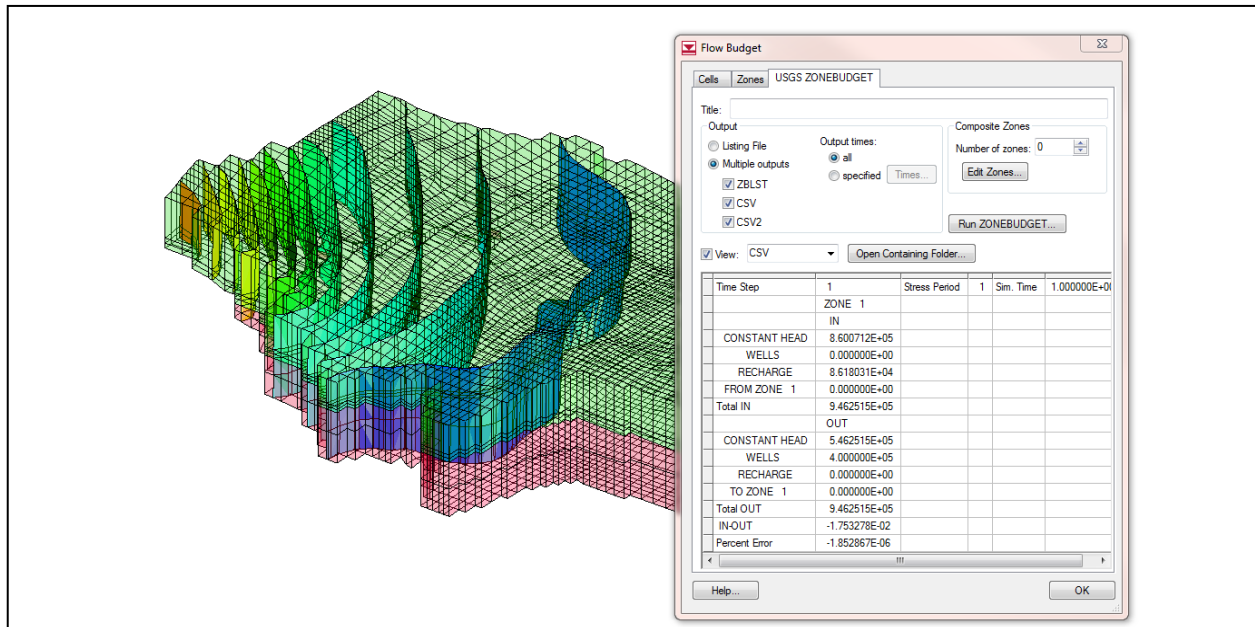


GMS 9.2 Tutorial

MODFLOW – ZONEBUDGET

Use ZONEBUDGET With a Multi-layer Model



Objectives

Learn how to use ZONEBUDGET with MODFLOW in GMS.

Prerequisite Tutorials

- MODFLOW - Grid Approach
- MODFLOW - Conceptual Model Approach

Required Components

- Grid
- Map
- MODFLOW
- Zonebudget

Time

- 15-30 minutes



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2 Introduction

ZONEBUDGET is USGS program that reads cell to cell flow data produced by MODFLOW and calculates water budgets for subregions of the modeled area.

This tutorial builds on the *MODFLOW - Grid Approach* and the *MODFLOW - Conceptual Model* tutorial. You should complete those tutorials before this one. The purpose of this tutorial is not to teach you all about ZONEBUDGET, but simply to demonstrate the ZONEBUDGET interface in GMS.

2.1 Outline

This is what you will do:

1. Read an existing MODFLOW 2000 model.
2. Run ZONEBUDGET and view the outputs for a steady state MODFLOW solution.
3. Assign Zone Budget Ids to the model grid and run ZONEBUDGET.
4. Assign Zone Budget Ids using a conceptual model.
5. Run ZONEBUDGET on a transient MODFLOW solution.

3 Description of Problem

The problem we will be working with is the same model used in the *MODFLOW - Generating Data From Solids* tutorial. This is a multi-layer MODFLOW model of a site with complex stratigraphy. A cross section of the site is shown in the figure below.

