Documentation of Unit Response Functions

created for Western Water Use Model

of the Nebraska Panhandle

by

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Introduction

This report documents Unit Response Functions (URF) generated for the Western Water Use Model. This model is being constructed as a joint effort among North Platte Natural Resources District (NPNRD), South Platte Natural Resources District (SPNRD), and Nebraska Department of Natural Resources (DNR). This documentation replaces one completed August 23, 2010. The differences between the previous documentation and this documentation are outlined below.

A URF is a mathematical or tabular representation of the effects of a unit stress on a system. In this case, the URF is a tabular representation of the streamflow effects in a specific reach due to pumping (or recharging) a unit amount of water from the aquifer in a specific area. The URF will then be multiplied by the actual amount of water pumped (or recharged) to get the actual effect on streamflow. Strictly speaking, a URF should only be used for a linear system and the groundwater flow system in the area is not a linear system. However, the flow system in most of the area is sufficiently linear that the URF can be a useful tool.

After the previous documentation was completed, two problems were identified with the URF's. First, in a few places, the areas for which URF's were defined were not sufficiently detailed for use in a surface-water model being created for the same area. For example, one such area was between Winters Creek Canal and Minatare Canal and included the area both west and east of Winters Creek. However, Winters Creek Canal has a water right on Winters Creek, so the surface-water model needs to account for the area west of the creek separately from the area east of the creek. Therefore, one area in the previous documentation became two areas in the current documentation. A similar situation occurred between Belmont Canal and the North Platte River because of Cedar Creek, from which Belmont Canal has a water right. Again, one area in the previous documentation became two areas in the current documentation. An area east of Winters Creek where Enterprise Irrigation District has a small service area was not identified in the previous documentation. Therefore, a small area was carved out of several previous areas and a URF was generated for this area. Finally, one area in the previous documentation that represented the area around upper Blue Creek was split into two areas in the current documentation.

The areas for which URF's were previously generated were numbered sequentially from 1 through 143. This numbering system was retained, but some area numbers were retired because these areas were split or modified. Area numbers that were retired were 33, 37, 45, 109, and 119. The new areas were numbered 201 through 209 to clearly mark them. As a result, the new numbering system has gaps in it.

The second problem had to do with how evapotranspiration (ET) from the shallow water table in riparian areas was handled in the groundwater flow model used to generate the URF's. The model used the typical method to compute ET in which the simulated ET rate is a function of the simulated water level in the model. With this method, pumping near the riparian forest along the North Platte River or South Platte River would partially reduce simulated ET and would partially reduce streamflow. Some people now believe that small changes is water levels probably do not change the ET rate, so the model overestimates change in ET and underestimates change in

streamflow. The next groundwater flow model of the area probably will not make the simulated ET rate along the North Platte River or South Platte River a function of the simulated water level. To make the URF's consistent with the next model, changes in ET rates along the rivers were treated as changes in streamflow. The consequence of this is that the URF's along these rivers sum much closer to one than they did in the previous documentation.

Creating Zones for the Unit Response Functions

Two types of zones were created for producing the URF's. Stream zones were created by subdividing the streams into various zones so that the effect of pumping or recharge could be calculated for each stream zone. Land use zones were created so pumping or recharge within a small area that represents a land use zone could be grouped together for the surface-water model.

Stream Zones

Stream zones were created using canal diversion points and streamflow gages along the North Platte River. These zones were drawn so that they extended to the boundary of the groundwater flow model, although these zones have no effect except at river, stream, general head boundaries, and riparian ET areas in the model. The zone boundaries are based on the previous model's 160-acre grid. These zones are in shapefile "stream_zone_100623 ". This shapefile was used to make a ZoneBudget zone file "stream_zones_100722.dat". Stream zones are numbered 1-48, although number 46 was omitted. Zones 40-45 did not contain river, stream, general head boundary, or riparian ET cells in the previous model. Figure 1 shows the stream zones used to make the URF's.

After the new model with 40 acre cells is constructed and calibrated, the stream zones will have to be somewhat modified because shapefile "stream_zone_100623" will no longer accurately represent stream cells.

Land Use Zones

Land use zones were created using various criteria. Within the surface-water irrigated areas, zones were created between canals, and these zones were subdivided going downstream at convenient places. Outside of the surface-water irrigated areas, zones were based on similar land use patterns. To determine these zones, the 1997 land use map was overlain on the shaded relief map. For example, one zone may represent predominately dryland agriculture and another zone may represent predominately rangeland. The land use zones tend to be larger further from the surface-water irrigated areas because the effects of pumping or recharge on streamflow gets smaller further from the surface-water irrigated areas. The zone boundaries are based on the 160-acre model grid. There are 147 land use zones. Land use zones are numbered 1-209, with some numbers not used. Zones 33, 37, 45, 109, and 110 from the August 23, 2010 documentation were retired and were replaced with zones 210-209 in this documentation. These zones are in shapefile "LU_zone_101215". Figure 2 shows the land use zones used to make the URF's.

The centroid of each land use zone was used to create the point shapefile "LU_zone_101215_ point". The use of that shapefile is explained below.

The average streamflow accretion for each land use zone was determined by doing a spatial join of the land use polygons with shapefile "Transects_100629". "Transects_100629" is a point shapefile based on nodes for the 160-acre grid model. This shapefile contains the 50-year stream accretion computed with the previous model with a single stream zone. In this case, streamflow accretion was not adjusted based on changes in riparian ET. The average streamflow accretion for 50 years is also in the spreadsheet "URF_zone_notes_101213". Shapefile "Transects_100629" may be documented and released at a later date.

