDirectory
Polygon	1	79725.0343	361671354.3	1	1	Upper	C:\Data\GeoRAS\Examples\Terrain Tiles\DTMs

Figure 9-4. Attributes for the polygon representing the Upper TIN.

After entering the attribute information for the first polygon, create a second polygon for the "Middle" TIN. Enter the attribute information for the section polygon.

The polygons must be edge matched. During the digitizing process, just make sure that the new polygon overlaps the old polygon. To edge match the two polygons, select the polygon for the "Upper" TIN, as shown in Figure 9-5.
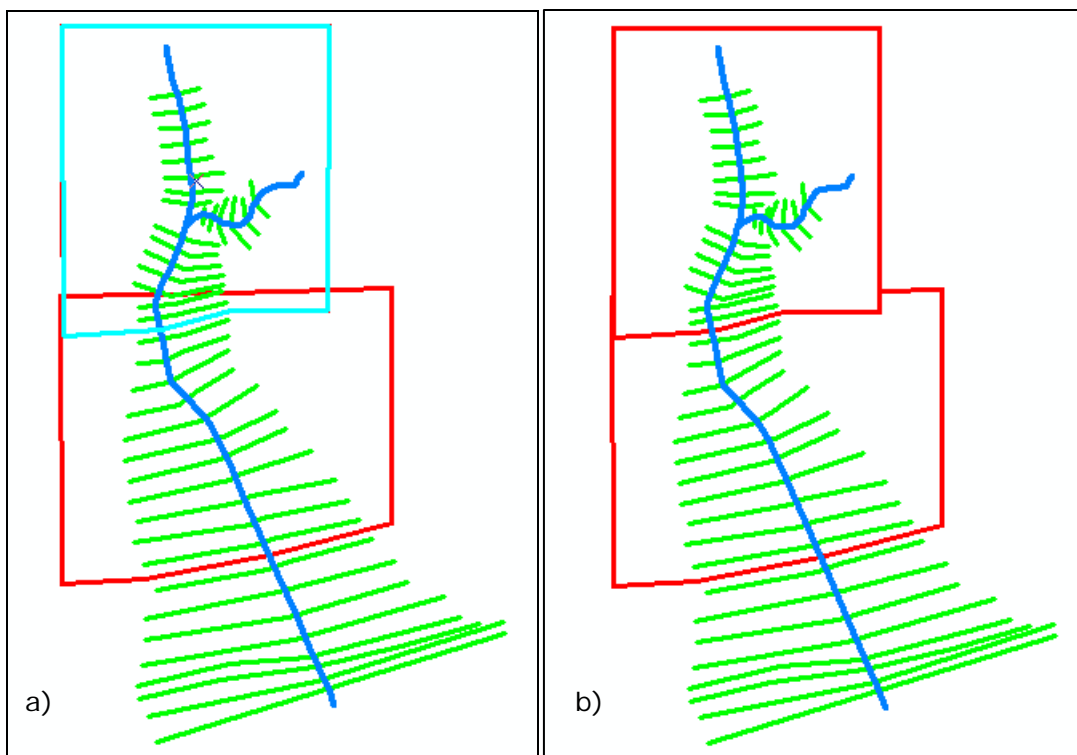
Figure 9-5. Polygons (a) overlapping and (b) edge matched and have no cross sections overlapping polygons.

Next select the **Editor | Clip** menu item. The dialog shown in Figure 9-6 will be invoked allowing you to choose a *Buffer Distance* and

clipping option. Choose a zero *buffer distance* and to *discard* the intersecting area.
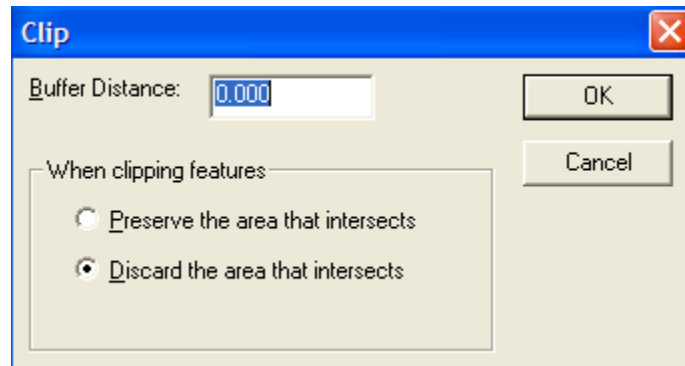
Figure 9-6. Clipping options available from the Editor.

Repeat the process of digitizing a polygon boundary and clipping out the overlapping area for the "lower" terrain model. Verify that each cross section feature falls within a polygon and the associated TIN. Upon final inspection, the polygon's boundaries and approximate DTM boundaries will look like that illustrated in Figure 9-7 and the attribute table should look similar to that shown in Figure 9-8.
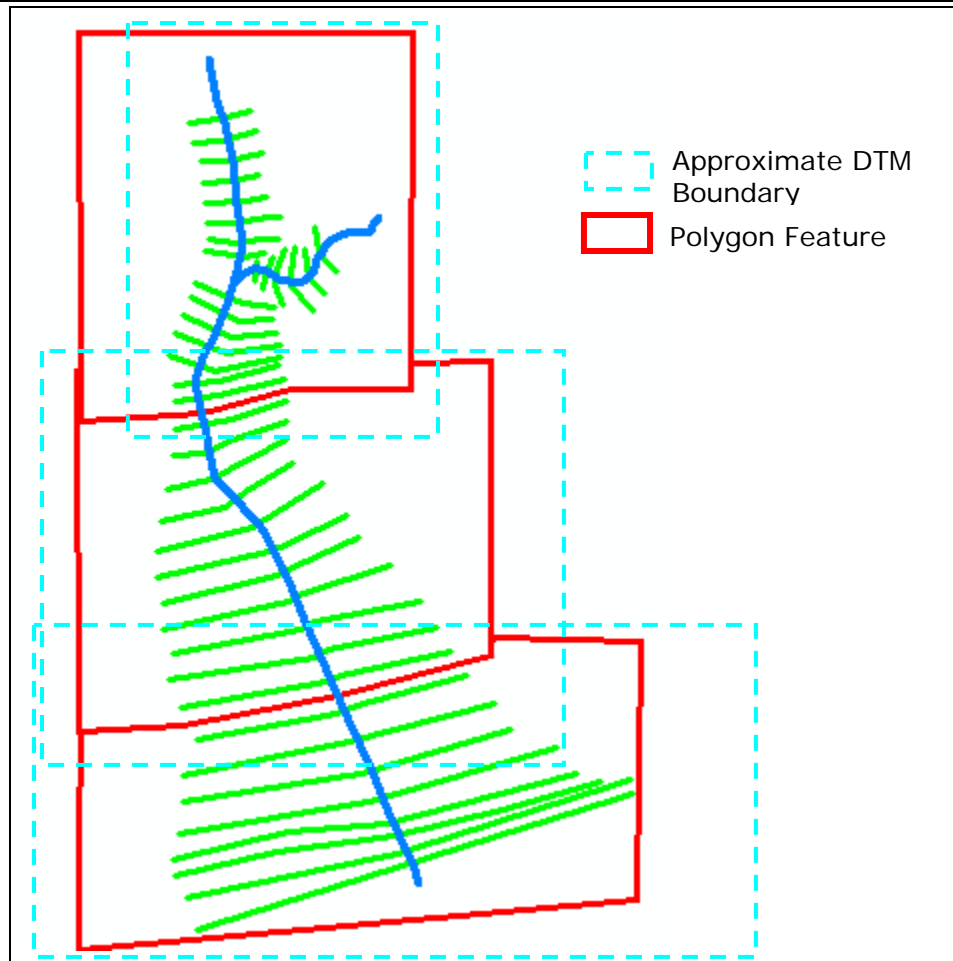
Figure 9-7. DTM and Polygon bounds for multiple terrain models.

OBJECTID*	SHAPE*	HydroID	TileName	TileDirectory	TerrainType
5	Polygon	108	Upper	C:\Data\RAS\GeoRAS\ArcGIS\Examples\TerrainTiles\DTMs	1
6	Polygon	109	Middle	C:\Data\RAS\GeoRAS\ArcGIS\Examples\TerrainTiles\DTMs	1
7	Polygon	110	Lower	C:\Data\RAS\GeoRAS\ArcGIS\Examples\TerrainTiles\DTMs	1

Figure 9-8. Attribute data for the polygon feature class for using multiple terrain models.

Extract Cross Sections

Prior to extracting the cross-section data, verify that the attribute information is correct for the river stations, bank locations, and reach lengths. If you modified the layout of any cross section, you will need to re-attribute the cut lines with updated information.

After updating the attributes, elevation data is extracted. The data extraction process will appear to work the same way as with a single terrain model. GeoRAS does it the same way, it just needs to load each terrain model one at a time and will do so in sequence using the name and directory path specified in the polygon feature class.

Extract RAS Layers

Elevation information for the other RAS Layers can be done using multiple feature classes. The rules for the other feature classes are the same as those for the cross sections – the entire feature must lie within one terrain model and may not overlap multiple terrain models!

RAS Mapping

You can import the data extracted in HEC-RAS, complete the model, simulate, and export the results to the GIS, or use the RAS GIS Export File provided.

In ArcMap, select the **RAS Mapping | Layer Setup** menu item. Specify a name ("Delineation", for example) for the *New Analysis* and select the "**Wailupe.RASExport.xml**" file. Next specify *Multiple* for the terrain analysis and select the "**TerrainPolygons**" layer. Lastly, specify the *Output Directory* and *Rasterization Cell Size*. The parameters for the Layer Setup are shown in Figure 9-9.
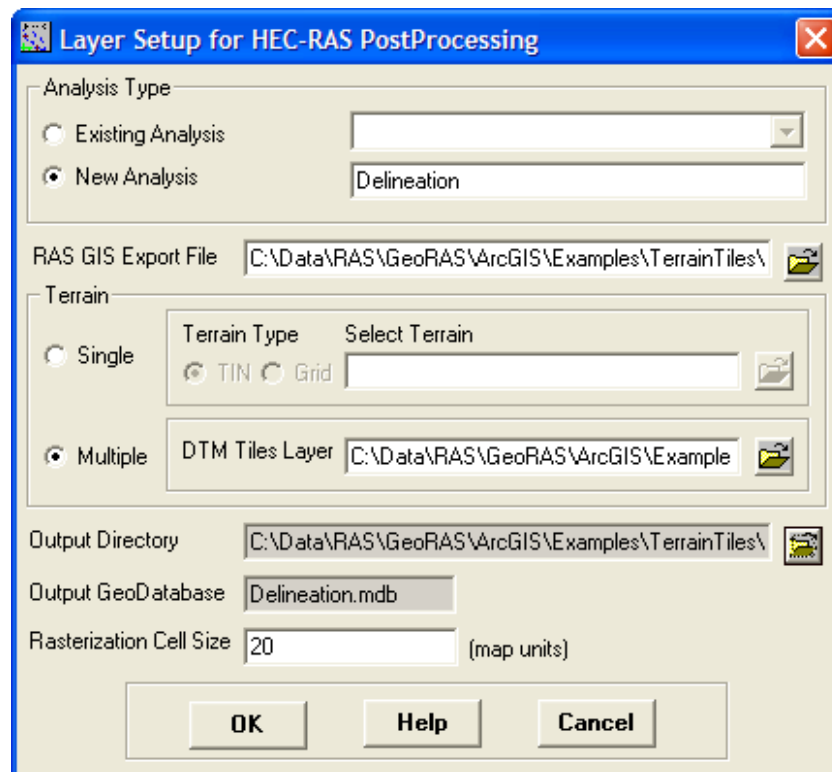
Figure 9-9. Layer setup parameters for floodplain delineation.

