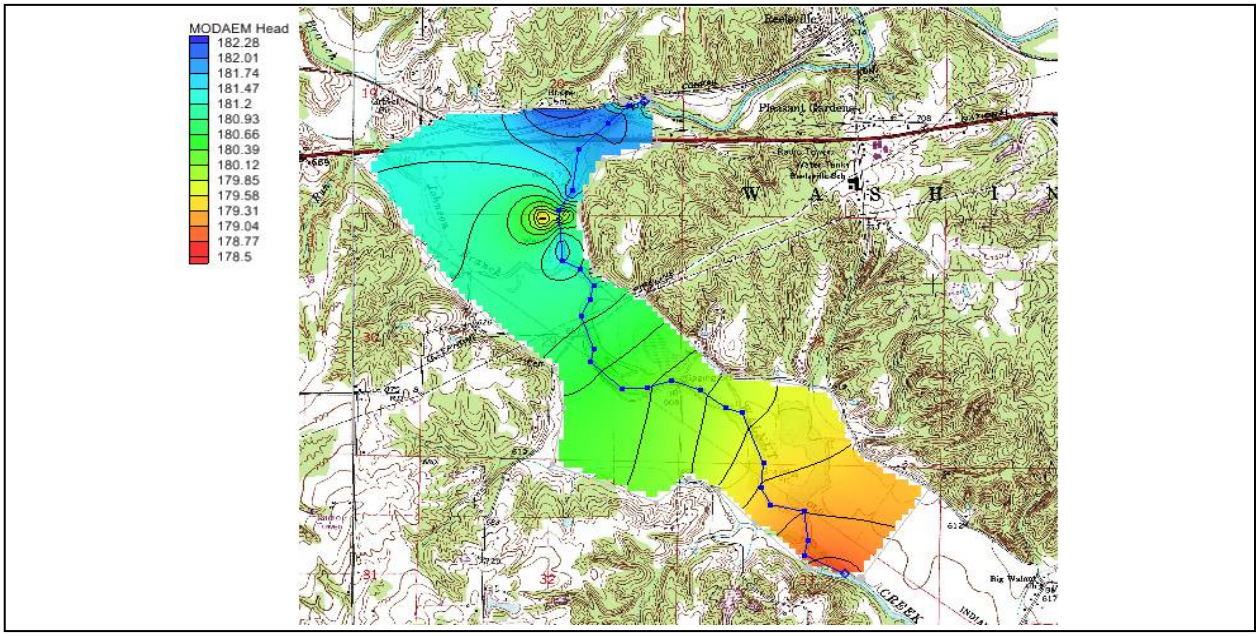
GMS

v. 9.2

GMS 9.2 Tutorial
MODAEM
Analytic element modeling with MODAEM



Objectives
Illustrate the use of GMS for analytic element modeling with MODAEM.

Prerequisite Tutorials
- GMS Basics

Required Components
- Map
- MODAEM

Time
- 30-60 minutes

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2 Introduction

MODAEM is a single-layer, steady-state analytic element groundwater flow model that has been enhanced for use with GMS. This chapter introduces MODAEM to the new user and illustrates the use of GMS for analytic element modeling. This tutorial does not go into detail in explaining the analytic element method. For a more detailed explanation of analytic element modeling and MODAEM, refer to the MODAEM Help manual.

2.1 Outline

This is what you will do:

1. Read in a background map.
2. Create a conceptual model and define the parameters.
3. Run MODAEM for different conditions.

3 Description of Problem

This tutorial describes the use of GMS to model groundwater flow near the well field of Brazil, IN, USA. Brazil (population 8188) operates a well field about 5 miles east of town, in the floodplain of Big Walnut Creek (see Figure 1). The objectives of this model are to:

- Model the 5-year capture zone for the wellfield for use in the Brazil wellhead protection effort.
- Examine the effects of the addition of a well to the wellfield.

The following figure shows the site location, along with the model boundaries.