The points in "Transects_100629" were examined within each land use zone starting near the centroid of the land use polygon (shapefile "LU_zone_101215_point") to find a point with 50-year stream accretion similar to the average for the land use zone. Considerable professional judgment was exercised in selecting the point, so this was a subjective process. The locations of the selected points are recorded in the spreadsheet "URF_zone_notes_101213" and shapefile "LU_well_node_101213". Figure 3 shows the centroids of the land use zones and the model nodes that were selected to represent the land use zones.

The groundwater flow model was run in double precision with a test well placed at one model node as described in the previous paragraph. The test well injected water at a rate of 8000 ft^3/d for 1 month (30.4375 days) and was then shut off for the remainder of the 50-year simulation. That simulation was compared to a baseline simulation run without a test well, which was also run in double precision, and the difference in streamflow (rivers, streams, and general head boundaries) plus the difference in riparian ET on a monthly basis was the initial URF for each stream zone for that particular land use zone. That difference in streamflow plus riparian ET is called stream accretion in the remainder of this document, although stream accretion is frequently calculated with continuous injection over the entire 50-year period. Stream accretion is expressed as a ratio of the rate of stream accretion for that month to the injection rate. Stream accretion in "Transects_100629" is based on continuous injection over the entire 50-year period.

After each simulation, a specialized program called ZoneBudget was run to compute a water budget for each of the 48 stream zones. These results were stored in output files with the suffix "zbo". The ZoneBudget outputs were then stored in Access databases "URF_Database_101129_1" (Land use zones 1-80) and "URF_Database_101129_2" (Land use zones 81-209). Note that data for zones retired as described in the Land Use Zones section are still in these databases. A description the database tables and queries is given in Appendix A. The inputs to ZoneBudget were stored in a text called "ZB_input.txt" and the batch file "zonbud.bat" was used to run ZoneBudget in a DOS command window using the ZoneBudget input file. The ZoneBudget input file was then changed using a text editor for the next simulation. The use of an input file reduced the chances of making an error as well as speeding up the URF production process. The exact steps followed are in Word and Adobe files "URF_Production_proceedure_100623", and the procedure was followed for each simulation to reduce the chances of making an error. The procedure is shown in Appendix B.

Data were retrieved from the databases using a query called "URF by stream zone" and placed in spreadsheet "QC_chart_101201". The retrieval was done for one stream zone at a time and yielded results for each land use zone. The results were plotted in the "Charts" worksheet. There were 80 graphs labeled "Land Use Zone 001" through "Land Use Zone 080". When using the second database, mentally add 80 (or 157 for land use zone 201-209) to the land use zone number. The graphs were examined to determine the reasonableness of the results and to see the amount of noise in the results. The vertical axis on each graph was set to scale automatically, so some graphs just show noise. These tend to be a long way from the stream, have negligible stream accretion, and will be filtered out in a later step.

Figure 4 shows an example URF for a stream zone close to the land use zone. Land use zone 7 represents the area between the Tri-State Canal and the North Platte River from the Tri-State Canal diversion point on the North Platte River to the Enterprise Canal diversion point. Stream zone 5 contains Sheep Creek below the Tri-State Canal diversion point on Sheep Creek, Horse Creek, Kiowa Creek, and part of the North Platte River. Stream zone 5 represents the surface-water system from Ramshorn Canal (abandoned) diversion point to Enterprise Canal diversion point. The URF rises rapidly and reaches a maximum of 0.057 in month 3. The URF declines rapidly after that, dropping below 0.01 in month 15 and below 0.001 in month 34.

Figure 5 shows an example URF for a stream zone more distant from the land use zone. Land use zone 11 represents the area between Interstate Canal and Tri-State Canal from about the west end of Dutch Flats Drain to east of Dry Spottedtail Creek. Stream zone 5 is described in the previous paragraph. Note that land use zone 11 is down-gradient from stream zone 5, but still has an effect on stream zone 5. This is hydrologically correct because the effects of injection or pumping radiate outward in all directions, including up-gradient. The URF is below 0.0001 for the first 17 months and reaches a peak of 0.00034 in month 42. The URF declines slowly, dropping below 0.0001 in month 99 and below 0.00001 in month 188. The noise in the model can be seen in the latter part of the URF. Note that full scale on figure 5 is 175 times smaller than that of figure 4, so the noise is more apparent.

Data were also retrieved from the databases and were placed in spreadsheet "URF_zone_notes_ 101213". The exact steps followed are in Word and Adobe files "URF_Notes_procedure", which is also shown in Appendix B. The spreadsheet contains a "Notes" worksheet, which has a matrix of land use zones along the rows and streams zones along the columns with values representing the sum of 50-year stream accretion for the stream and land use zone combination. This matrix was checked on a land-use by land-use basis to make sure only reasonable stream zones were affected by a particular land use zone. The stream and land use zone combination matrix is shown in table 1. Sums of 50-year stream accretion greater than or equal to 0.01 (before rounding) are highlighted in yellow or orange. If the sum of stream accretion was exactly zero, table 1 shows "0". Where table 1 shows "-0", the sum of stream accretion was negative and was not exactly zero. If the sum of stream accretion was small, the table will show something like "7E-05". If the sum of stream accretion was larger, the table will show something like "0.061".

The URF's for stream zone 41 for all land use zones were manually set to zero. Stream zone 41 does not contain any perennial streams, but does contain ET areas around Sand Hill lakes and

other areas. The procedures used here produced some apparent stream accretion in stream zone 41 due to changes in ET in these non-riparian areas. Setting these URF's to zero corrected this problem.

