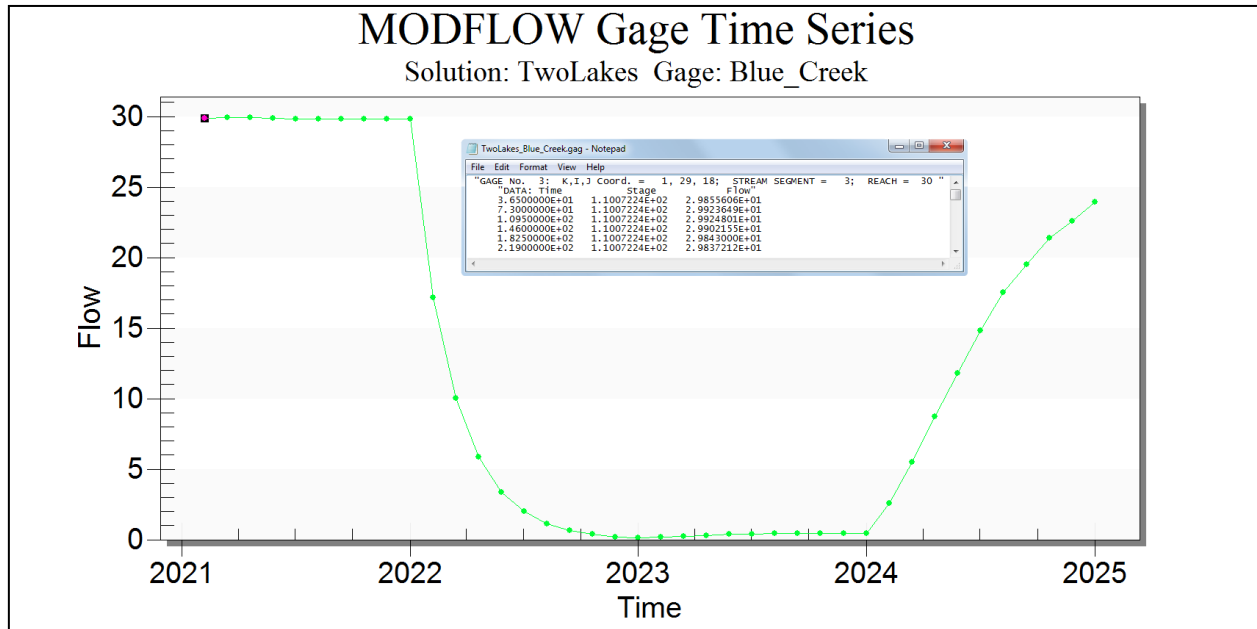


# GMS 10.1 Tutorial

## MODFLOW – GAGE Package

The MODFLOW GAGE Package Interface in GMS



### Objectives

This tutorial explains how to use the MODFLOW GAGE package interface in GMS.

#### Prerequisite Tutorials

- MODFLOW - Grid Approach
- MODFLOW – Conceptual Model Approach I

#### Required Components

- Grid Module
- MODFLOW

#### Time

- 20-30 minutes



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## 1 Introduction

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The Gage package (GAGE) was developed by the USGS to allow output of detailed time series data for a given lake ID or SFR stream reach. GAGE provides an extensive list of options for lake time series output including stage, volume, inflows, outflows, lake conductance, UZF interaction, and several others. For an SFR reach associated with a model cell, some of the options include stage, flow, depth, width, diversion specific output, and unsaturated flow routing.

The conceptual model for this tutorial is shown in Figure 1. The model consists of two lakes—Clear Lake and Blue Lake—connected by a stream. The stream flows from Clear Lake and feeds Blue Lake. Blue Lake is also fed by a second stream, and a third stream flows from Blue Lake into much larger body of water.

The model is transient with stress periods set to cover a 4-year period, with the starting head values for the model set at steady state. The first and fourth years have normal precipitation, and second and third years are below normal.

This tutorial will discuss and demonstrate adding gage stations to an existing MODFLOW simulation of the lakes and the streams, analyzing the gage file output to see how the change in precipitation affects the lakes and streams, and generating a gage plot.

