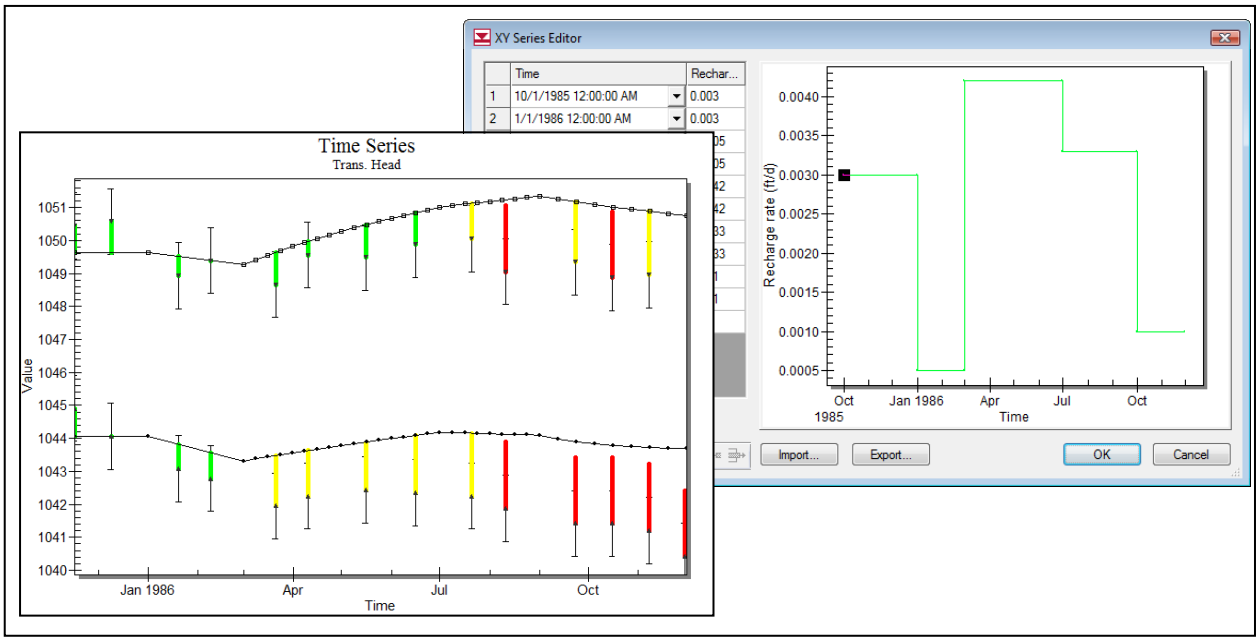
GMS

v. 9.2

GMS 9.2 Tutorial

MODFLOW – Transient Calibration

Calibrating transient MODFLOW models



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 with transient model calibration.

Prerequisite Tutorials

- MODFLOW - Managing Transient Data

Required Components

- Grid
- Map
- MODFLOW

Time

- 30-60 minutes

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1 Contents

2 Introduction

Building a transient simulation typically requires the management of large amounts of transient data from a variety of sources including pumping well data, recharge data, river stages, and water levels in observation wells. Gathering and formatting such data can be very tedious. GMS provides tools for importing time series data and converting that data to inputs for MODFLOW models.

2.1 Outline

This is what you will do:

1. Open a MODFLOW model and solution.
2. Set up a transient observation coverage.
3. Import transient head observations.
4. Create plots to visualize error in the model.
5. Adjust model parameters to better match the transient data.

3 Description of Problem

The model we will be using in this tutorial is the same model used in the **MODFLOW - Conceptual Model** tutorial. We will start with a steady state model. Next, we will set up MODFLOW stress periods and import transient recharge and pumping data. Then, we will import a set of transient-field-observed heads from observation wells and then calibrate the model. Finally, we will try adjusting the hydraulic conductivity, specific storage, and specific yield values to see how they affect the model.

4 Getting Started

Let's get started.