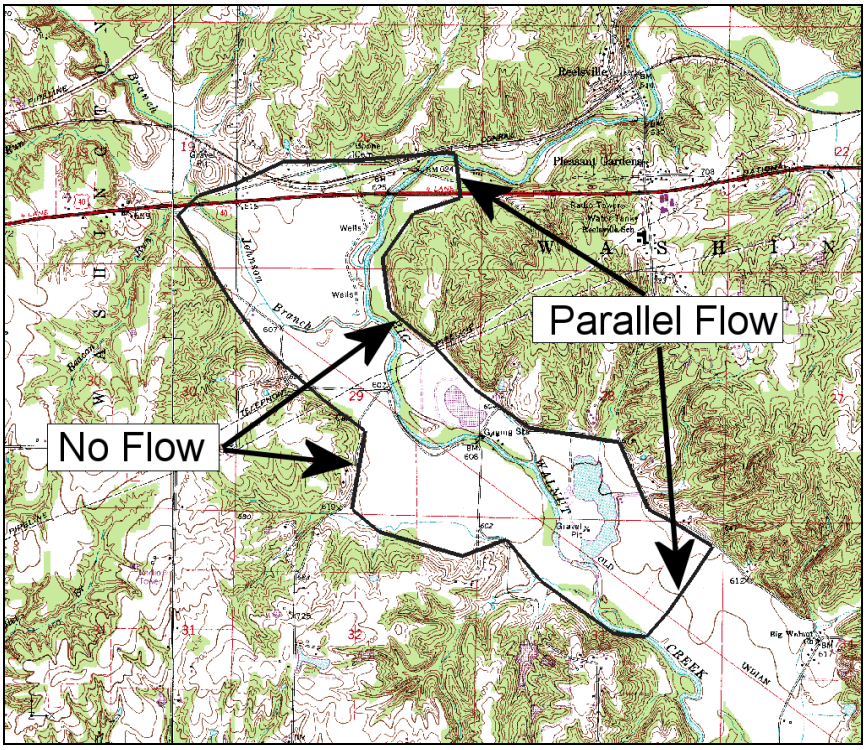

Figure 1. Model boundary.

3.1 Setting and Data Collection

The well field is situated in the floodplain of Big Walnut Creek. The aquifer is composed of coarse gravel with an average hydraulic conductivity of 250 ft/d (60.9 m/d), deposited in a buried bedrock valley. Although the bedrock surrounding the valley is slightly permeable, it is not considered an important source of water. The thickness of the gravel aquifer in the valley varies from 10 – 80 ft (3.0 – 24.4 m). At the wellfield, the ground elevation is roughly 600 ft (183 m), and the aquifer is roughly 60 ft (18.3 m) thick.

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 Background Map

The first step to create our model is to read in a background image of the site we are modeling. We will use the image to guide us as we create points, arcs, and polygons to define features of our model.

1. Select the *Open* button .
2. Locate and open the directory entitled **Tutorials\MODAEM\modaem**.
3. Change the *Files of type* to Images (*.tif; *.tiff; *.jpg; *.jpeg; *.png; *.sid).
4. Select and open the file **brazil_topo.jpg**.
5. Depending on your program preferences a prompt may appear asking if you want to build image pyramids. Select *No* at the prompt.

6 Defining the Units

At this point, we can also define the units used in the conceptual model. The units we choose will be applied to edit fields in the GMS interface to remind us of the proper units for each parameter. The

1. Select the *Edit* | *Units* command.
2. For *Length*, select the "…" button next to the length area. In the following dialog change the Units to "Meters" for both Vertical and Horizontal Units, and click the *OK* button~~m (for meters).~~
3. For *Time*, select **d** (for days). We will ignore the other units (they are not used for flow simulations).
4. Select the *OK* button.

7 Creating the Conceptual Model

We are now ready to enter our model data. First, we will create a MODAEM conceptual model. Then we will create coverages to define the boundary conditions and aquifer properties. The boundary of our model is shown in the following figure.

1. In the *Project Explorer* right-click on the empty space and then, from the pop-up menu, select the *New* | *Conceptual Model* command.