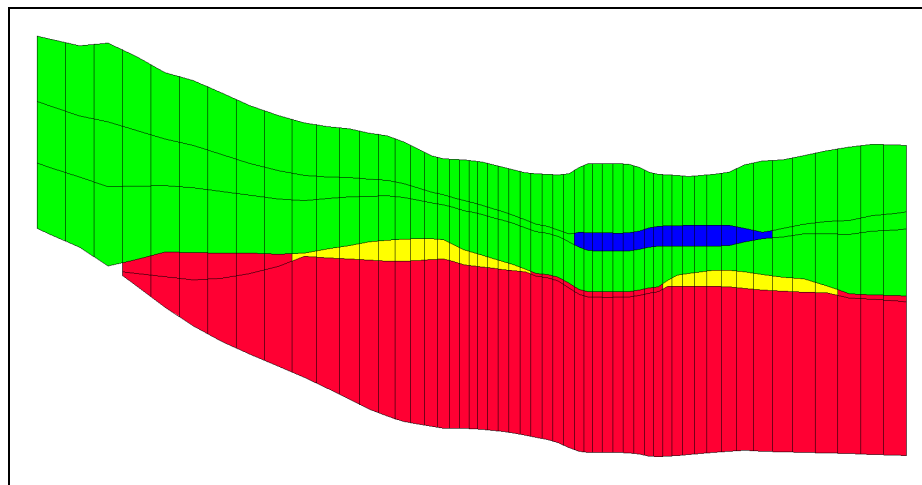


Figure 1. Multi-layer MODFLOW model.

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 Read in the MODFLOW 2000 Model

First, we will read in an existing model:

1. Select the *Open* button .
2. Locate and open the **Tutorials\MODFLOW\zonebudget** directory.
3. Open the file entitled **model.gpr**.

You should see a MODFLOW model with color contours of the head solution.

6 Viewing the Flow Budget

First, we will look at the flow budget for the MODFLOW model.

1. Select the *MODFLOW | Flow Budget* menu command.

The first tab that comes up in this dialog shows the flow budget for any selected cells or if no cells are selected then it shows the budget for the entire model domain. You can see that this model has flow into the model from Constant head and Recharge boundary conditions and flow out through Constant head and Well boundary conditions.

2. Select the *Zones* tab in the dialog.

This tab provides features similar to USGS ZONEBUDGET; you can see a more concise summary of the flow budget. However, the information displayed in this tab comes from GMS reading the MODFLOW cell to cell flow output file (*.ccf).

7 Running ZONEBUDGET

Now we will run ZONEBUDGET and view the outputs. We run ZONEBUDGET from the USGS ZONEBUDGET tab in this dialog.

1. Select the *USGS ZONEBUDGET* tab.
2. Select the *Run ZONEBUDGET* button.

A dialog will appear showing ZONEBUDGET while it runs.

3. Select the *Close* button when ZONEBUDGET has finished running.

Notice that the ZONEBUDGET output has been displayed in the dialog. This output is very similar to the output that we saw in the *Zones* tab. We are currently viewing the CSV output from ZONEBUDGET. When we ran ZONEBUDGET two other output files were created. You can see under the Output section of the dialog that ZBLST, CSV, and CSV2 outputs are selected under the *Multiple outputs* option.

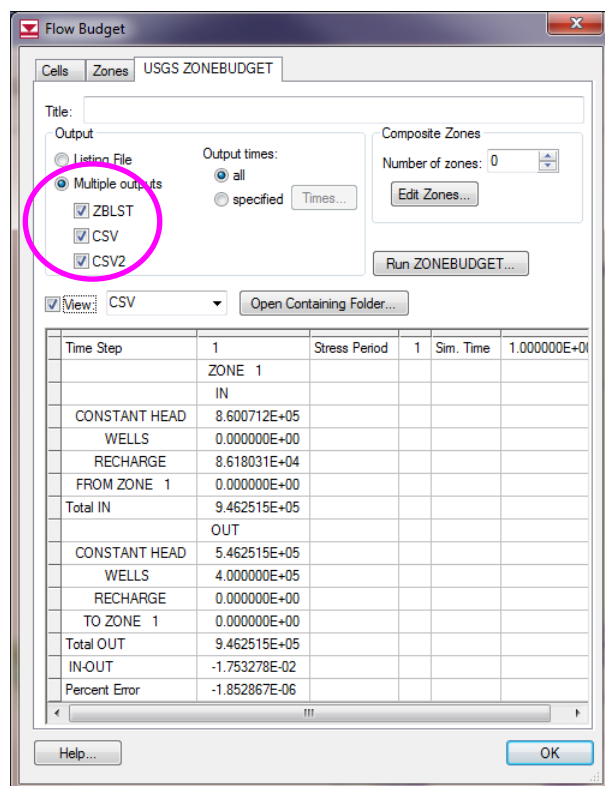


Figure 2. ZONEBUDGET dialog.

- In the drop down list next to the *View* toggle change the selection to **ZBLST**.

