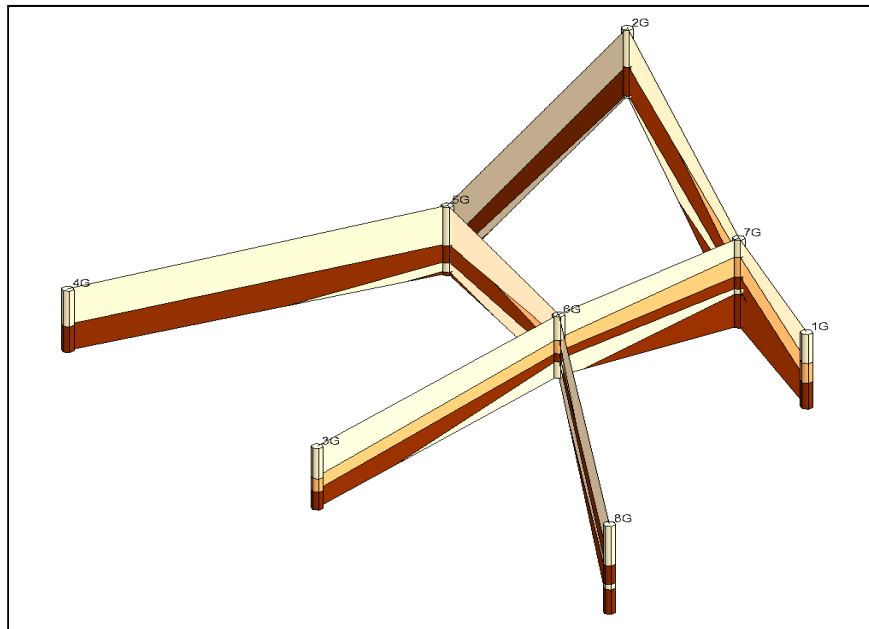


GMS 10.0 Tutorial

Stratigraphy Modeling—Boreholes and Cross Sections

Become familiar with boreholes and borehole cross sections in GMS



Objectives

Learn how to import borehole data and construct a set of cross sections between the holes to achieve site characterization. Edit the cross sections in the *Cross Section Editor*.

Prerequisite Tutorials

- None

Required Components

- Sub-surface Characterization

Time

- 15-25 minutes



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1 Introduction

The Borehole module of GMS can be used to visualize boreholes created from drilling logs. Also, three-dimensional cross sections between boreholes can be constructed. These cross sections show the soil stratigraphy between two boreholes. Once a set of cross sections is built, the cross sections can be displayed in 3D space to help characterize and visualize the soil stratigraphy at a site.

This tutorial will illustrate how to construct a set of cross sections for site characterization using borehole data.

1.1 Outline

Here are the steps of this tutorial:

1. Import boreholes.
2. Change the borehole names and edit the materials.
3. Create and fill cross sections automatically and manually.


2 Getting Started

To get started, do the following:

1. If necessary, launch GMS.
2. If GMS is already running, select the *File / New* command to ensure that the program settings are restored to their default state.

3 Reading Borehole Data


The first step in the construction of borehole cross sections is to create some boreholes. The second step is to read in a set of previously defined borehole logs.

1. Select the **Open**  button.
2. Locate and open the directory entitled *Tutorials\Stratigraphy_Modeling\Boreholes_and_Cross_Sections*.
3. Change the *Files of type* to “Text Files (*.txt;*.csv).”
4. Select the file named “holes.txt,” and click on the **Open** button.

This brings up the *Text Import Wizard*. All kinds of data can be imported into GMS via the *Text Import Wizard*.

5. Turn on the *Heading row* option, and click **Next**.
6. Change the *GMS data type* to “Borehole data” (not “Borehole sample data”).




Notice all the column types are automatically assigned based on the header row because GMS recognized the headings. Consider taking a minute to examine the format of the borehole file being imported.

7. Click **Finish**.
8. Select the **Oblique View**  button.

A 3D view of the boreholes should now appear.

4 Displaying the Hole Names

Right now the boreholes probably appear very long and thin—so much so that it isn’t possible to distinguish the different materials. The next step is to adjust the borehole display options to improve the view.

1. Select the **Borehole Data**  folder in the Project Explorer.
2. Select the **Display Options**  button.
3. Make sure the **Borehole Data**  item in the list on the left is selected.