2. Change the *Name* to **Indiana** and the *Type* to **MODAEM** and click *OK*.

3. Right click on the **Indiana** conceptual model and select the *New Coverage* menu command.

4. Change the *Coverage name* to **Boundary** and select the *Use to define model boundary* option. Click *OK*.

5. Select the *Create Arc* tool .

6. Click out the boundary as shown in Figure 3 below.

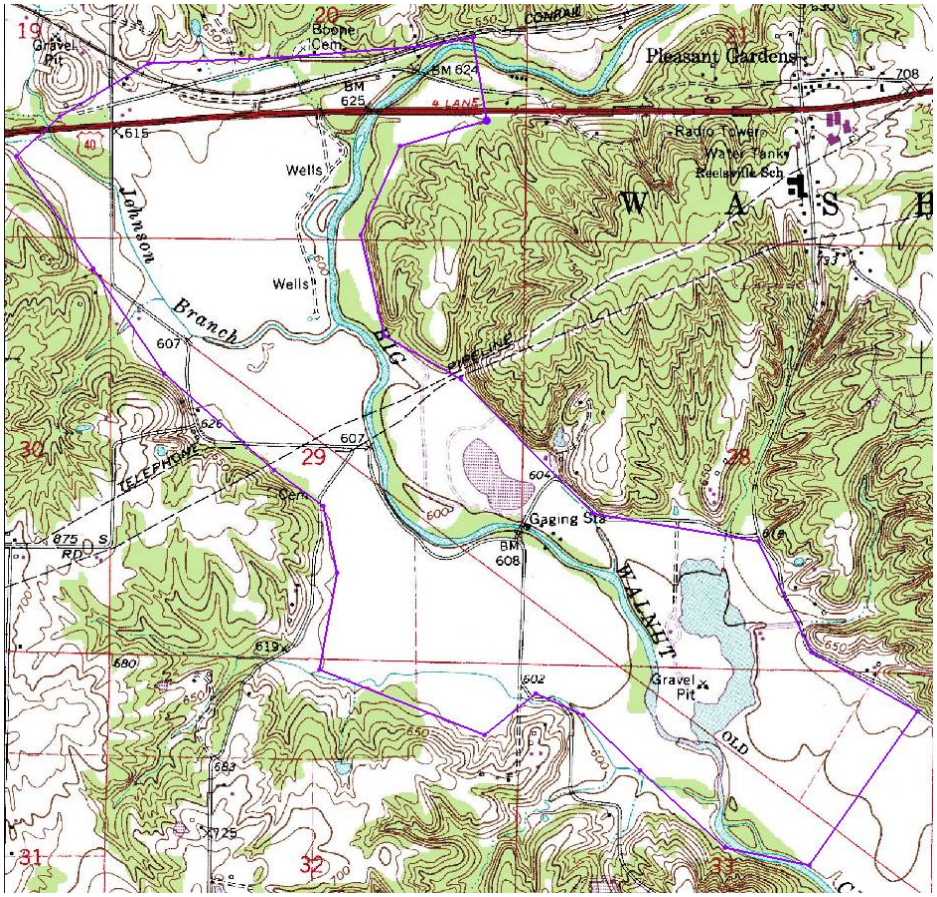

Figure 3. Boundary arcs.

8 Creating the Specified Head Arcs

By default, the arcs in a MODAEM boundary coverage are "no flow" boundaries. This means the arc's type is set to "specified flow" and the flow is set to 0. Next we will add

specified head arcs to this coverage. To create the specified head arcs we will split the boundary arc into four separate arcs.

8.1 Convert Vertices to Nodes

1. Select the Display Options macro .
2. On the left side of the dialog make sure that Map Data is selected.
3. Turn on **Vertices** and click *OK*.
4. Select the *Select Objects* tool .
5. Select the four points (vertices and/or nodes) displayed in the figure below. To select more than one point, you must hold the shift key while selecting.