This is the ZONEBUDGET listing file. It provides information on the inputs to ZONEBUDGET as well as the outputs. If you scroll to the end of the file you will see a report similar to what we viewed with the CSV output file.

- Select the *Open Containing Folder* button.

Windows Explorer opens to the directory where all of the ZONEBUDGET inputs and outputs are stored. The files are in the same location as the MODFLOW ccf that is used in the ZONEBUDGET run. The following figure shows the ZONEBUDGET files.

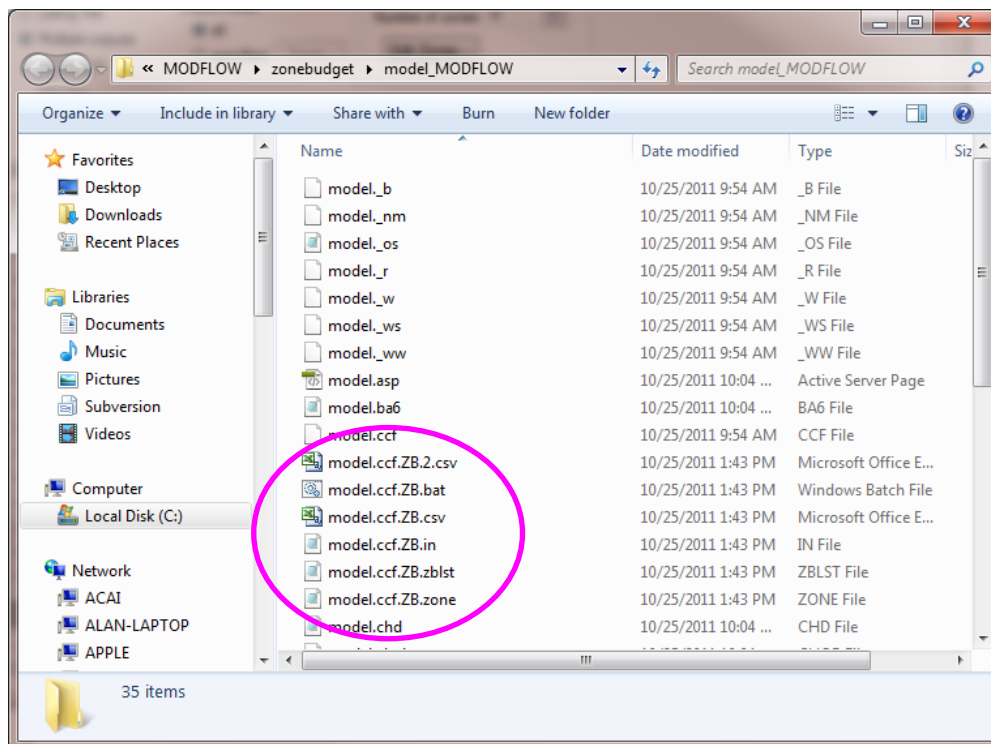


Figure 3. ZONEBUDGET input and output files.

All of the ZONEBUDGET files have the name of the ccf file with the added **.ZB** to clearly identify the files. The **.zblst**, **.csv**, and **.2.csv** are the ZBLST, CSV, and CSV2 files respectively. The **.in** and **.zone** files are inputs to ZONEBUDGET. The **.bat** file is a Windows batch file that can be used to rerun ZONEBUDGET.

6. Close Windows Explorer and return to GMS.
7. Select *OK* to exit the dialog.

8 Assigning Zone Budget IDs

Now we will assign different Zone budget IDs to our grid. When we ran ZONEBUDGET previously every cell in the model grid was assigned a Zone budget ID of 1. First we will assign different zone IDs to the layers of our grid.

1. Expand the items below *3D Grid Data* and *MODFLOW* in the *Project Explorer* so that you can see *Zone Budget IDs*.

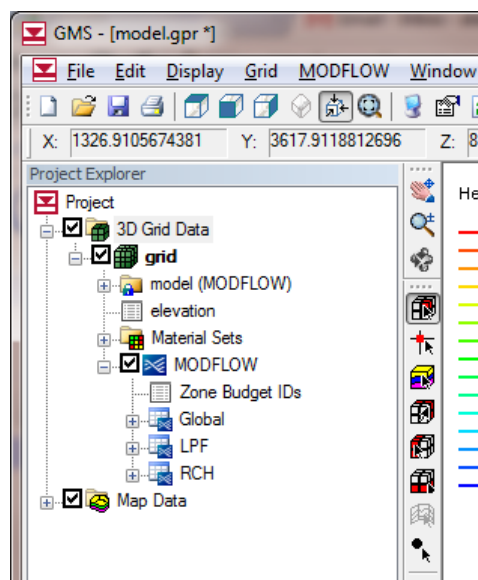


Figure 4. Expanded items in the Project Explorer.