Stream and land-use zone combinations for which the sums of the 50-year stream accretions were less than 0.01 (1 percent) were eliminated and their URF's will be assumed to be zero in the surface-water model. These stream and land-use zone combinations are not shaded in table 1. In addition, stream and land-use zone combinations where the monthly stream accretion never reached 0.0001 (0.01 percent) for a particular land use zone will be assumed to be zero in the surface-water model. The procedure to check if the URF's rose above 0.0001 is also shown in Appendix B. Stream and land-use zones combinations for which sums of the 50-year stream accretion were greater than or equal to 0.01, but monthly accretion never reached 0.0001 are shaded yellow in table 1. Stream and land-use zone combinations which passed both tests were retained and are shaded orange in table 1. The two tests eliminated URF's that showed essentially or predominately noise in the model. The sum of the 50-year stream accretions for the eliminated stream and land-use zone combinations were used to upward adjust the retained URF's. The adjustment factor for a particular stream and land-use zone combination was the ratio of total stream accretion for the eliminated stream zones divided by total stream accretion for all stream zones before elimination. The URF's for the retained stream zones were multiplied by 1.0 plus the adjustment factor on a month-by-month basis.

The URF's were further modified by setting stream accretion to exactly zero for months when it was less than 0.00001 (0.001 percent). When stream accretion reached this level, the URF essentially showed noise in the model. The remaining months were adjusted upward to account for the eliminated months. The adjustment factor was the ratio of total stream accretion for the eliminated months divided by total stream accretion for all months. The URF's for the remaining months were multiplied by 1.0 plus the adjustment factor on a month-by-month basis. The procedure for applying both modifications to the URF's is also shown in Appendix B.

After both modifications were applied to the URF's, the modified URF's were summed by land use zone and the sums were compared to the sums all URF's for the same land use before any adjustment. This comparison was a check that the modifications were done correctly and that the modification procedure was followed correctly.