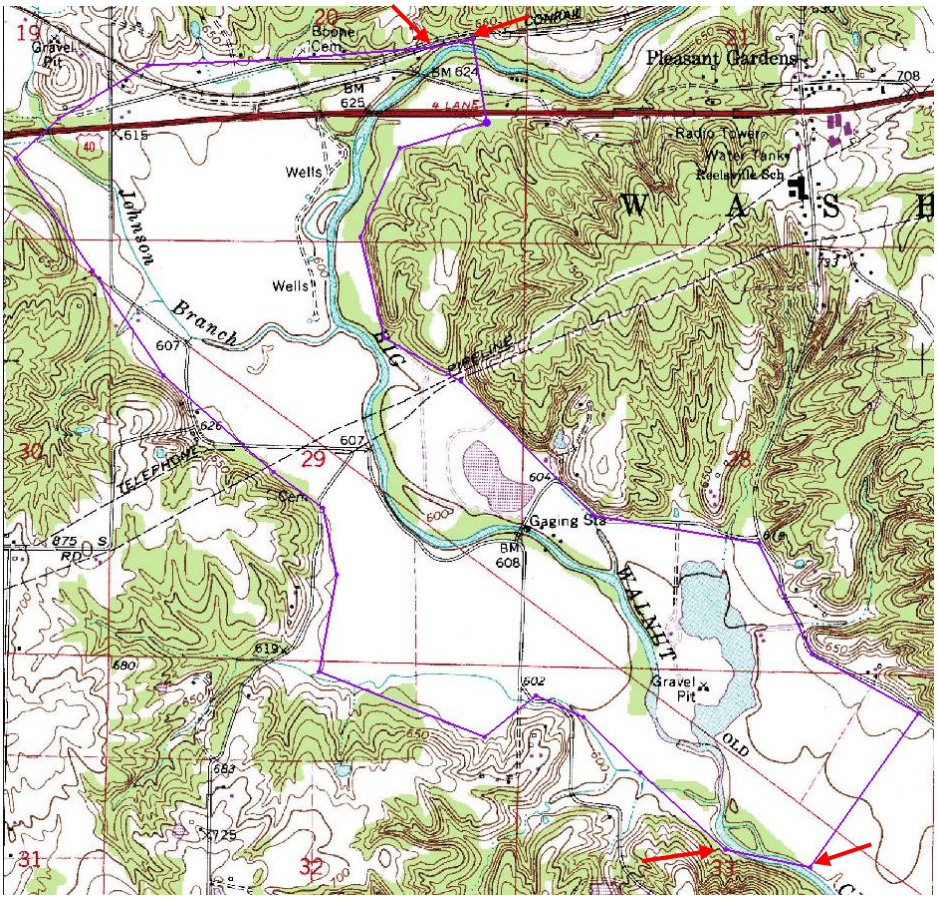

Figure 4. Convert vertices to nodes.

You may need to insert additional vertices. This can be done by using the *Create Vertex* tool . Simply select the tool and then click on the arc in the location that you want the new vertex to be. Also, depending on how you created your boundary arc, one of the vertices shown in the figure above may actually be a node. In that case you will not be

able to select it with the select vertex tool. If you do have a node at one of the locations shown above just select the other three vertices.