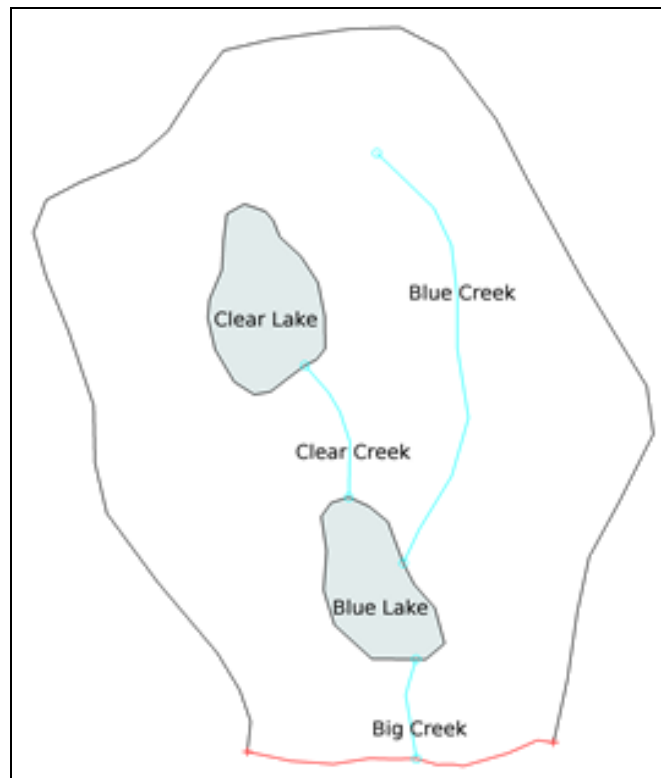


Figure 1 Conceptual model

## 2 Getting Started

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Do the following to get started:

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

### 2.1 Importing the Project

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First, import the project:

1. Click **Open**  to bring up the *Open* dialog.
2. Select “Project Files (\*.gpr)” from the *Files of type* drop-down.
3. Browse to the `\Tutorials\MODFLOW\gage` folder and select “start.gpr”.
4. Click **Open** to import the project and exit the *Open* dialog.

A MODFLOW model should appear in the Graphics Window (Figure 2).

