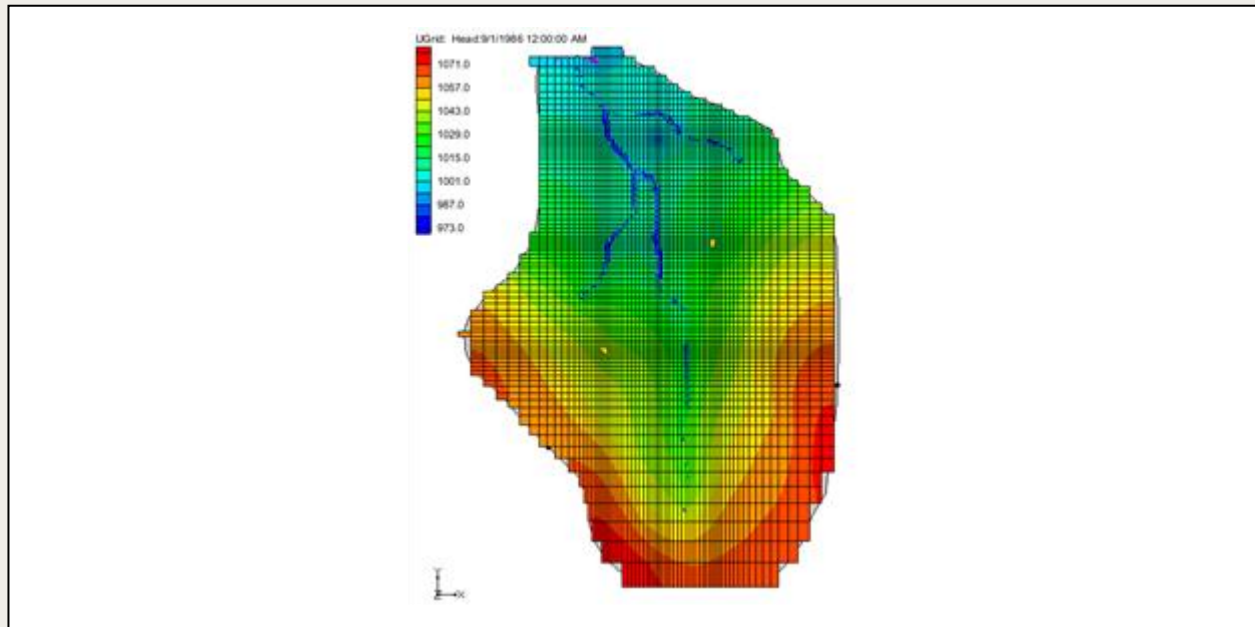




## GMS 10.9 Tutorial

# **MODFLOW 6 – Building a Transient Model**

Creating transient MODFLOW 6 models with time-varying inputs



## Objectives

GMS provides a powerful suite of tools for inputting and managing transient data. These tools allow all data to be managed using a date/time format that eliminates much of the extra data processing that is often required with modeling projects. This tutorial illustrates how these tools are used.

### Prerequisite Tutorials

- MODFLOW 6 – Conceptual Model Approach
- MODFLOW – Building a Transient Model

### Required Components

- GMS Core
- MODFLOW-USG Model & Interface

### Time

- 15–30 minutes

<b>1</b>	<b>Introduction.....</b>	<b>2</b>
1.1	Getting Started.....	2
<b>2</b>	<b>Importing and Saving the Project.....</b>	<b>2</b>
<b>3</b>	<b>Examining the Transient Conceptual Model .....</b>	<b>3</b>
<b>4</b>	<b>Adding the STO Package .....</b>	<b>4</b>
<b>5</b>	<b>Adding Stress Periods to the TDIS Package.....</b>	<b>4</b>
<b>6</b>	<b>Mapping the Recharge .....</b>	<b>5</b>
<b>7</b>	<b>Mapping the Wells .....</b>	<b>6</b>
<b>8</b>	<b>Saving the Simulation .....</b>	<b>6</b>
<b>9</b>	<b>Checking the Simulation.....</b>	<b>6</b>
<b>10</b>	<b>Running MODFLOW 6.....</b>	<b>6</b>
<b>11</b>	<b>Examining the Solution.....</b>	<b>7</b>
<b>12</b>	<b>Conclusion .....</b>	<b>7</b>