Take a minute to look at the display options available for boreholes. Ignore the right side of the dialog for now—this isn’t sample data, only stratigraphy data.


4. Change the *Diameter* to “7.”
5. Turn on the *Hole names* option.

6. Select the **OK** button.



The boreholes should be more visible now and the names of the holes should appear at the tops of the holes.

5 Editing the Materials

Each of the colors represents a different type of soil. The file that was just imported specified a material ID number for each section of each borehole. GMS also created materials with those IDs and gave them default names and colors. The next steps show how to change the material names and colors.

1. Select the **Materials**  button. The *Materials* dialog will appear
2. Click on “material_1” and change its name to “Clean Sand”.
3. For this same material, click on the down arrow in the *Color/Pattern* field to change the color to green.
4. In a similar manner, rename “material_2” to “Silty or Clayey Fine Sand” and change its color to blue.
5. Also rename “material_4” to “Silty Clay” and change its color to red.
6. Click **OK**.

To turn on the material legend, do the following:

7. Select the **Display Options**  button.
8. Select the **Materials**  option in the list on the left.
9. Turn on *Display material legend*.
10. Select the **OK** button.

6 Creating Blank Cross Sections

The next step is to create a set of blank cross sections. The set of cross sections will be “blank” because, at this point, this step indicates where the cross section should be, not what it should look like. The blank cross sections will appear as two lines connecting the tops and bottoms of the two boreholes. Cross sections created between two boreholes are named using a combination of the two holes’ names. For example, a cross section created between holes 1G and 7G will be named 1G-7G.

6.1 Auto-Create Blank Cross Sections


The easiest way to create blank cross sections is to do it automatically.

1. Select the *Boreholes* / **Auto-Create Blank Cross Sections** menu command.


Notice that GMS connects the holes with blank cross sections. GMS simply triangulates the boreholes to determine how to connect them.

6.2 Snapping the Cross Section Tops to a Surface

The top and bottom lines that define each cross section can be adjusted to match a TIN that defines each surface. The next step is to read in a TIN and snap the cross-section tops to the TIN elevations.


1. Select the **Open**  button.
2. Locate and open the directory entitled *Tutorials\Stratigraphy_Modeling\Boreholes_and_Cross_Sections*.
3. Change the filter to “All Files (*.*)”.
4. Select the file named “top_elev.tin,” then click **Open**.

A TIN should appear in the graphics window.

5. Now select the *Boreholes/Advanced* / **Snap Cross Sections to TIN** command.
6. The *Snap Cross Sections to TIN* dialog will appear.
7. Turn on the *Snap Top to TIN* option for the Top TIN Selection, and select **OK**.
8. To hide the TIN, go to the Project Explorer and uncheck the check box next to the “top elevation”  TIN in the “TIN Data” folder.


The cross-section tops should now be adjusted to match the TIN elevations.

The next step is to create cross sections manually. Before doing this, it is necessary to delete all the cross sections that were just created.

9. Select the **Select Borehole Cross Sections**  tool.
10. Select the *Edit* / **Select All** menu command.
11. Press the *Delete* key.

6.3 Manually Create Blank Cross Sections

The set of blank cross sections to be created are as follows: 1G-7G, 7G-2G, 2G-5G, 4G-5G, 5G-6G, 6G-7G, 3G-6G, and 6G-8G.

1. Select the **Create Borehole Cross Sections**  tool.
2. Click on hole 1G to begin, then single-click on hole 7G, 2G, 5G, and 6G in sequence.
3. Then double-click on hole 8G to end.
4. Create cross sections 3G-6G and 6G-7G by clicking on hole 3G to begin, then single-clicking on hole 6G, and double-clicking on hole 7G to end.
5. Create cross section 4G-5G by clicking on hole 4G to begin and double-clicking on hole 5G to end.

The “blank” cross sections should look like those in the figure below.