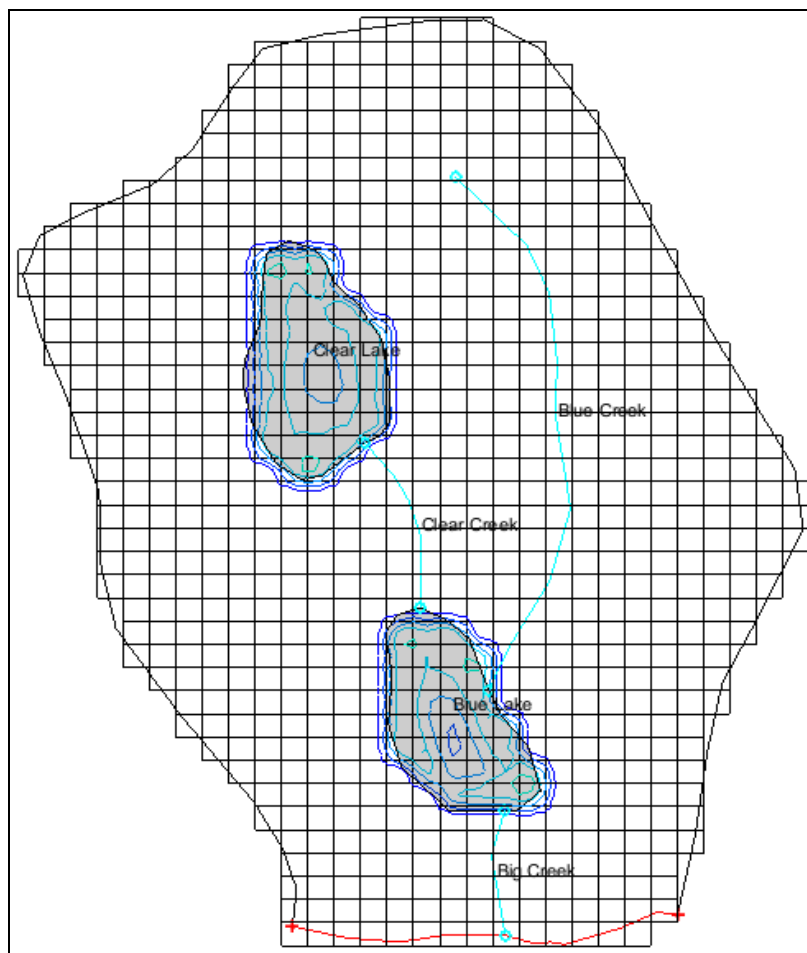


Figure 2 Layer 2 of the MODFLOW model

## 2.2 Saving the Model with a New Name

Before making changes, save the model with a new name.

1. Select the *File / Save As...* to bring up the *Save As* dialog.
2. Select “Project Files (\*.gpr)” from the *Save as type* drop-down.
3. Enter “TwoLakes.gpr” as the *File name*.
4. Click **Save** to save the project under the new name and close the *Save As* dialog.

## 3 Adding the Gages

Before adding gage stations to the simulation, it is necessary to determine the stream segment and reach for each SFR gage. To do this, view the lake and SFR boundary conditions in the package dialogs.

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### 3.1 The Lake Package Dialog

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1. Select *MODFLOW / Optional Packages / LAK – Lake...* to open the *MODFLOW Lake Package* dialog.

The lake boundary conditions are shown in this dialog. In the spreadsheet in the *Lake attributes* section, Blue Lake is listed as “Lake 1” and Clear Lake is listed as “Lake 2”.

2. Click **OK** to exit the *MODFLOW Lake Package* dialog.

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### 3.2 The SFR Package Dialog

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1. Select *MODFLOW / Optional Packages / SFR2 – Streamflow-Routing* to open the *MODFLOW Stream (SFR2) Package* dialog.

The dialog contains two tables. The *Segments* table contains a segment entry for each stream, and the *Reaches* table contains the reaches for all segments. In order to find the appropriate segment and reach, it is necessary to look in the reaches table.

The *ISEG* column of the table contains the segment number, and the *IREACH* column contains the reach number. Reaches are ordered in the direction of flow, so look for the highest numbered reach for each segment. From the table, the segment-reach pairs to be located include 1-10, 2-7, and 3-30.

2. Click **OK** to exit the *MODFLOW Stream (SFR2) Package* dialog.

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### 3.3 Enabling the GAGE Package

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Before adding gages, ensure that GAGE is enabled.

1. Select *MODFLOW / Global Options...* to bring up the *MODFLOW Global/Basic Package* dialog.
2. Click **Packages...** to open the *MODFLOW Packages/Processes* dialog.
3. In the *Optional packages / processes* section, turn on *GAGE - Gage*.
4. Click **OK** to exit the *MODFLOW Packages / Processes* dialog.
5. Click **OK** to exit the *MODFLOW Global/Basic Package* dialog.


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### 3.4 Adding Gages

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Gages are added in the *GAGE Package* dialog.

1. Select *MODFLOW / Optional Packages / GAGE – Gage...* to open the *Gage Package* dialog.

2. In the *Stream Gages* table at the top, add three rows by clicking three times on the **Insert Row**  button at the bottom of the *Stream Gages* table.
3. Enter the following values:

Name	GAGESEG	GAGERCH
Clear_Creek	1	10
Big_Creek	2	7
Blue_Creek	3	30

The *OUTTYPE* column gives options for several different types of gage output. For this tutorial, use the default value.

4. Below the *Lake Gages* table, click on **Add All Lakes** to add gages for both lakes.




Now change the lake names.

5. Replace “Lake 1” with “Blue\_Lake” and “Lake 2” with “Clear\_Lake”.
6. Click **OK** to exit the *Gage Package* dialog.

## 4 Running MODFLOW

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Now save these changes and run MODFLOW.

1. **Save**  the project.
2. Click **Run MODFLOW**  to bring up the *MODFLOW* model wrapper dialog.
3. When MODFLOW finishes, turn on *Read solution on exit* and *Turn on contours* (if not on already).
4. Click **Close** to import the solution and close the *MODFLOW* model wrapper dialog.
5. **Save**  the project with the new solution.

