**Advanced Topics—Streamflow Routing (SFR6) Package Problems**

**Streamflow Routing Problem—1a**

We will be taking the transient McDonald Valley problem with the lake package that you previously created (lake problem 1b) and converting the river package to a streamflow routing package. The streamflow routing package solves for stream stage based on inflows and outflows from SFR6 reaches.

1. Copy the files in advanced\_topics/sfr/sfr0 directory to the empty advanced\_topics/sfr1a directory.
2. Run the existing model prior to making any changes. We have added observations to the river (RIV6) stress package (riv.obs) which will create a comma-spaced-values file (riv.csv) with the net base flow for all river boundaries.

Exercise 1:

Use the net base flow from the RIV6 package and Manning’s equation to calculate the steady state stage in the downstream river reach. Manning’s equation is

where *Q* is streamflow (*L3/T*), n is Manning’s roughness coefficient (*T/L*1/3), *W* is the reach width (*L*), *D* is the reach depth (*L*), and *S* is the slope of the reach streambed (*L/L*). Rearranging Manning’s equation to solve for depth is

The factor in Manning’s equation (1.49) converts *Q* from SI units (m3/s) to US units (ft3/s), as a result the net base flow from the river package needs to be converted from ft3/day to ft3/s in order to solve for the reach depth.

Calculate the conversion factor that would convert m3/sec to ft3/day (UNIT\_CONVERSION). \_\_\_\_\_\_\_\_\_\_\_\_

Use the stages specified in the river package and cell size to calculate the slope of the reach streambed (rgrd). \_\_\_\_\_\_\_\_\_\_\_\_

Calculate the downstream stream depth given the net base flow from the RIV6 package, the calculated slope, a Manning’s value of 0.03 sec/m1/3, and a reach width of 100 feet. \_\_\_\_\_\_\_\_\_\_\_\_

The river bottom was specified to be -2.0 feet but did not have any effect on the simulated base flow since groundwater levels were above the river bottom in each cell. Calculate the reach bottom to use for each reach assuming the stage in the downstream reach (reach 18) is 0.05 feet and the calculate reach streambed slope.

|  |  |  |
| --- | --- | --- |
| Reach | Reach bottom, feet | Stage, feet |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |
| 10 |  |  |
| 11 |  |  |
| 12 |  |  |
| 13 |  |  |
| 14 |  |  |
| 15 |  |  |
| 16 |  |  |
| 17 |  |  |
| 18 |  | 0.05 |

The river package uses conductance to calculate the simulated base flow. Conductance can be calculated from physical parameters using

where *C* is the river conductance (*L2/T*), *K* is the hydraulic conductivity of the river bed sediments (*L/T*), *L* is the length of the river in the cell (*L*), *W* is the river width in the cell (*L*), and *b* is the thickness of river bed sediments (*L*). Calculate the hydraulic conductivity of the river bed sediments (rhk) using the river conductance (1x105 ft2/day), the length of the river in the cell (DELC and rlen – 500 feet), a river width of 100 feet (rwid), and a river bed thickness of 1 foot (rbth). \_\_\_\_\_\_\_\_\_\_\_\_

1. Create a SFR6 input file using the SFR6 Example Input File in the MODFLOW 6 – Description of Input and Output (p. 98 to 99) document as a template. Replace the RIV6 package (at.riv) with the SFR6 package (at.sfr) in the GWF name file (at.nam).
2. Add the provided observation file (sfr.obs) as an OBS6 FILEIN entry and the calculated UNIT\_CONVERSION value to the OPTIONS block.
3. Modify NREACHES in the DIMENSIONS block to 18.
4. Use the layer, row, column (cellid) data from the RIV6 packages and the data calculated above to complete the PACKAGEDATA block. Each reach has 2 connections (ncon), except for reach 1 and 18. The upstream fraction (ustrf) and number of diversions (ndiv) will be 1.0 and 0 for all reaches, respectively.
5. Complete the CONNECTIONDATA block for the 18 reach. Each reach is connected to the previous reach and the next reach, except for the first and last reach. The upstream reach is defined as a positive reach number and the downstream reach is defined as a negative reach number (for example, the reach connectivity line for reach 8 is 8 7 -9).
6. Delete the DIVERSIONS and PERIOD blocks. The PERIOD block is not needed since the streamflow will be 100% base flow.

Exercise 1:

Compare the net base flow calculated using the river package and the streamflow routing package. Explain any differences in the net base flow between the simulations run using the RIV6 and SFR6 packages.

**Streamflow Routing Problem —1b**

In this problem we will modify problem 1a by adding runoff to the river. Rainfall in the GWF model domain is 36 inches per year, evapotranspiration is 8 inches per year, and runoff is 12.05 inches per year. Assuming that runoff south of Sand Ridge flows into the river, calculate the volumetric runoff rate (ft3/day) for the southern half of GWF model domain. \_\_\_\_\_\_\_\_\_\_\_\_

Calculate the volumetric runoff rates for each SFR8 reach, assuming the runoff would be applied equally. \_\_\_\_\_\_\_\_\_\_\_\_

1. Copy the files from streamflow routing problem 1a to the empty advanced\_topics/sfr/sfr1b directory.
2. Add the PERIOD block and the calculated runoff rate to each SFR8 reach in the SFR8 input file that you created in problem 1b.

Exercise 1:

Compare the reach stages and the net base flow calculated with and without runoff. Explain any differences between the simulations.