Go through each of the **Inundation Mapping** menu items to perform the floodplain delineation. Note that the process works the same as for a single terrain model. The only difference is the polygon feature

class for the terrain tiles is loaded to the map and a grid is created for each terrain model for performing the floodplain delineation. The terrain grids will be named based on the HydroID for the polygon feature prefixed by "grd". The data generated by the floodplain delineation process in shown in Figure 9-10.
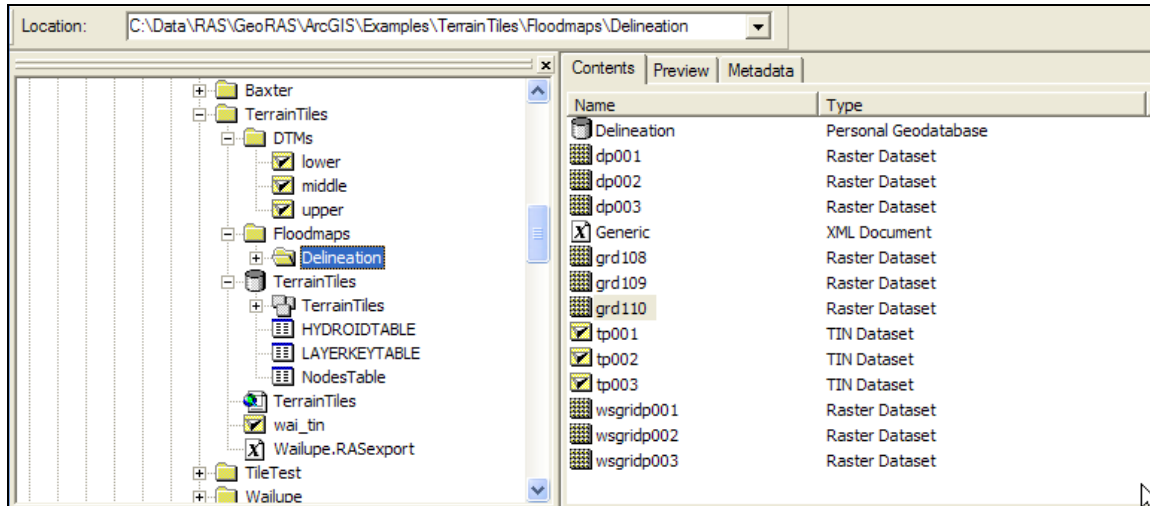
Figure 9-10. Data created during the floodplain delineation process.

During the Water Surface TIN process a single TIN is created for a specific profile. The water surface TIN is then used to perform the floodplain delineation process for each terrain model. The result from each terrain tile is then merged to create one floodplain for the entire area.

A P P E N D I X A

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A P P E N D I X   B

HEC-RAS Data Exchange

At Version 2.0, HEC-RAS introduced a geospatial component to the geometry for the description of river networks and cross sections. This capability makes it possible to import channel geometry from CADD or GIS programs though automated data extraction procedures. Similarly, water surface elevations and other HEC-RAS results can be exported to CADD and GIS where they can be used to create water surfaces for inundation mapping.

The spatial data that HEC-RAS can import and export are evolving - each new version of the software results in additional capabilities. HEC-RAS Version 4.0 will import and export data using a spatial data format in an ASCII text file.

Data import options include:

- The structure of the river network, as represented by a series of interconnected reaches.

- The location and geometric description of cross sections for elevation data, bank positions, downstream reach lengths, Manning's *n* values data, levee positions and elevations (limited to one per bank), ineffective flow area positions and elevations, and blocked obstruction positions and elevations.

- Bridge deck information for top-of-weir profile, deck width, and distance to the upstream cross section.

- Lateral and inline structure information, top-of-weir profile, deck width, and distance to the upstream cross section for inline structures.

- Storage area elevation-volume information.

- Storage area connection information, top-of-weir profile, width, and storage areas connected.

Data export options include:

- Cross section locations and elevation data.

- Water surface elevations at each cross section.

- Bounding polygon information for each water surface profile.

- Cross-sectional properties.

- Velocity information at a cross section.

- Ice thickness information at a cross section.

Spatial Data Format

HEC-RAS Version 4.0 will import and export data using a formatted ASCII text file. In general, the spatial data format consists of records, keywords and values. This section provides the general rules for constructing the HEC-RAS import and export file.

This file format is evolving in that additional data types will be added and existing ones may be modified for future versions. If you are writing software to read and write to the HEC-RAS spatial data format, keep in mind that you may need to modify your software to remain compatible with future versions of HEC-RAS.

Records

The spatial data format is composed of records, which are composed of keywords and values. All records must begin with a keyword. A record can also contain a value or a set of values following the keyword. Spaces, tabs, or line ends can be used as delimiters within a record.

A record that contains a keyword and no value marks the beginning or end of a group of related records. For example, the record "BEGIN HEADER:" marks the beginning of the header section of the file. A record that contains a keyword and a value assigns that value to the part of the model being named by the keyword.

Keywords

Keywords are used to identify that values unique to the part of the model being named by the keyword will follow. Keywords must end with a colon separating the keyword and the values. All keywords will have the spaces removed up to the colon and the letters capitalized. The keywords "Begin Header:", "Begin header:", and "Be GiNH eadEr:" are all equivalent. For readability, keywords named in this document will contain internal spaces.

Values

A record can assign a single value to a single variable or multiple values in an array. Values can be integers, floating point numbers, text strings, or locations (X, Y, Z, label). A single value in an array of values is called an "element" of that array.

A **numerical value** cannot contain internal blanks. A floating point number can contain a decimal point; an integer cannot. Elements in an array can be separated by commas, blanks, tabs, or line ends.

A **text string** can contain internal blanks, tabs, and commas, but cannot contain internal line ends.

A **location** consists of three coordinate values and a label (X, Y, Z, label). The first two coordinates are planar and the third is elevation. The coordinate values are floating point numbers and the label can be any type of value. In certain contexts, the elevation value or the label may not be required. If a label is used, all three coordinate values must be given; the value of "NULL" is valid for the elevation coordinate only. The coordinate values and the label can be separated by commas, blanks, or tabs, but a location cannot contain internal line ends.

Data Groups

Records in the data file can be collected in two types of groups: objects and file sections. An object is a group of records that combine to describe an entity within the model – a cross section, for example. A file section is a logical or functional grouping of data. The file header, for example, is a section that contains a description of the entire file.

Objects and file sections begin and end with records that contain keywords but no values. A file section starts with a record containing a keyword composed of the word "BEGIN" followed by the section name and a colon and ends with a keyword composed of the word "END" followed by the section name and a colon. For example, records containing only the keywords "BEGIN HEADER:" and "END HEADER:" are used to start and end the header section of a file. An object starts with a record containing a keyword naming an object type and "END:" only. For example, a cross-section object with the record containing the keywords "CROSS-SECTION:" and ends with the keyword "END:" only.

Comments

Hash characters (#) are used to identify comments. When a hash character is encountered in the file all data from the hash to the next line end is ignored. A line that begins with a hash is equivalent to a blank line.

RAS GIS Import File (RASImport.sdf)

HEC-RAS reads channel geometry from a text file composed of several sections. A discussion of the sections in the import file is provided. And example RAS GIS Import File is provided at the end of this appendix.

Header

The header is bounded by the records "BEGIN HEADER:" and "END HEADER:" and should contain a record to identify the units system used in the imported data set. The units system can be "US CUSTOMARY" or "METRIC". A summary of records that may be used in the Header section are provided in Table B-1.

Table B-1. Header options for the spatial data file.

Keyword	Value Type	Value
UNITS:	String	US CUSTOMARY or METRIC
DTM TYPE:	String	Type of terrain model (TIN or GRID)
DTM:	String	Name of terrain model
STREAM LAYER:	String	Name of Stream Centerline layer used in the CADD or GIS.
NUMBER OF REACHES:	Integer	Number of reaches in the SDF file.
CROSS-SECTION LAYER:	String	Name of the Cross-Sectional Cut Lines layer used in the CADD or GIS.
NUMBER OF CROSS-SECTIONS:	Integer	Number of cross sections in the SDF file.
MAP PROJECTION:	String	Projection (coordinate) system used (e.g. Stateplane)
PROJECTION ZONE:	String	Projection zone (if applicable, e.g. 5101)
DATUM:	String	Reference datum for planar coordinates.
VERTICAL DATUM:	String	Reference datum for vertical coordinates.
BEGIN SPATIAL EXTENT:	None	None. Begin of Spatial Extents object.
Xmin:	Float	Minimum easting of geospatial data.
Ymin:	Float	Minimum northing of geospatial data.
Xmax:	Float	Maximum easting of geospatial data.
Ymax:	Float	Maximum northing of geospatial data.
END SPATIAL EXTENT:	None	None. End of Spatial Extents object.
NUMBER OF PROFILES:	Integer	Number of profile exported from HEC-RAS. RAS GIS Export File only.
PROFILE NAMES:	String array	Water surface profile names exported from HEC-RAS. RAS GIS Export File only.

River Network

The river network section is bounded by the records "BEGIN STREAM NETWORK:" and "END STREAM NETWORK:" and contains records describing reaches and reach endpoints. At a minimum, the stream network section must contain at least two endpoints and one reach.

A reach endpoint is represented by a record containing the keyword "ENDPOINT:" followed by four comma-delimited values containing the endpoint's X, Y, Z coordinates and an integer ID.

A reach consists of a multi-record object that begins with a record containing only the keyword "REACH:" and ends with a record only containing the keyword "END:". At a minimum, a reach object must contain records setting values for a Stream ID, a Reach ID, a FROM point, and a TO point. A reach's FROM and TO point IDs must match IDs for endpoints listed before the reach object in the file. The reach object must also contain an array of locations defining the stream centerline. This array begins with a record containing only the keyword "CENTERLINE:" and ends when any keyword is encountered. A location element in the array contains the X, Y, and Z coordinates of a point on the stream centerline, and the point's river station. In HEC-RAS, elevation and stationing are optional in the stream network definition. If a location element includes a station value, it must occupy the fourth field in the element.

Stationing is used for indexing locations along reaches, and is not used to precisely locate objects in the model. A summary of records that may be used in the River Network section are provided in Table B-2.

Table B-2. River network options for the spatial data file.

Keyword	Value Type	Value
ENDPOINT:	Location	X, Y, Z coordinates and integer ID.
REACH:	None	Marks beginning of Reach object.
END:	None	Marks end of Reach object.

The following records are required for a Reach object.

STREAM ID:	String	River identifier to include reach.
REACH ID:	String	Unique ID for reach within river.
FROM POINT:	String	Integer reference to upstream endpoint.
TO POINT:	String	Integer reference to downstream endpoint.
CENTERLINE:	Location array	Array elements contain coordinates and station values.

Cross Sections

The cross-sectional data section begins with a record containing only the keyword "BEGIN CROSS-SECTIONS:" and ends with a record containing only the keyword "END CROSS-SECTIONS:". A cross section is represented by multi-record object beginning with a record containing only the keyword "CROSS-SECTION:" and ending with a record containing only the keyword "END:."