The final URF's were stored in spreadsheet "URF_adjust_101213". Worksheet "Final_URF_1" contains the URF's for stream zones 1-25 and land use zones 1-143. Worksheet "Final_URF_2" contains the URF's for stream zones 26-48 and land use zones 1-143. Worksheet "Final_URF_3" contains the URF's for land use zones 201-209 for all stream zones. There are a total of 364 URF's, including some for land use zones that have been retired. The rows in the worksheets represent months 1 through 600 and the columns represent a stream and land use zone combinations. For example, the column labeled 05_007 represents stream zone 5 and land use zone 7. The worksheet "Sums" compares the sum of the modified URF's by land use zone to the sum of the initial URF's from spreadsheet "URF_zone_notes_101213". After all URF's were properly adjusted, the largest difference in sums was 4.1×10^{-7}.
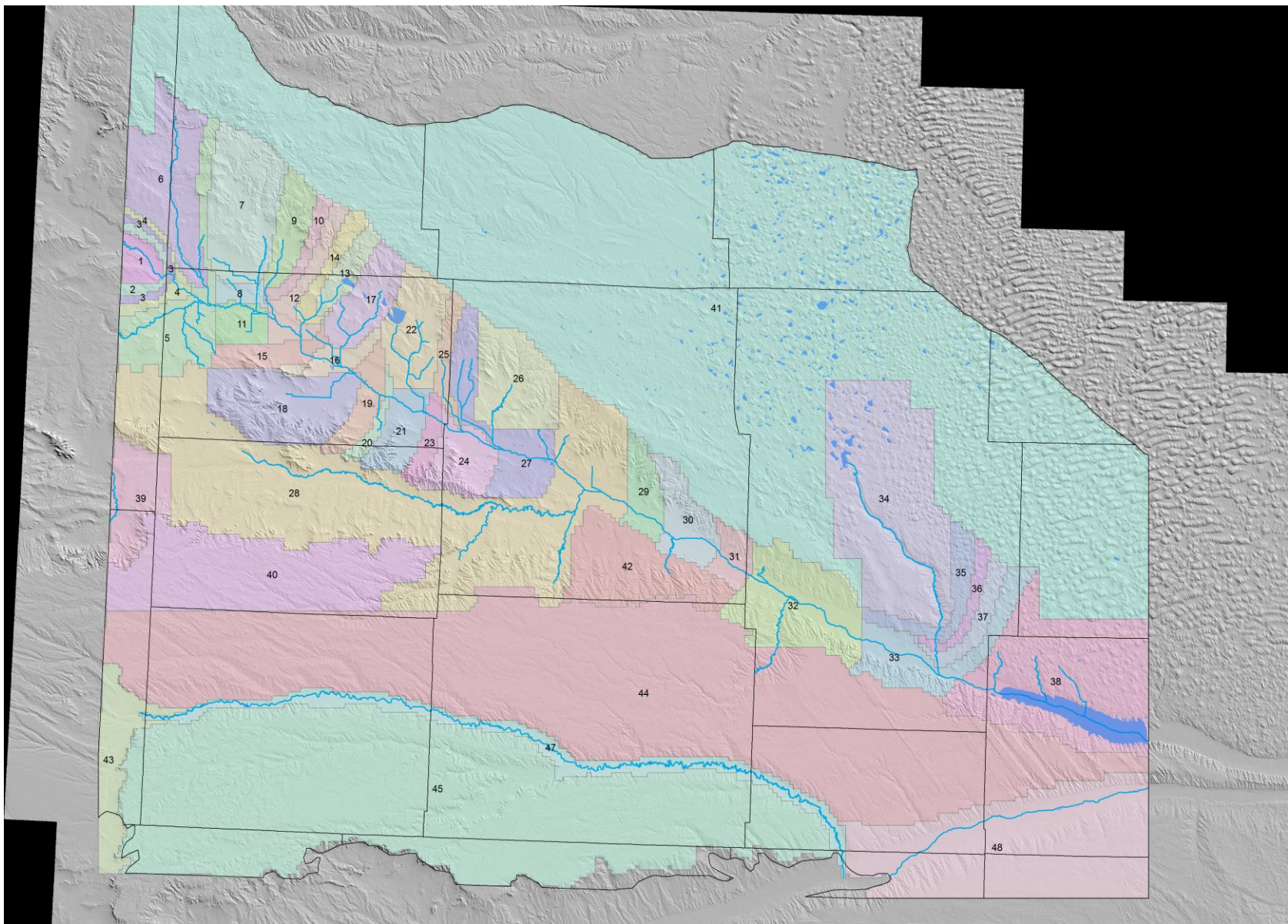
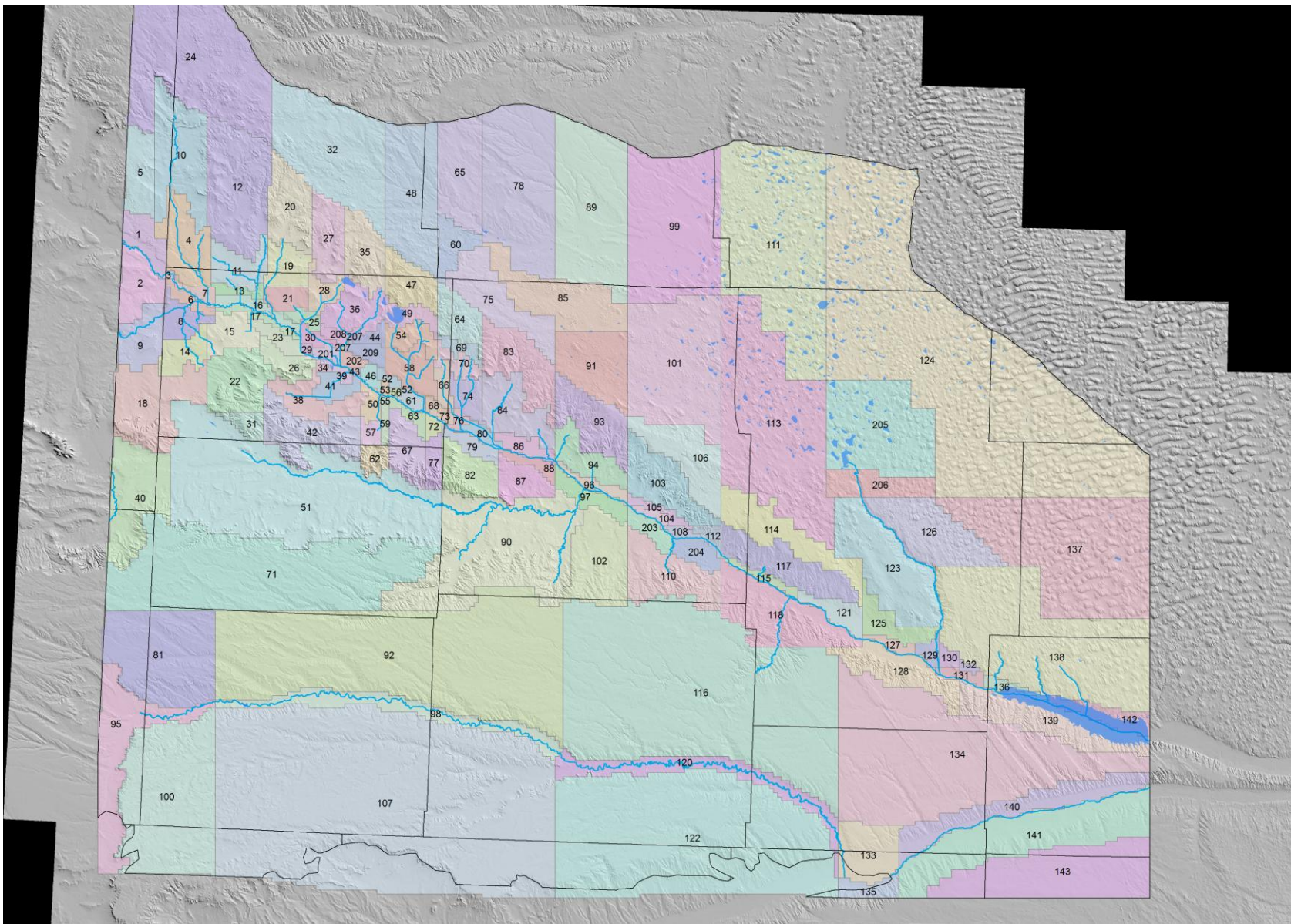Figure 1. Stream zones used to produce unit response functions.