## 1 Introduction

---

This tutorial builds on the “MODFLOW – Building a Transient Model” tutorial. That tutorial demonstrates how to enter and import transient recharge and well pump data. This tutorial does not repeat that, but instead demonstrates how to create a transient MODFLOW 6 model given the transient conceptual model data.

This tutorial discusses and demonstrates opening a MODFLOW 6 model and solution, entering transient data, setting up stress periods and defining additional inputs, running MODFLOW, and reviewing the results.

### 1.1 Getting Started

---


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 Importing and Saving the Project

---

To 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 *mf6\_transient\* directory and select “start.gpr”.
4. Click **Open** to import the project and close the *Open* dialog.

A MODFLOW 6 model with a solution and a set of map coverages should be visible (Figure 1). Two of the coverages are the source/sink and hydraulic conductivity coverages used to define the conceptual model. The third coverage is the recharge coverage.

Before continuing, save the project with a new name.

5. Select *File* | **Save As...** to bring up the *Save As* dialog.
6. Select “Project Files (\*.gpr)” from the *Files of type* drop-down.
7. Enter “trans.gpr” and click **Save** to close the *Save As* dialog.

It is recommended to save the project periodically.

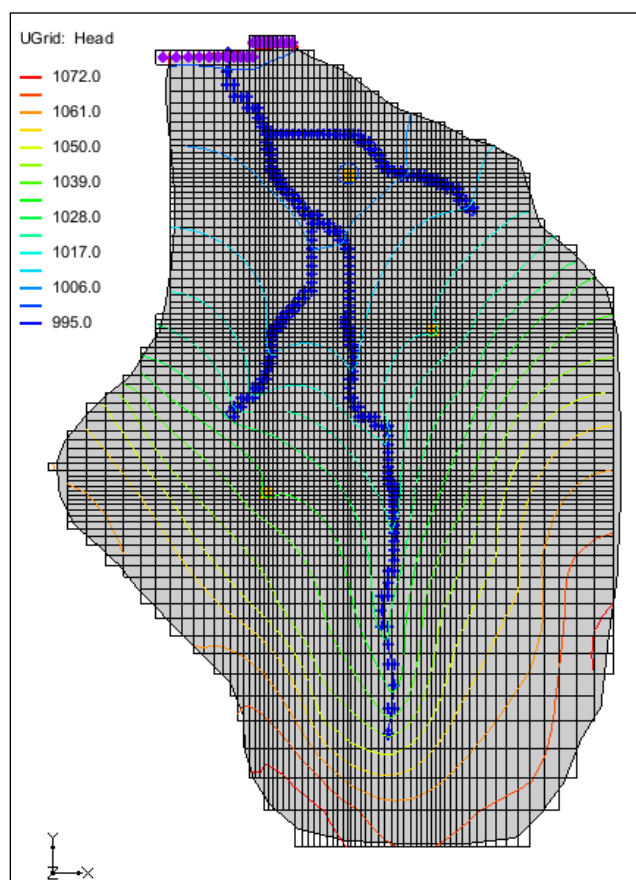



Figure 1 The initial project in the Graphics Window

### 3 Examining the Transient Conceptual Model

The initial transient data for the wells and recharge has already been included in the conceptual model. To see how to add this data to a conceptual model, see the “MODFLOW – Building a Transient Model” tutorial. Before continuing, review this transient data included with the wells in the conceptual model.


1. Right-click the “Sources & Sinks” coverage and select **Attribute Table...** to open the *Attribute Table* dialog.
2. Make certain the *Feature type* is set to “Points”, *Show* is set to “All”, and *BC type* is set to “well”.