The new solution will be visible (Figure 3). Notice the contours.

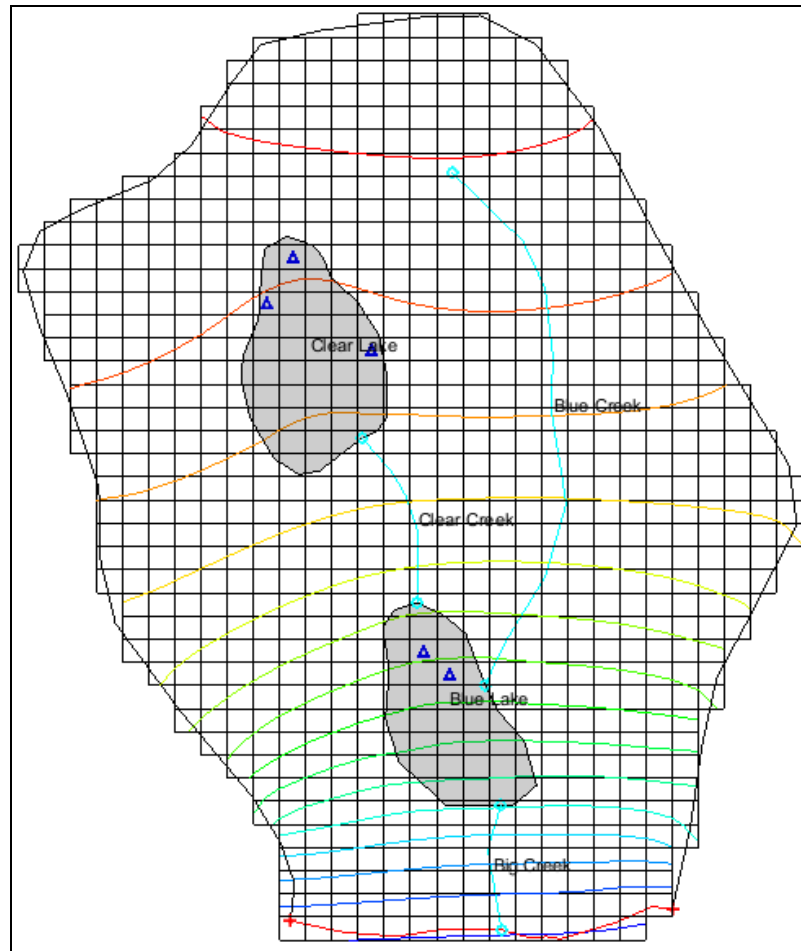


Figure 3 The computed solution after the MODFLOW run

## 5 Examining the Solution

Now look more closely at the computed solution.

### 5.1 The Head Solution

1. Expand the “3D Grid Data” folder in the Project Explorer and select the “Head” dataset under the “TwoLakes (MODFLOW)” solution.

The Time Step window appears at the bottom of the Project Explorer, and the first stress period is selected.

2. Scroll through the timesteps, clicking on a time step near the middle of the simulation and then the time step at the end.

When changing between the different time steps, notice that the first and last time steps have similar head contours. For time steps near the middle of the simulation, the head values are lower.

## 5.2 Gage Output Files

The gage output files can be found in the solution folder in the Project Explorer.

1. Expand the “Gage Files” folder under the “TwoLakes (MODFLOW)” solution.
2. Double-click on the “TwoLakes\_Blue\_Creek.gag” file (or right click on the file and select **View File**) to bring up the *View Data File* dialog.
3. If you have previously turned on the *Never as this again* option in this dialog, this dialog will not appear. Skip to step.
4. Select the desired text editor from the *Open with* drop-down.
5. Click **OK** to close the *View Data File* dialog and open the gage output file in the desired text editor.

The gage output file shows columns for time, stage, and flow (Figure 4).

6. Scroll through the text file that opens, noticing the change in the *Flow* column.

For this stream, the flow rate drops by about 30 percent during the time of below-normal precipitation.