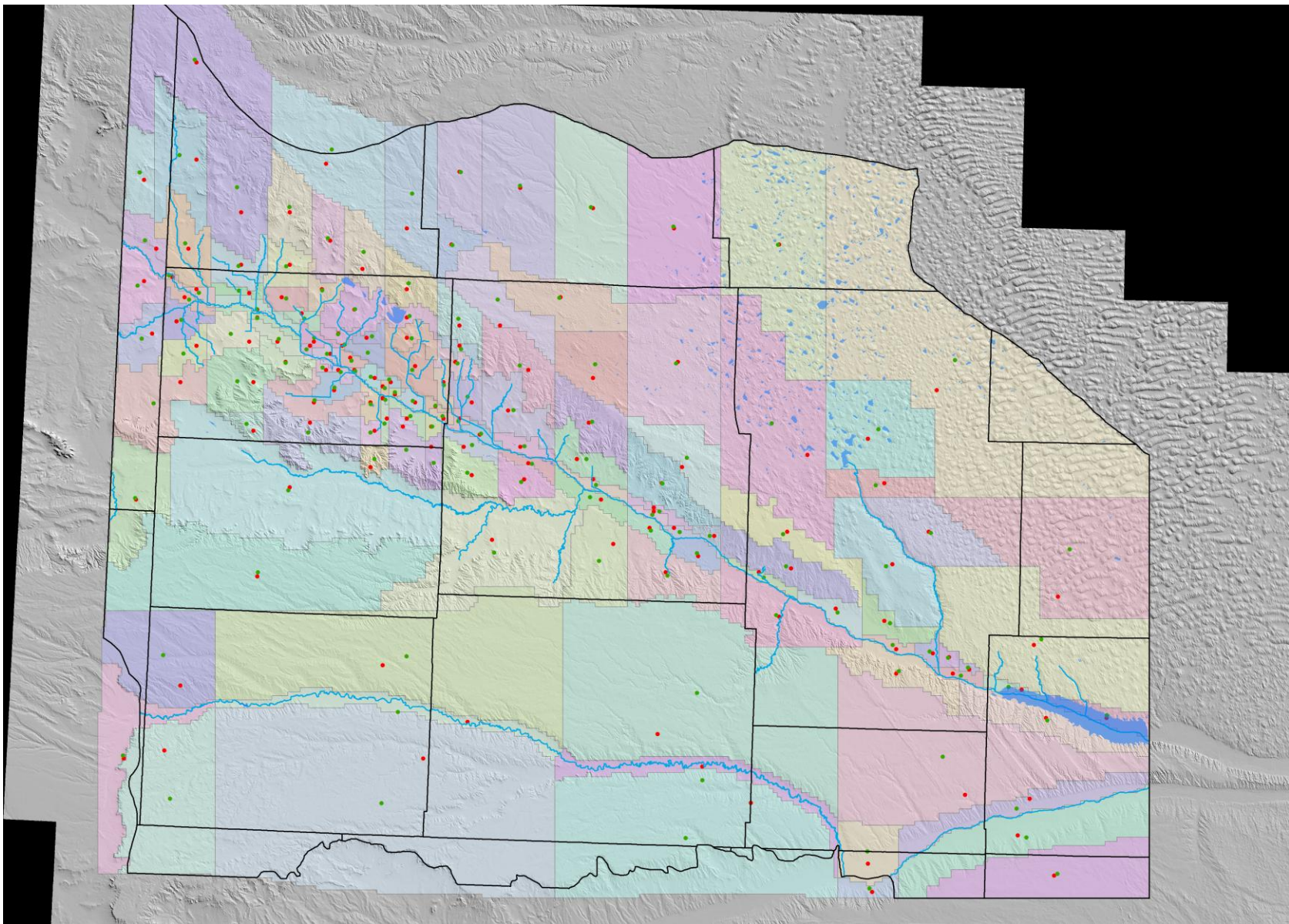Figure 2. Land use zones used to produce unit response functions.