A cross-sectional object must include records identifying the Stream ID, Reach ID, and Station value of the cross-section, a 2D cut line, and a series of 3D locations on the cross section. Stationing is given in miles for data sets with plane units of feet and in kilometers for data sets with plane units of meters. A cut line is composed of the label "CUT LINE:" followed by an array of 2D locations. A cross-sectional polyline consists of the label "SURFACE LINE:" plus 3D coordinates written as comma-delimited X, Y, Z real-number triples, one triple to a line. A summary of records that may be used in the River Network section are provided in Table B-3.

Table B-3. Cross-sectional data section options for the spatial data format.

Keyword	Value Type	Value
CROSS-SECTION:	None	Marks beginning of Cross Section object.
END:	None	Marks end of a Cross Section object.

The following records are required for a Cross Section object.

Keyword	Value Type	Value
STREAM ID:	String	Identifier for the River on which the cross section resides.
REACH ID:	String	Identifier for the Reach on which the cross section resides.
STATION:	Float	The relative position of the cross section along the river reach.
CUT LINE:	Location array	Array elements contain planar coordinates of cross section strike line.
SURFACE LINE:	Location array	Array elements contain 3D coordinates of cross section.

The following records are optional for a Cross Section object.

Keyword	Value Type	Value
NODE NAME:	String	Description of cross section.
BANK POSITIONS:	Float	Fraction of length along cut line where main channel bank stations are located. (*Left, Right*)

Keyword	Value Type	Value
REACH LENGTHS:	Float	Distance along left overbank, main channel and right overbank flow paths to next cross section downstream. (*Left, Channel, Right*)
N VALUES:	Float	Manning's *n* values and fractional distance along the cut line to start of *n* value. (*fraction, n value*)
LEVEE POSITIONS:	String, Float	Levee positions expressed as a fraction along cut line and elevation. (ID, *fraction, elevation*)
INEFFECTIVE POSITIONS:	String, Float	Ineffective flow areas expressed as a fraction along cut line to beginning and end positions with trigger elevation. (ID, *begin fraction, end fraction, elevation*)
BLOCKED POSITIONS:	Float	Blocked flow areas expressed as a fraction along cut line to beginning and end positions with trigger elevation. (ID, *begin fraction, end fraction, elevation*)
WATER ELEVATION:	Float array	Water surface profile names exported from HEC-RAS. RAS GIS Export File only.

Additional Cross Section Properties

Geospatial data used for display purposes in HEC-RAS for levees, ineffective flow areas, and blocked obstructions are stored outside of the Cross Section block of information. A summary of additional cross section properties is summarized in Table B-4.

Table B-4. Additional cross section properties options for the spatial data file.

Keyword	Value Type	Value
Levee records		
BEGIN LEVEES:	None	Marks beginning of Levees object.
LEVEE ID:	String	Levee identifier. Corresponds to ID in LEVEE POSITIONS object on cross section.
SURFACE LINE:	Location array	Array elements contain 3D coordinates of levee profile points. Array concludes with END:
END LEVEES:	None	Marks end of Levees object.
Ineffective flow area records		
BEGIN INEFFECTIVE AREAS:	None	Marks beginning of Ineffective Areas object.
INEFFECTIVE ID:	String	Ineffective area identifier. Corresponds to ID in INEFFECTIVE POSITIONS object on cross section. Concludes with an "END:".
POLYGON:	Location array	Array elements contain 2D coordinates of ineffective area polygon points.
END INEFFECTIVE AREAS:	None	Marks end of Ineffective Areas object.
Blocked obstruction records		
BEGIN BLOCKED AREAS:	None	Marks beginning Blocked Obstructions object.
BLOCKED ID:	String	Blocked obstructions identifier. Corresponds to ID in BLOCKED POSITIONS object on cross section.
POLYGON:	Location array	Array elements contain 2D coordinates of ineffective area polygon points.
END BLOCKED AREAS:	None	Marks end of Blocked Obstructions object.

Bridge/Culverts

The bridge/culvert data section begins with a record containing only the keyword "BEGIN BRIDGE/CULVERTS:" and ends with a record containing only the keyword "END BRIDGE/CULVERTS:". A bridge is represented by multi-record object beginning with a record containing only the keyword "BRIDGE/CULVERT:" and ending with a record containing only the keyword "END:."

Bridges/Culverts have the same required records as the Cross Sections object, but have other optional records. A summary of Bridge/Culvert records is provided in Table B-5.

Table B-5. Bridge/Culvert options in the spatial data format file.

Keyword	Value Type	Value
BRIDGE/CULVERT:	None	Marks beginning of Bridge/Culvert object.
END:	None	Marks end of a Bridge/Culvert object.

The following records are required for a Bridge/Culvert object.

Keyword	Value Type	Value
STREAM ID:	String	Identifier for the River on which the bridge/culvert resides.
REACH ID:	String	Identifier for the Reach on which the bridge/culvert resides.
STATION:	Float	Relative position of the bridge on the river reach.
CUT LINE:	Location array	Array elements contain planar coordinates of bridge location.
SURFACE LINE:	Location array	Array elements contain 3D coordinates of bridge deck.

The following records are optional (but recommend) for a Bridge/Culvert object.

Keyword	Value Type	Value
NODE NAME:	String	Description of cross section.
US DISTANCE:	Float	Distance to upstream cross section.
TOP WIDTH:	Float	Top width of bridge deck.

Inline Structures

The inline structures data section begins with a record containing only the keyword "BEGIN INLINE STRUCTURES:" and ends with a record

containing only the keyword "END INLINE STRUCTURES:". An inline structure is represented by multi-record object beginning with a record containing only the keyword "INLINE STRUCTURES:" and ending with a record containing only the keyword "END:."

Inline structures have the same required records as the Bridge/Culvert object. A summary of Inline Structures records is provided in Table B-6.

Table B-6. Inline structure options in the spatial data format file.

Keyword	Value Type	Value
INLINE STRUCTURES:	None	Marks beginning of Inline Structure object.
END:	None	Marks end of a Inline Structure object.

The following records are required for a Inline Structure object.

STREAM ID:	String	Identifier for the River on which the inline structure resides.
REACH ID:	String	Identifier for the Reach on which the inline structure resides.
STATION:	Float	Relative position of the inline structure on the river reach.
CUT LINE:	Location array	Array elements contain planar coordinates of inline structure location.
SURFACE LINE:	Location array	Array elements contain 3D coordinates of inline weir profile.

The following records are optional (but recommend) for an Inline Structure object.

NODE NAME:	String	Description of inline structure.
US DISTANCE:	Float	Distance to upstream cross section.
TOP WIDTH:	Float	Top width of inline weir.

Lateral Structures

The lateral structures data section begins with a record containing only the keyword "BEGIN LATERAL STRUCTURES:" and ends with a record containing only the keyword "END INLINE STRUCTURES:". A lateral structure is represented by multi-record object beginning with a record containing only the keyword "LATERAL STRUCTURES:" and ending with a record containing only the keyword "END:."

Lateral structures have the same required records as the inline structures object. A summary of Lateral Structures records is provided in Table B-7.

Table B-7. Lateral structure options in the spatial data format file.

Keyword	Value Type	Value
LATERAL STRUCTURES:	None	Marks beginning of Lateral Structures object.
END:	None	Marks end of Lateral Structures object.

The following records are required for a Lateral Structure object.

Keyword	Value Type	Value
STREAM ID:	String	Identifier for the River on which the lateral structure resides.
REACH ID:	String	Identifier for the Reach on which the lateral structure resides.
STATION:	Float	Relative position of the lateral structure on the river reach.
CUT LINE:	Location array	Array elements contain planar coordinates of lateral structure location.
SURFACE LINE:	Location array	Array elements contain 3D coordinates of weir profile.

The following records are optional (but recommend) for a Lateral Structure object.

Keyword	Value Type	Value
NODE NAME:	String	Description of lateral structure.
US DISTANCE:	Float	Distance to upstream cross section.
TOP WIDTH:	Float	Top width of weir.

Storage Areas

The storage areas data section begins with a record containing only the keyword "BEGIN STORAGE AREAS:" and ends with a record containing only the keyword "END STORAGE STRUCTURES:". The keyword "SA ID:" identifies a storage area object. A summary of Storage Areas records is provided in Table B-8.

Table B-8. Storage area options in the spatial data format file.

Keyword	Value Type	Value
SA ID:	String	Storage area identifier.
POLYGON:	Location array	Array elements contain 2D coordinates of storage area boundary. Concludes with an "END:"
ELEVATION-VOLUME:	Float array	Elevation volume information for storage area. (*Elevation, Volume*) Concludes with an "END:"

The following records are optional for a Storage Area object.

TERRAIN:	Float array	X,Y,Z coordinates for terrain data within storage area. Concludes with an "END:".

Storage Area Connections

The storage area connections data section begins with a record containing only the keyword "BEGIN SA CONNECTIONS:" and ends with a record containing only the keyword "END SA CONNECTIONS:". A summary of Storage Area Connection records is provided in Table B-9.

Table B-9. Storage area connection options in the spatial data format file.

Keyword	Value Type	Value
SACONNID:	String	Storage area connection identifier.
USSA:	String	Identifier of upstream storage area (SA ID).
DSSA:	String	Identifier of downstream storage area (SA ID).
CUT LINE:	Location array	Array elements contain planar coordinates of storage area connection location.
SURFACE LINE:	Location array	Array elements contain 3D coordinates of weir profile.

The following records are optional for a Storage Area Connection object.

NODE NAME:	String	Description of storage area connection.
TOP WIDTH:	Float	Top width of weir.

RAS GIS Export File (RASExport.sdf)

HEC-RAS exports model results to a text file using the same spatial data format as the data import file. The contents of the file, however, are not identical. An example HEC-RAS model export file is shown at the end of this appendix. A summary of model elements for data export from HEC-RAS that differs from the import file is provided in Table B-10.

Table B-10. HEC-RAS export options in the spatial data format file

Keyword	Value Type	Value
The following records are required for Header section of the RAS GIS Export File		
NUMBER OF PROFILES:	Integer	Number of profile exported from HEC-RAS. Required if greater than 1.
PROFILE NAMES:	String array	Water surface profile names exported from HEC-RAS. Required if number of profiles is greater than 1.
The following records area required in the Cross Section portion of the Export File		
WATER ELEVATION:	Float array	Elevation of water surface at the cross section. The array must contain a value for each profile.
PROFILE ID:	String array	Water surface profile name(s). This must match the name(s) in the Profile Names record.
The following records are optional in the Cross Section portion of the Export File		
WATER SURFACE EXTENTS:	Location array	A series of 2D locations marking the limits of a water surface on the cross section.
VELOCITIES:	Float, paired array	Fraction along cut line and value of velocity (*fraction, value*). Velocity records must follow Profile ID record.
ACTIVE WS EXTENTS:	Location array	A series of 2D locations marking the limits of the active water surface on the cross section. Used for interpolation of the velocity data.
ICE THICKNESS:	Float, paired array	Fraction along cut line and value of ice thickness (*fraction, value*). Ice thickness records must follow Profile ID record.

Keyword	Value Type	Value

The following records make up a section defining Storage Areas in the Export File

Keyword	Value Type	Value
BEGIN STORAGE AREAS:	None	Marks beginning of Storage Area object.
END STORAGE AREAS:	None	Marks end Storage Area object.
SA ID:	String	Storage area identifier.
WATER ELEVATION:	Float array	Elevation of water surface at the storage area. The array must contain a value for each profile.
POLYGON:	Location array	Array elements contain 2D coordinates of storage area limits.