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

5 Reading in the Project

First, we will read in the project:

2. Select the *Open* button .

3. Locate and open the **Tutorials\MODFLOW\trans_calib** directory.

4. Open the file entitled **start.gpr**.

You should see a MODFLOW model with a set of head contours.

6 Save the Project With a New Name

Before we continue, let's save the project with a new name.

1. Select the *File* | *Save As* command.

2. Save the project with the name **trans1.gpr**.

It's a good idea to save your work periodically as you proceed.

7 Entering Transient Data in the Map Module

The first step in setting up our transient model is to associate our transient data with the recharge polygon and the pumping well in the Map Module.

7.1 Importing Transient Recharge Data

First, we will assign the transient recharge rate for the recharge polygon. We will do this by importing time series data from a text file.. Transient data can be imported for polygons, arcs, points, or nodes. The format for the text files is shown below.

Id	Date	Recharge
3	Dec 3, 1999	0.0005
3	Jan 30, 2000	0.001
4	Mar 27, 2000	0.002
…		

In the case above we only have a date field; GMS also supports specifying both a date and a time. The *Id* column is used to match the *Date* data with a particular polygon.

1. Expand the *East Texas* conceptual model item in the *Project Explorer*.
2. Select the *Recharge* coverage to make it active.
3. Select the *Open* button.
4. In the *Open* dialog, change the *Files of type* selection to **Text Files (*.txt)**.
5. Select the file named **recharge.csv** and click *Open*.

You should now see the Text Import Wizard. It should look similar to the next figure. This Wizard is used to import text data into a GMS project.

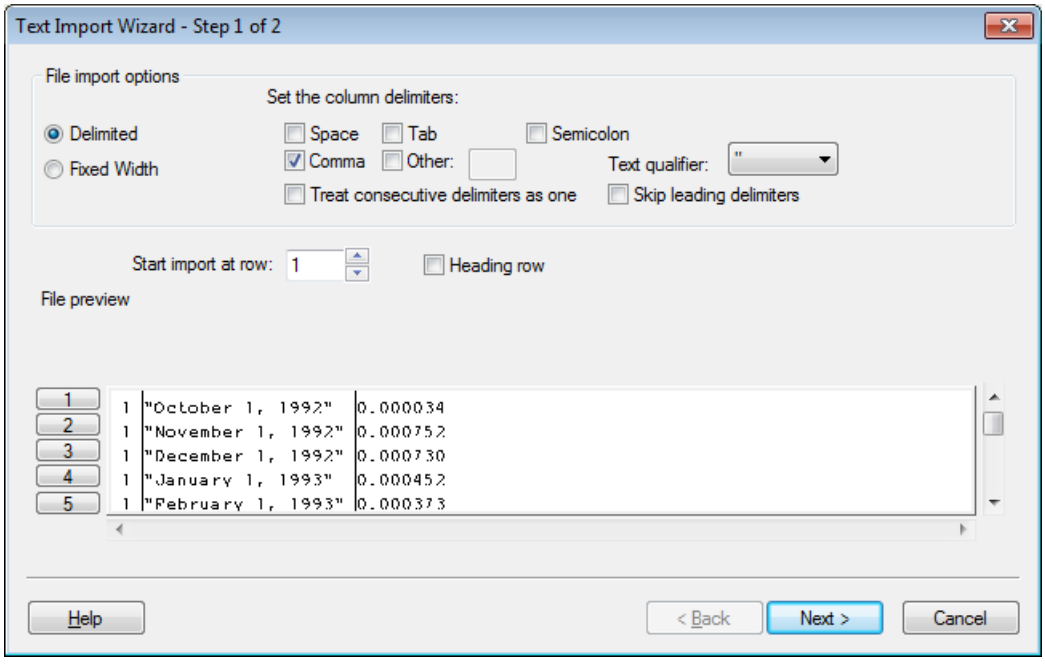

Figure 1. Text Import Wizard

6. Click the *Next* button.

7. Near the top of the dialog, change the *GMS data type* to **Transient polygon data**.

8. In the **Type** row change the item in the first column to be **ID**, the item in the second column to **Date**, and the item in the third column to **Recharge rate TS**. The dialog should look like the following figure.