6. Select the *Feature Objects* | *Vertices -> Nodes* command to convert all the selected vertices to nodes.

8.2 Assigning Arcs

1. Select the *Select Arcs* tool .

2. Select the two new arcs that we created on the north and south of the boundary.

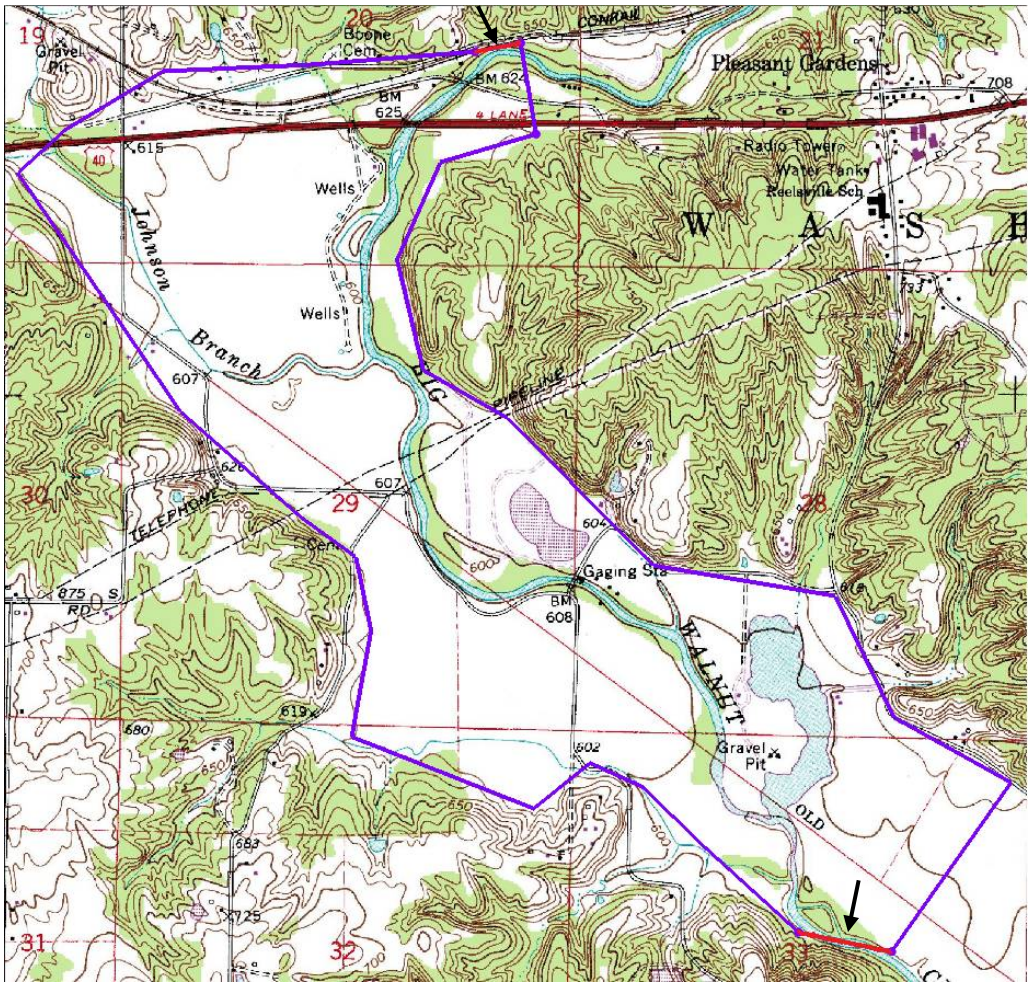

Figure 5. Specified head arcs.

3. Select *Properties* button .

4. In the *All* row change the type to **spec. head**.

5. Select *OK* to exit the dialog.

6. Select the *Select Points/Nodes* tool.

7. Select both nodes on the northern specified head arc. To select more than one node, you can hold the shift key down while you click or you can drag a box around both nodes.

8. Select the *Properties* button.

9. In the *Head* field for both nodes enter **182.0**.

10. Repeat steps 10-12 for the nodes attached to the southern specified head arc and enter **178.6** for the head value.

9 Entering the Aquifer Properties

Next we will enter the properties of our aquifer. Aquifer properties can be assigned to individual polygons, and we can also define properties for a "background aquifer."

1. Select the *MODAEM* | *Global Options* command.

2. In the *Background aquifer properties* section enter **170.0** for the *Base*, **18.0** for the *Thickness*, and **60.0** for the *Hyd. cond.*

3. Select *OK* to exit the dialog.

With a boundary coverage we must also have a single polygon that defines the aquifer we are modeling.

4. Select the *Feature Objects* | *Build Polygons* command.

10 Saving the Project

We are now ready to run MODAEM. With other models in GMS, like MODFLOW for example, you must first save your changes to the project before you run the model. When you run MODAEM, however, the data currently in memory is written to temporary files that MODAEM reads to compute its solution. Therefore, you don't have to save your changes in GMS before running MODAEM. However, it's a good idea to save your work periodically anyway, so let's do so now.