Figure 3. Comparison of location of centroid of land use zone (green) and model node (red) used to represent land use zone. In some cases, the centroid blocks out the model node.
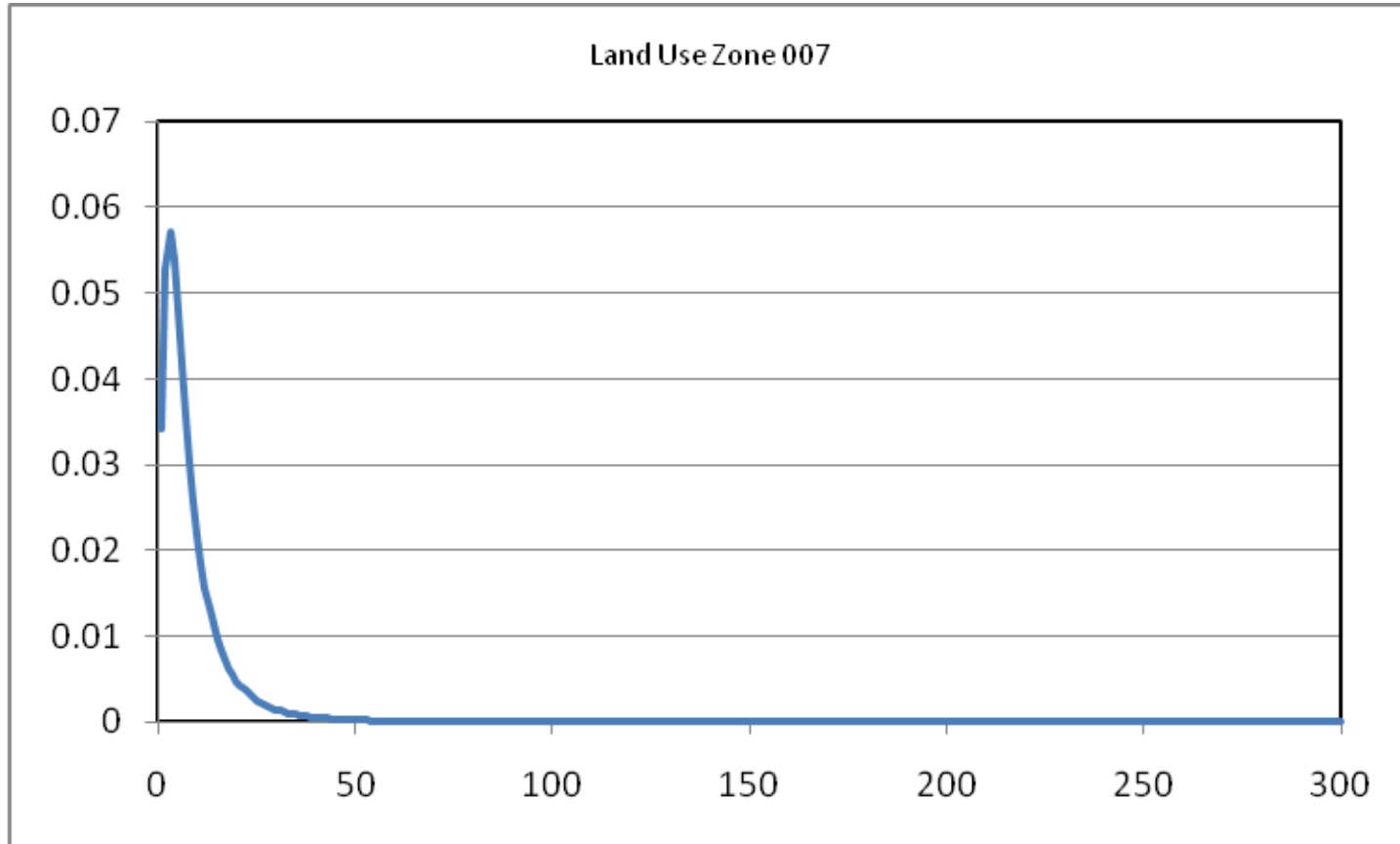
Figure 4. Unit response function for land use zone 7 on stream zone 5. Vertical axis is unit response function as a fraction of the injection rate. Horizontal axis is time since simulation began, in months.
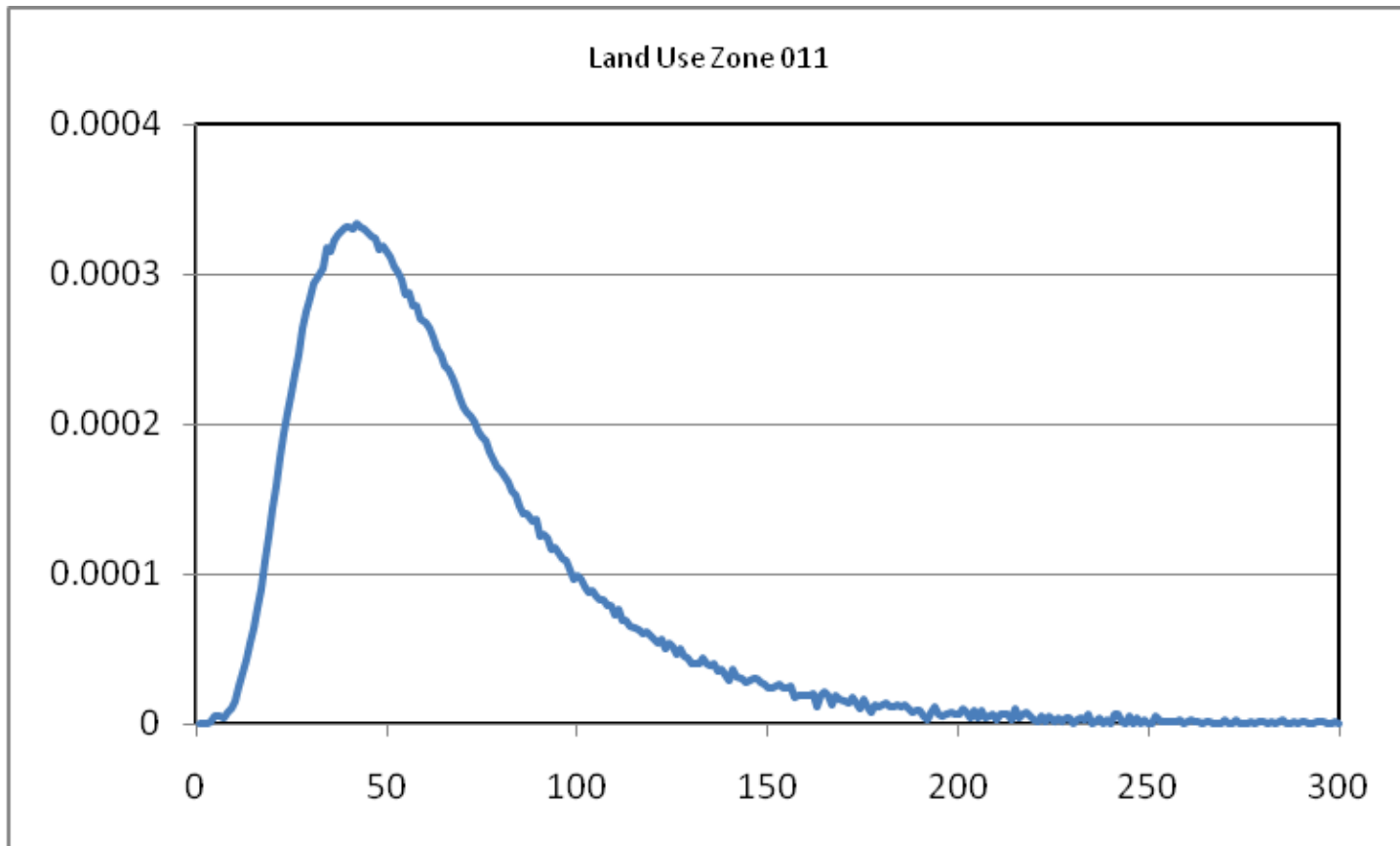
Figure 5. Unit response function for land use zone 11 on stream zone 5. Vertical axis is unit response function as a fraction of the injection rate. Horizontal axis is time since simulation began, in months.

Table 1. Matrix showing 50-year stream accretion by land use zone (rows) and stream zone (columns). Unit response functions were retained for those land use/stream zones shaded in orange.

Table 1 follows on next two pages.

Appendix A

December 16, 2010

Documentation of Databases Used to Store ZoneBudget Output

Unit Response Functions (URF's) were generated from output from a specialized program called ZoneBudget. ZoneBudget uses the MODFLOW cell-by-cell output file and generates cumulative volumetric water budgets and rate water budgets for several user-defined zones for all time steps of the simulation. The ZoneBudget output is then stored in an Access database using a program called ZoneBubgetToDatabase14. Data from ZoneBudget can be more easily handled using the database. The database is also used to perform various calculations on the data.