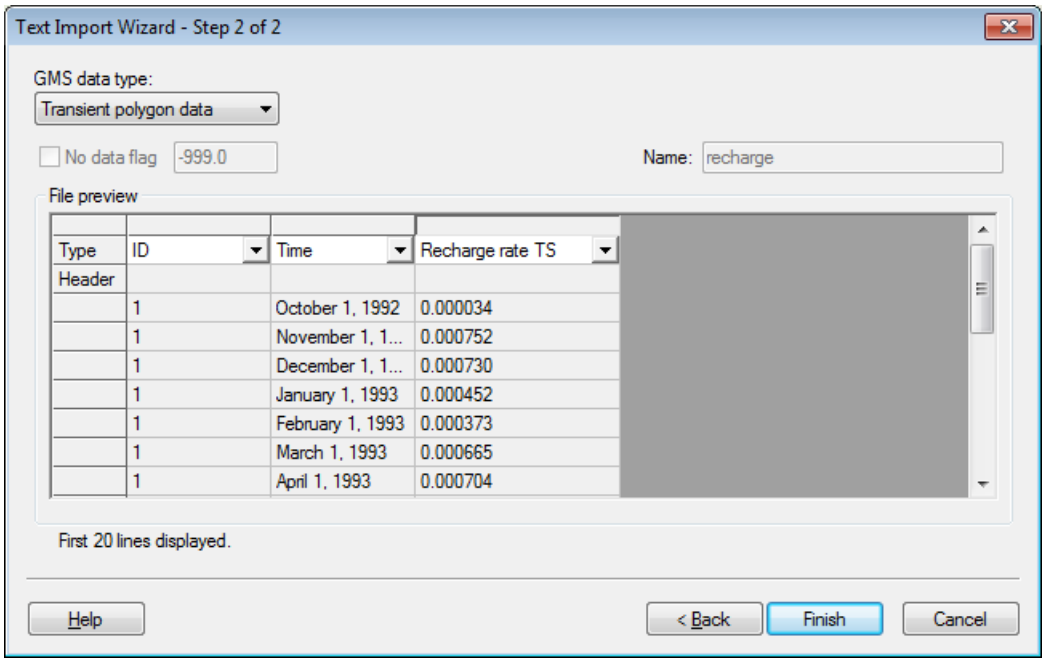

Figure 2. Step 2 of the Text Import Wizard

9. Click on the *Finish* button.

10. Select *Yes* at the prompt to make the time series data a step function.

7.2 Importing Pumping Well Data

In addition to the transient recharge data, our simulation will also contain a transient pumping schedule a well in the model. Pumping well data is typically imported using two files. The first file contains the name, screen geometry, and xy coordinates of the wells. The second file contains the pumping schedules. Since the well locations are already defined, we only need to import the pumping schedules. The format for this file is as follows:

Name	date	time	Q
"well 1"	12/3/1999	18:00:00	625.0
"well 1"	1/30/2000	7:38:25	0.0
"well 1"	3/27/2000	18:00:00	200.0
"well 2"	12/3/1999	18:00:00	0.0
"well 2"	12/5/1999	14:48:32	100.0
…			

When importing text data for points, we need to indicate to GMS which point the date/time data goes with. This can be done using a name, an id, or an x,y coordinate. In the case above we are using a name. The first time an entry is found for a particular well, if the well is steady state, it is changed to transient and a pumping rate time series is created for the well. Each time a subsequent line is read with the same well name, GMS adds a point to the time series. The dates and times can be in any standard format.