Notice that the *Flow rate* column says “<transient>” for all the wells.

3. On the first well, click the  button in the *Flow rate* column to open the *XY Series Editor* dialog.


Notice that the pumping rate varies with time and that the time is entered as dates/times, not just numbers.



4. Click **OK** to close the *XY Series Editor* dialog.
5. Click **OK** to close the *Attribute Table* dialog.



Recharge is also time-varying. If desired, the *Attribute Table* for the “ Recharge” coverage can be viewed following steps similar to those above. The rest of the data is constant, including the river, specified head, and hydraulic conductivity data.

## 4 Adding the STO Package

Transient models need to specify a storage coefficient. Since this is a one-layer unconfined aquifer, the specific yield needs to be assigned. The Storage (STO) package includes the specific yield. To add the STO package, complete the following:

1. Right-click on “ flow” model and select **New Package | STO**.

The “ STO” package will appear in the Project Explorer. The values for the STO package are defined in the conceptual model. The polygons in the “ Hydraulic Conductivity” coverage contain the specific yield. To map those polygons to the STO package, complete the following:



2. Right-click the “ STO” package and select **Open** to bring up the *Storage (STO) Package* dialog.
3. Click the **Map from Coverage...** button to bring up the *Select Coverage* dialog.
4. Select the “ Hydraulic Conductivity” coverage.
5. Click **OK** to close the *Select Coverage* dialog.
6. Click **OK** to close the message dialog.
7. Select the SY tab.

Notice the specific yield data has been added.

8. Click **OK** to close the *Storage (STO) Package* dialog.

## 5 Adding Stress Periods to the TDIS Package

MODFLOW 6 discretizes time using stress periods and time steps. This project uses the Temporal Discretization (TDIS) package for discretization.

1. Right-click the “ TDIS” package and select **Unlock**.
2. Right-click the “ TDIS” package and select **Open...** to bring up the *Temporal Discretization (TDIS) Package* dialog.
3. Click **Add Rows...** to bring up the *Rows To Add* dialog.
4. For the *Number of rows to add at bottom*, enter “7”.
5. Click **OK** to close the *Rows To Add* dialog.

Eight stress periods are now in the *PERIODDATA* table.

6. In the *STEADY-STATE flow* column, make certain all the boxes past the first row are unchecked so that only the first row is checked on.

The steady-state versus transient information for each stress period is actually stored in the STO package, not the TDIS, but GMS presents it as a column in the TDIS package for convenience.

Continue with entering the remaining values for the *PERIODDATA* table.

7. From the table below, enter the *PERLEN* and *NSTP* values.

Row	PERLEN	NSTP
1	30.0	1
2	92.0	2
3	59.0	1
4	61.0	8
5	31.0	4
6	30.0	4
7	62.0	8
8	91.0	8

Next set the starting date and time by doing the following:

8. Under *Sections*, turn on *OPTIONS*.
9. Make sure *TIME\_UNITS* is on and set to “DAYS”.
10. Turn on *START\_DATE\_TIME*.
11. In the *START\_DATE\_TIME* field, enter “9/1/1985”.




Alternatively, the **Date/Time** button can be used to bring up a dialog where the date and time can be selected.

Notice the *ENDDATE* column now shows the ending date/time for the stress periods.

12. Click **OK** to exit the *Temporal Discretization (TDIS) Package* dialog.

## 6 Mapping the Recharge





Now to map the recharge values from the conceptual model over to the MODFLOW 6 simulation. To do this:

1. Right-click the “ RCH” package and select **Unlock**.
2. Right-click the “ RCH” package and select **Open...** to bring up the *Recharge (RCH) Package* dialog.
3. Select the *RECHARGE* tab.
4. Change the *Period* and notice that only the first stress period is defined.
5. Click the **Map from Coverage...** button to open the *Select Coverage* dialog.
6. Select the “ Recharge” coverage.
7. Click **OK** to close the *Select Coverage* dialog and map the coverage.
8. When the process finishes, click **OK** to close the message dialog.
9. Select the *RECHARGE* tab.
10. Change the *Period* and notice that all seven stress periods have been defined.
11. Click **OK** to close the *Recharge (RCH) Package* dialog.