- Right click on the  *Zone Budget IDs* item and select the *Properties* command.

This command brings up an array editor that we can use to edit the IDs. This is the same editor that is used to edit all array inputs to MODFLOW. We are going to assign a different ID to each layer in our grid. The dialog is currently showing the IDs for layer 1.

- Change the *Layer* to **2**.

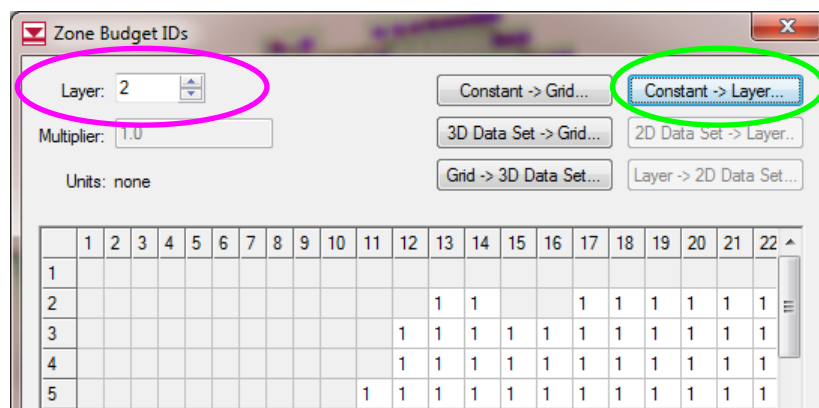



Figure 5. The Zone Budget IDs Editor.

- Select the *Constant* \rightarrow *Layer* button.
- Enter a value of **2** at the prompt and select *OK*.
- Repeat this process for layers 3, 4, and 5. Assign the layer number as the Zone Budget ID.
- Select *OK* to exit the dialog.

8. In the *Project Explorer*, click on the  *model (MODFLOW)* item to make it active.

9 Running ZONEBUDGET

Now we will run ZONEBUDGET again.

1. Select the *MODFLOW | Flow Budget* menu command.
2. Select the *USGS ZONEBUDGET* tab.
3. Select the *Run ZONEBUDGET* button.
4. Select the *Close* button when ZONEBUDGET has finished running.

Notice that in addition to the information about flows from boundary conditions we now have information about the flows exchanged between zones.

5. Select **CSV2** in the drop down box next to the *View* toggle.

The CSV2 output file contains the same information that the CSV output file contains but it is formatted differently.

6. Click *OK* to exit the dialog.

10 Assigning Zone Budget IDs from a Conceptual Model

Next we will assign Zone Budget IDs using coverages that are part of a conceptual model. We will use polygons to assign Zone Budget IDs to different areas of the model grid.

1. Expand the items below  **Map Data** in the *Project Explorer*.

You should see several coverages. There are 5 coverages that will be used to assign Zone Budget IDs.

2. Select the **Zones_layer_2** coverage.
3. Change the current grid layer that we are viewing by changing the *Lay (k)* to **2** in the *Mini Grid* toolbar at the top of the GMS window.

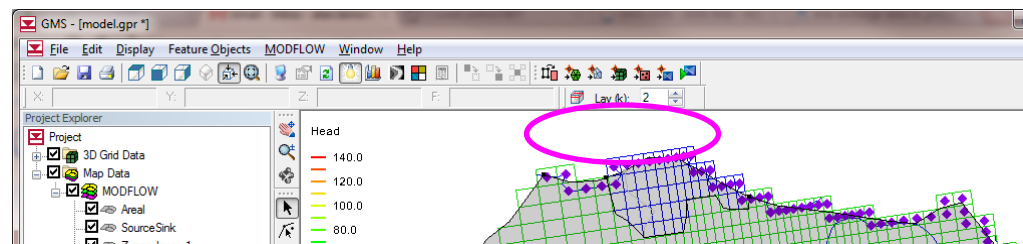



Figure 6. Mini Grid toolbar.


Notice that there are polygons that match with the different material zones (the color of the grid cells changes with the feature polygon boundaries). In this model there are 4 major material zones. Polygons have been created in the different coverages so that we can assign IDs to these zones.

4. Double click on the polygon that overlaps the blue material zone at the top of the model. Notice that a *Zone budget ID* of 2 is assigned.
5. Select *OK* to exit the dialog.
6. Select the  *Map* → *MODFLOW* macro button.
7. The Zone Budget IDs have now been assigned to the grid.