To import the well pumping data file:

1. Select the **Sources&Sinks** coverage from the *Project Explorer* to make it the active coverage.
2. Select the *Open* button.
3. In the *Open* dialog, change the *Files of type* selection to **Text Files (*.txt)**.
4. Select the file named **pumping.csv** and click *Open*.
5. In the *Import Wizard*, click *Next*.
6. Change the *GMS data type* to **Pumping data**.
7. In the **Type** row change the item in the first column to be **Name**, the item in the second column to **Date**, and the item in the third column to **Recharge rate TS**. The dialog should look like the following figure.

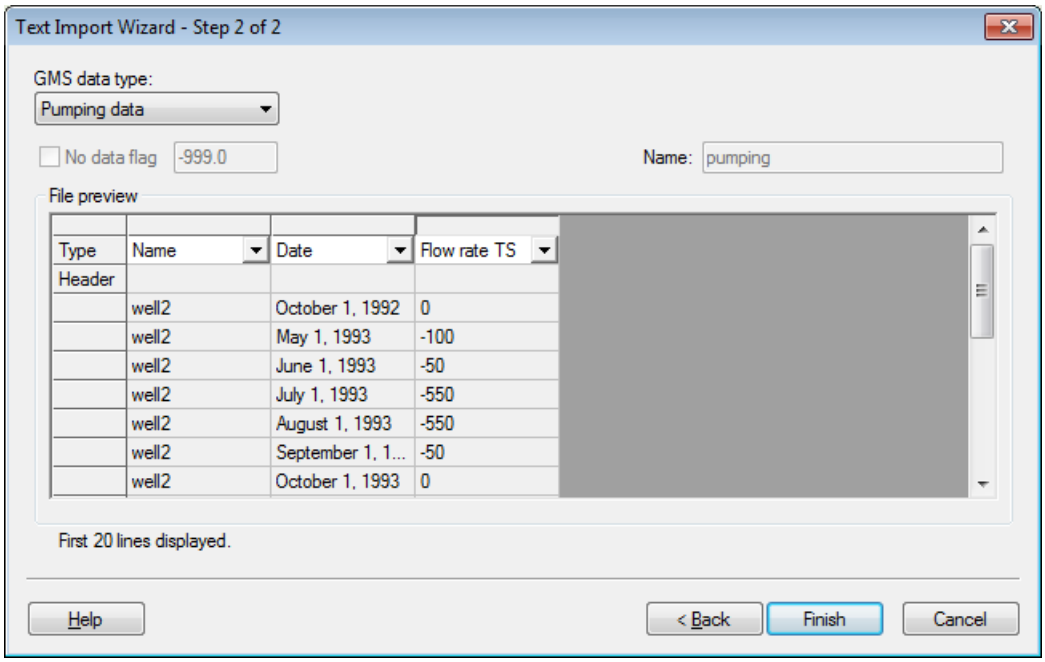

Figure 3. Step 2 of the Text Import Wizard

8. Select the *Finish* button.

9. Select *Yes* at the prompt to import the pumping data as a step function.
10. Select the *Select Points/Nodes* tool .
11. Double-click on the well on the east side of the model and note that the *Flow rate* says **<transient>**. You may want to click on the button to see the curve.
12. Select *OK* to exit the dialog(s).

7.3 Assigning Storage Parameters

Next, we need to assign the storage coefficient to the aquifer. Since this is a 2 layer model with an upper unconfined aquifer and a lower confined aquifer, we need to assign specific yield and specific storage.

1. Double-click on the **Layer 1** coverage in the *Project Explorer* to bring up the *Coverage Setup* dialog.
2. In the list of *Areal Properties*, turn on *Specific yield.*
3. Click *OK* to exit the dialog.
4. Select the *Select Polygon* tool and double-click on the polygon.
5. Assign a *Specific yield* value of **0.01** and select the *OK* button to exit the dialog.
6. Double-click on the **Layer 2** coverage in the *Project Explorer* to bring up the *Coverage Setup* dialog.
7. In the list of *Areal Properties*, turn on *Specific storage.*
8. Click *OK* to exit the dialog.
9. Select the *Select Polygon* tool and double-click on the polygon.
10. Assign a *Specific yield* value of **0.0001** and select the *OK* button to exit the dialog.