## 7 Mapping the Wells

---

The wells now need to be added to the MODFLOW 6 simulation.

1. Right-click the  "WEL" package and select **Unlock**.
2. Right-click the  "WEL" package and select **Open...** to bring up the *Well (WEL) Package* dialog.
3. Change the *Period* to "2" and notice that only the first period is defined.
4. Click the **Map from Coverage...** button to open the *Select Coverage* dialog.
5. Select the  "Sources & Sinks" coverage.
6. Click **OK** to close the *Select Coverage* dialog and map the coverage.
7. When the process finishes, click **OK** to close the message dialog.
8. Change the *Period* to "2" and notice that all wells have been defined for the second period and that Q values have been entered.
9. Repeat the previous step to view the other periods.
10. Select a cell in the Q column for any of the wells in any of the periods.
11. Click the  **Plot All Periods** button to open the *XY Series Editor* dialog.



The *XY Series Editor* dialog shows the pumping rate (Q) for the well for each stress period. If the XY series is edited here, the changes will be made in the *Well (WEL) Package* dialog.

12. Click **Cancel** to close the *XY Series Editor* dialog.
13. Click **OK** to close the *Well (WEL) Package* dialog.

## 8 Saving the Simulation

---

Before running the model simulation, the data needs to be saved out.

1. Click the **Save**  macro to save the project.
2. In the Project Explorer, right-click on  "sim" and select **Save Simulation**.

The files for the simulation have now been exported.

## 9 Checking the Simulation

---

Now check the simulation again before running MODFLOW 6.

1. In the Project Explorer, right-click on  "sim" and select **Check Simulation...** to bring up the *Check MODFLOW 6 Simulation* dialog.


There should be no errors.

2. Click **OK** to close the *Check MODFLOW 6 Simulation* dialog.

## 10 Running MODFLOW 6

---

It is now possible to run MODFLOW:

1. Right-click on  "sim" and select **Run Simulation** to bring up a warning message.

Because a solution was already loaded into the project, this solution will have to be unloaded in order for MODFLOW 6 to run.

2. Click **OK** to close the warning dialog and start the *Simulation Run Queue* model wrapper dialog.



The *Simulation Run Queue* shows all simulation model runs currently in progress. Since this project only has one simulation, only one is shown.

3. When MODFLOW 6 finishes, click **Load Solution**.
4. Click **Close** to exit the *Simulation Run Queue* dialog.

## 11 Examining the Solution

---

Review the MODFLOW 6 solution with the transient values by doing the following:

1. Make sure the “ Head” dataset is active in the Project Explorer.
2. Click **Display Options**  to bring up the *Display Options* dialog.
3. Select “UGrid: UGrid – [Active]” from the list on the left.
4. Ensure that *Define UGrid specific options* is turned on.
5. Turn on *Face contours* and click **Options** to open the *Dataset Contour Options–UGrid – Head* dialog.
6. Change the *Contour method* to “Color Fill”.
7. Click **OK** to close the *Dataset Contour Options–UGrid – Head* dialog.
8. Click **OK** to close the *Display Options* dialog.
9. Select different time steps to see how the solution varies with time.

## 12 Conclusion

---

This concludes the “MODFLOW 6 – Managing Transient Data” tutorial. The following topics were discussed and demonstrated:

- The steady-state versus transient information for each stress period is stored in the STO package but GMS displays it in the TDIS package for convenience.
- If the transient conceptual model uses absolute dates/times, the TDIS package must define the START\_DATE\_TIME and UNITS options.
- With list packages like WEL, an XY series plot of the values over time can be viewed and used to edit the data for a particular well.