The following records make up a section defining Bounding Polygons for the water surface limits in the Export File

Keyword	Value Type	Value
BEGIN BOUNDS:	None	Marks start of boundaries section.
END BOUNDS:	None	Marks end of boundaries section.
PROFILE LIMITS:	None	Marks start of an object defining the limits of a single water surface profile. Concludes with an "END:"
PROFILE ID:	String	Name of the profile. This must match a name in the Profile Names record in the header.
POLYGON:	Location array	Array elements contain 2D coordinates of water surface limits. A single profile limit can be merged from multiple polygons.

Water Surface Bounding Polygon

In addition to a water surface elevations at each cross section (one for each profile), the HEC-RAS program sends a bounding polygon for each hydraulic reach in the model (the program outputs a new set of bounding polygons for each profile computed). The bounding polygon is used as an additional tool to assist the GIS (or CADD) software to figure out the boundary of the water surface on top of the terrain.

In most cases, the bounding polygon will represent the outer limits of the cross section data, and the actual intersection of the water surface with the terrain will be inside of the polygon. In this case, the GIS software will use the water surface elevations at each cross section and create a surface that extends out to the edges of the bounding polygon. That surface is then intersected with the terrain data, and

the actual water limits are found as the location where the water depth is zero.

However, in some cases, the bounding polygon may not represent the extents of the cross-section data. For example, if there are levees represented in the HEC-RAS model, which limit the flow of water, then the bounding polygon will only extend out to the levees at each cross section. By doing this, when the information is sent to the GIS, the bounding polygon will prevent the GIS system from allowing water to show up on both sides of the levees.

In addition to levees, the bounding polygon is also used at hydraulic structures such as bridges, culverts, weirs, and spillways. For example, if all of the flow is going under a bridge, the bounding polygon is brought into the edges of the bridge opening along the road embankment on the upstream side, and then back out to the extent of the cross-section data on the downstream side. By doing this, the GIS will be able to show the contraction and expansion of the flow through the hydraulic structures, even if the hydraulic structures are not geometrically represented in the GIS.

Another application of the bounding polygon is in FEMA floodway studies. When a floodway study is done, the first profile represents the existing conditions of the floodplain. The second and subsequent profiles are run by encroaching on the floodplain until some target increase in water surface elevation is met. When the encroached profile is sent to the GIS, the bounding polygon is set to the limits of the encroachment for each cross section. This will allow the GIS to display the encroached water surface (floodway) over the terrain, even though the water surface does not intersect the ground.

Import/Export Guidelines

The following rules apply to channel and cross-section import/export data.

Defining the River Network

- The stream network is represented by a set of interconnected reaches. A stream is a set of one or more connected reaches that share a common Stream ID.

- A stream is composed of one or more reaches with the same Stream ID, and each reach in a stream must have a unique Reach ID. Every reach must be identified by a unique combination of stream and reach IDs.

- Stream IDs and Reach IDs are alphanumeric strings. Reach endpoint IDs are integers.

- Streams cannot contain parallel flow paths. (If three reaches connect at a node, only two can have the same Stream ID.) This prevents ambiguity in stationing along a stream.

- A reach is represented by an ordered series of 3D coordinates, and identified by a Stream ID, a Reach ID, and IDs for its endpoints.

- A reach endpoint is represented by its 3D coordinates and identified by an integer ID.

- Reaches are not allowed to cross, but can be connected at their endpoints (junctions) to form a network.

- The normal direction of flow on a reach is indicated by the order of its endpoints. One point marks the upstream or "from" end of the reach, the other marks the downstream or "to" end of the reach.

Defining Cross Sections

- Each cross section is defined by a series of 3D coordinates, and identified by a stream name and reach name (which must refer to an existing stream and reach) and a station, indicating the distance from the cross-section to the downstream end of the stream.

- A cross-section line can cross a reach line exactly once, and cannot cross another cross-section line.

Results of a water surface calculation are exported in a file that contains cross-section locations in plane (2D) coordinates, water-surface elevations for the cross-sections, and boundary polygons for the reaches.

Water Surface Export Data Rules

- A cross-section is represented by a water surface elevation and a series of 2D coordinates on the cross-section cut line. The full width of the cross-section is included.

- One bounding polygon is created for each reach in the stream network, and for each profile.

- A reach's bounding polygon is made up of the most upstream cross-section on the reach, the endpoints of all cross-sections on the reach, and the most upstream cross-sections of reaches downstream of the reach.

- For purposes of defining bounding polygons *only*, the endpoints of a cross-section are adjusted to the edge of the water surface at the cross-section if the cross-section is part of a floodway, a leveed section of the reach, or the water extent is controlled by a hydraulic structure. This allows calculated water surfaces that are higher than the land surface to be reported back to the CADD or GIS program.

Sample RAS GIS Import File

```
#This file is generated by HEC-GeoRAS for ArcGIS
BEGIN HEADER:
    DTM TYPE: TIN
    DTM: C:\Examples\Baxter\baxter_tin
    STREAM LAYER: C:\Examples\Baxter\baxter.mdb\River
    NUMBER OF REACHES: 3
    CROSS-SECTION LAYER: C:\Examples\Baxter\baxter.mdb\XSCutLines
    NUMBER OF CROSS-SECTIONS: 173
    MAP PROJECTION: STATEPLANE
    PROJECTION ZONE:
    DATUM: NAD83
    VERTICAL DATUM:
    BEGIN SPATIAL EXTENT:
        XMIN: 6366478.85990533
        YMIN: 2010839.52690533
        XMAX: 6468128.45990533
        YMAX: 2112489.12690533
    END SPATIAL EXTENT:
UNITS: FEETEND HEADER:


BEGIN STREAM NETWORK:

    ENDPOINT: 6453740, 2051685, 60, 1
    ENDPOINT: 6421541, 2051194, 34, 2
    ENDPOINT: 6387438, 2035323, 32.95776, 3
    ENDPOINT: 6426447, 2059280, 52.14808, 4

    REACH:
        STREAM ID: Baxter River
        REACH ID: Upper Reach
        FROM POINT: 1
        TO POINT: 2
        CENTERLINE:
            6453739.98997957, 2051684.77998051, 59.99999997, 89378.4140625
                    --- many lines omitted ---
            6421540.44998505, 2051194.18999834, 34.00000001, 48157.06640625
    END:

    REACH:
        STREAM ID: Baxter River
        REACH ID: Lower Reach
        FROM POINT: 2
        TO POINT: 3
        CENTERLINE:
            6421540.44998505, 2051194.18999834, 34.00000001, 48157.06640625
                    --- many lines omitted ---
            6387438.24001357, 2035323.14001705, 32.95775604, 0
    END:

    REACH:
        STREAM ID: Tule Creek
        REACH ID: Tributary
        FROM POINT: 4
        TO POINT: 2
        CENTERLINE:
            6426446.76000561, 2059279.84000069, 52.14807890, 12551.4970703125
                    --- many lines omitted ---
```

```
                6421540.44998505, 2051194.18999834, 34.00000001, 0
        END:

    END STREAM NETWORK:


    BEGIN CROSS-SECTIONS:

        CROSS-SECTION:
            STREAM ID: Baxter River
            REACH ID: Upper Reach
            STATION: 84815.69
            NODE NAME:
            BANK POSITIONS: 0.5417204, 0.6313727
            REACH LENGTHS: 343.447, 815.2449, 627.6476
            NVALUES:
                0, 0.06
                0.2595427, 0.035
                0.6867172, 0.06
            LEVEE POSITIONS:
            INEFFECTIVE POSITIONS:
            BLOCKED POSITIONS:
            CUT LINE:
                6451252.61043617, 2049658.48075948
                6450473.97548097, 2050754.33739816
                6449753.01716107, 2051480.10208855
            SURFACE LINE:
                6451252.61043617, 2049658.48075948, 125.00000002
                        --- many lines omitted ---
                6449753.01716107, 2051480.10208855, 110.31235503
        END:

        CROSS-SECTION:
            STREAM ID: Baxter River
            REACH ID: Upper Reach
            STATION: 77909.16
            NODE NAME:
            BANK POSITIONS: 0.4635276, 0.572924
            REACH LENGTHS: 223.1558, 229.2013, 233.3537
            NVALUES:
                0, 0.06
                0.4353712, 0.035
                0.6486487, 0.06
            LEVEE POSITIONS:
            INEFFECTIVE POSITIONS:
                354, 0, 0.3630761, 93.26781
                355, 0.6235623, 1, 105.4026
            BLOCKED POSITIONS:
                379, 0.37786, 0.9548786, 79.19141
            CUT LINE:
                6446531.40685930, 2048445.67038340
                6446341.91498890, 2048655.03933954
                6446207.54346581, 2049102.94440073
                6446140.35770426, 2049409.01289628
                6446028.38145080, 2049909.17358660
                6445838.02350501, 2050713.98307530
            SURFACE LINE:
                6446531.40685930, 2048445.67038340, 93.26781466
                        --- many lines omitted ---
                6445838.02350501, 2050713.98307530, 105.40263370
        END:

        --- many Cross Sections omitted ---
```

```
     CROSS-SECTION:
         STREAM ID: Baxter River
         REACH ID: Lower Reach
         STATION: 34251.78
         NODE NAME:
         BANK POSITIONS: 0.2088515, 0.2746628
         REACH LENGTHS: 678.4368, 652.6373, 592.5861
         NVALUES:
             0, 0.06
             0.2023585, 0.035
             0.5760272, 0.05
         LEVEE POSITIONS:
             380, 0.5949767, 72.00802
         INEFFECTIVE POSITIONS:
         BLOCKED POSITIONS:
         CUT LINE:
             6412787.19596798, 2042663.48848210
             6412627.43755387, 2043633.45026854
             6412056.87180271, 2047399.18430193
         SURFACE LINE:
             6412787.19596798, 2042663.48848210, 80.15862274
                     --- many lines omitted ---
             6412056.87180271, 2047399.18430193, 77.57256318
     END:

END CROSS-SECTIONS:


BEGIN BRIDGES/CULVERTS:

     BRIDGE/CULVERT:
         STREAM ID: Tule Creek
         REACH ID: Tributary
         STATION: 4514.028
         NODE NAME: Yosemite Street
         US DISTANCE: 100
         TOP WIDTH: 96
         CUT LINE:
             6422221.24109452, 2055203.79594125
             6421766.89378999, 2055127.22052519
             6421302.33643314, 2054958.75468559
             6421128.76554372, 2054912.80947382
             6420924.56454467, 2054892.38936919
         SURFACE LINE:
             6422221.24109452, 2055203.79594125, 88.73309329
                     --- many lines omitted ---
                 6420924.56454467, 2054892.38936919, 83.88871764
     END:

     --- many Bridges/Culverts omitted ---
END BRIDGES/CULVERTS:


BEGIN LEVEES:

     LEVEE ID: 380
         SURFACE LINE:
                 6416224.46794023, 2048201.03890064, 80.30300144
                 --- many lines omitted ---
                 6408127.91921907, 2047348.05802148, 73.83999635
     END:
```

```
    END LEVEES:




    BEGIN INEFFECTIVE AREAS:

        INEFFECTIVE ID: 354
            POLYGON:
                6446126.65267778, 2049275.06766575
                6446347.63945516, 2049062.58037434
                6446466.63230616, 2048960.58649530
                        --- many lines omitted ---
                6446126.65267778, 2049275.06766575
        END:

        INEFFECTIVE ID: 355
            POLYGON:
                6446009.40721919, 2049877.88188569
                6445816.78229256, 2050758.82118551
                        --- many lines omitted ---
                6446009.40721919, 2049877.88188569
        END:

        --- many Ineffective Areas omitted ---
    END INEFFECTIVE AREAS:


    BEGIN BLOCKED OBSTRUCTIONS:

        BLOCKED ID: 379
            POLYGON:
                6422107.09773554, 2052558.24567028
                6423542.24950153, 2052503.04750541
                6422076.43212521, 2052184.12491178
                6422107.09773554, 2052558.24567028
        END:

    END BLOCKED OBSTRUCTIONS:


    BEGIN LATERAL STRUCTURES:

        LATERAL STRUCTURE:
                STREAM ID: Baxter River
                REACH ID: Lower Reach
                STATION: 27469.68
                NODE NAME: North LS
                US DISTANCE: 0
                TOP WIDTH: 20
                CUT LINE:
                        6407389.53497197, 2047168.40301990
                        6406371.11447597, 2046886.24321303
                                --- many lines omitted ---
                        6402363.56369299, 2045153.60574580
                SURFACE LINE:
                        6407389.53497197, 2047168.40301990, 69.83999637
                                --- many lines omitted ---
                        6402363.56369299, 2045153.60574580, 65.27986148
        END:

    END LATERAL STRUCTURES:
```

```
BEGIN STORAGE AREAS:

        SA ID: 369
        POLYGON:
                6402631.96981374, 2045430.51958869
                        --- many lines omitted ---
                6402631.96981374, 2045430.51958869
        END:
        ELEVATION-VOLUME:
                63.34, 0
                64.59, 272682.8
                65.84, 2102153
                67.09, 1.130536E+07
                68.34, 2.241535E+07
                69.59, 3.505853E+07
                70.84, 4.921408E+07
                72.09, 6.477892E+07
                73.34, 8.095226E+07
                74.59, 9.734569E+07
                75.84, 1.142249E+08
        END:
        TERRAIN:
        END:

END STORAGE AREAS:

BEGIN SA CONNECTIONS:

    SA CONNECTION:
         SACONN ID: 444
         NODE NAME:
         US SA:   369
         DS SA:   371
         TOP WIDTH: 20
         CUT LINE:
                6407389.53497197, 2047168.40301990
                6406371.11447597, 2046886.24321303
                        --- many lines omitted ---
                6402363.56369299, 2045153.60574580
         SURFACE LINE:
                6407389.53497197, 2047168.40301990, 69.83999637
                        --- many lines omitted ---
                6402363.56369299, 2045153.60574580, 65.27986148

    END:

END SA CONNECTIONS:
```