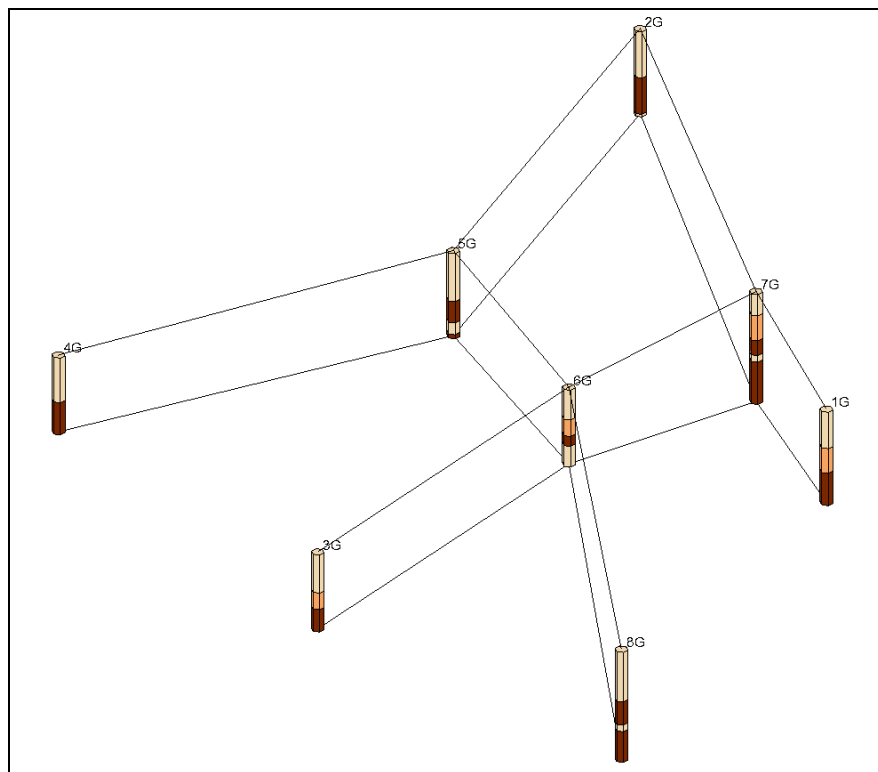


Figure 1 Blank cross sections

7 Auto-Fill Blank Cross Sections

The next step is to delineate soil layers for the blank cross sections. This is done using arcs and polygons, just like the arcs and polygons created in the Map module of GMS. If

the user is unfamiliar with the Map module, don't worry. It is not necessary for this tutorial.

The easiest way to fill the blank cross sections is to let GMS do it automatically.

1. Select the *Boreholes*/ **Auto-Fill Blank Cross Sections** menu command.
2. The *Auto-Fill Cross Sections* dialog will appear

This dialog has two options: *Match using horizon IDs* and *Match using materials*. Horizons are discussed in the next tutorial, so they won't be discussed in detail here. However, it is preferable to first assign horizon IDs before using the **Auto-Fill** command and to then use the horizon IDs to fill the cross sections. That way, the cross sections are consistent with the horizon IDs. Since this tutorial has not done anything yet with horizon IDs, they will not be covered now. Instead, select the *Match using materials* option.

3. Select the *Match using materials* option, and click **OK**.




After a moment, GMS fills the blank cross sections.

8 Manually Fill Cross Sections 7G-2G

GMS cannot always automatically fill all cross sections. If two boreholes are too dissimilar, GMS cannot fill in the details of the cross section between the two holes. Or, if it can, the results may not be desirable. For these reasons, it is usually necessary to manually fill and edit cross sections.

With these relatively simple set of boreholes, GMS had no problem automatically filling all the cross sections. But the next steps will illustrate how to do it manually.

8.1 Building Cross Section 7G-2G

1. In the Project Explorer, expand the "Cross Sections"  folder and double-click on cross section 7G-2G.
2. The *Cross Section Editor* dialog will appear.
3. Click the **Delete All**  button to delete the existing polygons and arcs (the top and bottom arcs will not be deleted).
4. Select the **Create Arc**  tool.
5. Create all the arcs shown in Figure 2.