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

6. Save the project with the name **brazil**.

Now you can hit the save button periodically as you develop your model.

11 Running MODAEM

We are now ready to run MODAEM. This can be done by selecting the menu command *MODAEM* | *Solve* or by hitting the *F5* key. Once this command is executed a dialog will appear showing the output from the MODAEM model.

1. Hit the *F5* key.
2. When MODAEM is finished, select the *Close* button.

Head contours should now appear inside our boundary coverage.

3. Select the *Contours* macro .
4. Change the *Contour method* to **Linear and Color Fill**.
5. Under the *Fill options* section of the dialog change the *Transparency* value to **40** and select *OK*.

12 Creating the River

Now we will add the river to our model.

1. Right click on the **Indiana** conceptual model in the *Project Explorer* and select the *New Coverage* option.
2. Change the name of the coverage to **River**.
3. Under the *Source/Sink/BCs* section toggle on the **River** option.
4. Select **OK** to exit the dialog.
5. Select the *Create* Arc tool .
6. Click out the river arc starting near the northern specified head boundary and ending near the southern specified head boundary, as shown in Figure 6 below. Don't extend the river beyond the boundary coverage.

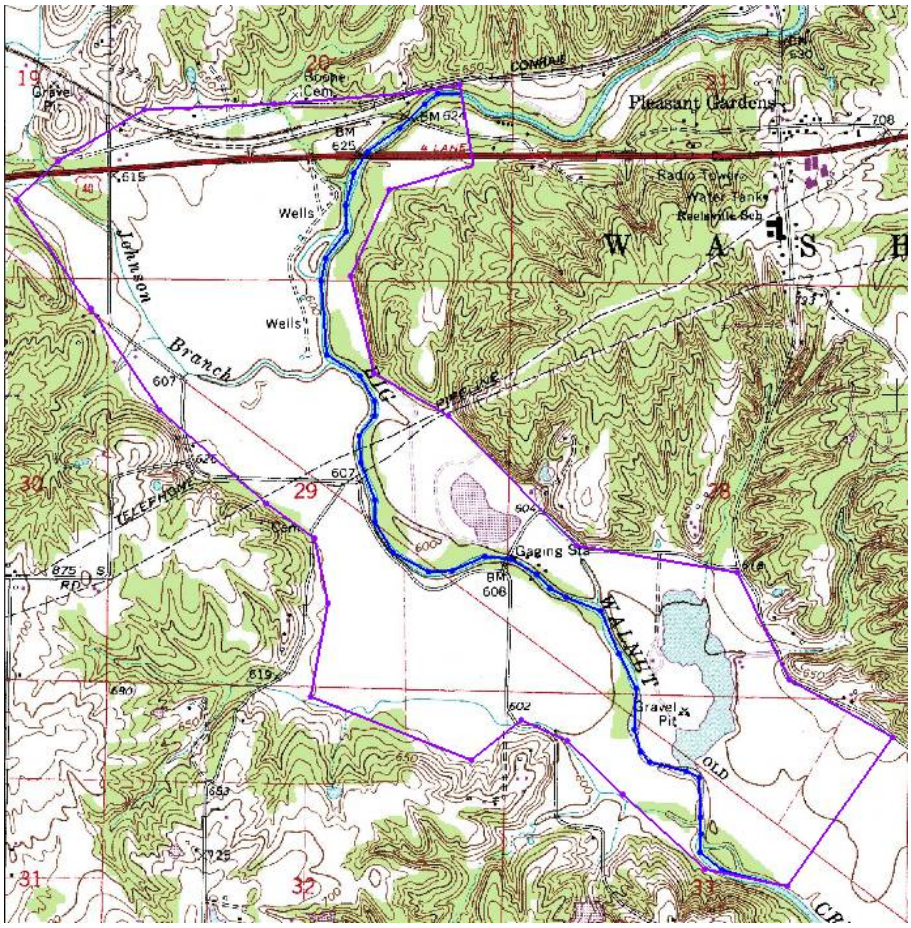

Figure 6. Modeling the river.