Tables

The database contains three tables. Table "tblIdentifier" identifies the particular simulation. Field "Identifier" is 25 text characters long and uniquely identifies the simulation. If the "Identifier" is reused, the previous data in the database is overwritten. "Identifier" is defined in the window "Form1" that appears when program ZoneBubgetToDatabase14 in invoked. Field "Description" is 255 text characters long and gives more information on the simulation. This field is also defined in the "Form1" window. Two additions fields, "UserName" and "ComputerName" are automatically generated by ZoneBubgetToDatabase14 using system information. These identify who ran the program and which computer that person was using.

Table "tblZoneBudget" is used to store the various water budget components for each zone generated by ZoneBudget. The first field, "Identifier", is the same as in the previous paragraph. The second field, "Period", is the stress period of the simulation. The third field, "Step", is the time step within the stress period of the simulation. The forth field, "Zone", is the zone number, or in the case of composite zones, is the zone letter of the composite zone. Field "Zone" is a text field in these databases although it usually contains a number. These fields are followed by a series of fields starting with "IStorage", which represents change in storage from the Input side of the volumetric water budget. There is one field for each component of the budget and they all begin with the letter I. These fields are the cumulative volumetric water budget component in whatever units the MODFLOW model was using. These are then followed by the output components of the volumetric water budget and they all start with the letter O.

Table "tblZoneInOut" is used to store the zone-to-zone flow components generated by ZoneBudget. Fields "Identifier", "Period", "Step", and "Zone" are identical to table "tblZoneBudget". Field "Direction" is either IN or OUT, indicating whether flow is in to or out of "Zone". Field "FromTo" is also a zone, indicating which zone the flow is coming in from or going out to. If "Zone" is 1, "Direction" is OUT, and "InOut" is 5, flow is going out of zone 1

and into zone 5. The last field is "Flow" and it is the cumulative volumetric flow in whatever units the MODFLOW model was using.

Queries

Several queries have been changed since these databases were last documented on July 27, 2010 and other queries have been added since that time. These changes were the result of the decision to treat a change in evapotranspiration (ET) along the riparian corridor along the North Platte River and South Platte River as if it were a change in streamflow. These changes are documented in the next two sections.

User Queries

Query "Select by name and zone" retrieves the cumulative net water budget for all components for all time steps for one "Identifier" and one "Zone". The user is prompted for values for "Identifier" and "Zone". Fields "Identifier", "Period", "Step", and "Zone" are identical to table "tblZoneBudget". These fields are followed by field "netsto" or net storage, which is field "IStorage" in table "tblZoneBudget" minus field "OStorage". This field is followed by a series of fields, all beginning with net, one for each remaining water budget component.

Query "Total URF by Land Use zone" retrieves the difference in streamflow, including changes in all shallow water table ET, between the baseline condition and the test condition for Period 101, Step 7 for all stream zones for one "Identifier". Period 101, Step 7 is the last step of MODFLOW simulation and represents the 12th month of the 50th year. The prompt for the query says "Enter Land Use zone" but that really means the "Identifier". For example, the answer to the prompt might be LU_078 because that was the "Identifier" used for the simulation that represented land use zone 78. Fields "Identifier", "Period", "Step", and "Zone" are identical to table "tblZoneBudget". Field "URF" is volume of stream accretion (including change in ET) due to the test well divided by the volume injected by the test well. The latter is hard-coded in a formula in the query as (8000*30.4375), so it depends on both the injection rate and the time step length. The baseline simulation is assumed to have the "Identifier" called Baseline. All other simulations are assumed to be test simulations. See Utility Queries for information on how to change the name of the baseline simulation.

Query "URF by stream zone" retrieves the difference in streamflow (including change in ET) between the baseline and a test simulation for all time steps for one stream "Zone" for all test simulations. The prompt says "Enter stream zone number" and that means stream "Zone". Fields "Identifier", "Period", "Step", and "Zone" are identical to table "tblZoneBudget". Field "URF" is volume of stream accretion (including change in ET) due to the test well up to that point in the simulation divided by the volume injected by the test well. The latter is hard-coded in a formula in the query as discussed in the previous paragraph.

Query "URF by name and zone" retrieves the difference in streamflow (including change in ET) between the baseline and a test simulation for all time steps for one land use "Identifier" and one stream "Zone". Fields are as described in the previous paragraph.

Query "URF by name and zone woET" is similar to "URF by name and zone" except that change in ET is not treated as if it were a change in streamflow. This query is useful for areas where there is non-riparian ET and there is no riparian ET.

Utility Queries

The database contains several utility queries that prepare data for the User Queries. These are not generally used by the user but can be used to examine and troubleshoot the database. For example, if a User Query returns an empty table, it may be because the baseline condition was not run or was not identified in the way the queries expect it to be identified. Utility Queries can help troubleshoot this problem by identifying which query returned an empty table.

Query "qrynet1" subtracts the OUT side of the water budget from the IN side of the water budget on a component-by-component basis. It returns fields such as "netStorage", "netRiver", and "netET".

Query "qrybase1" retrieves the baseline simulation water budget for all time steps. It returns fields such as "netStorage", "netRiver", and "netET" which were produced by "qrynet1". The identifier for the baseline simulation is assumed to be Baseline. If that is not the case, the criterion for "Identifier" needs to be changed in the query and in "qrynetdif".

Query "qrynetdif" subtracts the test simulation water budget from the baseline water budget for all time steps for all test simulations. It returns fields such as "difsto", "difriv", and "difet". The identifier for the baseline simulation is assumed to be Baseline. If that is not the case, the criterion for "Identifier" needs to be changed in this query and in "qrybase1".