Sample RAS GIS Export File

```
# RAS export file created on Mon 21Feb2005 16:18
# by HEC-RAS Version 3.1.3

BEGIN HEADER:
  UNITS:
  DTM TYPE: TIN
  DTM: C:\Examples\Baxter\baxter_tin
  STREAM LAYER: C:\Examples\Baxter\baxter.mdb\River
  CROSS-SECTION LAYER: C:\Examples\Baxter\baxter.mdb\XSCutLines
  MAP PROJECTION: STATEPLANE
  PROJECTION ZONE:
  DATUM: NAD83
  VERTICAL DATUM:
  BEGIN SPATIALEXTENT:
       XMIN: 6366478.85990533
       YMIN: 2010839.52690533
       XMAX: 6468128.45990533
       YMAX: 2112489.12690533
  END SPATIALEXTENT:
  NUMBER OF PROFILES:  3
  PROFILE NAMES:
    50yr
    100yr
    500yr
  NUMBER OF REACHES:  3
  NUMBER OF CROSS-SECTIONS:  179
END HEADER:

BEGINSTREAMNETWORK:

ENDPOINT:6421540.50,2051194.25, , 1
ENDPOINT:6453739.99,2051684.78, , 2
ENDPOINT:6387438.24,2035323.14, , 3
ENDPOINT:6426446.76,2059279.84, , 4

REACH:
 STREAM ID: Baxter River
 REACH ID: Upper Reach
 FROM POINT:  2
 TO POINT:  1
 CENTERLINE:
      6453739.99,     2051684.78, ,
      6421540.45,     2051194.19, ,
END:

REACH:
 STREAM ID: Baxter River
 REACH ID: Lower Reach
 FROM POINT:  1
 TO POINT:  3
 CENTERLINE:
      6421540.45,     2051194.19, ,
      6387438.24,     2035323.14, ,
END:

REACH:
 STREAM ID: Tule Creek
 REACH ID: Tributary
```

```
  FROM POINT:  4
  TO POINT:  1
  CENTERLINE:
      6426446.76,      2059279.84, ,
      6421540.45,      2051194.19, ,
  END:


ENDSTREAMNETWORK:


BEGIN CROSS-SECTIONS:

  CROSS-SECTION:
    STREAM ID:Baxter River
    REACH ID:Upper Reach
    STATION:84815.69
    NODE NAME:
    CUT LINE:
      6451252.6104362 , 2049658.4807595
      6450473.975481 , 2050754.3373982
      6449753.0171611 , 2051480.1020886
    REACH LENGTHS:826.24,806.49,525.17
    BANK POSITIONS:0.45159,0.51309
    LEVEE POSITIONS:
            380,0.93260,79.95625
    WATER ELEVATION:70.39427,76.72782,86.74971
    WATER SURFACE EXTENTS:
      6450877.21,    2050186.83,    6450289.15,    2050940.40
      6450896.85,    2050159.18,    6450262.99,    2050966.73
      6450912.28,    2050137.47,    6450189.98,    2051040.23
    PROFILE ID:50yr
        VELOCITIES:
          0.32733,   1.558
          0.46174,   2.381
          0.55094,   3.764
          0.56925,   4.280
          0.58721,   6.164
          0.60317,   5.713
          0.62166,   3.942
          0.64436,   1.926
    PROFILE ID:100yr
        VELOCITIES:
          0.31866,   2.972
          0.45698,   3.829
          0.55086,   5.019
          0.56908,   5.459
          0.58709,   7.245
          0.60341,   6.737
          0.62189,   5.168
          0.65404,   3.202
    PROFILE ID:500yr
        VELOCITIES:
          0.31332,   4.739
          0.45464,   5.533
          0.55081,   6.526
          0.56894,   6.860
          0.58698,   8.456
          0.60365,   7.890
          0.62206,   6.635
          0.66467,   4.272
    SURFACE LINE:
      6451252.61,   2049658.48,   125.00
          --- many lines omitted ---
```

```
         449753.02,    2051480.10,    110.31
      END:
   CROSS-SECTION:
      STREAM ID:Tule Creek
      REACH ID:Tributary
      STATION:1595.102
      NODE NAME:
      CUT LINE:
        6422369.1971783 , 2052943.6596315
        6421588.0439919 , 2052573.50648
            --- many lines omitted ---
        6420275.0509832 , 2052670.3666247
      WATER ELEVATION:62.67044,69.44948,78.49661
      WATER SURFACE EXTENTS:
        6421432.49,    2052554.70,    6420609.83,    2052432.00
        6421570.89,    2052571.43,    6420459.69,    2052510.35
        6422048.65,    2052791.77,    6420316.40,    2052634.53
      PROFILE ID:50yr
          VELOCITIES:
            0.47364,    0.016
            0.65126,    0.056
            0.74604,    0.171
            0.75411,    0.221
            0.76221,    0.247
            0.77030,    0.207
            0.77842,    0.151
            0.79265,    0.059
      PROFILE ID:100yr
          VELOCITIES:
            0.44844,    0.116
            0.62783,    0.185
            0.74591,    0.383
            0.75406,    0.466
            0.76221,    0.514
            0.77035,    0.444
            0.77857,    0.350
            0.81222,    0.177
            0.86985,    0.096
      PROFILE ID:500yr
          VELOCITIES:
            0.21051,    0.019
            0.42227,    0.092
            0.62301,    0.192
            0.74582,    0.350
            0.75403,    0.407
            0.76221,    0.444
            0.77039,    0.393
            0.77866,    0.327
            0.81602,    0.232
            0.88706,    0.146
            0.94874,    0.075
      SURFACE LINE:
        6422369.20,    2052943.66,    80.22
            --- many lines omitted ---
        6420275.05,    2052670.37,    85.26
      END:

   END CROSS-SECTIONS:
```

```
BEGIN STORAGE AREAS:


  SA ID: 369
    WATER ELEVATION:65,65,65
  POLYGON:
      6402631.9698137  , 2045430.5195887  ,
      6402648.7543614  , 2046009.5857725  ,
            --- many lines omitted ---
      6402631.9698137  , 2045430.5195887  ,
  END:


  SA ID: 370
    WATER ELEVATION:65,65,65
  POLYGON:
      6411089.902679  , 2043584.9518455  ,
      6411100.24735   , 2041762.9675571  ,
            --- many lines omitted ---
      6411089.902679  , 2043584.9518455  ,
  END:

END STORAGE AREAS:


BEGIN BOUNDS:

  PROFILE LIMITS:
    PROFILE ID:50yr
    POLYGON:
     6449753.02,2051480.10,70.39
      --- many lines omitted ---
     6449462.09,2051308.23,70.35
    POLYGON:
     6424775.60,2059535.58,62.69
      --- many lines omitted ---
     6424246.32,2059434.43,62.69
    POLYGON:
     6420221.24,2052718.80,62.36
      --- many lines omitted ---
     6420143.38,2052744.69,62.32
  END:

  PROFILE LIMITS:
    PROFILE ID:100yr
    POLYGON:
     6449753.02,2051480.10,76.73
      --- many lines omitted ---
     6449462.09,2051308.23,76.73
    POLYGON:
     6424775.60,2059535.58,69.51
      --- many lines omitted ---
     6424246.32,2059434.43,69.52
    POLYGON:
     6420221.24,2052718.80,69.19
      --- many lines omitted ---
     6420143.38,2052744.69,69.17
  END:

  PROFILE LIMITS:
    PROFILE ID:500yr
    POLYGON:
     6449753.02,2051480.10,86.75
      --- many lines omitted ---
     6449462.09,2051308.23,86.83
```

```
        POLYGON:
         6424775.60,2059535.58,78.54
          --- many lines omitted ---
         6424246.32,2059434.43,78.54
        POLYGON:
         6420221.24,2052718.80,78.18
          --- many lines omitted ---
         6420143.38,2052744.69,78.16
      END:

    END BOUNDS:
```

A P P E N D I X   C

HEC-RAS Results Interpolation

HEC-RAS results may be interpolated spatially between cross section locations within HEC-GeoRAS, but the interpolation program can also be used as a "stand-alone" piece of software. The interpolation process allows for interpolation of velocity, shear stress, stream power, and ice results subsequent to performing the floodplain delineation; therefore, interpolation must be done using preexisting floodplain boundary results and the HEC-RAS output (*RASEXport.sdf*). Interpolation of Velocity is discussed in detail; interpolation of Shear Stress, Stream Power, and Ice Thickness data may be accomplished using identical methods (specifying the "shear", "power", "ice" keywords rather than the "velocity" keywords in the parameters import file). Results may be viewed in ArcGIS.

Software

The interpolation of data outside of the HEC-GeoRAS software is comprised of several DLLs and one executable to access the interpolation routines. It is not required that the software is registered with the operating system; however, you must have the .NET Framework 2.0 installed on the computer. The interpolation software components are enumerated below.

1. XSTransitionEXE.exe

2. XSTransition.dll

3. MatrixSolutions.dll

4. HECGraphics.dll

It is suggested the software is copied to the same directory in which the required data are stored, for user simplicity, but it is not necessary (by default this software is installed to the "C:\Program Files\HEC\HEC-GeoRAS\bin" directory).