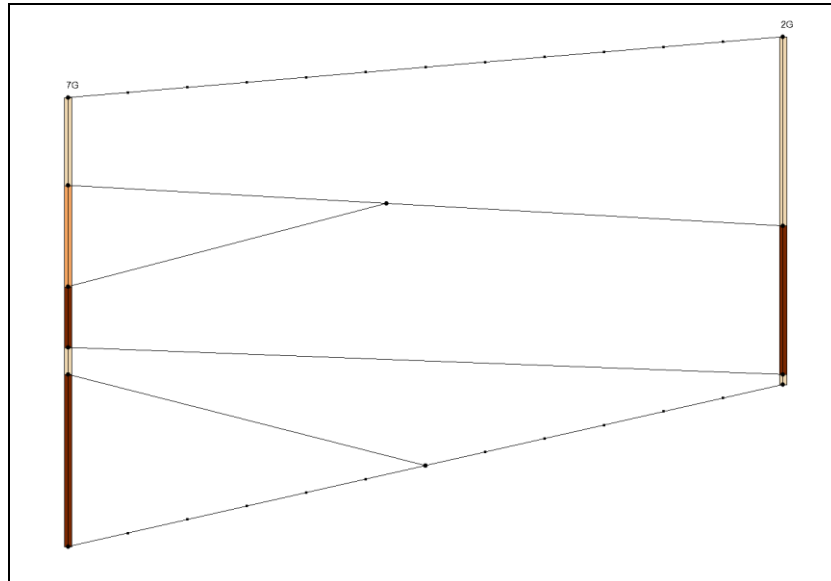




Figure 2 Cross section 7G-2G

6. Select the **Build Cross-Section Polygons**  button.
7. Select the **OK** button.

9 Manually Editing Multiple Cross Sections

GMS also allows users to edit multiple cross sections in the *Cross Section Editor*. This is useful when the user must consider geologic trends from adjacent cross sections.

1. Select the **Select Borehole Cross Sections**  tool.
2. While holding down the *Shift* key, select the following cross sections in the graphics window: **6G-8G**, **5G-6G**, and **2G-5G**.
3. Select the **Cross Section Editor** command from the *Boreholes* menu.

If desired, it is possible to maximize this dialog to better see the cross sections. The dialog should look like Figure 3:

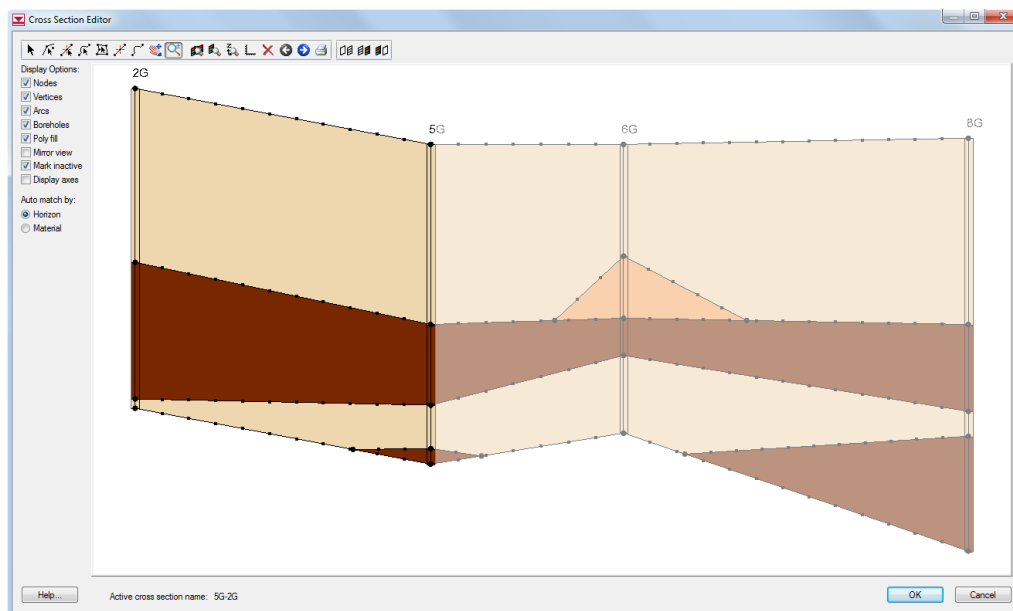


Figure 3 Multi-panel cross section editor

Notice that the first panel from the left is brighter than the other panels in the dialog. This is the active panel that can be edited. To change the active panel, select the **Left Arrow** ← or **Right Arrow** → buttons. The next step is to edit the middle panel.