8 Initializing MODFLOW Stress Periods

MODFLOW discretizes time using stress periods and time steps. A length of time is associated with each stress period, and boundary conditions (or stresses) can change at the beginning of a stress period. Stress periods are subdivided into time steps. Before converting our conceptual model we need to set up the stress periods.

8.1 Changing the MODFLOW Simulation to Transient

First, we will change the current MODFLOW simulation from a steady-state simulation to transient.

1. In the *Project Explorer* expand the *MODFLOW* item located below the 3D Grid Data.

2. In the *Project Explorer* right-click on the *Global* package and select the *Properties…* command.

3. In the *Model type* section, select the **Transient** option.

8.2 Setting up the Stress Periods

Now we will set up the stress period information for MODFLOW.

1. Select the *Stress Periods* button.

2. Make sure the *Use dates/times* option is turned on.

When the *Use dates/times* option is used, all input fields in the MODFLOW interface in the *3D Grid* module expect the date/time format for input. The date/time format is used to display time values such as the time step values when post-processing. If the option is not used, scalar time values (e.g., 100, 120, etc.) are displayed.

3. Change the *Number of stress periods* to 37.

We want the stress periods to match the times where our input data in the map module changes. For example, the value for recharge changes monthly. Therefore, we need to make sure that we have stress periods that start at those times and at the time corresponding to changes in the pumping schedules.

4. Using notepad (or any suitable text editor), locate and open the following file: **Tutorials\MODFLOW\trans_calib\stress_periods.txt**.

5. Select all of the text in the file and copy the text.

6. Now paste these dates into the spreadsheet. You should end up with monthly stress periods from Oct 1, 1992 through Oct 1, 1995. The first stress period will have a length of 0.0 and be steady state. The dialog should look similar to next figure.

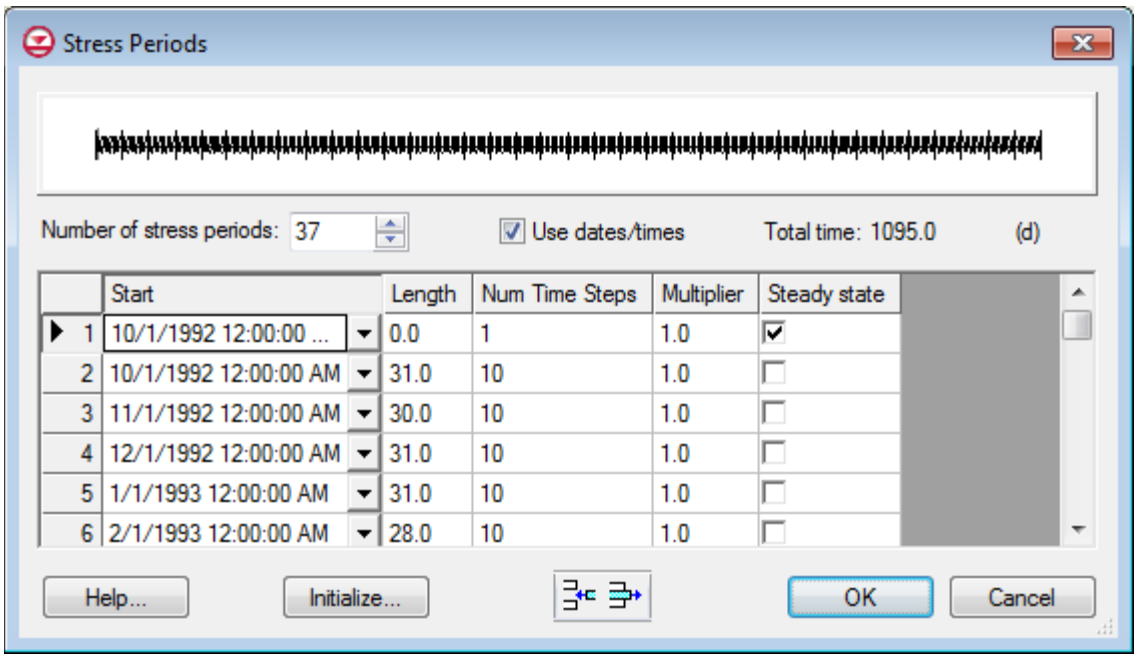

Figure 4. Stress Periods Dialog.