Additionally, the VBA script ("Export_Flood2XML") may be needed to export floodplain boundaries to the specified format.

Required Data

There are three pieces of required data for use with the interpolation software: the HEC-RAS exported results (with velocity, shear stress, stream power, ice, etc) including bank station data, floodplain boundaries for each water surface profile, and input parameters identifying what to process. [The final release of HEC-RAS 4.0 has a new output parameter specifying the water surface extents of the active conveyance area (Active WS Extents) important to the velocity interpolation routines.]

HEC-RAS Export File

The HEC-RAS export file must be in the form of the *RASExport.xml* file. This file is generated by taking the *RASExport.sdf* file and processing it using the SDF2XML converter program installed with HEC-GeoRAS (the SDF2XML program may also be executed separately from GeoRAS). Conversion from the SDF format to the XML format is the first step when performing inundation mapping using HEC-GeoRAS – it is assumed that the inundation mapping will be performed to develop the floodplain boundaries.

The HEC-RAS results GIS file is referred to as the *RAS Export* file. The *RAS Export* file must contain simulation results for the data to be interpolated; therefore, the user must turn on the correct simulation options in HEC-RAS and choose to export the data to the GIS export file.

Floodplain Boundaries

The floodplain boundaries for each profile must be exported to the specified XML format. The data may be contained in a separate file (referred to as the *Floodplains* file) or the data may be appended to the *RAS Export* file.

The VBA script "Export_Flood2XML" may be used to export floodplain layers from ArcMap to an XML file. The script expects the profile names to be of the form "bP00n" or "b P00n" as generated using HEC-GeoRAS. Directions for exporting the floodplain boundaries are provided in this step-by-step example.

The *Floodplains.xml* file must have a "RAS2GIS" root node. All floodplain boundaries are contained within the "FloodplainBoundaries" node (in order that the boundaries may be included in the RAS Export file) and each floodplain boundary described by the "FloodplainBoundary" node with the "ProfileID" attribute identifying the profile name. The structure of the *Floodplains.xml* file is shown in Figure C- 1.
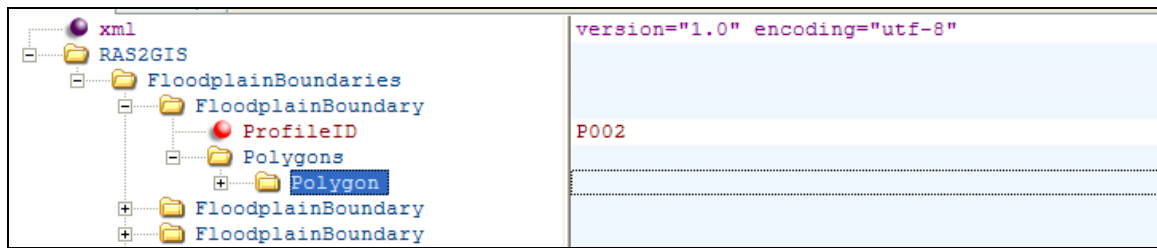
Figure C- 1. Floodplains.xml structure for the floodplain boundary node.

Interpolation Parameters

The interpolation *Parameters.xml* file is used for establishing the profiles to process and RAS results parameters of interest. This file is also used to establish the file names and locations for the *RAS Export* file and the *Floodplains.xml* file. Lastly, this file establishes the registration information for the resulting grids computed from the interpolation. An example of the parameters used for velocity analysis are shown in Figure C- 2.

```xml
<?xml version="1.0" encoding="utf-8" ?>
<Parameters>
  <Rasters>
    <Raster Name="Tile1" LowerLeftX="2058332.1044126181" LowerLeftY="13277599.276147507"
      NumberColumns="2063" NumberRows="2012" CellSize="66" NoDataValue="-9999" />
  </Rasters>
  <Files>
    <File Type="RASExports" Name="Failure.RASexport.xml" />
    <File Type="Floodplains" Name="Floodplains.xml" />
  </Files>
  <Transitions>
    <Transition ProfileID="P028" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
    <Transition ProfileID="P029" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
    <Transition ProfileID="P030" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
    <Transition ProfileID="P031" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
    <Transition ProfileID="P032" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
  </Transitions>
</Parameters>
```

Figure C- 2. The Parameters.xml file establishes what will be processed.

Raster parameters may be created by looking at depth grid source data developed by HEC-GeoRAS through the ArcMap interface. (The ESRI GRID format uses -9999 for 'No Data' cells.) If multiple Raster nodes are present in the parameters file, the output grids will be "tiled" based on the raster parameter values in a directory based on the ProfileID value.

Individual parameter values for velocity, shear stress, stream power, and ice thickness are provided in Table C- 1.

Table C- 1. Parameter file keywords for HEC-RAS results interpolation.

Parameter Name	Parameter	Values	Value	GridAbr
Velocity	Velocities	VelocityValues	Velocity	vel
Ice Thickness	IceThicknessData	IceThicknessValues	IceThickness	ice
Shear Stress	ShearStressData	ShearStressValues	ShearStress	shear
Stream Power	StreamPowerData	StreamPowerValues	StreamPower	power

Example

This example guides you through how to do interpolation of velocity data outside of HEC-GeoRAS using the "Example Data" provided with the stand-alone version of the interpolation software.

Establish Workspace

Create a directory for the interpolation software.

You will also need the geodatabase of floodplain boundaries from the "data" directory (or you can use your own shapefiles or geodatabase) and a corresponding RASExport.sdf file.

Convert RAS Export file to XML

Convert the RASExport.sdf file to the XML equivalent. This is done using the HEC-GeoRAS toolbar (Version 4.2) or the stand-alone SDF2XML.exe program.
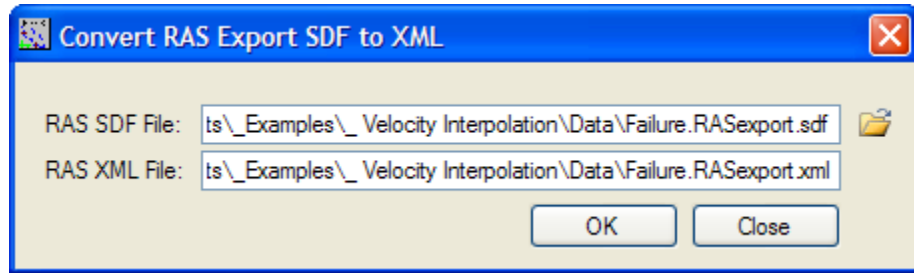
Open a New ArcMap Document

Create a new ArcMap document and save it to the workspace location.

Load the Floodplain Boundary Layers

Load the floodplain boundaries into the ArcMap document.
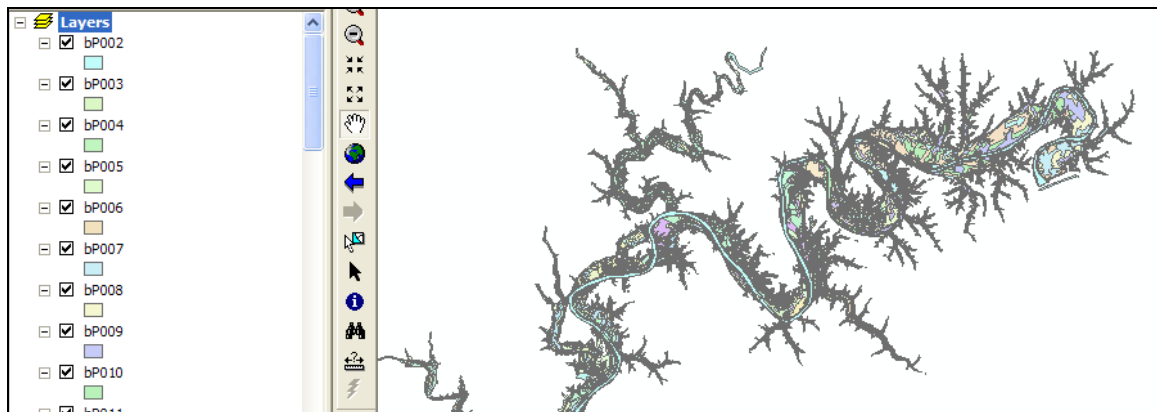
The floodplain boundary names should be of the generic form of the ProfileID - "bP00n" or "b P00n". The parameter data is stored in the RAS Export file based on the ProfileID and the floodplain boundary feature classes are written to the output geodatabase using the same name structure.

Export Floodplains to XML

You must load the "Export_Flood2XML" VBA script to export the data. By default the exported data will be created in the location of the MXD with the name "Floodplains.xml".

You first need to create a new button to attach the script to. Click on the **Tools | Customize** menu item. Click on the **Commands** tab.
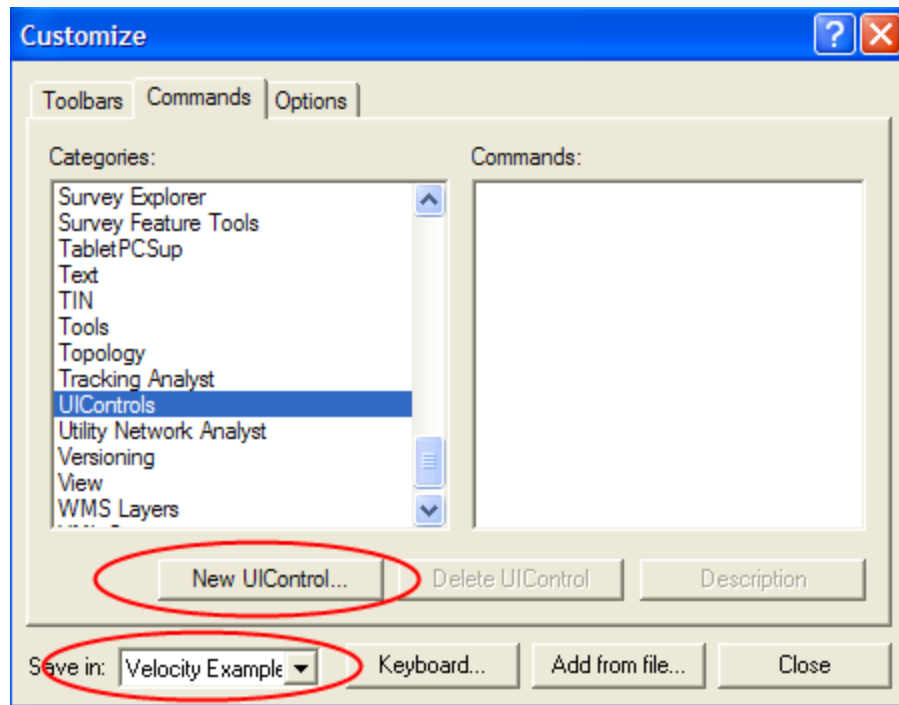
Choose to "Save in" the active project if you don't want to see the tool in future ArcMap documents.

Click the **New UIControl** button.