11 Reading a Transient MODFLOW Solution

Before running ZONEBUDGET again we will read in a transient MODFLOW solution.

1. Select the *MODFLOW* | *Read Solution* menu command.
2. Locate and open the **Tutorials\MODFLOW\zonebudget\trans_MODFLOW** directory.
3. Open the file entitled **trans.mfn**.

Notice that  *trans (MODFLOW)* is now the active solution in the *Project Explorer*. This means that when we bring up the *Flow Budget* dialog we will be looking at the CCF file associated with this solution.

12 Advanced ZONEBUDGET Options

Now we will look at some of the advanced inputs to ZONEBUDGET.

1. Select the *MODFLOW* | *Flow Budget* menu command.
2. Select the *USGS ZONEBUDGET* tab.

Previously, when we ran ZONEBUDGET the model was steady state so there was only one time step in the CCF file. The current model solution comes from a transient model with multiple time steps. With ZONEBUDGET we can analyze all time steps or we can select specific time steps to analyze.

3. Select the **specified** option under the *Output times* section of the dialog. (See the next figure.)

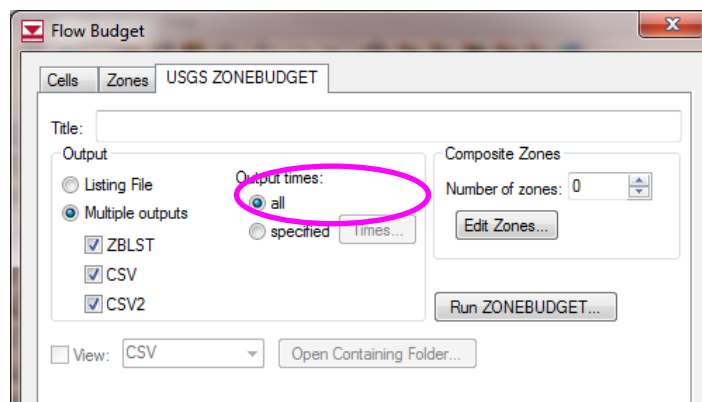


Figure 7. Specified output times.

4. Click on the *Times* button.
5. Select the check boxes next to **300.0**, **450.0**, and **600.0**.
6. Select *OK* to exit the dialog.

ZONEBUDGET also provides functionality to combine zones into Composite Zones. For example, in our problem we have zones 1, 2, 3, and 4. We can make a composite zone comprising zones 1 and 2; then ZONEBUDGET will give us a report for zones 1, 2, 3, 4, and for the composite zone.

7. In the *Composite Zones* section of the dialog change the *Number of Zones* to 2.
8. Click on the **Edit Zones** button.
9. Fill in the spread sheet as shown in the figure below.

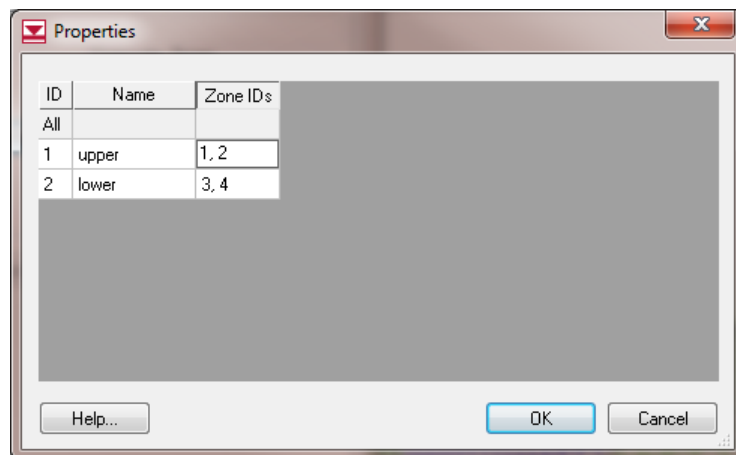


Figure 8. Composite zones.

10. Select *OK* to exit the dialog.

13 Running ZONEBUDGET

1. Select the *Run ZONEBUDGET* button.
2. Select the *Close* button when ZONEBUDGET has finished running.

Notice that the output contains data from 3 different time steps. To view information about the composite zones you must look at the listing file (ZBLST).

3. Change the *View* to **ZBLST** and scroll to the bottom to see information on the "lower" composite zone.

14 Conclusion

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

- GMS includes an interface to the USGS program ZONEBUDGET.
- You can view ZONEBUDGET output in GMS.
- GMS supports all features of ZONEBUDGET.
- Zone Budget IDs can be assigned manually to the grid or by using the conceptual model approach.