7. Select the *Select Arcs* tool .
8. Click anywhere on the river arc to select it.
9. Select *Properties* button .
10. Change the type of the arc to **river**.
11. Enter a value of **5000.0** for the *Cond.* (conductance) and click *OK*.
12. Select the *Select Points/Nodes* tool .
13. Double click on the river node at the northern end of the model.
14. Enter **182.0** for the *Head* and **179.0** for the *Elev*.
15. Select *OK* to exit the dialog.
16. Repeat the same process for the southern river node and enter **178.6** for the *Head* and **175.6** for the *Elev*.

13 Running MODAEM

We are now ready to run MODAEM again.

1. Hit the *F5* key.
2. When MODAEM is finished, select the *Close* button.

You should notice some change in the head contours, particularly around the river arc.

14 Adding Recharge

Now we will add recharge to the model.

1. Right-click on the **Boundary** coverage and select the *Duplicate* command.
2. Double click on the new coverage (called **Copy of Boundary**) to bring up the *Coverage Setup* dialog.
3. Change the *Coverage Name* to **Recharge**.
4. In the *Sources/Sinks/BCs* section of the dialog, toggle **off** *Specified Head* and *Specified Flow*.
5. In the *Areal Properties* section of the dialog, toggle **on** *Recharge*.
6. Select *OK* to exit the dialog.
7. Select the *Select Polygons* tool .
8. Double click on the polygon and assign a value of **.00042** to the *Recharge* field. Click *OK* to exit the dialog.

15 Running MODAEM

We are now ready to run MODAEM again.

1. Hit the *F5* key.
2. When MODAEM is finished, select the *Close* button.

16 Production Wells

Now we will import production wells from a tab delimited text file.

1. Right-click on **Indiana** in the *Project Explorer* and select the *New Coverage* option.
2. Change the name of the coverage to **Wells**.
3. Under the *Source/Sink/BCs* section toggle on the *Wells* option.
4. Select *OK* to exit the dialog.
5. Select the *Open* button.
6. Locate and open the directory entitled **Tutorials\modaem**.
7. Change the *Files of type* to **All Files (*.*)**.
8. Select and open the file **prod_wells.txt**.
9. Toggle on the *Heading row* toggle.
10. Click the *Next* > button.
11. Change the *GMS data type* to **Well data**.
12. In the *File preview* section of the dialog change the *Type* of the first column to **X**, the second to **Y**, and the third to **Flow Rate**.
13. Select the **Finish** button to exit the dialog.

You may have difficulty seeing the wells. The well symbol can be changed in the *Display Options* dialog by clicking on the *Display* macro.

17 Observation Wells

Before running MODAEM again we will also read in field measured head values.

1. Right-click on **Indiana** in the *Project Explorer* and select the *New Coverage* option.
2. Change the name of the coverage to **Observation**.
3. Under the *Observation Points* section toggle on the **Head** option.
4. Select *OK* to exit the dialog.
5. Select the *Open* button.
6. Locate and open the directory entitled **Tutorials\modaem**.
7. Select and open the file **well_head.txt**.

8. Toggle on the *Heading row* toggle.
9. Click the *Next* > button.
10. Change the *GMS data type* to **Observation data**.
11. In the *File preview* section of the dialog change the *Type* of the first column to **Name**, the second to **X**, the third to **Y**, and the fourth to **Obs. Head**.
12. Select the **Finish** button to exit the dialog.
13. You should now see observation targets appear.

18 Running MODAEM

We are now ready to run MODAEM again.

1. Hit the *F5* key.
2. When MODAEM is finished, select the *Close* button.

19 Conclusion

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

- MODAEM is an analytic element model, and it uses points, arcs, and polygons to compute solutions.
- The *Map* module is used to construct conceptual models using feature objects (points, arcs and polygons).
- Feature objects are grouped into coverages. There is always only one active coverage, and only the active coverage can be edited.