Query "sum_SW and ET" sums the streamflow components, including changes in all shallow water table ET, from query "qrynetdif" and returns the sum in field "sum_sw". The streamflow components are drains, rivers, streams, general head boundaries, and ET.

Query "sum_SW_only" sums the streamflow components, excluding changes in all shallow water table ET, from query "qrynetdif" and returns the sum in field "sum_sw". The streamflow components are drains, rivers, streams, and general head boundaries.

Appendix B:

Some of these procedures use file names that were in use at the time these procedures were written and do not reflect file names used at the time this documentation was written. Mentally change to the file names in the procedures to the current file names.

The adjustment procedure talks about two worksheets in the adjustment spreadsheet that were used to store the final URF's. In this documentation there are actually three worksheets in the adjustment spreadsheet used for the final URF's.

The adjustment procedure talks about doing all land uses for a single stream zone. This was done for much of the data used to produce this report. However, late in the production of this data, it became obvious that doing all stream zones for a single land use zone was a more efficient way to populate the adjustment spreadsheet. The labeling of columns in the adjustment worksheets proved to be confusing. The columns are labeled like 01_004, indicating stream zone 01 and land use zone 004. In other places, the land use zone came first and the stream zone came second. If the adjustment procedure is used in the future, the procedure should be revised accordingly.

Procedure to produce Unit Response Functions using Groundwater Vistas file URF_100705.gwv.

1. Create MODFLOW data sets – ctrl+shift+M in Vistas.

2. Update well file using TextPad – Replace all function (watch spacing).

3. Update ZoneBudget input file (ZB_input.txt) using TextPad (2 places).

4. Update ZoneBudget to Database initialization file (ZoneBubgetToDatabase.ini) using TextPad (3 places).

5. Make sure all files have been saved in TextPad.

6. Run MODFLOW – ctrl+shift+R in Vistas.

7. Check MODFLOW output file to verify that well was placed in correct location.

8. Run zonbud.bat in command window.

9. Run ZoneBudgetToDatabase14.exe after checking Form1 window to make sure all is okay. The inputs to Form1 were set in step 4, but can be changed here.

10. Make checkmark on spreadsheet showing procedure was completed for this well placement.

About every 10 zones, process to QC spreadsheet to make sure everything is still going well.

Procedure to put stream zone Unit Response Function (URF) by land use zone into notes spreadsheet

Open spreadsheet URF_zone_notes_101213 and database such as URF_Database_100728.

1. In database, perform query "Total URF by Land Use zone." Enter land use zone such as LU_021. Copy table to clipboard.

2. Paste table to worksheet By_stream_zone in spreadsheet.

3. Convert Zone to number by selecting values (not heading) and on information tab, select Convert to Number.

4. Sort the table by Zone.

5. Select URF values (not header) and copy to clipboard.

6. In Notes worksheet, select cell in column E for appropriate Land Use zone and Paste Special (Transpose).

7. Verify that values have been pasted all the way to SUM column.

Occasionally save the spreadsheet.

Procedure to check Unit Response Functions (URF's) to see if URF rises above 0.0001 for some months

Open spreadsheets URF_zone_notes_101213 (notes spreadsheet) and QC_chart_101201 (chart spreadsheet). Open appropriate database or databases.

1. Query database using "URF by stream zone" for one stream zone

2. Copy data to clipboard

3. Go to chart spreadsheet and paste data in cell A1 of "Data" worksheet

4. Note which land use zones in notes spreadsheet are shaded orange for this stream zone

5. Go to chart worksheet and look at chart for one land use zone that was shaded orange:

   a) If URF goes above 0.0001, do nothing

   b) If URF does not go above 0.0001, change shading in notes spreadsheet for that land use zone and stream zone from orange to yellow

6. Return to step 5 until all orange land use zones are checked

7. Return to step 1 and repeat process for next stream zone

Procedure of populating URF adjustment spreadsheet URF_adjust_100727.xls

1. Make retrieval from database using query "URF by name and zone" for a stream zone/land use zone where the URF is to be retained. These are shaded orange in the URF_zone_notes_101213 spreadsheet. Identifier is like LU_004 for land use zone 4 and Zone is like 8 for stream zone 8.

2. Copy data to clipboard.

3. Go to Raw worksheet of spreadsheet URF_adjust_100727 and paste to A1.

4. Copy data values for Sum, Retained, and Adj_1 (BA:BC) from the appropriate row of the Notes worksheet of spreadsheet URF_zone_notes_101213 to clipboard. The appropriate row is the land use zone number part of the Identifier in step 1.

5. Go to Adjusted_1 worksheet of spreadsheet URF_adjust_100727 and Paste Special (Values) in G2:I2.

6. Go to Final_URF worksheet and add label to row 1 indicating stream zone and land use zone. For example, 01_004 indicates stream zone 1, land use zone 4. See note below.

7. Go to worksheet Adjusted_2 and copy data (not heading) from column G labeled URF_mod of to clipboard.

8. Look at value of Adj_2 and make note if it is greater than 1.1.

9. Look at chart and make note if its shape looks suspicious.

10. Go to worksheet Final_URF and Paste Special (Values) in line 2 of the appropriate column.

11. Look at label from step 6, go to database table and make sure label was correct, and close database table.

12. Save the spreadsheet after completing all land use zones for one stream zone.

Note: Spreadsheet URF_adjust_100727 also has worksheet Final_URF_2 because not all URF's would fit on one worksheet. Make appropriate adjustments in steps 6 and 9 for stream zones greater than 25.

After Final_URF and Final_URF_2 are populated, go to worksheet Sums and sum URF's that were generated for each land use. The sum should match the Sum value in spreadsheet URF_zone_notes_101213 within tight tolerances. There is no easy way known to sum the URF's, so the formulas to create the sums had to be done manually. After all URF's were properly adjusted, the largest difference in sums was 2E-15.