At this point you might adjust the number of time steps and the multiplier for each stress period. However, for this example we will use the default values.

7. Select the *OK* button to exit the *Stress Periods* dialog.

8. Select OK at the prompt. We want the first stress period to have a length of 0.0.

9. Select the *OK* button to exit the *Global Package* dialog.

9 Converting the Conceptual Model

Now we will convert our conceptual model data to MODFLOW input data.

1. Right-click on the *East Texas* conceptual model in the *Project Explorer* and select the *Map to* | *MODFLOW/MODPATH* command.

2. Select *OK* at the prompt to use *All applicable coverages*.

3. Select *OK* at the prompt to acknowledge that the xy series will be extrapolated to our numerical model.

10 Saving and Running MODFLOW

We are now ready to save the model and launch MODFLOW.

1. Select the *Save* button.

2. Select the *Run MODFLOW* button.

3. Once MODFLOW has finished, select the *Close* button to close the window and return to GMS.

The contours should change.

4. Expand the *trans1 (MODFLOW)* item in the *Project Explorer* and select the *Head* data set .

5. Use the *Time* Steps window to cycle through the different time steps of the solution to see how the pumping schedules of the wells affect the computed heads.

11 Creating Observation Wells

We will now use a shape file to define the locations of our observation wells and then we will import time series data of the transient observed heads.

1. Right-click on the **East Texas** conceptual model and select the *New Coverage* command.

2. Change the coverage name to **Obs** and turn on the **Trans. Head** under the *Observation Points* section of the dialog.

3. Near the bottom of the dialog, change the *3D grid layer option for obs. pts* to **By layer number**.

4. Select *OK* to exit the dialog.

5. Select the *Open* button .

6. Locate and open the **Tutorials\MODFLOW\trans_calib** directory.

7. Open the file entitled **well_pts.shp**. You can change the *Files of type* filter to **Shapefiles (*.shp)** to help locate the file.

8. Right-click on the **well_pts.shp** shapefile in the *Project Explorer* and select the *Convert to* | *Feature Objects* command.

9. Select *Yes* at the prompt to use all shapes.

10. Select *Next* on first step of the *GIS to Feature Objects* wizard.

11. On the second step of the wizard, in the *Mapping* row, change the second column to **Name**. The dialog should look similar to the next figure.