4. Click the **Right Arrow** → button to make the middle panel available to edit.
5. Click the **Zoom to Panel** 🔍 button to see this panel more clearly.
6. Click the **Delete All** 🗑️ button to delete the existing polygons and arcs (the top and bottom arcs will not be deleted).
7. Using the **Create Arc** 📐 tool, make the cross section look like Figure 4.

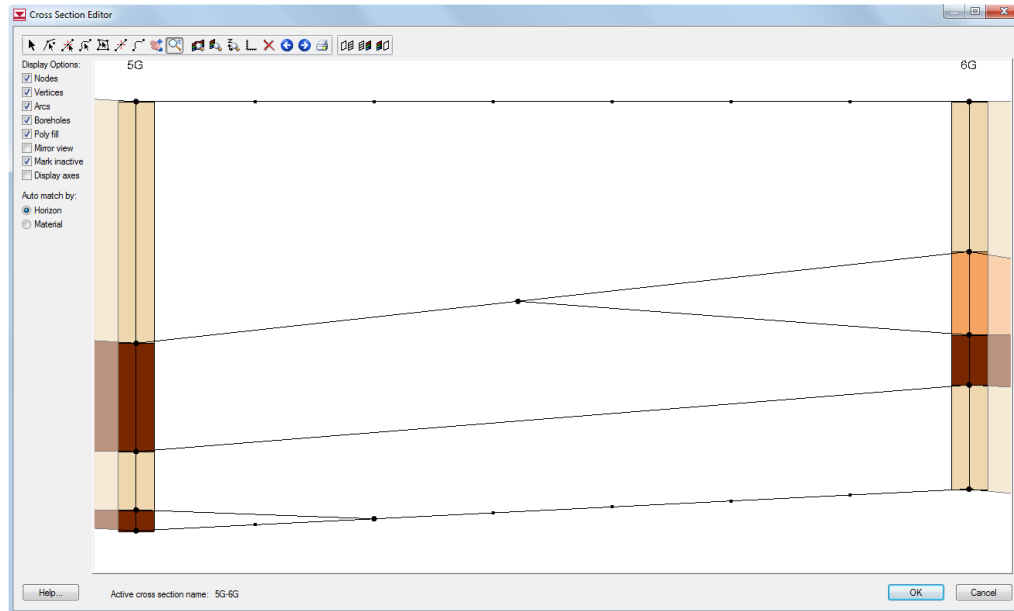





Figure 4 Panel 5G-6G in the cross section editor

8. Now click the **Build Cross-Section Polygons**  button so that the cross section will be filled with the materials.
9. Now click the **Frame All Cross Sections**  button to see all of the cross sections again.

The *Cross Section Editor* also lets the user adjust the plot that is displayed around the cross sections for high quality print outs. It is possible to add titles as well as show grid lines on the plot.

10. Click the **Plot Options**  button.
11. The *Plot Options* dialog will appear.
12. Enter “Section A-A” in the *Title 1* edit field.
13. Click on the *Y-Axis* tab and toggle on the *Display grid* option in the middle of the dialog.
14. Select **OK** to exit the dialog.
15. Turn off the *Nodes*, *Vertices*, and *Mark inactive* options on the right side of the dialog. The plot should now look something like Figure 5:

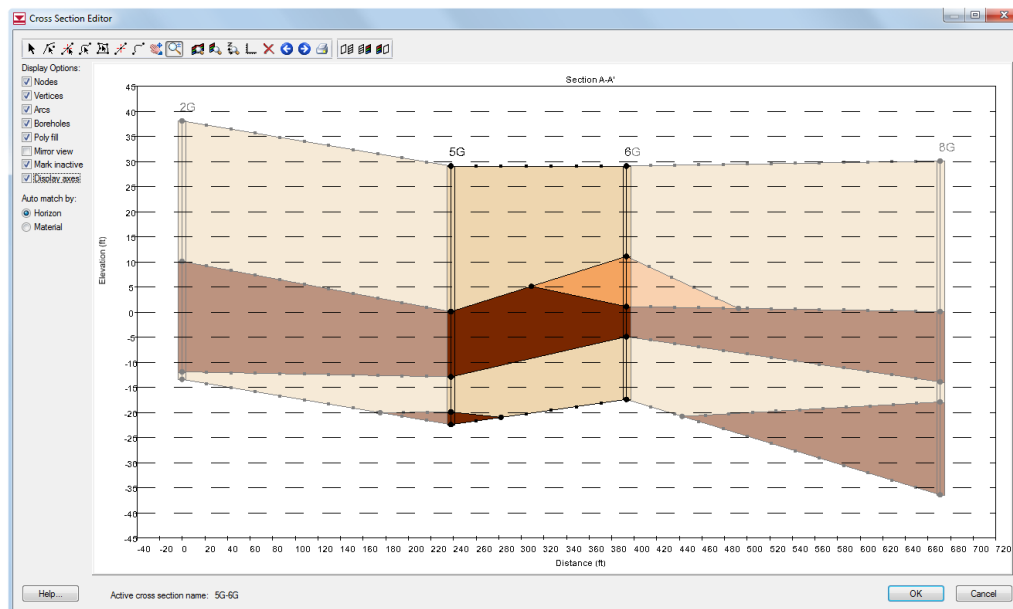


Figure 5 Multi-panel cross section editor ready for printing

16. Select **OK** to exit the dialog.

10 Viewing the Stratigraphy

Building the cross sections is now complete. The cross sections should be similar to Figure 6 below.

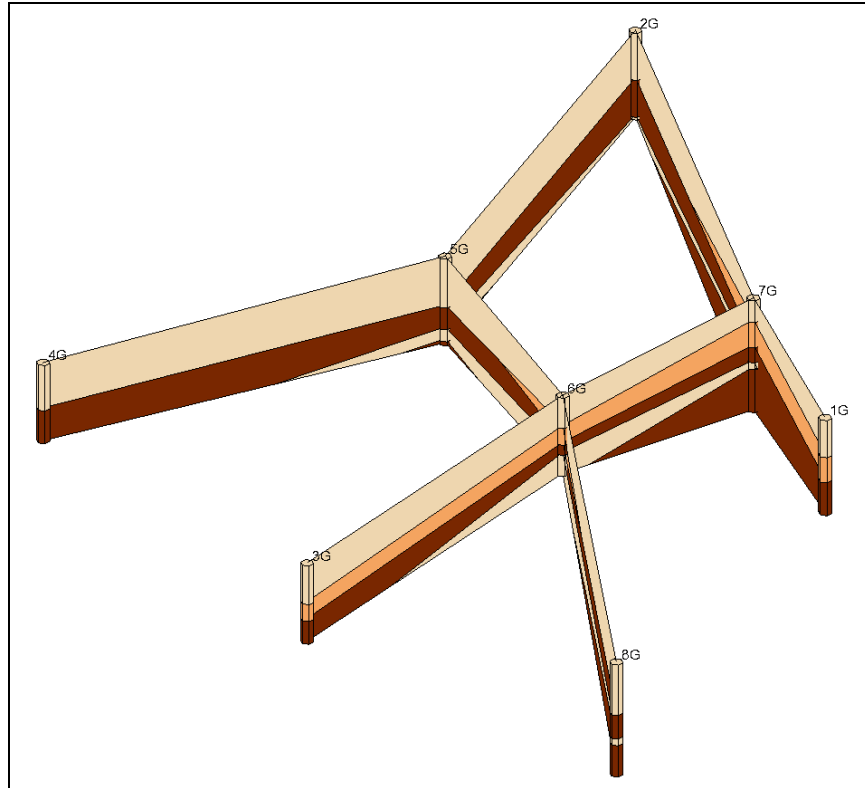



Figure 6 Site stratigraphy

11 Conclusion

This concludes the tutorial. Here are the things that this tutorial covered:

- Boreholes can be imported via the *Text Import Wizard*.
- The display options for boreholes can be changed to aid in visualization.
- Borehole names and materials can be edited.
- When borehole cross sections are first created, they are blank.
- The boreholes can be manually connected to create cross sections.
- Cross sections can also be created automatically using the **Auto-Crete Blank Cross Sections** command.
- Cross sections can be automatically filled using the **Auto-Fill Blank Cross Sections** command.
- Cross sections can be manually filled by creating the desired arcs between the two boreholes and then selecting the **Build Cross-Section Polygons**  button in the *Cross Section Editor*.

- The *Cross Section Editor* can be used to define how the soil layers are connected.
- Cross section arcs can be matched to a TIN.