Select the **UIButtonControl** (default) and then click **Create**.
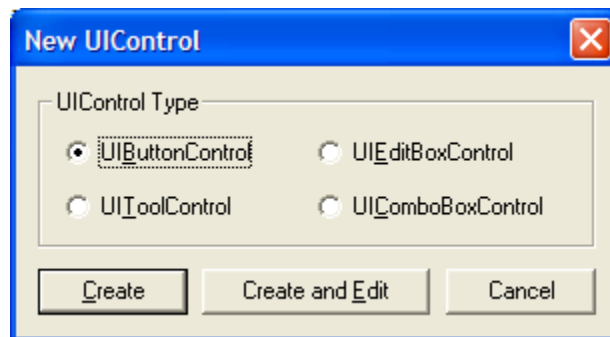
This adds a new Command in the Commands list. Select it and rename it to something meaningful to you (Project.ExportFloodplains is shown below).
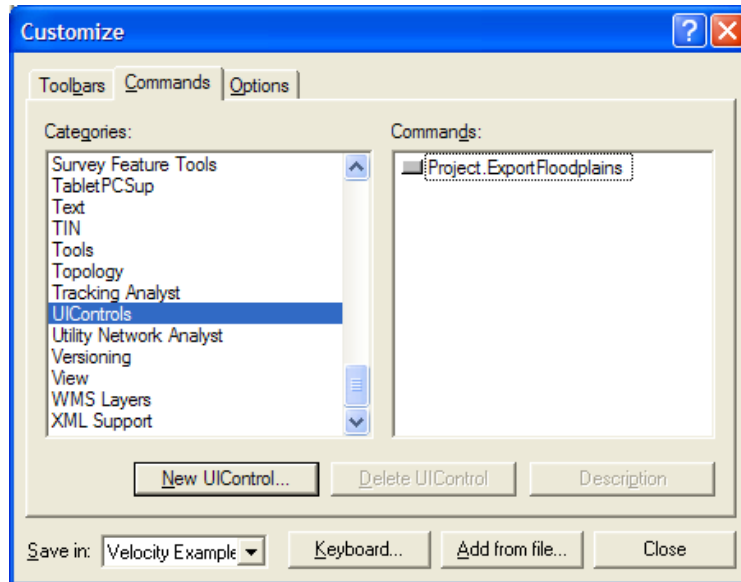
Next, drag the new button up onto a toolbar. Here it is added to the GeoRAS toolbar.
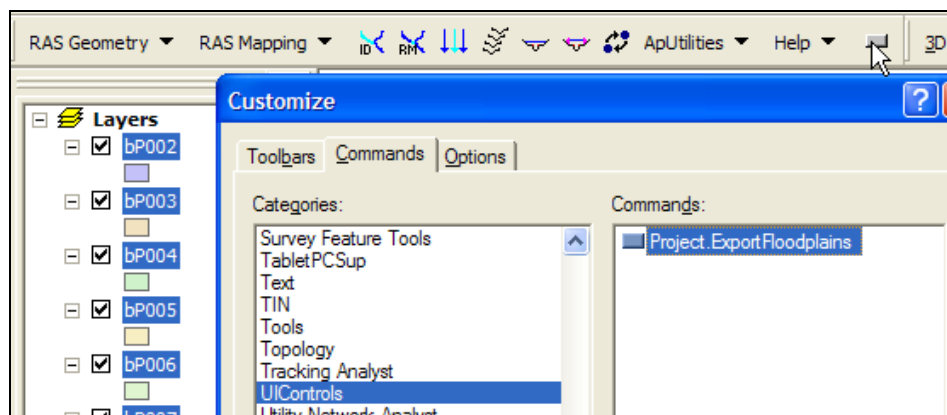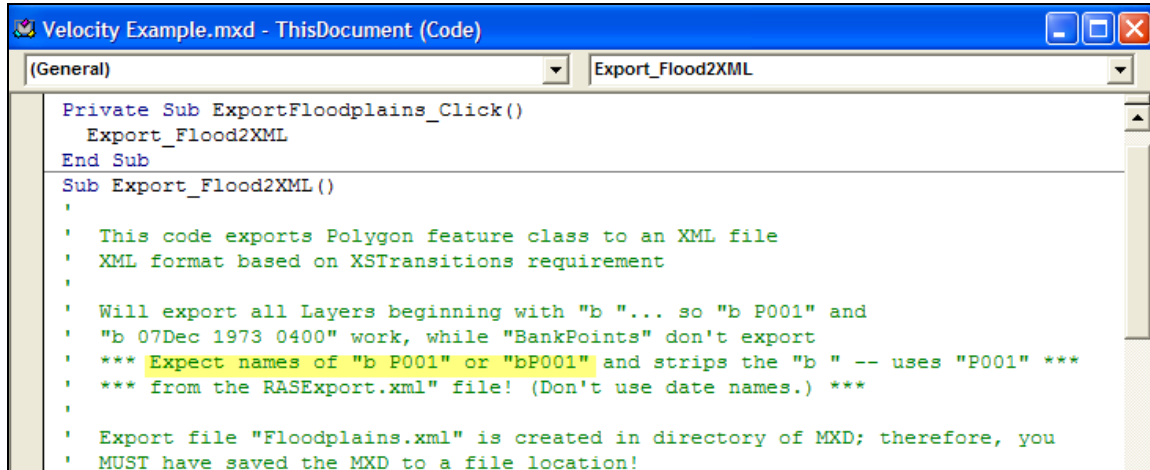
Right-click on the tool and choose the **Change Button Image** menu item and select an image so you can pick it out from all your other custom tools.
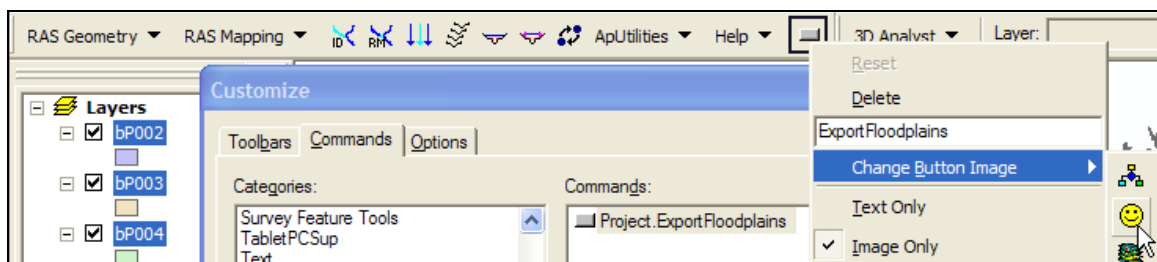
Right-click on the button and choose the **View Source** menu item (at the bottom). This opens the VBA editor. Now **copy and paste the Export_Flood2XML subroutine** from the text file into the code window beneath the Click event for the button you just created.

Next, type in (or copy and paste) in the Click event for the button the name of the subroutine "**Export_Flood2XML**".

Click back on the ArcMap document. You can now run the code by clicking on the new button previously created. While it is running you will see "[running]" appended to the VBA project title.

When the process finishes, a message box will come up. Note there is no error trapping in this piece of code, so check the *Floodplains.xml* file to see if it looks correct. There will be a "FloodplainBoundary" node in the XML tree with a ProfileID of the form "P00n". Each floodplain boundary node will have several polygon nodes describing the floodplain boundary.
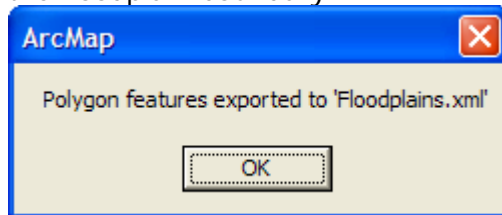
The *Floodplains.xml* file should have been created in the workspace directory.

Complete Interpolation Parameters File

The interpolation *Parameters.xml* file holds the "registration" information for the grids that are going to be created. This indicates the grid-cell size (number of rows and columns) for the rasterization and the origin of the lower-left corner of the grid. You also specify which profiles you want interpolation to work on and whether to do the velocity, shear stress, stream power, or ice thickness information.

To identify the grid file information, load a grid to ArcMap. Right-click on the grid layer name and select the properties menu item. Next, select the Source tab. You can identify the grid-cell size and the Left and Bottom coordinates for the grid. In general, you should choose either the grid with the maximum inundation extent or the terrain grid that was used to perform the floodplain delineation (to be on the safe side, use the terrain grid).
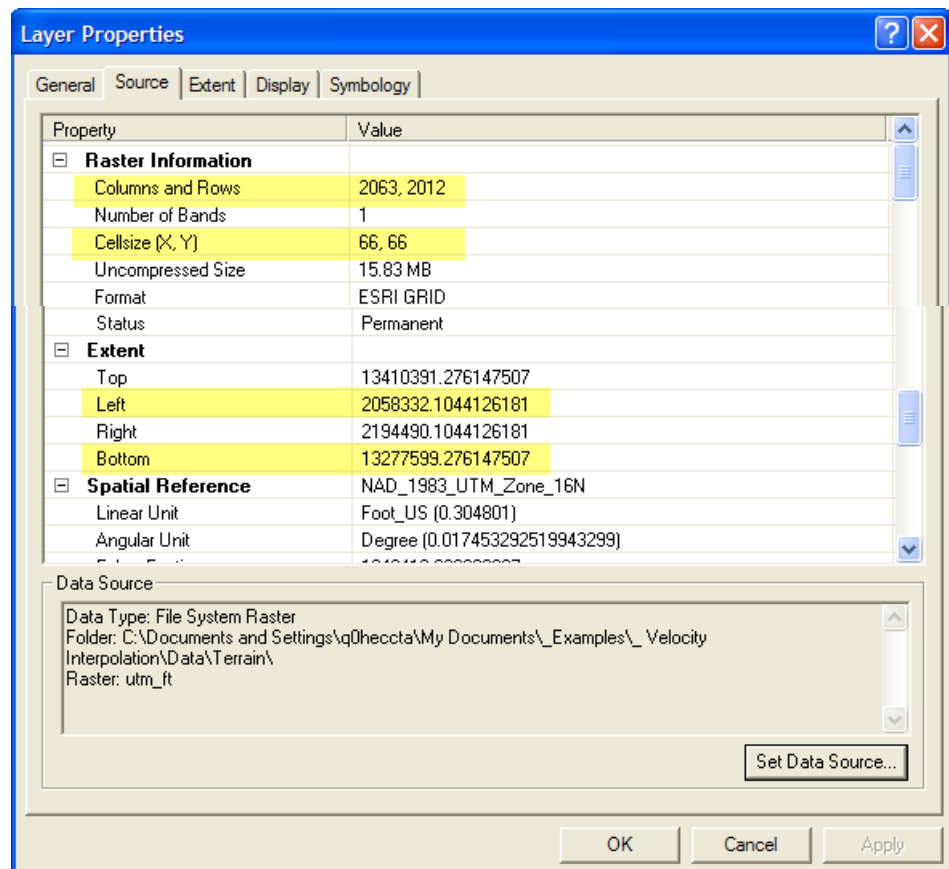
Edit the example "*Parameters.xml*" file that has been provided to you for your specific dataset.