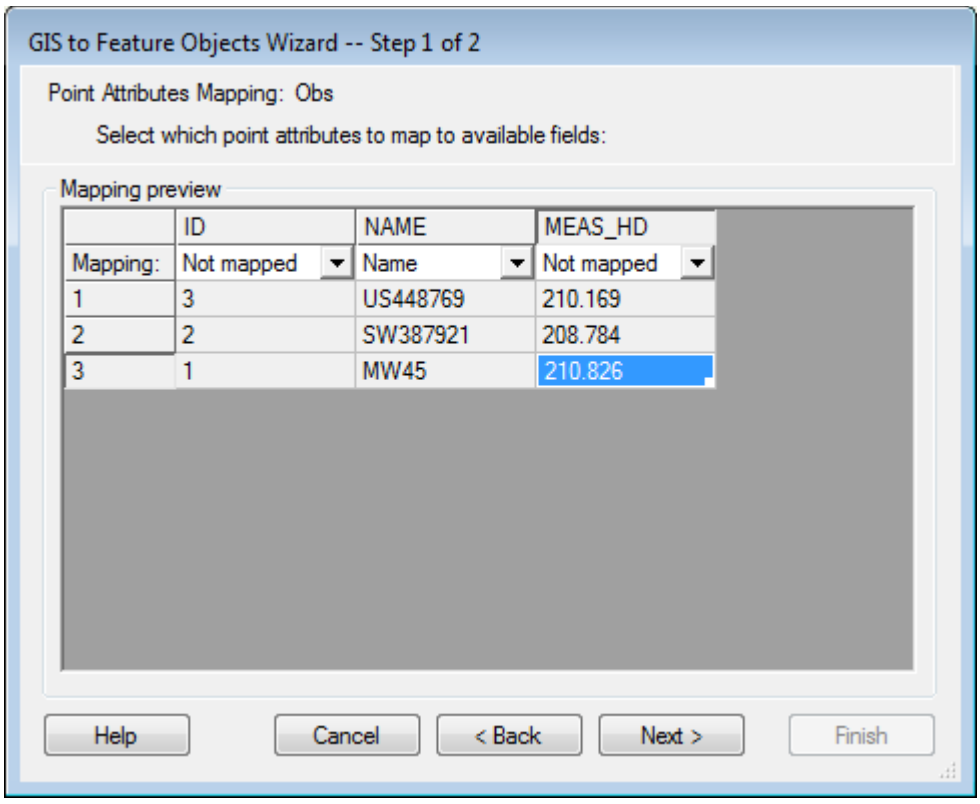

Figure 5. Step 2 of GIS to Feature Objects Wizard

12. Select *Next* and then select the *Finish* button.

13. Right-click on the **Obs** coverage in the *Project Explorer* and select the *Attribute Table* command.

14. In the *All* row change the *Type* to **obs. pt**.

15. Select *OK* to exit the dialog.

12 Importing Transient Head Observations

We have now created points in our Obs coverage from the points in the shape file. Now we will import the transient head data.

1. Select the *Open* button.

2. Locate and open the **Tutorials\MODFLOW\trans_calib** directory.

3. Open the file entitled **well_head.txt**.

4. In the *Import Wizard*, turn on the *Heading row* and click *Next*.

5. Change the *GMS data type* to Transient observation data.

6. Based on the names of the columns in the header, GMS has automatically mapped the **Type** row. Click on the *Finish* button.

At this point you can go into the attribute table and see the time series for each of the points.

13 Saving and Running MODFLOW

We are now ready to save the model and launch MODFLOW.

1. Select the *Save* button.
2. Select the *Run MODFLOW* button.
3. Once MODFLOW has finished, select the *Close* button to close the window and return to GMS.
4. Right-click on the *trans1 (MODFLOW)* item in the *Project Explorer* and select the Properties command.

The properties dialog shows the model error. Notice that we only have error associated with Heads. Currently, our model only has head observations and lacks any flow observations.

5. Select *Done* to exit the dialog.
6. Expand the *trans1 (MODFLOW)* item in the *Project Explorer* and select the *Head* data set.
7. Use the *Time* Steps window to cycle through the different time steps of the solution.

You should notice that targets on the observations change as the time steps change. Also, if the current time step of the MODFLOW heads is before or after the time series data for a particular well then the target for that well will be "washed out" (or dimmed).

14 Creating a Time Series Plot

One of the plots that GMS can create that is useful for transient observation data is the time series plot.

1. Select the *Plot Wizard* button.
2. Change the plot type to *Time Series*.
3. Select the *Next* button.

4. Turn on the *Calibration Target* and *Observed Values* options.

5. Select the check box next to **MW45** and select the *Finish* button. You should see a plot similar to the next figure.