"GAGE NO. 3: K,I,J Coord. = 1, 29, 18; STREAM SEGMENT = 3; REACH = 30"		
"DATA: Time	Stage	Flow"
3.6500000E+01	1.1007209E+02	2.8492020E+01
7.3000000E+01	1.1007199E+02	2.7619947E+01
1.0950000E+02	1.1007191E+02	2.6920345E+01
1.4600000E+02	1.1007185E+02	2.6389833E+01
1.8250000E+02	1.1007179E+02	2.5862461E+01
2.1900000E+02	1.1007175E+02	2.5492924E+01
2.5550000E+02	1.1007171E+02	2.5189039E+01
2.9200000E+02	1.1007171E+02	2.5171335E+01
3.2850000E+02	1.1007171E+02	2.5142708E+01
3.6500000E+02	1.1007171E+02	2.5114166E+01
4.0150000E+02	1.1007008E+02	1.3658599E+01
4.3800000E+02	1.1006879E+02	7.4523335E+00
4.7450000E+02	1.1006771E+02	3.9387918E+00

Figure 4 Gage output file for Blue Creek


7. Double-click on the TwoLakes\_Clear\_Creek.gag file in the Project Explorer.

This stream shows a less significant change in flow rate. If desired, check the gage output for the other three gage stations as well.

8. Close the open gage files and return to GMS.

## 5.3 Creating a Gage Plot

Plots can be generated in GMS from solution gage files.

1. Click **Plot Wizard**  to bring up the *Step 1 of 2* page of the *Plot Wizard* dialog.
2. In the *Plot Type* section, select *Gage Package Value vs. Time* from the list on the left.
3. Click **Next** to go to the *Step 2 of 2* page of the *Plot Wizard* dialog.



4. In the *Gage file* list, select “Blue\_Creek”.
5. In the *Data column* list, select “Flow”.
6. Click **Finish** to close the *Plot Wizard* dialog.

The generated plot is shown in Figure 5. The plot shows that the flow rate drops rapidly for this stream as the period with less precipitation begins and then recovers to near the initial flow rate during the final year.

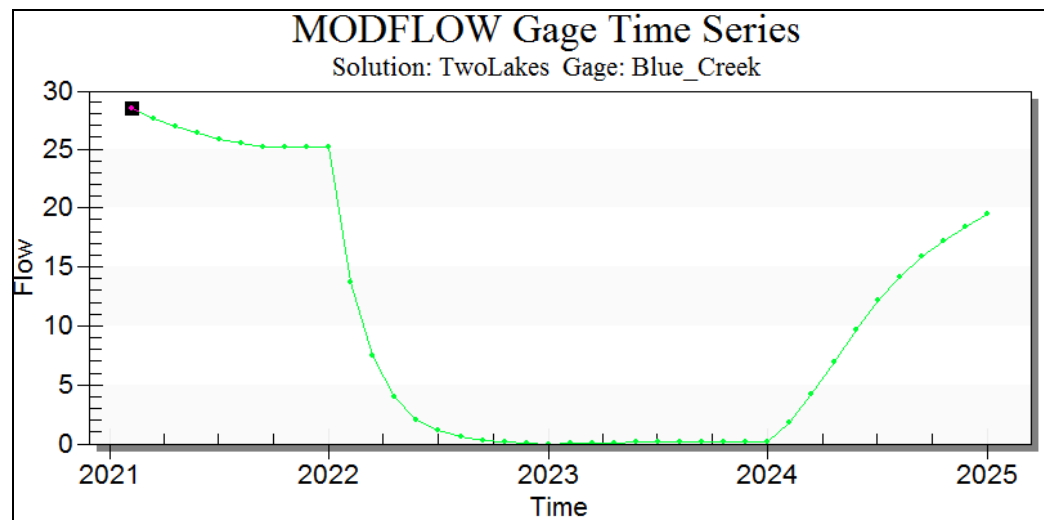


Figure 5 Gage plot for Blue Creek

## 6 Conclusion

This concludes the “MODFLOW – GAGE Package” tutorial. The following key concepts were discussed and demonstrated:

- GMS supports the MODFLOW GAGE package.
- Gages are entered in the *Gage Package* dialog.
- Gage output text files can be viewed by opening them from the Project Explorer.
- Gage plots can be generated using the *Plot Wizard*.