Multiple Profiles

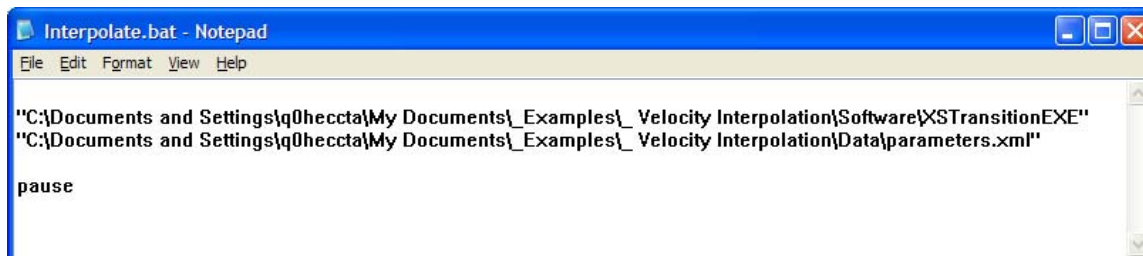Specify multiple profiles in the one *Parameters.xml* using the "Transitions" node.

```xml
<?xml version="1.0" encoding="utf-8" ?>
- <Parameters>
  - <Rasters>
      <Raster Name="Tile1" LowerLeftX="621130.6800356" LowerLeftY="4045553.6200231" NumberColumns="2430"
        NumberRows="2245" CellSize="20" NoDataValue="-9999" />
    </Rasters>
  - <Files>
      <File Type="RASExports" Name="Failure.RASexport.xml" />
      <File Type="Floodplains" Name="Floodplains.xml" />
    </Files>
  - <Transitions>
      <Transition ProfileID="P028" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
      <Transition ProfileID="P029" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
      <Transition ProfileID="P030" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
      <Transition ProfileID="P031" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
      <Transition ProfileID="P032" Parameter="Velocities" Values="VelocityValues" Value="Velocity" GridAbr="vel" />
    </Transitions>
  </Parameters>
```

An alternate option is to create a new *Parameters.xml* file for each profile. You can duplicate the parameters file and then edit the profile number. Next, you will have to run each of the parameter files one after another. A batch file is handy for this.

Running the Interpolation

There are several ways to run the interpolator. The easiest is to edit the included batch file (*Interpolate.bat*) with the path name to parameters file. (Note that the bat file calls *XSTransistionsEXE* program and passes the *Parameters.xml* filename all on the same line.) The *Interpolate.bat* file is at the location of the sample data. The "pause" in the batch file will inform you when the process is complete by taking you to a command prompt (hit the space bar to continue). More importantly, the "pause" allows you to see if the process didn't run due to a bad file name!
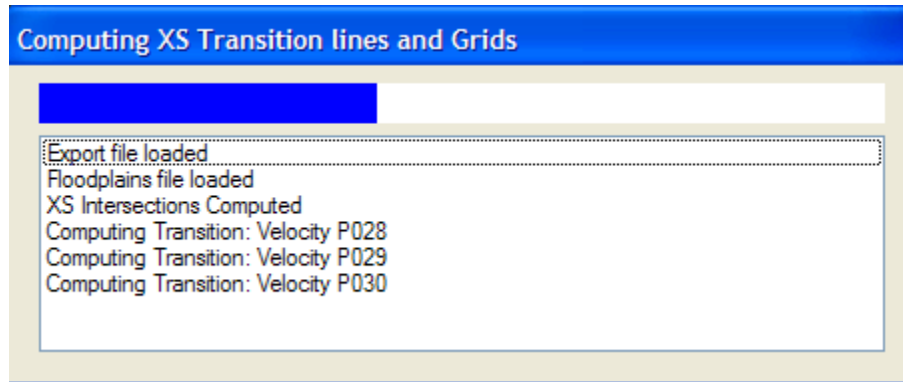

- or –

If the data is in the same location as the interpolator, you can just drag the *Parameters.xml* file onto the **XSTransitionEXE.exe** file.

- or –

From the command line type something like the following:

```
"C:\Examples\Velocity Interpolation\Software\XSTransitionEXE"
"C:\Examples\Velocity Interpolation\Data\parameters.xml"
```

While the interpolation is processing a dialog will appear showing you the status of the computations.

When the interpolator has finished, it will have created a binary file (or files) in the ESRI Binary Floating Point format. This format is fairly efficient and can be easily transferred. The file will have the ".flt" extension.


If raster tiling is indicated in the *Parameters.xml* file (because there are multiple Raster nodes) the computed grids are stored by *ProfileID* and then broken up by the Raster (tile) name. Because ESRI grids names must be 13 characters or less, the combination of the *GridAbr* and *Raster Name* (or *ProfileID*) must be 13 characters or less.

Import to ESRI GRID (Single Grid)

After the FLT files are created, open ArcToolbox and import the data to an ESRI grid. Navigate the **ArcToolbox to Conversion Tools | To Raster | Float to Raster**.
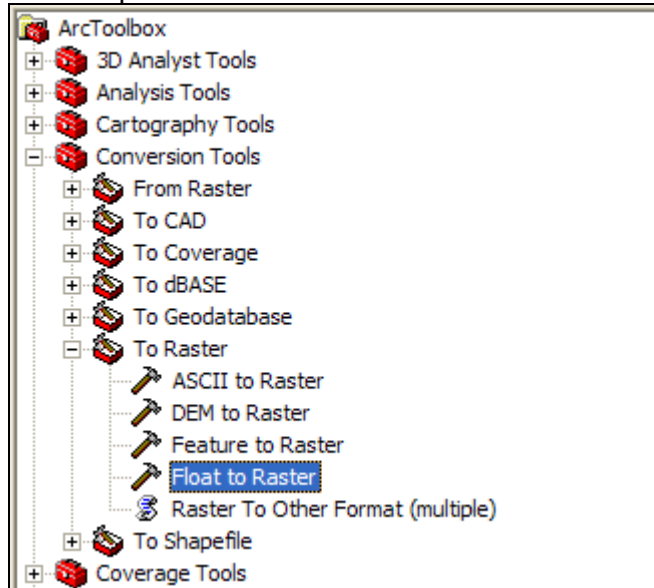
Open the tool and specify the input and output grid name.
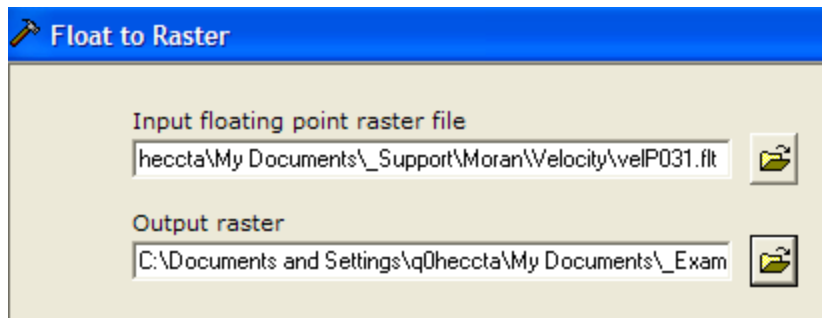
The grid will not have the projection information. However, you can define the projection, or just copy and paste the "prj.adf" file from the depth or terrain grid used for the raster registration in the parameters file.

Import to ESRI GRID (Multiple Grids)

You can do this a couple different ways from ArcCatalog using a script or from the Command Line.

Open ArcCatalog.

To use the script method, select the **Tools | Macros | Visual Basic Editor** menu item. In the Project Pane, navigate to **Normal | ArcCatolog Objects | ThisDocument**.
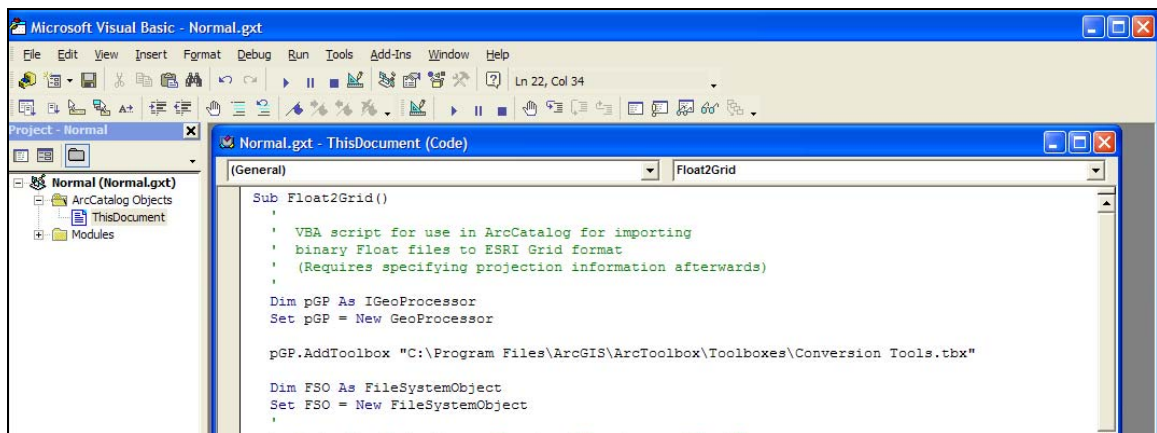
Copy and paste the script provided in the "Float2Grid.txt" file. Change the directory paths making sure the pathnames are valid and the output directory exists!

Verify that you have the "Microsoft Scripting Runtime" reference option turned on using the **Tools | References** menu option.
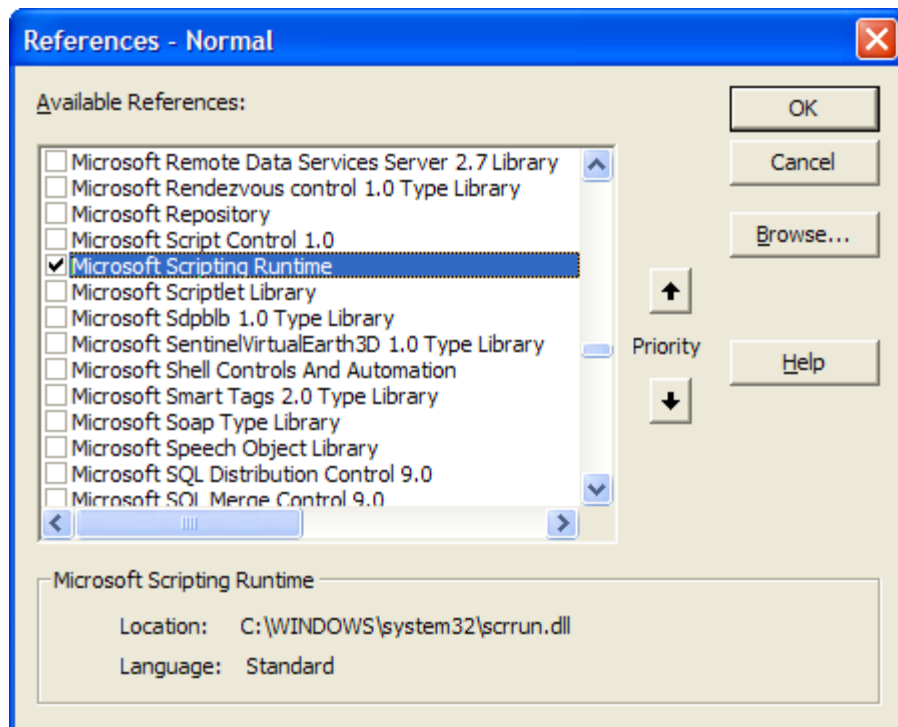
Run the script.

If you would rather use the command line, select the **Windows | Command Line** menu item. Create multiple entrees in a text

document that specify the command followed by the .flt file and the
output locations. For instance:

```
FloatToRaster_conversion "C:\Data\velP001.flt"
"C:\Data\Vel_Grids\velP001"
FloatToRaster_conversion "C:\Data\velP002.flt"
"C:\Data\Vel_Grids\velP002"
FloatToRaster_conversion "C:\Data\velP003.flt"
"C:\Data\Vel_Grids\velP003"
```

Copy and paste the items in the Command Line and press Return. The
files will be converted to ESRI grid format as specified.

Regardless of the method used, the grid(s) will not have the projection
information. You can define the projection using the ArcGIS tools, or
just copy and paste the "prj.adf" file from the depth or terrain grid
used for the raster registration in the parameters file.