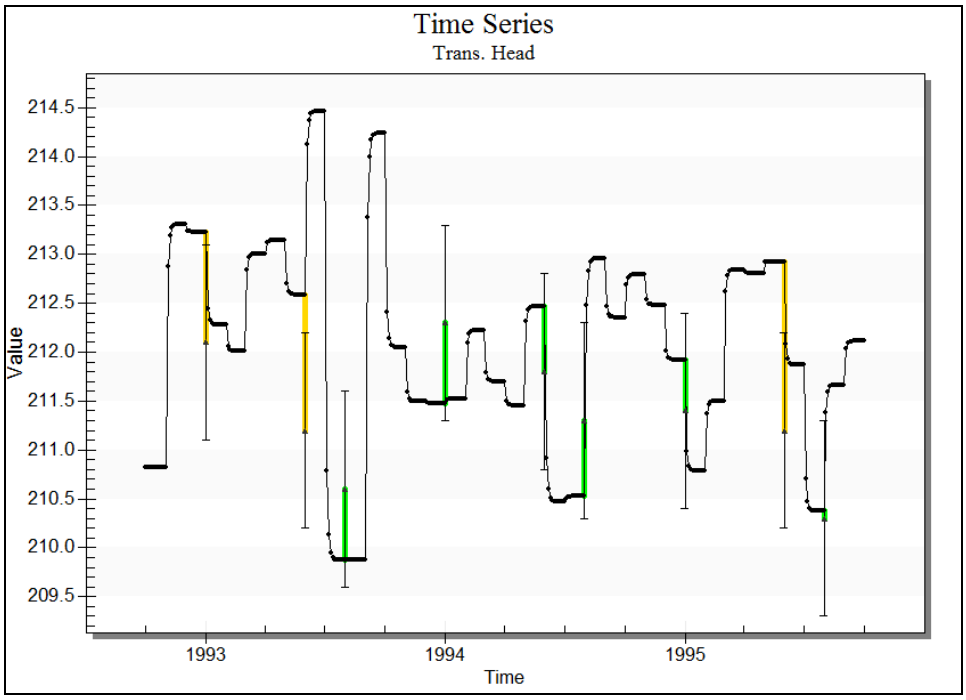

Figure 6. Time Series Plot

Notice that the computed heads are sometimes within the min/max of the calibration target (green targets) and at other times the computed heads are just outside of the calibration target well. You may wish to make time series plots for the other two wells.

14.1 Creating Transient Observation Plots in Excel

The transient observation plots in GMS are useful for quickly understanding the relationship between the observed data and the computed values from MODFLOW. However, when preparing reports of modeling projects it is useful to use a spreadsheet such as Microsoft Excel to create plots. The transient observation data can be exported from GMS to a text file; this text file can then be opened in Excel and used to generate plots for a report. If you have Excel installed with the ability to run macros, continue with the steps below. Otherwise, skip to the next section.

1. Select MODFLOW | Observations menu command.

2. Select the *Export Trans. Obs…* button.

3. Accept the default name of *TransObservation.csv* and select the *Save* button.

4. Now open Windows Explorer and browse to the **Tutorials\MODFLOW\trans_calib** directory.

5. Double click on the *modflow trans obs plotter.xls* file.

6. In Excel, enter the name *TransObservation.csv* file in the *File name* field and click the import button.

7. Select *Yes* at the prompt to delete existing sheets.

A macro should run in Excel to create a new sheet for each observation point along with a plot. These sheets are a copy of the *template* base sheet with the data for each observation point added to the sheet. Thus, you could modify the base sheet with the desired plotting options and then run the macro to create plots with your own customizations.

At this point you can try adjusting the hydraulic conductivity and the storage parameters to see if you can get a better fit with the observation data.

15 Conclusion

This concludes this tutorial. Here are the things that you should have learned in this tutorial:

- When you bring up the properties dialog for objects in the Map module, you can enter transient data by using the  button.
- You can import transient data for points, arcs, polygons, and nodes using the text import wizard. The points, arcs, polygons, and nods must already exist in the active coverage.
- You can use a shapefile to define the location of observation wells.
- You can import transient head observations.
- You can create time series plots with calibration targets to show how well a model fits the observed data.

